UNIVERSITY FOR DEVELOPMENT STUDIES

FARMERS' PREFERENCES AND USE OF CERTIFIED GROUNDNUT SEED IN NORTHERN GHANA

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BY

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, NYANKPALA CAMPUS, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE (M.PHIL.) IN AGRICULTURAL ECONOMICS

FEBRUARY, 2019

DECLARATION

I hereby declare that this thesis/dissertation is the result of my own original work and that no part of it has been presented for another degree in this University or elsewhere.

……………………………… Date……………………….

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

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(Head of Department)

DEDICATION

I dedicate this work to my parents; Mr. Konja Tasila and Mrs. Priscilla Kina Konja for their love and encouragement throughout this study.

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I am very grateful to the Almighty Lord for granting me outstanding knowledge and guidance throughout this research. I humbly beseech the Lord's blessings in the lives of everyone who contributed in diverse ways to the completion of this research.

My special thanks goes to both my supervisors, Dr. Michael Ayamga and Dr. Franklin N. Mabe, my head of department, Dr. Joseph A. Awuni and Mr. Isaac Gershon K. Ansah who with due diligence and guidance, supervised and reviewed the project to a successful completion.

I also express my deepest gratitude to the Savannah Agricultural Research Institute (SARI), especially Dr. Richard Oteng-Frimpong, for funding the data collection of this project. I further wish to express my heartfelt gratitude to all the actors along the value chain of certified groundnut seed production in the Northern Ghana for their support during data collection.

I say may God restore all their losses.

ABSTRACT

Groundnut farmers face production losses through Aflatoxin infestation and bad weather conditions. These losses could be avoided if the right planting material is used. Unlike in the case of rice and maize, use of CGS is limited, largely due to the unavailability and low level of usage by farmers in Northern Ghana where much of the production is done. Motivated by this argument, the study examines farmers' preferences and use of certified groundnut seed in Northern Ghana. Multi-stage sampling technique was used to collect cross-sectional data from 250 smallholder groundnut farmers, 10 input dealers, 10 seed production companies and one research institution for the analysis. Using descriptive data analysis approach, the study demonstrated that, the incentives for commercial production of CGS on the producer and supplier side include; high demand, high profit, contracts and support from NGOs and projects. The study also identified the most preferred seed attributes by farmers to be high-yielding and big-nut whereas reddish-nut was the least preferred. Jute sack and selling of CGS to farmers in their communities in group was the most preferred packaging material and distribution channel respectively. The Cragg's Double Hurdle model was used to estimate farmers' decision and use intensity of CGS. The results revealed that farmers' decision to use CGS was influenced by age, educational status, extension service, credit access, farm size, household size, input distance, output distance and transport access. However, farmers' use intensity of CGS was affected by access to extension service, price of CGS, Farmer-Based Organizations' (FBO) membership, output distance, and input distance. The identified constraints in groundnut seed production and marketing include; lack of government subsidy, land tenure issues, high price of CGS, poor road networks, ineffective field inspection by Plant Protection and Regulatory Services Directorate, few producers and poor partnership among value chain actors. The study recommends that Ministry of Food and Agriculture (MoFA) should increase farmers' knowledge of CGS through their extension agents. FBOs should be established to help input dealers market and distribute CGS to farmers through Seed Brokerage System (SBS). SBS can facilitate bulk purchase by farmers in groups thereby ensuring timely acquisition and delivery of seeds to farmers in their communities. Groundnut seed breeders should consider the preferences of farmers in the production of foundation seeds.

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AGRA	Alliance for Green Revolution in Africa
ATT	Agricultural Technology Transfer Project
CSSS	Community-based seed supply Scheme
EU	European Union
IPVs	Improved peanut varieties
CGS	Certified Groundnut Seed
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistics Database
FASDEP	Food and Agriculture Sector Development
FBOs	Farmer Based Organizations
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ISSER	Institute of Statistical, Social and Economic Research
PCS	Preference Component Score
PCI	Preference Component Index
PII	Preference Indicator Index
SARI	Savannah Agricultural Research Institute
SBS	Seed Brokerage System
SEEDPAG	Seed Producers Association of Ghana
SPSS	Statistical package for Social Sciences
SRID	Statistics Research and Information Directorate
SMU	Seed Multiplication Unit
SSA	Sub-Saharan Africa
STAG	Seed Trade Association of Ghana
GAIDA	Ghana Agricultural Input Dealers Association
GART	Golden Valley Agriculture Research Trust
GSS	Ghana Statistics Service
GDP	Gross Domestic Product
GLDB	Grains and Legumes Development Board
GSID	Ghana Seed Inspection Division
GSC	Ghana Seed Company
MoFA	Ministry of Food and Agriculture

MDGs	Millennium Development Goals
NSTL	National Seed Testing Laboratory
USAID	United State Agency for International Development
UNIDO	United Nations Industrial Development Organization
WASP	West Africa Seed Program

CHAPTER ONE

INTRODUCTION

1.1 Background

The contribution of the agricultural sector to the overall development of Ghana cannot be underscored. Over the years, the agricultural sector which employs the majority of the labour force has contributed significantly to the Gross Domestic Product (GDP) of Ghana. The sector remains key to overall economic growth and development of the country and it is expected to lead the growth and structural transformation of the economy. In the year 2015, the agricultural sector contributed 19.0% to GDP as against 26.9% industry sector and 54.1% service sector [Ghana Statistical Service (GSS), 2015].

The agricultural sector is dominated by small scale farmers mostly in rural areas. About 80% of farm holdings are less than 1.2 ha in size, although there are some large farms and plantations for cash crops such as rubber, oil palm and coconut and to a lesser extent, rice, maize and pineapples [United State Agency for International Development (USAID), 2011; Ministry of Food and Agriculture (MoFA), 2011)]. It is also important to note that, in 2013, the sector yielded foreign exchange earnings of US$2,709 million to the economy [Institute of Statistical, Social and Economic Research (ISSER), 2014], and employed 53.6% of the labour force in the country [Food and Agricultural Organization (FAO), 2016]. The trickle-down effect of this sector on the livelihood of farmers with regards to food security and other gains cannot be underscored.

Since agriculture is and remains key for economic growth, the need to enhance agricultural output and productivity becomes important in Ghana. Population growth in many developing countries continue to widen the gap between food production and demand, necessitating major improvement in productivity. The relationship between the world population growth and the agricultural growth was first postulated by a pessimist Economist, Thomas Malthus in 1803. Malthus pointed out that, an exponential increase in population cannot be sustained in the long run since land and other natural resources are fixed in supply. Considering this, there is a growing concern about the ability of some nations especially in sub-Saharan Africa to produce enough food to be self-sufficient.

According to World Bank (2012), countries that have undertaken initiatives to expand producers' access to agricultural technologies such as certified or hybrid seeds and fertilisers have generally been the most effective at increasing agricultural productivity. Seed, fertiliser and irrigation are the three most critical inputs for enhancing crop productivity in developing countries (Fargher and Edmeades, 2013). Among the three, seed is the cheapest way to go for a successful green revolution (Fargher and Edmeades, 2013). A survey by Alliance for a Green Revolution in Africa (AGRA) in 2014, noted that main stream of farmers who use improved seed recorded about 50-100 percent increase in output above local varieties users. Improved seeds can make a significant contribution to agricultural productivity in African countries. Whiles the importance of seed for productivity is widely recognised, access to seed for specific crops is constrained due to seed production and supply issues (Etwire *et al.*, 2013).

Seed development in Africa differs considerably among countries. Effective and diversified seed industries exists in few countries (e.g. Egypt, Kenya and Zimbabwe). In countries like Malawi and Zambia, seed production and supply systems are relatively well for some crops. In the case of countries like Ghana, Cameroon, Ethiopia, Tanzania and Uganda, progress has been very limited in spite of investment and assistance (AGRA, 2014). In Africa countries, the annual seed demand exceeds production, with over 80% of seeds available to farmers not certified and of unknown quality (Barnett *et al.*, 2011).

The seed sector in Ghana was privatised in 1990, in order to introduce efficiency in the private sector. It was expected that the private sector would usher in a period of efficient, widespread and profitable seed programme. This is yet to materialize and currently less than 5% of Ghanaian farmers get access to improved seed from approved sources (MoFA, 2015). The Ministry of Food and Agriculture believes that Ghana's agricultural achievements could be improved if the seed sector is developed (MoFA, 2015). Currently, the seed sector focuses on few crops such as rice, maize, sorghum and soybeans. Other crops like groundnut, have poorly developed seed systems. Many farmers engaged in groundnut production do so with local varieties. Unlike other crops (rice, maize and soybeans), there is no subsidy on groundnut seeds, despite the crop being one of the key oil crops in the country.

Although some effort has been made by research institutes including Savannah Agricultural Research Institute (SARI) to develop the groundnut seed system, improved seed use rates remain low and inconsistent (Ibrahim *et al.*, 2012). Two government seed agencies, the National Seed Committee and National Seed Services, were linked to just 0.05% of groundnut production in 2011 (Masters *et al.*, 2013). One factor that supports the growth of seed production for other crops like maize is strong adoption and high demand for improved seed. This has served as a signal to breeders and private entities to set up seed production and distribution businesses. The poor knowledge of improved groundnut seed use and demand continues to constrain effort to develop the sector.

Developing countries constitute 97% of the global area and 94% of the global production of groundnut (FAO, 2011). South Africa, Nigeria, Senegal and Ghana are the major producers in Africa, with Nigeria producing 94% total groundnut in Africa. In Ghana, it is estimated that about 92% (382, 759Mt) of groundnuts is produced in northern Ghana. The Northern Region leads with an estimated annual total output of 188,080Mt, representing 45% of the national per annum production; the Upper West Region follows with an annual output of 154,179Mt (37%); while the Upper East Region has an annual output of 40,500Mt (10%) (MoFA, 2016). The growth of the groundnut sub-sector would require a vibrant seed sector. This would increase the quantity and quality of certified groundnut seed supplied to farmers for use in production.

1.2 Problem Statement

Groundnut is ranked second most important oil crop worldwide after soybean (FAO, 2013). Reducing rainfall across the three regions of the north has meant that crops requiring longer periods of rainfall are no longer suitable. Groundnut which requires less rain has therefore become the preferred crop. Groundnut is often intercropped or rotated with maize, sorghum and millet in the country due to its nutrient fixing capacity and as a cover crop.

Despite the recognition of groundnut as a cash crop with the potential to alleviate poverty in the northern Ghana, it is evident that potential yield per hectare is not encouraging. In 2015, the highest yield recorded in northern region was 1.65Mt/Ha, followed by the Upper West, 1.19 Mt/ha and Upper East region recording the lowest yield of 0.65Mt/Ha (MoFA, 2016). The average yield of groundnut for the country in 2015 was estimated as 1.24 Mt/ha, a figure significantly below the achievable level of about 2.50 Mt/Ha (MoFA, 2016).

Low productivity in the groundnut industry can be ascribed to several factors including pest and diseases; use of poor quality seeds and low-yielding varieties; and poor agronomic practices and farm management in sub-Saharan Africa (Ross and Klerk, 2012, Mukuka and Chisanga, 2014). In Ghana, the major constraint to groundnut production is disease particularly, early and late leaf spots diseases, which is widely distributed and occur in epidemic proportions in northern Ghana (Frimpong *et al.,* 2006; Nutsugah *et al.*, 2007 and Thakur, 2014). Aflatoxin and leaves defoliation has also tremendously reduced the quality and the yield of groundnut in the north and Ghana at large. The contamination of Aflatoxin also seems to be the major constraint for Ghana groundnut export market especially in Europe and America.

Aflatoxin is mostly spread through groundnut seeds (Nigam 2015), meaning the use of certified seed would significantly reduce Aflatoxin contamination on seed to enable farmers participate in international markets. Seed carries the genetic potential of the variety and determines the ultimate productivity of other inputs. The main role of other inputs in crop production, in which groundnut is no exception, is to exploit to maximum genetic potential of seed. It is estimated that the direct contribution of quality seed alone to the total production is about 15%-20%, depending upon the crop and it can be further raised up to 40%-50% with effective management using other inputs (Singh, 2013). Therefore, seed is and should at all times be the basic precondition of any food security scheme.

Over 80% of smallholder farmers in Africa rely on informal seed channels such as; farmers' own saved seeds, seed exchanges among farmers and purchases from the local grain or seed markets (Louwaars and De Boef, 2012). Low productivity as a result of using unimproved and uncertified groundnut seeds in production prevent farmers from participating in the market and encourages subsistence farming. One of the ways groundnut farmers can improve their productivity is by using certified groundnut seed produced by formal seed markets in the country. A sustainable supply of certified groundnut seed by the formal seed value chain actors can effectively be achieved if there are economic prospects. High demand for improved and certified seed will incentivise commercial seed producers to upscale their production level.

The National Seed Committee and National Seed Service Agencies that form part of Ministry of Food and Agriculture, control the formal system for certified seed. However, in 2011, this channel was projected to be producing only 0.05% of all peanuts used in the country (Tripp and Akwasi-Mensah, 2013). From Figure 1 below, the quantity of certified groundnut seed produced from 2003 to 2015 has been fluctuating. According to Tripp and Akwasi-Mensah (2013), the fluctuation can be attributed partly to weather, demand, and support from various government and donor projects and the fact that there are small-scale producers engaged in the sector. The researchers indicated that in recent times, new seed companies have entered into seed production with much of their concentration on maize, although they have also produced legume seed, particularly in response to demand from several donor projects. Research institutes and other public sector servicing institutions such as Grains and Legumes Development Board (GLDB) and Ghana Seed Inspection Division (GSID) are under-funded and this limits their critical roles in seed multiplication. The question is; are there incentives for commercial production of certified groundnut seed?

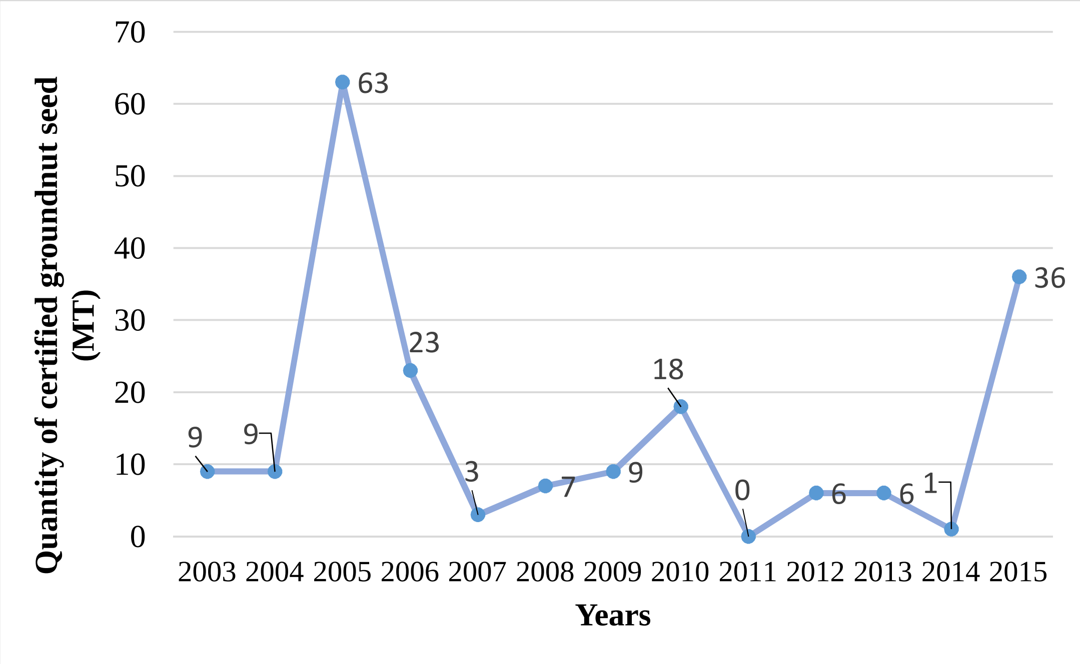

Figure 1: Certified Groundnut Seed Production in Ghana, 2003-2015
Source: ***Plant Protection and Regulatory Services Directorate (PPRSD) and NASTAG***

It is impossible for certified groundnut seed producers to integrate in the market and enjoy the potential economic incentives, unless what they supply meets the demand of farmers. Most of the certified seed producers enter into business without knowing farmers' preferences for seeds with regards to; prices, their willingness to pay, desired seed attributes, packaging and selling outlets among others. There is little documentation of smallholder farmer preferences in Ghana (Horna and Nagarajan, 2010; Tripp and Mensah-Bonsu, 2013). Subsequently, this may have led to the persistent absence of options in providing efficient seed distribution services to smallholder farmers. There are limited empirical studies on factors likely to influence use intensity of certified groundnut seed. The following research questions will underscore the importance of this study:

1. What are the economic prospects for commercial production of certified groundnut seed in the study area?

2. What are the preferences of smallholder groundnut farmers in relation to seed?

3. What are the factors that influence smallholder farmers' decision to use certified groundnut seed in the study area?

4. What is the use intensity of certified groundnut seed and its determining factors in the study area?

5. What are the constraints in the production and marketing of certified groundnut seed in the study area?

1.3 Objectives of the study

The main objective of this study is to examine farmers' preferences and use of certified groundnut seed in Northern Ghana. Specifically, the study seeks to:

1. identify the incentives or disincentives for commercial production of certified groundnut seeds.

2. assess smallholder groundnut farmers' preferences for seed in relation to: seed attributes, selling outlets and packaging.

3. analyse the factors that influence smallholder farmers' decision to use certified groundnut seed.

4. estimate certified groundnut seed use intensity and its determining factors.

5. identify constraints facing groundnut seed production, certification, distribution and marketing.

1.4 Hypotheses of the Study

The following hypotheses were tested and validated.

H_0: Each of: demand, donor support, contracts to produce CGS, government subsidy, profit etc. are not the incentives for producing certified groundnut seeds.

H_1: Each of: demand, donor support, contracts to produce CGS, government subsidy, profit etc. are the incentives for producing certified groundnut seeds.

H_0: Each of: big pod, big nut, more nut oil, high yield, resistance to pest and diseases, good germination rate, package in jute bags, sold in input shops, MoFA office etc. are not the preferences of smallholder groundnut farmers for certified groundnut seeds.

H_1: Each of: big pod, big nut, more nut oil, high yield, resistance to pest and diseases, good germination rate, package in jute bags, sold in input shops, MoFA office etc. are the preferences of smallholder groundnut farmers for certified groundnut seeds.

H_0: Each of: sex, age, farming experience, input distance, FBO membership, farm size, labour, credit access, access to transport and price of certified groundnut seeds etc. do not affect the adoption and use intensity of certified groundnut seeds.

H_1: Each of: sex, age, farming experience, input distance, FBO membership, farm size, labour, credit access, access to transport and price of certified groundnut seeds etc. affect the adoption and use intensity of certified groundnut seeds.

1.5 Justification of the Study

The study seeks to examine farmers' preferences and use of certified groundnut seeds in Northern Ghana. Conducting research on this topic is very important since the use of improved and certified groundnut seed is necessary for agricultural intensification. The study will highlight some of the incentives and disincentives available to the main actors along the certified groundnut seed production value chain. Knowledge about the viability and incentives of groundnut seed production as a commercial enterprise, is required to help entrepreneurs make entry and investment decisions.

The need to link groundnut seed producers to farmers also becomes paramount to ensure seed adoption. This study would bring to bear smallholder groundnut farmers' preferences for certified groundnut seed in relation to price, packaging, seed attributes and marketing. With that, policies can be designed to enable certified groundnut seed producers produce to meet the needs of farmers and to encourage adoption.

The factors that influence intensity of certified groundnut seed use would be analysed in this study. This would enable the researcher make policy recommendations that would help farmers to re-orient their production systems to ensure high efficiency in seed used. This study would provide strong argument to entice government and other stakeholders in agricultural sector on how to improve efficiency in groundnut seed production and marketing.

Literature on farmers' preferences and use of certified groundnut seed in the country is scanty. For instance, Ibrahim *et al.* (2012) focussed their attention on the determinants of farmers' adoption of improved peanut varieties and their impact on farm income in Northern Ghana. Tanzubil and Yahaya (2017) also researched on assessment of yield losses in groundnut (*Arachis hypogaea* L.) due to arthropod pests and diseases in the Sudan savannah of Ghana. Kassie *et al.* (2010) also researched on adoption of improved groundnut varieties in Uganda. However, this study went further to examine smallholder farmers' preferences for CGS to enable breeders and suppliers meet their demand to encourage adoption and usage in the study area.

This study will contribute to existing literature while generating useful information for the Ministry of Food and Agriculture and other stakeholders, especially the Crops Directorate for management, planning and monitoring purposes. Policies could also be designed to strengthen the groundnut seed industry by addressing the identified associated constraints along the certified groundnut seed production value chain.

1.6 Scope of the Study

The researcher considered Northern Ghana as the study area. The choice of the region and the sampled districts was mainly based on the larger number of groundnut producers relative to other regions in the country. Smallholder groundnut farmers, seed companies, breeder/foundation seed institution and input dealers were sampled for the study. This helped the researcher to review the seed system and roles of actors along the CGS value chain.

This research foremost will like to identify the incentives and disincentives for commercially produced certified groundnut seed along the value chain in the study area. The identification of the potential incentives and disincentives will provide indications as to whether it is viable for investors to venture into certified groundnut seed production. So far as every business targets the end users, in this case farmers, this study carried out a demand analysis to highlight the preferences of farmers with regards to seed attributes, packaging, and selling outlets. It further looked at farmers' extent of preferences for seed attributes, packaging materials and selling outlets disaggregated by their characteristics. Notwithstanding, it also becomes paramount for the researcher to determine the possible driving factors of the intensity of use of CGS in the study area. Lastly, the study identified the constraints face in the production and marketing of certified groundnut seed in the study area.

1.7 Organization of the Study

This study is structured into five chapters. Chapter one starts with the background of the study which is followed by the problem statement, research questions and the objectives of the study. Additionally, chapter one highlights the hypotheses, justification, scope and the organization of the study.

Chapter two reviews literature connected to the study. Chapter three outlines the methodology for the study and is divided into three. The first part of the chapter describes the study area whiles the second part describes the sampling approach. The third part of chapter three presents the theoretical framework of the study and the methods of data analyses. Chapter four presents the results and discussions of the analysed data. The study concludes with chapter five which presents the summary of major findings, conclusions, recommendations, and limitations and suggestions for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature on theoretical, empirical and policy related issues as pertains relevant to the study. The chapter presents an overview of groundnut production, review of seed production in Africa, overview of the seed industry in Ghana and the structure of the seed system in Ghana. It also reviewed literature on seed marketing and distribution, source of seeds, incentive and disincentives of CGS and preference of smallholder farmers for certified seeds. The chapter concludes with a review of empirical studies on adoption and use intensity of CGS, productivity and adoption of certified seeds, Cragg's double hurdle regression model and its applications in related research.

2.2 Groundnut Production in the World

Groundnut (*Arachis hypogaea* L) is an annual legume crop grown in semi-arid regions of the world. Peanut is the thirteenth most imperative food crop grown by over 100 countries in the world. The world yearly production of groundnut (shelled) was 42 million tonnes with average yield of 1.2 Mt/Ha in 2014, led by china with 38% of the global total followed by India (15%). Nigeria, United State of America and Sudan were also significant producers (FAOSTAT, 2016). The anticipated demand of groundnut in Asia alone by 2020 is expected to be 1.6 times more than the level in 2000. This anticipated demand could be met, if productivity and production of groundnut increases at a much higher growth rate than the present one. Main exporters of groundnut in 2013 were India with 541,337 tonnes, which accounts for 32% of the world total exports (1.7 million tonnes), and the United States with 19% of the total exports (FAOSTAT, 2017). The European

Union imported 52% of the world supply of shelled peanut in 2013, with the Netherlands alone accounting for 40% of the European total (FAOSTAT, 2017). Groundnut is also a staple crop in most of the Africa countries with South Africa, Nigeria, Senegal and Ghana as the major producers. Africa accounts for 40% of the global area planted to groundnut, but for only 26% of production, with the highest average yields observed in Southern Africa and the lowest in East Africa (FAOSTAT, 2013, and World Bank, 2015).

2.3 Trends in the Production of Groundnut in Ghana

In Ghana, groundnut is cultivated by almost all farmers in the various regions. It is especially a major crop for the youth and women and provides inevitable livelihood benefits. Due to its importance, the objective 1 of the second Food and Agriculture Sector Development Policy (FASDEP II) of MoFA, prioritise groundnut production as an important enterprise in promoting income stability among smallholder farmers (MoFA, 2007). The annual area planted to groundnut in 2015 was 336,450 hectares, yielding a total output of 417,199 MT with zero importation and an exports value of 529 MT. The mean annual growth rate for groundnut production as from 2006-2015 was -1.17% (MoFA, 2016). It is estimated that about 92% (382, 759Mt) of groundnuts is produced in northern Ghana. The Northern Region leads with an estimated annual total output of 188, 080Mt, representing 45% of the national per annum production; the Upper West Region follows with an annual output of 154,179Mt (37%); while the Upper East Region has an annual output of 40,500Mt (10%) (MoFA, 2016).

Although areas cultivated to groundnut has been increasing due largely to increasing groundnut farmers in the rural areas but such increases in area is not translated into high production due to poor yields. Over the period, the northern region recorded the maximum yield of 1.65Mt/Ha with Upper West 1.19 Mt/Ha and Upper East region recording the lowest yield of 0.65Mt/Ha (MoFA, 2016). The average yield of groundnut for the country in 2015 is 1.24Mt/Ha and this figure is substantially below the achievable level of about 2.50 Mt/Ha, according to Ghana's Ministry of Food and Agriculture (MoFA) estimates. Figure 2 below illustrates the various regions in Ghana and their respective average yields in 2014 and 2015.

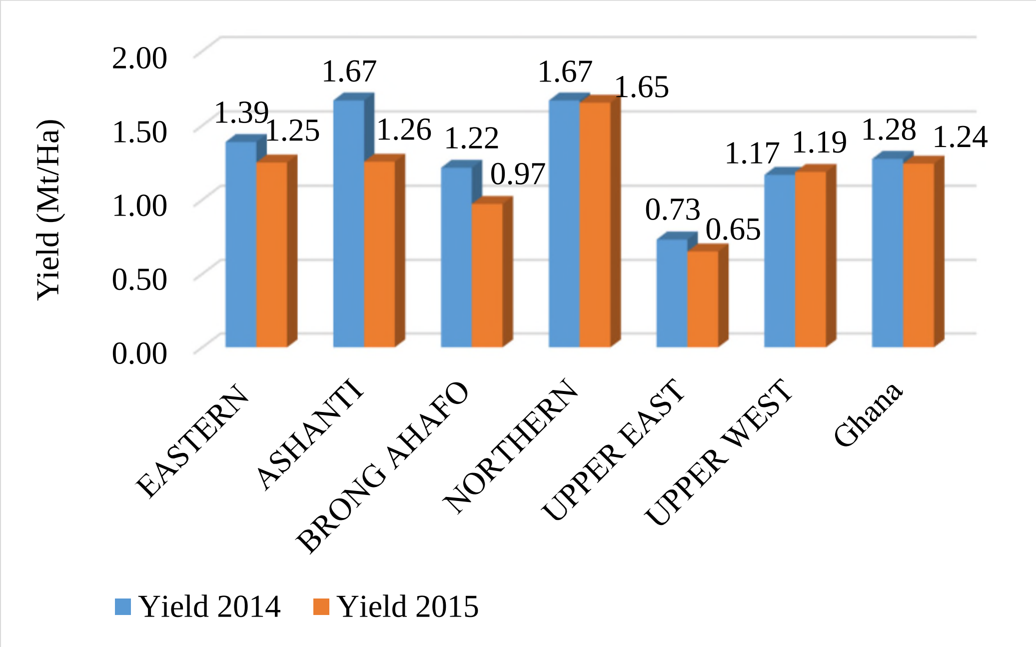

Figure 2: Yield of groundnut among the major producing regions in Ghana
Source: ***Ministry of Food and Agriculture (MoFA), (2016).***

2.4 Economic Importance of Groundnut

Groundnut (*Arachis hypogaea* L.), is one of the most essential legume oilseed crops, commercially popular due to its superior quality of edible oil and protein (Shanthala, *et al.*, 2013). Over 60% of worldwide groundnut production is crushed for extraction of oil and industrial uses, whereas 40% is consumed in food uses and as planting material (Birthal, 2010). Peanut has over the years been considered a female crop and this perception continued to exist in West African countries including Ghana (Owusu-Adjei *et al.*, 2017). Sales from groundnut is a prime source of income for women which enables them to acquire basic needs in life. Apart from being a major cash crop for households, groundnut is largely used in the preparation of soup, cakes and eaten as a desert in Ghana (Asibuo *et al*, 2008; Ibrahim *et al*., 2012). In addition, groundnut seeds contain numerous health enhancing nutrients such as minerals, antioxidants, and vitamins and are rich in mono-unsaturated fatty acids. Peanut kernels contain fat (40 to 50%), protein (20 to 50%) and carbohydrates (10 to 20%). Groundnut haulms also constitute nutritious fodder for livestock during long dry season. Peanut farming contributes to the sustainability of mixed crop-livestock production systems, the most principal system of the semi-arid area. Furthermore, the crop has the ability to incorporate atmospheric nitrogen into soils and thus improves soil fertility and saves fertilizer costs in subsequent crops (Stagnari *et al.*, 2018). The shells of peanut are used for making particle boards or as fuel or filler in fertiliser and feed industry (Benitta and Kavitha, 2018). Groundnut is an important raw material for industries in making soap, cosmetics and lubricants, olein stearin and their salts.

2.5 Agronomic Constraints to Groundnut Production

Groundnut is best grown in a well-drained sandy loam, or sandy loam soil. Deep well-drained soils with a pH of 6.5 to 7.0 and high fertility, are perfect for groundnut (Ajeigbe, 2014). The optimal soil temperature appropriate for good germination rate of groundnut is 30^{o}c. Low temperature at sowing delays germination and increases seed and seedling diseases. Groundnut cannot compete effectively with weeds, particularly 3 to 6 weeks after sowing; as a result, timely removal of weeds is key (Ntare, 2008). Usually, two weddings are optional, the first before flowering and at least another for the period of pegging. Production of groundnut starts immediately the rains starts in the season. Groundnut harvesting and plucking is done by hand and in some cases after harvesting the pods with the vines are carried home. Cracking of pods is mostly by hand and on a limited scale by the use of manually operated machinery. In most cases, harvested groundnut is dried in open air on the soil and left at the mercy of the weather whereas after drying the produce is either stored in sacks or in specially constructed structure made from thatch (Ajeigbe, 2014).

Biotic and abiotic factors militate against increased and sustainable production of groundnut. The most essential biotic constraints include; leaf spots, virus diseases, millipedes, aphids, leaf hoppers, termites, and white grubs (Owusu-Akyaw, *et al.*, 2014). The yield losses in groundnut as a result of these soil arthropods in West Africa have been reported by most researchers to be in the range of 10 to 40% (Tanzubil and Yahaya (2017) and the present results point out that the condition may be similar for Ghana. Low kernel yields of groundnut have partially been ascribed to poor soil fertility caused by unsuitable cropping systems [Golden Valley Agriculture Research Trust (GART), 2011], and use of low-yielding varieties (Mukuka and Chisanga, 2014) which are vulnerable to rosette disease and pests (Ross and Klerk, 2012). Groundnut rosette disease, early leaf spot, late leaf spot and rust are the major biotic constraints responsible for low yield of groundnut in Nigeria (Ajeigbe, *et al.*, 2014). Groundnut production in Ghana is also constrained by both early and late leaf spots diseases (Nutsugah *et al*., 2007).

Drought also increases the probability of pre-harvest Aflatoxin contamination (due to infection by Aspergillus flavus). The warm and moist climate conditions especially during the farming season makes the crop more prone to Aflatoxin contamination (Bandyopadhyay *et al.,* 2012). Aflatoxin contamination may happen throughout pre-harvest and post-harvest handling of groundnut. Pre-harvest contamination is severe during periods of drought at the pod filling stage. Post-harvest contamination results typically from poor drying and curing processes.

According to Tanzubil and Yahaya (2017), completely neglecting pest and disease control can result in up to 57% yield loss, whereas neglecting control of soil pests, foliar diseases and foliar insects can lower yield by 27%, 32% and 37% respectively. The need for African countries to develop effective seed systems to produce seed with good attributes (i.e, pest and disease tolerance, high-yielding, and early maturity etc.) coupled with good agronomic practices and policies becomes paramount.

2.6 Seed Production in Africa

The need to increase agricultural productivity to feed the ever-growing population in the world is a key concern of both developed and developing countries. However, the Asian Green Revolution that began in the 1960's as a result of the development and dissemination of high-yielding varieties, improved access to fertilizer coupled with state-supported subsidies, rural credit, and better infrastructure contributed to strong productivity growth in major staple crops. Hence, Sub-Saharan Africa is also replicating the Asia Green Revolution through the development and dissemination of improved agricultural technologies. Seed in this regard, is the first and foremost source of all food and an important input in agricultural production. Seeds are not only a valuable asset to farmers but also to the global society. Hence, efforts towards a world without hunger must inevitably target seed system development. Figure 3 below shows a gradual growth in seed production in Africa from a period of 2007 to 2013.

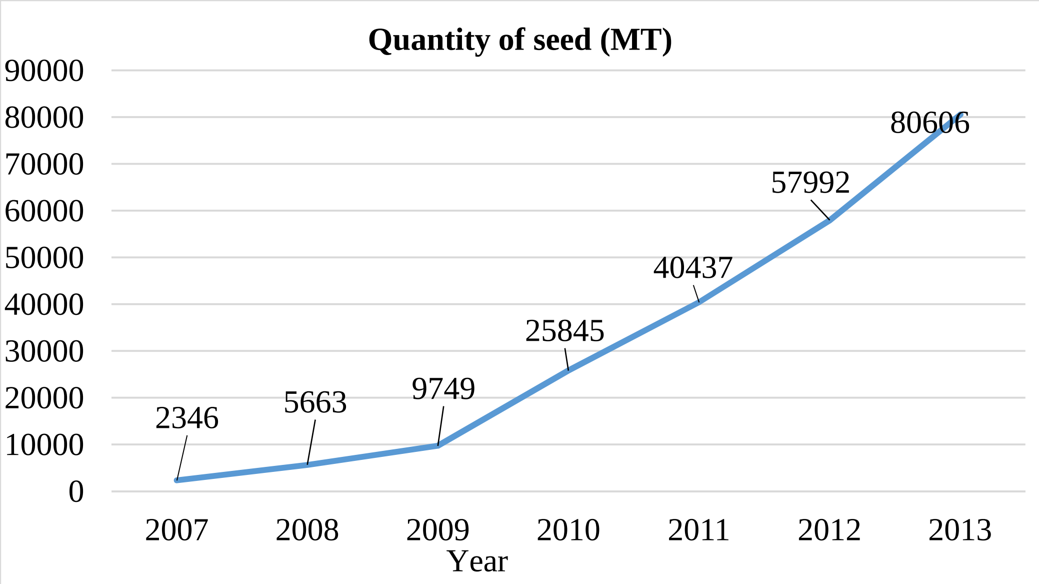

Figure 3: Seed production in Africa, 2007-2013
Source: ***AGRA, (2014)***.

Nigeria leads in the production of seed with 22,684.7 Mt and followed by Ethiopia (15,833.0 Mt), Uganda (14,600.8 Mt), Burkina Faso (3,543.1 Mt), Ghana (1,356.5 Mt), Tanzania (8,283.6 Mt), Mozambique (3,158.6 Mt) among others (AGRA, 2014). Meanwhile, not many countries have adequately addressed the question of providing farmers sufficient quantities and good quality seed. Several countries in Africa for example, yearly seed demand surpasses production. In 2013, the total seed demand of six major crops (in Table 1) in West Africa was 1,335,437Mt but only 182,034Mt was supplied. According to Niangado (2010) the trend of demand for improved varieties of seed is not always predictable. In the case of some countries in West and Central Africa, farmers only ask for seed under the following situations: following a disaster; when their own varieties are not performing well; when they want to test new varieties following an advertisement or a research day. Table 1 below shows the total quantity of seed supplied and seed needed for six selected major crops in West Africa in 2013.

Table 1: The Seed Demand and Supply of Six Major Crops in West Africa

Crops	Seed demand (MT)	Seed supply (MT)	Seed deficit (MT)
Maize	180,072	58,464	-121,608
Rice	364,457	106,395	-258,062
Sorghum	104,107	3,703	-100,404
Millet	301,724	6,506	-295,218
Cowpea	302,318	1,257	-301,061
Groundnut	302,318	5,709	-296,609
Total	***1,335,437***	***182,034***	***-1,153,403***

Source: WASP, (2013).

The Table 1 above sanctions the need for Africa to up-scale seed production especially for groundnut, cowpea and maize since their demand deficits are high. The seed systems in most Sub-Saharan Africa countries focus on a narrow band of crops, principally maize and sorghum. Less attention is paid to grain legumes, tuber crops, and horticultural crops. Low production of seeds in Sub-Saharan Africa and other countries in the world have substantially increased their seed importation to meet farmers' demand. For instance, in 2013, African countries imported about 40, 000 tonnes of field crop and vegetable seed whereas countries in Asia imported 79,000 tonnes (Cairns *et al.,* 2013). Farmers' access to quality seed of diverse range of adapted cultivars is still hampered by insufficient and inefficient seed production and distribution systems, poor seed quality assurance, inadequate seed policies, and seed price (Singh *et al.,* 2013; Cairns *et al.,* 2013 and Barnett *et al.,* 2011).

The challenges for seed production which exist currently in developing countries will upsurge with climate change (Singh *et al.,* 2013). The program for Africa's seed system is seeking to encourage the development of seed systems that deliver improved, locally adapted crop varieties to smallholder farmers and uptake and use of released cultivars (Barnett *et al.,* 2011). International donors and international research centres are providing support to enhance seed multiplication and awareness of quality consideration according to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 2009). For example, ICRISAT is involved in the development of new varieties and Aflatoxin certification. In 2009, United Nations Industrial Development Organization (UNIDO) developed a project to build capacity in improving Aflatoxin management in the groundnut value chain. World Vision has also implemented a seed multiplication programme targeting groundnuts in Ghana.

2.7 Overview of the Seed Industry in Ghana

In sub-Saharan Africa, seed is arguably the most key production factor and perhaps the inexpensive input for crop production. High-quality seed is fundamental to enhancing agricultural productivity, increasing food security, and improving rural livelihoods (Abebe and Alemu, 2017). The Ministry of Food and Agriculture (2015) strongly believes that Ghana's current agricultural achievements can further be improved; and the seed sector is one of the important areas which can contribute towards the required improvement.

The Ghana seed industry started in 1958 with the establishment of a Hybrid Maize Seed Multiplication Unit within the then Ministry of Agriculture. The Unit produced only hybrid maize seed until 1961 when it was converted into a Seed Multiplication Unit (SMU) which introduced other crop seeds into the seed production portfolio. By the close of the sixties, the SMU had adopted a contract grower system, whereby contract seed growers were assigned to produce all the certified seed requirements of the country. The SMU was later on converted into Ghana Seed Company (GSC) in 1979. The role of the Ghana Seed Company was to produce and distribute all classes of seeds except breeder seeds. Over some years, the Ghana Seed Company controlled and managed by the State was dissolved paving way for the privatization of the seed sector in 1990. This was to allow the private sector to take over the commercial aspects of the sector (GSP, 2013). This is because it is generally accepted that the private sector is more efficient in delivery of good and services relative to the public sector (MoFA, 2015).

In June, 2013, Ghana adopted a National Seed Sector. It was expected that the private sector would usher in a period of efficient, widespread and profitable seed programme. The Ghana's National Seed Plan was also released in 2015 to serve as a comprehensive implementation strategy for effective implementation of the released National Seed Policy in 2013. This implementation strategy is to highlight the importance to expedite a shift in leadership in the commercial aspect of the seed industry to the private sector. The National Seed Plan was also spell the need for a strong government role in the provision of support services important for the effective development of the seed industry (MoFA, 2015).

There exist two parallel seed systems in Ghana: a formal system established by the government and its technical partners and a traditional or informal system centred on a tradition of exchanges and mutual support among farmers within any one zone (Niangado, 2010). The formal system is characterized by the production and purchase of commercial certified seed while the informal sector is based on seed production and exchange among farmers at the local level (Lyon, 1998). The National Seed Committee and National Seed Service Agencies that are part of Ministry of Food and Agriculture, operate the formal system for certified seed. The Ministry of Food and Agriculture (MoFA) has primary regulatory oversight over the seed sector and exercises oversight over the formal seed sector.

The hybrid seed system is an evolving seed delivery system in Ghana where the community seed production is being encouraged by developmental projects to supplement the formal seed system and in that way making improved seeds available to local communities (Louwaars and De Boef, 2012). This community based seed production system access certified foundation seeds through developmental projects, from the formal system in groups (Etwire *et al.*, 2013). Generally, these farmer groups obtain chemical inputs and capacity building support from the projects and the accompanying costs are repaid after selling their harvest. In this manner, this system seeks to increase farmers' access to certified seeds (Etwire *et al.*, 2013). According to Buruchara and Kimani (2009), another option to fill the smallholder quality seed gaps is to reinforce the capacities of selected farmers or farmer-based organizations who will produce and manage the delivery of quality seeds of both improved and good local varieties.

There are about 1,500 certified seed producers in Ghana, all of which are privately owned, and each year, about 150 certified seed growers produce improved seeds (World Bank, 2012). The private sector's role in Ghana's seed system is increasing, with private companies actively involved in seed multiplication and sale, yet much activity remains in the public sector, including varietal development. The failings of the seed industry are manifested in weak institutional linkages and unclear mandates, inadequate collaboration among participating partners, poor oversight arrangements and inadequate resources to support both public servicing agencies and the fledgling private seed production and supply entities (MoFA, 2015).

There are multiple seed allied associations presently existing in Ghana. The Seed Producers Association of Ghana (SEEDPAG) is a private association of seed producers that includes 600 of the 1,500 private certified seed producers in Ghana. In 2015, the Seed Trade Association of Ghana (STAG) was also formed. The Seed Trade Association of Ghana is an umbrella body of enterprises in the seed value chain. STAG membership also includes private entities involved in the supply, processing, distribution, and marketing of improved seeds, as well as NGOs engaged in extension services, distribution, and marketing of seed. Since many companies are members of both associations, there is a need to streamline the activities.

The plan is to establish a National Seed Trade Association (NSTA), which brings together SEEDPAG, STAG, and the Ghana Agricultural Input Dealers Association (GAIDA), Crop life Ghana, and Ghana Rice Farmer Association. Thus far, SEEDPAG has been active in development of the Seed Plan, Seed Policy, 2010 Seed Law, new Seed Regulations, and PVP bill. In the future, it is expected that NSTA will play that role, and it holds the potential to be a voice for a growing industry going forward. It will be important that the NSTA engage in regulatory questions as they arise and balance the different aspects of the seed industry.

2.8 Structure of the Seed System in Ghana

The seed industry can be effectively coordinated when the role of the institutional systems along the seed value chain is well outlined. The general structure and role of actors along the seed value chain of the formal seed system of Ghana is illustrated in Figure 4 below. In Ghana, the Plant and Fertiliser Act (Act 803, 2010) makes provision with respect to plant health and protection from pest and diseases, the importation and exportation of plant material, the production and marketing of seed, the quality control of seeds, and the control on the manufacturing and use of, and trade in fertilizers. The Act establishes the Plant Protection and Regulatory Services Directorate, the Plant Protection Advisory Council, the National Seed Council, a Technical and Variety Release Committee, a National Variety Release and the National Fertiliser Council.

The Plant Protection Advisory Council, the National Seed Council and the National Fertilizer Council, provide Advisory services to government on plant protection, handling of seed and fertilizers associated matters for the purpose of safeguarding public health, agriculture and environment. The National Seed Council formulates policies on the development, production, inspection, sampling, analysis, conditioning and marketing of seeds. The Ghana Seed Inspection Division (GSID) is in charge of seed certification and provides advisory services to seed growers, seed dealers, seed importers and seed exporters. The GSID houses the National Seed Testing Laboratory (NSTL) which conducts seed sampling and laboratory seed quality analysis. The National Seed Service under the Ministry of Food and Agriculture and National Seed Technical Advisory Committee advice the government on seed concerns.

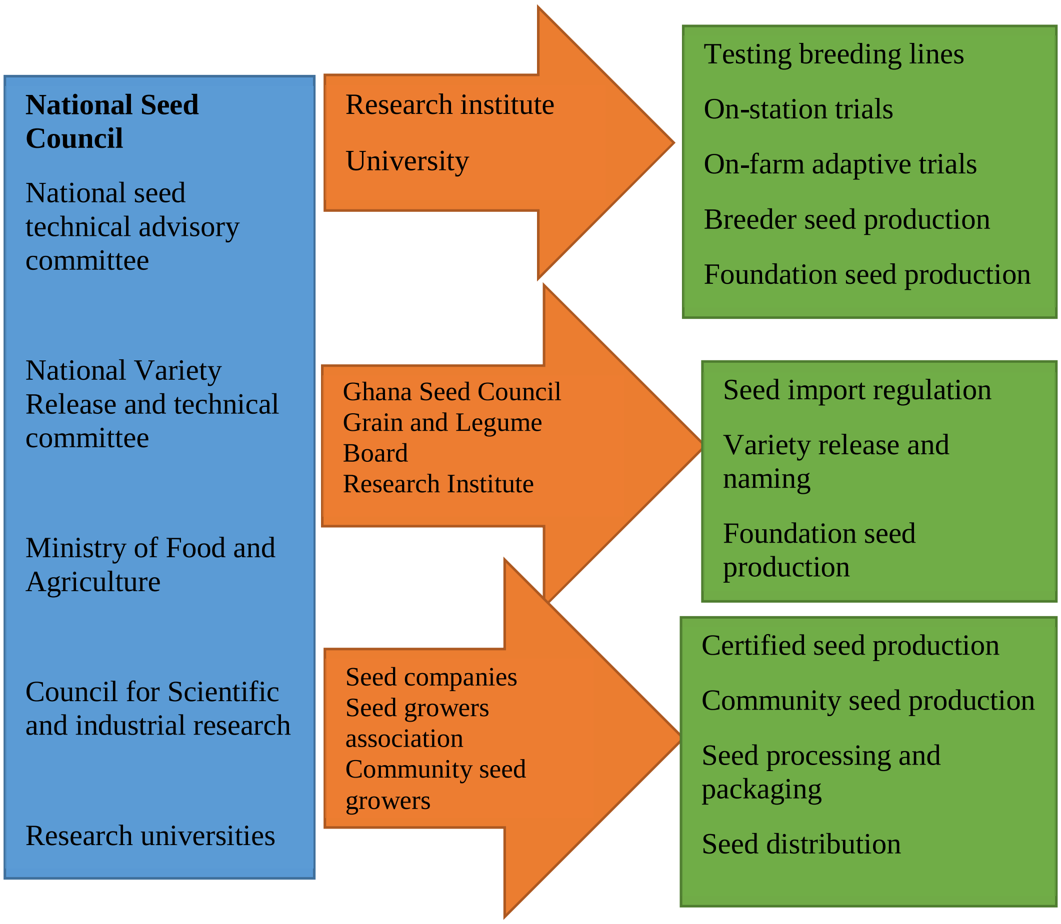

Figure 4: Flow chart of the structure of formal seed system of Ghana

The Variety Release and Technical Committee is accountable for indorsing varieties for release and cataloguing, whiles the Ghana Seed Inspection Division ensures that varieties produced goes through rigorous field inspection. The Research Institutes and Universities produce and maintain breeding lines and breeder seed. Usually, foundation seed is produced by registered persons, private seed growers, companies and cooperatives. The Seed Producers Association of Ghana (SEEDPAG) is in charge of the production, distribution and marketing of certified seed. Seed trade and distribution is conducted by agro-input traders who have sale outlets or agents mostly at urban and district capitals.

2.9 Sources of Groundnut Seed in Ghana

High quality, improved seed plays a crucial role in the production of every crop. Helping smallholder farmers to access improved seed is an important step towards increasing productivity and sustainability of crop production systems. Promoting smallholder access to sustainable seed production systems can boost groundnuts production in the target area and improve the livelihoods of farmers. Improved seed has the potential for increasing the total output of crops, and consequently generating the marketed surpluses needed to link farmers to the market, and lift them from purely subsistence basis to profit-oriented producers with a high level of market participation. Thus; sustainable seed systems have a prominent role to play in the commercialisation of agriculture and improvement of livelihoods in northern Ghana. Overall, the level of awareness and adoption of new seed varieties appear to be low, most likely due to inadequate delivery systems (CORAF, 2013).

In Sub-Saharan Africa, majority (over 80%) of smallholder farmers continue to obtain their seeds from informal sources (Louwaars and De Boef, 2012; and Etwire, 2013). These may include seed exchanges with other farmers, farmers retained seed, purchases from local markets, extension agents, certified seed dealers and others. Farmers keep part of their unshelled groundnuts with the aim of shelling and using it as seed in the next cropping season. Usually, the seed remains in the pods throughout the storage to maintain the germination potential, and removed and sorted out only shortly before planting. Farmers who also run out of their own produce during the off-farm season, purchase groundnuts from other farmers or traders in the market for use as seed.

2.9.1 Community-based Seed Supply Scheme (CSSS)

The community-based seed production is another innovative scheme to increase the diffusion of certified groundnut seeds to farmers (Setimela, 2014). Under the group seed production, community-based seed supply schemes (CSSS) are established to produce, distribute, and market improved seed timely and at affordable prices to smallholder farmers. The CSSS approach involved the training of small scale, community-based seed producers with the aim of equipping them with business management skills to be able to use the value chain approach to produce, grade, preserve, distribute and market improved seed to smallholders (Setimela, 2014).

2.10 Seed Marketing and Distribution

The availability of market space and the relevant market information is necessary for the distribution of improved groundnut seed among smallholder crop farmers. The global seed market is presently about US$ 54 billion. Domestically, the largest seed market is in the USA (US$ 14 billion) followed by China (US$ 11.9 billion), France (France (US$ 3.4 billion), Brazil (US$ 3.1 billion) and Canada and India (each US$ 2.5 billion) (ISF, 2016). Seed value US$ 10.9 billion was imported by 125 countries in 2013, globally (ISF, 2016). The global seed market has tripled over the past three decades driven largely by the progress of multinational seed companies, the increased availability of F1 hybrid, protection of intellectual property, an increasing use of counter-season production, and the development of genetically engineered crops (Hampton *et al.,* 2016). Seed is the basic and most important input of agriculture and the industry must be able to continue to distribute the quantities of quality seed required for this purpose (Maity and Pramanik, 2013).

In Ghana, the seed marketing and delivery is growing at a very slow pace with Aflatoxin contamination being the major constraint reducing its international trade. The minimum standards set for traded groundnut seeds have greatly limited access to international markets by many African countries. After harvesting, cleaning and packaging, the seeds are ready for distribution. Seed is supposed to be sold through agro-dealers. However, Etwire (2013) in study on analysis of the seed system in Ghana disclosed that, majority (78%) of the agro inputs shops were not dealing in certified seed sale. The few that sell certified seeds mostly concentrate on maize and rice seeds. Most dominant markets for groundnuts in Ghana are open space food crops markets characterised by a large number of sellers and buyers of all categories. Due to lack of suitable market infrastructure and the required technical skills, these markets are often unsuitable as distribution channels for improved seed. There seems to be very little advertising of the availability of improved seeds in rural areas since most agro-input shops have no channels in rural areas and most on-farm varietal evaluations are normally restricted in scope across diverse agro-ecologies.

2.11 Groundnut Varieties Produced and Grown in Ghana

Raising groundnut yield by accurate targeting of varieties to suitable agro-ecologies remains a crucial strategy for increasing production and decreasing losses due to risk factors. For the mid altitude and uplands there is need to focus on high-yielding rosette and early leaf spot-resistant varieties, while drought-resistant, early-maturing early leaf spot-resistant varieties will be the focus in lowlands and lakeshore areas (Ajeigbe *et al.* 2014). The formal groundnut seed production industry is now gaining grounds in Sub-Saharan Africa. This seed supply channel produces high yielding and quality groundnut seed free from diseases to farmers in the country.

High-yielding groundnut varieties such as Musekara Groundnut Variety 4 (MGV4) and Musekara Groundnut Variety 5 (MGV5) have been produced and introduced to farmers in Zambia (Ross and Klerk, 2012). The pace at which new groundnut seed varieties are released in Ghana is low with most produced decades ago. For example, in Ghana, the following improved peanut varieties have been released over the years: Mani pinta (1986), Shi Tao Chi ((Chinese) 1980), F-mix (1986), ICGS 114 ((Sinkarzei) 1989), JL 24 (not known), Endorpo Munikpa- SARGV (2005), Nkatiesari-SARGV (2005), Gusie-Balin-ICGV 92099 (2005) and Kpaneli–ICGV 90084 (2005)). Some of these old varieties may lack adaptive attributes to cope with the current ecological changes in the agricultural sector and may need replacement. These improved groundnut varieties have mainly been produced by the Savanna Agricultural Research Institute (SARI), typically in partnership with international research institutions and donors (Ibrahim *et al.*, 2012, and Asiedu-Darku, 2014). The Research Institutes and Universities produce and sustain breeding lines and breeder seed. Some of these improved varieties released are presented in Table 2 below, with their respective characteristics.

Table 2: Groundnuts Varieties in Ghana and Characteristics

Variety	Growth Habit	Days to Maturity	Seed Colour	Kernel yield t/ha	No. of maxi bags /acre
CHINESE	Erect	90-95	Reddish brown	1.8	8
Edorpo-Munikpa	Erect bunch	100	Brown and cream	2.0	9
Jusie-Balin	Erect bunch	100	Light brown	2.0	9
Sinkarzie	Semi erect (decumbent)	110	Dark red	2.0	9
Nkatie sari	Erect	110	Brown	2.2	10
Mani pintar	Creeping	115	Red and white	2.2	10
Kpanielli	Semi erect (decumbent)	118	Red	2.8	12
F-Mix	Semi erect (decumbent)	120	Brown and cream	2.5	11

Source: ***Food crops development project in 2014.***

The use of improved varieties coupled with good management practices is the possible way to improve the efficiency level of resource used which in turn reduces the cost of production. Traditionally, the most suited groundnut varieties to the agro-ecology of northern Ghana and thus the most commonly cultivated groundnut varieties in northern Ghana include: Shi Tao Chi (popularly called *chinese*), Mani Pinta, ICGS 114 (known in NR as *sinkarzie*) and F-mix. Among these varieties, the *chinese* (50.2%) and Mani pinta (38%) are the most popular and widely adopted by farmers in northern Ghana (Ibrahim *et al.,* 2012). Farmers are limited to these cultivars, and choice of any is influenced by the rainfall regime and duration of maturity. The Figure 5 below shows a distribution of groundnut varieties across the various regions in Ghana.

Figure 5: Varietal distribution of groundnut in Ghana
Source: Tsigbey et al. (2004).

2.12 Incentives and Disincentives for Commercially Produced CGS

Agricultural production involves the investment of resources, and farmers will have no enticement for making investments in ventures where there is little prospect for selling their goods, or if the benefits accruing from the sales of agricultural products do not reflect the opportunity cost of investment. It is therefore paramount to investigate whether there are economic incentives for commercially produced groundnut seed or not, although there is little literature concerning this argument.

The seed subsidy policy for certified seed crops do not favour the groundnut seed industry with the reason that the government subsidizes the cost of producing certified seeds for maize and rice at an annual cost of GH¢ 2.6 million, but no such program exists for groundnuts (MoFA, 2013). Due to this, seed producers have low monetary incentives to produce improved groundnut seeds owing that demand for it compared to that of maize, soybean, rice and cowpea, is generally low in the northern Ghana. Lack of subsidy on certified groundnut seeds increases the cost of production resulting into high unit price of certified groundnut seeds above farmers' purchasing power. Groundnut have been slow to spread to under-developed areas and are thus unavailable to those that could most benefit from them. The seed of groundnut has a low multiplication rate relative to other crops. Groundnut also losses its viability when stored for longer period of time relative to cereal crop seeds (Begum, 2013).

According to Etwire *et al.* (2013) poor road network discourages agro-dealers to create more input outlets in the rural area. This challenge affects the delivery of farm inputs in general and seed in specific to farmers in the rural areas where demand is high. This is a major hindrance for seed growers and agro-dealers since poor road networks to the rural areas increases cost of seed distribution. Another infrastructural challenge is the lack of constant electricity supply which negatively affects the cold room thereby catalysing the deterioration of seeds leading subsequently to loss of viability for production.

The registration and supervision charges creates little incentives for private seed companies to get involved in certified groundnut seed production and trade in the country. Keyser (2013) identified that seed companies in Ghana pay a minimum of US$ 3,500 per year for the expression of interest and seed entry, plus the full cost of site supervision and all materials used in on-station and farmer field trials even when other test data available or if the variety has been approved elsewhere with similar growing conditions. This discourages the actors along the value chain to participate in the production of certified seed in the three northern regions and Ghana at large.

Guel *et al.* (2011) also established that the private sector is least interested in developing varieties of self-pollinated or vegetative propagated crops with low market value since such varieties yield low profits because farmers often use part of their harvested material as seed in the subsequent seasons. Groundnut is a self-pollinated crop and as such farmers use its seeds for a particular period of time until it losses it genetic purity (Hasanuzzaman, 2015). This hinders farmers from increasing their demand for groundnut seeds in every farming season. However, Nigam *et al.* (1983) argued that although groundnut is a self-pollinating crop but at location where bee activity is predominant, cross-pollination may be likely. In addition, the informal market also supplies to farmers a mixture of groundnut seed varieties making farmers uncertain on the specific variety cultivated. Mixed varieties may mature at different times which lead to problems in harvesting, post-harvest handling, and result in lower yields (Hasanuzzaman, 2015). This will eventually motivate groundnut farmers to purchase certified groundnut seeds from the formal market delivery system in order to obtain viable seeds of their desire. It is also more difficult to maintain the viability of stored groundnut seed in the tropics than for many other crops, hence there could be a reasonable demand for good quality commercial seed.

According to Ntare *et al.* (2008) there are incentives for commercial production of certified groundnut seeds, however, low demand of groundnut seeds is imperatively attributed to these outlined factors; lack of information on the availability and yield potential of improved seed, insufficient availability of improved seed in input markets, segmentation of existing seed markets, inadequate financial access due to high prices of improved seed (relative to the farmer's budget), and a limited physical access because fewer enterprise produce and market improved groundnut seed for smallholder farmers.

Another incentive for commercially produced certified groundnut seed is the fact that donor agencies provides financial support to actors producing it. They also demand large quantities of certified groundnut seeds, in the case of ICRISAT, for their targeted farmers on their project. For instance, the Feed the Future-Ghana Agricultural Technology Transfer Project (ATT) is partnering reputable financial institutions in the northern Ghana with a loan programme of $9,000,000.00 to stimulate improved seed production, processing, and marketing [United State Agency for International Development (USAID), 2017]. The programme is to fuel the nascent private sector seed business that serves farmers in Upper East, Upper West and Northern Regions. This is a possible incentive to actors along the value chain of certified seed industry to get financial support to up-scale their production to sufficiently meet the demand of farmers in the Northern Ghana.

2.13 Preferences of Smallholder Farmers for CGS

The characteristics of a seed itself plays a critical role in farmers' adoption decision process. When selecting seeds of groundnut for cultivation, there are three key factors to consider – the source of the seed, the viability of the seed and its life cycle. (Tanzubil and Yahaya, (2017). When a good viable seed is obtained, it is essential to know how long it takes to mature so that the prevailing rain in the specific environment suits its production. Early-maturing varieties, for example, are more appropriate for areas with shorter yearly rainfall, whereas late maturing types will not perform in such environments but rather in areas with longer rainfall period (Ajeigbe *et al.*, 2014). The seed used for production will determine the ultimate yield that will be obtained at the end. The maturity duration typically comes from the source of the seed, and information about this may be gotten from extension agents and senior farmers. High yield is one of the most cited and significantly noted attributes of seed varieties as expected but farmers are also selecting varieties for myriad reasons.

Pest and drought resistance are vital production attributes to farmers but are not often publicised effectively. According to Ajeigbe *et al.* (2014) smallholder farmers usually prefer disease-free, clean, unbroken and physiologically-matured seeds for their production. They explained that disease-free and fully matured seeds increase the germination rate of the seed which translates into higher yields. Broken and unclean seeds discourage farmers to patronise them since they always spend most of their time sorting and grading those seeds before planting. Tsigbey *et al.* (2004) also established that farmers' choice for varieties of groundnut seed in northern Ghana was highly driven by the maturity period of the variety even though other characteristics such as yield potential, and the seed size, colour, oil content and the marketability were also important factors. This was so because the northern region experiences shorter annual rainfall in the season and cultivating long maturing seed varieties will render severe post-harvest losses. In addition, Etwire *et al.* (2016) also investigated the seed delivery systems and farm characteristics affecting the uptake of improved seeds by smallholder farmers in Northern Ghana. The researchers established that, availability of certified seed, affordability, availability of a grain market, ability of certified seed to resist pest and disease attack, profitability of grain production and packaging of certified seed were the factors farmers look for before purchasing seeds.

The degree to which seeds are available and easily accessible also play a major role for its use by farmers. Seed availability to farmers implies that there is sufficient quantity of seed within reasonable proximity and in time for sowing (Sperling and Longley, 2002). Farmers in Sub-Saharan Africa lack the capacity to preserve seeds in storages which influences their timing of seeds purchases. Farmers in Africa also depend on rainfall for sowing and any delay in seed supply reduces the likelihood of its use in production. Owing to this, the findings of Asare *et al.* (2016) showed that farmers value a Seed Brokerage System (SBS), which is expedited through group's bulk patronage, timely acquisition and distribution of seeds. The seed brokerage system will ensure timely availability of seeds to farmers and enhance early sowing to avoid the menace pose by climate change. According to David and Sperling (1999) farmers' preferences for a particular seed delivery channel is often hinged on the fact that they trust these channels to deliver high quality seeds, can buy seeds in small quantities instead of bulk, or obtain credit, or other additional benefits.

The study of Okori *et al.* (2017) on farmer's preferences for maize attributes in Eastern and Western Uganda, found out that farmers' preference for medium plant height, medium grain size, medium pest and diseases and medium drought tolerance of maize influenced their willingness to pay for improved maize seeds. They further declared that majority of farmers often prefer smaller seed to larger ones. With the reason that smaller seed varieties plants farther and germinate faster relative to bigger seeds. However, it does not imply that larger seeds are of poor quality but they relatively take more period to hydrate and germinate. Besides this, seeds should also have uniformity in size, shape and colour that conform to the variety in question. Interestingly, Elepu (2011) also found that about 90% of the farmers preferred maize varieties with high pest and disease, and drought tolerance. They also affirmed that about 51% and 98% of the respondents preferred maize with medium grain size and grain colour respectively.

Also, whether the production is largely for home consumption or for the market, yield potential of its seed plays a central role in a giving variety (Langyintuo and De-Boef, 2012). Low yields impede households' commercialization and confines smallholder farmers in subsistence agriculture. Adesina and Forson (1995) disputed that technologies that increase agricultural production like improved varieties and fertilizer have greater possibility of being adopted and used. They further argued that most emerging countries have land problem as a challenge due to greater population and as such one way farmers' increases output is to adopt technologies that are higher yielding and tolerance to drought which is additional serious canker in emerging countries.

2.14 Studies on Factors that Affect the Intensity of Use of CGS

Over the last decades, there has been massive increased in research on the adoption of improved technologies in the agricultural sector. This is a response to the Asian Green Revolution approach in order to increase sufficient food in the world. Several researchers, including (Asfaw, *et al.*, 2012; Feleke and Zegeye, 2006; Getacher, *et al.*, 2013; and Tekleword, *et al.*, 2013) argued that the effective way to increase agricultural productivity is through adoption of improved technologies. Most of these researchers concentrated primarily on fertilizer, irrigation and seed technological adoption.

The intensity of seed usage is highly dependent on a wide range of factors. Obayelu *et al.* (2017) classified these factors into human specific factors, social factors, cultural factors, economic factors, characteristics of the innovation itself, educational levels, capital, income, farm size, information access, utilization of social networks, and cost of inputs. The use intensity of CGS is express as the ratio of acres of land planted with CGS to total size of groundnut farm in acres.

For instance, the studies conducted by Feleke and Zegeye (2006), Mignouna *et al.* (2011), Awfaw *et al.* (2012) and Mariano *et al.* (2012) revealed that the availability of extension service to farmers significantly increases the use of improved rice varieties, underlying the important role of extension in promoting adoption. The availability of improved seeds in the local stores was also found to positively influence the use intensity of seeds. The availability of certified seeds in the nearly by local stores ease the household to buy and cultivate new improved varieties in their fields. In addition, in the study of Ghimire *et al.* (2015) on factors influencing the adoption of improved rice varieties among rural farm households in central Nepal, education, extension service, seed access, potential seed yield, seed acceptability, farm size and land type were found to significantly influence the likelihood of improved rice seed adoption. It has also been established by Okello *et al.* (2016) that the extent of use of certified potato seed is significantly influenced by distance to produce market, farm size, taste of seeds, membership of farmer group, access to mobile phone and perception towards seed resistance to pest infestations.

Besides this, Kassie *et al.* (2010) in their research on adoption of improved groundnut varieties in Uganda also found farm size, years in education, membership of farmer group, distance to agriculture centre, bicycle ownership and distance to village market to significantly affect the intensity of certified groundnut varieties use. Again, Kapalasa (2014) affirmed that distance to market, agro-ecological difference, farm size, extension, yield, taste, and maturity significantly influence. Namwanta *et al.* (2010) also reasoned that farmers closer to the markets have higher chance of adopting improved varieties since they have access to information about availability of market and also prices prevailing on the market and inform the farmers when deciding what to grow for the next growing season. Notwithstanding, Kalinda *et al.* (2014) in their study on adoption of maize seed varieties in Southern Zambia, found that sex, age, marital status, farm size, membership of farmer group, high-yielding potential, high price of seed significantly influences the likelihood of a farmer to adopt and use improve maize seeds in the study area. In the exception of age and marital status of the farmers, all the other variables positively affect the adoption decision of farmers for improved maize varieties.

In the study of Ghimire *et al.* (2015); livestock assets, farm size, seed access, distance to produce market, yield potential, extension, pest resistance, ecological difference and participation in farmer groups were found to significantly influence the intensity of adopting improved maize seeds. Access to credit is found to be significant factor affecting the adoption of agricultural technology by smallholder farmers (Lavison, 2013). Access to credit can ease farm households to buy the required agricultural inputs and increase their capability to effect long-term investment in their farms. Lee (2011) also assessed whether cultural behaviours influence the dissemination of agricultural technologies in emerging countries using data collected in Ghana and noted that farmers belonging to clans with greater proportion of adopters are more probable to adopt agricultural technologies.

2.15 Certified Seed Use and Productivity

Seed is the basic input in every crop production in the agriculture sector. The quality of seed used by farmers determines the status of agriculture they practice. However, for maximum gain in productivity the use of improved varieties combined with proper crop management practices is prerequisite. The large gap between actual and potential yields is due to several factors, including non-availability of seeds of improved varieties for a particular ecology, poor soil fertility, inappropriate crop management practices, pests and diseases (Ahmed *et al.*, 2010). The past fifty years have seen seed yield increases for the world's major crops of 1% - 3% per year (Bruins, 2009) due largely to genetic gains obtained from plant breeding. Information gathered from rice farmers and extension agencies indicates that normally rice farmers obtain a yield of 2.0 – 3.0 t/ha with farmer-saved seed, but with the use of certified seed and good farming practices, up to 6.0 – 8.0 t/ha can be achieved (Gluel, 2011).

There is a strong correlation between seed quality and improved crop productivity with some studies showing up to 100% yield improvement (FAO, 2015). For instance, 69 percent of farmers in Kenya, 74 percent in Nigeria, and 79 percent in Mozambique said improved maize varieties had doubled harvests per hectare. Meanwhile, 79 percent of farmers in Ghana reported doubling rice yield, and 85 percent of farmers surveyed in Uganda reporting doubling yields from cowpea. The study of Asekenye *et al.* (2016) on the productivity gaps among groundnut farmers in Kenya and Uganda also revealed that farmers who planted improved groundnut varieties enjoyed, on average, a 143% and a 58.6% output advantage over those who planted local varieties in Uganda and Kenya respectively. This is a tremendous productivity gain in the region and calls for an increased investment in agricultural production, including the production and delivery of improved seeds. Increased output is essential, because this leads to improved food security and better nutritional level.

The use of certified seeds is capable of reducing the cost of production since it usage reduces the cost of farm maintenance. This is evident in the study of Monyo *et al.* (2014), where they found a range of 21% and 44% reduction in per unit cost of cultivating improved varieties relative to local varieties in Malawi and Uganda respectively. The ability of improved seeds to weeds tolerance, pest and diseases resistance, drought tolerance offsets some outrageous expenses that would have been made by farmer if they had used local seed varieties. Also, the capacity to cope with adverse conditions in the short term or long term duration, for example due to climate change, is centred on the characteristics of seeds used in production (Louwaars and de Boef, 2012). Therefore, using improved seeds serve as an adaptive measure in reducing damages usually caused by climate change in the agricultural sector. This recommends that research should be keen to the generation of improved varieties, combined with extension work to encourage the patronage and use of improved and certified seeds.

2.16 Challenges Facing the Value Chain of the Seed Industry

The seed industry in Sub-Saharan Africa is usually controlled by the public sector with few private entities currently emerging. The pressing need of developing countries to develop effective seed system cannot be underscored since seed is the ultimate input capable to increase productivity level in the agriculture sector. Regardless of the interventions in developing a formal seed delivery system in Ghana, it has been renowned that the formal seed distribution system has not lived up to expectations in terms of ensuring effective distribution of certified seeds to smallholder farmers (Etwire *et al.*, 2016). Over the years, the informal seed sector has managed to bridge the demand deficit of seed supplied by the formal sector but the quality of the material thus used is in most cases poor and questionable. The informal system dominates in the supply of seeds in the country but there are numerous technical and infrastructural gaps in their production (Monyo *et al.*, 2014).

There also seems to be little interaction and flow of information among the various value chain actors within the seed delivery system in northern Ghana which has resulted in a weak system that supplies less than 20 percent of the seed requirement of farmers (Etwire *et al.*, 2013; Tripp and Mensah-Bonsu, 2013). Nevertheless, similar actors on different seed delivery channels have similar goals, they appear to be working in isolation resulting in repetition and dissipation of effort. MADE (2014) has also emphasized that the Savannah Agricultural Research Institute (SARI), Grains and Legumes Development Board (GLDB) and the seed companies have not developed effective partnerships so the supply of breeder, foundation and certified seed is low. Essentially, when a breeder develops a new crop variety, the next step is to produce foundation seed that manufacturers require to generate the large quantities necessary to meet farmers demand. However, late supply of foundation seed has long been viewed as a significant barrier to African smallholder farmers' access to high-yield crop varieties. The benefits of improved varieties developed by scientists can be achieved if there is steady supply of adequate foundation seed moving through the seed production system (AGRA, 2014).

Also, within the formal seed delivery system, more emphasis has been placed on developing the physical aspects such as breeding new seed varieties, multiplication, processing, storage and marketing rather than addressing key institutional issues that can assist the system to perform effectively (Niangado, 2010). Furthermore, most agricultural development projects implemented in Ghana have placed less attention in facilitating seed delivery to poor smallholder farmers as compared to other inputs such as fertilizers and pesticides (Louwaars and De Boef, 2012).

A range of high-yielding varieties of groundnut and improved agronomic practices to optimize their yield potentials are available, but wide-scale dissemination is limited by lack of seed (MADE, 2014). The adoption of improved groundnut varieties is said to be hindered by lack of awareness of the improved groundnut varieties and other constraints such as seed availability and accessibility in Malawi (Bocher and Simtowe, 2016). Etwire *et al.* (2013) also highlighted that there is the need for farmer education in local dialects about the significance of using certified seed in general and hybrid seed to be specific through field demonstrations, radio and television programs among others.

Smallholder farmers play an important role in the adoption procedure of certified seed varieties for cultivation. Majority of private investors enter into the production of certified seeds without effective demand analysis on farmers' needs and wants. Subsequently, this may have led to the persistent absence of substitutes in providing efficient seed distribution services to smallholder farmers in the agricultural sector. When smallholder farmers examine the characteristics of new technologies and discover them to meet their preferences, they habitually introduce the technologies to other farmers to test and appraise thereby setting into motion an endogenous process of technology dissemination (Obayelu *et al.*, 2017).

The research institutes and other public sector servicing institutions such as GLDB, GSID are under-funded and this limits their critical roles in seed multiplication (MOFA, 2015). These public institutions in charge of seed production lack adequate funds to secure production equipment for larger quantity and good quality seed production in the country. This for the past years has serve as a deterrent for seed companies to register and being regulated, and as such produces seeds which when farmers purchased, complain of low germination (MADE, 2014). It is also an observable fact that majority of registered seed companies do not receive field inspections from the Plant Protection and Regulatory Services Directorate and even if any, at latter part of the season. Awotide *et al.* (2014) recommended that the seed certifying agency should be properly funded and monitored to ensure that improved seed released by the breeders are adequately certified before handing them to the farmers.

In addition, there is always poor credit availability, especially from banking institutions to actors within the value chain of certified seed production and adoption process. Particularly, farmers are poorly connected to credit and input markets which are essential to increase productivity for crops such as groundnut (Ajeigbe *et al.*, 2014). The potential losses in groundnut in case there is a disaster is very high, and due to this, financial institutions are usually reluctant to disburse loans to groundnut producers. Access to enough credit can facilitate certified seed producers to engage in a long term investment in the seed industry and also enable rural farmers to adopt and expand their production scopes to maximize output. Also, lack of storage facilities (cold rooms) is the commonest constraint facing seed distribution and sale in Ghana since seeds not sold lose their viability over time thereby compelling seed growers to either sell their seeds cheaply as grains or transport their seeds at an additional cost to centres that have cold storage facilities (Etwire *et al.*, 2013).

2.17 Theory of the Double Hurdle Regression Model

The Tobit model was first proposed in a pioneering study of Tobin (1958). He examined household expenditure on durable goods using a regression model which took account of the fact that the expenditure (the dependent variable of his regression model) cannot be negative. Tobin called his model the model of limited dependent variables. Tobin postulated this model to help overcome the challenges of the Ordinary Least Square and the binary models (probit and logit) in analysing survey data with limited dependent variables. The application of these models are not appropriate in this study because the value of the dependent variable are all zeros and positive values (Greene, 2007) and using them will yield inconsistent estimates. Owing to this, the Tobit model (Tobit, 1958) has been broadly used to estimate adoption equations for survey data with zero observations.

The standard Tobit model assumes that the observed use intensity of CGS of households is determined by a latent variable that is normally distributed. In this case, both adoption and use intensity of CGS is determined by the same equation with the zero values of the use intensity of CGS resulting from a corner solution to the utility maximization problem. This may not be desirable if some factors affecting the adoption of CGS do not impact on the use intensity of CGS directly. In addition, some of the independent variables may also have opposite effects on the adoption and use intensity of CGS decisions. It is therefore advisable to separate the two equations into a two-stage model.

In the two-stage model, the household first decides whether or not to adopt CGS in their production, followed by the use intensity of the adopted CGS on their farm lands. The double hurdle regression model and Heckman model qualifies for this analysis. However, in the Heckman selection model, in order to separately identify the decision regarding adoption of CGS from the use intensity of CGS, it is necessary to have at least one variable which affect the adoption decision but do not affect the use intensity of CGS. However, in this particular research, the variable that affects the adoption decision of CGS also affects the use intensity of CGS. Therefore, the Cragg's double-hurdle model has been chosen for its flexibility. In most cases the estimation of the double-hurdle model is done using the maximum likelihood method (Park *et al.*, 2008). The Cragg's double-hurdle model implies that observations with values in the outcome variable below and above certain thresholds are systematically excluded from the sample. This means that the whole observations are missing so that neither the dependent nor the independent variables is known to be included in the regression model.

In the double hurdle regression model, farmers' decision to adopt CGS is modelled as a binary variable, E_i^*, which is a function of a vector $Z_{i,}$ a vector of coefficients α, and an error term V_i. The observed use intensity of CGS variable has a truncated distribution because it is only non-zero when households decide to adopt CGS and conditions are favourable for the actual use of the seeds in production.

According to Cragg (1971) and Moffatt (2005), the equations for the Cragg's double-hurdle model can be specified are follows:

$$E_i^* = \alpha' Z_i + V_i \qquad [1]$$

$$Y_i^* = \beta' X_i + \varepsilon_i \qquad [2]$$

$$E_i = \begin{cases} \text{Yi}*, \text{if} \quad \text{Ei}* > 0 \\ 0, \text{ if} \quad \text{Ei}* \leq 0 \end{cases} \qquad [3]$$

$$Y_i = \begin{cases} \text{Yi}* \text{ if} \quad \text{Yi}* \quad > 0 \text{ and if} \quad \text{Ei}* > 0 \\ 0, \text{ if} \quad \text{otherwise} \end{cases} \qquad [4]$$

The advantage of the truncated model over the standard Tobit (Censored) model is that the former allows variable to have differing effects on adoption decision of CGS and the use intensity of CGS (Brouhle and Khanna, 2005; and Burke, 2009). That means, the two equations are allowed to have different coefficients (Ground and Koch, 2008; Brouhle and Khanna, 2005; and Yen and Huang, 1996). Cragg's double-hurdle model postulates that to observe positive use intensity of CGS, the household must pass two hurdles; thus; be an adopter of CGS and also actually use it. However, the decision of whether to adopt CGS and the intensity of CGS use can be jointly or separately modelled. If the independence model applies, the error term is distributed as follows (Cragg, 1971):

V_i , N (0,1) and ε_i $(0, \sigma_z^{\ 2})$

This means:

$$\begin{pmatrix} V_i \\ \varepsilon_i \end{pmatrix}, \mathrm{N}\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 0 \\ 0 \sigma^2 \end{pmatrix}\right]$$

In the first stage, a model is run to capture the decision of whether the farmer adopts CGS or not. The second stage is a truncated model for farmers' intensity of CGS use conditional on adoption of CGS. The log-likelihood function for the Cragg's model that assumes probit and truncated regressions to be uncorrelated is given as:

$$L = \prod_{Y_i} = \left[1 - \Phi(z_i^{'}\alpha)\Phi(\frac{x_i^{'}\beta'}{\sigma})\right] + \prod_{Y_i \succ 0}\left[\Phi(z_i^{'}\alpha)\frac{1}{\sigma}\phi(\frac{y_i - \beta' x_i^{'}}{\sigma})\right] \quad [5]$$

Where: Φ and ϕ represent the standard normal cumulative distribution function and density function, respectively. The first part on the right hand side of equation (5) represents the log-likelihood for a probit model, whereas the second part represents the likelihood for a truncated regression, with truncation at zero. Consequently, the log-likelihood from Cragg's model is the sum of log-likelihood from a probit and a truncated regression.

In fact, it is possible to compare the Tobit model and the Cragg's double-hurdle model. The test of hypothesis for the truncated model verse Tobit model can be determined by estimating Tobit, truncated and probit regression models separately. Afterwards, the log likelihood ratio (LR) test is used to determine the suitability of either Tobit or truncated model. The LR statistic is computed according to (Green, 2003).

$$\Gamma = -2\left[1nL_T - (LnL_p + LnL_{TR})\right] = x^2k \qquad [6]$$

Where: L_T represents the likelihood ratio of Tobit regression model, L_P is the likelihood ratio of probit regression model, L_{TR} is the likelihood ratio for truncated regression model and K is the number of explanatory variables in the equations. If hypothesis test of $H_0 : \lambda = \frac{\beta}{\sigma}$ and $\lambda \neq \frac{\beta}{\sigma}$, then, H_0 will be rejected on a pre-specified level if $\Gamma \succ x^2k$.

Conversely, the estimates of the double-hurdle regression model might not be efficient if the error term is heteroskedastic across observations. This problem can be further improved by permitting the standard deviation to differ across observations (Yen and Su, 1995). Heteroskedasticity is incorporated into the model by assuming that the variance of the error term is an exponential function of a set of exogenous variables, K_i, a subset of X_i. In precise, the standard deviation σ_i is parameterized as follows;

$$\sigma_i = \exp(k_i h)$$

2.17.1 Empirical Application of the Cragg's Double Hurdle Model

The Cragg's Double Hurdle regression model has shown to be very simple for analysing survey data with limited dependent variable and straightforward interpretation. As a result, it is attaining larger usage by most researchers on recent studies concerning adoption and use intensity of improved technologies. Thus, there are a number of current studies that used Cragg's double hurdle model (e.g. Yan and

Huo, 2014; Wan and Hu, 2012; Ouma *et al.*, 2014; Anik and Salam 2015; Wiredu *et al.*, 2014 & Fosu-Mensah *et al.*, 2016).

For instance, in the study of Yan and Huo (2014) the Cragg's double hurdle model was used to identify determinants of household entry and intensity in land rental market in China: evidence from North Henan Province. Their study found that relocations, share of certificates, land transfer rights, migration days, farm size, number of plots, years in education and village average rent price significantly influences household's land rent-out decision in the study area. Again, in the work of Wan and Hu (2012) on at-home seafood consumption in Kentucky in China, the double-hurdle model was used. In their study, they also found that household size, household income, race and employment status were significant determinants of at-home seafood consumption in Kentucky in China.

Besides this, the double-hurdle model was also used by Ouma *et al.* (2014) in their study on determinants of adoption of improved maize varieties in moist transitional zone of eastern Kenya. The researchers found that extension service, household size, remittance from relatives, adoption of manure, maize/legume intercropped, farm size, confidence in extension officer, mobile phone access, access to radio, and late seed availability significantly influences the use intensity of certified maize varieties in the study area. Again, Anik and Salam (2015) also used the truncated regression model in their study on the drivers of adoption of improved onion varieties in Bangladesh. The result from the truncated regression estimates showed that crop diversification, farmers' satisfaction about extension service, access to credit, farm size and land fragmentation have a significant effect on the decision of farmers to adopt improved onion varieties in the study area.

In Ghana, the use of Cragg's double hurdle model is equally attaining importance. Classical example includes that of Wiredu *et al.* (2014) and Fosu-Mensah *et al.* (2016). In the study of Wiredu *et al.* (2014) the truncated regression model was used to determine fertilizer adoption and use intensity among smallholder farmers in the northern Ghana. The result of the truncated regression estimates showed that, household's income, FBO membership status, distance to agricultural office and input shop access were the important factors influencing fertilizer use intensity.

Fosu-Mensah *et al.* (2016) also used the double-hurdle model to estimate cocoa farmers' willingness to pay for crop insurance in Ghana. The double hurdle model result showed that, marital status, age of farmers, and educational status significantly and directly affected cocoa farmers' willingness to insure their farms whereas household size and cropped area negatively influenced farmers' willingness to insure their farms. Similarly, household size, age of household's head, and cropped area significantly and positively influenced the premium cocoa farmers were willing to pay whiles marital status and cocoa income negatively influenced the premium farmers willing to pay.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section describes the methods and tools employed in the study. The chapter is in two parts. The first part describes the study area, the data and sampling techniques employed to analyse the data. The second part explains the methods of data analysis.

3.2 Study area

The study was conducted in the Northern Ghana. The Northern Ghana includes the Upper East, Northern and Upper West regions in this case. The three regions share borders with Republic of Togo to the east, Ivory Coast to the west and Burkina Faso to the north. Within the country, the northern Ghana is bordered by Volta Region on the south east and Brong-Ahafo Region on the south west (Figure 1). Geographically, the three regions are between longitude 8°46'01.88" N and 10°58'34" S and latitude 2°45'45.40'' W and 0°32'59.95'' E and cover a total land area of 97,666 km² with an estimated population of 3,317,478 (GSS, 2010).

The vegetation is a typical Guinea Savannah type; which is characterized by drought-resistant grasses and trees. The main vegetation is grassland, interspersed with guinea savannah woodland, characterised by drought-resistant trees such as acacia, (*Acacia longifolia*), mango (*Mangifera*), baobab (*Adansonia digitata* Linn), shea-nut (*Vitellaria paradoxa), dawadawa,* and *neem (Azadirachta indica).* The Northern Ghana plays a significant role in agriculture and is usually mentioned as the grain basket of the country. Presently, more than 80% of the inhabitants of northern Ghana are full-time farmers (MoFA, 2011). Majority of farm households in this part of the country have benefited greatly from developmental projects aimed at increasing productivity and improving livelihoods.

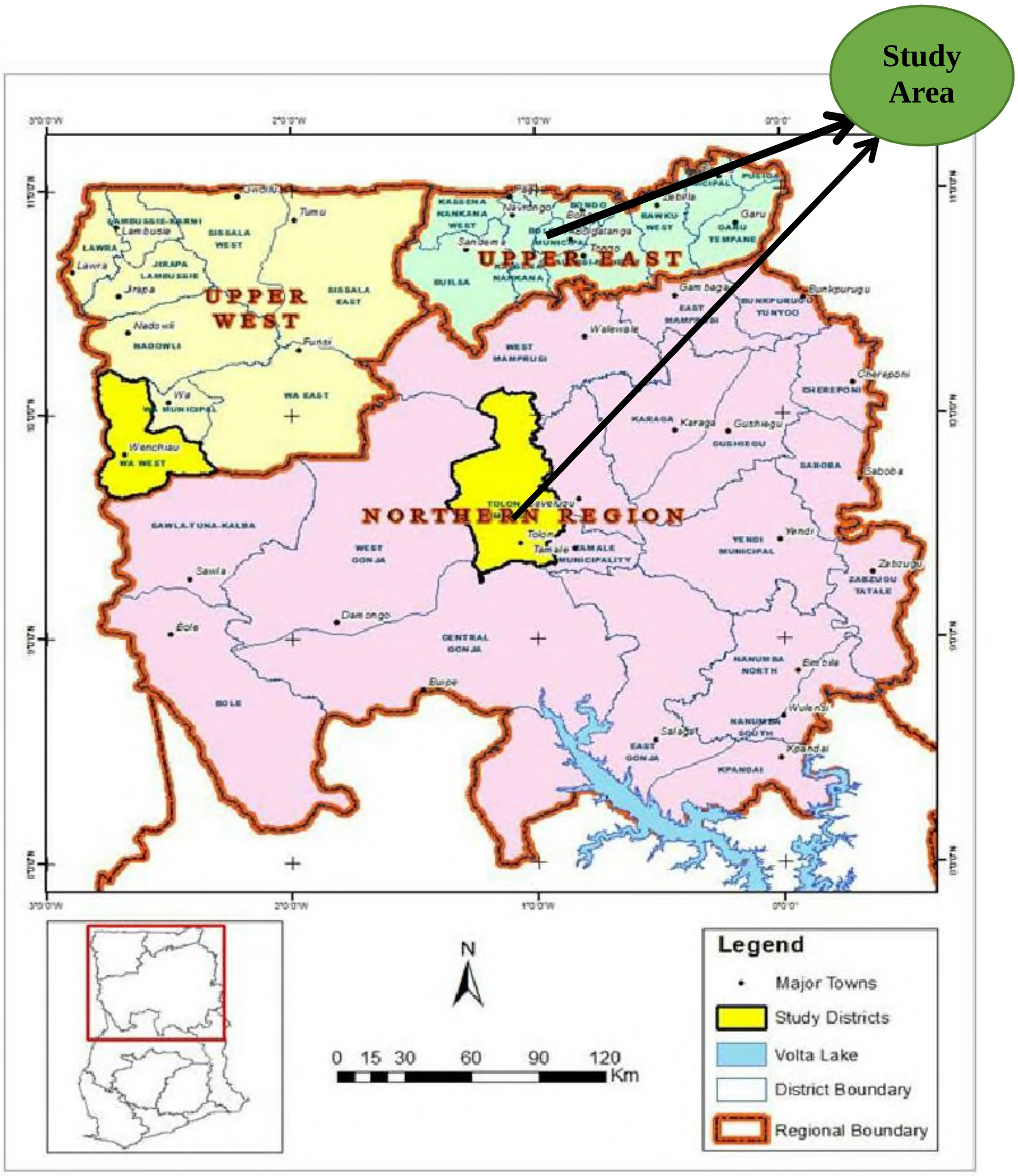

Figure 6: The Map of Northern Ghana

Source: ***https://www.google.search?q=map+of+northern+ghana***

3.3 Sources and Type of Data

The main source of data for the research was primary data. The study used farm level cross-sectional data from groundnut farm households in the 2017 cropping season. Also, primary data was solicited from input suppliers/ dealers, breeder/foundation seed institutions and seed companies. The study used both quantitative and descriptive data analysis approach (thus; the mixed method approach). The data collected from groundnut producers included; private/public asset stock, household specific characteristics and preferences for seed type.

3.4 Sampling technique and Sample size

A multi- stage sampling method was employed in this study. The first stage involved the selection of regions. The Northern and Upper East regions were selected as representative of Northern Ghana. These study regions are appropriate because of presence of a large number of groundnut farmers, as well as having larger number of smallholder groundnut seed producers in the country comparative to others [Ministry of Food and Agriculture (MoFA), 2015].

In the second stage, the districts within the sampled regions were clustered into two (i.e. districts with average groundnut production above or equal to 6000 Mt and below 6000Mt respectively). The districts were clustered using data from Research and Information Directorate (SRID) on production estimates for major crops in 2015. Afterwards, four districts from the Northern region and two districts from the Upper East region were selected from the cluster of districts with average groundnut production above or equal to 6000Mt using proportional probability sampling technique.

In the fourth stage, two communities within each of the selected districts were randomly selected, totalling twelve (12) communities in all. In the last stage, between 15 and 25 groundnut farm households were randomly sampled from each of the selected communities due to unequal number of groundnut farmers in the communities. A sample size of 250 smallholder groundnut farm households was obtained for this study, where each household had equal chance of being included in the study.

Seed companies and input dealers were also stratified into two strata each (i.e. those into CGS and otherwise) respectively. Ten (10) seed companies and input dealers each were randomly selected from each stratum whiles the Savannah Research Institute (SARI) – seed breeder/foundation seed producer was purposively sampled for the study. The Savannah Research Institute was purposively selected because it is the main seed breeder in the study area.

3.4.1 Sample size

The sample size was based on rule of thumb predictions as suggested in the literature. Literature has indicated that, the appropriate sample size for any research is determined by the number of explanatory variable in the models. The sample size should be statistically large, as the number of explanatory variables increase, to avoid biased results (Ayele, 2011). According to Hair (2006), there is a negative effect on statistical test if the sample size is small or very large. The sample size may either not big enough to make generalisations or too big to make conclusions. A sample size of N >= 50 + 8*M, according to Tabachnick and Fidell (2007) is appropriate for regression analysis and factor analysis, where *M* is the number of the explanatory variables considered. This study considered twenty (20) explanatory variables and a sample size of 250 farm households. However, computing the sample size of 50 + 8*20 = 210, which makes this study's sample size adequate for regression analysis. The rule of thumb was used because the study could not get the population figures of groundnut farmers in the study area.

3.5 Conceptual Framework

The conceptual base for this study lies in the need for smallholder groundnut farmers to adopt and use CGS to reduce or avoid production losses in Northern Ghana. The study investigated the seed system to find out if there are incentives to produce and supply CGS. Once there are incentives, the seed sector is expected to start producing and supplying CGS to farmers. An increase supply and the possibility to meet farmers' preferences will change their partialities towards CGS. Meeting the preferences of farmers means they will purchase and use CGS, which results in high demand for CGS to which companies respond.

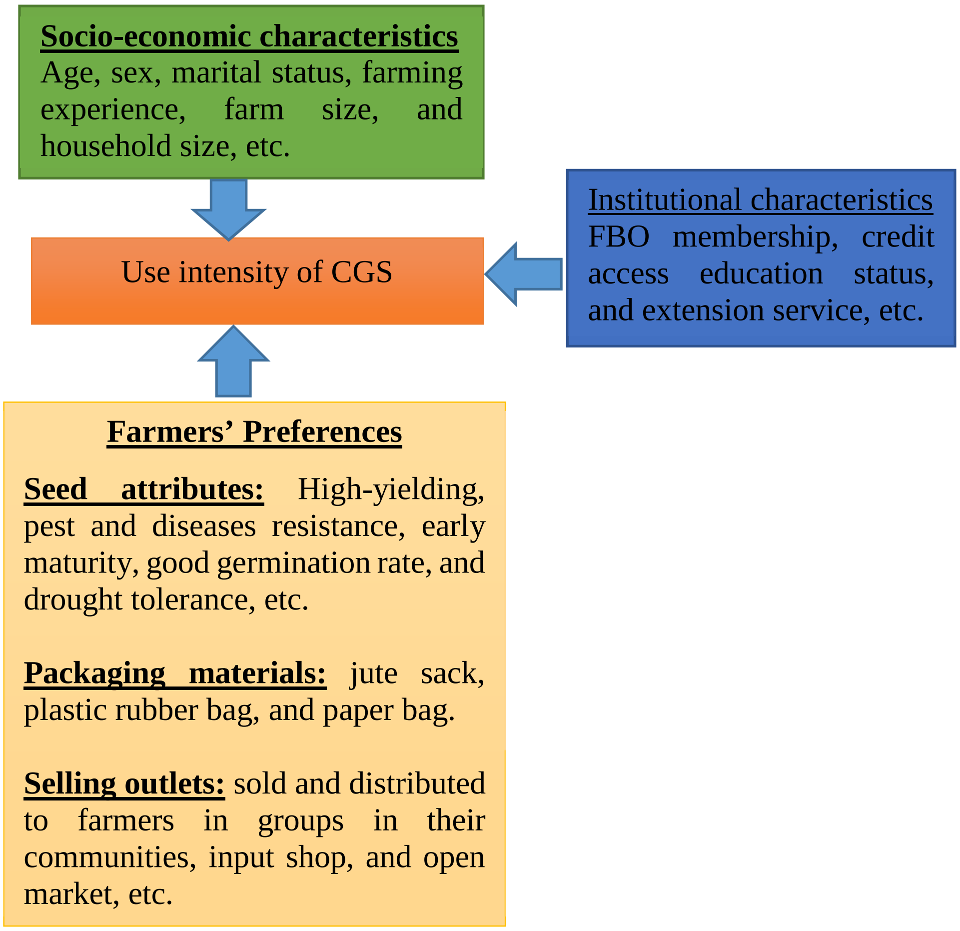

Figure 7: Conceptual framework of the research
Source: ***Computed by Author (2018)***

The adoption and use of CGS would increase the productivity level of farmers encouraging them to commercially use CGS in the study area. The level of adoption and use intensity of CGS by farmers would encourage the breeder institution, seed companies, input dealers to also commercialise its production and supply to farmers. Notwithstanding, farmers' decision to use and use intensity of CGS is also influenced by their socio-economic characteristics and institutional factors.

3.6 Theoretical Framework

The study seeks to examine farmers' preferences and use of certified groundnut seed in Northern Ghana. The theoretical framework underpinning this study is utility maximisation theory. Farmers are rational and always perceive the most utility maximizing decision among several alternatives. Therefore, the decision of a farmer to use CGS or not is dependent on the utility they derived from each of these alternatives. Meanwhile, these decisions are influenced by farmers' socio-economic characteristics, institutional factors and their preference factors. Assuming a farmer's utility to use CGS is 'U_{ij}' and the utility derived for not using CGS is 'U_{ik}'. A rational farmer would choose j^{th} decision to use CGS over k^{th} decision not to use CGS, if only the utility derived from choosing *'j' is greater than that of 'k'*. The behaviour model of whether a farmer should use CGS or not is specified as;

$$E(U_{ij(\text{adopt and use CGS})}) > E(U_{ik(\text{not adopt and use CGS})}) \quad [7] \qquad \text{where; } j \neq k.$$

Where; *j* and *k* represent, the decision to adopt and use CGS and decision not to adopt and use CGS respectively, U_{ij} and U_{ik} represent, the utility derived by i^{th} farmer for choosing j^{th} and k^{th} alternatives, and *E* is the probability.

3.7 Analytical Framework

The analysis of the data involved both qualitative and quantitative techniques. Specifically, two analytical tools were used for analysing the data. Firstly, descriptive statistics such as means and percentages were used to analyse respondents' socio-economic characteristics, the incentives and disincentive for commercial production of groundnut seed (objective one), farmers' preferences for seed in relation to seed attributes, packaging and selling outlets (objective two), and constraints facing groundnut seed production and marketing (objective five). Lastly, the Cragg's double hurdle regression model was used to examine the factors that affect farmers' decision to use and use intensity of CGS. The double hurdle regression model is two-stage econometrics estimation namely; first hurdle and second hurdle which are estimated once. The first hurdle employs Probit model to analyse factors that affect farmers' decision to use CGS. The second hurdle employs truncated Tobit model to analyse factors that predicts farmers' use intensity of CGS.

3.7.1 Incentives and Disincentives for Commercial Production of CGS

The study assessed the seed system to identify the factors that could serve as incentive or disincentive for commercial groundnut seed production. These identified incentives are likely to motivate entrepreneurs to enter into commercial production of CGS whiles the disincentives would discourage participation. The factors analysed will also lead to better understanding of economic feasibility. Descriptive statistics was used to analyse the identified incentives and disincentives for commercial production of CGS and discussed in terms of percentage distribution of respondents. The actors interviewed along the value chain of CGS production include; seed companies, breeder/foundation seed producing institution and input dealers.

3.7.2 Preferences of Smallholder Groundnut Farmers for CGS

The study assessed preferences of smallholder farmers for CGS in relation to seed attributes, selling outlets and packaging materials. Each of these components (i.e. seed attributes, selling outlets and packaging materials) comprise of indicators of which farmers were assessed. Farmers' degree of preferences for these indicators was measured using Likert scale of the form 1, 2, 3, and 4 representing highly do not prefer, do not prefer, prefer, and highly prefer, arranged in ascending order of importance respectively and standardised. Attached to each preference component are their various indicators respectively, thus; seed attributes (e.g. big pod, big nut, more oil content nut, reddish nut, brownish nut, good germination rate, early maturity, drought tolerance, pest and disease resistance, high-yielding, uniform plant growth, and groundnut without foreign materials and mixture of varieties); packaging (e.g. plastic rubber bags, paper bags and jute bags); and selling outlets (e.g. open market, input shops, research institutions, MoFA offices, regional capitals, and distribution of CGS to farmers at their homes or communities). In order to standardise each of the indicators of the preference components measured with Likert scale, the study adopted the UNDP (2007) measure of life expectancy index. This is to ensure that different unit of measurement can be catered for. The indicators under each of the preference components were standardized using the formula below;

$$I_{ij}^{k} = \frac{X_{ij}^{k} - \min X_{ij}^{k}}{\max X_{ij}^{k} - \min X_{ij}^{k}} \qquad [8]$$

j = 1, 2, 3……….J

i = 1, 2, 3……… 250

k = 1, 2 and 3

Where;

I_{ij}^{k} is the index measuring the relative performance of i^{th} farmer's score of j^{th} indicator in k^{th} preference component (i.e. seed attributes, selling outlets and packaging). This index is a measure of variability.

X_{ij}^{k} is the value of the j^{th} indicator scored by i^{th} farmer under j^{th} preference component. This means that X_{ij}^{k} is the value of the indicator as collected from the field survey. Numerator $X_{ij}^{k} - \min X_{ij}^{k}$ indicates the extent to which X_{ij}^{k} varies from its maximum value and the denominator $\max X_{ij}^{k} - \min X_{ij}^{k}$ denotes the range which measures the variability or spread.

j is the number of indicators used in each of the preference component, where in this case; seed attribute (12), selling outlets (7) and packaging materials (3).

After obtaining the relative performance score index (I_{ij}^{k}) of farmers for each indicator in equation 8 above, a preference indicator index (PII) was calculated. Preference indicator index (PII) is the average of all the relative performance score index (I_{ij}^{k}) of farmers for j^{th} indicator in k^{th} preference component. This was done to enable the researcher identify farmers' order of preferences for indicators in each component based on their preference indicator indices. The preference indicator index was calculated using the formula below;

$$\hat{PII}_{i}^{k} = \frac{\sum_{j=1}^{J} I_{ij}^{k}}{N} \qquad [9]$$

Where $\hat{PII}_{i}^{k}$ is the preference indicator index of i^{th} farmer for j^{th} indicator in k^{th} preference component. N, represents the sample size of the study.

After the standardization of the indicators of each of the preference components, the various preference components' score for each farmer can be estimated using equation 10 below. The preference component score for each farmer is the mean or average value of the standardized indicators.

$$\hat{PCS}_{i}^{k} = \frac{\sum_{j=1}^{J} I_{ij}^{k}}{J} \qquad [10]$$

Where; PCS_i^k is the preference component score of the i^{th} farmer, implying PCS_i^k , can be any of the three preference components for the i^{th} farmer. As already indicated, preference component index is the weighted average of all the preference component index, specified as showed below;

$$PCI_i^k = \frac{\sum_{k=1}^{K} W_i^k PCS_i^k}{\sum_{k=1}^{K} W_i^k} \qquad [11]$$

Where; PCI_i^k is the preference component index for i^{th} farmer, and W_i^k is the weight of k^{th} preference component which is determined by the number of indicators used in each preference component. The value obtained in equation (11) was compared to determine which of the preference component is most valued and preferred.

3.7.3 Use Intensity of CGS and its Driving Factors

This section entails the calculation of CGS use intensity index of smallholder groundnut farmers. It also details the Cragg's Double Hurdle Model and how it would be used to analyse factors that affect CGS use intensity.

3.7.3.1 Intensity of Use of Certified Groundnut Seeds

The intensity of use of CGS is express as the ratio of acres of land planted with CGS to total size of groundnut farm in acres. The intensity of use of certified groundnut seed index can be calculated as follows:

$$Y_i = \frac{\text{Acres of CGS seed planted by ith farm household}}{\text{Total size of groundnut farm by ith farm household}} \qquad [12]$$

Where, Y_i denotes the intensity of use of certified groundnut seed index.

In order to analyse factors that influence households' use intensity of CGS, the Cragg's Double Hurdle Model (DHM) was employed. Groundnut farmers' decision to adopt CGS and intensity of use are two separate decisions. These two decisions are closely connected but do not exactly follow the same data generation process. These two decisions of farm households are determined by two separate stochastic processes, where two equations incorporate the effects of explanatory variables. Such explanatory variables may appear in both equations or in either of one (Teklewold *et al.,* 2006). The first hurdle denoted by *(E_i)* takes the value of 1 if a farmers used CGS and 0 if otherwise, using the Probit model. The first hurdle of the double hurdle regression model has an adoption equation specified as follows;

$$E_i = \alpha Z_i + \mu_i \qquad [13]$$

Where: E_i represents a dummy variable that takes the value of 1 if a farmer used CGS, and 0, if otherwise. Z_i, is a vector of the covariates, α is a vector parameter to be estimated and u_i , represents the error term which is normally distributed with zero mean and constant variance.

The second hurdle, consist of an outcome equation which uses a truncated Tobit model to analyse factors that predicts farmers' use intensity of CGS. With the second hurdle model, the information on both sides of the truncated model concerning farmers who did not use CGS are lost. The truncated regression model which is closely connected to the Tobit model is specified as follows;

$$Y_i^* = X_i \alpha + v_i \qquad [14]$$

Where; $$Y_i = \begin{cases} \text{Yi* if Yi*} > 0 \\ 0, \text{if otherwise} \end{cases} \qquad [15]$$

The log-likelihood function for truncated Tobit model is specified as follows:

$$L = \prod_{Y_i} = \left[1 - \Phi(z_i'\alpha)\Phi(\frac{x_i'\beta'}{\sigma})\right] + \prod_{Y_i \succ 0}\left[\Phi(z_i'\alpha)\frac{1}{\sigma}\phi(\frac{y_i - \beta' x_i'}{\sigma})\right] \quad [16]$$

Where: Φ and ϕ represent the standard normal cumulative distribution function and density function, respectively. The first part on the right hand side of equation (16) represents the log-likelihood for a probit model, whereas the second part represents the likelihood for a truncated regression, with truncation at zero. As a result, the log-likelihood from truncated Tobit regression model is the addition of log-likelihood from a probit and a truncated regression.

The Tobit, truncated and probit models are estimated separately, to ensure the test of hypotheses for the truncated model verse Tobit model. The suitability of either Tobit or truncated model for the analysis is determined through the log likelihood ratio test. According to Green (2003), the log likelihood ratio (LR) is calculated as:

$$\Gamma = -2\left[1nL_T - (LnL_p + LnL_{TR})\right] = x^2k \quad [17]$$

Where: L_T represents the likelihood ratio of Tobit regression model, L_P is the likelihood ratio of probit regression model, L_{TR} is the likelihood ratio for truncated regression model and K is the number of explanatory variables in the equations. If hypothesis test of $H_0 : \lambda = \frac{\beta}{\sigma}$ and $\lambda \neq \frac{\beta}{\sigma}$, then, H_0 will be rejected on a pre-specified level if $\Gamma \succ x^2k$.

The empirical model of the truncated Tobit model is specified as showed below:

$$Y_i = \begin{bmatrix} \alpha_0 + \alpha_1 Sex_i + \alpha_2 Age_i + \alpha_3 Hhs_i + \alpha_4 Msta_i + \alpha_5 Edu_i \\ + \alpha_6 Exp_i + \alpha_7 CropLstock\ Incom_i + \alpha_8 Fms_i + \alpha_9 SeedPx_i \\ + \alpha_{10} AcxMob_i + \alpha_{11} \mathrm{SaleFom}_i + \alpha_{12} AcxTrans_i + \alpha_{13} NExtCon_i \\ + \alpha_{14} Lab_i + \alpha_{15} DInptMkt_i + \alpha_{16} Credt_i + \alpha_{17} DOutptMkt_i \\ + \alpha_{18} \mathrm{AgrochQty}_i + \alpha_{19} \mathrm{AcxMktInfo}_i + \alpha_{20i} MFBO + u_i \end{bmatrix} \quad [18]$$

Where: Y_i depends on the latent variable Y_i^* in equation 14 above, being greater than zero and conditional to the decision to use CGS in the study area. α, is the vector of parameters. v_i , represents the error term which is equally distributed with zero mean and constant variance. Table 3 depicts the description, measurement and expected signs of the explanatory variables in the truncated regression model.

Table 3: Description of the explanatory variables used in the Cragg's DHM

Variables	Description	Measurement	Expected sign
E_i	Decision to use CGS	1 if a farmers used CGS and 0 if otherwise	
Y_i	Use intensity of CGS	Ratio of acres of CGS to total acres of groundnut farm	
Household specific characteristics			
Age	Age of household head	Number of years	+/-
Msta	Household head's marital status	Dummy = 1 if married and 0 if otherwise	+
Sex	Sex of household head	Dummy = 1 if male and 0 if otherwise	+/-
Edu	Household head's educational status	Dummy = 1 if educated and 0 if not educated	+
Hhs	Household's number of persons who assist on the farm	Number	+
Exp	Household's experience in CGS farming	Number of years	+
Private Asset Variables			
Fms	Size of the farm	Acreage	+
AcxMob	Mobile phone ownership access of household	Dummy = 1 if yes; 0 if no	+
Public Social Capital Variables			
Extcon	Household's access to extension services	Dummy =1 if yes; 0 = otherwise	+
Credt	Households' access to credit	Dummy =1if yes; 0 = no	+
MFBO	Household's membership of farmer-based organisation	Dummy =1 if a member; 0 = not a member	+
AcxMktInfo	Household's access to market information	Dummy =1 if yes; 0 if no	+
Transaction Cost Variables			
AcxTrans	Households' access to transport means to market	Dummy =1 if yes; 0 if no	+
DOutputMkt	Distance between farmers' residence to output market	Kilometres (Km)	+
DInputMkt	Distance between farmers' residence to input market	Kilometres (Km)	+
SaleFom	Groundnut form of sale	Dummy = 1 if unshelled; 0 if shelled and 2 if Both	+/-
SeedPx	Price of 1kg of certified groundnut seeds	Ghana cedis (GH¢)	-
AgrochQty	Price of 1 litre of Agrochemical	Ghana cedis (GH¢)	-
CropLstockIncom	Total household Livestock income	Ghana cedis (GH¢)	+
Lab	Quantity of labour used on groundnut farm	Man-days	-

3.7.4 Constraints in Groundnut Seed Production and Marketing

Descriptive statistics was used to analyse constraints in groundnut seed production and marketing along the value chain. The actors interviewed include; seed companies, breeder/foundation seed producing institution, input dealers and smallholder farmers. The percentage distribution of responses of these actors to the identified constraints are presented using tables and figures.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the empirical results of the study. The chapter is organised into five sections based on objectives of the study. The first section presents a descriptive overview of demographic and socio-economic characteristics of the surveyed farmers. The second section presents a review of the seed system, analysing policies and incentives for seed production. The third part of the chapter identifies and describes groundnut farmers' preferences for seed in relation to seed attributes, packaging and selling outlets. Farmers' preferences in relation to seed attributes, packaging and selling outlets are also disaggregated by their characteristics. The fourth part of this chapter presents estimates of factors that influence farmers' decision to adopt and use intensity of certified groundnut seed using truncated regression model. Lastly, this chapter concludes with the constraints in CGS production and marketing in the study area.

4.2 Socio-economic Characteristics

This section used frequency tables, bar charts and pie charts to describe the socio-economic characteristics. These characteristics of the respondents are grouped into both categorical and continuous variables as presented in Table 4 and Table 5 respectively. The categorical variable considered are; sex, marital status, educational status, access to extension, access to credit, access to transport, access to mobile phone, access to market information, FBO membership and output form of sale, which are presented in terms of percentage of respondents. The continuous variables also include; age, household size, farm experience, price of groundnut seeds, quantity of weedicide, distance to output market, distance to input market, livestock and other crops income, farm size, quantity of labour, represented in means, minimum and maximum values with their respective standard deviations.

4.2.1 Description of Categorical Variables

The results in Table 4 shows equal percentage (50%) of respondents for both male and female farmers interviewed. Although, groundnut is considered as women crop but this study revealed that the proportion of males in groundnut production has now improved. This could be the impact of the implementation of the objective 1 of the second Food and Agriculture Sector Development Policy (FASDEP II) of MOFA, which entreated that groundnuts production be considered as an important enterprise in promoting income stability among smallholder farmers (MoFA, 2007). The study also finds that about 79% of the respondents were married with the remaining (21%) unmarried. This could create possibility of high childbearing to increase family labour for groundnut production.

Table 4: Summary statistics of categorical variables in the model (n= 250)

Variables		Frequency	Percentage
Sex:	Male	125	50.0
	Female	125	50.0
Marital Status:	Single	52	20.8
	Married	198	79.2
Educational status:	Not educated	168	67.2
	Educated	82	32.8
Access to extension visit:	No	152	60.8
	Yes	98	39.2
Access to market information:	No	56	22.4
	Yes	194	77.6
FBO membership status:	No	120	48.0
	Yes	130	52.0
Access to Credit:	No	228	91.2
	Yes	22	8.8
Access to mobile phone:	No	73	29.2
	Yes	177	70.8
Access to transport means:	No	90	36.0
	Yes	160	64.0
Form of Sale:	Unshelled	85	34.0
	Shelled	157	62.8
	Both	8	3.2

Source: Field survey (2018)

Majority (67%) of the respondents were not educated with few (33%) of them being educated. This suggest that there is high illiteracy rate among the farmers. High illiteracy rate discourages the adoption of new technologies, which in this case, certified groundnut seed use. It was also revealed that most (61%) of the respondents interviewed did not receive extension service in the last farming season whiles about 39% received. Majority of these farmers had no access to extension service due to low farmer-extension ratio (i.e. 1:1500) in the country (MOFA, 2015). About 78% of the respondents also accessed market information whiles 22% did not. About 52% of the respondents were part of farmer-based organisations whiles 38% were not part. It is also indicated in the Table 4 above that majority (91%) of the respondents did not receive credit for groundnut production in the study area. Also, about 71% of the respondents had access to mobile phone with few (29%) of them who did not have. Access to mobile phone encourages farmers to subscribe to E-agricultural services on their production schemes and be introduced to new technologies.

With reference to Table 4, majority (64%) of the respondents interviewed were affirmed to have access to transport means with the remaining (36%) of them who did not. The high percent of access to transport means could be ascribed to the current existence of tricycle motor in the rural areas. Lastly, it was also revealed that majority (63%) of the groundnut farmers sold their produce in shelled form, unshelled (34%) and in both forms (3.2%) in the study area. The study realised that the few people who sold their groundnut unshelled was out of emergency for money to solve their problems.

4.2.2 Description of Continuous Variables

The Table 5 shows that; average age of the respondents is 41 years in the study area. This affirms that, majority of the respondents in the study area were young adults. The study also revealed a mean household size of 8 number of persons which is higher than the national average value of 4.0 (GSS, 2014). Also, the average farming experience of respondents in groundnut production was 13 years. The average price of one kilogram of groundnut seed was GH¢ 10.0 in which farmers considered too expensive.

Table 5: Summary statistics of continuous variables in the model

Variables	Min.	Max.	Mean	Standard Deviation
Age	19.0	75.0	41.3	12.1
Household size	1.0	20.0	7.8	3.7
Farming experience	1.0	50.0	12.7	11.2
Price of groundnut seeds	6.0	15.0	9.7	1.7
Quantity of weedicide used	0.0	27.0	2.22	3.5
Distance to output market	0.8	25.0	6.4	6.5
Distance to input market	0.8	78.6	36.3	28.8
Income from livestock and other crops	0.0	3944.5	137.1	338.6
Farm Size	0.5	27.0	2.0	2.1
Quantity of labour	0.0	840.0	80.5	115.2

Source: ***Field survey (2018)***

The average quantity of weedicide used per an acre was 2.2 litres in the study area. Also, the mean distance from the residence of farmers interviewed to the output market and input market were 6.4 km and 36.3 km respectively. The average income obtained from livestock and other crops production exclusively was GH¢ 137.1 with an average farm size for groundnut production being 2 acres. According to Amikuzuno (2015) the overall farm sizes of groundnut in northern Ghana range from 0.5 – 15 acres. It was also revealed that the mean quantity of labour used for groundnut production in the study area was 80.5 man-days.

4.2.3 Use of CGS disaggregated by Farmers' Characteristics

The Table 6 below presents the results disaggregated by use and non-use of CGS for the sampled households. The statistics are for farmers growing certified groundnut seeds, farmers using recycled and indigenous groundnut seed, the means difference and level of significance for a test for difference in the means. Note that, all the variables in Table 6 are significant at 1% except sex. The results from the Table 6 showed that majority (66%) of male farmers did not use CGS. The study noted that, about 46% of female farmers used CGS. It was also revealed that farmers with a mean farm size of 1.7 acres used CGS whiles those with a mean farm size of 2.1 did not. Ewire *et al.* (2016) also observed that farmers who did not adopt improved maize varieties had significantly large farm sizes (4.2 hectares) as compared to farmers who have adopted (3.1 hectares). This means that farmers with small farm size are likely to use CGS relative to those with larger acreages.

It was also indicated in Table 6 that users of CGS had more number of extension visits than non-users showing 2 and 1 number of times respectively. This connotes that, frequent contact of extension agents may increase their likelihood of adopting CGS. In the same vein, the users of CGS had more number of FBO meetings than the non-users (3 and 1 number of times respectively). This also implies that being a member of FBO increases farmers' chances of adopting CGS in the study area. This study also found that, about (39%) of groundnut farmers who were aware about the existence of CGS grew it whiles 32.8% did not. This confirms the importance of public advocacy on the existence of CGS on the market to increase its adoption in the study area. The result indicated that, groundnut farmers who cultivated CGS used less quantity of weedicide per acre than the non-users. Currently, the average quantity of weedicide used for an acre of land planted with CGS is 2.2 litres whiles those without requires 2.3 litres. This implies that, CGS production reduces the quantity of weedicide use, largely due to its weeds tolerance attributes.

Table 6: Disaggregated descriptive statistics by CGS usage

Variables	Mean		
	Users	**Non-users**	**Difference**
Household Characteristics			
Age (years)	42.32	40.61	1.71
Female (n=125)	45.6	54.40	-8.80*
Male (n=125)	34.40	65.60	-31.20*
Household size	8.44	7.44	1.00
Years in education	2.75	2.44	0.31
Farm size (acres)	1.70	2.12	-0.42***
Public Assets/ Social Capital Variables			
Number of FBO meetings	3.40	0.78	2.62***
Number of extension meetings	2.03	0.62	1.41***
Awareness of CGS (%)	39.20	32.80	6.40***
Transaction Cost Variables			
Quantity of weedicide used (litres)	2.15	2.27	-0.12***
Quantity of output sold (Kg)	220.68	158.01	62.67***
Quantity of output consumed (Kg)	42.57	36.17	6.40***
Quantity of output (Kg)	337.58	251.90	85.68***
Total revenue from produce (GH¢)	1330.89	822.76	508.13***
Distance to input market (Km)	53.44	24.95	28.49***

Note: *** Significant at 1%, **Significant at 5%, *Significant at 10%
Source: Field survey, (2018)

It was found that, farmers who cultivated CGS sold large quantity of their output (220.9 Kg) than their counterparts (158.0 kg). This means that, CGS producers are more market oriented than their counterparts who use recycled seeds. From the table, farmers who cultivated CGS tend to consume more of their output (42.6 Kg) than their counterparts who consumed an average of 36.2 Kg. It was found that, groundnut farmers who cultivated CGS obtained higher output (337.9 Kg) than their counterparts (251.9 kg). This means that, the use of CGS in production would increase output and income of farmers than recycled seeds.

Again, as farmers who cultivated CGS got higher revenue per acre (GH¢ 1330.9/acre), their counterparts who used recycled seeds obtained lower revenue per acre (GH¢ 822.8/acre). This means that, if groundnut farmers adopt CGS in production their income level would improve. It was noted that, groundnut farmers who travel longer distance (averagely 53.4 km) to input markets rather tend to cultivate CGS more than those who travel short distance (averagely 25.0 km). This could be ascribed to the fact that, NGOs and projects that provide inputs often deliver them to the farmers in their communities so farmers do not have to travel to access them.

4.2.4 Knowledge of CGS

The study assessed farmers' knowledge of certified groundnut seed using percentage of respondents. The farmers were asked whether they had knowledge on the existence of certified groundnut seed. The study shows that, majority (72%) of the respondents are aware that certified groundnut seeds exist. Only 28% of the respondents have never heard that there exist certified groundnut seeds as it is for other crops on the market.

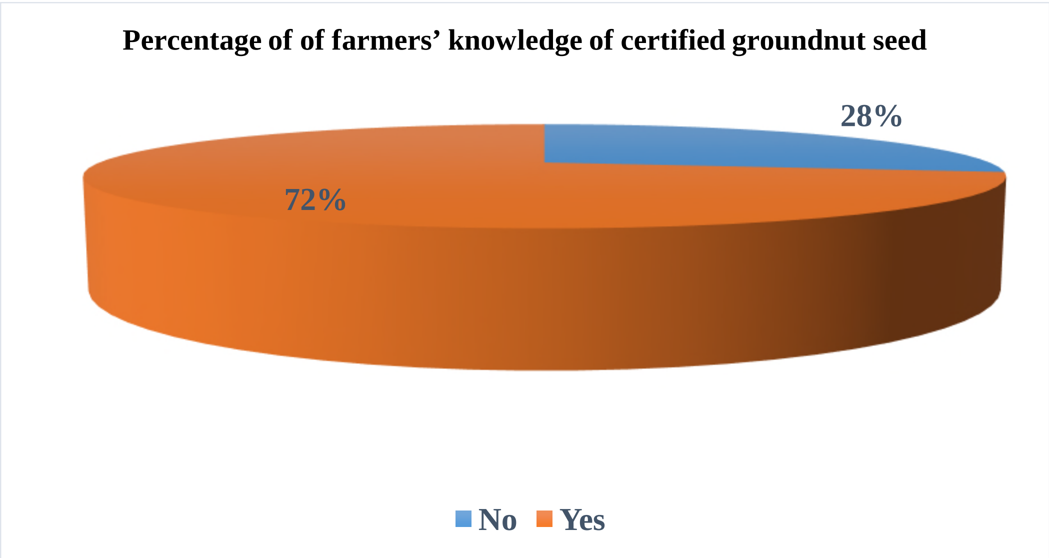

Figure 8: Percentage of farmers' knowledge of certified groundnut seed

Source: ***Field survey, (2018)***

4.2.5 Sources of Groundnut Seed

The various sources from which farmers obtain groundnut seed in production were investigated and discussed using percentage of respondents. The productivity level of seed depends on the source for which a farmer obtains it. This study identified four sources of groundnut seed used by groundnut farmers (Figure 9). These identified sources of groundnut seeds include; farmer to farmer exchange, previous harvest, informal market and formal market.

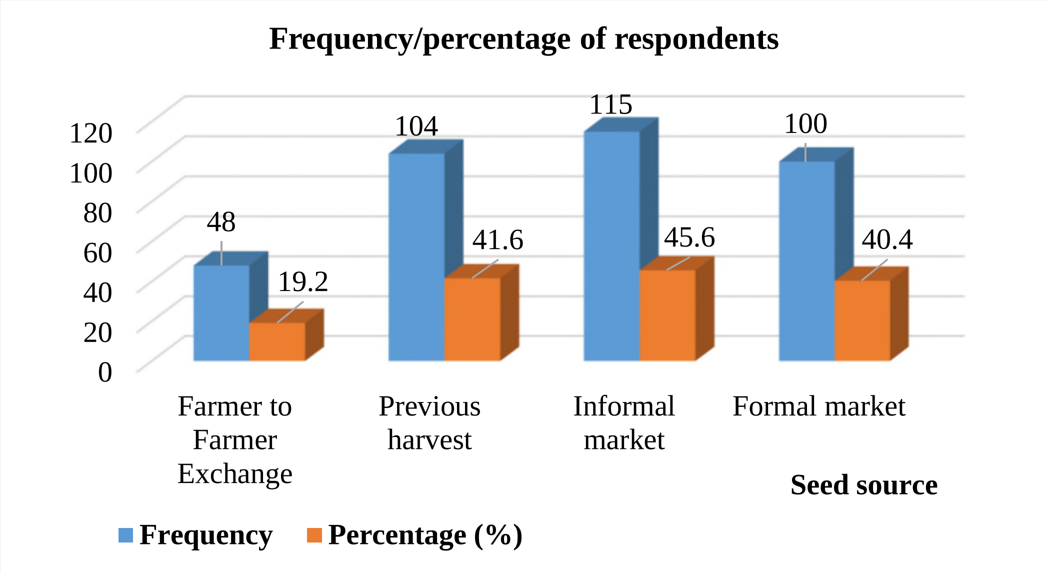

Figure 9: Percentage of farmers using seeds from different sources
Source: *Field survey, (2018*)

The study found that, about 47% of the respondents obtained their seeds from the informal market whiles least (19%) of them also accessed their seeds through farmer to farmer exchange. However, about 40 percent of the respondents interviewed also obtained their seeds from the formal market. The study shows that, a maximum of 60 percent of the respondents obtained their seeds not from the formal market but from other means. The farmers asserted that, seeds from farmer to farmer exchange, previous harvest and the informal market sources are not regulated and contains undesirable seed attributes such as poor yielding, pest and diseases, long maturity durations and poor resistance to drought among others required for efficient production.

4.3 Incentives and Disincentives for Commercial Production of CGS

The study assessed the seed system to find factors that could serve as incentive or disincentive for commercial groundnut seed production. The actors that were interviewed include; seed companies, input dealers and a breeder/foundation seed producing institution. These identified incentives are likely to motivate entrepreneurs to enter into commercial production of CGS whiles the disincentives would discourage participation. The identified incentives and disincentives were measured using percentage of respondents.

4.3.1 Factors that Affect CGS Production Enterprise

Seed companies

Seed companies were interviewed to identify factors that affect the business of seed production in the study area. Figure 10 presents factors that affect the business of CGS production measured using percentages of respondents. These factors include; cost of production, suitable environment, demand, contracts, price of foundation seed, government subsidy and profit. From the figure, seed companies prefer that the cost of production is low so they can produce more to encourage farmers buy more. Currently, majority (60%) of seed companies think groundnut seed production costs are high and is a disincentive for production. The study noted seed companies agree that, the environment in the study area is suitable for CGS production. Currently, majority (90%) of seed companies think that, the environment in the study area is suitable for groundnut seed business and is an incentive for production. The study indicates seed companies agree that, there is demand for CGS. At the moment, about (80%) of seed companies think that, there is demand for CGS and is an incentive for production. The seed companies stated that most NGO and projects implemented import CGS from Burkina Faso and Ivory Coast to supply farmers on their programmes. This is because there is inadequate production of CGS in the country. Presently, majority (70%) of seed companies think there could be contracts from these agencies for CGS supply and is an incentive for production.

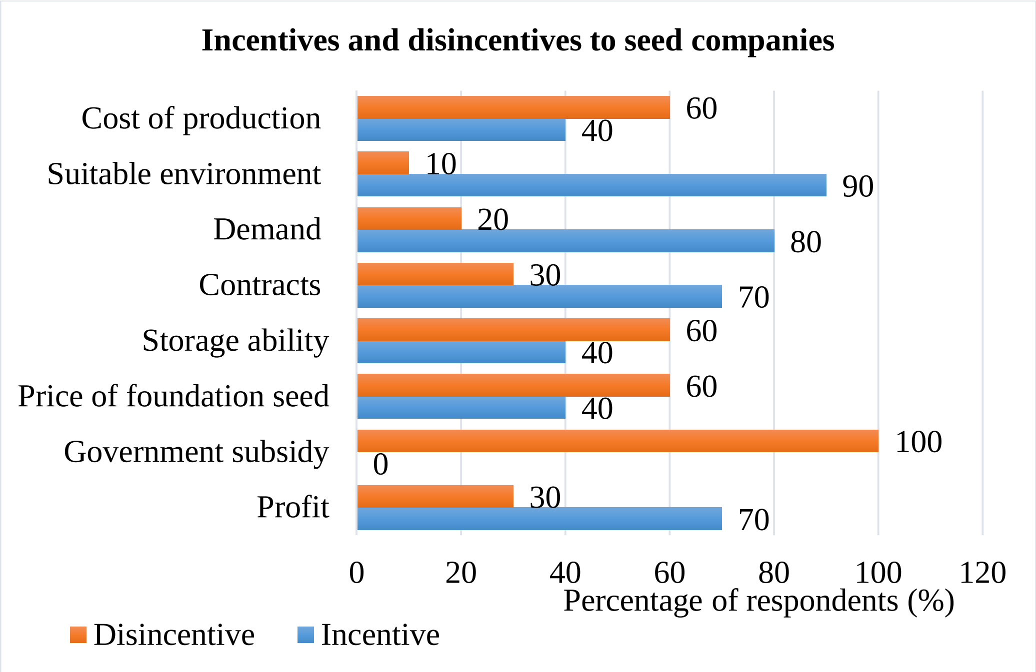

Figure 10: Percentage of incentives and disincentives to seed companies for commercial production of CGS
Source: *Field survey, (2018)*

Seed companies prefer that breeders should find possible ways to improve the storageability level of groundnut during breeding process. At the moment, about (60%) of seed companies think that, storageability of groundnut seed is low and is a disincentive for production. Besides this, seed companies prefer that the price of foundation seed be low to help them increase demand to produce adequate seeds for farmers to buy more. Currently, most (60%) of seed companies think that, prices of foundation seed are high and is a disincentive for production.

The study noted that unlike other crops (maize, rice and soybean), there is no subsidy for groundnut seeds. Presently, all (100%) seed companies think that implementation of subsidy on groundnut would serve as an incentive for production. Lastly, majority (70%) of seed companies in groundnut seed production think that, the business is profitable and is an incentive for production.

Agro-input dealers

Figure 11 illustrates incentives or disincentives for commercial input dealers to market and distribute CGS. The factors include; price of groundnut seed, government subsidy, storage facilities, accessibility, demand and profit. On price, about 60% of input dealers think price of CGS is high and is a disincentive for them to deal with it. The input dealers proposed that, the price of CGS should be low to incentivise them increase sales to farmers. The study noted that, the current condition of storage facilities of input dealers discourages them to deal with CGS. At the moment, about 60% of input dealers think that, they do not have improved storage facilities to store CGS and is a disincentive for them to deal with it.

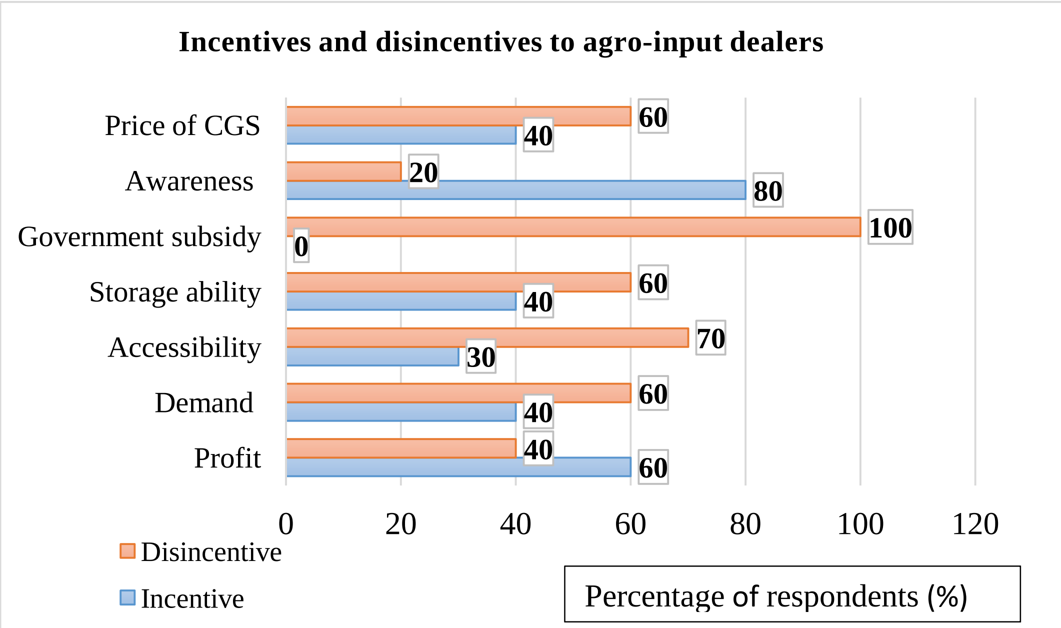

Figure 11: Percentage of incentives and disincentives to agro-input dealers for marketing and distribution of CGS

Source: ***Field survey, (2018)***

The study noted that, all (100%) input dealers think that, government support in the form of providing improved storage facilities and increasing electricity supply would incentivise them store good seed and expand business. Also, it was discovered that, input dealers find it difficult to get access to CGS due to inadequate production and major sales done by seed companies. Currently, majority (70%) of input dealers think, difficult access to adequate CGS from seed companies is a disincentive for them to deal with it. The input dealers prefer that, marketing of CGS should be done solely by them to increase farmers' demand. Currently, majority (60%) of input dealers think that, demand for CGS is low and is a disincentive to them. Public awareness advocacy would increase input dealers' knowledge of CGS to encourage sale. At the moment, few (20%) of input dealers surprisingly admitted not to have ever heard the existence of CGS as it is for other crops and is a disincentive to them. The input dealers (60%) who are dealing with CGS think the business is profitable and is an incentive for them to deal with it.

Breeder/foundation seed institution

An official in a Breeder/foundation seed institution was interviewed to find out the factors that could motivate them to commercially produce CGS. The official asserted that *'' we will commercially produce CGS if only there is high profit and farmers' demand for it''. He added that, "currently, there is profit and farmers' demand for breeder and foundation seed and is an incentive for them to commercially produce CGS". However, he exclaimed that, '' there is no government subsidy and adequate budget allocation for groundnut seed breeding and is a disincentive for them to increase production''. He proposed that, ''government support in the form of subsidy and funds will enable them to produce adequate and good quality seeds to meet the preferences of farmers".*

The study infers that there is high profit and farmers' demand for CGS, however, the breeder/foundation seed institution is unable to increase production due to inadequate funds and no CGS subsidy from the government. The study noted that seed breeding requires adequate funds to acquire advanced technological equipment for good quality seed production to meet farmers' preferences.

4.4 Preferences of Smallholder Groundnut Farmers for CGS

The study assessed preferences of smallholder farmers for CGS in relation to seed attributes, selling outlets and packaging materials. Farmers' preferences were derived by assessing each of these components (i.e. seed attributes, selling outlets and packaging materials) using certain indicators. Farmers' degree of preferences for these indicators was measured using Likert scale of the form 1, 2, 3, and 4 representing highly do not prefer, do not prefer, prefer, and highly prefer, arranged in ascending order of importance respectively. The Likert scale was transformed and an index was calculated (preference indicator index (PII)) and discussed in terms of percentages. The PII helps the researcher compare indicators in each preference component (i.e. seed attributes, selling outlets and packaging) to know their preference schedules in production. This would inform breeders and entrepreneurs about the priorities of these indicators to farmers so policy interventions can meet their targeted needs. An overall index (preference component index (PCI)) for each component was calculated from their respective indicators' scores and compared in terms of percentages.

4.4.1 Preferences of Farmers for CGS Attributes

The study asked farmers to examine extent to which they prioritise each attribute indicators (i.e. high-yielding, early maturity, pest and disease resistance etc.) of CGS in production. Table 7 presents farmers' preference indicator index, frequency and percentage distribution for each attribute indicator. The study discusses farmers' preference indicator index of each attribute indicator in terms of percentages as follows. The study noted that, groundnut farmers prioritise high-yielding and big nut as first most preferred attribute indicator for CGS in production. Currently, groundnut farmers use unimproved varieties which result into low yields in production. They think that, access to high-yielding CGS would enable them improve yield so as to participate in both domestic and international output markets. Presently, smallholder farmers use groundnut varieties with small nut which reduces market gains during sales. They think that, access to CGS with big nut attribute would increase their market gains during sales as it weighs high and easily fills measuring materials. The preference indicator index (PII) for high-yielding and big nut attribute was 0.989 and 0.988 respectively. This means that, about (99%) of groundnut farmers scored high-yielding and big nut indicators as first most preferred attributes of CGS among others respectively.

Table 7: Preferences of farmers for CGS Attributes (n=250)

Attributes of CGS	Scale percentage of response (%)								PII_A
	Highly prefer		*Prefer*		*Do not prefer*		*Highly do not prefer*		
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Big pod	221	88.4	22	8.8	7	2.8	0	0.0	**0.952**
Big nut	242	96.8	7	2.8	1	0.4	0	0.0	**0.988**
more nut oil	213	85.2	33	13.2	4	1.4	0	0.0	**0.945**
Reddish nut	161	64.4	65	26.0	22	8.8	2	0.8	**0.847**
Brownish nut	203	81.2	36	14.4	10	4.0	1	0.4	**0.921**
Early maturity duration	238	95.2	12	4.8	0	0.0	0	0.0	**0.984**
Good germination rate	238	95.2	11	4.4	1	0.4	0	0.0	**0.983**
Groundnut without foreign materials and mixture of varieties	214	85.6	34	13.6	2	0.8	0	0.0	**0.949**
High yielding	243	97.2	6	2.4	1	0.4	0	0.0	**0.989**
Drought tolerance	223	89.2	24	9.6	3	1.2	0	0.0	**0.960**
Pest and diseases resistance	238	95.2	10	4.4	2	0.8	0	0.0	**0.981**
Uniform plant growth	201	80.4	44	17.6	5	2.0	0	0.0	**0.928**
Preference component index (PCI) for seed attribute = 0.952									

Note: ***PII_A represents preference indicator index for each indicator in attribute preference component.***

Source: ***Field survey, (2018)***

From Table 7, high resistance to pest and disease, early maturity and good germination rate attribute indicators of CGS were the second most important attributes prioritised by farmers in production. The farmers asserted that, the current groundnut varieties used are of low resistance to pest and disease, poor germination rate and late maturity. They think that, access to CGS with high resistance to pest and disease, good germination rate and early maturity would help them improve productivity. Farmers' preference indicator indices for CGS with high resistance to pest and disease, early maturity and good germination rate attributes were 0.984, 0.983 and 0.981 respectively. This means that, about 98% of groundnut farmers scored high resistance to pest and disease, early maturity and good germination rate attribute indicators as second most preferred attributes of CGS among others respectively.

The study also found that, groundnut farmers prioritise tolerance to drought indicator as third most preferred attribute of CGS among others in production. At the moment, farmers complain that, the current groundnut varieties used are less tolerant to drought resulting in post-harvest losses. Groundnut farmers think that, access to CGS with drought tolerant attribute would withstand the current harsh weather conditions to reduce post-harvest losses in production. Drought tolerance indicator of CGS attribute recorded a preference indicator index of 0.960. Implying that**,** about 96% of groundnut farmers scored drought tolerance indicator as the third most prioritised attribute of CGS preferred among others.

Again, the result finds that, groundnut with big pod, more oil content and without foreign materials and mixture of varieties indicators were prioritised by farmers as the fourth important attributes of CGS preferred among others. Smallholder farmers stated the present groundnut varieties used have thin and small pods inhibiting embryo's enlargement. They think that, access to big podded groundnut would create allowance for groundnut embryo's enlargement and also shields it from pest and disease attacks. On more oil content attribute, farmers purported the current groundnut varieties used do not contain adequate oil for sale and household's consumption. They think that, access to CGS with more oil content attribute would improve their livelihood status. The farmers also expressed that, the current groundnut varieties purchased from market contain mixture of varieties and foreign materials giving them extra job for sorting and grading before sowing. Farmers' preference indicator index for CGS with big pod, more oil content and without foreign materials and mixture of varieties attributes were 0.952, 0.945 and 0.949 respectively. This implies that, about 95% of groundnut farmers scored big pod, more oil content and without foreign materials and mixture of varieties indicators as fourth most preferred attributes of CGS among others.

Table 7 above shows that, groundnut farmers prioritise uniform maturity and brown coloured nut as fifth and sixth most preferred indicators of CGS attributes among others in production. Groundnut farmers think brown coloured nut is less attractive to pest and disease attacks relative to other nut colours. Also, farmers disclosed that, most of the current groundnut varieties used do not have uniform maturity dates, largely due to mixture of varieties sold in markets. They think that, access to CGS with uniform maturity attribute would reduce Aflatoxin contaminations which is usually severe in immature harvested groundnut. Farmers' preference indicator indices for uniform maturity and brownish nut was 0.928 and 0.921 respectively. This means that, about 93% and 92% of groundnut farmers scored uniform maturity and brownish nut indicators as fifth and sixth most preferred attribute of CGS respectively among others. Lastly, groundnut with reddish nut was least preferred among the indicators of CGS attributes by groundnut farmers. The farmers think that, reddish nuts are highly susceptible to disease infestation than other nut colours. Reddish nut indicator recorded a preference indicator index of 0.847. This implies that, about 85% of groundnut farmers scored reddish nut indicator as the least most preferred CGS attribute among others in the study area.

4.4.2 Preferences of Farmers for CGS Packaging Materials

This study discovered three forms of packaging materials of CGS namely; plastic rubber bags, paper bags and jute sacks. Farmers were asked to examine their degree of preferences for packaging materials they think CGS should be packaged. Table 8 shows farmers' preference indicator index, frequency and percentage distribution for each packaging form. The study discusses farmers' preference indicator index of each packaging material in terms of percentages. From the table, groundnut farmers tend to like jute sack as first most preferred packaging material of CGS. Currently, groundnut seeds sold on market are packaged in air-tight rubber bags with no ventilation which render seed into deterioration due to excessive heat. The jute sack packaging material recorded a preference indicator index of 0.956. Implying that, about 96% of groundnut farmers prefer that, CGS should be package in jute sacks.

It was also noted groundnut farmers prefer rubber bag packaging material to paper bag. The farmers think jute sack is costly, therefore packaging CGS in rubber bag would reduce its price for them to buy more. The rubber bag packaging material recorded a preference indicator index of 0.547. At the moment, about 54% of groundnut farmers prefer that, CGS should be package in rubber bags.

Table 8: Preferences of farmers for CGS packaging materials (n=250)

Packaging materials of CGG	**Scale percentage of response (%)**								**PII$_P$**
	Highly prefer		***Prefer***		***Do not prefer***		***Highly do not prefer***		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	
Plastic rubber bags	41	16.4	98	39.2	91	36.4	20	8.0	**0.547**
Paper bags	16	6.4	25	10.0	111	44.4	98	39.2	**0.279**
Jute sacks	228	91.2	13	5.2	7	2.8	2	0.8	**0.956**
Preference component index (PCI) for packaging material = 0.594									

Note: ***PII$_P$ represents preference indicator index of each indicator of packaging material.***

Source: ***Field survey, (2018)***

The least preferred packaging material of CGS was paper bag, recording 0.279 preference indicator index. This means that, about 28% of groundnut farmers prefer that, CGS should be package in paper bags. Groundnut farmers think that, paper bag packaging material could easily be destroyed through water contacts relative to others.

4.4.3 Preferences of Farmers for CGS Selling Outlets

The study identified some selling outlets of CGS namely; open markets, input shops, research institutions, MoFA offices, district capitals, regional capitals and marketing and distributing CGS to farmers in their communities in groups. Farmers were asked to examine the degree to which they prefer that CGS should be sold through these selling outlets. Table 9 presents farmers' preference indicator index, frequency and percentage distribution of each selling outlet. The study discusses farmers' preference indicator index of each selling outlet in terms of percentages as follows. From the table, groundnut farmers prioritise marketing and distribution of CGS to them in their communities in groups as first most preferred selling outlet of CGS. Smallholder groundnut farmers think their residence are far distant from the available CGS selling outlets causing them to incur transport cost to access them. The preference indicator index of marketing and distribution of CGS to farmers in their communities in groups is 0.980. This implies that, about 98% of groundnut farmers prefer that CGS should be marketed and distributed to them in their communities in groups through bulk purchase.

The study noted that, input shop was second most prioritised selling outlet of CGS by groundnut farmers. The groundnut farmers think that, CGS are often not available in input shops unlike other crops (maize, rice and soybeans) for them to buy. In addition, groundnut farmers asserted that, they do not understand how to use CGS, therefore experienced input dealers could educate them. Input shop selling outlet of

CGS recorded a preference indicator index of 0.959. This means that, about 96% of groundnut farmers currently think that, CGS should be sold through input shops. The study also indicated that, groundnut farmers prioritise open market as third most preferred selling outlet of CGS. The smallholder groundnut farmers think that, selling CGS in open market would increase its accessibility. The preference indicator index of open market selling outlet of CGS is 0.876. This means that, about 88% of groundnut farmers prefer that, CGS should be sold through open market selling outlets.

Table 9: Preferences of farmers for CGS selling outlet (n=250)

Selling outlets of CGS	**Scale percentage of response (%)**								**PIIs**
	Highly prefer		***Prefer***		***Do not prefer***		***Highly do not prefer***		
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	
Open market	178	71.2	54	21.6	15	6.0	3	1.2	**0.876**
Input shops	229	91.6	13	5.2	6	2.4	2	0.8	**0.959**
Research institutions	40	16.0	12	4.8	18	7.2	180	72.0	**0.216**
MOFA office	14	5.6	107	42.8	100	40.0	29	11.6	**0.475**
District capitals	12	4.8	73	29.2	138	55.2	27	10.8	**0.427**
Regional capitals	0	0.0	6	2.4	35	14.0	209	83.6	**0.063**
Sold and distributed to farmers at their communities in groups	237	94.8	11	4.4	2	0.8	0	0.0	**0.980**
Preference component index (PCI) for selling outlet = 0.571									

Note: ***PIIs represents preference indicator index of each indicator of selling outlet component.***
Source: ***Field survey, (2018)***

The study found that, groundnut farmers ranks MoFA office and district capitals as fourth and fifth most preferred selling outlets of CGS respectively. The MoFA office and district capitals recorded preference indicator indices of 0.475 and 0.427 respectively. This means that, about 48% and 43% of groundnut farmers think that, CGS should be sold at both MoFA offices and district capitals respectively.

The sixth most preferred selling outlet was research institutions, scoring a preference indicator index of 0.216. Implying that less than quarter (22%) of groundnut farmers agree that, research institutions should be used as selling outlets of CGS. The least preferred selling outlet of CGS was regional capitals recording 0.063 preference indicator index. Implying that, only few (6%) of groundnut farmers, currently agree that, CGS should be sold at the regional capitals.

4.4.4 Preferences for CGS Attributes, Packaging Materials and Selling Outlets Disaggregated by Farmers' Characteristics

This section tries to assess farmers' degree of preferences for selected attributes, selling outlets and packaging materials based on their characteristics. Assessing farmers based on their characteristics would help entrepreneurs identify each market segment and what they prefer. The degree of farmers' preferences for these components was measured using Likert scale of the form 1, 2, 3, and 4 representing highly do not prefer, do not prefer, prefer, and highly prefer, arranged in ascending order of importance respectively. The selected characteristics of farmers include; age, sex, marital status, educational status, extension service access and farmer-based organisation (FBO) membership status.

4.4.4.1 Preferences for CGS attributes disaggregated by farmers' characteristics

The selected attributes of CGS for this analysis include; high-yielding, early maturity, pest and disease resistance, drought tolerance and more oil content. Farmers' preference for each of these attributes were measured with Likert scale as mentioned above and discussed in terms of percentage of respondents based on their characteristics.

Preferences for high-yielding attribute of CGS disaggregated by farmers' characteristics

Table 10 presents the degree of farmers' preferences for high-yielding attribute of CGS disaggregated by their characteristics. From the table, females tend to like CGS with high-yielding attribute more than males. Presently, about 97% of female groundnut farmers highly prefer that, CGS should have high-yielding attribute. Groundnut farmers within youthful age range (14 to 24 years) tend to like CGS with high-yielding potential more than adult age range (25-64 years). At the moment, all (100%) youthful groundnut farmers highly prefer that, CGS should have high-yielding attribute. Groundnut farmers who were unmarried (98%) tend to place much importance to CGS with high-yielding attribute more than those married. The study noted that educated groundnut farmers (99%) tend to like CGS with high-yielding attribute more than the uneducated.

Table 10: Preferences for High-yielding Attribute of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	120	96.0	4	3.2	1	0.8	0	0.0	125	100
Female	122	97.6	3	2.4	0	0.0	0	0.0	125	100
Age										
14-24	18	100	0	0.0	0	0.0	0	0.0	18	100
25-64	218	96.5	7	3.1	1	0.4	0	0.0	226	100
Marital status										
Married	191	96.5	6	3.0	1	0.5	0	0.0	198	100
Not married	51	98.1	1	1.9	0	0.0	0	0.0	52	100
Educational status										
Educated	81	98.8	0	0.0	1	1.2	0	0.0	82	100
Not educated	161	95.8	7	4.2	0	0.0	0	0.0	168	100
Access to extension										
Yes	96	98.0	1	1.0	1	1.0	0	0.0	98	100
No	146	96.1	6	4.0	0	0.0	0	0.0	152	100
FBO membership										
Yes	126	96.9	3	2.3	1	0.8	0	0.0	130	100
No	116	96.7	4	3.3	0	0.0	0	0.0	120	100

Source: ***Field survey (2018)***

It was also unfolded that, groundnut farmers who had access to extension service (98%) tend to highly prefer CGS with high-yielding potential more than those without (96%). The study noted that, all groundnut farmers like CGS with high-yielding attribute irrespective of their FBO membership status. Currently, equal percentage (97% each) of groundnut farmers highly prefer CGS with high-yielding attribute irrespective of their FBO membership status.

Preferences for good germination rate attribute of CGS disaggregated by farmers' characteristics

Table 11 presents the degree of farmers' preferences for CGS with good germination rate disaggregated by their characteristics. From the table, female groundnut farmers (96% out of 125 female farmers) tend to highly prefer CGS with good germination rate attribute more than males (94% out of 125 males). The study noted that, groundnut farmers within adult age range 25 to 64 years (95% out of 126 adult farmers) highly prefer CGS with good germination rate attribute more than youthful age range 14 to 24 years which recorded a percentage of 94% out of 18 youth farmers. As depicted in Table 11, more groundnut farmers who were married (96% out of 198 married farmers) highly prefer CGS with good germination rate attribute than the unmarried (94% out of 82 unmarried farmers).

It is important to note that, majority of all farmers interviewed irrespective of whether or not they are educated highly prefer CGS with good germination rate. However, the percentage of uneducated farmers (96%) who highly prefer CGS with good germination rate are higher than educated farmers (94%). The study noted that, equal percentage (95% each) of groundnut farmers highly prefer CGS with good germination rate irrespective of their FBO membership status. Proportionately, as 96% of farmers having access to agricultural extension service highly prefer that

CGS should have good germination rate attribute, 95% of farmers without access to agricultural extension service highly prefer.

Table 11: Preferences for good Germination Rate Attribute of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	118	94.4	6	4.8	1	0.8	0	0.0	125	100
Female	120	96.0	5	4.0	0	0.0	0	0.0	125	100
Age										
14-24	17	94.4	1	5.6	0	0.0	0	0.0	18	100
25-64	215	95.3	10	4.4	1	0.4	0	0.0	226	100
Marital status										
Married	189	95.5	8	4.0	1	0.5	0	0.0	198	100
Not married	49	94.2	3	5.8	0	0.0	0	0.0	52	100
Educational status										
Educated	77	93.9	4	4.9	1	1.2	0	0.0	82	100
Not educated	161	95.8	7	4.2	0	0.0	0	0.0	168	100
Access to extension										
Yes	94	95.9	4	4.1	0	0.0	0	0.0	98	100
No	144	94.7	7	4.6	1	0.7	0	0.0	152	100
FBO membership										
Yes	124	95.4	5	3.9	1	0.7	0	0.0	130	100
No	114	95.0	6	5.0	0	0.0	0	0.0	120	100

Source: ***Field survey (2018)***

Preferences for pest and disease resistance attribute of CGS disaggregated by farmers' characteristics

Table 12 shows the degree of farmers' preferences for CGS with pest and disease resistance attribute disaggregated by their characteristics. From the table, higher proportion of female groundnut farmers (96% out of 125) tend to highly prefer CGS with pest and disease resistance attribute more than males who recorded a percentage of 94% out 125. The study also found that, all groundnut farmers within the youthful age range 14 to 24 years highly prefer CGS with pest and disease resistance attribute as compared to adult age range (25 to 64 years) which recorded 95% out of 226.

From Table 12, it can be seen that though all farmers have high preference for CGS with pest and disease resistance attribute, much higher percentage of unmarried farmers (98% out of 198), educated farmers (97% out of 82), farmers having access to agricultural extension services (99% out of 98) and FBO members (98% out of 130) highly prefer CGS with pest and disease resistance attribute than their respective counterparts with contrasting features.

Table 12: Preferences for Pest and Disease Resistance Attribute of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Sex										
Male	118	94.4	5	4.0	2	1.6	0	0.0	125	100
Female	120	96.0	5	4.0	0	0.0	0	0.0	125	100
Age										
14-24	18	100	0	0.0	0	0.0	0	0.0	18	100
25-64	214	94.7	10	4.4	2	0.9	0	0.0	226	100
Marital status										
Married	187	94.4	9	4.6	2	1.0	0	0.0	198	100
Not married	51	98.1	1	1.9	0	0.0	0	0.0	52	100
Educational status										
Educated	79	96.6	2	2.4	1	1.2	0	0.0	82	100
Not educated	159	94.6	8	4.8	1	0.6	0	0.0	168	100
Access to extension										
Yes	97	99.0	1	1.0	0	0.0	0	0.0	98	100
No	141	92.8	9	5.9	2	1.3	0	0.0	152	100
FBO membership status										
Yes	127	97.7	3	2.3	0	0.0	0	0.0	130	100
No	111	92.5	7	5.8	2	1.7	0	0.0	120	100

Source: ***Field survey (2018)***

Preferences for drought tolerance attribute of CGS disaggregated by farmers' characteristics

Table 13 shows the degree of farmers' preferences for CGS with drought tolerance attribute disaggregated by their characteristics. It is noted from Table 13 that, though all farmers have higher preference for drought tolerance attribute for CGS, the proportion of female groundnut farmers, married farmers, educated farmers, farmers having access to agricultural extension services and membership of FBOs have high preference for drought tolerance attribute of CGS much higher than their respective counterparts with contrasting features. The study noted that, both youthful age range

(14 to 24 years) and adult age range (25 to 64 years) groundnut farmers highly prefer groundnut seed with drought tolerance attribute with equal percentage of 89% each.

Table 13: Preferences for Drought Tolerance Attribute of CGS

Variables	***Highly prefer***		***Prefer***		***Do not prefer***		***Highly do not prefer***		***Total***	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	110	88.0	14	11.2	1	0.8	0	0.0	125	100
Female	113	90.4	10	8.0	2	1.6	0	0.0	125	100
Age										
14-24	16	88.9	2	11.1	0	0.0	0	0.0	18	100
25-64	201	88.9	22	9.7	3	1.3	0	0.0	226	100
Marital status										
Married	177	89.4	18	9.1	3	1.5	0	0.0	198	100
Not married	46	88.5	6	11.5	0	0.0	0	0.0	52	100
Educational status										
Educated	75	91.5	6	7.3	1	1.2	0	0.0	82	100
Not educated	148	88.1	18	10.7	2	1.2	0	0.0	168	100
Access to extension										
Yes	89	90.8	9	9.2	0	0.0	0	0.0	98	100
No	134	88.2	15	9.9	3	2.0	0	0.0	152	100
FBO membership status										
Yes	118	90.8	12	9.2	0	0.0	0	0.0	130	100
No	105	87.5	12	10.0	3	2.5	0	0.0	120	100

Source: *Field survey (2018)*

<u>Preferences for more oil attribute of CGS disaggregated by farmers' characteristics</u>

Table 14 shows the degree of farmers' preferences for CGS with more oil attribute disaggregated by their characteristics. From the table, female groundnut farmers (96%) tend to place much importance to CGS with more oil content attribute more than males (85%). Proportionately, as 100% of farmers within the youthful age range 14 to 24 years highly prefer more oil attribute of CGS, 84% within the adult age range (25 to 64 years) highly prefer more oil attribute of CGS. Again, married groundnut farmers, educated farmers and farmers having access to agricultural extension services tend to like CGS with more oil content attribute more than their respective counterparts. The study noted that, equal number of groundnut farmers like CGS with more oil content attribute irrespective of their FBO membership status.

Table 14: Preferences for more Oil Content Attribute of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	106	84.8	17	13.6	2	1.6	0	0.0	125	100
Female	120	96.0	3	2.4	2	1.6	0	0.0	125	100
Age										
14-24	18	100	0	0.0	0	0.0	0	0.0	18	100
25-64	190	84.1	32	14.2	4	1.8	0	0.0	226	100
Marital status										
Married	192	96.0	3	2.0	3	2.0	0	0.0	198	100
Not married	44	84.6	7	13.5	1	1.9	0	0.0	52	100
Educational status										
Educated	71	86.6	8	9.8	3	3.7	0	0.0	82	100
Not educated	142	84.5	25	14.9	1	0.6	0	0.0	168	100
Access to extension										
Yes	85	86.7	12	12.2	1	1.0	0	0.0	98	100
No	128	84.2	21	13.8	3	2.0	0	0.0	152	100
FBO membership status										
Yes	111	85.4	17	13.1	2	1.5	0	0.0	130	100
No	102	85.0	16	13.3	2	1.7	0	0.0	120	100

Source: *Field survey (2018)*

4.4.4.2 Preferences for Packaging Materials Disaggregated by Farmers' Characteristics

The identified packaging materials of CGS include; plastic rubber bag, paper bag and jute sack. Farmers' preferences for each of these packaging materials was measured using Likert scale of the form 1, 2, 3, and 4 representing highly do not prefer, do not prefer, prefer, and highly prefer, arranged in ascending order of importance respectively. Farmers' degree of preference for each of these packaging materials was disaggregated by their characteristics and discussed in terms of percentages as follows.

Preferences for plastic rubber bag packaging material of CGS disaggregated by farmers' characteristics

Table 15 presents the degree of farmers' preferences for rubber bag as packaging material of CGS disaggregated by their characteristics. From the table, female groundnut farmers (44% out of 125 female farmers) prefer rubber bag as packaging material of CGS more than males (38% out of 125 male farmers) who do not prefer. The study noted that, groundnut farmers within youthful age range 14 to 24 years (44% out of 18 youthful farmers) prefer rubber bag as packaging material of CGS more than adult age 25 to 64 years who recorded 39% out of 226 adult farmers.

Table 15: Preferences for Rubber Bag as Packaging Material of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	22	17.6	43	34.4	47	37.6	13	10.4	125	100
Female	19	15.2	55	44.0	44	35.0	7	5.6	125	100
Age										
14-24	4	22.2	8	44.4	5	27.8	1	5.6	18	100
25-64	37	16.4	87	38.5	83	36.7	19	8.4	226	100
Marital status										
Married	29	14.7	79	39.9	72	36.4	18	9.1	198	100
Not married	12	23.1	19	37.5	19	35.5	2	3.9	52	100
Educational status										
Educated	15	18.3	26	31.7	35	42.7	6	7.3	82	100
Not educated	26	15.5	63	37.5	65	38.7	14	8.3	168	100
Access to extension										
Yes	19	19.4	7	7.1	33	33.7	39	39.8	98	100
No	22	14.5	59	38.8	58	38.2	13	8.5	152	100
FBO membership status										
Yes	22	16.9	50	38.5	49	37.7	9	6.9	130	100
No	19	15.8	48	40.0	42	35.0	11	9.2	120	100

Source: *Field survey, (2018)*

Also, the study found that, married groundnut farmers (40% out of 198 married farmers) prefer rubber bag as CGS packaging material more than unmarried (38% out of 52 unmarried farmers). The study indicated that, educated farmers (43% out of 82 educated farmers) do not prefer rubber bag as packaging material of CGS more than uneducated (39% out of 168 uneducated farmers). As 40% out of 98 groundnut farmers who accessed agricultural extension service highly do not prefer rubber bag as packaging material of CGS, 39% out of 153 farmers who did not accessed prefer. Again, groundnut farmers who were not members of FBO (40% out of 120) tend to prefer rubber bag as CGS packaging material more than members (39% out of 130).

Preferences for paper bag packaging material of CGS disaggregated by farmers' characteristics

Table 16 shows the degree of farmers' preferences for paper bag as packaging material of CGS disaggregated by their characteristics. The study noted that, female groundnut farmers (45% out of 125) do not prefer paper bag as CGS packaging material more than males (44% out of 120 male farmers). The study found that, groundnut farmers within youthful age range 14 to 24 years (50% out of 18 youthful farmers) do not prefer paper bag as packaging material of CGS more than adult age 25 to 64 years who recorded 43% out of 226 adult farmers.

Table 16: Preferences for Paper Bag as Packaging Material of CGS

Variables	***Highly prefer***		***Prefer***		***Do not prefer***		***Highly do not prefer***		***Total***	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Sex										
Male	8	6.4	16	12.8	55	44.0	46	36.8	120	100
Female	8	6.4	9	7.2	56	44.8	52	41.6	125	100
Age										
14-24	1	5.6	5	27.8	9	50.0	3	16.7	18	100
25-64	15	6.6	20	8.9	98	43.4	93	41.2	226	100
Marital status										
Married	14	7.1	18	9.1	84	42.4	82	41.4	198	100
Not married	2	3.9	7	13.5	27	51.9	16	30.8	52	100
Educational status										
Educated	4	4.9	14	17.1	38	46.3	26	31.7	82	100
Not educated	12	7.1	11	6.6	73	43.5	72	42.9	168	100
Access to extension										
Yes	3	3.1	11	11.2	49	50.0	35	35.7	98	100
No	13	8.6	14	9.2	62	40.8	63	41.5	152	100
FBO membership status										
Yes	3	2.3	10	7.7	71	54.6	46	35.4	130	100
No	13	10.0	15	12.5	40	33.3	52	43.3	120	100

Source: *Field survey, (2018)*

It can be seen that though all farmers have low preference for paper bag as packaging material of CGS, however, much higher percent of unmarried farmers (52% out of 52), educated farmers (46% out of 82), farmers having access to agricultural extension services (50% out of 98) and FBO members (55% out of 130) do not prefer that CGS should be packaged in paper bag more than their respective counterparts with contrasting features.

Preferences for jute sack packaging material of CGS disaggregated by farmers' characteristics

Table 17 presents the extent of farmers' preferences for jute sack as packaging material of CGS disaggregated by their characteristics. From the table, female groundnut farmers (92% out of 125) highly prefer that, CGS should be package in jute sack more than males (90% out of 125 male farmers). The study noted that, groundnut farmers within adult age range 25 to 64 years (92% out of 226) highly prefer that, CGS should be package in jute sack more than youthful age range 14 to 24 years (78% out of 18).

Table 17: Preferences for Jute Sack as Packaging Material of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Sex										
Male	113	90.4	6	4.8	4	3.2	2	1.6	125	100
Female	115	92.0	7	5.6	3	2.4	0	0.0	125	100
Age										
14-24	14	77.8	3	16.7	1	5.6	0	0.0	18	100
25-64	208	92.0	10	4.4	6	2.7	2	0.9	226	100
Marital status										
Married	184	92.9	9	4.6	3	1.5	2	1.0	198	100
Not married	44	84.6	4	7.7	4	7.7	0	0.0	52	100
Educational status										
Educated	75	91.5	4	4.9	2	2.4	1	1.2	82	100
Not educated	155	92.3	7	4.2	5	3.0	1	0.6	160	100
Access to extension										
Yes	90	91.8	6	6.1	2	2.0	0	0.0	98	100
No	141	92.8	5	3.3	4	2.6	2	1.3	152	100
FBO membership status										
Yes	116	89.2	8	6.2	6	4.6	0	0.0	130	100
No	112	93.3	5	4.2	1	0.8	2	1.7	120	100

Source: *Field survey, (2018)*

Table 17 above indicated that, married groundnut farmers (93% out 198) highly prefer jute sack as packaging material of CGS more than the unmarried who recorded 85% out of 52 unmarried farmers interviewed. The study noted that, equal percentage (92% each) of groundnut farmers highly prefer jute sack as packaging material of CGS irrespective of their educational and access to agricultural extension status. Again, non-members of FBO (93% out of 120 FBO non-members) highly prefer that, CGS should be package in jute sack more than groundnut farmers who belongs to FBO (89% out of 130 FBO members).

4.4.4.3 Preferences for Selling Outlet Disaggregated by Farmers' Characteristics

The selected selling outlets of CGS for this analysis include; open market, input shops, and distribution and marketing of CGS to farmers in their communities in groups. Farmers' preferences for each of these selling outlets was disaggregated by their characteristics and measured using Likert scale of the form 1, 2, 3, and 4 representing highly do not prefer, do not prefer, prefer, and highly prefer, arranged in ascending order of importance respectively. Farmers' degree of preferences to each selling outlet is discussed in terms of percentage of respondents as follows.

Preferences for open market selling outlet of CGS disaggregated by farmers' characteristics

Table 18 presents farmers' degree of preferences for open market as selling outlet of CGS disaggregated by their characteristics. From the table, male groundnut farmers (73% out of 125) highly prefer that, CGS should be marketed in the open market more than females (70% out of 125 female farmers). The study noted that, groundnut farmers within youthful age range 14 to 24 years (78% out of 18 youthful farmers) highly prefer that, CGS should be sold in open markets more than adult age range 25 to 64 years who recorded a percentage of 71% out of 226 adult farmers. From Table 18 below, it can be seen that though all farmers have high preference for open market selling outlet, much higher percentage of married farmers (74% out of 198), uneducated farmers (73% out of 82), farmers having access to agricultural extension services (73% out of 98) and FBO members (74% out of 130) highly prefer that, CGS should be sold in open markets more than their respective counterparts with contrasting features.

Table 18: Preferences for Open Market as Selling Outlet of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	91	72.8	25	20	8	6.4	1	0.8	125	100
Female	87	69.6	29	23.2	7	5.6	2	1.6	125	100
Age										
14-24	14	77.8	2	11.1	1	5.6	1	5.6	18	100
25-64	160	70.8	50	22.1	14	6.2	2	0.9	226	100
Marital status										
Married	147	74.2	41	20.7	8	4.0	2	1.0	198	100
Not married	31	59.6	13	25.0	7	13.5	1	1.9	52	100
Educational status										
Educated	56	68.3	17	20.7	8	9.8	1	1.2	82	100
Not educated	122	72.6	37	22.0	7	4.2	2	1.2	168	100
Access to extension										
Yes	71	72.5	19	19.4	7	7.1	1	1.0	98	100
No	107	70.4	35	23.0	8	5.3	2	1.3	152	100
FBO membership status										
Yes	96	73.9	22	16.9	10	7.7	2	1.5	130	100
No	82	68.3	32	26.7	5	4.2	1	0.8	120	100

Source: ***Field survey, (2018)***

Preferences for Agro-input shop selling outlet of CGS disaggregated by farmers' characteristics

Table 19 presents farmers' degree of preferences for input shop as selling outlet of CGS disaggregated by their characteristics. From the table, male groundnut farmers (93% out of 125 male farmers) highly prefer that, CGS should be marketed through input shops more than females (90% out of 125 females). The study noted that, groundnut farmers within youthful age range 14 to 24 years (94% out of 18 youthful farmers) highly prefer that, CGS should be sold through input shops more than adult age range 25 to 64 years who recorded a percentage of 91% out of 126 adult farmers.

Table 19: Preferences for Input Shop as selling outlet of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		*Total*	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Sex										
Male	116	92.8	6	4.8	2	1.6	1	0.8	125	100
Female	113	90.4	7	5.6	4	3.2	1	0.8	125	100
Age										
14-24	17	94.4	0	0.0	0	0.0	1	0.4	18	100
25-64	206	91.2	13	5.8	6	2.7	1	0.4	226	100
Marital status										
Married	181	91.4	10	5.1	6	3.0	1	0.5	198	100
Not married	48	92.3	3	5.8	0	0.0	1	1.9	52	100
Educational status										
Educated	77	93.9	3	3.7	1	1.2	1	1.2	82	100
Not educated	152	90.5	10	6.0.	5	3.0	1	0.6	168	100
Access to extension service										
Yes	90	91.8	6	6.1	1	1.0	1	1.0	98	100
No	139	91.5	7	4.6	5	3.3	1	0.7	152	100
FBO membership status										
Yes	119	91.5	7	5.4	3	2.3	1	0.8	130	100
No	110	91.7	6	5.0	3	2.5	1	0.8	120	100

Source: *Field survey, (2018)*

Also, higher proportion of unmarried groundnut farmers (92% out of 52) highly prefer that, CGS should be sold through input shops more than married who recorded a percentage of 91% out 198 married farmers. As depicted in Table 19, more groundnut farmers who were educated (94% out of 82 educated farmers) highly prefer that, CGS should be sold through input shops more than uneducated (91% out of 168 uneducated farmers). The study noted that, equal percentage (92% each) of groundnut farmers highly prefer that, CGS should be sold through input shops irrespective of their access to agricultural extension service and FBO membership status respectively.

Preferences for marketing and distribution of CGS to farmers in their communities in groups selling outlet of CGS disaggregated by farmers' characteristics

Table 20 presents farmers' degree of preferences that, CGS should be marketed and distributed to them in their communities in groups, disaggregated by their characteristics. From the table, higher proportion of male groundnut farmers (95% out of 125) highly prefer that, CGS should be marketed and distributed to them in their communities in groups more than females who recorded a percentage of 94% out 125 female farmers. The study also found that, all groundnut farmers within the youthful age range 14 to 24 years highly prefer that, CGS should be marketed and distributed to them in their communities in groups as compared to adult age range (25 to 64 years) which recorded 94% out of 226 adult farmers.

Table 20: Preferences for Community-based distribution and Marketing Selling outlet of CGS

Variables	*Highly prefer*		*Prefer*		*Do not prefer*		*Highly do not prefer*		Total	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sex										
Male	119	95.2	4	3.2	2	1.6	0	0.0	125	100
Female	118	94.4	7	5.6	0	0.0	0	0.0	125	100
Age										
14-24	18	100	0	0.0	0	0.0	0	0.0	18	100
25-64	213	94.3	11	4.9	2	0.9	0	0.0	226	100
Marital status										
Married	186	93.9	10	5.1	2	1.0	0	0.0	198	100
Not married	51	98.1	1	1.9	0	0.0	0	0.0	52	100
Educational status										
Educated	80	97.6	2	2.4	0	0.0	0	0.0	82	100
Not educated	157	93.5	9	5.4	2	1.2	0	0.0	168	100
Access to extension										
Yes	91	92.9	5	5.1	2	2.0	0	0.0	98	100
No	146	96.1	6	4.0	0	0.0	0	0.0	152	100
FBO membership status										
Yes	122	93.9	6	4.6	2	1.5	0	0.0	130	100
No	115	95.8	5	4.2	0	0.0	0	0.0	120	100

Source: *Field survey, (2018).*

It can be seen that though, all farmers have high preference that, CGS should be marketed and distributed to them in their communities in groups, much higher percentage of unmarried farmers (98% out of 52), educated farmers (98% out of 82), farmers without access to agricultural extension services (96% out of 152) and non-members of FBO (96% out of 120) highly prefer that, CGS should be marketed and distributed to them in their communities in groups more than their respective counterparts with contrasting features.

4.5 Determinants of CGS Usage and Use Intensity

Some groundnut farmers were found using CGS in small quantities in production. This propelled the researcher to analyse the factors that influence farmers' decision to use and their use intensity of CGS so as to enable the research make recommendations on the factors to look for in up-scaling farmers' usage. The intensity of use of CGS is express as the ratio of acres of land planted with CGS to total size of groundnut farm in acres. The double hurdle regression model was used to estimate the coefficient and direction of the determinants of CGS use intensity**.**

The significant Wald chi-square value of 108.87 indicates that the explanatory variables jointly influence the farmers' decision to use and use intensity of CGS (Table 21). Usage of CGS was determined by age, household size, educational status, farm size, access to credit, extension service, distance to input market, distance to output market, access to mobile phone, quantity of weedicide, access to transport, income from livestock other crops and form of sale. The use intensity of CGS was predicted by form of sale, distance to output market, distance to input market, extension service, price of certified groundnut seed and FBO membership status.

Age: The age of the respondents was significant at 1% and positively influences farmers' decision to use CGS. The result implies that increase in farmers' age increases their propensity to use CGS in the study area. The findings might be explained by the fact that although older farmers face higher search costs for information on new technologies which reduces their exposure, once they overcome the information barrier, older farmers are quick to adopt new technologies because they have higher resource endowment than young farmers. Age was also positively significant in the study by Ademiluyi (2014) and Lopes (2010) in adopting new technologies.

Table 21: Determinants of farmers' decision to use and use intensity of CGS: Cragg's double Hurdle regression model

Variables	First Hurdle		Second Hurdle	
	Coef.	*Std. Err.*	*Coef.*	*Std. Err.*
Age	0.011	0.004***	0.009	0.020
Sex	0.163	0.103	0.166	0.497
Marital status	0.080	0.110	-0.306	0.443
Household size	-0.026	0.011***	-0.016	0.054
Educational Status	0.265	0.097***	0.642	0.427
Farming experience	-0.005	0.005	0.027	0.024
FBO membership status	-0.202	0.219	2.756	0.567***
Access to mobile phone	-0.366	0.136***	0.712	0.535
Access to extension	0.166	0.100*	1.319	0.452***
Access to credit	0.551	0.193***	-0.706	0.628
Access to transport	-0.181	0.101**	-0.307	0.419
Farm Size	0.175	0.049***	0.118	0.297
Labour	-0.029	0.023	0.093	0.092
Quantity of weedicide	-0.094	0.033***	-0.130	0.132
Income from livestock and other crops	-0.003	0.001***	0.010	0.010
Price of groundnut Seeds	0.008	0.013	-0.115	0.042***
Distance to input market	-0.010	0.003***	0.035	0.010***
Distance to output market	-0.022	0.009***	0.109	0.038***
Access to market information	0.021	0.100	0.458	0.493
Form of sale	-0.561	0.079***	-0.876	0.344***
Constant	1.273	0.557**	-4.708	2.280**
1nsigma_con	1.058	0.071***		
Number of obs. = 250 Wald Chi2 (20) = 108.87 Pseudo R2 = 0.147 Log likelihood = 355.63 Prob.>Chi2 = 0.000				

Note: *** Significant at 1%, **Significant at 5%, *Significant at 10%
Source: *Field survey, (2018)*

Household size: This variable was significant at 1% and negatively influences farmers' decision to use CGS. The direction of the coefficient implies that households with large number of persons diminishes their probability to use CGS. This could be that; farmers with larger households' size allocate much of their households' income on consumption which reduces their capacity to buy and use CGS. This result is consistent with Awotide *et al.* (2014), Kuti (2015), and Jaleta *et al.* (2013) who also reported a negative and significant relationship between household size and adoption of improved rice varieties in Nigeria and Ethiopia respectively. Contrary, Legese *et al.* (2009), and Kassie *et al.* (2010) found out that household size and adoption of improved technologies were inversely related.

Educational Status: The educational status of the respondents was significant at 1% and positively affects farmers' decision to use CGS. The sign of the coefficient implies that farmers with educational access are more likely to use CGS than the uneducated. This is because, education makes farmers more receptive to extension agents' advice or enhances their ability to deal with technical recommendations that require a certain level of numeracy or literacy. The more complex the technology to be adopted, the higher the likelihood that education will be needed for the adoption. This result is consistent with earlier literature (Langyintuo and Mungoma, 2008; Kassie *et al.*, 2010; Asfaw *et al.*, 2012, and Ebojei *et al.*, 2013).

***FBO membership status*:** Farmer-Based Organization was significant at 1% and positively influences the use intensity of CGS in the study area. The sign of the coefficient indicates that, farmers who are members of FBO are likely to increase their use intensity of CGS by 276% more than FBO non-members. This is because farmers within FBO group share ideas on newly improved technologies during their meetings thereby increasing their likelihood to use them. This result conforms to the findings of Ouma *et al.* (2014); Tura *et al.* (2010); and Akinbole and Barime (2015).

Access to mobile phone: Contrary to a prior expectation, access to mobile phone was significant at 1% and negatively influences farmers' decision to use CGS in the study area. The result shows that farmers with mobile phone access are less likely to use CGS than those without.

Access to extension: As expected, access to extension service was significant at 10% and 1% whiles positively influences farmers' decision to use and the use intensity of CGS respectively. The results in the first hurdle implies that farmers who have access to extension service are more likely to adopt CGS than their counterparts. However, in the second hurdle, farmers with extension access are more likely to increase their use intensity of CGS by 132% than those without. This is because farmers who have contact with extension agents are introduced to new technologies which increases their likelihood of usage. This results confirms the study by Ebojei *et al.* (2013), Ouma *et al.* (2014), and Idrisa *et al.* (2012) where access to extension service was also found to positively influence farmers' decision to adopt new technologies.

Access to credit: As expected, farmers' access to credit was significant at 1% and positively influences the decision of farmers to use CGS. The sign of the coefficient shows that farmers who have access to credit are more likely to use CGS than their counterparts without credit access. This is because farmers who borrow money from the lending institution overcomes cash constraint which enables them access new technologies. This result conforms to Lavison (2013), and Anik and Salam (2015) where access to credit was also found to positively influence farmers' adoption decision for improved technologies.

Access to transport: Access to transport was significant at 5% and negatively affects farmers' decision to use CGS in the study area. The results denote that farmers with transport access are less likely to use CGS than their counterparts. In the other way, farmers without access to transport are more likely to use CGS than those with access. This result is contrary to a prior expectation of this study. But this could be that, seed companies have inadequate farm lands for seed production and usually contract farmers in the remote areas where there is much farm lands to dedicate portions of their lands for seed production. These remote areas have poor transport systems but since these farmers get exposure to CGS during the contract production, increases their likelihood to adopt and use it. In addition, developmental projects access certified foundation seeds from the formal system and pass them to farmer groups based locally (Etwire *et al.*, 2013). These farmers have possession of certified seeds and using them without traveling to access them in the market.

Farm Size: Farm size of respondents was significant at 1% and positively influences the decision of farmers to use CGS. The result indicates that farmers with large farm size are more likely to use CGS than their counterparts with small farm size. This is because large farm size is a good proxy for wealth. Larger-scale farmers will be more likely to adopt a technology, especially if the innovation requires an extra cash investment. The finding of this study is consistent with Awotide *et al.* (2014) who also observed a positive and significant relationship between farm size and use intensity of improved rice varieties in Nigeria. Kasirye (2013) noted that farmers with small farm sizes may be credit constrained, and such resource poor farmers may not be able to purchase key inputs.

Quantity of weedicide: As expected, quantity of weedicide used on groundnut farm was significant at 1% and negatively influences farmers' decision to use CGS. This means that, the use of CGS in production reduces the quantity of weedicide usage. This could be that, CGS has the ability to tolerate weeds in production reducing the quantity of weedicides farmers use for farm management. Contrary, Fadare *et al.*

(2014) found a positive relationship between quantity of herbicides usage and adoption of improved maize varieties among farmers in Nigeria.

***Income from livestock and other crops*:** Incomes obtained from sales of livestock and other crops was significant at 1% and showed a negative relationship with usage decision of CGS. The results imply that farmers with high income from livestock and other crops sale are less likely to adopt CGS in the study area. This result is contrary to a prior expectation of this study.

Price of groundnut Seed: As expected, the price of CGS was significant at 1% and negatively influences the use intensity of CGS. This result implies that, an increase in price of CGS reduces the use intensity of CGS of farmers by 12%. This means that, the higher the seed cost, the less likely farmers will access and use it. Kalinda *et al.* (2013) also found similar result in their study where high cost of technology was hindrance to the adoption of improved agricultural technology.

Distance to input market: The distance of farmers' residence to input market was significant at 1% and exhibited a negative and positive relationship with farmers' decision to use and use intensity of CGS respectively. The sign of the coefficient in the first hurdle implies that farmers whose residence are far from input market are more likely to use CGS than their counterparts who are closer. However, in the second hurdle, farmers whose residence are far from input market are likely to increase CGS use intensity by 1% more than their counterparts. The finding of Wiredu *et al.* (2014) conforms to this result. The researchers found a negative relationship between access to input shop and farmers' decision to adopt certified maize varieties in northern Ghana. Contrary, Munnion *et al.* (2010) also established a positive association between distance to seed source and farmers' decision to adopt improved maize varieties.

Distance to output market: The distance of farmers' residence to output market was significant at 1% and exhibited a negative and positive relationship with farmers' decision to use and use intensity of CGS respectively. The sign of the coefficient in the first hurdle implies that, farmers whose residence are far from output market are more likely to use CGS than their counterparts. However, in the second hurdle, farmers whose residence are far from output market are likely to increase CGS use intensity by 2% more than their counterparts who are closer. Ghimire *et al*. (2015) and Namwanta *et al.* (2010) also found similar result in their study.

Form of sale: The form in which groundnut produce was sold was significant at 1% and negatively influences farmers' decision to use and use intensity of CGS respectively. This result implies that farmers who sold their groundnut in shelled form are more likely to use CGS than those who sold theirs in unshelled form. However, in the second hurdle, farmers who sold their groundnut in shelled form are likely to increase CGS use intensity by 87% more than their counterparts. Farmers obtain low income from their produce when sold unshelled and this constrain them financially to buy and increase CGS use intensity.

4.6 Constraints in Certified Groundnut Seed Production

The study identified the various constraints in certified groundnut seed production. These identified constraints were measured using percentage of respondents and presented in figures and in tables. The actors involved in certified groundnut seed production include; seed companies, breeder/foundation seed producers and smallholder groundnut producers. The production constraints peculiar to each of these actors are discussed in paragraphs below.

Constraints facing seed companies in CGS production

Figure 12 present the identified constraints faced by seed companies in seed production. These constraints identified during the field survey include; high price of foundation seeds, inadequate capacity building services, poor visits of field inspectors, late release of foundation seeds, poor weather condition and no government subsidy for groundnut. However, lack of government subsidy on certified groundnut was ranked as first most challenging constraint faced by seed companies in CGS production. All (100%) seed companies think that, there should be a subsidy policy for groundnut. High price of foundation seed was ranked as second most pressing constraint by 90% of the seed companies. The seed companies think that low price of foundation seeds would encourage them buy more to increase their production to meet market demand.

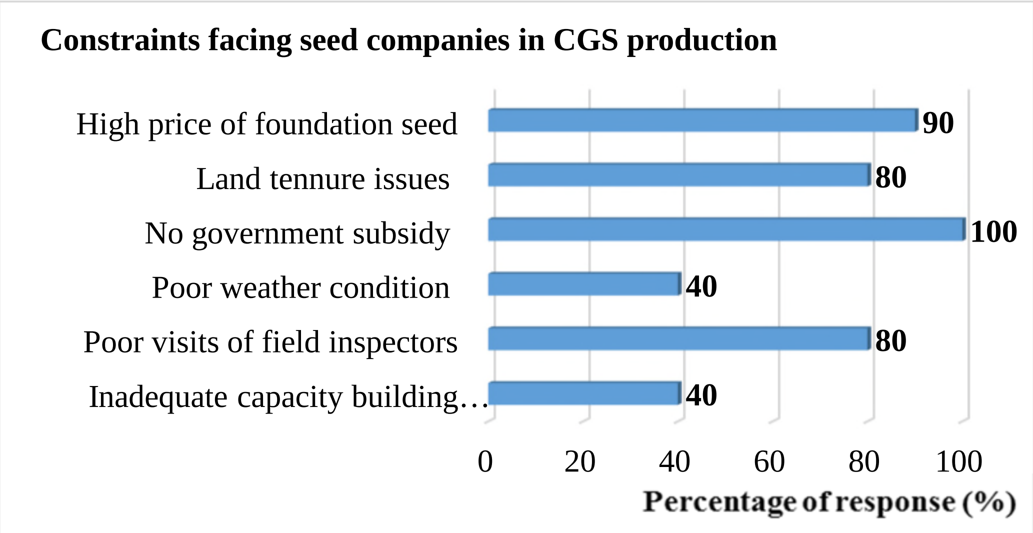

Figure 12: Percentage of response to constraints facing seed companies in CGS production
Source: ***Field survey (2018)***

About 80% of seed companies ranked land tenure issues and poor field inspectorate division service as fourth most challenging constraints faced in production respectively. On land tenure issues, seed companies have little access to farm land hindering large scale production of CGS. Through an out-grower scheme, farmers could be contracted by seed companies to dedicate portions of their farm lands for CGS production. The seed companies asserted that, there are inadequate field inspecting officers in the system so the few available do not frequently visit and supervise seed production activities as expected. About 40% of the seed companies ranked poor weather and inadequate capacity building as the least challenging constraints in production. The seed companies think that, seminars and demonstration site should be organised to train them on how to produce good and quality seeds.

Constraints in breeding and foundation seed production

A breeder/foundation seed producer was also interviewed to find the constraints faced in production. These constraints identified in seed breeding and production of foundation seeds were stated and grouped under: institutional / human resource, marketing / financial, infrastructural and social constraints as shown in Table 22 below.

Table 22: Institutional / human resource, Marketing/financial, Infrastructural and social constraints in breeding and foundation seed production.

Institutional / human resource constraints	Marketing/financial constraints	Infrastructural constraints	Social constraints
Poor technical know-how of other partner institutions such as; GSID and seed companies	High cost of seed breeding	Inadequate farm lands for large scale certified groundnut seed production	Inadequate labour in the surrounding communities
Poor partnership of other actors with the research institution to produce large quantities and quality seeds	There is no funding support to embark on irrigational seed production during the lean season to increase seed quantity	There are no enough laboratory equipment for certified groundnut seed breeding	Lack of gender sensitivity in the breeding process of certified groundnut seed
MoFA is under staffed with few extension agents to disseminate	Lack of budget allocation for certified groundnut seed production	There are inadequate farm machineries for field works and	Majority of rural farmers find it difficult to access the

information on new seed varieties developed for farmers	which increases cost of production	for transporting harvested certified seeds to the research institution	little quantity of certified groundnut seed produced due to poor transport means
Poor visit of certified seed field inspectors on the farm for field certification	High cost of labour in the surrounding communities	There are no enough storage facilities to preserve certified seeds in good quality	
The GLDB has low capacity to absorb all the breeder seeds produced	The demand for breeder groundnut seed is unpredictable		

Source: ***Field survey (2018)***

<u>Constraints facing smallholder farmers in groundnut production</u>

Smallholder groundnut farmers were also interviewed to state constraints facing them in groundnut production. The constraints identified include; inadequate storage and drying facilities, weeds invasion, poor yield, poor soil fertility, poor germination rate, inadequate labour, poor weather condition, inadequate tractor services and lack of credit. The identified constraints were measured using percentage of respondents and presented in Figure 13 below. From the figure, majority (95%) of smallholder farmers ranked poor yield as first most challenging constraint in production. These proportion of farmers think that, high yielding groundnut varieties should be produced and made accessible for them to buy more to increase yield.

About, 92% and 89% of the smallholder farmers ranked pest and disease invasion and poor germination rate of seeds, as the second and third most pressing constraints in groundnut production respectively. On diseases, Aflatoxin was observed to severely affect groundnut on the field and after harvest leading to large post-harvest losses in production. Farmers think that groundnut breeders should produce potential varieties which can mitigate Aflatoxin infections. Mitigation of Aflatoxin and other diseases infection would improve germination rate of groundnut seeds in production

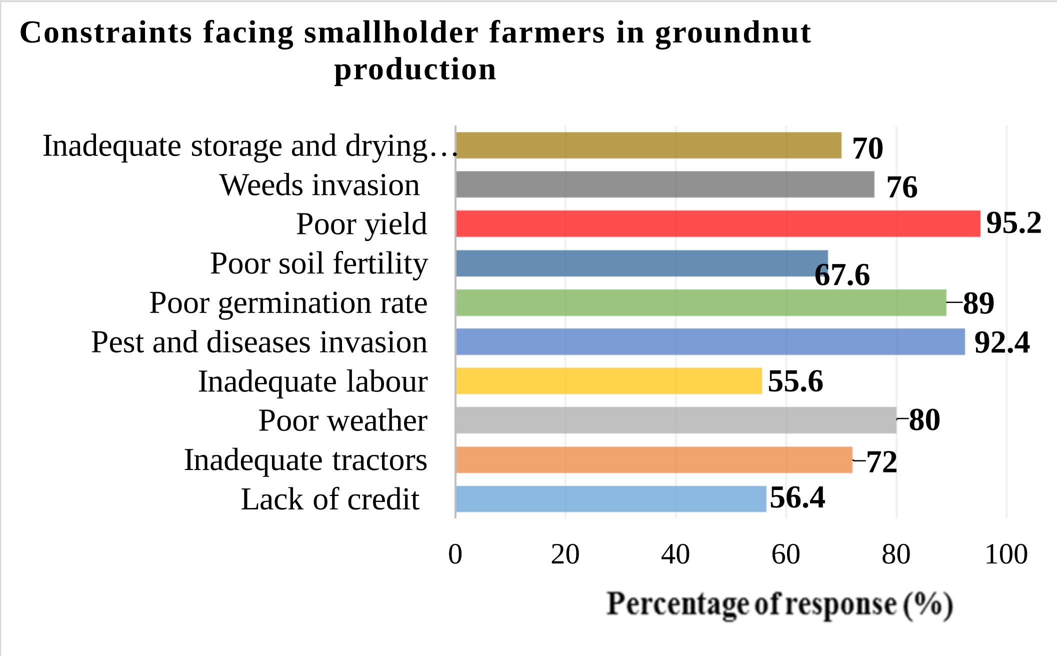

Figure 13: Percentage of response to constraints facing smallholder farmers in groundnut production
Source: ***Field survey (2018)***

Figure 13 also shows that, about 80% and 76% of smallholder farmers ranked poor weather and weeds invasion as the fourth and fifth most pressing constraints in production respectively. Inadequate storage and drying facilities, and high cost of labour were the sixth and seventh most pressing constraints currently faced by farmers in groundnut production. Smallholder groundnut farmers think that, their inability to maintain seed quality is due to inadequate of improved storage and drying facilities. Direct floor drying and storing groundnut on floor of rooms were the practices of groundnut farmers in preserving groundnut which make seeds extremely susceptible to diseases infestation. Poor extension services and inadequate credit access were also ranked by 57% and 56% of farmers as the eighth and ninth most pressing constraints in production. The farmers think that, presence of extension service would increase their knowledge of improved technologies and access to financial credit would enable them patronise. Lastly, about 49% of smallholder farmers ranked inadequate tractor services as the least pressing constraint in groundnut production.

4.7 Constraints in Marketing and Distribution of CGS

The input dealers were interviewed to solicit the constraints in marketing and distribution of certified groundnut. Currently, constraints facing input dealers in seed marketing and distribution include; poor road networks, high price of CGS, late released of certified seed from the seed companies, low demand and inadequate storage facilities. These constraints were measured using percentage of respondents and presented in Figure 14. From figure, majority (90%) of input dealers ranked poor road network and high price of CGS as first most pressing constraints in marketing and distribution of CGS respectively. On poor network, input dealers think that, the government should improve road networks to rural areas to encourage them increase input delivery to farmers. The input dealers also think that, price of CGS should be reduce to enable them demand more from seed companies so that farmers can buy more from them.

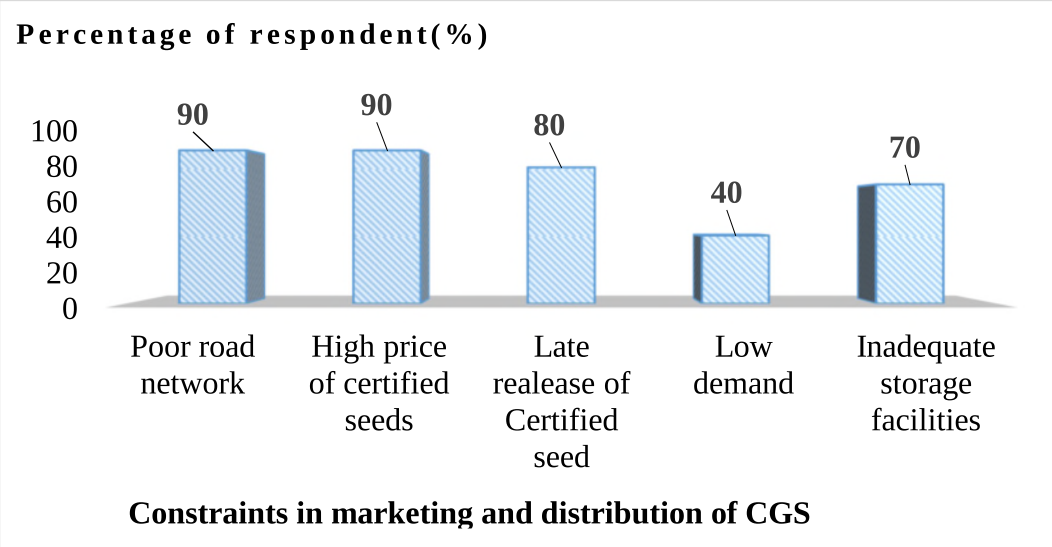

Figure 14: Percentage of response of input dealers to constraints in marketing and distribution of CGS
Source*: Field survey (2018)*.

About, 80% and 70% of input dealers ranked late release of certified seed by seed companies and inadequate storage facilities as second and third most challenging constraints in marketing of CGS respectively. The input dealers reason that, certified groundnut seeds are usually not available and accessible on the market at the right time the farmers need them. This could be attributed to late release of certification result of seeds to seed company by the seed inspector directorate division to guarantee them sell their seeds to input dealers timely. On inadequate storage facilities, the input dealers propose that government support in the form of providing improved storages would help them preserve adequate seeds in good quality for farmers. The last most pressing constraint in marketing and distribution of CGS was low demand, as 40% of the input dealers think. This percentage of input dealers think that, most seed companies also directly market and distribute seeds to farmers reducing the number of customers who buy seeds from them. They proposed that each actor's role in the industry should be well defined and strictly followed along the value chain through effective seed systems.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter entails the summary, conclusions and recommendations of this study. The summary of key findings and conclusions of results are presented in sections 5.2 and 5.3 respectively. The chapter also presents policy recommendations and limitations of the study in section 5.4 and 5.5 respectively. The last section (5.6) presents suggestions for future research.

5.2 Summary of Key Findings

Groundnut production is a major economic activity of smallholder farmers in Northern Ghana. However, these farmers face production losses through Aflatoxin infestation and bad weather conditions which requires immediate intervention. The appropriate measure which would mitigate these losses in production is the use of right planting materials by farmers. Meanwhile, CGS production and use is still at the infantile stage as compared to maize and rice. Therefore, this study seeks to examine farmers' preferences and use of CGS in Northern Ghana. The study identified the incentives or disincentives for commercial production of CGS. It also assessed smallholder groundnut farmers' preferences for seed in relation to: seed attributes, selling outlets and packaging. The study estimated CGS use intensity and its determining factors. The study concluded by identifying constraints facing CGS production and marketing in the study area.

The identified incentives for commercial production of CGS includes; high demand, high profit, availability of contracts and support from NGOs and projects. The identified factors that serve as disincentive for commercial production of CGS include; poor field inspections, no government support and untimely delivery of CGS among the actors.

The study shows that majority of farmers highly preferred CGS with the following attributes; high-yielding, early maturity date, good germination rate, tolerant to drought, resistant to pest and disease and uniform plant growth, among others. High-yielding and big nut attributes were most preferred CGS attributes among farmers. Jute sack was the most preferred packaging material of CGS among others farmers. Distribution of CGS to farmers in their communities was the most preferred selling outlet among farmers.

Again, it was noted that, whiles age, educational status, extension service, credit access and farm size positively influenced farmers' decision to use CGS, household size, access to mobile, input distance, output distance, form of sale, quantity of weedicide used, transport access, and income from livestock and other crops affected farmers' decision to use CGS negatively. Also, whiles extension service and price of CGS positively influenced use intensity of CGS, FBO membership, output distance, input distance and form of sale also affected use intensity of CGS negatively in production.

The study identified constraints that face seed companies in commercial production of CGS. These constraints include; high price of foundation seeds, inadequate capacity building services, poor visits of field inspectors, late release of foundation seeds, poor weather condition and no government subsidy for groundnut. However, no government subsidy for groundnut was ranked as first most pressing constraint faced by seed companies in production.

The constraints facing the breeder/foundation seed producing institution in commercial production of CGG includes; land tenure issues, poor partnership with other actors, inadequate and high cost of labour, high cost of breeding, inadequate storage facilities, low demand, poor field inspection, lack of gender sensitivity in breeding process, lack of government funding for; irrigational seed production, transportation, purchase of machineries and enough laboratory equipment for seed breeding.

The study identified constraints facing smallholder farmers in groundnut production include; lack of storage and drying facilities, weeds invasion, poor yield, poor soil fertility, poor germination rate, inadequate labour, poor weather condition, inadequate tractor services and lack of credit. However, poor yield was ranked as first most pressing constraint faced by smallholder farmers in production.

Besides this, the study identified constraints that face the marketing and distribution of CGS. The identified constraints include; poor road networks, high price of CGS, late released of certified seed from the seed companies and inadequate storage facilities. However, poor road network was ranked as first most pressing constraint faced by firms in marketing and distribution of CGS.

5.3 Conclusions

Groundnut farmers think that, improved CGS varieties with these attributes should be produced, packaged in jute sack, and marketed and distributed to them in their communities. They think, this will enable them to buy more and use to reduce production losses through Aflatoxin infestation and bad weather conditions.

Again, factors that significantly affect farmers' decision to use CGS include; age of farmers, farm size, quantity of weedicide used, transport access, input distance, output distance, access to extension service, credit access and FBO membership status. The factors that predict farmers' use intensity of CGS include; access to extension service, price of CGS, FBO membership, output distance and input distance.

Currently, the constraints facing CGS production include; no government subsidy for groundnut, inadequate production due to few producers, land tenure issues, poor field inspection and poor partnership between the various actors along the value chain. The constraints facing smallholder groundnut farmers in production includes; poor yield, pest and disease infestation, poor germination, weed invasions, poor weather, and lack of storage and drying facilities. At the moment, constraints facing the marketing and distribution of CGS include; poor road networks, inadequate storage facilities and few selling outlets in the study area.

5.4 Policy Recommendations

The study recommends that, the government should implement subsidy policy on groundnut as done for other crops such as; maize, soybean and rice. Government support in this form would incentivise domestic CGS producers to commercialise in CGS production to meet farmers' demand. Groundnut seed breeders should take note of qualities of CGS preferred by farmers and produce foundation seed to meet their preferences.

It is also recommended that the government should improve road networks to farming communities to incentivise input dealers establish input outlets in rural areas to increase accessibility and farmers' usage rate of CGS in production.

Again, the study recommends that, the Ministry of Food and Agriculture should increase farmers' knowledge of CGS through their extension agents. The extension agents should form farmer-based organisation to help input dealers market and distribute CGS to farmers through Seed Brokerage System (SBS). SBS can facilitate bulk purchase by farmers in groups thereby ensuring timely acquisition and delivery of seeds to farmers in their communities.

Lastly, the study recommends that seed companies should adopt out-grower schemes to increase production of adequate CGS to farmers. Out-grower scheme is a system whereby farmers are contracted to dedicate portions of their farm lands for seed production. Seed companies provides seed to farmers on credit and buys all the produce after harvest excluding the credit amount.

5.5 Limitations and Suggestions for Future Research

This study was conducted based on the assumption that the sampled groundnut seed value chain actors were a fair representation of all the other actors due to the fact that they are homogenous in characteristics either in cultural or socio-economic. This assumption might not be true for the rest of the actors. Also, majority of the respondents interviewed do not keep production records and only tried to remember information from their memories. The assumption that they remembered and gave accurate information is not entirely true. There was language barrier between the respondents and the researcher which propelled him to involve interpreters during the data collection. This study suggests that future researchers should look at comparative analysis of profitability and profit efficiency of CGS and conventional groundnut production in Northern Ghana. This will help future research to conduct a benefit-cost ratio analysis to statistically justify the economic feasibility of CGS production on the producers and suppliers side.

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APPENDIX 1

University for Development Studies
Faculty of Agribusiness and Communication Sciences
Department of Agricultural and Resource Economics

SAMPLE QUESTIONNAIRE

Title: Economic Feasibility of Commercial Production of Certified Groundnut Seed in Northern Ghana

My name is…………………………This questionnaire is meant for data collection to address the above topic in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Agricultural Economics. Your response to the questions would help the researcher get appropriate findings that will contribute to knowledge in the academia. Your confidentiality is assured.

Reference Information

Serial number: .... ……… Date of interview: ....

Community/Place of resident: .... Region ……………………………

A. SAMPLE QUESTIONNAIREGROUNDNUT FARMERS

1. ***Respondent's demographic characteristics***

1.1 Age of respondent (number)	…………..
1.2 Sex of respondent	(1) Male [ ] (2) Female [ ]
1.3 Marital status of respondent	(1) Single/unmarried [ ] (2) Married [ ] (3) Widow or widower [ ] (4) Divorced/Separated [ ]
1.4 Household size (number)	……………….
1.5 Household composition by sex	(1) Number of males: ………. (2) Number of females: …………..
1.6 Tick the highest level of education you completed	(1) No education [ ] (2) Non-formal/only Islamic education [ ] (3) Primary school [ ] (4) Middle school/JSS/JHS [ ] (5) Voc/Sec. Tech/SSS/SHS [ ] (6) Teacher/Nursing Colleges [ ] (7) Polytechnic/University [ ]
1.7 Number of years of schooling by respondent	…………………..

2. ***Household's Land ownership and others***

2.1. What is the ownership status of your groundnut farm land? 1. Owned [ ] 2. Leased/rent [ ] 3. Family/Communal land [ ]

2.2. If rented in Q 2.1, how much did you pay for an acre groundnut of land cultivated? GH¢…..

2.3. What is the distance from your residence to the input market? Km……………….

2.4. Fill the table below

Other crops	Farm size (acres)	Land ownership (1= Owned, 2=leased/rent and 3=family/ communal owned)	If rented, cost of rent (Gh¢)

2.5 Household income from the following animals in 2017

Animals	Goats	Sheep	Pigs	Cattle	Donkey	Horse	Domestic fowl	Guinea fowl	Ducks	Turkey
Number of animals sold in 2015 sold										
Unit price (Ghc)										
Total value (Ghc)										

2.5. Fill in the table below by indicating the quantity of crop produced in 2017 by the entire household.
2.6. Indicate their respective unit prices for 2017.

Crop produce	Maize	Soya bean	Rice	Millet	Groundnuts	Sorghum	Beans	Cassava	Yam	Sweet potato
Farm size										
Unit of measurement										
Quantity										
Average price (Ghc)										
Total value (Ghc)										

3. *Private Asset Variables and Public Assets/ Social Capital Variables*

3.1. Do you belong to any farmer based organization? 1. Yes [ ] 2. No [ ]
3.2. How many times have you met in 2017 farming to discuss on groundnut production or marketing? …………………………………
3.3. Do you have access to mobile phone? 1. Yes [ ] 2. No [ ]
3.4. Have you had an extension contact in the 2017 farming season? 1. Yes [ ] 2. No [ ]
3.5. If yes to Q 3.4, kindly indicate the number of visits you received in the 2017 farming season? …………………………………..
3.6. Have you received credit from any financial institution for groundnut farming? 1. Yes [ ] 2. No [ ]
3.7. How much did you received GH¢……………………………
3.8. How much did you use for groundnut farming? GH¢……………………………

4. *Farm Size, Farming Experience and groundnut cultivation decision*

4.1. How many years have you been farming? ....
4.2. How many years have you been engaged in groundnut production? …………..
4.3. How many acreages of your farm land have you allocate for groundnut production in the 2017 farming season? …………………….
4.4. Size of farm planted with certified groundnut seed in 2017……………..acres
4.5. Size of farm planted with uncertified (local) groundnut seed in 2017……………..acres
4.6. Tick from the below, the reasons why you cultivate groundnut?(Multiple response)
1. Consumption [ ]
2. Good market price [ ]
3. To fix nutrient into my farm land [ ]
4. Forage to feed my animals [ ]
5. Specify others…………………………………………………………………

5. Incentives and disincentives for certified and local groundnut seeds use

5.1. From what source did you access your groundnut seeds for the 2017 production season? (Tick as many as applicable) 1. Farmer to farmer exchange [ ] 2. From previous harvest [ ] 3. From informal grain market [ ] 4. From formal grain market [ ]

5.2. Have you ever heard about certified groundnut seeds before? 1. Yes [ ] 2. No [ ]

5.3. Where do you often get/ hear information about new certified groundnut seed varieties? Tick as many as applicable. 1. Mass media (radio, Tv, newspapers) [ ] 2. Agric. Extension agents [ ] 3. Output aggregators [ ] 4. Input dealers [ ] 5. FBOs [ ] 6. NGOs [ ] 7. Other farmers [ ]

5.4. Did you use certified groundnut seeds in 2016 farming season? 1. Yes [ ] 2. No [ ]

5.5. If yes to question 5.4, fill the table below.

	Units	**Amount**
Farm size planted with certified groundnut seed		
Quantity of certified groundnut seed used		
Unit price	Gh¢	
Total cost	Gh¢	

5.6. Did you use uncertified (local) groundnut seeds in 2017 farming season? 1. Yes [ ] 2. No [ ]

5.7. If yes to question 5.6, fill the table below.

	Units:	Amount
Farm size planted with uncertified (local) groundnut seed		
Quantity of uncertified (local) groundnut seed used		
Unit price	Gh¢	
Total cost	Gh¢	

5.8. Tick the incentives (reasons) for using certified groundnut seed

Incentives (reasons) for using certified groundnut seed	**Disincentives (reasons) for not using or not fully using certified groundnut seed**
Good germination rate [ ]	Poor germination rate [ ]
Because of government subsidy on certified groundnut seeds [ ]	High price of certified groundnut seeds [ ]
Can be stored for long [ ]	Easily perishable when stored [ ]
Availability of certified groundnut seeds [ ]	Unavailability of certified groundnut seeds [ ]
Easy to access [ ]	Difficulty to access [ ]
Understand how to use it [ ]	Low understanding (complexity) how to use it [ ]
High resistant to pest and diseases [ ]	High susceptible to pest and diseases [ ]
High yielding of certified groundnut seeds [ ]	Low yielding of certified groundnut seeds [ ]
Aware of the benefits of certified groundnut seeds [ ]	Lack of awareness of the benefits of certified groundnut seeds [ ]
Certain about the returns or the yield [ ]	Fear of crop failure (Lack of trust) [ ]
Land is infertile and I need to use certified groundnut seeds [ ]	Land is fertile and there is no need for using certified groundnut seeds [ ]
High return on the use of certified groundnut seeds [ ]	High cost of maintaining farms planted with certified groundnut seeds [ ]
Quality output [ ]	Low output quality [ ]
Draught resistance [ ]	Low draught resistance [ ]
Higher market value of produce (higher income) [ ]	Low market value of produce (higher income) [ ]
Short maturity duration [ ]	Long maturity duration [ ]

5.9. From your own perspective to what extent has certified groundnut seeds contributed to your productivity level? 1. Extremely high [ ] 2. High [ ] 3. Moderate [ ] 4. Reduced [ ]

5.10. Fill in the table below

How has the use of certified groundnut seeds affected the following	**Highly reduced (-2)**	**Reduced (-1)**	**No change (0)**	**Increased (1)**	**Highly increased (2)**
Groundnut yield					
Quality of nut					
Germination of groundnut seeds					
Pest and diseases resistance					

6. *Preferences for certified and local groundnut seeds use*

6.1 How satisfied are you with the current status of certified groundnut seeds on the market?
1. Highly satisfied [ ] 2. Satisfied [ ] 3. Not satisfied [ ] 4. Highly dissatisfied [ ]

6.2 To what extent does the following factors in the table below affect your decision for certified groundnut seeds in your production?

Factors	**Highly affect (3)**	**Moderately affect (2)**	**Lowly affect (1)**	**Do not affect at all (0)**
Cost price of seed				
Size of pod				
Size of nut				
Quality of nut				
Early maturity				
Yield				
Market value of produce				
Packaging				
Availability				
Germination rate				
Pest and diseases resistivity				
Drought resistivity				

6.3 What are your preference attributes of certified groundnut seeds?

Attributes of produced certified seed should	**Highly prefer (4)**	**Prefer (3)**	**Do not prefer (2)**	**Highly do not prefer (1)**
Have big pod				
Have big nut				
Have nut with more oil				
Have reddish nut				
Have brownish nut				
Have short maturity duration				
Have good germination rate				

Not contained impurities or other unwanted variety of seeds				
Be high yielding				
Be resistant to drought				
Be resistant to pest and diseases				
Have uniform plant growth				

6.4. What are your preferences for packaging and selling outlets of certified groundnut seeds?

Attributes of produced certified seed should	**Highly prefer (4)**	**Prefer (3)**	**Do not prefer (2)**	**Highly do not prefer (1)**
Be packaged in plastic rubber bags				
Be packaged in paper bags				
Be packaged in jute bags				
Be sold in the open market				
Be sold in input selling shops				
Be sold at research institutions				
Be sold at the MoFA office				
Be sold at district capitals				
Be sold in regional capitals				
Be sold and distributed to farmers at their homes or communities				

7. ***Transaction Cost Variables***

7.4. Do you have access to vehicle to convey produce to market? 1. Yes [ ] 2. No [ ]

7.5. What is the distance from your residence to the nearest output market? Km …………..

7.6. Do you have access to market information? 1. Yes [ ] 2. No [ ]

7.7. Where is the point of sale of your groundnut output? 1. Market [ ] 2. Home [ ] 3. farm-gate [ ]

7.8. What is the form of sale of your groundnut: 1. Unshelled [ ] 2. Shelled [ ]

7.9. Quantity and cost of variable inputs (seed, fertilizer, weedicides and pesticides)

Inputs	**Seed**		**Weedicides**		**Fertilizer**		**Pesticides**	
Type of farm	Certified groundnut farm	Local groundnut farm	Certified groundnut farm	Local groundnut farm	Certified groundnut farm	Local groundnut farm	Certified groundnut farm	Local groundnut farm
Units								
Quantity								
Unit price (Gh¢)								
Total cost								

7.10. Quantity and cost of fixed inputs

Inputs	**Cutlass**		**Big hoe**		**Small hoe**		**Pan/Basket**		**Knapsack**		**Sack**	
Type of farm	Certified G'nut farm	Local G'nut farm	Certified G'nut farm	Local G'nut farm	Certified G'nut farm	Local G'nut farm	Certified G'nut farm	Local G'nut farm	Certified G'nut farm	Local G'nut farm	Certified G'nut farm	Local G'nut farm
Useful life												
Quantity												
Unit price (Gh¢)												
Total cost												

7.11. Quantity and cost of hired labour on certified groundnut seed farm

Farming activities	**No. of adult hired labourers**		**Number of days worked**		**Average number of hours worked per day**		**Wage per person per day (Gh¢)**		**Total mandays (*one manday is 8hrs)***	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Clearing the land/Spraying the field										
Ploughing/tilling the land										
Planting										
Weeding/Spraying										
Fertilizer application										
Harvesting										
Shelling and drying										

'.12. Quantity and cost of hired labour on local groundnut seed farm

Farming activities	No. of adult hired labourers		Number of days worked		Average number of hours worked per day		Wage per person per day (Gh¢)		Total mandays **(*one manday is 8hrs)***	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Clearing the land/Spraying the field										
Ploughing/tilling the land										
Planting										
Weeding/Spraying										
Fertilizer application										
Harvesting										
Shelling and drying										

'.10. Quantity and cost of family labour on certified groundnut seed farm

Farming activities	No. of adult family labourers		Number of days worked		Average number of hours worked per day		Wage per person per day if were to be paid (Gh¢)		Total mandays **(*one manday is 8hrs)***	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Clearing the land/Spraying the field										
Ploughing/tilling the land										
Planting										
Weeding/Spraying										
First fertilizer application										
Second fertilizer application										

Harvesting										
Shelling and drying										

7.12. Quantity and cost of family labour on local groundnut seed farm

Farming activities	No. of adult family labourers		Number of days worked		Average number of hours worked per day		Wage per person per day if were to be paid (Gh¢)		Total mandays ***(one manday is 8hrs)***	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Clearing the land/Spraying the field										
Ploughing/tilling the land										
Planting										
Weeding/Spraying										
First fertilizer application										
Second fertilizer application										
Harvesting										
Shelling and drying										

'.13. Cost of machinery operations and animal traction for groundnut production in 2017 farming season

Activities	***Tractor plowing***		***Tractor harrowing***		***Tractor plowing***		***Tractor harrowing***		***Transportation***	
Farm type	*Certified G'nut farm*	*Local G'nut farm*	*Certified G'nut farm*	*Local G'nut farm*	*Certified G'nut farm*	*Local G'nut farm*	*Certified G'nut farm*	*Local G'nut farm*	*Certified G'nut farm*	*Local G'nut farm*
Number of acres										
Cost per acre										
Total cost (Gh¢)										
Grand total cost (Gh¢)										

8. Household income information

8.1. Did you receive any remittance in the 2017 farming season? 1. Yes [ ]   2. No [ ]
8.2. Indicate in GH¢, the amount of remittance received in the 2017 farming season? GH¢...........
8.2. What is your average monthly salary (if a salary worker)? GH¢………………………….

8.4. Kindly fill in the table by writing names of Variety of certified groundnut cultivated, quantity given as gift, quantity consumed as well as the unit price per 50kg of groundnut sold.

Type of farm	**Acre of land cultivated**	**Quantity sold (50kg bag)/bowls**	**Quantity given as gift (50kg bag)/bowls**	**Quantity consumed (50kg bag)/bowls**	**Total quantity (50kg bag)/bowls**	**Unit price of 50kg bag (GH¢)/bowls**	**Total income (GH¢)**
Certified groundnut seed farm							
Local groundnut seed farm							

9. Mention the main challenges facing groundnut producers in your community?

1………………………………………………………………………………………
2………………………………………………………………………………………
3……………………………………………………………………………………...
4………………………………………………………………………………………
5………………………………………………………………………………………

10. Mention the main challenges facing certified groundnut seed access and use?

1……………………………………………………………………………………..
2……………………………………………………………………………………..
3…………………………………………………………………………………….
4…………………………………………………………………………………….
5…………………………………………………………………………………….

B. SAMPLE QUESTIONNAIRE FOR INPUT DEALERS/ SELLERS

1.1. Name of the input dealer (’s)/shop……………………………………………
1.2. Age of the Respondent ………….. Sex: 1. Male [ ] 2. Female [ ]
1.3. From what source do you access your certified seeds for sale?
1……………………………………………………………………………
2……………………………………………………………………………
1.4. Tick from the below, the specific certified seed crops you sell as an input dealer?
1. Groundnut [ ] 2. Maize [ ] 3. Rice [ ] 4. Soya beans [ ] 5. Others …………
1.5. If you sell certified groundnut seeds as mention in Q 1.4, state some of the reasons why you sell it?
1 Profit [ ] 2. High demand [ ] 3. Government subsidy [ ] 4. NGOs support [ ] 5. Suitable environment for production relative to others [ ] 5. Good collateral for loans [ ]
6. Specify others ………………………………………………………………..
1.6. If you do not sell certified groundnut seeds, tick from the below, some of the reasons why you do not sell it?
1. Low profit [ ]
2. Easily perishable when stored [ ]
3. Low demand for certified groundnut seed [ ]
4. Not aware there is certified groundnut seeds [ ]
5. Specify others ………………………………………………………………..

1.7. Tick from the below, some of the challenges facing you as an input seller in the distribution and marketing chain of certified groundnut seeds?
1. Inadequate storage facilities [ ]

2. Inadequate production of certified groundnut seeds [ ]
3. Low demand of certified groundnut seeds [ ]
4. High price of certified groundnut seeds from seed companies [ ]
5. Poor road networks to enable us to distribute and open more rural inputs outlets [ ]
6. Late release of certified groundnut seeds by the seed companies [ ]
7. Specify others…………………………………………………………………..

C. SAMPLE QUESTIONNAIRE FOR SEED COMPANY

1.1. Name of the seed producing company/farmer………………………………
1.2. Age of Respondent ……………… Sex: 1. Male [ ] 2. Female [ ]
1.3. From what source do you access your breeding / foundation seeds from?
  1. SARI [ ]
  2. Specify others …………………………………………………………
1.4. Mention the specific certified seed crops you produce as a seed company?
  1. Groundnut [ ] 2. Maize [ ] 3. Rice [ ] 4. Soya beans [ ] 5. Specify others……………………………..

1.5. If you produce certified groundnut seeds as mention in Q 1.4, state some of the reasons (incentives) why you produce it? (Tick as many as applicable)
  1. Profit [ ]
  2. High demand [ ]
  3. Government subsidy [ ]
  4. NGOs or donor agency support [ ]
  5. Suitable environment for production relative to others [ ]
  6. Good collateral for loans [ ]
  7. Provision of capacity building services [ ]
  8. Frequent visits by seed inspectorate division [ ]
  9. Contracted by nucleus farmer(s) to produce for them [ ]
  10. Contracted by input dealer(s) to produce for them [ ]
  11. Contracted by government (MoFA) to produce for them [ ]
  12. Specify others ………………………………………………………………..

1.6. If you do not produce certified groundnut seeds, tick from the below, some of the reasons (disincentives) why you do not produce it?
  1. Highly perishable [ ]
  2. Cost of production is high [ ]
  3. Low technical know-how on groundnut [ ]
  4. The procedures for groundnut seed certification is cumbersome [ ]
  5. Low demand of groundnut [ ]
  6. High price of foundation seeds [ ]
  7. No gov't and NGOs supports for groundnut [ ]
  8. Poor collateral for loans [ ]
  9. No frequent visits by seed inspectorate division [ ]
  10. Not contracted by nucleus farmer(s) to produce for them [ ]
  11. Not contracted by input dealer(s) to produce for them[ ]
  12. Not contracted by government (MoFA) to produce for them [ ]
  13. Specify others ……...……………………………………………......

1.7. How many times have certified groundnut seed inspectors visited your field? ....
1.8. Tick from the below, some of the challenges facing you during certified groundnut seeds production? (Tick as many as applicable)
  1. Inadequate capacity building services [ ]
  2. Poor visits of field inspectors [ ]
  3. Late release of breeder/foundation seeds [ ]
  4. Poor energy supply [ ]

5. Poor weather [ ]
6. Poor germination of foundation seeds [ ]
7. No support from Gov't and NGOs [ ]
8. Specify others …………………………………………………………………….

1.9 Tick from the below, some of the challenges that you face in going through groundnut seeds certification? (Tick as many as applicable)

1. Delay in releasing certification results [ ]
2. High charges for groundnut seed certification [ ]
3. Poor visits of field inspectors [ ]
4. Do not inform you the basis for your disqualification [ ]
5. The procedures for groundnut seed certification is cumbersome [ ]
6. Specify others ………………………………………………………………..

D. SAMPLE QUESTIONNAIRE FOR BREEDER/FOUNDATION GROUNDNUT SEED RESEARCH INSTITUTIONS

1.1. Name of the Research institution: ……………………………………………

1.2. Age of Respondent ………………… Sex: 1. Male [ ] 2. Female [ ]

1.3. State the specific breeder/foundation seed crops you produce as a research institute?

1. Groundnut [ ] 2. Maize [ ] 3. Rice [ ] 4. Soya beans [ ] 5. Others ………..

1.4. Tick the incentives (reasons) or disincentive for breeding certified groundnut seed

Incentives (reasons) for breeding certified groundnut seed	**Disincentives (reasons) for not breeding or not fully breeding certified groundnut seed**
Profit [ ]	Loss [ ]
High demand [ ]	low demand [ ]
Government subsidy [ ]	No Government subsidy [ ]
Donor support [ ]	No donor support [ ]
Cheap to be produced relative to others [ ]	High cost to be produced relative to others [ ]
Specify if any……………………………………..	…………………………………………………………

1.5. As a breeder/foundation groundnut seed producer, tick from the below, some of the challenges facing you in the production of breeder/foundation groundnut seeds?

1. Low technical know-how [ ]
2. Inadequate production equipment [ ]
3. High production cost [ ]
4. Inadequate budg*et al*location for groundnut by the government [ ]
5. The GLDB has low capacity to absorb all the breeder seeds produced [ ]
6. The department is under staffed [ ]
7. Specify others ………………………………………………………………..

1.6. Is there the desire to dissolve foundation seed production to out-growers?

(1) Yes [ ] (2) No [ ]

1.7. If yes to Q 1.6, state the driving factors?

1……………………………………………………………………………
2……………………………………………………………………………
3……………………………………………………………………………
4……………………………………………………………………………
5……………………………………………………………………………
6……………………………………………………………………………

1.8. Fill the table below by indicating funding, institutional, social and economic challenges of breeding groundnut

Funding challenges	**Institutional challenges**	**Social challenges**	**Economic challenges**

Telephone contact of the Respondent …………………………….....

Thanks for your time!

APPENDIX 2

Matrix for Objectives, Method of analyses, Key Findings, Conclusions, and Policy Recommendations

Objectives	Method of analyses	Key findings	Conclusions	Recommendations
1. To identify the incentives or disincentives for commercial production of certified groundnut seeds.	Descriptive	i. The identified incentives for commercial production of CGS includes; high demand, high profit, availability of contracts and support from NGOs and projects. ii. The identified disincentives for commercial production of CGS includes; poor field inspections, no government support and untimely delivery of CGS among the actors.	i. The incentives for commercial production of CGS includes; high demand, high profit, contracts and support from NGOs and projects with some few institutional and policy disincentives such as poor field inspections, no government support and untimely delivery of foundation seed from breeding institutions.	i. The government should implement subsidy policy on groundnut to incentivise domestic CGS producers to commercialise in CGS production.
2. To assess smallholder groundnut farmers' preferences in relation to seed attributes, selling outlets and packaging	Descriptive: Cross tabulation.	i. The current groundnut market do not meet farmers' preferences in relation to: seed attributes, packaging and selling outlets.	i. Smallholder farmers highly preferred CGS with the following attributes; high-yielding, early maturity date, good germination rate, tolerant to drought, and resistant to pest and disease etc. ii. Farmers prefer that CGS should be packaged in jute sack. ii. Farmers prefer that CGS should be sold and distributed to them in their communities in groups.	i. Groundnut seed breeders should take note of qualities of CGS preferred by farmers and produce foundation seed to meet their preferences. ii. Extension agents should form FBO to help input dealers market and distribute CGS to farmers through Seed Brokerage System (SBS).
3. To analyse the factors that influence farmers' decision to use certified groundnut seed.	Cragg's Double Hurdle Regression Model: Probit model for the first hurdle.	i. Factors that affected farmers' decision to use CGS includes; age, educational status, extension service, credit access, farm size, household size, input distance, output distance, transport access.	i. Age, educational status, extension service, credit access, farm size, household size, input distance, output distance and transport access affects farmers' decision to use CGS.	i. MoFA should increase farmers' knowledge of CGS through their extension agents to encourage CGS usage.
4. To estimate certified groundnut seed use	Cragg's Double Hurdle Regression Model: Truncated	i. Factors that predicted farmers' use intensity of CGS includes; access to extension service, price	i. Access to extension service, price of CGS, FBO membership status, output	i. The price of CGS should be low to incentivise farmers to buy

intensity and its determining factors.	model for the second hurdle	of CGS, FBO membership status, output distance and input distance.	distance and input distance predicts farmers' use intensity of CGS.	more to increase their use intensity rate.
5. To identify constraints facing groundnut seed production and distribution and marketing.	Descriptive: Chart and Tables	i. Constraints in groundnut seed production and marketing include; lack of government support, land tenure issues, high price of CGS, poor road networks, ineffective field inspection by Plant Protection and Regulatory Services Directorate, few producers and poor partnership among value chain actors.	i. Presently, constraints in groundnut seed are; lack of government support, land tenure issues, high price of CGS, poor road networks, ineffective field inspection by Plant Protection and Regulatory Services Directorate, few producers and poor partnership among value chain actors.	i. CGS producers and other actors in the value chain should form partnership to enable easy follow of information for up scaling of CGS production. ii. The government should improve road networks to farming communities to incentivise input dealers establish input outlets in rural areas to increase accessibility and farmers' usage rate of CGS in production.