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THE DETERMINANTS OF ADOPTION AND IMPACT OF IMPROVED MAIZE VARIETIES IN THE EASTERN REGION OF GHANA

MASTER THESIS

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DECLARATION

I hereby declare that this diploma thesis "THE DETERMINANTS OF ADOPTION AND IMPACT OF IMPROVED MAIZE VARIETIES IN THE EASTERN REGION OF GHANA" is my own work and effort and it was written under the supervision of Ing. Kandakov Alexander, Ph.D., I however attest to the fact that I have incorporated to my work, views and opinions of others.

I used materials listed in the references.

Prague, 2015

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Eunice Ansah

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Abstract

Major investments to improve maize yield have been made by the Ghana Government with support from donor partners. Despite these efforts, average maize yield in Ghana remains one of the lowest in the world. This study was aimed at examining the factors influencing the adoption of improved maize varieties (IMVs), constraints to production of improved varieties and evaluates profitability on smallholder maize farmers in the eastern region of Ghana. It also examines the level of awareness and identifies the various IMVs cultivated in the research area. Data was collected from 100 smallholder maize farmers selected from nine rural communities in and around the Nsawam-Adoagyire and New-Juaben districts (Kweku Tawiah, Jaadwira, Teshie, Bekoekrom and Akototse, Huhunya, Suhum Kraboa Coaltar, Asafo Akim and Asesewah).

A semi-structured questionnaire was administered. Descriptive statistics and logistic regression were employed as analytical tools. The results indicated that the awareness of improved maize varieties was high (90%) as well as adoption. Generally, farmers preferred Obaatanpa open pollinated varieties (OPV) released in 1992 to other varieties. Results from the logistic regression model analysis of the survey data showed that age and extension services were significant and important factors that influenced the adoption of improved maize varieties. Ranking of constraints to production showed that drought was the most pressing constraint. Gross margin results indicated that, IMVs was profitable mean gross margin of 833.65 per hectare for men as against 410.61 for women. Policies aimed at enhancing farmers' access to credit, fertilizers should be put in place to enable farmers purchase necessary inputs and encourage adoption of IMV. Training on the recommended practices for cultivation of IMVs should be intensified and farmers should be more involved in on-farm field trials for new varieties on the use of improved seeds will reduce the problem of low yields and consequently improve income levels.

Key words: Agricultural innovation, improved maize varieties, extension services, Ghana

Table of Contents

List of tables

List of figures

List of appendices

List of Abbreviations

NGOs	Non-governmental Organization
CIA	Central Intelligence Agency
CIMMYT	International Maize and Wheat Improvement Center
CRI	Crops Research Institute
CIDA	Canadian International Development Agency
CSIR	Council for Scientific Industrial Research
°C	Degree Celsius
SARI	Savannah Agricultural Research Institute
QPM	Quality Protein Maize
IFPRI	International Food Policy Research Institute
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
MoFA	Ministry of Food and Agriculture
DT	Drought Tolerant
DTMA	Drought Tolerant Maize for Africa
GGDP	Ghana Grains Development Project
GLDB	Grains and Legumes Development Board
OPVs	Open Pollinated Varieties
FCDP	Food Crops Development Project
IITA	International Institute of Tropical Agriculture
Mm	Millimetres

Mt	Metric tons
Sept.	September
SPSS	Statistical Package for Social Sciences
SRID	Statistics, Research and Information Directorate
SSA	sub-Saharan Africa
Per hectare	(/ha)
Km	Kilometres
Km^2	Square kilometres
%	Percent
USD	United States Dollars
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
GHS	Ghanaian Cedi
Yr	Year
Conversion	1 USD ≈ 3.56 GHS

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the important cereal crops produced and widely consumed staple foods in Ghana. It is predominantly produced by small-scale poor farmers under rain-fed conditions. There has been an increasing trend of maize production since 1965 (Morris et al, 1999). The crop serves as a major source of food and cash and accounts for more than 45% of the agricultural cash income among smallholder farmers in the country (DTMA, 2013).

An estimated 75 % of the world's poor is reported to be living in rural areas and most of them engage in farming. In these areas, development of agricultural sector is often faced with the challenge of lack of access to the right technologies to the due to "weak institutions" and problems with organization and management of research, education, and extension systems. As a result many countries agricultural systems are affected by underdevelopment and face barriers to the use of knowledge and innovation for development (Asenso Okyere, 2008).

Farming in most developing countries is dominated by small-scale farms which is the most significant way of production at the core of rural family economies. The absence of technology and limited access to or the use of inappropriate technology is among some of the factors blamed for food deficiency in many parts of the developing world (von Braun and Pandya-Lorch, 2007; McCalla, 1999). In light of these constraints facing maize farmers in sub-Saharan Africa (SSA) including Ghana, there is a need to breed or cultivate maize varieties that can withstand dry weather conditions and low water levels.

Problem Statement

Developing countries in partnership with NGOs and foreign donors, have invested resources to strengthen their agricultural research systems. According to Alene et al (2009), Ghana has made the largest maize research investments in West and Central Africa. From 1971-2005 a total of 308 million dollars was invested in maize research with international maize research accounting for 66 % (204 million dollars). Agricultural economists are in agreement with this strategy, arguing that technological innovations in agricultural production play a key role in the development of the agricultural sector, which in turn leads to general economic development (Eicher and Staatz, 1998).

In Ghana, one such example is the Crops Research Institute (CRI) with support from the Ghana Government and funding from the Canadian International Development Agency (CIDA). An important component of the research mandate of SARI and CRI is varietal improvement and testing focusing on high yield, quality protein maize (QPM), tolerance to pests and disease and early maturity.

Through its varietal improvement programmes, the CRI, SARI and International Maize and Wheat Improvement Center (CIMMYT) a number of improved varieties have been released to farmers after being tested on-farm. Notable among such varieties are Obaatanpa, Mamaba (hybrid), Dada-ba (hybrid), Aziga (yellow) and Aburohemaa (IFPRI, 2013). However surveys or studies on maize technology adoption are scarce and rarely conducted. Factors affecting the adoption of these technologies and constraints to adoption are not known.

Figures from annual reports of the Crops Research Institute (CRI) and the Savannah Agricultural Research Institute (SARI) show a huge gap between actual and achievable yield. Many experts attribute Ghana's slow productivity growth in maize to low adoption of productivity-enhancing technologies, including improved varieties and management practices, and low use of purchased inputs, especially fertilizer. Furthermore, in light of the fact that a lot of resources has been allocated to agricultural research, it is important therefore that these investments are justified in terms of returns to these investments.

According to Morris et al (1999), studies on the adoption of technology and impact on maize production in Ghana are outdated with the latest nationwide maize technology and impact study conducted in 1997. This study therefore examines factors influencing the adoption of improved maize varieties among small-scale maize farmers from nine maize farming communities in the eastern region of Ghana. Review of relevant literature is done in the second part of the study; the methodology used for the analysis of the survey data is presented in section 3, results and discussions are presented in fourth part; and finally conclusions from the findings are drawn and recommendations made in section 5.

2. LITERATURE REVIEW

2.1 Benefits and Disadvantages of Improved Maize Varieties

Maize (*Zea mays* L.) is considered the third most essential cereal crop in the world after wheat and rice. According to Jonsson and Radman (2012) maize is a dominant food crop in Africa; accounting for a large source of nutrition. It is a major staple crop for about 1.2 billion people mostly in SSA and Latin America The grains serves as a good source of energy; rich in dietary fiber and calories. The crop is also said to be a rich source of carbohydrates, vitamins A, C and E and about 9 % protein, however, a heavy reliance in the diet can lead to malnutrition. All parts of the crop can be used for food and non-food purposes (IITA, 2000).

With rapid growth in population and more people to feed, adoption and spread of improved maize varieties such as hybrids and OPVs are important and can immensely increase maize yield per unit of land. Thus, improving production of the crop is viewed as an important strategy for the reduction of food insecurity in developing countries.

According to Jonsson and Radman (2012) one disadvantage of improved seeds is that when improved seeds are recycled, it results in a drop in its ability to increase the yields. This means new seeds must be bought and planted each sowing season to get high yield resulting in an increase in farm income. This however means more costs for farmers.

Application of fertilizer is required for production of quality crops by restoring nutrient levels of soils after growing on the plot year after year. IMVs respond better to fertilizers in comparison with local varieties, however to maintain high yield, both inputs require additional production practices. This is another expensive investment and its use is not always profitable. Furthermore, improper handling of fertilizers can have a negative impact on nature and the health of humans and animals (Jonsson and Radman, 2012).

According to Hall and Khan (2002) the obvious determinants of new technology adoption are the benefits received by the user and the costs of adoption and in many cases for instance, these benefits are simply the difference in profits when a firm shift from an older technology to a newer one. These new varieties sometimes referred to as 'high-yielding varieties or ‘modern varieties’ have contributed largely to yield increases in many parts of the world. Widespread replacement of diverse varieties by a small number of homogenous modern varieties, a feature of early formal plant breeding efforts, according to Koziell et al. (2001) can lead to genetic vulnerability; a condition which occurs when a widely plated crop is uniformly susceptible to a pest pathogen or environmental hazard as a consequence of its genetic constitution. Even though this risk still exits, formal plant breeders are now more aware of them and use various techniques to maintain more genetic heterogeneity in the varieties they release or provide newer varieties rapidly replace those becoming vulnerable.

In many developing countries, farmers in environments where high-yield crop and livestock varieties do not do well; rely on a wide range of minor crops and livestock types. Such minor or underutilized crops which are usually found next to main staple or cash crops; help them maintain their livelihoods in the occurrence of uncertain rainfall, price fluctuations, and unpredictable availability of agro-chemicals, pathogen infestation and socio-political disruptions. These underutilized crops and plants that grow in infertile soils and livestock that eat degraded vegetation are in most cases crucial to nutritional strategies of households; therefore playing an important role in food production systems at the local level.

2.1 Determinants of Adoption

In relation to the preference of farmers for one technology against another are dependent many factors, like the socio-economic characteristics of a farming unit, relative cost of each technology which varies from place to place, risk involved in adopting that specific technology and other relevant variables.

One fundamental hypothesis in regards to transfer of technology is that, adoption of an innovation will tend to take place earlier on larger farms than on smaller farms. Feder et al. (1985) however cautions that farm size may be a substitute for other factors such as access to credit, wealth, scarce inputs or information. Access to credit moreover, is related to farm size and land tenure because both factors are determinants of potential collateral availability in obtaining credit.

Ability to adopt new farm technologies for use on the farm also influences farmers' decision to adopt. Most studies on adoption attempt to measure this trait by farmers' age, formal education or years of farming experience (Fernandez-Cornejo et al., 1994).

Economic analysis of agricultural technology adoption has traditionally focused on imperfect information, risk, uncertainty, institutional constraints, human capital, input availability and infrastructure as potential explanations for adoption decisions. In explaining adoption behavior and determinants of technology adoption overall, three paradigms are commonly used. These are the innovation-diffusion model, adoption perception and the economic constraints models.

The underlying assumption of the innovation-diffusion model is that the technology is technically and culturally appropriate but the problem of adoption is one of asymmetric information and very high cost. The adopters' perception paradigm, on the other hand, suggests that the perceived attributes of the technology condition adoption behavior of farmers. Understanding farmers' perceptions of a given technology is thus crucial in the generation and diffusion of new technologies. The economic constraint model asserts that fixed inputs in the short run, such as access to credit, land, labour or other critical inputs limits production flexibility and conditions technology adoption decisions (Uaeieni et al, 2009).

2.3 Biodiversity

Agricultural biodiversity, also known as agrobiodiversity according to the FAO is a vital sub-set of biodiversity which exists as a result of the natural selection processes, careful selection and inventive developments of farmers, herders and fishers over millennia. Thus crop species or varieties, livestock and fish species as well as cultural and local knowledge of diversity among others are considered a part of agrobiodiversity. Agrobiodiversity is defined as the variety and variability of animals, plants and micro-organisms that are directly or indirectly necessary and in support of food production and food security.

Agricultural biodiversity is actively managed by farmers and comprises of all parts of biological diversity of relevance to food and agriculture. Agricultural biodiversity is essential for the function of sustainable food production and providing the building blocks for the evolution or deliberate breeding of useful new crop varieties.

Local knowledge and culture is considered an integral part of agricultural biodiversity because it is the human activity of agriculture which is said to converse this biodiversity. Most plants are reported to have lost their original seed dispersal mechanisms due to domestication and thus can no longer thrive without human input.

Out of 270,000 species of higher plants, about 7000 species are used in agriculture, however, maize is one of the only three apart from wheat and rice, reported to provide half of the world's plant derived calorie intake.

Koziell et al. (2001) distinguish between more 'traditional' and more 'industrial' agricultural systems; they however state that in reality most agricultural systems contain a unique and complex mixture of both systems. More 'traditional' systems are characterized as being less integrated into the market network due to lack of financial capital, infrastructure and access to relevant agricultural research and extension. Farmers involved in this system place less reliance of their livelihoods n selling produce or buying external inputs for agricultural production but rely heavily on availability of natural capital, in the form of quantity and quality of land, water resources and agricultural biodiversity to sustain their livelihoods.

On the other hand more 'industrial' agricultural systems are heavily integrated into the market system and farmers produce mainly for the market and use financial capital generated to fund investments in external inputs.

The formal sector plant breeding programmes strongly influences crop diversity. Through such programmes a stream of new varieties of many crops have been released to increase yields, or resistant to pests and disease in order to reduce reliance on chemical pesticides, or other specific agronomic benefits. Koziell et al. (2001) further report that farmers in Africa have benefited less from Green Revolution than their counterparts in Asia and Latin America. This is because the new high yield varieties of crops such as wheat, rice and maize and sorghum do not respond well to the more heterogonous, low input environment under which much farming takes place in Africa.

As a part of biodiversity as a whole, agrobiodiversity has a lot of distinctive features in comparison with other components of biodiversity. Both male and female farmers are involved in the active management of agrobiodiversity and without this human intereferance; local knowledge and culture, all important parts of agrobiodiversity management, many other components of agrobiodiversty would not survive.

2.4 Concept of Adoption

There exists a vast amount of literature on agriculture technology adoption is vast making it somewhat difficult to summarize compactly. As stated in Feder et al. 1985, traditionally, the economic analysis of agricultural technology adoption or non-adoption focuses on institutional constraints, human capital, input availability, uncertainty, imperfect information, risk and infrastructure as likely explanations for adoption decisions. According to Carr (2001) “adoption” refers to the stage in which a technology is chosen to be used by an individual or an organization.

Extensive contributions typically focusing on long-term rate of adoption and the factors that influence adoption and diffusion of technological innovation in agriculture have been made by various economists and sociologists (Batz et al., 1999). Hall and Khan (2002) define technology adoption as the choice of acquiring and using a new invention or innovation.

2.5 Adoption-Diffusion Theory

According to Hall and Khan (2002) diffusion is the process by which something new spreads throughout a population. Unlike the invention of a new technology which often appears to occur as a single event, diffusion of technology usually appears as a continuous and rather slow process. Furthermore, the pace of economic growth and rate of change in productivity is ultimately determined by diffusion rather than invention or innovation. An observation made in the modeling of diffusion by observers is the fact the number of users of a new invention is plotted versus time, the resulting curve is typically an S-shaped or the cumulative frequency distribution. Naturally, adoption can be imagined to proceed slowly at first, accelerating as it spreads throughout potential adopters, and the slowing down as relevant population becomes saturated (Hall and Khan, 2002). Cavane (2007) further describes the diffusion process as being represented by the S-shaped curve where time is plotted against cumulative percent of adoption. In this case when the number of individuals adopting a new technology is plotted on a cumulative basis over time, the resulting distribution is an S-shaped curve.

2.6 Adoption of Improved Technology Among Farmers

Technology is defined as the application of knowledge for practical purposes. Technology is generally used to improve human conditions, the natural environment, or to carry out other socioeconomic activities (Swanson et al, 2003). According to Swanson et al (2003) technology can be classified into two major categories. These are material and knowledge–based technology. Material technology is the embodiment of knowledge into a technological product such as tools equipment, agrochemicals, improved plant varieties or hybrids or improved breeds of animals and vaccines. Knowledge-based technology includes technical knowledge, management skills and other processes that farmers need to successfully grow a crop or produce animal products. Crops technology is also mentioned as a type of technology which includes crop management practices, plant protection and cropping systems and genetic (improved varieties or hybrids) which is the main focus of this work.

Generally, older varieties are more popular among maize farmers in Ghana. Despite higher yields recorded from other new hybrids compared with Obaatanpa, farmers still have little interest in replacing the Obaatanpa. Inability to recycle seed for the next season and the high amounts of fertilizer required are reported as a disincentive to using hybrid seed by farmers. Another disincentive for farmers to adopt hybrid seeds is the need for regular supply of water required for hybrid production to realize its potential high yields. A drought risk is therefore another disincentive for farmers to adopt hybrid seeds (Ragasa et al. 2013).

2.7 Country Overview

2.7.1 Geography

Ghana, officially the Republic of Ghana, is geographically located on the West coast of Africa and bordered by Burkina Faso to the north, Togo to the east and Cote d'Ivoire to the west while the Gulf of Guinea washes its shores to the south (see appendix 3). The country lies between latitude 4º and 11º north of the equator. The total land area is 238,500 square kilometers (Oppong-Anane, 2006). Ghana is a tropical country and as such the climate is warm and dry along the south-eastern coast; hot and humid in the south-western parts; and it is hot and dry in the northern part (CIA, 2009).

In general the topography is low and gently undulating with slopes of less than 1 %. Despite the gentle slopes, about 70 % of the land is prone to moderate to severe erosion. There are five distinct geographical regions: Low Plains, Akwapim-Togo Ranges, Ashanti Uplands, Volta Basin and High Plains. The highest elevation is Mount Afadjato; rises 880 metres above sea level (Aquastat-FAO, 2005).

2.7.2 Agro-ecological Zones and Climate

There are six agro-ecological zones in Ghana (see appendix 1) characterized by natural vegetation and influenced by climate and soil characteristics. The movement and interaction of continental and maritime winds controls difference in precipitation and temperature. The southern half of the country is comprised of the evergreen rain forest, deciduous rain forest, transitional and coastal zones. These agro-ecological zones experience bimodal equatorial rainfall pattern which allows for two growing seasons; the major and minor growing seasons (see Table 1 below).

Table 1: Precipitation and growing seasons in Ghana by agro-ecological zones

Agro-ecological Zone	Area (km2)	Mean Annual Precipitation (mm)	Annual Precipitation Range (mm)	Major Rainy Season	Minor Rainy Season	Growing Period (days)	
						Major Season	Minor Season
Rain Forest	9,500	2,200	800 - 2,800	March - July	Sept. - Nov	150 -160	100
Deciduous Forest	66,000	1,500	1,200 -1,600	March - July	Sept. - Oct	150 - 160	90
Transition Zone	8,400	1,300	1,100 -1,400	March - July	Sept. - Oct	200 - 220	60
Coastal Savannah	4,500	800	600 - 1,200	March - July	Sept. - Nov	100 -110	60
Guinea Savannah	147,900	1,000	800 - 1,200	May – Sept.		180 - 200	

Sudan Savannah	2,200	1,000	800 - 1,000	May – Sept.	150 -160

Source: (FAO, 2005)

Temperature across the country, do not have the same degree of variation as precipitation (see appendix 2). Mean monthly temperature across the country rarely falls below 25°C and this is as a result of Ghana's proximity to the equator and absence of wide-spread high altitude regions. Mean annual temperature is 27°C. Mean maximum annual temperature approaches 40°C, while mean minimum annual temperature is nearly 15°C (Oppong-Anane 2006).

Mean annual rainfall of the country is estimated at 1 187mm. Mean annual temperatures range from 26.1 °C near the coast to 28.9 °C in the extreme north (Aquastat-FAO, 2005). The rainfall pattern in the country has become unpredictable due to climate changes and global warming. The northern half of Ghana is made up of the Guinea and Sudan Savannah. These agro-ecological zones have a unimodal tropical monsoon which allows for only one major growing season. The single growing season in the north is bound by the harmattan period which refers to the hot, dry continental winds that blow from the northeast across the Sahara desert and into Ghana causing extremely hot, dry days, and cool nights; starts in December and ends in March (Oppong-Anane 2006). Table 2 shows characteristics of the six agro-ecological zones with main food crops grown and rainfall patterns.

Table 2: Characteristics of agro-ecological zones in Ghana

Zone	Rainfall	Portion of total area	Length of growing season	Dominant use of systems	Main food crops
	(mm.yr)	(%)	(days)		
Rain Forest	2200	3	Major season:150-160 Minor season: 100	forest, plantations	roots, plantain
Deciduous Forest	1500	3	Major season 150-180 Minor season 90	forest, plantations	Roosts, plantain
Transition Zone	1300	28		annual food and cash crops	Maize, roots, plantain

Coastal Savannah	800	2	Major Season 100-110 Minor season 50	Annual food crops	Maize, roots, plantain
Guinea Savannah	1100	63	180-200	annual food and cash crops, livestock	Sorghum, maize
Sudan Savannah	1000	1	150-180		Millet, sorghum, cowpeas

Source: (FAO, 2005)

2.8 Agricultural Sector in Ghana

According to World Bank Data (2013) 68 % which is about 155,000 square km (km²) of Ghana's total land area is classified as agricultural land and approximately 78,500 square km of is the land cultivated while 300 square kilometers is irrigated. The agricultural sector is dominated by smallholder rain-fed farmers using basic technologies accounts for 80 % of total agricultural production.

The Agricultural sector is the most important sector driving the country's economic growth and contributes 25.6 % to Ghana's GDP. About 90 % of smallholder farms are less than two hectares in size and they produce a variety of crops. The agricultural sector is singularly responsible for providing food security for both rural and urban populations.

Bigger farms and plantations mainly produce industrial crops such as cocoa and oil-palm which are important cash crops for export revenue, rubber and coconut, and to a lesser extent, cereals and pineapples (MoFA, 2011).

Socioeconomic factors as well as the biological and physical characteristics of the ago-ecosystem, dictate which crops and farming systems will yield the most benefit or pose a lower risk for the farmer and the household (FAO, 2005). Table 3 below shows the major crops grown in Ghana.

Table 3: Major Crops produced in Ghana

Group	Crops
Cereals	Maize, millet, sorghum, rice
Roots and tubers	Yam, cassava, cocoyam, sweet potato, taro
Legumes	Cowpea, Bambara nut, groundnut, soybean, dawa-dawa
Vegetables	Tomato, eggplant, onion, pepper, okra, cabbage, lettuce, carrot
Fruits	Papaya, avocado, mango, cashew, melon, plantain, coconut, banana, Pineapple, orange, pawpaw
Industrial	Cocoa, oil-palm, rubber, coffee, cotton, tobacco, sheanut, cola nut
Industrial	Cocoa, oil-palm, rubber, coffee, cotton, tobacco, sheanut, cola nut

Source: MoFA 2011, and FAO 2005

Cereals such as maize and rice as well as starchy crops and vegetables are grown in all regions. Tree crops are mostly found in the southern agro-ecological zones with the exception of sheanut and cashew trees which grow in the northern savannah. Legumes are also grown in all regions except in high forest zones. Sorghum and millet are primarily grown in the transition and northern savannah zones. Table 4 below shows the major crops grown in the six agro-ecological zones (FAO, 2005).

Table 4: Major Crops produced in agro-ecological zones

Zone	Cereals	Starchy crops	Legumes	Vegetables	Tree crops
High Rain Forest	Maize, rice	Cassava, cocoyam, plantain		Pepper, okra, eggplant	Citrus, coconut, oil-palm, rubber
Deciduous Rain Forest	Maize, rice	Cassava, cocoyam, plantain	Cowpea	Pepper, okra, eggplant, tomato	Citrus, oil-palm, coffee, cocoa
Transition	Maize, rice, sorghum	Cassava, cocoyam, plantain, yam	Cowpea, groundnut	Pepper, okra, eggplant	Citrus, coffee, cashew
Coastal Savannah	Maize, rice	Cassava	Cowpea	Tomato, Shallot	Coconut, Pineapple
Guinea	Maize,		Cowpea,	Tomato,	Sheanuts,

Savannah	rice, sorghum, millet	Cassava, yam	soybean, groundnut, bambara	Pepper	Cashew
Sudan Savannah	Maize, rice, sorghum, millet	Sweet potato	Cowpea, soybean, groundnut, bambara	Tomato, Onion	

Source: MoFA 2011, and FAO 2005

2.9 History of maize cultivation

Maize (*Zea mays* L.) is a major cereal crop in West Africa, accounting for slightly over 20 % of domestic production for the sub-region and an important staple food for about 1.2 billion people in Sub-Saharan Africa (IITA, 2000). Maize is one of the most important cereals in Ghana and cultivated in all the agro-ecological zones (Fening et al., 2011). Among smallholder farmers in Ghana, it is a major source of cash accounting for more than 45 % of their agricultural cash income. It is the country's largest and most widely cultivated crop accounting for 50 to 60 % of total cereal production (DTMA, 2013).

The maize crop was introduced by the Portuguese in the 16th century. The growing of maize in Ghana started to be visible in the early 1930's. The main goal of maize growers in Ghana at the time was to develop maize varieties of high quality and stable yielding varieties which can perform best in all the ecological zones of Ghana (GGDP, 1986).

Maize is cultivated in all regions of the country. As Ghana's most important cereal crop, maize is grown by a vast majority of rural households, widely consumed throughout the country and regarded as the second most important staple food in Ghana, next cassava. A large quantity of maize grown in Ghana is of the white variety and used mainly for human consumption (around 87 %). Yellow maize is produced in smaller quantity and mostly imported and used as animal feed. Majority of maize produced is consumed directly by farmer's household which accounts to about 57 % and the rest about 30 % is sold formally or informally. A small quantity of production about 13 % is used as animal feed in the poultry industry (IFPRI, 2013).

In 2009 the global maize yield averaged 4.9 tons/ha (per hectare). The United States for instance recorded remarkable increase in yields from an average of 1.6 tons per hectare in the early 1930’s to a recent approximated yield of 9.5 tons per hectare according to Edgerton 2009, while yields in Ghana is around only 1.7 metric tons per hectare (MoFA, 2011).

Yields in major maize growing countries in developing countries however, continue to fall behind the world average producing only about 3.1 tons per hectare (Pixley et al., 2009). This large difference in yields has been attributed partly to the use of unimproved or open pollinated varieties instead of hybrids, along with low input rates and poor soil management (Edgerton, 2009).

A MoFA 2011 report showed attainable yields of 6 tons per hectare was obtained after maize yield evaluation trials. This is therefore an indication that the current average yield of 1.7 tons per hectare (ha) is about 70 % less than what is achieved by researchers in maize yield trials. In order to reduce this gap between the current low yields and the achievable yields, there have been attempts made through maize breeding programmes in Ghana over the last 10 years towards developing hybrid varieties due to its superior potential over the local varieties.

2.9.1 Maize Production in Ghana

In Ghana, the maize crop is planted in April and May and harvested in August and September for the major season. Though it is grown throughout the country the leading producing areas are mainly the middle-southern part which falls under the transitional and forest zones, with estimates 15 % produced the northern region (USDA, 2011).

Maize grown in Ghana is cultivated mostly together with other crops particularly in the in the coastal savannah and forest zones resulting in generally low planting densities. An observed pattern of the transition zone shows that the zone has become increasingly important for maize production. This rising importance of the transition zone as a source of maize supply is attributed to a combination of factors which including the presence of favourable agro-ecological conditions and availability of improved production technology (Morris et al, 1999).

As the most widely consumed staple food in Ghana, a nationwide survey revealed that 94 % of all households had consumed maize during an arbitrarily selected two-week period. Maize is consumed in a variety of ways and as a base for several food preparations. It is used to prepare porridges and more solid dishes made from fermented or unfermented dough (Morris et al, 1999). In 2000, MoFA estimated per capita consumption at 42.5 kg and national consumption was estimated at 943000 Mt in 2006 (SRID, 2007).

Maize is an extensively traded commodity in Ghana. The proportion of maize produced has increased over the years with the rise in commercial farming and at least half of the national maize crop believed to enter the market. Extensive marketing of maize is said to have important welfare implications because revenues from the sale of maize represents a key source of income for many households that grow the crop primarily to satisfy their own consumption requirements (Morris et al, 1999). Maize is the most important cereal crop on the Ghanaian domestic market. Producers are usually outside the marketing chain but sell to traders, who are mainly women coming from markets in the cities to collect the produce from the farms. The maize is then sold in urban wholesale and retail traditional markets (USAID, 2012). Ghana is considered to be about 99 % self-sufficient in maize production and a major staple food for many low-income Ghanaians (Nyanteng and Asuming-Brempong, 2003).

2.10 Structure of seed system in Ghana

Seeds are the fundamental unit of any production. Its importance therefore to crop based production cannot be overemphasized and improving the quality of seed of any variety is the basis for agricultural productivity improvements.

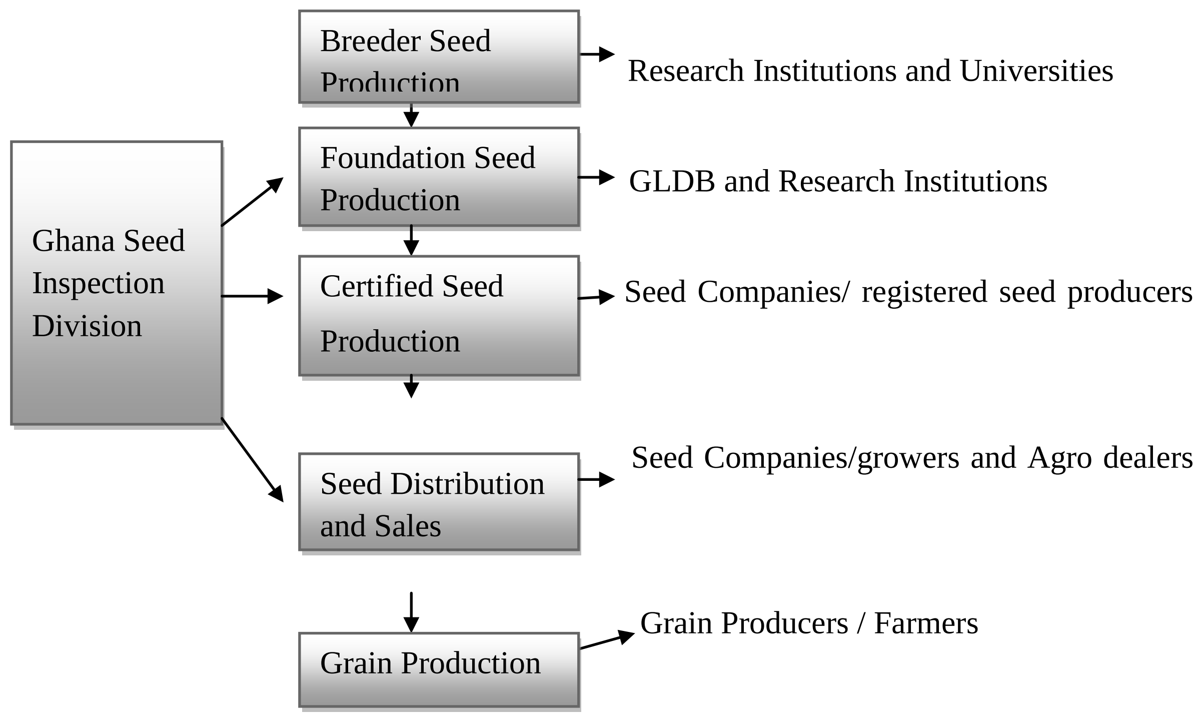
Development of varieties has recently seen increased investments resulting in the release of several varieties of crops such as maize, sorghum, millet, groundnut and cowpea. Despite the availability of new varieties, together with promotional efforts by government and its development partners, awareness and adoption of new varieties seems to be low as a result of weak seed delivery systems. As a result of increasing global interest in agriculture, in terms of rising prices of food and concerns about food security and climate change adaptation, the seed sector development in Africa has regained the attention from governments, donor communities, civil society and other stakeholders (Louwaars and De Boef, 2012). For most countries in sub-Saharan Africa including Ghana, seeds are the most important production factor and cheapest input for crop production. There are two parallel seed systems in Ghana; a formal system established by state and its technical partners and an informal or traditional system which is based on a tradition of exchanges and mutual support among producers within a particular zone (Niangado, 2010).

More than 80 % of smallholder farmers in Africa mainly obtain their seeds through the informal channels which include farmers; own seeds saved or seeds exchanged among farmers or purchased from the local grains or seed markets (Louwaars and De Boef, 2012).

The Ministry of Food and Agriculture heads the formal system, under which we have the National Seed Committee and the National Seed Services while research and development of seeds or varieties is however handled by research institutions such as the Council for Scientific and Industrial Research (CSIR) and the Universities. After all conditions are accepted by the National Variety Release Committee, the variety is released. The Grains and Legumes Development Board (GLDB, then acquires the breeder seed to produce foundation seed.

Seed companies and seed growers acquire the foundation seeds to produce certified seeds for sale to agro-dealers, NGOs and sometimes directly to farmer or grain producers. The Ghana Seed Inspection Division of MoFA has the mandate of inspecting and certifying the production and distribution of foundation and certified seeds. Figure 1 below shows the formal seed structure in Ghana.

Figure 1: Flow chart of the formal seed sector in Ghana



Source: Etwire et al. (2013).

2.11 Research and development of Improved Varieties

Most research activities carried out by national research institutions in relation to maize have been geared toward the improvement of varieties and testing. During the GGDP and FCDP projects, even though agronomic research was limited, trials on agronomic practices have been conducted on land preparation, row planting, fertilizer and herbicide use and pest and disease control. High yielding and disease-resistant varieties adaptable to SSA's various agroecological zones have been developed by IITA research scientists. This helped to mitigate the serious outbreak of maize streak virus in the 1970s (IITA, 2009).

Since the 1960s about 27 improved varieties have been released. The CRI and SARI varietal improvement and testing's focused on high yield, quality protein maize (QPM) and tolerance to pests and diseases. The emphasis over the last 10 years has been on open pollinated varieties (OPVs), hybrid seeds and as an important staple food; QPM for enhanced nutrition is stressed. The main sources for seeds were the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute of Tropical Agriculture while the CRI and SARI scientists conducted genetic improvements through crosses (IFPRI, 2013).

The Ghana Grains Development Project (GGDP) (1979-1997) was a long-term program focusing on the maize sector. A number of successes were realized before it ended in 1997. During the project, several varieties were developed and disseminated. Agronomic practices were evaluated; investment was made towards the extension and spread of improved technologies and production guides were made. Among the notable achievements of the project was the development of the quality protein maize called Obaatanpa, which has become widely popular in Ghana and other African countries.

The Sasakawa-Global 2000 project was created by the Nippon Foundation of Japan to alleviate reliance on food aid and build agricultural self sufficiency in sub-Saharan Africa. The project became operational in Ghana and Sudan in 1986 and expanded to other countries in Africa. The programme focused on large and dynamic field demonstration of improved technologies for 2 or 3 of the most important food crops. However it was criticized for being too narrowly focused on maize production, insensitive to smallholders’ resource endowments and risk capacity and exchange rate instability which posed major difficulties for private fertilizer importers (Word bank, 2003).

The Food Crops Development Project (FCDP) between the years 2000 and 2008 funded field trials, provision of inputs, production manuals, extension and processing. A study conducted in one of the focus districts for the project showed that, it increased access to credit, improved access to information about improved technologies, increased maize output and improved food security levels after the project as compared to prior the project.

In 2010 four Quality Protein Maize (QPM) varieties, which were drought tolerant and disease resistant were released to Ghanaian farmers to boost maize production in drought-prone areas of the country. The varieties were early and extra-early maturing which were released by the Ghanaian Crops Research Institute (CRI), Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) of Ghana. Few local maize varieties were developed by T.L Williams between the years 1939-1942.

Maize cultivation programmes in Ghana has transformed from the early dedication to the development of Quality Protein Maize (QPM) and unimproved or open pollinated varieties (OPVs) and to the current phase of hybrid variety promotion. 31 new varieties were released between 1965 and 1998 (IITA, 2000). Despite these major investments to improve maize yield, average yield in Ghana remains one of the lowest in the world. Statistics according to the Food and Agriculture Organization (FAO) shows it is also lower than yields in similar lowland, rain fed, tropical environments in Thailand and southern Mexico. Maize yield in Ghana have been growing by only 1.1 % per year (IFPRI, 2014).

Table 5: Improved maize varieties developed and released by CRI and SARI

Name of Variety	Year of Formal Release	Origin (Institution)	Maturity Period (days)	Potential (tons/hectare)	Selected Characteristics
Mex 17 Early	1961	CIMMYT	90-105		Early,resistance to lodging
Comp W	1972	CRI/CIMMYT	120		Yield, tolerance to pests
Aburotia	1983	CRI/CIMMYT	105-110	3.5	High yield
Dobidi	1984	CIMMYT	120	5.5	High yield
Okomasa	1988	IITA/CIMMYT	120	5.5	High yield, streak resistance
Abeleehi	1990	IITA/CIMMYT	105-110	4.6	Yield, streak resistance
Obaatanpa	1992	IITA/CIMMYT	105	4.6	Yield, QPM, tolerance to pest
Mamaba (hybrid)	1996	CIMMYT	105	6.0-7.0	High yield, drought tolerant(hybrid)
Cida-ba (hybrid)	1997	CIMMYT	110	6.0-7.0	High yield, protein content (hybrid)
Etubi (hybrid)	2007	CIMMYT	105-110	6.5-7.0	QPM, hybrid, DT

Aburohemaa	2010	IITA	90	5.0	DT, QPM, *Striga* tolerant
Opeaburoo	2012		110-115	7.5	Hybrid white, DT

Source: IFPRI, 2013

2.12 Relevance of the study

Though research efforts have made available improved varieties of maize to farmers, the adoption of these technologies is low with persisting major technological challenges and yield gaps. Currently, information regarding the adoption of improved maize varieties is scarce. Adoption studies are not regularly done or in most cases researchers are not well connected with farmers, extension agents and other innovation actors. Thus, there is a knowledge gap in this area. The provision of information on such micro level could be helpful for researchers and extension officers to be more effective in responding to farmers' needs. In addition, this study may provide insight for other institutions such as CSIR, MoFA and other partners involved in crop improvement programmes and working with farmers in Ghana on the design of future projects and investments in the maize sector.

3. OBJECTIVES

Many projects have been undertaken to improve maize production systems by introducing economically and environmentally suitable varieties. Notable among such projects is the Ghana Grains Development Project (GGDP) and Drought Tolerant Maize for Africa (DTMA) project.

3.1 Main Objective

The main objective of the thesis is to evaluate the adoption of improved maize varieties introduced by the Savannah Agricultural Research Institute (SARI) and the Crops Research Institute (CRI). The study will identify specific varieties preferred by maize farmers in the chosen areas, the impact on incomes and well-being of farmers after the adoption of newly improved maize varieties and certified seed.

3.2 Specific Objectives

The main objectives will be accomplished through the specific objectives as follows:

- Determine the level of awareness of improved maize varieties through percentages.
- Determine the factors that influence the adoption of improved maize varieties by farmers.
- Identify the main constraints faced by maize farmers in adoption of improved maize varieties.
- Estimate the profitability of farmers through cost of production and revenue.

3.3 Limitations of the study

In trying to reach its objectives, the study some limitations, they include:

The main reason for only focusing on nine communities in and around 2 districts is the limited amount of time and money for transportation to the area. The study used household level data and did not include community level variable.

Some farmers were not very open to discuss issues regarding their income. This was regarded as personal. Those who were willing did not keep proper records of their farming activities. The study is however considered credible.

4. METHODOLOGY

4.1 Study Area Description

The study was conducted in selected farming communities in the eastern region of Ghana. The region is located in southern Ghana and it is one of ten administrative regions. The region lies between longitudes 0°30 East and 1°30 West and latitude 5°30 North and 7°22 South (MoFA, 2010). The region covers an area of 19,323 square kilometers which makes about 8.1 % of the country's total landform. The region is the third most populated with a total population of 2,633,154 according to the 2010 population census. Population density in 2010 is 140 people per square kilometers (Ghanadistricts.com, 2014).

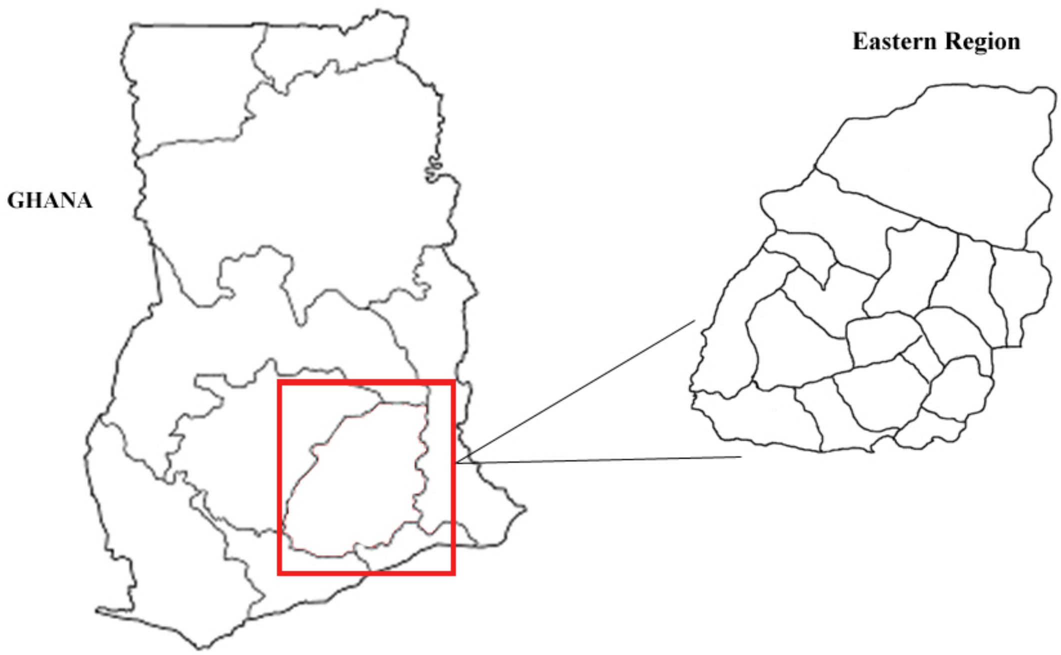
The area falls under two main ecological zones namely the semi-deciduous forest and the coastal savannah grassland. Total population of the town is about at 123,501 according to the 2010 population census (GSS, 2012).

This region is geographically dominated by four main features; the Akuapim highlands with an elevation of 1,530 feet, Kwahu plateau which is 2,586 feet above sea level, Atiwa ranges reaching an elevation of 2,400 feet and some isolated mountains or hills like the Krobo and Yogaga (Ghana.gov.gh, 2014). The region is rich in minerals such as bauxite, limestone, clay, but gold and diamonds are the only minerals mined commercially. The range serves as a habitat for many rare and exotic flora and fauna.

The region is located in the middle-southern part (Brong Ahafo, Eastern and Ashanti provinces) of the country which is the leading producing area where 84 percent of the maize is grown (FAO, 2012). The average farm size for maize production in the region is 2.5 hectares (MoFA, 2010).

This area was chosen for this study due to the importance of maize, which is a major food crop for small-scale famers and inhabitants. Total labour force involved in agriculture for the region is estimated at 531,635 economically active people based on 2000 population and housing census (MoFA, 2011).

Figure 2: Location of Eastern region, where the study was conducted



Source: modified by author, 2014

4.1.1 Nsawam Adoagyire: Nsawam

Nsawam is a town located in the Nsawam-Adoagyire District. This district covers an area of about 440 square kilometers.

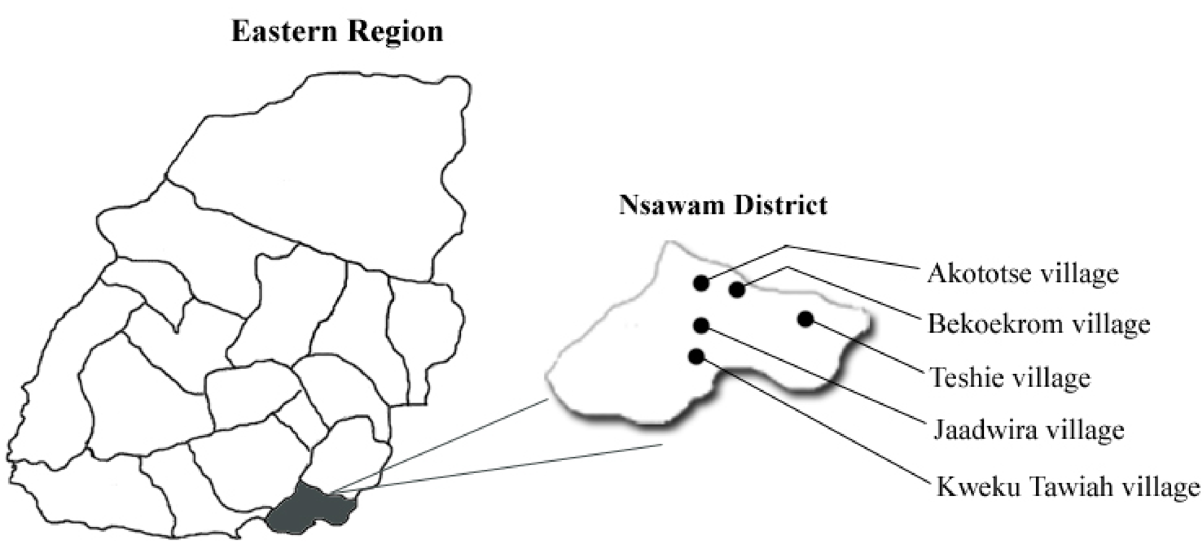
Soil type of the region is suitable for cultivation of staple food crops such as cassava, yam, cocoyam, maize, rice and vegetables. The region makes significant contributions to the production of industrial crops such as cocoa, pineapple, pawpaw and oil palm. A substantial amount of national production of maize, cassava and citrus also comes from this region. Crops such as sweet pepper, cashew nuts and Irish potatoes are also gaining importance as export commodities (Ghana.gov.gh, 2014).

The semi-deciduous zone nature of this area is characterized by double rainfall in June and October. The first rainy season is from May to June with the heaviest rainfall occurring in June while the second season is experienced from September to October. Temperatures are high and range between 26°C in August and 30°C in March.

Population of the region is considered very young with about 41.7 % aged below 15 years and 5.8 % older than 64 years. Females make up 50.8 % and males 49.2 % of total population (Ghana.gov.gh, 2014).

About 65.4 % of the people live in rural communities while 34.6 % live in urban areas. Approximately 58.4 % of the economically active population is employed in agriculture. The principal occupations for males are agriculture and its related work while females dominate in sales work (Ghana.gov.gh, 2014).

Figure 3: Location of Nsawam and study areas where study was carried out



Source: modified by author, 2014

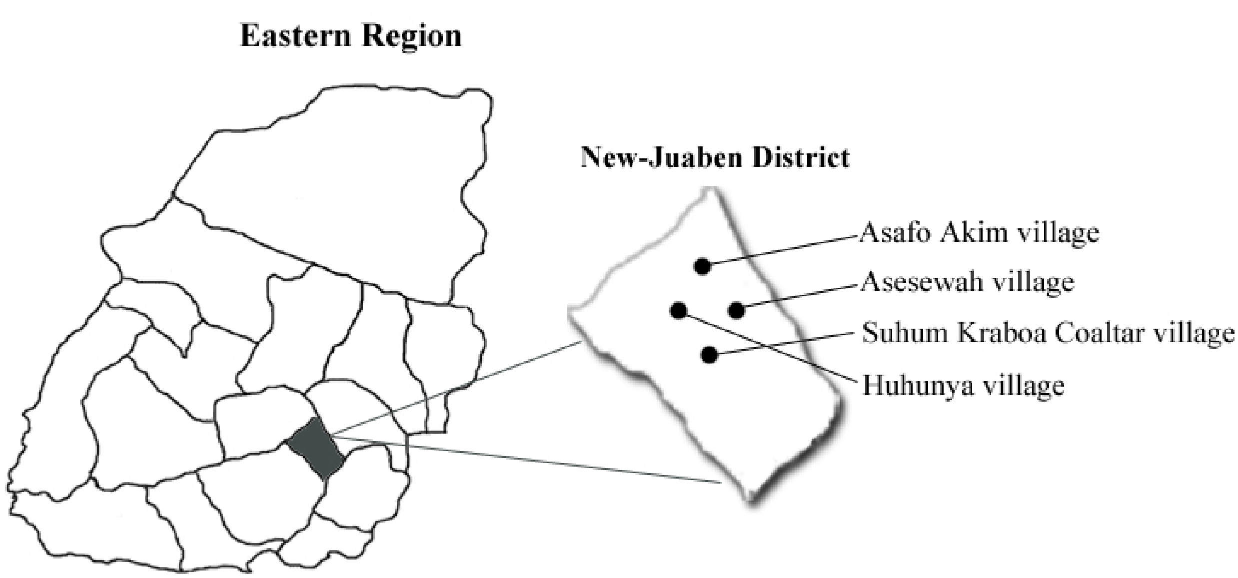
4.1.2 New-Juaben: Koforidua

Koforidua is the capital of the region and holds the offices of the New Juaben district. Population of the town in 2010 was 127,334 people. Koforidua acts as the centre of most commercial activities (MoFA, 2010).

Economic activities are mostly agro-based with agriculture constituting about 28.1 %, 27 % for industry and 44.5 % for services. Farming is practiced mainly in small settlements around the periphery of the town. Farmers predominantly grow staple crops like maize, cassava, plantain, cocoyam and vegetables. Cash crops like kola and cocoa are also cultivated. Livestock is also largely produced in the district. Animals bred include cattle, sheep, goats, pigs, poultry and snails with snails accounting for the highest production figures. There are many small scale farmers in the district and this as a result of high population density which leaves farmers with small land sizes for farming (newjuabeng.ghanadistricts.gov.gh, 2014).

The district falls within the semi-deciduous rain forest climatic zone with two rainy seasons of between 1200mm and 1700mm. From May to June and September to October are the two peak periods of the rainy season. The dry season is experienced between November and February. Humidity and temperature is generally high ranging between 20°C and 32°C (MoFA, 2010).

Figure 4: Location of New-Juaben where study was carried out



Source: modified by author, 2014

4.2 Research Design

The study was carried out between the months of July and September of 2014. Maize farmers were the target respondents for the study. The research tools employed were field survey, farm visits and personal interviews. A semi-structured questionnaire (see appendix 11) was used to capture information from 100 respondents through a convenience sampling technique.
The main research communities were determined before the field work had started. Rural communities in and around the Nsawam –Adoagyire and New-Juaben districts visited include Kweku Tawiah, Jaadwira, Teshie, Bekoekrom and Akototse, Huhunya, Suhum Kraboa Coaltar, Asafo Akim and Asesewah.

4.3 Data Sources and Collection Methods

Both qualitative and quantitative data were used in this study. Primary data was collected from maize producers from nine maize growing rural communities.
The study was conducted from July to September, 2014. A sample of 100 maize farmers was selected using the convenience sampling approach for individual personal interviews. This size was determined by using a sample size calculator; generating a 95 % confidence level and 10 % margin error, taking into account the number of farmers in the region.

Maize farmers used for the study were selected after consultations with extension agents for the two districts in order to identify the main maize growing communities. The survey involved individual interviews with maize farmers from selected areas using a semi-structured questionnaire. The questionnaire designed and administered consisted of both open and closed ended questions.

For more accurate data collection, transect walks, observations and focus group discussions (FGDs) together with and interview was combined.

The outline of the questionnaire covered issues such as constraints to production of improved maize varieties, cost of production, personal information; varieties cultivated, why farmers chose to adopt improved maize varieties and extension.

Review of literature was done to obtain broader understanding of how certified seeds can improve the economic situation of farmers, and what factors influence farmers' decision to adopt. Reviewed articles addressing similar topics were obtained from scientific journals, other well-known Internet sites such as FAO, Ministry of Food and Agriculture (MoFA), Council for Scientific Industrial Research (CSIR).

4.4 Data Analysis

All obtained empirical data from 100 respondents were transcribed into Microsoft Office Excel, and then coded and prepared for further processing and analysis. Data was transferred into the Statistical Package for Social Sciences (SPSS) Statistics 20 was categorized and coded for proper analysis.

The study applied qualitative analytical tools to generate descriptive statistics such as frequencies and percentage and mode were used to examine factors that determine the adoption of certified seeds by farmers and their awareness about certified seeds. Data collected was analyzed according to the methods described below.

Descriptive statistics was used to ascertain the level of awareness and adoption of IMVs. Farmers were asked about their awareness of certified seeds and the number of years they have cultivated it consistently. Farmers were also asked about where they obtained their seeds. The proportion of farmers who have adopted improved varieties and number of years was used to measure extent of awareness. Farmers were asked about their major sources of information, main reasons for growing improved maize varieties and if they received periodic trainings about the use of improved maize varieties. Maize varieties cultivated and reasons for the adoption of particular varieties were identified.

Adoption of technologies in the agricultural field is measured as a dichotomous response variable where (0= non-adoption of technology and 1-adoption of technology). The logit model is the standard method of analysis, when expected outcome variable is binary (Hosmer and Lemeshow, 2000). The use of the logit model for this analysis is consistent with the literature on adoption (Alston *et al*, 1998; Griliches, 1957; Rogers, 2003) which describes the process of adoption as taking on a logistic nature. The general form of the logistic regression model is specified as:

$$Y=X_i\beta_i+e$$

Where Y represents a dummy variable, which is equal to '1' when a choice is made and zero when a choice is not made. Thus, Y=1 if $X_i.>x^*$ and 0 if $X_i<x^*$ where x^* is when the combined effect of the explanatory variable ($X_i\beta_i$) reaches the threshold level. The dichotomous adoption decision model for the ith farmer is specified as follows:

$$Yi= 1 \text{ if } X_i\beta_i>X^*$$
$$= 0 \text{ if } X_i\beta_i<X^*$$
$$I=1, 2, 3\ldots\ldots\ldots n \text{ observations.}$$

Empirical Model

Reviewed literature shows that many factors influence adoption. However, this study focuses on five explanatory factors which include; age of farmers, educational level, gender, farm size and extension services. These socio-economic factors were considered because it is believed to influence farmers' decision to adopt an innovation or technology (Akudugu et al., 2012).

The explanatory variables included in the model were:

X_i- Age

X_2- Gender

X_3- Educational level

X_4- Farm size

X_5- Extension services

The Kendall's Coefficient of Concordance test was used to identify and rank the constraints to improved maize variety production in the study area. The Kendall's Coefficient of Concordance test is a nonparametric statistical procedure used to identify a given set of constraints or problems, from the most influential to the least influential as well as measure the degree of agreement or concordance among the respondents. The constraints were ranked from the most influential to the least influential using numerals 1, 2, 3 ... n in that order (where n is a positive integer). The total rank score for each constraint was computed and the constraint with the least score was ranked as the most pressing constraint, while the constraint with the highest score was ranked as the least constraint. The total rank score computed was used to calculate the Kendall's Coefficient of Concordance (W), which measures the degree of agreement between respondents in the ranking (Tetteh et al 2011).

Test of Hypothesis

The following null hypothesis was tested:

Ho: Respondents do not agree on the ranking of the constraints to maize production in the area. The null hypothesis is rejected if the calculated F – value exceeds the tabulated F – value (P-value), indicating that respondents agree with each other on the ranking of the constraints

To estimate the profitability of IMV production in the study area for the 2013/2014 cropping season, gross margin analysis was used. The Gross Margin is expressed as in equation 1 below to get the gross margin in amount per hectare which also expresses the Profit (P). If *P* is greater than zero, then maize production is adjudged to be profitable and vice versa. A value of zero is an indication of break even. The analysis was based on a hectare of land through scalar transformation of all individual observations (Bawa and Ani, 2014).

GM= GR-TVC………….. Eqn. (1)

GM= Gross Margin ($/ha)

GR= Gross Revenue ($/ha)

TVC= Total Variable Cost ($/ha)

Where GM is the Gross Margin ($/ha) and calculated by deducting the Total Variable Cost ($/ha) of production from the revenues generated; Gross Revenue ($/ha).

GM % = the gross margin percentage is derived by dividing the Gross Margin ($/ha) by Gross Revenue ($/ha) and then multiplying by 100 %.

5. RESULTS

5.1 Socio-economic Characteristics of Respondents

A summary of socio-economic characteristics of the farmers presented in Table 6 show that 1 % of the farmers were below 20 years of age. Those that fell within the age range 21-30 years accounted for 6 %, about 28 % of the respondents were of the age range 31-40 years while 38 % of the respondents fell within 41-50 years. Similarly 24 % of the respondents were of the age range 51-60 while only 3 % of the respondents were more than 60 years of age.

Sample data suggest that 24 % of the respondents had no formal education while 41 % of the respondents had basic education, 23 % had education up to the junior high level, and 7 % also had secondary education while only 5 % of the respondents attended the tertiary education.

Considering family size, it is also evident from table 6 that those who had between zero and less than five in the family consisted of 76 % while those who had between five and ten consisted 24 %.

Additionally, about 30 % of the farmers had below 5 years of farming experience (table 6). 33 % had between 5 and 10 years of farming experience, while about 37 % had 10 years of farming experience and above. The modal years of farming experience is 10 years and above.

The study indicated a male dominance in maize production in the study area (as shown in table 6). 69 % of the respondents were males with 31 % being females. The male dominance could be attributed to the capital intensity of maize production and the risks involved.

Also, majority (74 %) of the respondents are married. Only 12 % of the respondents were not married and 7 % were either divorced or widowed.

Table 6: Number and Percentage distribution of the farmers by socio-economic characteristics (n = 100)

Socio-Economic Characteristics	Frequency	%	Mode
Age Range (years)			
<20	1	1	
21-30	6	6	
31-40	28	28	41-50
41-50	38	38	
51-60	24	24	
>60	3	3	
Educational Level			
Non Formal	24	24	
Basic	41	41	
JHS	23	23	
SHS	7	7	
Tertiary	5	5	
Gender			
Male	69	69	
Female	31	31	
Family Size			
<5	76	76	<5
5-10	24	24	
Marital Status			
Single	12	12	
Married	74	74	
Divorced	7	7	
Widowed	7	7	

Farming Experience			
<5	30	30	
5-10	33	33	>10
>10	37	37	

Source: Field Survey Data, 2014

5.2 Level of Awareness of Improved Maize Varieties in the Study Area

The study observed that about 90 % of the respondents were aware of certified maize seeds however only 10 % of the farmers were not aware of certified maize seeds. This is confirmed by the fact that at least 80 % of respondents received information about certified maize seeds and also received periodic training 71 % on certified maize seeds (table 7).

15 % of respondents acquired their seeds from the local seed market. 20 % said they borrowed seeds from other farmers while 51 % said they used their own seeds saved from previous seasons. 14 % bought from certified seed market

Table 7: Farmers' level of awareness and knowledge on certified maize seeds (n=100)

Variable	Frequency	%
Awareness of certified seeds	90	90
Non awareness of certified seeds	10	10
Information about certified seeds	80	80
No information about certified seeds	20	20
Periodic training about certified seeds	71	71
No training on certified seeds	29	29

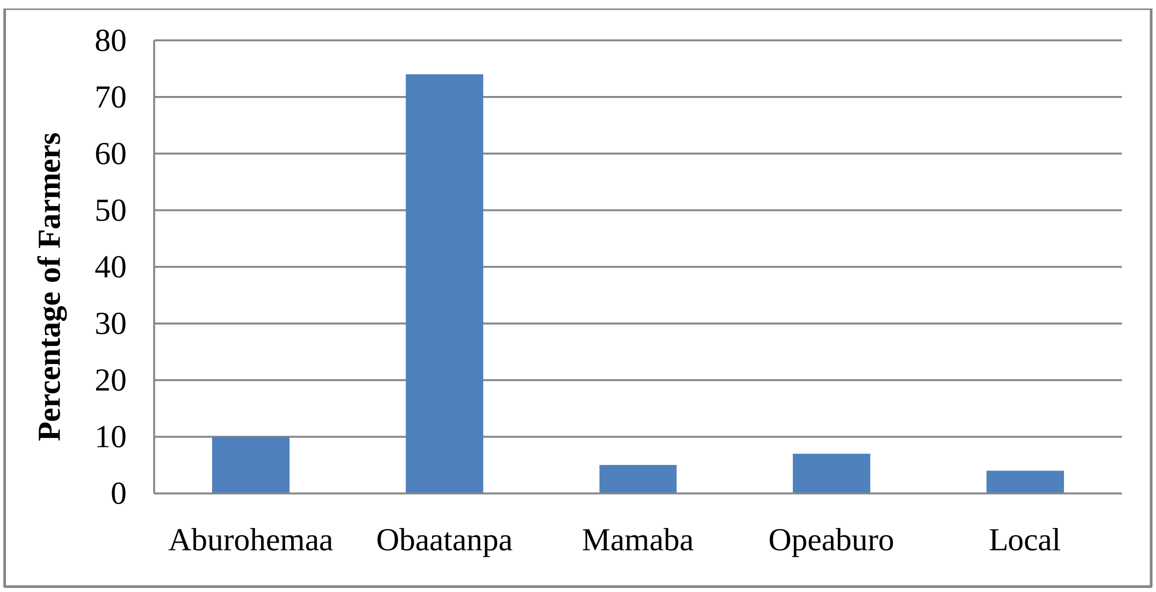
Source: Field Survey Data, 2014

Study result (Figure 5) showed that 74 % of farmers interviewed cultivated the Obaatanpa variety. Majority of farmers said they preferred this variety due to its high yielding, tolerance to pest and Quality Protein Maize (QPM) properties. 5 % cropped Mamaba, 7 % Opeaburo, 10 % Aburohemaa all certified seeds and only cultivated 4 % local maize.

The empirical studies showed that there was significance in yield difference between hybrids and OPVs. Popular OPVs in the study area showed variability in maturity. 10 % of respondents have planted maize for about 20- 26 years, 30 % between 5-10 years together with production of other crops such as cocoyam, plantain, peppers, cassava which are consumed at home. Average land size was 3.6 hectares per household. On average 3 hectares was allocated to maize production while the rest was used for cultivating other crops.

79 % of sampled farmers practiced farming as their main occupation and 65 % of farmers were involved in off-farm activities such as producing and selling honey in small quantities to support their families. 97 % of respondents also planted other crops, vegetables and pigs are reared as main domestic livestock.

Figure 5: Maize Varieties Cultivated in the Study Area



Source: Field Survey Data, 2014

Table 8 shows that majority of respondents (72 %) received information about improved maize varieties from extension agents. 5 % of farmers got their information from NGOs. 20 % received information from other fellow maize farmers while 3 % of those who had tertiary level education said they got information from Journals.

Table 8: Percentage distribution of farmers according to sources of information

Source of Information	Percentage
Extension Agents	72
NGOs	5
Fellow Maize Farmers	20
Textbooks/Journal	3

Source: Field Survey Data, 2014

5.3 Determinants of the adoption of IMVs

Table 9 shows maximum likelihood estimates of the logistic regression models, estimated odds ratios, measures of goodness-of-fit and associated with each coefficient. Only age of respondents and access to extension services were positively significant at 10 % and 5 % respectively. This implies that there is a positive relationship and an increase in age will increase likelihood of adoption. Gender, education and farm size were not statistically significant. The coefficient of age (0.756) increases by a factor of 2.130 which means as farmers advance in age they are more likely to adopt technologies that lead to increase in productivity since they will have a lot of farming experience. Similarly, the coefficient of extension services (2.148) also increases by a factor of 8.568 which means that the more farmers have access to extension services they are better off in adopting new technologies.

Also education and farm size were not statistically significant implying that the decision to adopt new technology does not necessarily dependent on farmers level of education and acreage of farm they cultivate. Gender, was not statistically significant, which implies that decision to adopt technology does not depend on whether a farmer is male or female.

Out of 100 maize farmers interviewed, 84 percent were adopters and 16 percent were non-adopters of improved maize varieties. The mean age of adopters was 45 years and 64 years for non-adopters; adopters were significantly younger in age than non- adopters

Households headed by females were made up 20 percent out of 100 respondents. The study captured averagely a household made up of 7 persons with a 67 year old adult as head of household with minimal formal education.

Table 9: Results of Logistic regression model for the adoption of improved maize varieties

Variable	Coefficient	S.E	Wald	Sig.	Exp(B)
Age	0.756	0.411	3.378	0.066*	2.130
Gender	0.829	0.828	1.001	0.317	2.290
Education	0.613	0.473	1.683	0.195	1.847
Farm size	0.172	0.305	0.318	0.573	1.187
Extension	2.148	0.781	0.781	0.006**	8.568
Constant	-2.704	1.677	2.601	0.107	0.067

***Significant at 1%, **Significant at 5%,*Significant at 10%
Source: Field Survey Data, 2014

Hosmer-Lemeshow Test: 6.427(P=0.599)
Likelihood ratio Test: 50.022
Correct prediction: 100 (29.1%)

5.4 Constraints in maize production

The result from the Kendall's Coefficient of Concordance analysis showed credit, drought, access to market and access to inputs as the main constraints in the study area as far as adoption of improved maize varieties is concerned (as shown in Table 10). Access to market, storage and access to inputs were the least occurring maize production constraints in the study area.

The null hypothesis (Ho) that there was no agreement among the respondents over their ranking of the constraints to maize production was rejected at the 1 % significance level because the calculated F-value (7.68) was greater than the p-value (0.000). Hence there was agreement among respondents on the ranking of the constraints. The Kendall's Coefficient of Concordance analysis showed that 7.2 % of the farmers were in agreement with each other on the ranking of the constraints to maize production.

Credit constraints were found to be the second most pressing challenge faced by respondents (Table 10).

Table 10: Ranking of Constraints to maize production in the study area

Production Constraints	Overall Rank	Mean Rank
Drought	1	2.51
Access to credit	2	2.63
Access to input	3	3.04
Storage	4	3.38
Access to market	5	3.45

W=0.072, TMR=15.01, Fcal=7.68, P-value (0.00)

Source: Field Survey Data, 2014

5.5 Profitability of IMVs for the 2013/2014 Cropping Season

Table 11 summarizes estimation of gross margin analysis of improved maize varieties production in the study area. The average yield of improved maize variety was found to range between 620 kg/ha and 876 kg/ha which is far below the national average of 1500 kg/ha (MoFA, 2010). Male farmers on the average out yielded their female counterparts in the study area which also translated into revenues received from maize produced.

Analysis of the result indicates that male maize farmers on the average received slightly higher prices for their produce as compared to their female counterparts.

The survey revealed that most farm lands were owned through inheritance hence farmers did not incur any cost associated with farm land. The cost of ploughing for males was found to be slightly higher than females. This was because tractor services in the area were considerate to female farmers.

Similarly, males had higher cost in terms of sowing than their female counter due to the fact that female farmers are better at organizing group work as labour for farm work.

Conversely females received higher cost for weeding than males because male farmers are stronger and resilient in farm work than female farmers. Cost of fertilizer for males was slightly higher than females. On the average the production cost for males were higher than that of females.

Results of the profitability analysis indicated that on average, maize production in the study area was highly profitable with males accruing a profit of ($833.65) and females ($410.61) with a gross margin percentage of 89 % and 80 % respectively.

Table 11: Costs and Return Analysis to IMVs Production in the 2013/2014 Season

	Male	Female
Average yield (Kg/Ha)	863	627
Price ($/Kg)	108.49	80.92
Gross Revenue ($/Ha)	**936.27**	**507.37**
Land and Capital Cost ($/Ha)		
Land (owned through inheritance)	-	-
Ploughing	18.66	17.15
Weeding	10.74	10.83
Depreciation (Hoe, Cutlass, Sacks	18.99	15.07
Miscellaneous	5.21	5.87
Labour Cost ($/Ha)		

Sowing/Planting	15.56	14.50
Weedicide application	13.87	14.09
Fertilizer application	19.59	19.25
Total Variable Cost	**102.62**	**96.76**
Gross Margin ($/ha)	**833.65**	**410.61**
% of Gross Margin Profit ($/ha)	**89 %**	**80 %**

Source: Field Survey Data, 2014

6. DISCUSSION

6.1 Socio-economic Characteristics of Respondents

The implication of these findings is that majority of the respondents belong to the middle aged group and those in their late 40s. This is an advantage since they are supposed to be physically able and more mentally alert in learning new technologies than the older farmers especially those in their 60s. This implies that majority of the farmers have small household size which does not ameliorate production and productivity since farm families who have large household size means less labour cost since family labour will be used to cut down other operational cost along the production chain. Education has been shown to be a factor in the adoption thereby increasing productivity. The percentage of farmers who had on formal education attest to the fact that at least majority of the respondent are in a better position to be aware of, understand and adopt new technologies of farming. The male dominance could be attributed to the capital intensity of maize production and the risks involved. Marriage is not only a social obligation in most communities in the study region but also a source of family labour especially for male farmers and a possible avenue for female farmers to increase their chances of having access to farm land.

6.2 Level of Awareness of Improved Maize Varieties in the Study Area

Level of awareness of IMVs is high in the study area. Majority (90 %) of sampled famers were aware of improved maize varieties. This high level of awareness of IMVs is also reported by Akinbode and Bamire (2014) whose results showed a 97.8 % level of awareness of IMVs with 91.2 % of farmers who were aware being adopters of IMVs in their study of determinants of the adoption of improved maize varieties in Nigeria. Kudi et al. (2011) obtained similar results by recording in their findings that 100 % of their respondents were aware f IMVs. Results obtained from descriptive statistics revealed that four IMVs were cultivated in the study area; Mamaba (5 %), Opeaburo (7 %), Aburohemaa (10 %) and Obaatana (74 %). Majority of respondents (74 %) preferred the Obaatanpa variety which was released in 1992. The general high preference for this variety by maize farmers in Ghana is confirmed by Ragasa et al. (2014) who also reported in their findings that older varieties are more popular among

Ghanaian maize farmers and even though there are new hybrids with higher yields, farmers still show little interest in replacing the Obaatanpa variety.

For majority of farmers, extension agents were their main source of information about IMVs. This finding is in line with Nsoanya and Nenna (2011) and Lightfoot (2003) who also found that farmers mostly depend on public extension agents for information services. The popularity of the Obaatanpa variety can be explained by the huge presence of extension agents in the study area can be said to account. Kudi et al. (2011) reported similar findings which revealed that extension agents are the key sources of information on improved technology thus; the more contact farmers have with extension agents, the more the tendency to adopt a technology.

6.3 Determinants of the adoption of improved Varieties

The coefficient of age of farmers was found to be significant at a 10 % probability level with a positive relationship with adoption of IMVs. This result is in line with the study of Bawa and Ani, (2014), which reported that adoption of agricultural innovation increases with the age of farmers. They further explain the positive relation of age with innovation stating that, farmers' attitude towards the use of innovation changes with age; the older the famers get the more willing they are to put related innovations to use. This finding is however in contradiction to other similar research work done by Cavane (2007), Chirwa (2005) stating that as farmers get older are the more risk averse they are, to adoption of new technologies.

An extension agent was observed as having a significant and relating positively with adoption of IMVs. The work extension agents are crucial as they represent a source of information new agricultural technologies. Akudugu et al. (2012) further reports that farmers' access to information through extension services reduces their uncertainty levels about a technologies performance and therefore allows them to make object assessment over time thereby facilitating adoption. Similar observations were made by (Ademiluyi, 2014; Etoundi & Dia, 2008; Bawa and Ani, 2014. Frequent contact with the extension service has been reported to have a positive and significant influence on the adoption decision of farmers (Nkonya et al., 1997; Tesfaye et al., 2001; Doss et al., 2002; Shiferaw & Tesfaye, 2006). This means farm households are more likely to adopt modern technologies if they have access to extension services.

6.4 Constraints in maize production

Farmers in the research area reported that their farms were mainly rain fed and are therefore affected by erratic changes in rainfall patterns which in turn affects their production. The reliance on this traditional farming method explains why respondents ranked drought as the most pressing constraint. This result is consistent Abdoulaye et al, (2012) who also noted in their findings that when there is consistent rainfall patterns over a number of years, farmers become used to a particular sequence of farming activities and thus, sudden and drastic changes from well-known patterns have severe implications on agricultural production.

During discussions with farmers, they mentioned that the lack of credit affected their ability to purchase inputs such as fertilizers and new seeds. Ragasa et al (2014) obtained similar results in their survey that indicated that credit constraint was a reason for sub-optimal use of fertilizers by maize farmers in Ghana. Nsoanya and Nenna (2011) also observed in their findings that the high cost of inputs such as fertilizers and agro-chemicals were major constraints associated with the adoption of improved varieties and most farmers will adopt a new idea if they have resources and were not hampered by physical, social or organizational constraints.

6.5 Profitability of adoption of improved varieties to farmers

Results showed that adoption of improved maize varieties were profitable in the study area. The total variable cost (TVC) incurred by male and female famers were 102.62 dollars/ha and 96.76 dollars/ha respectively. Generally male farmers had higher revenues than their female counterparts. The higher prices received by males could be due to better bargaining and marketing skills as compared to their female counterparts. To reduce the cost of production, all farmers employed organized labour and family labour which contributed to positive gross margin and higher profitability levels. The findings are in line with Ragasa et al. (2014) in their calculations of maize profitability in the different agro-ecological zones in reported that including family labour in the calculation of profitability results in negative gross margins. Okoboi et al. (2012) further confirm these findings in their study, reporting that when the cost family labour was imputed into maize production costs, the net profit is negative.

The use of recycled seeds was high among farmers in the study area which. Farmers did this to further reduce the cost of production. 51 % cultivated own seeds which they had saved from previous seasons. This practice however reduces yield which results in low gross profit margins. This result is also addressed by Okoboi et al (2012) who describes the use of home-saved seeds was a waste resource as the application of fertilizer on this type of seed resulted in either low or similar levels of yield and gross profit margins.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The study gave insight into the factors that influence the adoption of improved maize varieties and its impact on the financial situation of maize farmers in and around the New-jubeng and Nsawam-Adoagyire districts. The outcome of this study will enable agricultural policy makers to address the problems and factors that influence adoption of IMVs.

Results of the study have shown that the awareness and adoption of IMVs is high among farmers although proper knowledge of using certified seeds is lacking. Analysis showed that the age and extension services were key factors determining adoption. The importance of extension agents in the adoption of IMVs was further emphasized as majority of respondents identified extension agents as their main source of information. Farmers' characteristics such as gender, education and farm size did not significantly influence adoption.

The main constraints identified were drought, no access credit, and little access to inputs, unavailable storage facilities and market access difficulties with drought being the most pressing issue.

According to the study, IMVs despite all its challenges, the cultivation of IMVs was however profitable; with high gross profit margins.

With the rise in population size and urbanization there is the need to introduce farmers to more improved agricultural technologies to increase yield, food security and income levels among farmer households

The positive and significant effect of extension agents suggests a need for government and NGOs to improve quality of services in order to justify the high investments in the area of research.

7.2 RECOMMENDATIONS

Based on the findings of this study, it is recommended that policies should target improving access to fertilizers and seeds of IMVs. Since the adoption and continued use of improved maize varieties involves investment into more inputs, efforts should be made to increase credit accessibility to farmers to enable farmers invest in capital needed for production. An effective investment in inputs will help sustain an increase in output.

Farmers' heavy reliance on rainfall affected productivity of IMVs and drought was ranked as the most pressing problem faced by farmers, contributing to loss of yield in the study area.

This finding thus recommends an evaluation of the suitability of IMVs for particular agro-eclogical zones.

Even though majority of farmers are aware of the existence of IMV they lack the knowledge about its use. Therefore, to realize the full benefit of IMVs, field training of farmers should be more focused on following recommended practices in the use improved maize varieties. This has the potential to increase yield and further increase the probability of adopting improved maize varieties.

In addition, well trained and equipped extension agents will be required for disseminating information to famers. It is necessary to increase contact with extension agents considering the positive and significant relationship between extension and farmers. Extension agents are the first source of information to many farmers. Good communication of recommended practices from well equipped extension agents will ensure that farmers acquire the knowledge about use IMVs.

Finally, in order to effectively address the constraints faced by maize farmers, a bottom-up approach be should be followed. It is recommended that government and policy makers and seed researchers involve farmers in their activities.

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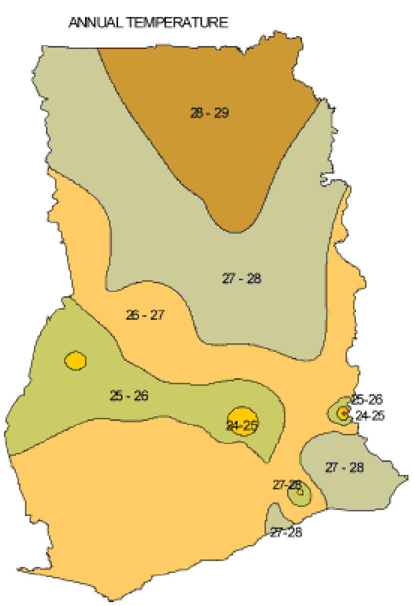
9. APPENDICES

Appendix 1: Map of Ghana showing the agro-ecological zones

Source: Germer and Sauerborn 2008

Appendix 2: Annual temperature ranges in Ghana



Source: apipnm.org, 2000

Appendix 3: Map of Ghana showing the 10 administrative regions, capitals and neighbouring countries

Source: Bizbilla.com, 2015

Appendix 4: A farmer with the Obaatanpa certified seed bought from the local seed market

Appendix 5: Interviews with local maize farmers

Appendix 6: A maize farm intercropped with cassava

Appendix 7: Harvested maize in a storage room

Appendix 8: A farmer with his harvested maize for use at home

Appendix 9: Some pigs reared for sale

Appendix 10: Questionnaire used

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Department of Economics and Development

THE DETERMINANTS OF ADOPTION AND IMPACT OF IMPROVED MAIZE VARIETIES IN THE EASTERN REGION

QUESTIONNAIRE

Collected Data will be used only for the purposes of this study

Eunice Ansah

Date of Interview………… Place of interview……………………………………

1. Name of respondent…………………………………………

2. Age of respondent in years

   a) 15-19 b) 20-24 b) 25-29 c) 30-34 d) 35-39 e) 40-44 f) 45-49 g) above 50

3. Gender of respondent a) male b) female

4. What is your highest level of formal education?

   a) Non-formal b) basic c) JHS d) SHS e) tertiary

5. Marital status? a) single b) married c)divorced d) widow /er

6. Number of children………………………….

7. What is your family structure?

Age	Male (n)	Female (n)	Study (n)	Work on farm (n)	Off-farm activities (n)
<7 years					
7-14 years					
15-22 years					

8. What is your religion?

a) Christian

b) Muslim

c) Other…………

9. If other please specify………………..

10. Is farming the main occupation?   A. YES   B. NO

11. If yes, how many years have you been farming? ………………

12. If no, what is your main occupation? ………………

13. What is the size of your farm land? (in acres)   Area :……………………ha

14. What size of your farm (in acres) did you use in planting maize last season? ....

15. Which maize variety do you grow? ....

16. Why do you grow these varieties?

a)………………………………………

b)………………………………………

c)……………………………………..

d)………………………………………

17. How long have you grown this variety? …………………….years

18. Which other varieties are you aware of?

a).…………………………………..

b)………………………………

c)……………………………………

d)…………………………………..

19. Which other varieties have you planted before?

a)……………………………..

b)………………………………

c)………………………………

20. Do you know about certified seeds? A) yes b) no

21. What are the names of certified seeds you know?

22. What is your main source of irrigation?

a) rain-fed b) well c) Small Reservoir-based d) Communal Irrigation Systems

23. Do you receive information about newly improved seeds or certified seeds? a. yes b. no

24. If yes, from who? a) other farmers b) NGOs c) extension officers
25. Why do you grow maize?
26. Do you receive any periodic training about the proper use of certified seeds? A) yes b) no

27. If yes, from who? ……………………………..
28. How many bags did you harvest last season?.....................................kg

29. At what price do you sell a bag? ………………………………..

30. What constraints do you face before, during production? Ranking constraints on a scale of 1-5 in ascending order 1 being the least constraint

a) Drought 1 2 3 4 5
b) Diseases 1 2 3 4 5
c) Credit 1 2 3 4 5
d) Access to input 1 2 3 4 5
e) Marketing access 1 2 3 4 5
f) Transportation 1 2 3 4 5
g) Distance to market 1 2 3 4 5
h) Access to storage facilities 1 2 3 4 5

31. If other, please state and rank ………………………………

32. How many years have you been a maize farmer? …………………..years

33. Do you plant other crops? A) yes b) no

34. If yes, which other crops do you grow? ....

35. What is the distance of the nearest sale point for agricultural inputs in your area?......km

36. From where do you obtain your seeds?

    a) Own saved seeds

    b) Seed exchange with other farmers

    c) Local seed market

    d) Certified Seed market

    e) Government

    f) NGOs

37. Do you have access to extension services? a) yes b) no

38. What quantity of maize do you

    a) Use at home ………

    b) Give as gifts…….

    c) Keep as seeds for next season

39. Do you have access to credit? a) yes b) No

40. If yes, name the source a) bank b) credit union c) NGOs d) other…………………

41. Do you have any off-farm activity for income? A)yes b) no

42. If yes, name the activities a) …… b) ………….. c)…………… d)………

43. How much does it cost you to plant an acre of maize?

	Cost /acres	Source of labour	
Ploughing			
harrowing			
Sowing/ planting			
weeding			
Harvesting			
Threshing			
Winnowing			
Other (specify)			
Total cost			

44. Is there a ready market for improved maize varieties? a) Yes b) no