YIELD GAP ANALYSIS IN MAIZE PRODUCTION FROM STAKEHOLDERS PERSPECTIVE IN *EJURA-SEKYEDUMASE* DISTRICT OF THE ASHANTI REGION OF GHANA

BY

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DECLARATION

I hereby declare that this submission is my own work towards the Masters in Environmental Resources Management and that, to best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree by the university, except where due acknowledgement has been made in the text.

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ABSTRACT

Maize is a major cereal crop in Ghana but production at the local level is often below both domestic and industrial demand. Promising ecologies exist in the *Ejura-Sekyedumase* District located in the transitional zone of Ghana with large stretches of land to favour large scale production of maize. Statistics indicate a low average yield below 1.9 t/ha in the *Ejura-Sekyedumase* District which is far below the potential yield of 4-5 t/ha. There is a necessity to discover and address yield constraints in order to boost maize production in the area. An investigation was undertaken using the Food and Agriculture Organization (FAO) guidelines and other considerations of yield gap (revolving around technical, biophysical and socio-economic issues) to ascertain yield limitations from the perspective of major stakeholders (farmers, researchers, and extensionists). The outcome showed that the current constraints to yield are poor seed source (use of seeds from farmer's own farm) and selection, mid-season drought, pest and disease prevalence, lack of access to credit and inadequate credit facilities, low market price, low profit from farming, high cost of fertilizer, low literacy and educational status of farmers. In addition, water stress, late or early rainfall, lack of irrigation facilities and practice, poor soil fertility monitoring, use of local varieties, low adoption of technologies, poor investment, poverty and low income level, landholding and land tenure were noted. Holistic and collaborative approach such as farmers, researchers and extension effort to the use of recommended varieties, timely credit availability and accessibility to farmers, reducing fertilizer cost, timely distribution of government subsidized fertilizer, intensification of extension activities will arrest the situation to boost maize production to meet both local domestic and industrial demand and for export.

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CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Ghana's agricultural sector is basically on small scale with minimal commercialization. It is characterized by different agro-ecological diversity, erratic and unreliable climatic conditions, poor socio-economic conditions of farmers and numerous technical constraints, which affect agricultural production. The unfavourable climatic factors constrain planting periods, crop growth and development, crop yield and even harvest and post harvest activities.

Environmental resources like soil and water contribute to maize yield. Soil minerals are needed in their right proportions for higher yield. Agricultural inputs are capital resources that must be optimized. A deficient soil mineral needs a restoration either with the use of organic or inorganic fertilizers to make soil condition conducive for higher yield. Fertilization was considered under the technical aspect of the yield gap analysis. Water resource mainly atmospheric, surface and ground water are major inputs in agriculture. Atmospheric water resource also known as rainfall is a major factor of production under rain-fed agriculture. Rainfall, prevailing pests and diseases are environmental factors of production that was captured under the biophysical factor in yield gap analysis.

Maize is a major staple food crop in Ghana and its domestic demand is projected to grow at a compound annual growth of 2.6 % between 2010 and 2015 (MiDA, 2010). Maize production serves as income generation activity to farmers (through sale of produce), job generation, agricultural research organizations, inputs dealers and service providers, intermediary traders, as well as private and government sectors. Maize is an important commodity in the West Africa sub-regional trade, particularly between Ghana, Burkina Faso, Mali, Togo and Niger through mainly informal trading (MoFA-SRID, 2006). One million out of the expected 5 million small scale farming households in Ghana derive their main income from maize production. In spite of all the benefits derived from maize, yield is still below the maximum potential.

The African continent demonstrates the greatest gaps between potential yield and realized yield for several types of crops more especially maize and rice (Licker *et al*., 2010; Neuman *et al*., 2010). The yield gap of maize is large in Africa and it varies from around 2.5 to over 12.5 t/ha per harvest (Meijerinka *et al.,* 2011). Demand for maize is high irrespective of the production deficit. In Sub-Saharan Africa alone, annual demand is projected to be around 504 million tonnes by 2020 and currently importation is around 2–3 million tonnes of maize annually and that amount is likely to rise rapidly, particularly through food aid programmes (IFPRI, 2000 cited in Mugo *et al.,* 2002).

In Ghana yield gap is real as well as in the *Ejura-Sekyedumase* district which remains the leading producer of maize in the Ashanti Region of Ghana. There is a gap between farmers and researchers yield, yield gap among farmers themselves and between projected demand and current production levels. A report by the Statistics Research and Information Directorate (SRID, 2007) shows average cropped areas per farm holder as 1.02 ha with an average yield of 2.4 t/ha. Maize is grown in the whole of Ghana but the leading producing areas are mainly in the middle-southern part (transitional and forest zones) with an estimated 15% grown in the northern regions of the country. Although the average volume of maize produced in Ghana has increased annually by 3.1% (1997-2006), the current national average estimated yield is still low at 1.6 t/ha (MoFA-SRID, 2008). However, with improved technologies, yields of 4-5 t/ha have been recorded in on-farm demonstration fields (MoFA-SRID, 2008). This means that it is possible to increase maize yield if relevant production factors and practices are put in place.

Primarily, yield gap in the production of maize like any other cereals is attributed to a number of production factors. FAO (2000) recognizes four causes of yield gaps namely, biophysical (including climate of the area, soil type, available water, pest and diseases), technical/management (varietal selection, seed source, tillage, resource or input efficiency), socio-economic (socio-economic status, income of household, family size, tradition and knowledge), institutional and technology transfer like market price, land tenure, credit were considered as part of socio-economic factors whilst inputs supply like fertilizer, seeds were added to the technical factors. Also, Lobell *et al* (2009 cited in Meijerinka *et al.,* 2011) identified biophysical constraints (including insufficient water, insufficient nutrients, sub-optimal time of planting, extreme weather events like windstorms, pests and diseases etc.), socio-economic (low profit maximization, lack of knowledge on best management practice, high transportation costs and distorted market for fertilizer) as cereals production factors.

In Ghana, yield increment has been constrained by low education among farmers resulting in low adoption of technology, high price of fertilizers, poor selection of seeds, poor access to markets, inadequate inputs availability and credits.

Among the biophysical parameters in yield gap, climatic change which causes erratic rainfall seems to be the most significant constraint in Ghana for the future. The Environmental Protection Agency (EPA) has projected 20-40% decline in rainfall and 4.5^{o}C temperature increase by the year 2080 and in this regard, 7 % reduction in maize production is anticipated (Donkor, 2008). Socio-economic limitations will greatly be felt especially considering the traditional ways of farming and knowledge of the famer. Lower yields in Ghana have been attributed to traditional farming practices (MoFA-SRID, 2008).

Social and economic status of farmers, family size, farm holding, knowledge and farmers' level of education and contact with extension agent (RAP, 1999).

Technical constraints also contribute to lower yield of maize production in Ghana. Background of the report drafted by WAB Consult (2008) shows that the use of traditional farming practices, low yielding varieties, poor soil fertility and insufficient fertilizer usage, low plant population and improper weed control immensely contribute to lower yield of maize in Ghana. The low yield persist even though improved maize varieties with varying maturity days have been developed and released by the Crops Research Institute of Ghana (CSIR) (Badu-Apraku *et al.*, 1992; Sallah *et al.,* 1997; Twumasi-Afriyie *et al*., 1997). Even though adoption of these varieties is wide spread by farmers in the country (Dankyi *et al*., 1997; Morris et al., 1999), maize yield is still low and below expectation. Average farmers' yield in Ghana is 1.5t/ha which is generally below expectation and in some instances as low as 0.5 t/ha (PPMED, 1998). Meanwhile, northern and southern Africa achieve 5.0t/ha (PPMED, 1992), Julin Province of China 6.3t/ha (Qiao *et al*., 1996), Indonesia 8.0 t/ha (Krisdiara and Heriyanto, 1992) and Ethiopia 7.0-8.9 t/ha (Onyango and Ngeny, 1997).

The differences in yield in maize production can be attributed to several factors such as climatic conditions, technical and institutional arrangement, soil conditions as well as socio-economic conditions of farmers. E-TIC (2012) noted that low yields of maize in sub-Saharan Africa can be attributed to a multiplicity of factors namely:

- Poor soil fertility as one of the leading challenges for small-scale farmers.
- The use of low quality seeds. Poor seed selection and limited use of new improved commercial varieties are among the reasons farmers are not able to cope with the productivity demand.

- Unsuitable crop husbandry practices such as late planting, poor weed management, pest and disease attacks (stem borers) and the striga weed are important constraints that lower maize yields.
- Soil moisture stress is a continuous problem for many farmers who continue cultivating maize under rainfed conditions. The erratic nature of rainfall, including distribution subject maize to severe soil moisture stress reducing yields significantly.

Ghana as part of Sub-Saharan Africa is also affected by these production constraints. Drought stress is a major constraint to Ghana's rainfed agricultural system especially maize production (Ohemeng-Dapaah, 1994; Kasei *et al.,* 1995; Obeng-Antwi *et al*., 1999). Lower yields have been attributed to traditional farming practices, the use of low-yielding varieties, poor soil fertility and limited use of fertilizers, low plant population, and inappropriate weed control (MoFA-SRID, 2008). Irrespective of these unfavourable production factors, yield should be increased to meet the growing demand. Means of bridging the yield gap therefore become paramount in order to meet demand.

Worldwide agricultural production ought to increase by 70% to meet demand by 2050 (Bruinsma, 2009). Koning *et at* (2007) suggested the followings as means to bridge the gap:

- Expansion of area under cultivation
- Intensification on existing farm land
- Narrowing yield gap in farmers' field
- Introducing high yielding varieties
- Postharvest losses reduction.

In other words, production efficiency and use of high inputs would bridge the production gap. Points noted by Koning *et al* (2007) are possible, espercially use of high yielding varieties which is duly considered in this work.

This research analyzed the existence of substantial yield gaps constraints across *Ejura-Sekyedumase* District in the transitional zone, and yield difference among farmers in the target area at a point in time (farm level yield). The question is what contribute to the yield gap at the study site? Answering this question reveals yield dependant factors like changing/varying climate (temperature and rainfall), socio-economic status (age, type of farmer, household size, education/farmers knowledge on best farming practices, credit facility, investment, market availability and accessibility) and technical issues (seed sources and seed selection, tillage practices, fertilizer application). These factors are pertinent to improved production as noted in literature surveyed.

1.2 Problem Statement / Justification

The truth is that Ghana as in other African countries, experiences low crop yield far below the maximum potential yield considering even the cropped area alone. Annual maize cropped area is on the average about 846,300 ha with total annual production of 1,470,000 Metric tonnes in Ghana (MoFA-SRID, 2009). That is about 1.7 t/ha. Approximately, maize average yield is 1.5 t/ha under traditional production methods and rain fed conditions according to MiDA (2010). Moreover, domestic maize production fell from 1,871,695 t in 2010 to 1,683,984 t in 2011, representing a decrease in production of the staple crop by 11%. The deficit of 267,000 t is expected to continue by 2015 if urgent measures are not put in place to address the cavernous gap. It has been noted that growth of agricultural production has seen area expansion whilst crop yields are at a standstill from 1960-2005 (Lal, 2010).

Average yield of maize in developed countries stands up to 8.6 t/ha whilst developing countries still experience very low yield up to 1.3 t/ha (FAO statics cited in IITA, 2009). This suggests a vast yield gap of 7.3 t/ha between the developed and developing countries. The continent of Africa shows the uppermost gaps in view of the potential yields and realized for several crops especially maize and rice (Licker *et al.,* 2010; Neuman *et al.,* 2010).

Current yield for most staple crops are below achievable yield in Ghana. Crop yield is 20-60% below achievable yield even under existing technology coupled with modern inputs like fertilizer and improved seeds (MoFA, 2007a). Again (MoFA, 2007) statistics on maize from 1990-2006 revealed 1.5 t/ha average yield, 2.5 t/ha achievable yield, 1.0 t/ha yield gap which is 40% yield gap in Ghana. Maize is a most essential cereal crop currently grown in Ghana (Al-Hassan and Jatoe, 2002). *Ejura-Sekyedumase* which is situated in the transitional zone is a major area of maize production in the country. Again, it has been noted that the transitional zone is essential for large scale cereal production (Morris *et al*., 1999). Analyzing the yield gap in the area will reveal production levels and constraints and help project into the future crop yields. Knowledge on production constraints will help administer appropriate mitigation measures to bridge the gap.

1.3 Importance of the Study

Maize is currently produced in almost 100 million hectares of land in 125 developing nations and it is one of the three most widely grown crops in 75 nations (FAOSTAT, 2010).

Maize is a very essential cereal crop both in terms of production and consumption in Ghana (Breisinger *et al.,* 2011). It is significantly placed third after wheat and rice in terms of production around the world (IITA, 2009).

Maize is a staple food and provides the needed energy to both humans and animals. More than 20 developing countries in Latin America and Africa acquire 15-20% of their total daily calories in diet from maize (Adetiminrin et al., 2008). Considering the benefits derived from maize locally and nationwide, it becomes worthy to find out why yield is low at the local level where production is on large scale in Ghana. Low yield of maize just like any other crop may be attributed to multiple factors grouped as biophysical, socio-economic and technical as identified in various literatures. The yield gap generally has two parts (Pratt et al., 2011). It is believed that one part can never be closed because it represents the difference between a theoretical maximum (model simulation) or laboratory setting (research station and experimental fields) and the optimum that can be achieved is non-perfect. The second part of the gap arises when farmers practice and use amounts of inputs that differ from what is needed to achieve the technical maximum farmer yield. This is a reflection of a number of biophysical constraints which could be solved (Meijerinka, 2011). Bridging the yield gap has a whole benefit to producers, direct and indirect consumers, the nation and the world at large: as yield increases, farmers income increases, food security is assured, researchers are also engaged in unravelling what is behind the gap. This approach has advantage of revealing any important details that may be ignored or overlooked, key holders participation and inclusions are better enhanced, their concerns and observations are identified and incorporated into the problem identification.

Identification of yield gap constraints is a step taken to solve food insecurity problems, alleviate poverty, and improve socio-economic conditions of smallholder farmers. Bridging the yield gap will ensure more food is available to meet the high domestic demand including the poultry industry and possibly for export.

1.4 Objective of the study

The main objective of the study was to assess the factors affecting low yields in the *Ejura-Sekyedumase* District in the Ashanti Region of Ghana.

1.4.1 Specific objectives

To achieve the main objective, the following specific objectives were considered:

1. To assess the biophysical factors that affect yield
2. To assess the socio-economic factors that affect yield
3. To assess the technical factors that affect yield
4. To propose solutions to the identified constraints.

1.5 Outline of the Study

The study is contained in six chapters. Chapter 1 presents the special scenery of yield gap analysis, concise history, nature and significance of the study, general and specific objectives of the study. Chapter 2 briefly takes a look at the important studies accomplished on yield gap from a global perspective and constraints in maize production.

Chapter 3 covers the materials and methods used to conduct the study starting with a description of the study area, sampling procedures and data sources, analytical tools and techniques utilized in the analysis. Chapter 4 presents the results of the study in graphical and tabular forms together with explanations. Also, the Chapter synthesizes the results of the study and tries to detect the cause-effect in dealing with the subject under study. The results are also discussed in relationship with other relevant studies wherever possible. Finally, Chapter 5 summarizes the results of the study and clarifies how far the objectives of the study have been achieved. It also puts forward the relevant policy implications, drawing conclusions and making recommendations for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There are quite a number of studies on changing climate constraints, socio-economic status of farmers and technical constraints in maize production and on yield gap analysis. Much more work has also been done on different crops and in different areas. These studies reviewed are grouped under the following sub-headings:

- The view of yield gap
- Physiology of the maize crop
- Factors affecting production
- Problems with maize production and challenges faced by smallholder maize farmers in Ghana.

2.2 The View of Yield Gap

Yield gap as defined by Alam (2006) is the difference between potential farm yield and actual yield and this gap is exploitable and can be curbed by research and extension approaches and government intervention. The concept of yield gaps originated from the studies conducted by the International Rice Research Institute (IRRI) in the1970's (Mondal, 2011). Yield gap has since become a global issue since its inception in crop production.

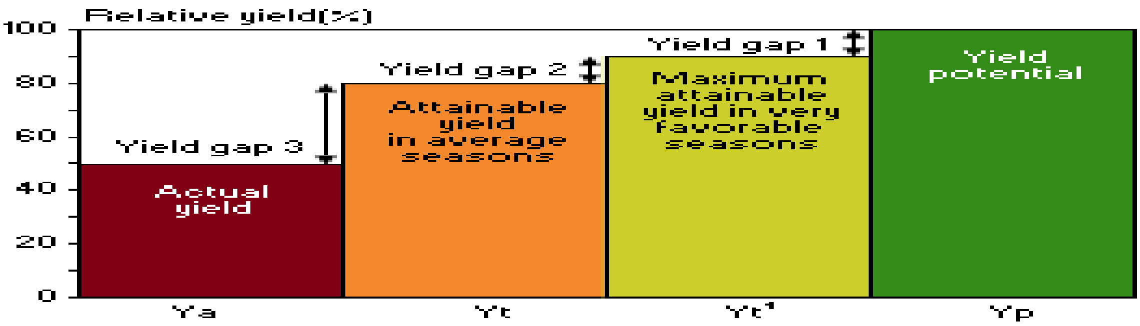


Figure 1: Schematic overview of yield gap analysis (Pasuquin and Witt, 2007)

2.2.1 Yield gap- a global issue

Yield gaps of approximately 20 % are common in developed countries (Keith *et al*., 2010). Comparing yields in Sub-Saharan Africa to other tropical regions gives a clearer picture of the yield gap. Average yields and yield growth rates in other countries in tropical rainfed environments prove the existence of a gap. From 2005-2008, average maize yields were estimated at 3.8 t/ha in Brazil, 3.1 t/ha in Mexico, 2.5 t/ha in the Philippines, and 3.9 t/ha in Thailand, compared to 1.4 t/ha in Sub-Saharan Africa (Melinda *et al.,* 2011). Annual yield growth of maize from 1961-2008 averaged 2.4 %, 1.8 %, 2.8 % and 1.6 % respectively in Brazil, India, Philippines and Thailand, on average about double the 1 %growth in Sub-Saharan Africa (Melinda *et al.,* 2011). By means ofspatial analysis, 10 % reduction in maize production has been predicted by 2050 in Sub-saharan African and Latin America (Thornton *et al*.,2009). Nigeria's national average maize and other cereals yield have actually decreased from its potential yield (Alamu, 2001). Average yield of maize in developed counties stands up to 8.6 t/ha whilst developing countries still experience very low yield up to 1.3 t/ha (FAO statistics cited in IITA, 2009). The continent of African shows the highest gaps in view of the potential yields and that is realized for several crops especially maize and rice (Licker *et al*., 2010; Neuman *et al*., 2010). It can therefore be assumed that current yield for most staple crops are below achievable yield in Ghana. Crop yields are 20-60% below achievable yield even under existing technology coupled with modern inputs like fertilizers and improved seeds (MoFA, 2007a). Again MoFA statistics on maize from 1990-2006 revealed 1.5 t/ha average yield, 2.5 t/ha achievable yield, 1.0 t/ha yield gap and 40% yield gap in Ghana (MoFA, 2007). Annual maize crop area is on the average about 846,300 ha with total annual production of 1,470,000 t in Ghana (MoFA-SRID, 2009). Meaning production is low comparing area under cultivation to production. Moreover, current yield is still very low at an average of

1.6 t/ha whilst 4 or 5 t/ha is achievable provided all other productions factors and investments in inputs and improved practices are sufficiently undertaken (WAB, 2008).

2.3 Physiology of maize crop

According to the International Institute of Tropical Agriculture (IITA) (2009) maize is high yielding, easy to process, readily digested, and cheaper than other cereals. It is also a versatile crop, growing across a range of agro-ecological zones. Every part of the maize plant has economic value: the grain, leaves, stalk, tassel, and cob can all be used to produce a large variety of food and non-food products.

2.3.1 The growth stages of maize

Distinctive maize plants develop 20 to 21 total leaves, silk about 65 days after germination, and mature around 120 days after germination. The specific time interval, however, can vary among hybrids, environments, planting date, and location (Melinda, 2011). The development of a maize plant is divided into two major phases:

- The vegetative stage and
- The reproductive stage.

The vegetative stage starts from seedling emergence up to tasselling. The reproductive stage commences at silking and pollination, up to grain-filling and maturity. Agronomists have further divided the vegetative phase by using the number of matured leaves (with exposed leaf collar) present on the maize plant. The reproductive phase starts with the fertilization of the kernels and ends with grain maturity. Almost all pest management decisions for maize are based on the vegetative stage. This means that the application of herbicides and other pesticides must be completed within the first two months of maize development. Fertilizer application, usually done in two batches, must be completed within the first month to aid the maize physiological progress. By the time the plant reaches the

5th leaf stage or 14 days after emergence, all leaves, ear shoots and the tassel are already formed in miniature. Although the plant may be only 20 cm in height, the numbers of kernel rows on the ear have already been determined. At this time, the growing point is still at or below the soil surface protecting the young plant from yield reductions due to outside stresses. The final vegetative stage is full emergence of the tassel. At this point, the maize plant has nearly attained its full height. The 14-day periods before and after silking are crucial to final yield. Growing conditions that place the plant under stress will reduce yield, since final plant elongation, and ear development will be affected. When the maize plant reaches silking with good fertility, good water reserves and no physical damage, growers will be well on their way to maturity.

2.4 Factors affecting maize production

Maize production factors can be viewed though in different perspective, since they have similarities. Low maize yields are due to biotic and abiotic stresses such as drought, low soil fertility, pests and diseases (Mugo *et al.,* 2002). Again, maize production constraints in general, can be categorized as follows (RAP, 1999):

- Biological factors such as variety, soil fertility and management practices (fertilizer, water, pests management, etc)
- Socio-economic factors including social and economic status of farmers, family size, farm holding, knowledge and education level of farmers, contact with extension agents, etc.

Similarly, low yields of maize have been attributed to traditional farming practices such as the use of low-yielding varieties, poor soil fertility and limited use of fertilizers, low plant population, inappropriate weed control and erratic rainfall. Also, Lobell *et al* (2009 cited in Meijerinka *et al.,* 2011) identified biophysical constraints (including insufficient water, insufficient nutrients, sub-optimal time of planting, extreme weather events like windstorm, pests and diseases, insects, etc) and socio-economic (as low profit maximization, lack of knowledge on best management practices, high transportation costs and distorted market for fertilizer).

The FAO (2000) recognizes four causes of yield gaps and for the purpose of clarity in line with the study, factors affecting maize production are namely biophysical (including climate of the area, soil type, available water, pest and diseases), technical/management (varietal selection, seed source, tillage, resource or input efficiency), socio-economic (socio-economic status, income of household, family size, tradition and knowledge), institutional and technology transfer like market price, land tenure, credit and supply of input grouped as (a) biophysical, (b) socio-economic and (c) technical with their respective parameters explained.

2.4.1 Biophysical factors of production

The biophysical factors of production in this study focuses on climate change and variation as well as rainfall since maize production is mainly under natural environment (rainfed condition) in the study area.

2.4.2 Climate change and variation

Climatic conditions such as rainfall become constraints in its insufficiency and extreme by affecting the life-cycle of maize production. WAB (2008) found that climatic characteristics rarely affect maize yield as a singular factor, as it determines the cropping season in Ghana. Climate change impact on livelihoods will be severe in the tropics and sub-tropics mostly in Africa since there are more poor small holder farmers who mainly depend on agriculture with no option (IPCC, 2001b). In Ghana, climate change is a constraint in all sensitive parts / sector of the economy mostly the agriculture sector estimation based on 20 years baseline climate observation show 7% reduction of maize and other cereals yield by 2050 (UNEP/UNDP, undated).

Maize as a biological entity will by all means be affected by the changing climate and variability. Inter-governmental Panel on Climate Change (IPCC) (2007) stated that climate change have considerable effect on biological systems. Other biological organisms like pests that constraint crop yield are also induced by climate change. Pests and pathogens influence the determination of actual yield to the highest degree (Gregory *et al.,*1999). This means that climate as a biophysical element can also triger the devastating effect of pest on crop yield. Direct effects on potential yield are driven by variation in temperature, carbon dioxide concentration in the atmosphere and water (Gregory *et a*l., 2009). Also directly, uncertainty and erratic incidence of rainfall which result in drought impact on untimely planting and harvest of seasonal crops and eventually reduces production per unit land area (Maharjan *et al.,* 2010). Effects of climate change on pest and pathogen has been detected and modelled (Garrett *et al*.,2006). Evan *et al* (2008) assessed the rare consequences on crop yield. These makes climate a considerable factor in maize production. Also Keith et *al* (2010) suggested that extreme weather events that cause crop failure are floods, frosts, hail and strong winds, prolonged droughts and heat waves are all likely to become more frequent with climate change.

Climatic parameters that mainly restrain maize yield are temperature and rainfall. Rise in temperature causes insects to multiply and flourish, lengthen breeding season, increase production rate, increase insect population thereby increasing crop losses. Pimentel (1993) suggested that warm and moist conditions in West Africa are suitable for insect and crop diseases. Moreover estimation under wetter condition will cause disease losses to be greater than 100% for some crops. Herbicidal control of pests and diseases are less effective under dry and hot conditions but mechanical cultivation is more effective (Pimental, 1993). Temperature also affect yield as growing season become extended in many places (Barnett *et al.,* 2006). High temperature enables earlier cropping and more crop species to be grown but greater probability of high disease pressure maypersist (Peltonen-Sainio *et al*., 2009).

As temperature increases and droughts are exercebated, maize production are severely affected. Rise in average temperature effects growing season which in turn reduce crop production. As a result, 30% drop in maize production has been projected by 2030 (BBC, 2008). Ghana's projection indicate that temperature will cause low cereal yield throughout the country (Masahudu, 2011). Effects of high temperature is becoming complicated in crop production. Lobell *et al* (2011) gave evidence that the effects of high temperatures on maize is currently higher compared to previous assumption. This means that high temperature is a factor of maize production under rainfed condition.

2.4.2.1 Rainfall

Rainfall of an area plays a major role in crop production and perhaps considered as a factor of maize production. Rainfall in its inadequacy or in its scantiness or excessivness will impact on best yield of maize crop. Rukuni *et al* (2004) found rainfall as the most outstanding critical climatic factor constraining crop production. Musara *et al* (2010) also attributed erratic rainfall pattern to be the cause of low yield of maize encountered by small scale farmers at Murinye communal area, Zimbabwe. Persistent drought stress is a major constraint to Ghana's rain dependant agricultural system especially maize production (Ohemeng-Dapaah, 1994; Kasei *et al*., 1995; Obeng-Antwi *et al.,* 1999). Again, irregular rainfall pattern both in quantity and distribution in growing seasons make maize production prone to the effect of drought in the production areas (Ohemeng-Dapaah, 1994; Kasei *et al*., 1995). For example, Ghana's 30% decline in maize production in 1982 resulted from drought effects (GGDP, 1983). Drought is a very significant factor constraining maize production in less endowed countries (Edmeads *et al.,* 1998). The negative effects of drought can be mitigated by drought tolerant varieties (Carrow *et at*., 1990). The use of drought tolerant varieties will withstand the adverse effects of drought and this can help improve production.

2.4.3 Socio-economic status of farmers

Socio-economic factors such as age, gender, education, family size, farm size, extension service, credit availablity and accessibility, farm income are production factors capable of constraining maize yield. Mondal (2011) identified socio-economic and institutional constraints, such as poor economic status of farmers, lack of supply of quality inputs, input/output price support and proper research-extension linkage can cause yield gaps in crops. It is therefore paramount to identify socio-economic factors that limit maize production in the Ejura-Sekyedumase.

2.4.3.1 Age as a factor of production

The age of the farmer would have a positive effect on technical effectiveness. Older farmers could be more traditional and conservative and show less willingness to adopt new practices (Coelli, 1996).

2.4.3.2 Gender as a factor of production

Gender is a determinant of agricultural yield. Male and female roles in agricultural production and household decision-making (resource allocation, technology adoption, marketing and consumption) differ across the target regions of Africa, Asia and Latin America. Gender relationships are entrenched in complex social systems, generating status, power and decision-making roles that result in a gender-based division of labour, control and access to resources and incomes, preferences and needs (CIMMYT, 2011). These make women less active in farming.

Women have significant role in agriculture and often make the decision about hectarage of each crop to be planted (CSA, 2011). Conversely, the preponderance of Ghanaian women farmers has limited access to land, labour and capital because of cultural and institutional factors. Access to land is often restricted and women cannot provide collateral for credit because they may not have legal ownership of tangible assets. Their reproductive roles, which are usually defined by culture, interfere with their productive roles in terms of time for the latter. Yet women lack the financial capability to hire labour in order to supplement their own. In some cultural scenery, women are likely to be missed by public extension services because they are not observed as farmers (CSA, 2011).

Women are likely to have difficulties in accessing credit which even start from home. Adam (2010) discussed that women seek permission from husbands before they could access credit which they may either be refused or be received on their behalf. Similarly Goetz and Gupta (1996) argued that it is mostly the men of the household and not the women who actually exercise control on financial acquisition.

2.4.3.3.Education as a factor of production

The educational level of farmers is likely to influences the extent of farm practices and adoption of new technologies . Badal and Singh (2001) stated that the educational level of farmers, existence of extension services and access to credit facilities are important factors that have power over farmer's ability to adopt improved technology in maize production. Also, lack of technical know-how (47 %), lack of will power (20 %), non-availability of high yielding variety seeds (38 %), inability to get inputs at peak period (45%), lack of purchasing power (48 %), absence of organized market structure (32 %), inadequate extension services (33%) were noted as factors that constrain farmers adoption of technology (Bala, 2005).

2.4.3.4 Extension service as a factor of production

Extension Officers and farmers coordination are linked to agricultural productivity to some extent. There is a connection between intensity of extension exposure and adoption of new technology capable to improve yield. Aman *et al* (1988) stated that the more intensively a farmer is exposed to extension activities, the more prepared and willing he/she should be to adopt new practices and also identified that individual farmers subjected to greater extension exposure have adopted the high-yielding varieties of maize.

Addai (2000) noted that a farmer regular contact with extension workers assists the practical use of modern technologies and adoption of agronomic norms of production.
Farmers access to extension services raised output by 15% in Zimbabwe (Owen *et al.,* 2001). However, Alemu *et al* (2002) suggested that reduction in farmers inefficiency level has nothing to do with extension services and education. But other school of thought share different opinion. Conversely, it has been pointed out that majority of Ghanaian farmers benefit from extension services for various reasons including technical advice to improve production, new technologies, improve income and livelihood among others (MOFA, undated)

2.4.3.5 Credit as a factor of production

The availability of credit will enable farmers to purchase inputs in a timely manner and engage in productive agriculture. Thus, credit becomes a factor of production. Lack of credit and high interest rate are some of the key constraints farmers face; the internal factors limiting credit access are lack of collateral due to lack of/or poor quality of farm assets, lack of ownership of assets for women farmers, poor financial management, risky nature of farming and inability of clients to prepare viable project proposals (CSA, 2011). Also, insufficient income and insufficient collateral have been identified as the most common reasons why farmers lack credit in all localities in Ghana (GSS, 2008).

Inadequate credit is a constraint to the entire maize production; limiting land acquisition, input acquisition and utilization. In a situation where there is no access to credit, yield is limited. Survey carried out by WAB (2008) indicated that few small scale farmers are able to meet banks criteria in their quest to access credit and are unable to utilize formal credits for maize production and most at times these small scale farmers are unable to provide collateral.

Obeng (2008) identified that credit acquisition require collateral security even with credit unions in addition to being a good standing customer. Later Obeng (2008) concluded that higher interest rates have a detrimental effect on farming in Ghana since growth and development of the sector depends on adequate available and accessible funds at favourable rates. It has also been stated in the challenges of Ghana's agriculture that financial constraints bring about lack of assets ownership which is a collateral security and lack of credit mostly to purchase inputs is the most prevalent constraint to agricultural development (MoFA, 2007).

Littlefield (2005) reports that the chances created by credit availability helps a lot of poor people to invest in their own businesses, educate their children, improve their health care and promote their overall well-being. The amount of times devoted to farm activities can constrain production. The impact of off-farm work has multiple effects on agricultural production. The argument is that off-farm labour reduces farming efficiency (Abdulai and Huffman, 2000). Others also contend that the additional income generated by other household members who engage in off-farm work, can pay off for constraints caused by reduced availability of labour (Abudulai and Eberlin, 2001).

2.5 Technical constraints

Maize production is a factor of technical elements such as varietal selection and seed source and supply, fertilizer use and application, tillage and resource inputs use efficiency.

2.5.1 Seed as a factor of production

Seeds rest as a significant technological parameter required to increase agricultural yield; it is the most precious resource of farmers and concern about variability of agricultural systems usually centre on the diversity and stability of seed supply system (Tripp, 2001). Drought tolerant maize varieties can make significant increase in maize yield and favour poverty reduction in sub-Saharan Africa (La Rovere *et al*., 2009). Cenacchi and Koo (2011) identified 12.6% average yield increase when drought tolerant varieties are used across all nations and agro-ecological zones. Estimation show that drought tolerant varieties can have an average yield increase by 20.03% in humid Ghana and has the potential to bridge the gap by 30.78 % and 30.71% under current climatic conditions in Ghana's sub-humid and humid areas respectively.

Seed source and supply has to be sufficient and accessible if a bumper harvest is to be achieved. However in Ghana, current seed supply is estimated as insufficient (shortfall of approximately 8,000 t) and in 1982, 500 acres of maize were cultivated and in 2006 seed supply was sufficient for 444 acres (22 % of the cropped area (WAB, 2008). Despite this insufficiecy, researchers have produced high yielding and secured varieties in an attempt to bridge the gap. Among these varieties are the Quality Protein Maize (QPM) which is a hybrid maize produced in 1997, *Mamaba* which is a 25-30% higher yielding variety than others of the same life-cycle; *Mamaba* yields 5-7 t/ha and is also disease resistant with early maturity; *Obaatanpa* released in 1992 has a potential yield of 4.6 t/ha (CRI, 1996).

2.5.2 Fertilization

Fertilizer use is determined by numerous factors like the price, availability, belief of the people and nutrient status of the soil. Maize farmers have lower inclination towards the use of inorganic fertlizers which differs across agro-ecological zones and as a result achieve lower yield 2 t/ha on the average (Al- Hassan and Jatoe, 2002). In Ghana, the use of fertilizer is believed to close the yield gap by 40% especially in maize production, and 2 t/ha has been identified as achievable yield due to pesticides use. However, fertilizer use is low due to transportation cost revealed by top five events in African Agriculture. Crop production has been reduced by 5.4 million hactares and 4.5 million hactares in 1994 and 2004 respectively due to little or no improved maize seed, and lack of fertilizer response by local varieties in Africa (Ebojei *et al.,* 2012).

2.6 Challenges faced by smallholder maize farmers in Ghana

Maize is the only staple grain which is grown extensively in all of coastal, forest and savannah zones with an estimated total annual value of about GH¢1,343.5 million, while the total value of sales is about GH¢977.2 million, or 73 % of harvest value (GSS, 2008). Besides the profitability, maize production is still on a small scale. Even though agriculture is the backbone of Ghana's economy, smallholder farmers represent about 80 % of total agricultural production. However, regardless of overall economic growth over the past decade, the agricultural sector has declined from 51- 36 % of GDP (AGRA, undated).

Smallholder maize farmers, whose farms average just 1.2 hectare, currently have limited opportunities to excel according to Alliance for Green Revolution (AGRA). Small farm size and low yield encountered by maize farmers are caused by a number of challenges faced by farmers.

The major obstacles faced by Ghana's smallholder farmers include farmers' access to good seed, fertilizer, and sustainable farming practices, credit, crop storage, markets, and strong farmer-based organizations **(**AGRA, undated). These challenges' have a big influence on the belief that increasing production only serves to make the local market crash and prices plummet (GGP, 2011).

WFP (2012) noted that agriculture is almost entirely rain fed and mainly in the hands of smallholder farmers who use traditional farming techniques on land sizes of two (2) hectares or less. In effect maize production falls below what can actually be produced. Then again, low productivity impede most farmers in producing marketable surpluses, and widely dispersed locations are aggravating market access. Finally, the chapter review shows that maize production is dependent on multiple factors from the local level, to national as well as global level. Therefore dealing with the yield gap at the local level will give a national advantage.

2.7 Some of the concepts of yield gap

a. Yield gap (YP) means the difference between the potential yield and actual farm yield. This gap is as a result of differences in practices and management, farm size, and inputs of production.
b. Potential yield (PY) is the yield obtained in an experiment station. The yield is measured as the absolute maximum production of the crop achievable in the given location, attained by the most excellent available methods, and with maximum inputs in assessing the experimental station in a specified season.
c. Actual yield (AY) refers to the yield obtained by the farmers on their farms under their management practices.

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

This chapter delineates the characteristics of the study area, the method of sampling and data collection, the analytical framework utilized and the concepts that are defined and explained to assist a clear understanding of issues associated with the study.

The methods used are presented under the following titles:

- Description of the study area
- Sampling procedures and data sources and
- Analytical tools and techniques utilized

3.1 Description of the Study Area

The *Ejura-Sekyedumase* District is among the 27 districts in the Ashanti Region, created by the Legislative Instrument 1400 (L. I. 1400) of 29th November, 1988. It was carved out from the then Sekyere and Offinso Districts.

3.1.1 Location and size

The District is located in the northern part of the Ashanti Region and shares boundaries in the north with Nkroanza North and Atebutu District of the Brong Ahafo Region, to the South with Sekyere West and Mampong Districts, To the West with the Offinso North District, Nkoranza North and Nkoranza South Districts and to the East with the Sekyere Central Districts. The District covers an area of 1,782.2km^2 which is about 7.3% of the total land area of the Ashanti Region. Ejura, the District capital is 106 km from Kumasi.

3.1.2 Relief and drainage

The southern part of the district has a smooth undulating topography with valleys 35 m deep and peaks 315m high above sea level. The northern part of the district is fairly flat and undulating with general altitudes ranging between 150-300 m. The ranges of hills, which run eastwards through Ejura and Mampong, forms part of the Kintampo-Koforidua range and represents the highest point in the districts. The notable hills in the district include Kwasi Manu Hill (411 m), Ejurachen Scarp, and Dente Scarp. The Scarps area is entirely under forest reserve. The altitude of Ejura which is about 228 m, with a flat and undulating topography allowing mechanized farming. A number of rivers and their tributaries drain the District. The main rivers are Afram, Akobaa, Chirade, Bresua, Subonta, Soko and Borahoho. Minor rivers include Aberewa, Yaya and Baba. With the exception of Afram, all the others are seasonal.

3.1.3 Climate and vegetation

Ejura–Sekyedumase District is situated in the transitional zone of the semi-deciduous forest and has a bimodal type of rainfall of the semi-deciduous forest and Guinea Savanna zones. Both forest and savanna climatic conditions occur in the district.

3.1.4 Temperature

High temperatures with a mean monthly of 21– 30°C usually occur. January – April are the warmest months whilst July-August is the coolest. Easter winds which is a period of windstorms more than 4 Knots (MSD, 1985) occurs in April and cause lodging of crops and trees and even damage to buildings.

3.1.5 Rainfall

The district has a bimodal rainfall pattern. The rainy season ranges from April-November. The major season is April–July while the minor season is August–November. The annual rainfall for the district varies between 1,200-1,500 mm. Generally, the rainfall pattern is extremely erratic and unreliable. The rainy periods are associated with very high humidity's. High relative humidity of 90 % occurs in June and as low as 55% in February. The dry season starts from November and ends in April.

3.1.6 Vegetation

Both forest and savanna vegetations exist in the district. The northern part has derived or open savanna vegetation (Guinea Savanna) whilst South-Eastern part has semi-deciduous forest vegetation. The Guinea Savanna vegetation consists of tall grasses intermingled with short fire-resistant tree species. Common grass species in the district are *Andropagon, Beckeropsis*, *Plasmodium* and *Rottbela* while common trees include *Butyrospermum*, *Damella, lophira* and *vitex.*

3.1.7 Environmental condition

Slash and burn which is the most common farming practice in the district consequently destroy the vegetation cover and alters the ecology. Soil becomes vulnerable to erosion activities and excessive leaching. Bushfire also imperils the vegetative cover of the district due to farming and game hunter's activities.

3.1.8 Markets and marketing

Three major weekly markets prevail in the district. The Ejura market which falls on Mondays is the principal trade centre in the district. The second largest market and it is the

Sekyedumase market which is held on Thursdays whilst the Anyinasu market, held on Tuesdays, is the third largest.

3.1.9 Maize storage

Maize is mostly stored as cobs in barns in farmer's homes. However, shelled maize is properly dried and treated with the recommended chemicals.

3.1.10 Farm implements

The agricultural sector is characterized by low application of technology. As a result of this, most farm operations are manual. Simple farm implements like the hoe, machete are the common tools used by farmers. However, on mechanized farms, ploughs, tractors, fertilizers, irrigation and other inputs for modern farming prevail. Most farm operations are done by the farm family.

3.1.11 Farming systems

Farming in this district is subjugated to small-scale subsistence farmers who cultivate plots below 2 ha with the average area per farm unit for a household of about 1.6 hectares. Crop production is mainly rain-fed in the district. Some maize and rice farmers practice mechanized farming. The traditional shifting cultivation system known as the "slash and burn" or the bush fallow system is the main system of farming. The prevailing continuous cropping leads to low crop yield due to loss of soil fertility. This occurs three or more years of continuous cultivation depending on the fertility of the soil and the types of crops cultivated. Maize though may be produced on the same land for five or more years by the use of chemical fertilizers. However, since irrigation systems are not rife, most farmers depend on the rains, shortening the cropping season and limiting it to the rainy months of May through November.

3.1.12 Water resources and availability

Access to good drinking water supply is very essential not only for human well-being but also for agricultural and industrial development. The District is however, characterized by water shortage in many towns and villages, especially in the dry seasons because most of the rivers and streams dry up during dry season. Sources of water supply in the district are rivers, streams, hand-dug wells, boreholes with pumps and pipe-borne water from mechanized boreholes.

3.1.13 Crop production

Ejura-Sekyedumase District remains the leading producer of maize and yam in the Ashanti Region. SRID (2007) estimated maize production of 28,861t with an average yield of 2.14t/ha, considering a cropped area of 13,486.44 ha and average crop area per holder of 1.02 ha. The production figures for various years can be seen in Tables 1-3.

Table 1: Area, yield and production estimates for 2007, *Ejura-Sekyedumase* District

	Cassava	**Cowpea**	**Plantain**	**Rice**	**Groundnut**	**Maize**	**Yam**
Total No of Holders Cultivating	3,952	7,068	1,905	1,184	2,060	13,222	4,287
Average Cropped Area per Holder (ha)	0.42	0.61	0.33	0.84	0.5	1.02	0.43
Estimated Cropped Area (ha)	1,659.84	4,311.48	628.65	994.56	1,030	13,486.44	1,893.41
Average Yield/ Crop (t/ha)	10.27	0.63	8.46	0.94	0.73	2.14	17.92
Estimated Crop Production (t)	17,046.55	2,716.23	5,318.37	934.88	751.90	28,860.98	33,033.90

Source: DADU SRID report (2007)

Table 2: Estimated crop **production tonnes for 2003 – 2008 (t) *Ejura-Sekyedumase* District**

YEAR	**MAIZE**	**RICE**	**CASSAVA**	**YAM**	**COCOYAM**	**PLANTAIN**	**COWPEA**
2003	22,547	55.5	19,763	100,049	318	927	-
2004	24,802	61	21,739	110,054	350	1.020	-
2005	27,282	67	23,913	121,059	385	1,120	-
2006	30,833	-	-	-	-	-	-
2007	28,861	934.88	17,046	133,033	-	5,318	-
2008	24,419	1,020	21,898	142,078	392	6,940	63,165

Source: DADU SRID report (2008)

Table 3: Estimated cropped area (ha) for 2008 *Ejura-Sekyedumase* District

YEAR	**MAIZE**	**RICE**	**CASSAVA**	**YAM**	**COCOYAM**	**PLANTAIN**
2003	16,139	82	3,031	7,079	59	116
2004	17,753	90	3,334	7,787	65	128
2005	19,528	99	3,667	8,566	72	140
2006	11,951	-	-	-	-	-
2007	13,486	994.56	1,659.84	-	-	628.65
2008	17,500	850	3,250	9,680	85	785

Source: DADU SRID Report (2008)

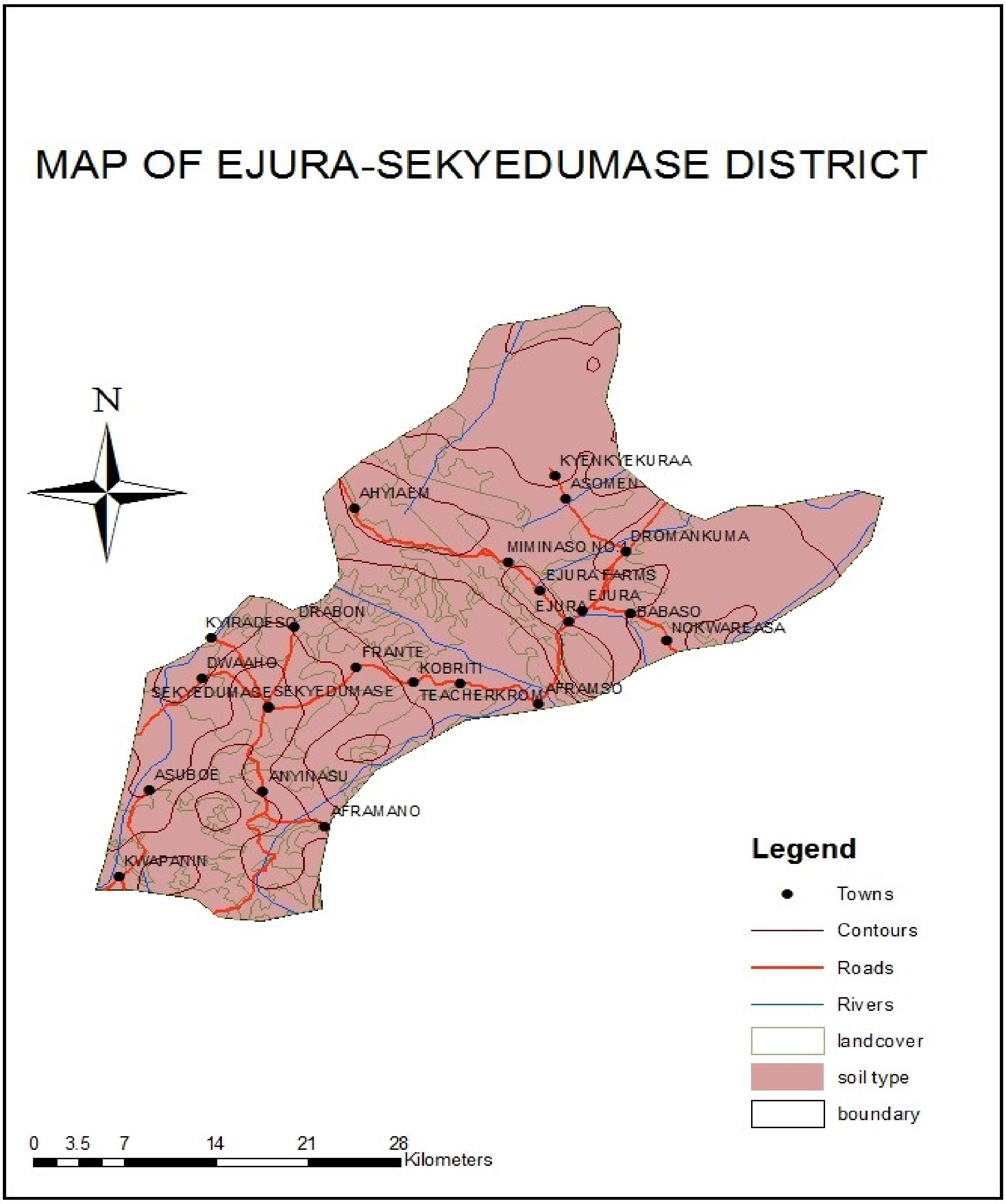


Figure 2: A sketch showing the location of various communities in the study area.

Source: *Author's Research Data Collected, (2013)*

3.2 Sampling Procedure and Data Source

A survey was conducted to identify farmer's socio-economic conditions through the administration of a questionnaire (Appendix 1) to a sample of farmers concentrating on their knowledge, tradition, sex, investment or savings, agronomic practices and climatic factors of production. Also, researchers (Appendix 2) and agric technical officers (Appendix 3) were interviewed on biophysical, socio-economic, technical factors of maize production through the administration of a questionnaire. Existing information on climatic variables especially rainfall was used to assess their effect on maize production.

3.2.1 Sampling

Ejura-Sekyedumase District is the largest producer of maize in Ghana. The District was purposively selected for the study because it is noted for large scale maize production and its contribution to food security in Ghana. Moreover, multistage random sampling method was used in selecting the maize farmers within the jurisdiction of the *Ejura-Sekyedumase* District's after farming communities have been stratified. Stakeholders selected were farmers, extension workers (MoFA) and researchers (CRI-Kumasi, University Lecturers, Plant Protection Regulatory Division-PPRD of MoFA).

Agricultural Extension Service Officers were contacted because their goal of "creating an environment for sustainable growth and development in the agricultural sector" has some connectivity with scaling yield gap in maize production. MoFA (2007c) declared its existence to promote sustainable agriculture and agribusiness through efficient policies and co-ordination, monitoring and evaluation. MoFA (2008) categorically stated its responsibilities in maize production entirely as co-ordination of projects and programmes in the maize industry through the Directorate of Crops Services (DCS) whose annual activities are geared towards:

a) Yield improvement in maize production and productivity level

b) Capacity building for farmer based organizations (FBO's)

c) Promotion of maize value chain development

d) Sustainable land and environmental management.

In Ghana, MoFA works directly and indirectly and collaborate with research scientist including Crops Research Institute (CRI)-Kumasi, SARI and the Soil Research Institute (SRI). Research scientist from the universities (KNUST, UCEW-Mampong), CRI, PPRD were contacted for primary information on maize production. This is because according to WABS (2008), researchers develop technologies for farmers to improve yield. The Grains and Legumes Development Board could have been contacted but time was limited. Farmers within the district were contacted in the sampled communities (see figure 2) such as Abrewano, Badukrom, Dromankuma, Hiawanwu, Kasei, Nokwareasa, Nkwanta, Nyambekyere and Saboline. Farmers are the main producers of maize and play a major role in decreasing the yield gap.

3.2.2 Source of Data

Questionnaires were administered to farmers, extension officers and research scientists. Data relating to the socio economic status, technical and biophysical parameters constraining maize production were collected from stakeholders considered in the research. Primary data from farmers were collected from 10th December, 2011 to March 2012. Research scientist's data were also interviewed from December 2011 to February 2012.

Secondary data pertaining to cropped area, production and average yield of maize and climatic parameters such as rainfall were collected from MoFA in the *Ejura-Sekyedumase* District. Questionnaire were distributed to researchers and extension workers and collected within varying periods of time. Two extension officers in the study area were involved in administering questionnaires to randomly selected farmers.

3.3 Analytical Tools and Techniques Utilized

To achieve of the objective in the study, the following analytical tools were utilized:

a. Tabular and excel analysis

b. Computation of yield gap and

c. Analysis of Variance (ANOVA).

3.3.1 Tabular and excel spreadsheet analysis

The primary data collected from the 100 respondent farmers, 10 researchers, 10 extension officers were subjected to simple tabular and excel analysis. Again excel was used to analyze rainfall data from 2002-2011.

3.3.2 Computation of yield gaps

Average yield was calculated for the period from 1996-2011 based on the cropped area and production. The production in tonnes was divided by the respective cropped areas in hectares. Factors that limit maize production were identified through the administration of questionnaires.

3.3.3 Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) was used to analyze the rainfall data in the major and minor cropping seasons from 2002-2011 to determine if there were significant difference between farmers planting period for the three periods which are the 3rd Week of March, 2nd Week of April and 3rd Week of April for the major season and the 1st week of August, 2nd week of August, 3rd week for August of Minor Seasons. Both descriptive and inferential statistics were used and hypotheses were tested. The test was conducted at 95% confidence level. The significant level was used to accept the null hypothesis (H0) or the alternative hypothesis (H1). At the significance of less than 0.05, the null hypothesis was rejected and the alternative accepted.

The required data collected from stakeholders including farmers across the entire District of *Ejura-Sekyedumase* and extension officers (MoFA staff) in the study area as well as relevant research scientists across Ashanti Region were analyzed. The data were exposed to various statistical tools and techniques for significant conclusions and the outcomes presented.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

The data collected were subjected to various statistical tools and techniques during the analysis. Then again, detailed descriptions of some of the factors responsible for the yield gap identified in the results have also been presented in this chapter. In addition to the results of the study, the chapter vividly discusses the results.

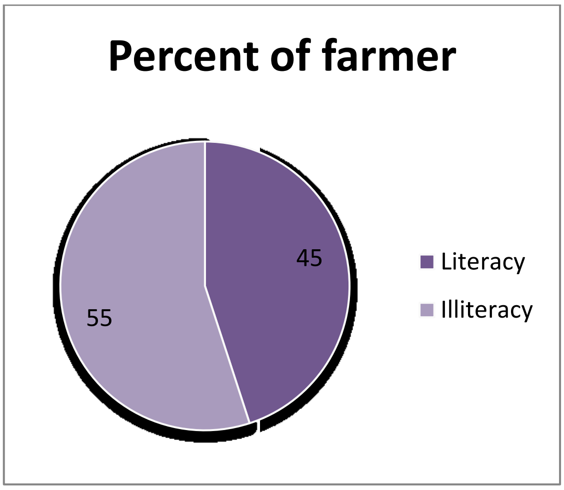
4.1 General Characteristics of the Sampled Respondents

The study was mainly carried out in the *Ejura-Sekyedumase* District of the Ashanti Region of Ghana.

Table 4 Gender of farmer respondents

Gender of farmer	Number of farmer respondents	Percent of farmer (%)
Male	80	80
Female	20	20
TOTAL	100	100

Table 4 shows that 80 % of farmers interviewed were males and 20 % as female. This may suggest that farming is controlled by men and also farming may be seen as a man's job. This discrepancy may be caused by a number of factors including domestic obligations, difficulties in accessing resource inputs, land and financial credit. It is a fact in typical Ghanaian setting like the study area that, domestic obligations like fetching water, cooking, washing, child caring are the sole responsibilities of women reducing their time devoted to farm activities. These social responsibilities may limit a woman's time and perhaps create gender inequity in farming. Indeed, women have difficulties in accessing credit which is a formidable factor of production. Adam (2010) suggested that women seek permission from husbands before they can access credit which they may either be refused or be received on their behalf by husbands. Similarly, Goetz and Gupta (1996) argued that it is mostly the men of the household and not the women who actually exercise control on financial acquisition.



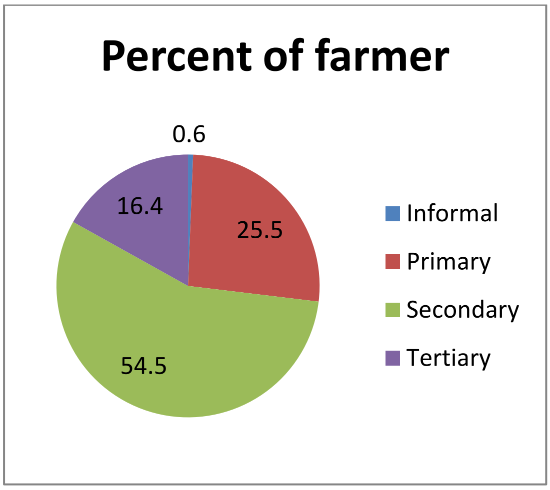


Figure 3: Educational status of farmers **Figure 4: Educational level of farmers**

Figure 3 shows the educational status of sampled farmers in the *Ejura-Sekyedumase* District. 55 % and 45 % were literate and illiterates farmers respectively. Although the literate farmers exceeded illiterate by 10 %, illiteracy is still high (45%). Illiteracy is a constraint to maize production since it influences the extent of farm practices and adoption of new technologies as noted by the FAO (undated). Illiteracy to a larger extent influences other factors of production such as credit acquisition and extension work. Illiteracy stands the chance to limit yield since dissemination of technology is complicated in the realm of illiteracy.

Figure 4 also shows the educational levels attained by farmers. The investigations into farmers' educational levels showed that 54.5 % of the literates had secondary education, 25.5% primary, 16.4 % tertiary and 3.6 % informal education. Farmers' level of education becomes relevant in analyzing the yield gap because educational level of farmers affect extension services and access to credit facilities which are important factors that have power over farmers' ability to adopt improved technology in maize production. Badal and Singh (2001) shared a similar opinion in India. Basic education is indeed crucial for small scale farmers to adopt new technologies

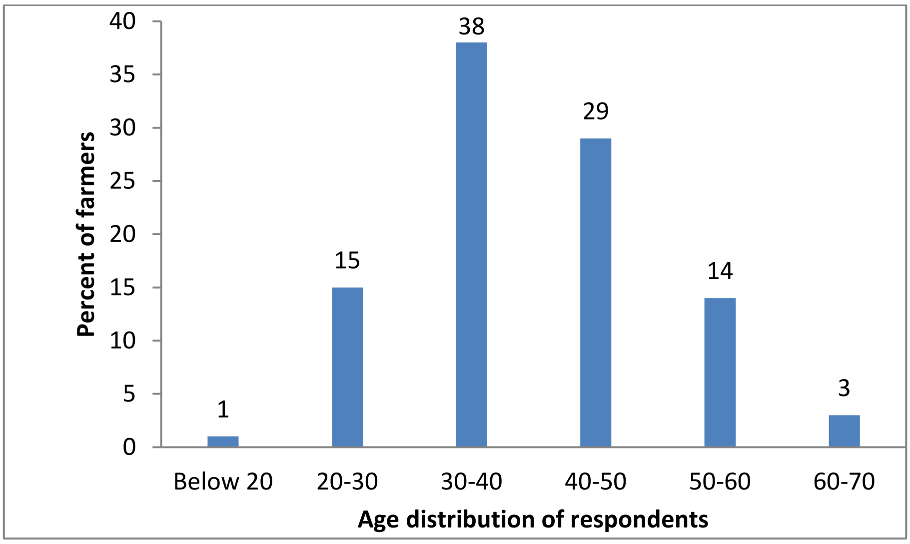


Figure 5: Age distribution of farmer respondents

The research showed that majority of farmers interviewed are in the 30-40 year age group constituting 38 % followed by 40-50 year age group which is 29%. Majority of farmers being youthful (< 40 years) is strength to increase production since they are seen as strong and active who can engage in farm activities for a lengthy period of time. This contradicts the findings of Adam (2010) that the youth are not attracted to farming because they want quick money and travel out of *Ejura-Sekyedumase* to seek non-farm jobs. However, the next groups aged 40-60 and above are likely factors to restrict yield since at this age they engage in subsistence farming are not fast adopters of technologies and prefer to hold on to their primitive (or known) farming practices.

4.2: Maize Yield Gap

Current maize production in the study area (Table 5) shows that maize production is below maximum potential yield. The highest averages annual yields of 1.80 t/ha (in 1997 and 2010) were found to be below the maximum potential yield. Table 5 indicates that maize varieties and their respective yield potentials, production and average yield from 1996-2011. Table 6 clearly shows cropped area in hectares, production in metric tonnes and average yield respectively from 1996-2011. Overall farm yield was found to be low however, average yield was relatively high in 2010.

Table 5: Characteristics of maize varieties recommended to farmers and their yield

Variety	Maturity group	Maturity period	Recommended Time of Planting	Attributes	Yield Potential
Akposoe	Extra-early	80-85 days	Major/minor season	White, drought tolerant quality protein maize (QPM)	3.5 t/ha
Abontem	Extra-early	80-85 days	Major/minor season	Yellow, drought tolerant, striga resistant QPM	5.0 t/ha
Aziga	Extra-early	80-85 days	Major/minor season	Yellow, drought tolerant, striga resistant QPM	5.0 t/ha
Omankwa	Early	90-95 days	Major/minor season	white, open pollinated (OPV) drought tolerant QPM	5.0 t/ha
Aburohema	Early	90-95 days	Major/minor season	white, open pollinated (OPV) drought tolerant QPM	5.0 t/ha
Obaatanpa	Intermediate*	105-110 days	Major season	white, open pollinated (OPV) drought tolerant QPM	5.5 t/ha
Golden jubilee	Intermediate*	105-110 days	Major season	Yellow, open pollinated (OPV) drought tolerant QPM	5.0 t/ha
Mamaba	Intermediate*	105-110 days	Major season	White, drought tolerant, striga resistant three-way QPM hybrid	7.5 t/ha
Etubi	Intermediate*	105-110 days	Major season	White, drought tolerant, striga resistant three-way QPM hybrid	7.5 t/ha
Enibi	Intermediate*	105-110 days	Major season	White, drought tolerant, striga resistant three-way QPM hybrid	7.5 t/ha

***Can be planted during the minor season but planting should be early enough to make use of the early rains in the season** (Source: CSIR, 2011).

Table 5 presents recommended maize varieties suitable for commercial production. The maturity group, maturity period, recommended planting time, attributes and yield potential of various varieties are indicated. The common varieties planted in the study area are *Obaatanpa* and *Mamaba* as shown in Figure 27.

Obaatanpa is intermediate in maturity with a maturity period of 105-110 days, recommended for the major season. *Obaatanpa* is white, open pollinated variety (OPV), drought tolerant and quality protein maize (QPM). All other things being equal, Obatanpa has yield potential of 5.5 ton/ha.

Mamaba, also an intermediate group has maturity period of 105-110 days, recommended for the major season, Mamaba is white, drought tolerant, striga resistant three-way QPM hybrid. It has 7.5 t/ha yields potential.

Improved varieties like *Obaatanpa* and *Mamaba* have the potential to bridge the gap by increasing production because of their special attributes like drought tolerance, striga resistant three-way QPM hybrid possessed by these varieties. Therefore, the assertion that drought tolerant maize varieties can make significant increase of maize yield and favour poverty reduction in sub-Saharan Africa (La Rovere *et al*., 2009) is complemented. Cenacchi and Koo (2011) also identified 12.6% average yield increase when drought tolerant variety is used across all nations and agro-ecological zones. In addition, an estimation show that drought tolerant variety can have an average yield increase by about 20.03% in humid Ghana and potential to bridge the gap by 30.78 % and 30.71% even under the current climatic condition in sub-humid and humid Ghana respectively.

Table 6: Cropped area, production and yield of maize over the period from 1996-2011 for *Ejura-Sekyedumase* District

Year	**Crop area (ha)**	**Production (t))**	**Average yield (t/ha)**
1996	16698	26717	1.60
1997	13,587	24457	1.80
1998	14,945	25408	1.70
1999	15500	23423	1.51
2000	15500	24360	1.57
2001	16120	18165	1.13
2002	16136	22553	1.40
2003	16139	22547	1.40
2004	16,140	-	1.40
2005	-	-	-
2006	-	-	-
2007	-	-	-
2008	17,500	21,875	1.25
2009	-	-	-
2010	19,764	35,575	1.80
2011	20,159	23,788	1.18

Author's data extracts from PPMED (Agric. Statistics and census Div) Ministry of Food and Agriculture 1996-1999 and Statistics, Research and Information Directorate 'SRID'2000-2011.

The cropped area (ha) in the study area was found to be increasing from 1997-2000. These are: 16120 ha, 16136 ha, 16139 ha, and 16140 ha, for 2001, 2002, 2003, and 2004 respectively, and 17,500 ha, 19,764 ha and 20159 ha in 2008, 2010, and 2011 respectively. Yield was better in 2010 (35,575t) than in 2011 because of the larger cropped area in 2011 (20,159 ha with 23, 788 t). This may be attributed to unfavourable production factors especially rainfall (see rainfall Figure 20 and 21). Even though production may have been under favourable technology and modern inputs in 2010 and 2011 yield was far below the achievable in 2011 therefore, the assertion of MoFA (2007a) that crop yield is 20-60% below achievable yield even under existing technology coupled with modern inputs like fertilizer and improved seeds is fairly true.

Table 6 also shows that average yields were below achievable yield from 1996 to 2011. The highest average yield was in 1997 and 2010 (1.8 t/ha) but this was followed by a lower yield 1.18 t/ha in 2011. These suggest an existence of a substantial yield gap in the study area. FAO statistics cited in IITA (2009) asserting that average yield in developing countries are very low, is confirmed in Table 6. Again, low average yields encountered by farmer in Ghana as stated by PPMED 1998) is affirmed. The low 1.80 t/ha average yield realized by farmers in the study area as presented in Table 6 can be improved with the use of high yielding and drought tolerant varieties. Potential yield of about 5.5-7.5 t/ha as shown in Table 5 are attainable if high yielding certified varieties like *Mamaba* and *Obaatanpa* are planted under favourable conditions and recommended agronomic practices.

4.3 Biophysical Factors

4.3.1 Choice of Sowing Time

Time of planting is important because the nature of the variability of weather/ climate is such that if the critical period of moisture stress coincides with favourable weather/ climatic condition the plant will do well and result in higher yield. It is therefore paramount to choose a suitable sowing time to meet required amount of rain for development and productivity since maize production is mainly under rainfed condition in

Ghana. Wrong timing of sowing time is a constraint to higher yield of maize and can further be used to identify other production limitations.

Farmers were asked if they are certain of planting time and 76 % responded “yes” whilst 24 % said “no”. Farmers who were sure of planting time were questioned about when they cultivate both in the major and minor seasons each year. Farmers who were not certain of planting periods were asked to give reasons why they were not sure of the planting periods.

The response from the farmers in the study area showed that maize cultivation certainly occurs both in the major season (from 3rd week of March through to 3rd week of April) and the minor season (from 4th week of July through to 1st week of October) as shown in Tables 7 and 8. Table 7 indicates that 63.2 % of the respondents were sure of sowing their maize seeds in the 2nd week of April, with few in the 1st, 2nd, 3rd, 4th week of March in the major season. The third week of August was identified as the popular planting time in the minor season (56.6 % of respondents), followed by the second and first weeks of August (14.5 and 13.1 % respectively).

Table 7: Sowing periods in the major season

Sowing date in major season	Number of farmers	Percent of respondents
1st week of March	2	2.6
2nd week of March	3	3.9
3rd week of March	8	10.5
4th week of March	2	2.6
1st week of April	3	3.9
2nd week of April	48	63.2
3rd week of April	10	13.2
TOTAL	76	99.9

Timely planting to meet sufficient rainfall is relevant to achieve best yield. It can be deduced from Table 7 that majority of the farmer’s (about 80.3 %) plant their maize in the month of April whilst about 18.6 % plant in March. This presupposes that 80.3 % of farmer respondents adhere to IITA *et al* (undated) recommendations that planting of maize should occur in the month of April in the southern part of Ghana. It also suggests that majority of farmers have reasonable knowledge with regards to cropping techniques which are a good foundation to improve yield if other production factors are well met since timely planting to meet favourable rainfall is a factor worth considering under rainfed agriculture. The Table shows that the most popular planting periods are 2nd week of April, 3rd week of April, and 3rdweek of March respectively in the major season.

Table 8: Planting periods in the minor season

Sowing date in minor season	Number of farmers	Percent of respondents
4th week of July	4	5.3
1st week of August	10	13.1
2nd week of August	11	14.5
3rd week of August	43	56.6
4th week of August	6	7.9
3rd week of September	1	1.3
1st week of October	1	1.3
TOTAL	76	100

It can also be deduced from Table 8 that majority of the farmer's (about 98.7 %) plant their maize between July and September whilst only 1.3 % plant in October. This presumes that 98.7 % of farmer respondents hold on to the recommended planting period (IITA *et al*., undated) for the southern part of Ghana which is between July and September. It also suggests that majority of farmers have reasonable knowledge with regards to cropping techniques (planting period) which are a good foundation to improve yield if production factors are well met. Again, if the maize crop is planted at the right time it is likely to receive adequate rainfall at all stages of development which will promote better yield and reduce harvest losses as harvesting occurs during the dry period. Table 8 also shows that the most popular planting seasons are third (3) week of August, second (2nd) week of August, and first (1st) week of August for minor season.

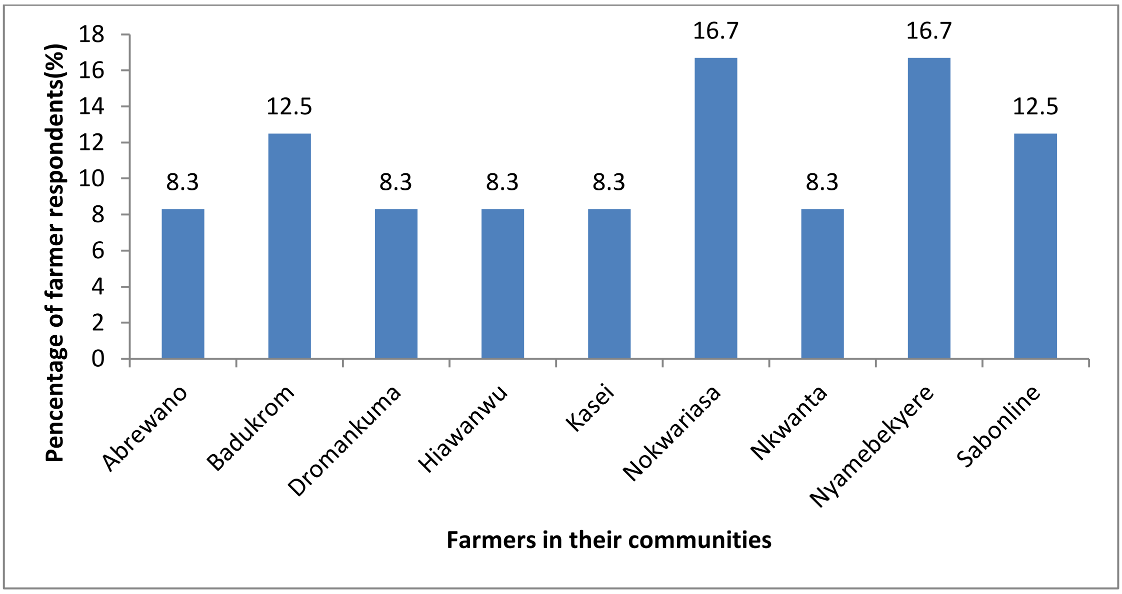


Figure 6: Farmers in various communities in the *Ejura-Sekyedumase* District in Ashanti Region of Ghana who are not certain of planting times

Figure 6 indicates that of farmers who were not certain of the planting period, (16.7%) were from *Nokwariasa* and *Nyamebekyere*, 12.5 % from *Badukrom* and *Sabonline*, 8.3 % from *Abrewano, Dromankoma*, *Hiawanwu*, *Kasei* and *Nkwanta.* The farmers at *Nokwariasa* and *Nyamebekyere* were the most uncertain about the planting period. It is therefore highly possible that they may plant at wrong times that may lead to low yields.

Table 9: Reasons why farmers are not certain of planting time

Reasons	Number of respondents	Percentage of respondents
Weather	13	38.2
Climate Change/variability	14	41.2
Pest and Disease	1	2.9
Soil water holding capacity	2	5.9
Land preparation	1	2.9
Readily available planting materials	3	8.8
TOTAL	34	99.9

Table 9 indicates that farmers' uncertainty of sowing time is influenced by the changing climate (41.2 % of farmer respondents), the weather (38.2 % of farmer respondents) and the ready availability of planting materials (8.8 % of respondents). This suggests that climate change, weather and availability of planting materials are production factors considered important by farmers in their quest to achieve optimum yield. This complements the claim by Maharjan *et al* (2010) that uncertainty and erratic incidence of rainfall which result in drought impact on untimely planting and harvest of seasonal crops and eventually reduces production per unit land area. Also, weather has been reported by Smale and Jayne (2003) as one of the uncertainty factors of production contributing to lower rates of growth in maize production and maize yields during the 1990s.

4.4: Climate as production factor, assessment of farmers practice and agro-meteorological implication

Climatic conditions especially rainfall is a production factor that needs a consideration if expected yield is to be attained. Rainfall influences land preparation, planting period, growth and development of maize crop thus affecting the entire yield. In the West African sub-region, the sowing time is determined by the sufficiency of soil moisture and rainfall is the major input to soil moisture. Cumulative rainfall was used because of the following reasons.

- Rainfall as a water resource is the major inputs to soil moisture under rain-fed condition
- Sufficient moisture in the soil determines the sowing time. Sufficient soil moisture in planting period affects germination, growth and development of maize plants thereby affecting the entire yield
- Therefore, assessing the sufficiency of soil moisture based on the popular planting times as prioritized by farmers reveal the real impact of rainfall as production factor.

Figures 7 to 16 show the cumulative rainfall in millimetres for the study area from 2002-2011

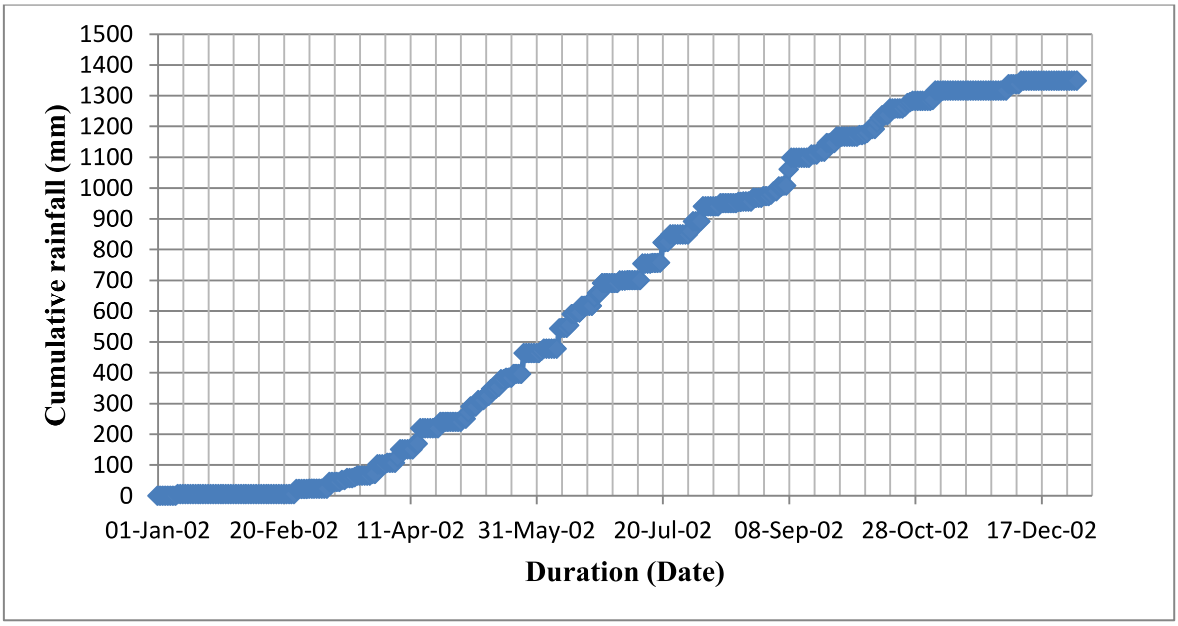


Figure 7: Cumulative rainfall in 2002 in the catchment area of *Ejura-Sekyedumase* District

In the Second week of April (98 days in the year) cumulative rainfall was 150.3mm, in the third week of April (104 days in the year) cumulative rainfall was 168.8mm and in the third week of March (80 days in the year) cumulative rainfall was 65.1mm. Figure 7 shows that rain fell on 9th January 2002 (4.7mm) was inadequate to start planting. The 56th and 69th day in 2002 had 21.1 mm and 44.2 mm cumulative rainfall respectively. The rain started showing up from the 69th day. Majority of farmers (63.2%) planting in the second week of April was a right practice since the accumulated rainfall of 150.3 mm will favour germination. 80.3% of farmers that plant in the month of April as illustrated in Table 7 were right since the accumulated rainfall were favourable to create sufficient soil moisture. However, the 18.6 % of farmers that plant in March were likely to have problems with the rain.

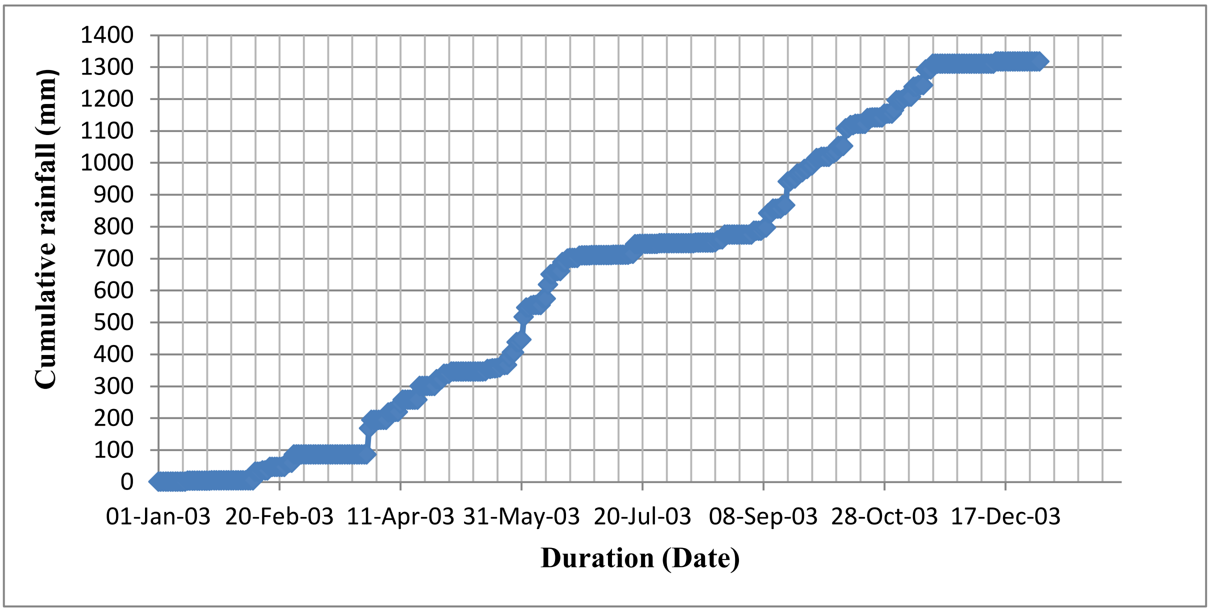


Figure 8: Cumulative rainfall in 2003 in the catchment area of *Ejura-Sekyedumase* District

The second week of April (11-April-2003) received 25.5 mm to the previous accumulating 244.5 mm of rainfall, third week of April (19-April-2003) had cumulative rainfall of 300.4 mm. third week of March had no rain but the 4th week (29th and 30th days of March) had heavy downpour of 82.3mm (167.5 mm cumulative) and 26.5 mm (194 mm cumulative) respectively. Figure 8 shows that the rainfall occurred earlier in 2003 than 2002. The second week of April (11-April-2003) was the most popular planting period (63.2 %) which had an accumulated rainfall of 244.5 mm suggesting an increase of soil moisture condition to start planting. Then also 80.3% of farmers that planted in the month of April were right since the accumulated rainfall was favourable. However, the 18.6 % of farmers that planted in March are likely to have problems with the rain.

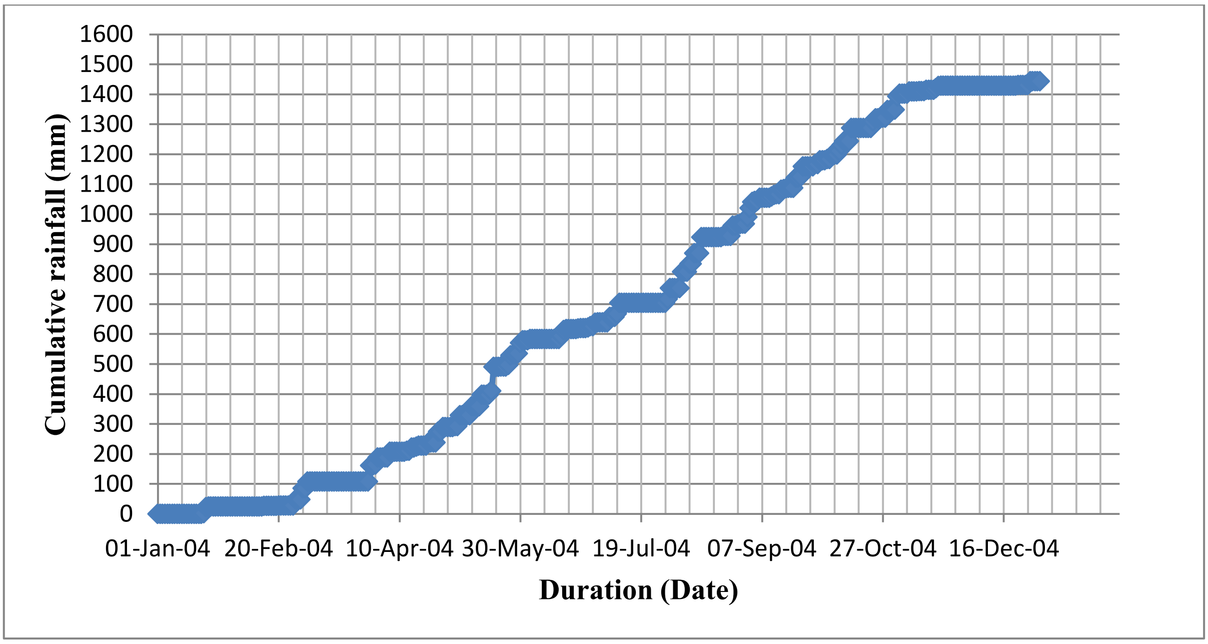


Figure 9: Cumulative rainfall in 2004 in the catchment area of *Ejura-Sekyedumase* District

Figure 9 shows that the second week of April (6-April-2004) had a cumulative rainfall of 207.2 mm, third week (15-April-2004) had cumulative rainfall of 220.2 mm but there was no rain in the third week of March. In March, 22.8 and 52.9 mm rain fell to cumulate 107.9 and 160.8 mm in the 3rd and 29th March, 2004. The cumulative rainfall in the second week of April was 207.0 mm which is less compared with that of 2003 even though cultivation started on the 99th day. This may account for the reason why average yield in 2003 and 2004 were the same (1.4t/ha) even though cropped area was higher in 2004 (16,140ha) than 2003 (16139ha). It was not advisable to plant in March in view of Fig. 9

Moreover, 80.3% of farmers that sowed their seeds in the month of April got it right since the accumulated rainfall was favourable. However, the 18.6 % of farmers that planted in March were likely to have problems with the rain. This complements the recommendation by (IITA *et al*., undated) that maize cultivation should be done in the month of April in Southern Ghana in order to meet the required rainfall for higher yield.

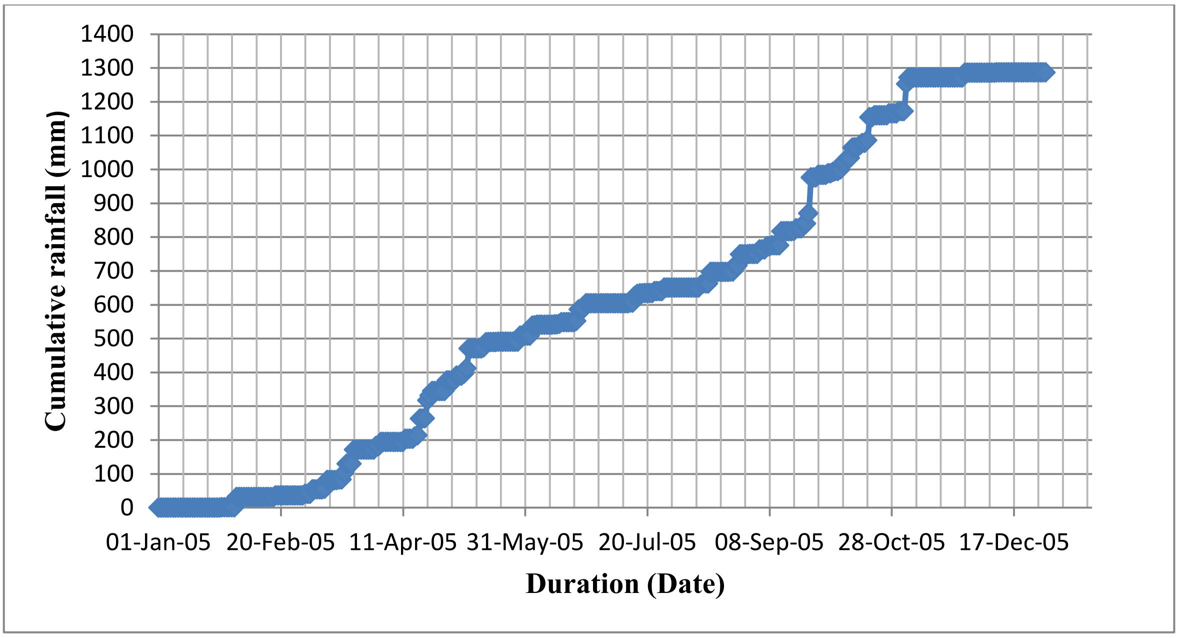


Figure 10: Cumulative rainfall in 2005 in the catchment area of *Ejura-Sekyedumase* District

Rainfalls were not reliable in the first and second weeks of April although 194 and 203 mm accumulated on 2nd and 12th April respectively. There were three consecutive rainfalls in the 3rd week of April (16th, 17th, 18th days of the month) where 263 mm was cumulated on 18th April, 2005. The third week of March (18th, 19th and 22nd days of the month) had cumulative rainfall was 102.1, 129.5 and 170.7 mm respectively after which there was no rain until 31st March, 2005.

From Figure 10 it can be suggested that planting in the 3rd week of April was good because soil moisture condition was suitable at that season. Therefore, the 13.3% were right. Moreover, with the use of drought tolerant varieties the 80.3% of farmers that cultivated their maize in the month of April would not suffer effect of water stress. However, the 18.6 % of farmers that planted in March were likely to have problem with the rain. This complement the recommendation that maize cultivation should be done in the month of April in Southern Ghana in order to meet the required rainfall for higher yields.

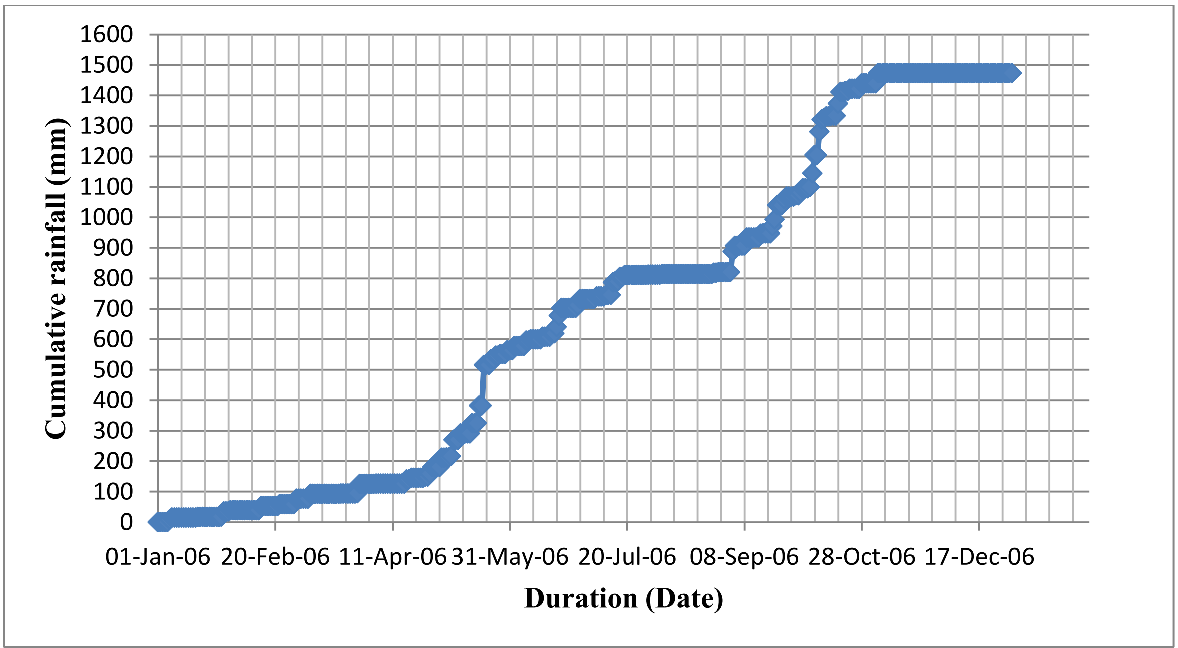


Figure 11: Cumulative rainfall in 2006 in the catchment area of *Ejura-Sekyedumase* District

Second week of April (4th and 5th days of the month) had 0.9 and 0.2 mm recorded rainfall to accumulate 126.4 and 126.6 mm correspondingly. The 3rd and 4th weeks of April received reasonable quantity of rainfall where 140 mm accumulated on 17the April, 2006. Again, 158.8 and 180.3 mm cumulated on 27th and 28th of April (4th week). Rainfall was not consistent in March moreover; 125.5 mm was cumulated on the 28th March, 2006. It can be seen that planting in March, first and second weeks of April in 2006 would be wrong due to the poor moisture conditions. Therefore, the 63.2% of farmers that cultivated their maize in the 2nd week April were not right since the accumulated rainfall was not favourable. Also, the 18.6 % of farmers that planted in March were likely to have problems with the rain. However, the 13.3% of farmers that plant in the 3rd week of April were rather right. It was also suitable to cultivate in the 4th week in 2006.

This harmonizes the recommendation that maize cultivation should be done in the month of April in southern Ghana in order to meet the required rainfall for higher yield.

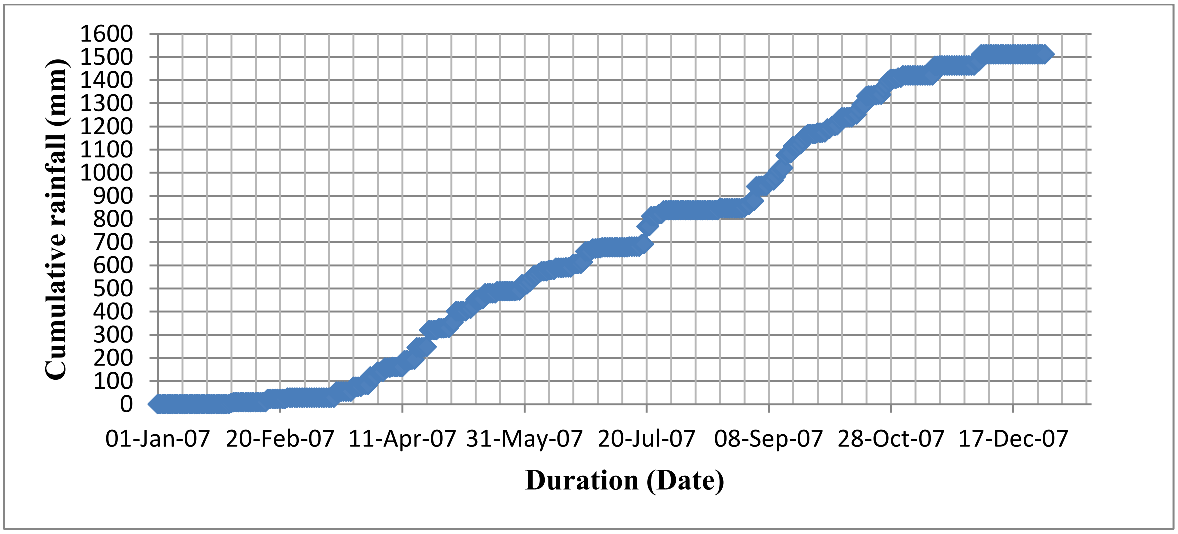


Figure 12: Cumulative rainfall in 2007 in the catchment area of *Ejura-Sekyedumase* District

The first and second weeks of April (1st, 4th and 7th April, 2007 received 20.4 mm, 18.3 mm and 2.8 mm of rainfall respectively) to accumulate 160.7 mm and 190.1 mm was accrue on 12-April-2007; third week (17th and 22nd April) had cumulative rainfall of 244.6 mm and 319.8 mm respectively. There was no rain in 1st week of March but there were storms on the 15^{th}, 22nd, 26th and 29th to accumulative rainfall of 119.2 mm on the 29th April, 2007. It can be seen that rainfall during the planting periods in 2007 was less compared with 2006. Thus the 80.3% of farmers who cultivated their maize in the month of April were right since the accumulated rainfall was favourable. Nonetheless, the 18.6 % of farmers that planted in March were likely to have problems due to the fact that there was no rain in 1st week and subsequent weeks had intermittent rainfall. This complements the recommendation that maize cultivation should be done in the month of April in southern Ghana in order to meet the required rainfall for higher yields.

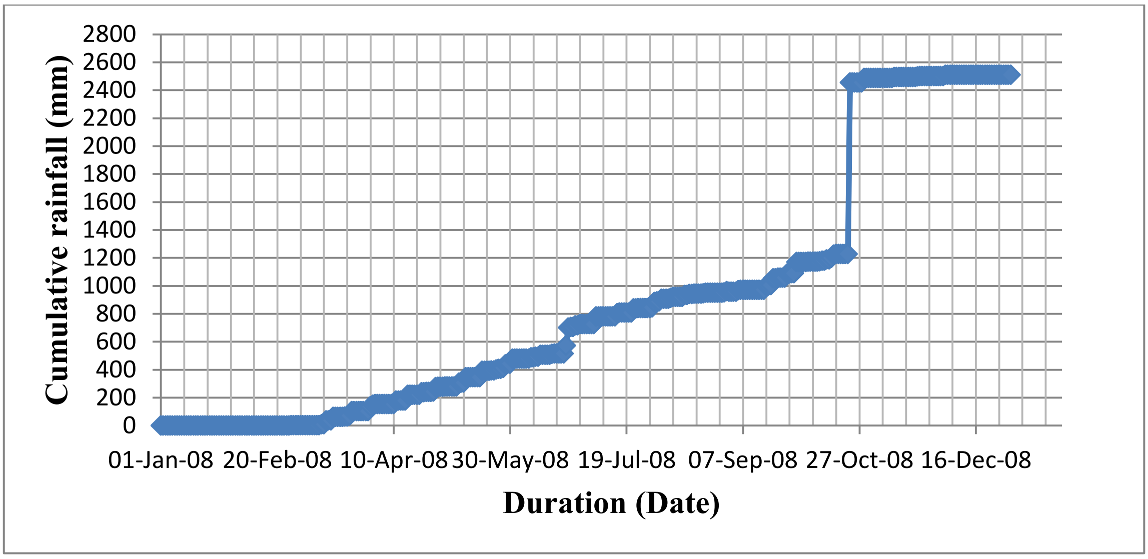


Figure 13: Cumulative rainfall in 2008 in the catchment area of *Ejura-Sekyedumase* District

The second week of April (11-April-2008) recorded 25 mm of rain adding to the previous to make up 177.5 mm, third week (16-April-2008) recorded 42.4 mm rains, accumulating 220.4 mm and in the third week of March (23-March-2008), 31.8 mm was added to make 103 mm. It can be figured out that rainfall was not good even from the onset of planting. Rainfall was irregular however; quantity recorded at each rainstorm was quite good. This irregular rainfall may be the possible cause of lower production in 2008 (21,875 tonnes) even though area cultivated was higher than the previous years as shown in Table 6. Nevertheless, the 80.3% of farmers who cultivated their maize in the month of April were right since the accumulated rainfall were favourable. On the other hand, the 18.6 % of farmers that planted in March were likely to have problems with the rain. This complements the recommendation that maize cultivation should be done in the month of April in southern Ghana in order to meet the required rainfall for higher yield.

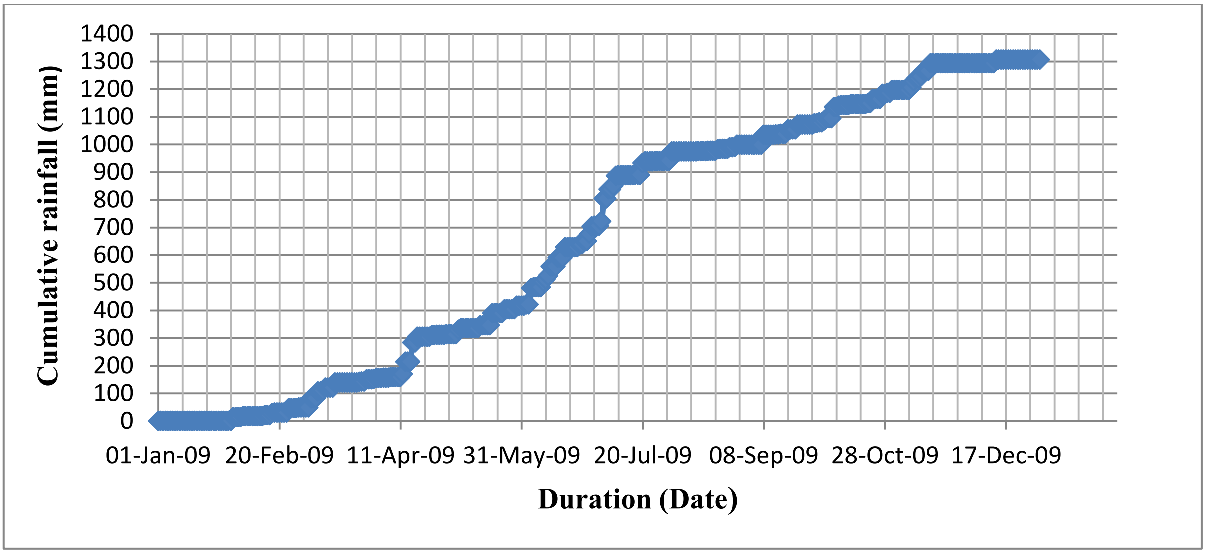


Figure 14: Cumulative rainfall in 2009 in the catchment area of *Ejura-Sekyedumase* District

The second week of April (12-April-2009) had cumulative rainfall of 169.6 and 214.1 mm respectively, third week of April (13-April-2009)) cumulative rainfall of 214.4 mm after a heavy down pour of 44.5mm after which 69.1 mm were added to accrue 283.2 mm on the 16th April, 2010. Rainfall in March (5th and 8th March, 2009) accumulated to 106.8 mm on the 8th March, 2009. From Figure 14, planting in the month of April rightly meet adequate amounts of rainfall. Therefore, the 80.3% of farmers cultivating their maize in the month of April were right since the accumulated rainfall was favourable. On the other hand, the 18.6 % of farmers that planted in March were likely to have problems with the rain, however, with the use of drought tolerant varieties and or irrigation system the impact drought would not be felt. This complements the recommendation that under rained condition, maize cultivation should be done in the month of April in southern Ghana in order to meet the required rainfall for higher yield.

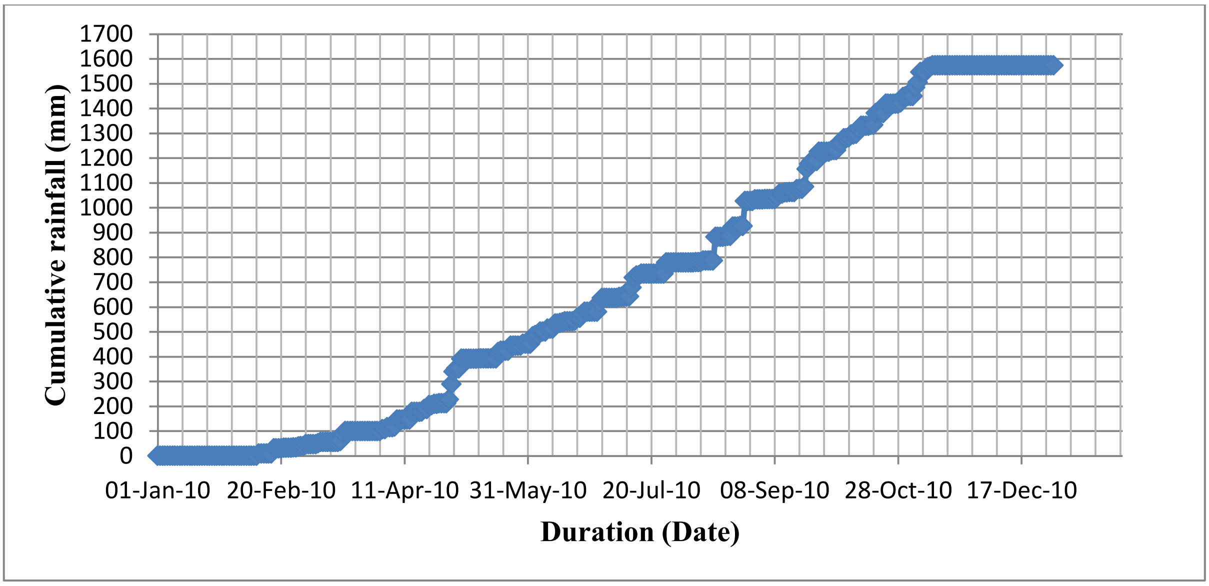


Figure 15: Cumulative rainfall in 2010 in the catchment area of *Ejura-Sekyedumase* District

Figure 15 shows that there was no rainfall from January to 10th February 2010. In February, 9.1 mm and 30 mm rain showed up on 11th and 17th correspondingly. In the 1st week of March (2nd and 7th March, 2010), 7.5 mm and 4.5 mm of rain fell to build up to 45.5 mm and 51 mm respectively. There was no rain in the 2nd week of March but the 3rd week between 16 and 18th days, 4.1, 30.8 and 9.4 mm were received to build up to 59.5, 90.4, 99.8 mm respectively after which there was no rain until 2nd April, 2010. Even though rainfall in April was intermittent, planting was still conducive due to favourable soil moisture as a result of the build up rains. Second week of April (8-April-2010 and 14-April-2010) had cumulative rainfall of 146.5 and 176.7 mm respectively, third week of April (19-April-2010) cumulated 188.6 mm. This is a suggestion that planting in the month of April in 2010 was the best and farmers who planted that season were right.

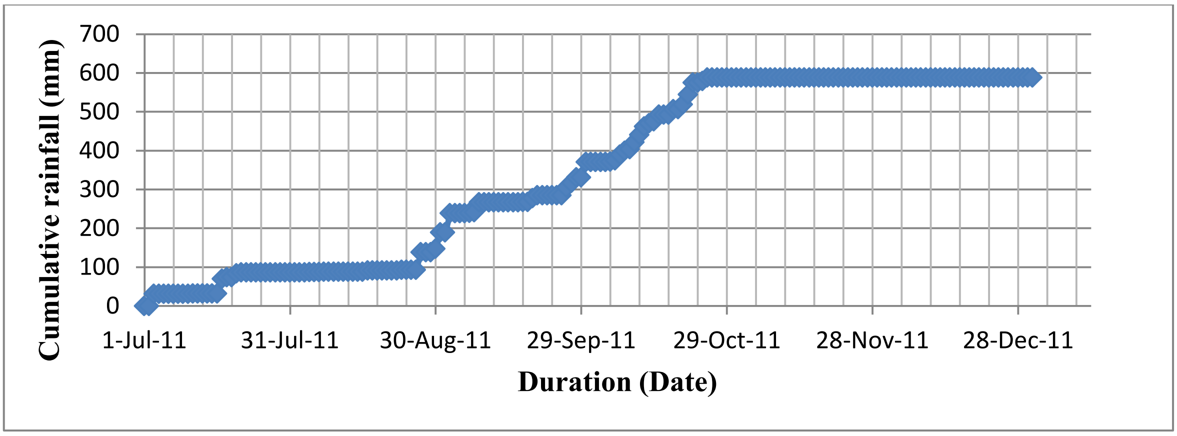


Figure 16: 2011 cumulative rainfalls in the catchment area of *Ejura-Sekyedumase* District in Ashanti Region of Ghana

From figure 16 there was no rain in the month of January, 2011. Rain fell on the 10th and 13th of February 7.7 and 20 mm were cumulated respectively. First week of March (4th day) and second week of March (12th day) had 42.7 mm and 50.2 mm rainfall respectively cumulated. There was three days consecutive rainfall from 20th-23rd March where 84.4 mm was cumulated on the 23rd day. In April 2011, 106 mm was cumulated in the 2nd week (9th-April-2011) and 148.3 mm in the 3rd week (17-Apr-2011) and irregular rainfall in the 4th week.

It can be seen that planting in March was good but the condition of water stress would persist to constrain growth in the early stage of the crop growth due to rain failure from 24th March to 3rd April. However, with the use of drought tolerant varieties farmers who planted in March would not encounter the water stress effect. Moreover farmers who planted in April were right on the basis of soil moisture condition prevailed especially in the second week of April (9-April-2011) where 20.2 mm of rain fell to accumulate 106.3 mm. There were enough rain subsequently to improve moisture condition which is suitable to support germination, growth and development of the maize plant for high yield.

4.5: Climatic factors in the Minor season.

The recommended planting period for the minor season in southern Ghana is between July and September. Farmers who adhere to this recommendation meet sufficient rainfall for higher yield and adequate sunshine to prepare maize for harvesting. It means the season of planting is affected by rainfall.

Table 8 shows third (3) week of August as the most popular planting period (56.6 %), followed by the second (2nd) week of August (14.5%) and then the first (1st) week of August (13.1 %). This indicates that the most popular planting periods are third (3rd) week of August, second (2nd) week of August, and first (1st) week of August in that order.

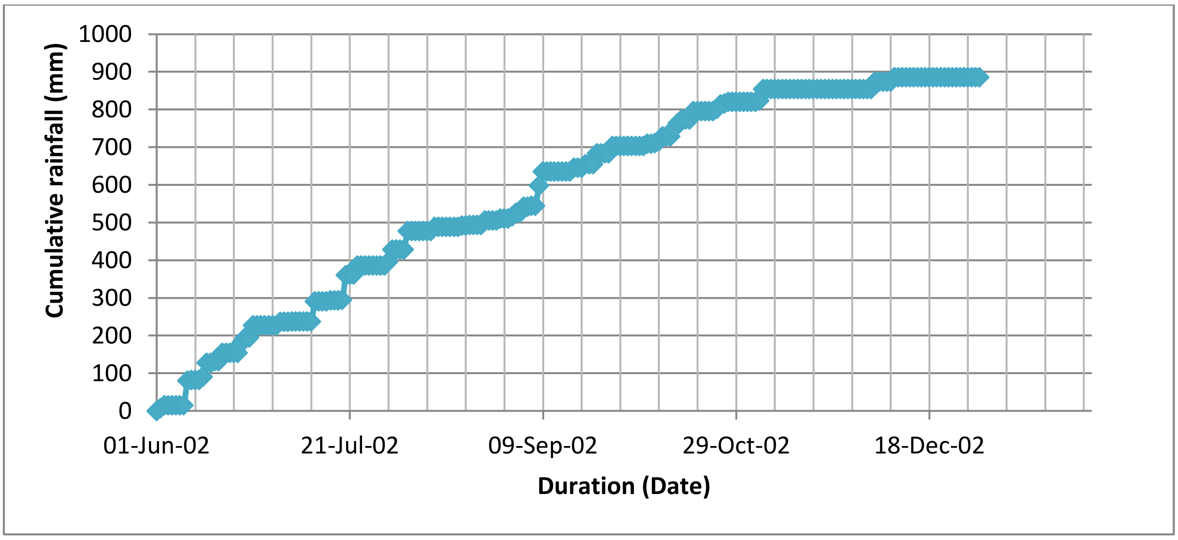


Figure 17: Cumulative rainfall from July-Dec 2002 in the catchment area of *Ejura-Sekyedumase* District

There was no sufficient rainfall in the month of July according to Figure 17. This makes planting unfavourable in July, 2002. The amounts of rainfall were 53.7 mm (on 12-July-2002), 65.5 mm (20-July-2002), 23.9 mm (23-July-2002) in the first, second and third weeks respectively with cumulative rainfall of 385.9 mm on the 23-July-2002. In first week of August 32.4 mm of rains fell and accumulated rain was 428 mm (1-August-2001) and 49.2 mm with 250.2 mm accumulated (5-August-2002). It therefore becomes right to plant in the month of August. Therefore farmers planting in the first, second, third, weeks of August were right since there was ample rainfall.

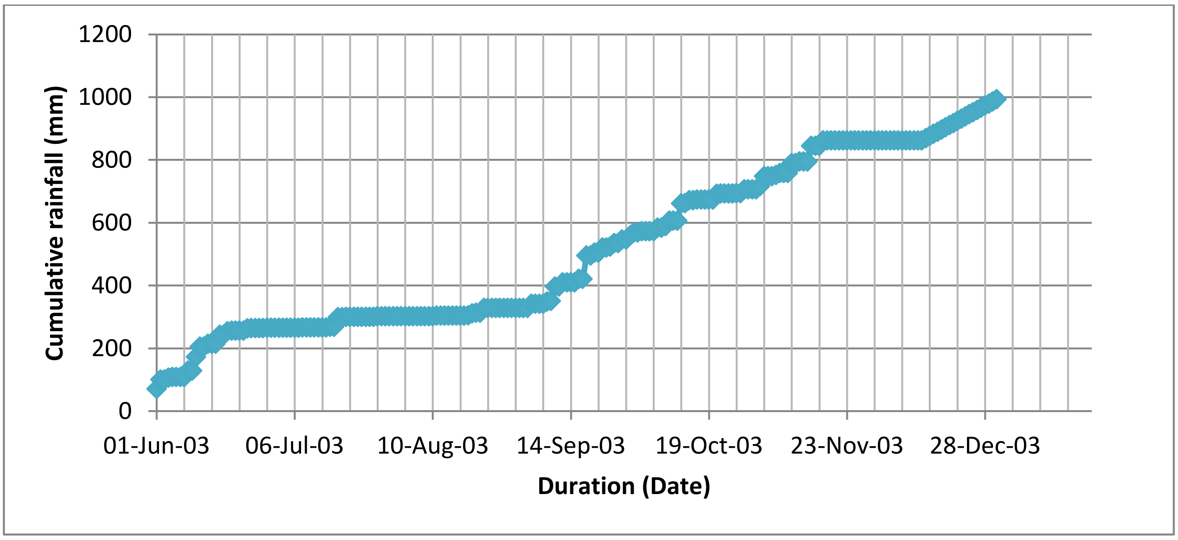


Figure 18: Cumulative rainfall from July-Dec 2003 in the catchment area of *Ejura-Sekyedumase* District

The first and second days of June respectively recorded rainfall of 71.2 mm and 29.5 mm. There was not sufficient rainfall in the month of July until the third week of August where 6.2 mm and 2.3 mm of rainfall were recorded (on 20th and 21st August, 2003). Amount of 15.3 mm rain fell to add up to 329 mm (on 23-August-2003). It can be seen that rainfall affected the normal planting period in 2003. In this case, planting should have been in 1st and 2nd weeks of September (between 4th and 12th Sept., 2003) to meet an accumulated rainfall of 341.6 mm and 410.2 mm respectively. Therefore planting at this time will meet enough rain for growth and development since the rain showed up in the month of September.

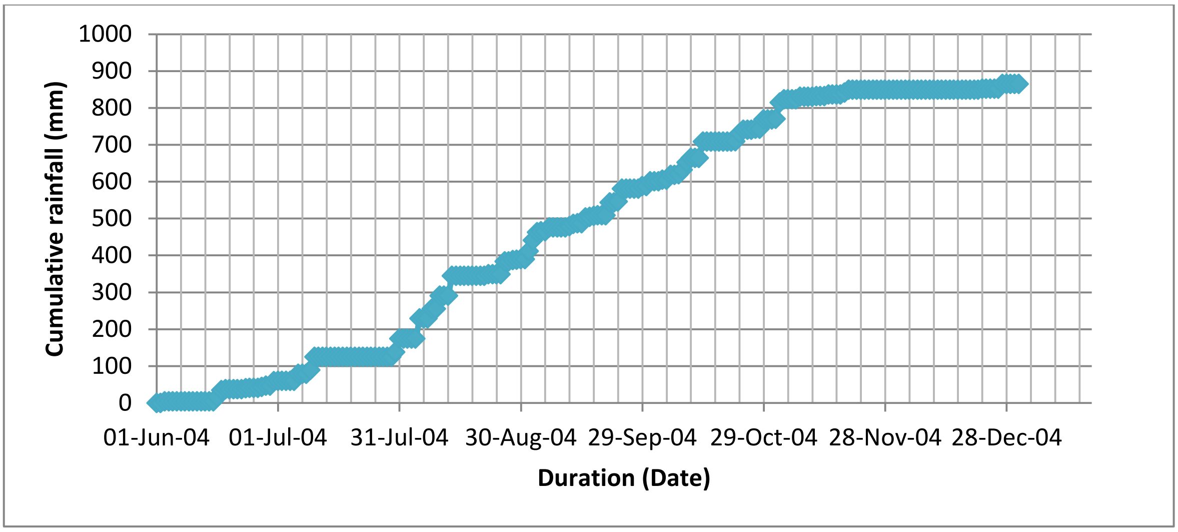


Figure 19: Cumulative rainfall from July-Dec 2004 in the catchment area of *Ejura-Sekyedumase* District

The Figure 19 shows that there was an early rainfall during the first and second weeks of July (18.7 mm, 10.5 mm, and 35.9 mm were recorded) where 124.9 mm was build up on 10th July, 2004. There was no rain after these days to add to what had been already accumulated until 30th and 31st July. Therefore planting in such periods will meet water stress effect since there was no rain until the end of July. The first, second and fourth weeks of August recorded rainfall as shown in Figure 19. Therefore, planting in the month of August is right since there was ample rainfall to avoid the water stress to support growth and development of maize.

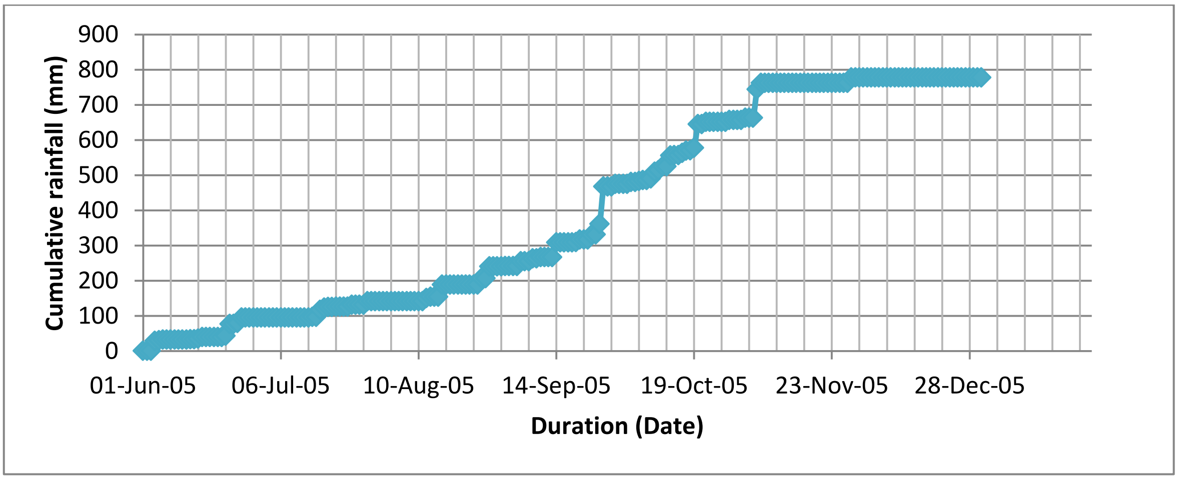


Figure 20: Cumulative rainfall from July-Dec 2005 in the catchment area of *Ejura-Sekyedumase* District

Figure 20 shows ample amount of rainfall (20.3, 5.3, 10.4 mm) were recorded on the 16th, 24th and 28th of July in 2005 respectively after which there was no rain until the end of second week, August (12-August-2005). 240 mm was accumulated on 28th August, 2005. This implies that farmers who depended on that first rain in the minor season of that year faced the consequences of water stress. However, those who planted from the end of the second week of August met rain and did the right thing.

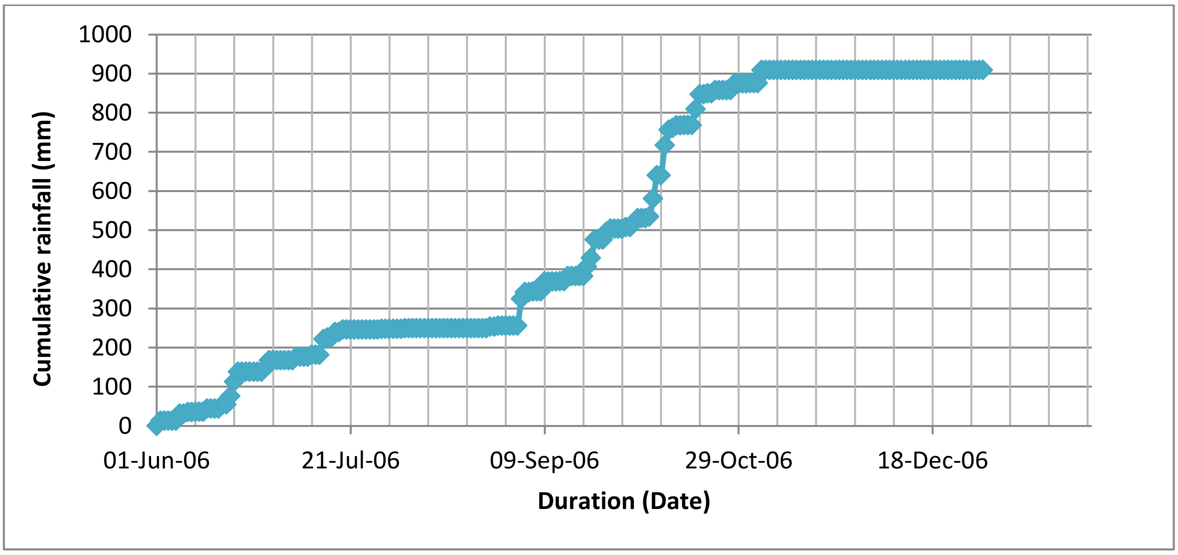


Figure 21: Cumulative rainfall from July-Dec 2006 in the catchment area of *Ejura-Sekyedumase* District

Figure 21 shows that there a significant rain add up in the second and third weeks of July particularly on the 14th July, 2006 (40.4mm was added and 222.1 mm cumulative was attained). There was no rain from 5-25th August, 2006. This suggests that planting in these weeks may be right. However, planting in August may face problems (no germination and scorching) resulting from the absence of rain. Even though early part of September (3-September-2006) received 62.1 mm amount of rainfall add up to 324.4 mm accumulated rainfall, planting in this period will not produce much due to the failure of latter rain which was necessary to ensure growth and development for higher yield. Drought tolerant varieties were the best option to prevent the poor rainfall in 2006 major season.

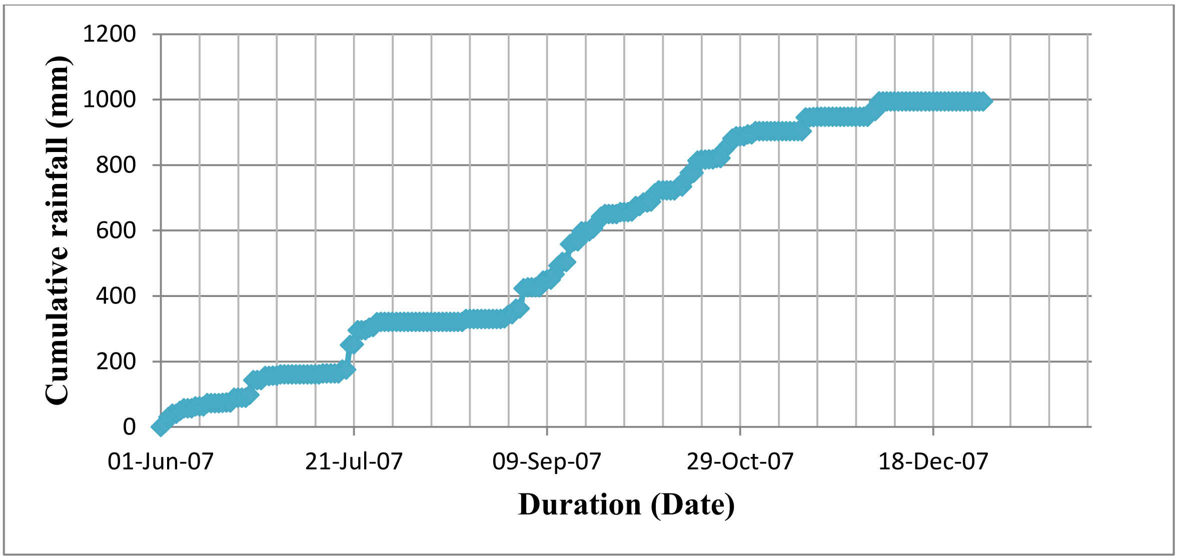


Figure 22: Cumulative rainfall from July-Dec 2007 in the catchment area of *Ejura-Sekyedumase* District

According to Figure 22, rainfall in the month of July was erratic but sufficient rain occurred on the 3rd and 4th weeks. Rainfall was very poor in 1st and 2nd weeks of August but the 4th week recorded substantial rainfall. This suggests that it was conducive to plant in the 3rd week of August and 1st week of September. However, rainfall in 2007 was erratic in between July and August (where majority of farmers cultivate their maize). Although planting in July could be good but the erratic nature of rains will stress maize plants at the early part of the vegetative stage. Notwithstanding, drought tolerant varieties can resist this unfavourable condition to ensure growth and development and result in higher yield.

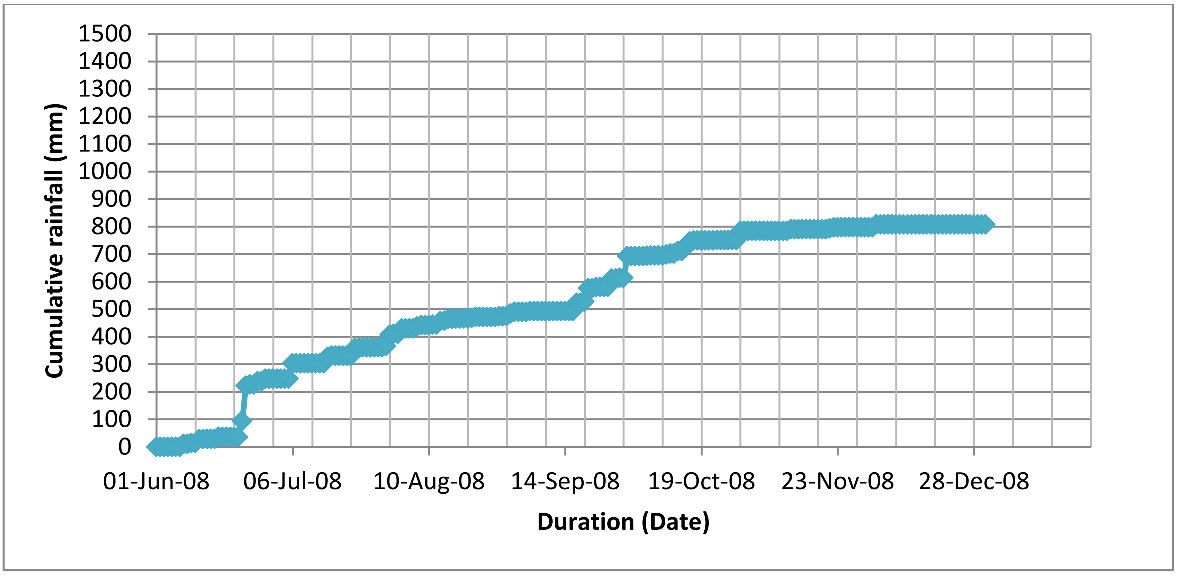


Figure 23: Cumulative rainfall from July-Dec 2008 in the catchment area of *Ejura-Sekyedumase* District

Figure 23 indicates that there was intermittent rainfall in the month of July. These rains accumulated to encourage planting in the month of August where most farmers sow seeds. There was rainfall to start cultivation in August and also plants met rains to support growth and development for higher yield. Therefore farmers who planted in August were right.

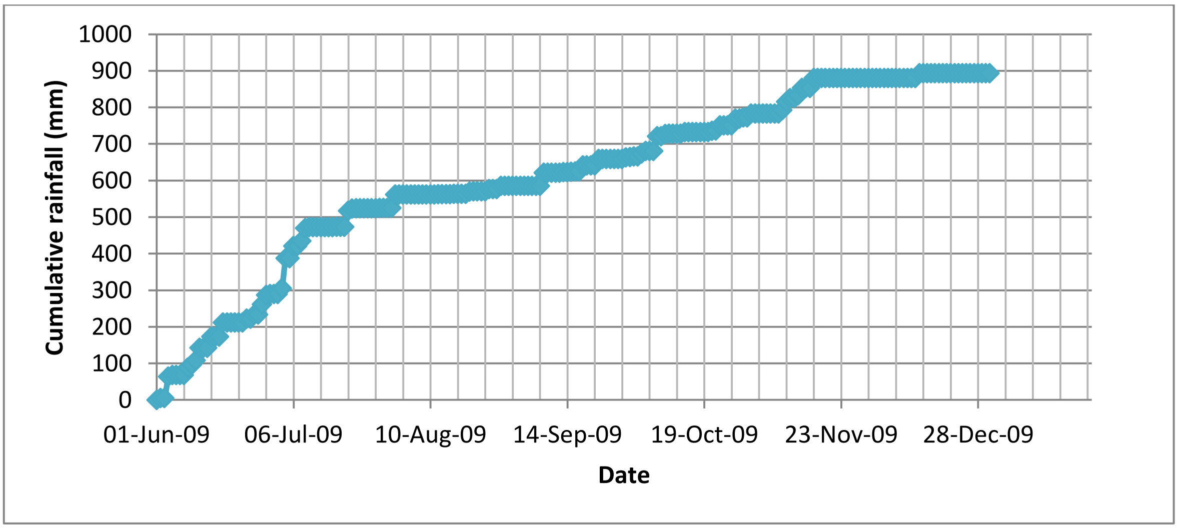


Figure 24: Cumulative rainfall from July-Dec 2009 in the catchment area of *Ejura-Sekyedumase* District

There was rain in the latter part of 1st week of July and early 2nd week of July. Planting in the month of July is right due to the accumulated rainfall of 180.3mm (9-July-2009).

Month of August received minimal or no rainfall aside from the first day of August where 36.5 mm of rain were added, rainfall was very poor in August. These suggest that majority of farmers that plants in the month of August got it wrong in this year.

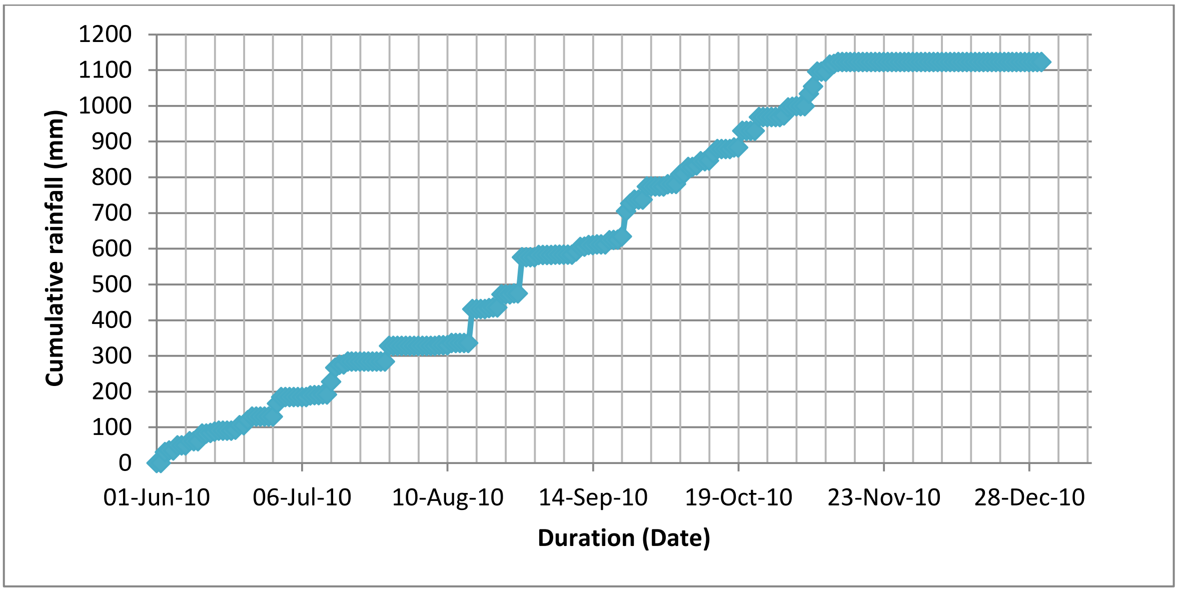


Figure 25: Cumulative rainfall July-Dec 2010 in the catchment area of *Ejura-Sekyedumase* District

From Figure 25, planting in the second and third weeks of July (8-17th July, 2010) may have been right since ample rain recorded but there was rain to improve the soil moisture at the end of July. This suggests that planting in the second week of July was good and plants will meet enough rain if other production factors were rightly considered. The first week of August had no rain, however, high rain was recorded on 16th August, 2010 (recorded 94.8 mm and 430.3 mm was cumulated) and 28th August, 2010 (received 101 mm and 575.5 mm was cumulated) to improve soil moisture condition.

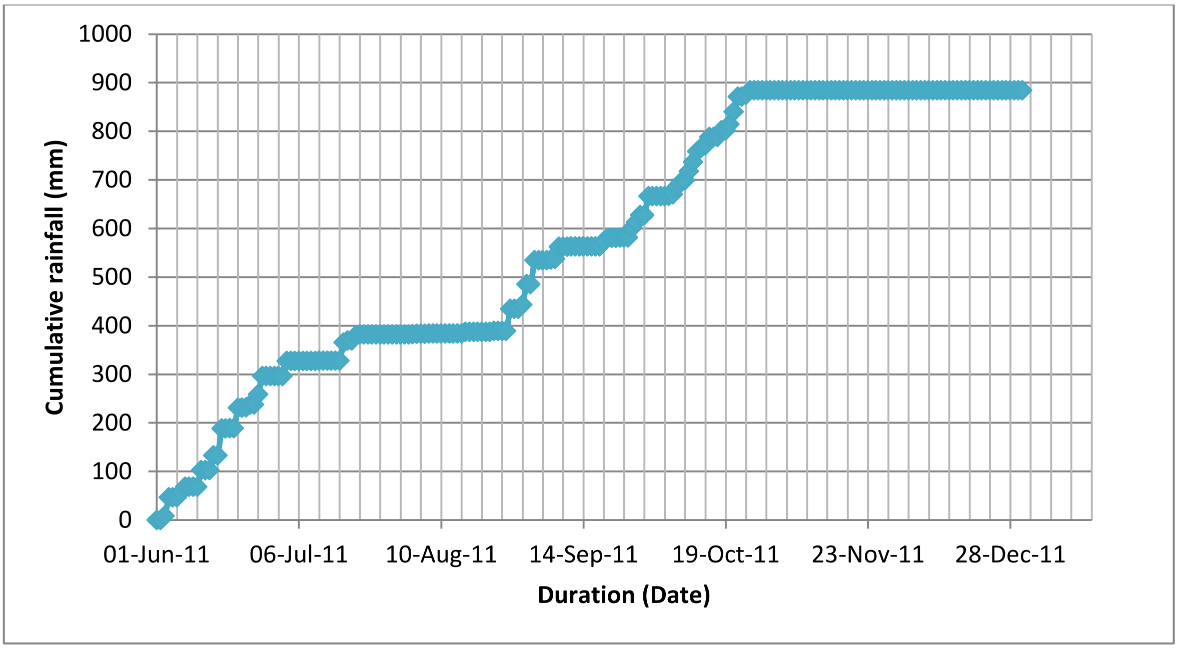


Figure 26: Cumulative rainfall from July-Dec 2011 in the catchment area of *Ejura-Sekyedumase* District

From figure 26, no rainfall was recorded at the beginning of July and on the third week (17-July-2011) 37.9 mm was recorded. The erratic nature of rainfall in July proceeded until 27th August, 2011 where 45.5 mm was received to cumulate 434.2 mm of rainfall. This suggests that planting was appropriate in the latter part of August and first week of September in 2011. At these times soil moisture conditions for plant growth and development was suitable to increase yield.

4.6 Popular planting period and their cumulative rainfall from 2002-2011

The popular planting period and cumulative rainfall was used to assess if rainfall at the time of planting constraint high yield of maize. As indicated Table 7 the most popular planting period is 2nd week of April. The cumulative rainfall at 2nd week of April from 2002-2011 respectively are 150.3 mm, 219 mm, 207 mm, 194 mm, 126.6 mm, 160.7 mm, 152.4 mm, 158.7 mm, 117.4 mm, 86.1 mm as it can be seen from Table 10.

Table 10: Popular planting period and their cumulative rainfall in major season from 2002-2011

Year	Cumulative rainfall (mm)		
	2nd week April	**3rd week April**	**3rd week March**
2002	150.3	168.8	65.1
2003	219	256.8	85.2
2004	207	220.2	108.9
2005	194	203.1	81.4
2006	126.6	126.6	92.3
2007	160.7	192.7	53.6
2008	152.4	178	61.4
2009	158.7	214.4	139
2010	117.4	176.7	55.4
2011	86.1	107.3	52.4

From Table 10, cumulative rainfall of each popular planting period varies from one to another. The highest build up of rainfall in the 2nd week of April occurred in 2003, followed by 2004, 2005, 2007, 2009, 2008, 2002,2006, 2010 and lastly 2011. This variability of cumulative rainfall at a given planting period varies every year. This instability of soil moisture can bring about poor germination which will reduce the population of maize plants on the field if replanting is not undertaken.

4.6.1 Minor season

To ascertain existence rainfall variability and its impact on yield gap, the popular planting period and their cumulative rainfall for minor season were also assessed for the period of 2002-2011

Table 11: Popular planting periods and their cumulative rainfall in minor season from 2002-

Year	Cumulative rainfall (mm)		
	3rd week of August	2nd week of August	1st week of August
2002	954.3	950.4	967.8
2003	304.7	303.7	302
2004	344.3	344.3	228.9
2005	118.4	153.8	141.3
2006	249.4	249.4	249.4
2007	329.3	320.9	320.9
2008	466.1	456	429.6
2009	569.7	562.2	561.5
2010	430.3	335.5	327.4
2011	387.1	383.8	383.2

From Table 11, it can be seen that cumulative rainfall in a particular planting period differs from one year to another. Also, cumulative rainfall for planting periods in a year at some instances remains constant as it occurred in 2006. In 2004, 2nd and 3rd week had the same cumulative rainfall of 344.3 mm, indicating no rainfall in the 3rd week. Also, in 2006, cumulative rainfall was the same in all the popular planting periods suggesting no downpour of rain, hence majority of farmers who plants in August were wrong and . The fact that rainfall varies year after year is an indication that planting periods should varies under rain-fed condition.

4.7 Analysis of choice of planting period using ANOVA

Analysis of Variance (ANOVA) was used to analyse the rainfall data in the major and minor cropping seasons from 2002-2011 to determine if there were significant differences between farmers planting periods which is 3rd week of March, 2nd and 3rd weeks of April for the major season and the 1st, 2nd, 3rd weeks of August for the minor seasons. Both descriptive and inferential statistics was used and hypotheses were tested. The test was conducted at 95% confidence level. The significant level was used to accept the null hypothesis (H_0) or reject the Alternative hypothesis (H_1). At a significance level of less than 0.05 the null hypothesis was rejected and the alternative accepted. Table 12 shows the descriptive results and Table 13 (the ANOVA) presents the inferential statistics. Between the groups, the Null hypothesis -H_0 there was no difference between the three sets of data i.e. the 3rd week of March, 2nd week of April and 3rd week of April. Alternative Hypothesis -H_1 there was difference between the three sets of data that is 3rd week of March, 2nd week of April and 3rd week of April. The test was conducted at 95% confidence level.

Table 12: Descriptive statistics

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
Major Season	1	10	5.8500	2.10093	.66437	4.3471	7.3529	3.50	10.60
	2	10	11.5200	3.15376	.99731	9.2639	13.7761	7.40	16.60
	3	10	11.9000	3.38001	1.06885	9.4821	14.3179	7.70	16.40
	Total	30	9.7567	3.99013	.72850	8.2667	11.2466	3.50	16.60
Minor Season	1	10	59.6800	9.00565	2.84784	53.2377	66.1223	49.50	75.30
	2	10	60.7700	9.05048	2.86201	54.2957	67.2443	50.00	74.70
	3	10	61.8800	8.16793	2.58293	56.0370	67.7230	54.20	74.60
	Total	30	60.7767	8.49291	1.55059	57.6054	63.9480	49.50	75.30

Table 13: ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Major Season	Between Groups	229.653	2	114.826	13.360	.000
	Within Groups	232.061	27	8.595		
	Total	461.714	29			
Minor Season	Between Groups	24.201	2	12.100	.158	.855
	Within Groups	2067.553	27	76.576		
	Total	**2091.754**	**29**			

For the major season the significance level given is 0.000 which is less than 0.05 hence the null hypothesis of no difference between the three data sets is rejected and the alternative accepted. This means that there are significant differences, among the three data sets 3rd week of March, 2nd week of April and 3rd week of April. This is clear from the descriptive statistics. The average figures for each group show that the differences are very small. This suggests that it is possible to plant in either 3rd week of March, 2nd week of April and 3rd week of April since there were no significant differences between the three data sets.

The null hypothesis (H_o) states that there is no significant difference between/within the groups in the major season.. Since the ANOVA test reveals that the test is significant at 1%, we reject the null hypothesis in favour of the alternate hypothesis (H_1). This indicates that there is significant difference between groups (which are the 3rd week of March, 2nd and 3rd weeks of April) in the major season. In the minor season, the test reveals that is not significant. Hence we fail to reject the H_0 and indicate that there is no significant difference between/within the groups in the minor season.

4.8: Technical Constraints

Technical factors such as maize varieties, source of seed, land preparation and fertilization were considered. Right inputs of such technical factors are a prerequisite for higher yield of maize. Maize yields are constrained where these factors are not properly considered.

a. **Types of Maize**

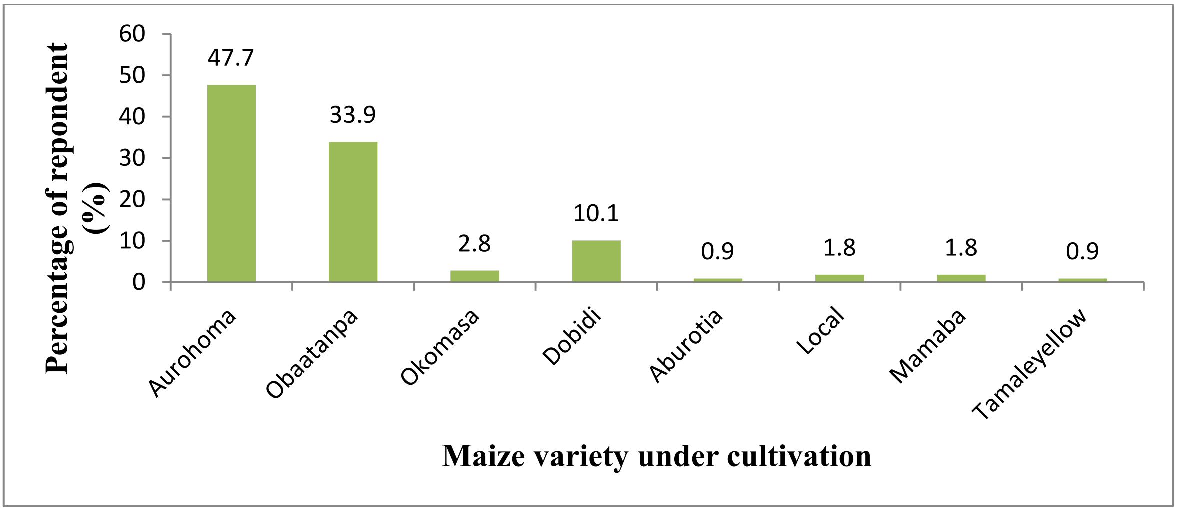


Figure 27: Type of maize farmers cultivate

The results from the survey in Figure 27 shows that the farmers cultivate Aburohoma (47.7%), *Obaatanpa* (33.9 %), *Dobidi* (10.1 %), *Okomasa* (2.8 %), *Mamaba* (1.8 %), Local variety (1.8 %), *Aburotia* and Tamale Yellow (0.9 %).

The recommended varieties farmers should cultivate are *Obatanpa* and *Mamaba* as shown in Table 5. This implies that only 35.7 % of the farmers use quality protein varieties (QPV) (Obaatanpa and Mamaba) with yield potential of 5.5 t/ha and 7.5 t/ha respectively.

On the contrary more than half of the farmer respondents (64.3 %) grow varieties that are not recommended such includes *Aburohoma* (47.7 %), *Dobidi* (10.1%), *Okomasa* (2.8 %), local variety (1.8 %), *Aburotia* and Tamale Yellow (0.9 %). These suggest that majority of farmers in the area still use non-recommended varieties, they thus produce below expectation irrespective of other inputs. *Aburohoma* is the most cultivated variety by farmers.

Table 14: Reasons for maize varietal selection from farmers' perspective

Reason	*Aburohoma*	*Obaatanpa*	*Okomasa*	*Dobidi*	Local variety	*Mamaba*	*Tamale yellow*	*Aburotia*
Yield superiority	37	25	2	3	3	1	0	0
Good taste	17	19	1	2	1	1	1	1
Pest resistance	31	10	3	7	1	1	1	0
Drought resistance	18	25	0	3	0	1	1	0
Disease resistance	15	5	0	6	0	0	0	0
Seed quality	11	21	2	3	1	2	1	0
Early maturity	14	32	0	4	1	1	0	1
According to farming season	9	4	0	0	0	1	0	0

Table 14 shows that farmers have reasons such as yield superiority, good taste, pest resistance, drought resistance, disease resistance, seed quality, early maturity and farming season behind their choice of variety. Identification of reasons is based on expert advice and also from literature. This presupposes that farmers have relevant knowledge with regards to why they choose their varieties. However, in reality most farmers still do not use the recommended variety. The assumption is that farmers may not have money to purchase recommended varieties. According to the respondents, the choice of *Aburohoma* was based on the yield superiority, pest resistance, drought, taste and for *Obaatanpa*, the choice was based on early maturity, yield superiority, drought resistance and seed quality.

b. Seed source

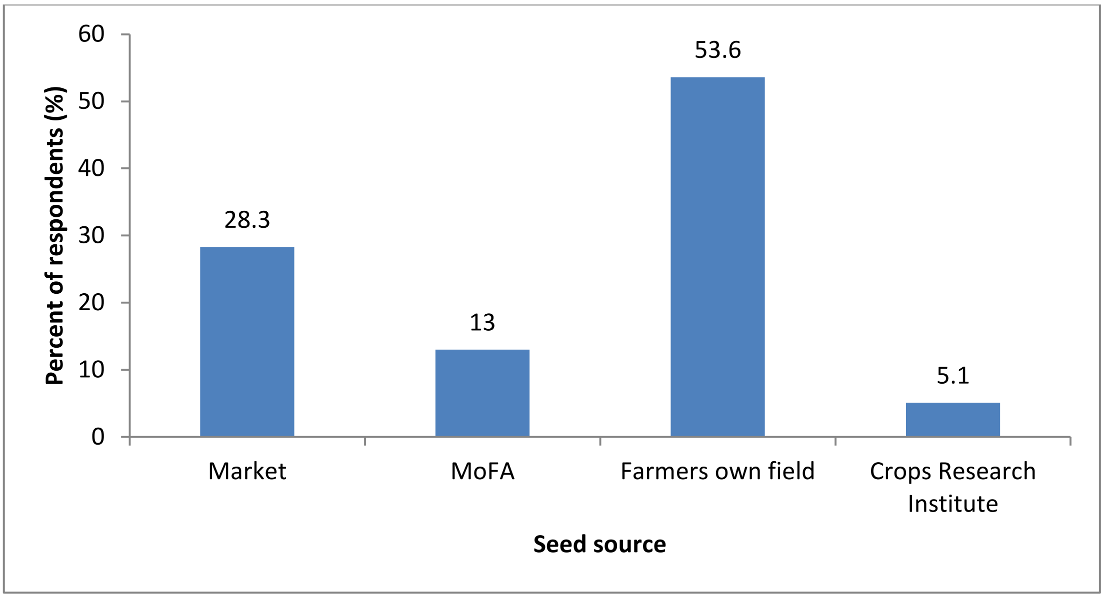


Figure 28: Sources of seed for farmers

Figure 28 shows that 53.6 % of the farmer respondents use maize from their own farm to cultivate. This suggests that farmers utilize seeds from their previous crops and hence the practice of using uncertified seeds is rife in the study area. The widespread usage of common seed has the potential to reduce yield. Farmers need training in the seed technology. The poor seed selection consequently reduces the yield potential and yield will drastically reduce. The assertion by E-TIC (2012) that low yield in Sub-Saharan Africa may be attributed to poor seed selection may be applicable here. Farmers practice with regards to seed selection implies 'seed recycling' which can be a contributory factor to the lower yield. The yield level of recycled variety reduces due to loss of hybrid vigour when recycling persists. This is in line with the report of Wanyama *et al* (2005) that yield levels of recycled maize variety-' H614'reduced by 15.86%, 16.70%, 32.25% and 46.80% for the first, second, third and fourth recycling generations respectively and noted a progressive loss in grain yield when maize is recycled by farmers.

c. **Land preparation method**

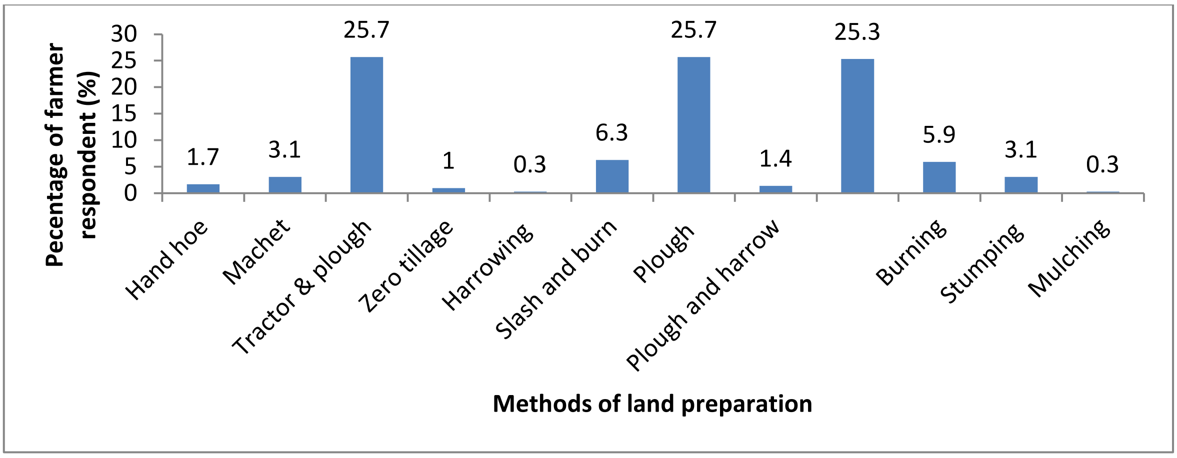


Figure 29: Method of land preparation

Technically, modern methods of land preparation promote better production of crops like maize. As revealed in Figure 29, modes of land preparation are mainly tractor with plough (25.7 % of farmer respondents), weedicide application (25.3% farmer respondents), slash and burn (6.3% farmers' respondent), burning (5.9%). These suggest that majority of the farmers use modern methods of land preparation. This confirms the finding that in the transitional zone of Ghana which is more or less becoming grassland, tractor services are being utilized for land preparation including ploughing and harrowing (WAB, 2008). Other farmers who still use the traditional mode of land preparation such as slash and burn (6.3% farmer's respondent) and burning (5.9%) are likely to impact negatively on the environment. Slash and burn method can reduce the productive level of the soil since macro and micro soil organisms can be burnt during the burning process. Also, moisture content of the soil can be lost after the burning process which becomes worst when rainfall becomes erratic. In effect farmers have to spend more on inputs like fertilizer to enrich the soil and farmers who are unable to do so may experience lower yield. To avert the detrimental effect of bush burning modern methods can be used.

d. Fertilizer application

On fertilizer application the research wanted to know if farmers are aware of the importance of fertilizer in their production, method of application and to know if farmers really apply fertilizer (s). Farmers' knowledge about the benefit of using fertilizer was tested through the reasons why they use fertilizer.

Table 15: Fertilizer application

Fertilizer usage	Number of farmers	Percent of farmers (%)
Yes	73	73
No	14	14
No answer	13	13
TOTAL	100	100

Table 15 shows the percentage of farmers who do not use fertilizer as 14 %, but 73% of farmers respondent use fertilizer on their maize farm which is a good approach to increase production. Although the research revealed a higher percentage of farmers with fertilizer usage, its impact on yield gap is not realized. However, the unfelt impact of fertilizer may be attributed to the method of application, quantity applied, time of application, as well as the high cost of fertilizer. Then also, 27 % of farmers respondent do not apply fertilizer. Report of FAO (2002) showed that maize yield increase at optimum use of fertilizer in Ghana.

Table 16: Methods of fertilizer application

Method of fertilizer application	Number of respondents	Percentage of respondents (%)
Broadcasting	6	7.4
Drilling	4	4.9
Ground placement	10	12.3
Top dressing	3	3.7
Side dressing	58	71.6
TOTAL	81	99.9

Table 16 indicates that side dressing is a major mode of fertilizer application (71.6%). This gives a clue that fertilizer used are in solid form. In effect maize plant may not get much of the nutrient since the fertilizer may either evaporate or be leached deep if much rainfall occurs soon after application.

Table 17: Reasons for use of fertilizer

Reason to the use of fertilizer	**Number of responses**	**Percentage of respondents**
Availability	14	16.2
Nutrient composition	7	8.1
Commonest	5	5.8
Improvement of land	1	1.2
Increase yield	20	23.3
Help plant development	8	9.3
Contain nutrient for plant growth	23	26.7
Economical	1	1.2
Effective	1	1.2
Nitrogen content	4	4.6
Good for stem	1	1.2
Cob formation and early tassel	1	1.2
TOTAL	86	100

Table 17 reveals that farmers use fertilizer for several reasons such as its nutrient contribution to plant growth (26.7%), yield increase ability (23.3%) and availability (16.2%). The results show that fertilizer application in the area is determined mainly by nutrient composition, yield enhancement and the availability of fertilizer. This suggests that making fertilizer available to farmers can be an opportunity to favour farmers in their quest to enrich the soil for bumper harvest.

4.9: Socio-economic status of farmers in the *Ejura-Sekyedumase* District

A. Credit facility

Credit is an important factor that needs a consideration if expectations are to be met. Under farmers perspective the research focused on farmers' perception of how access to credit would improve their production, access to credit and credit source.

a. Farmers perception of how access to credit would improve their production

Table 18: Answering the question how would access to credit help in your farm?

How access to credit influence farming	Number of respondents	Percent of respondent (%)
Purchase of inputs	21	20.4
Expansion of production area	37	35.9
Farm management	1	0.97
Rearing of animals	1	0.97
Increase crop yield	27	26.2
Labour acquisition	2	1.9
Income for the family	4	3.9
More food production	4	3.9
Labour use intensity	1	0.97
Increase productivity	2	1.9
Purchase agro-chemicals	1	0.97
More income	2	1.9
TOTAL	**103**	**99.88**

According to farmers, access to credit will help them expand their production area (35.9%), increase crop yield (26.2%), purchase inputs (20.4%) and do other things as tabulated in table 18. This is an indication that when credit is made available to farmers, yield stands the chance to increase because perception of farmers according to Table 18 is geared towards achieving a higher production. Declaration by Littlefield (2005) that the chances created by credit availability helps a lot of poor people to invest in their own businesses, educate their children, improve their healthcare and promote their overall well-being becomes vital here. It can therefore be said that credit when made accessible to farmers will results in larger farms and make farmers proactive in farm activities and eventually increased harvest.

b. Access to credit

Table 19: Farmer's response to the question do you have access to credit?

Farmers with Access to credit	Number of responses	Percent of respondents
Yes	27	27
No	73	73
TOTAL	**100**	**100**

The results of the research revealed that 73 % of farmer respondents have no access to credit but only 27 % have access to credit for maize farming activities. This suggests that majority of farmers (73%) are self-dependant with regards to maize production. In effect, production inputs such as improved maize varieties, fertilizer and labour will be negatively impacted since farmers' purchasing power is constrained in the absence of credit. Credit availability affects technology adoption.

c. Credit source

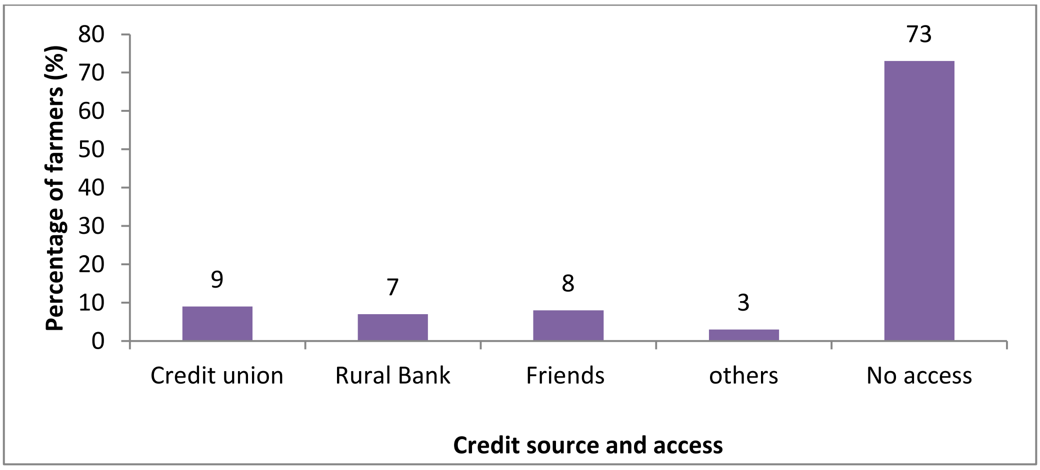


Figure 30: Sources of credit to farmers in the *Ejura-Sekyedumase* District

Figure 30 indicates that 73 % of the farmer respondents do not have access to credit, only 27 % have access to credit. 9 % source their credit from credit unions, 8 % from friends, 7

% from rural banks and 3 % from others. The outcome of the survey is a proof that farmers have a serious problem in obtaining credit for their farm activities. The 8 % of the farmers who receive credits from friends are likely to obtain it on high interest rates since their friends might have also acquired it from credit institutions because they are customers and even with collateral securities. This is a confirmation of the finding of Chaudhary (2009) that the intricacy in securing sufficient, timely credit for agricultural infrastructure development, capital cost and crop loan is a major constraint to maize production. Sampled farmers had no access to credit (73 %) suggesting that availability of credit is really a difficult issue in the study area. This difficulty may have resulted from lack of collateral security and knowledge about credit acquisition. Obeng (2008) identified that credit acquisition require collateral security even with credit unions in addition to being a good standing customer. Further Obeng (2008) concluded that a higher interest rate has a detrimental effect on farming in Ghana since growth and development of the sector depends on adequate, available and accessible funds at favourable rates. It has also been stated in the challenges of Ghana's agriculture that financial constraints bring about lack of assets ownership to serve as collateral security and lack of credit mostly to purchase inputs is the most prevalent constraints to agricultural development (MoFA, 2007).

d. Extension Services Received by Farmers

Table 20 shows that farmers are not ignorant of benefits they can derive from extension work. In effect, farmers will be ever ready to receive extension services. The question of what benefits extension service brings probably can be answered in the Table 20. It is clear that when farmers gain access to knowledge and information, yield will increase and hence income. The success of extension in achieving this will however, depend on the extension approach that is used to reach or communicate to farmers. Based on this results it can be said that farmer's extension work is geared towards yield increment. Extension service is critical in bridging the existing gap. It has been argued that agriculture-specific human resource is vital to raise farm yield in a changing environment since it enhances farmer's abilities to allocate resource (Schults, 1975 as cited in Evenson and Mwaba, 1998). The assertion that Ghanaian farmer's benefits from extension for various reasons including technical advice to improve production, new technologies, improve income and livelihood among others has been proved in the study.

Table 20: Forms of extension services received by farmers

Services farmers receives from extension officers	**No of farmers respondents**	**Percentage of farmers (%)**
Introduction of new technology	10	10
Advise	2	2
Modern methods of farming	14	14
Crop storage and preservation	2	2
Increasing yield	8	8
Improved cultural practices	13	13
Seed selections	8	8
How to apply fertilizer	7	7
Income generation	1	1
Improve farming activities	5	5
Proper use of chemical	1	1
Increase in farm size	2	2
Pest control	3	3
Mobilization techniques	2	2
Crop and animal production	1	1
Good agricultural practices	4	4
Planting techniques	2	2
Insect control	1	1
Weed control	1	1
Food security	1	1
Purchasing of farm inputs	1	1
Increase productivity	1	1
Farm sanitation	3	3
Reduce cost of production	1	1
Site acquisition for farming	1	1
No help	5	5
TOTAL	**100**	**100**

Table 20 shows that farmers benefit from extension service in many ways. Some of the services include introduction of new technology (10 %), modern methods of farming (14 %), increasing yield (8 %), improved cultural practices (13 %), seed selections (8 %), how to apply fertilizer (7 %), improve farming activities (5%), farm sanitation (3%), and no help (5%). Majority of the farmers about 95 % receive extension service of some sort.

Further questioning showed that extension service occurs either on farmers' home or farm. Extension work occurs at farmer's field (about 54.8 %), farmer's home (about 45.2%) suggest how farmers can be reached within a specific cropping season. Assuming every farmer is to be visited on their field, considering extension to farmer ratio in Ghana there will not be enough and frequent contact with farmers. In effect extension works become ineffective because of the resource available. Approach used in reaching out to the farmers in various communities within the study area is shown in figure 34.

e. Frequency of Extension Visit

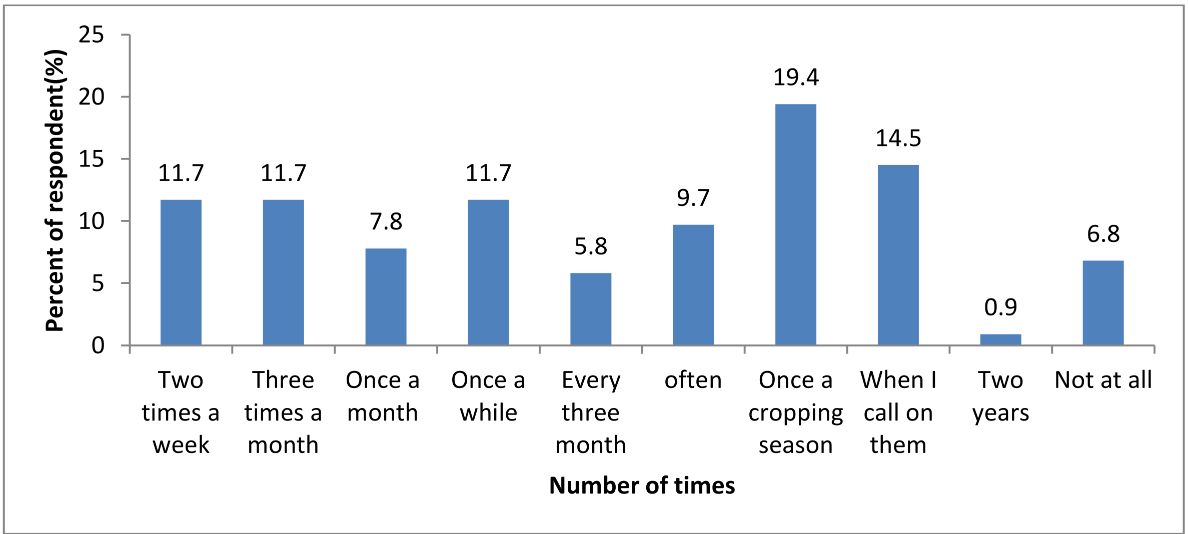


Figure 31: Farmer respondents on the number of times extension officers visit them

Figure 31 indicates that farmers contact with extension workers is irregular. 19.4 % of farmer respondents are visited once a cropping season, 14.5% when farmers call on extension workers, 11.7 % once a while and 6.8 % are not at all visited. These suggest that farmers are not intensively exposed to extension services. In effect farmers are likely to apply their own knowledge and adoption of technology becomes weak. Aman *et al* (1988) claim that intensive exposure of farmers to extension work is important.

Another implication is poor accessibility of extension work and service which can contribute to low yield in the area. It has been argued that access to agricultural extension services and advisory service is linked with the number of extension visits, and in their results using the control function approach it was found that adoption of new technology increases yield (Mugisha and Diiro, 2010).

f. Farmers' perception of the importance of the extension services

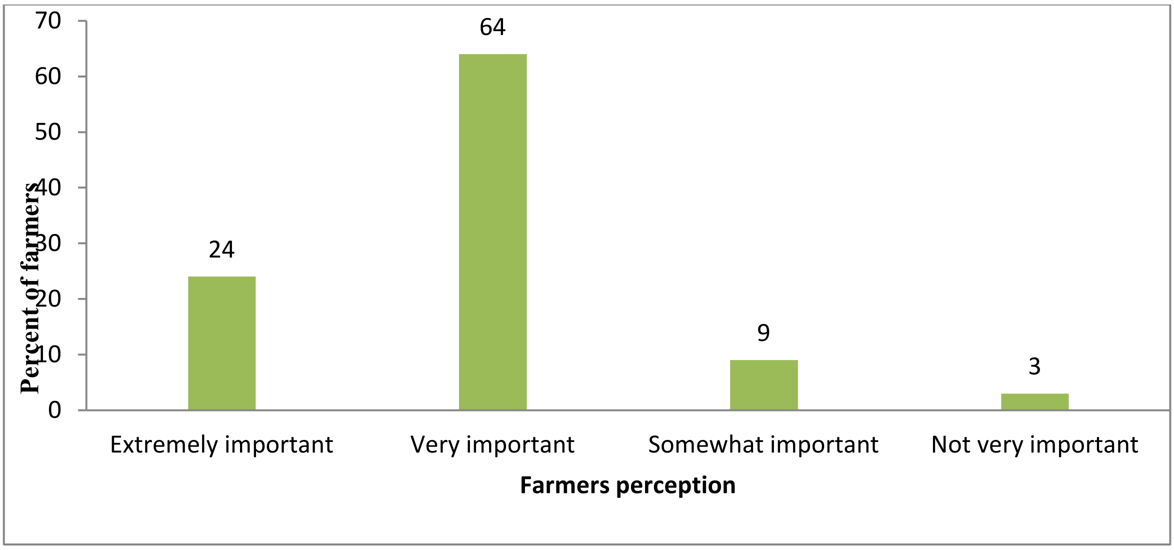


Figure 32: How farmers in *Ejura-Sekyedumase* District perceive extension work

The outcome indicates that extension work is perceived as very important (64 %), extremely important (24 %), somewhat important (9%), and not very important (3 %) according to farmer respondents. Majority of the farmers have a friendly perception about extension work which is a good trait to ensure smooth dissemination of information. However, those who esteem extension education as somewhat important (9%), and not very important (3 %) are likely to denounce technology adoption and improved practices and therefore limiting their chance of gaining a higher yield.

g. Investment

The research considered farmers farm size, as well as the way money from their farm is spent as investment. The farm size can be used to group the farmers as subsistence, medium or large scale farmers. Subsistent farmers grow to feed their own family with little or no surplus for sale and therefore it becomes difficult for subsistent farmer to save in financial institutions and to acquire credit to expand the farm. How money from farming is spent can determine advancement in production. Farmers who spend their money on income generating activities and made savings can easily obtain inputs for the subsequent cropping seasons.

h. Farm size

Table 21: Farm size (acre) of respondent in the study area

Farm size (acres)	Number of farmer respondents	Percent of respondents
2.5	7	8.2
3	11	12.9
4	4	4.8
5	21	24.7
6	18	21.2
8	8	9.4
10	3	3.5
13	2	2.3
15	5	5.9
16	1	1.2
Not determined	5	5.9
TOTAL	**85**	**100**

The survey revealed that 16 acres (6.4 ha) as the highest farm size (only 1 response), followed by 15 acres (5 respondents). It was revealed that majority of farmers (24.7% respondents) have 5 acre size of farm (21.2% respondents) had 6 acres farm size. However, few farmers (5.9%) have 15 acres and (1.2 %) 16 acres of farm size. 5.9 % of farmers do not know their farm size. The suggestion that the number of farm acres farmed has positive effect on net income (Dunn and Jeffery, 2000) is likely to be applicable here since farmers make minimum profit. Small acres farmed may be as a result of land rent. It can also be said that farmers in the study area are smallholders and large scale farmers.

i. Usage of farm profit

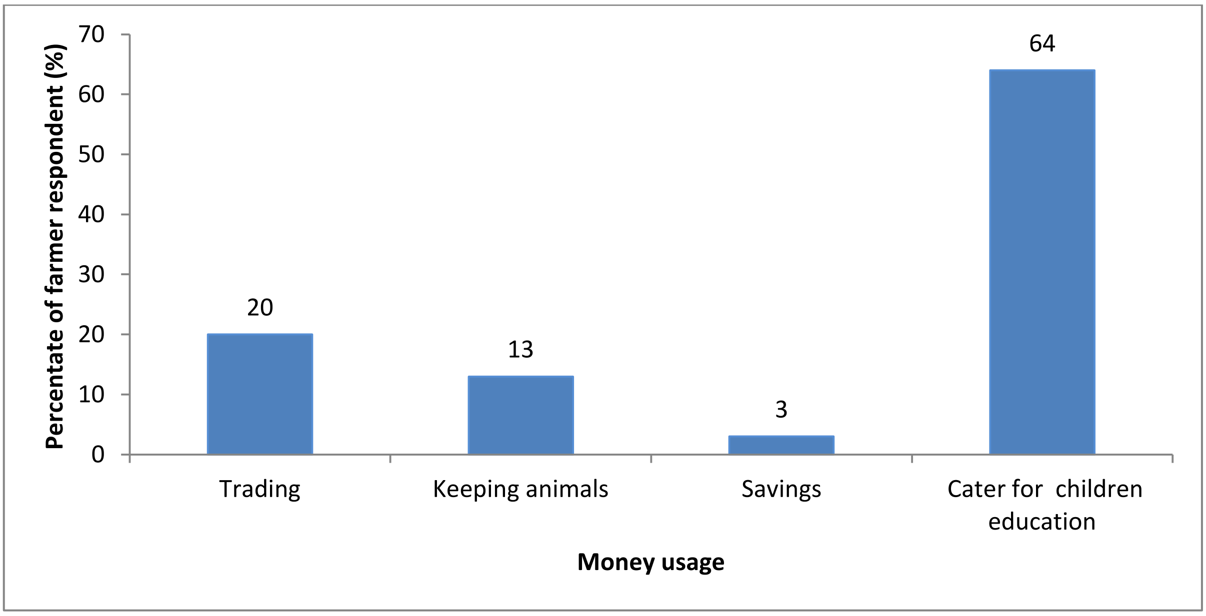


Figure 33: How returns from maize production are spent by farmers

The result of the research revealed that majority of the farmers income are used on student's fees (64%), trading (20%), rearing animals (13%) and savings (3%). Farmers saving are minimal only 3 % of the farmers respondent. This suggests that collateral for loan or credit will be a difficult issue for most farmers. Possibly farmers ability to increase cropped area in subsequent years will be restricted and farmers will have no option than to maintain existing farm sizes or increase just a bit.

Other income generating activities were asked in order to assume how they are occupied and perhaps determine how they can spend ample time farming.

Table 22: Other income generating of farmers

Other activities aside farming	Number of respondent	Percent of respondents
Trading	32	47.7
Driving	2	3.0
Teaching	5	7.5
Hair dressing	1	1.5
Poultry farmer	3	4.5
Civil servant	1	1.5
Livestock farmer	9	13.4
Painter	1	1.5
Motor fitter/mechanic	1	1.5
Welder	1	1.5
Assemblyman	1	1.5
Fitting (Mechanic)	1	1.5
Hunting	1	1.5
Blacksmith	1	1.5
Photographer	1	1.5
Crops officer	4	5.9
Banker	1	1.5
Meteorological officer	1	1.5
TOTAL	**67**	**100**

Table 22 indicates that maize farmers are occupied with diverse income generating activities of which majority are traders (47.7%), livestock farming (13.4%) and teachers (7.5%). This indicates that farmers will have multiple sources of income. However, time devoted to farm activities is questionable. There is high probability of devoting lesser time to farming activities due to this diverse work.

4.10: Yield constraints from researchers' perspective

The result of the study reveals that 62.5% of researcher respondent had fields for their research purpose whilst 37.5% are without fields.

a) Need for Soil Testing

71.4% viewed soil testing as very important in maize production and 28.6% as extremely important. 85.7% agreed that testing the soil will help bridge the gap in maize production and 14.3% strongly agreed. 57.1% test the soil anytime before planting, 28.6% do so once a year and 14.3% test the soil when undertaking fertilizer experiments.

Soil is tested for nitrogen (17.2% of respondents), phosphorus (17.2%), potassium (17.2%), pH (17.2%), electrical conductivity (6.9%), salt (6.9 %), organic matter (10.3 %), micro elements (3.4%) and calcium (3.4%)

b) Varietal Selection

Maize varieties researchers recommend to farmers are improved varieties (33.1% respondents), pest resistant variety (16.7%), disease resistant (16.7%), high yielding (16.7%) and early maturing variety (16.7%). Reasons being that these varieties have yield superiority (19.2%), good taste (15.4%), pest resistant (11.5%), economic value (11.3%), drought resistant (15.4%), disease resistant (11.5%), seed quality (11.5%) and better shelf life (3.8%).

c) Seed Source

Researchers perceived that farmers obtain planting seeds from the market (about 22.2%) MoFA (11.1%), farmers own field (16.7%), Crop Research Institute (16.7%), grain Development Company (16.7%), certified seed growers (3.8%), agro input dealers (3.8%) and seed companies (3.8%).

d) Recommended Agricultural Practices to Improve Yield

According to the researchers, agricultural practices necessary to improve yield include irrigation (10.3%), fertilizing (20.7%), weeding (17.2%), planting density (17.2%), slash and burn as part of tillage practices influence yield.

e) Recommended Fertilizer

Fertilizers used on researchers field include NPK (15:15:15 as basal) (46.1%), urea (15.4%) sulphate of amonia as top dressing (23.1%), poultry manure (7.7%), chemical fertilizers (7.7%). Reasons for using such fertilizers include easy availability on the market (25%) easy accessibility (12.5%), nutrient improvement (25%), and soil structure improvement (25%) as well as higher yield (12.5%). Recommended methods used for applying fertilizers are broadcasting (9.1%), drilling (18.2%), ring placement (45.5%), bond placement (9.1%) and side placement (18.2%).

f. Socio-economic factors

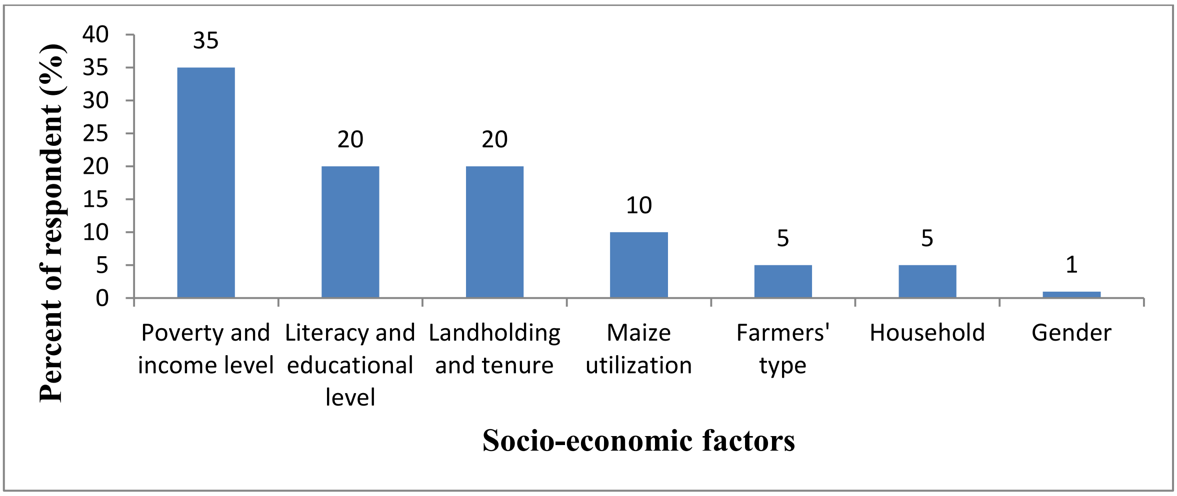


Figure 34: Socio-economic factors of production considered from researcher's perspective

From Figure 34, it can be observed that poverty and income level (35%), literacy and educational level (20%), landholding and tenure (20%) are the major socio-economic factors accounting for low yield of maize in the study area. The high percentage of poverty and income (35%) may be as a result of the fact that farmers in the area make low profits as identified in this study. Low profits also go hand in hand with the poor attitude of farmers towards investment; in effect difficulties in securing credit persist.

g. Attitude to Investment

To get a clearer idea about investment, researchers were asked to rate farmers' attitude to investment. This can help to appreciate some generic causes or problems associated with credit acquisition.

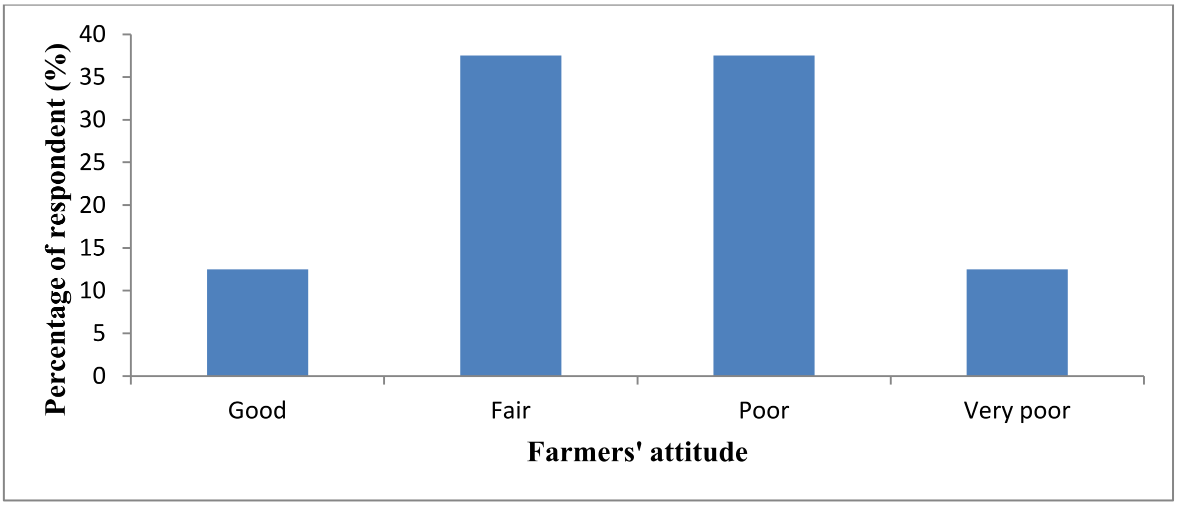


Figure 35: Rating farmers' attitude to investment from researcher's perspective

Farmers have poor and fair attitude to investment (37.5 % for each) as in Figure 35. The poor attitude (37.5%) of farmers can be seen as a socio-economic limitation to maize production. Poor attitude to investment leads to difficulty in acquiring credit due to lack of collateral which is a prerequisite to credit acquisition.

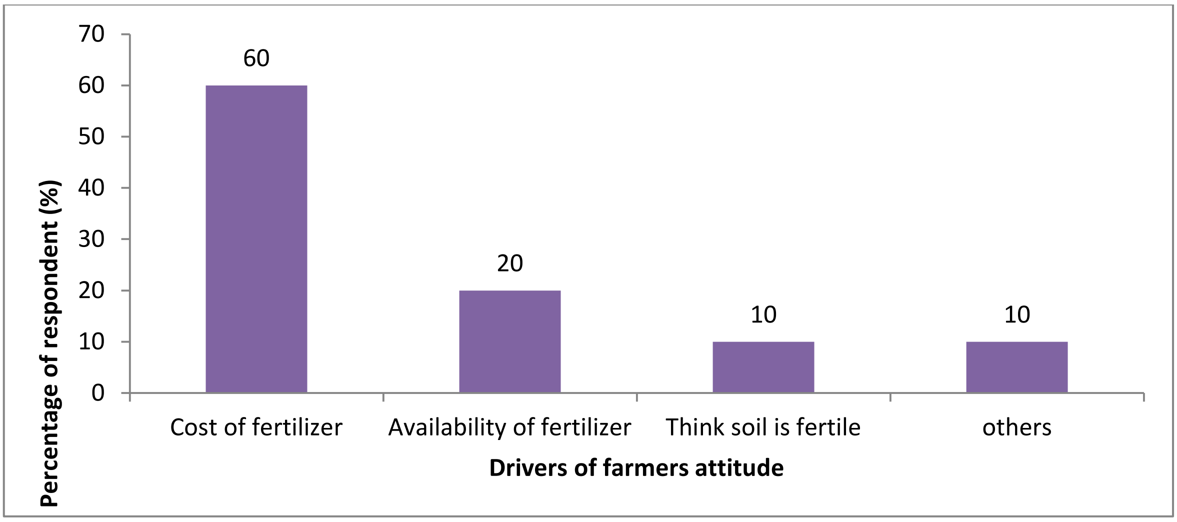


Figure 36: Drivers of farmer's attitude towards the use of fertilizer

The study reveals cost of fertilizer (60%), availability of fertilizer (20%) as factors that determine usage of fertilizer by farmers. These imply that when price of fertilizer soars high, farmers will not be able to purchase enough quantity to boost yield. Similarly, when fertilizer is made available at low cost, farmers can purchase to apply on their maize farms.

4.10.1 Technical constraints

Table 23 Researchers' view on importance of soil testing in bridging the gap

Views	Number of respondents	Percentage
Strongly agree	1	14.285
Agree	6	85.714
Total	**7**	**99.999**

4.10.2 Biophysical factors influencing maize yield gap

The biophysical factors determining maize yield considered in the study included the changing climate, its effect on maize yield, and associated pests and diseases.

4.10.3 Climatic constraints

a**) Climate change**

Table 24: The extent to which researchers agree to the influence of climatic change on yield in Ghana

serious influence yield gap	Number of respondents	Percentage
Strongly agree	5	71.428
Agree	2	28.571
Total	**7**	**100**

The outcome of the study showed that researchers strongly agree (71.4%), agree (28.6%) to the fact that climate change influence maize yield in Ghana. This assertion is right since various schools of thought support this idea. Maize as a biological entity will be affected by climate change and hence the claim of Inter-governmental Panel on Climate Change (IPCC, 2007) is assumed to happen in Ghana. Even pest and pathogens may also be influenced by climate change and the actual yield of maize will not be achieved according to Gregory *et al* (1991 and 2006). The changing climate will have a direct impact on maize production by affecting land preparation, planting period, harvesting and therefore those accounts for low yield. This complements the statement that uncertainty and erratic nature of rainfall will result in drought impact on choice of planting time and harvest of seasonal crops and eventually reduce production per unit land area (Maharjan *et al*., 2010).

Also the opinion of Keith *et al* (2010) that extreme weather events that cause crop failure are floods, frosts, hail and strong winds, prolonged droughts and heat waves are all likely to become more frequent, complementing researchers' belief of the consequence of climate change.

b) Climatic parameters

Climate paramters that mainly restrain maize yield are temperature and rainfall. Herbicidal control is less effective under dry and hot conditions but mechanical cultivation is more effective (Pimental *et al.*, 1993). Temperature also affect yield as the growing season becomes extended in many places (Barnett *et al.*, 2006). High temperatures enable early cropping and more crop species to be grown but greater probability of higher disease pressure persists (Peltonen-Sainio *et al.*, 2009).

As temperature increases droughts are exercebated, maize production is dangerously affected. Rise in average temperature affects growing season which in turn reduces crop production in temperate regions. As a result, 30% drop in maize production has been projected by 2030 (scienceinafrica, 2008). Ghana's projection indicates that temperature will cause low cereal yield throughout the country (Masahudu,2011). Lobell *et al* (2011) testify that effects of present high temperatures on maize is higher compared with previous assumptions of high temperature.

c) Climate change effect rating

Questions were asked about climate change impact in the last 10 years as to whether the impact has been fair, high, low or moderate. This can help to appreciate the nature of the impact of climate on maize production by researchers.

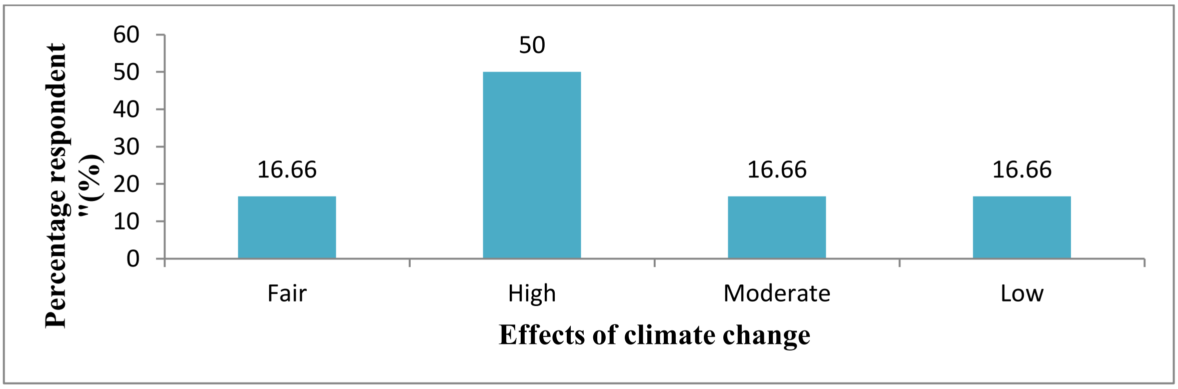


Figure 37: Rated effects of climate change on maize production in the transitional zone of Ghana for the past 10 years

Researchers showed that the impact of changing climate has been high (50 %) on maize production in the transitional zone within which the study area, *Ejura-Sekyedumase* District, is located.

d) Climate effect that constrains maize production

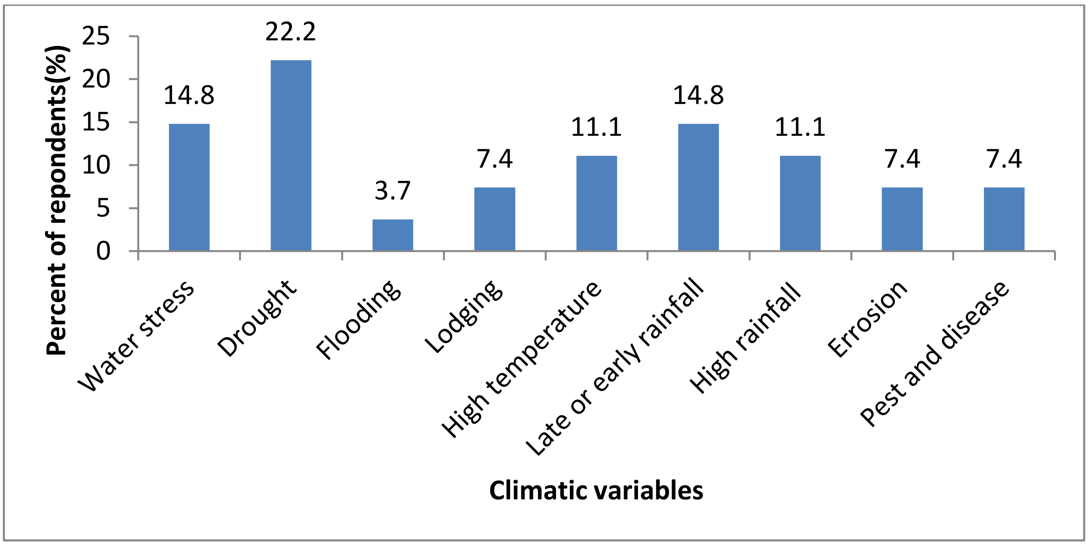


Figure 38: Climate characteristics/ effects in the study area

The results from researcher respondents show that drought (22.2%), water stress and late or early rainfall (14.8% respectively), high temperature and rainfall (11.1 % respectively), lodging, erosion and pest and diseases (7.4 % respectively) constrain maize production in the study area. Drought (22.2%) and water stress and late or early rainfall (14.8% respectively) are the major climatic parameters which negatively influence maize production. The assertion that drought is a very significant factor that constrain maize production in less endowed countries (Edmeads *et al.,* 1998) is likely to be true. This is because maize production is purely under rain-fed conditions, without irrigation scheme in the study area. Since there is no irrigational scheme in the area, the effect of drought will be severely felt. Maharjan *et al* (2010) also stated that uncertainty and erratic incidence of rainfall which result in drought impact on untimely planting and harvest of seasonal crops and eventually reduce production per unit land area.

Water stress and late or early rainfall which identified were all confirmed by the findings of (Ohemeng-Dapaah 1994; Kasei *et al*., 1995; Obeng-Antwi., 1999) as maize yield limitations.

Then also the effect of high temperature was also noted by Lobell *et al* (2011) as it endangers maize production than previously assumed. Influence of high temperature is likely to be felt during the minor season as available data reveal. Pest and disease (7.4% researcher respondents) introduced by climatic condition in the study area also contribute to low maize production in the study area.

e) Pest and disease

83.3% of researcher respondents agreed that certain diseases and pests that constrain maize production are associated with climate change. The notion by Pimentel (1993) that warm and moist conditions in West Africa are suitable for insect and crop diseases is given credence according to the study. Pests and pathogens influence the determination of actual yield to the highest degree (Gregory *et al*., 1991). Keith *et al* (2010) suggested that extreme weather events that cause crop failure are floods, strong winds, prolonged droughts and heat wave was visualized in the study.

Table 25: The extent to which researchers agree to the statement that certain diseases and pests constraining maize production are associated with climate change

Degree of agreement	Number of respondent	Percent of respondent (%)
Agree strongly	1	16.6
Agree	5	83.3
TOTAL	**6**	**100**

The outcome of the research showed that 83.3% of researcher respondents agreed that certain diseases and pests that constrain maize production are associated with climate change. Pimentel(1993) noted that warm and moist conditions in west Africa are suitable for insect and crop diseases is affirmed according to the study.

f) Pests and diseases know to affect maize production in the study area

Table 26: Pests and diseases prevailing in the transitional zone from researchers' perspective

Pest and disease	Number of respondents	Percent of respondent (%)
Stem borer	6	50
Army worm	3	25
water weevil	1	8.3
Leaf hopper	2	16.6
TOTAL	**12**	**100**

The research revealed that the stem borer (50% of researcher respondents) is the most prevailing maize pest in the transitional zone where the study area is followed by the army worm (25 % of researcher respondents). Stem borer, *Busseola fusca,* prevailing in the study area is believed to contribute to maize yield gap. This is a complement to the findings that *Busseola fusca* has been accredited in March 2010 as the most economically important pest of maize in sub-Saharan Africa with high yield loss of 40% (CIMMYT, 2010). Although the damaging effect of stem borer increases the yield gap, ways of mitigating their impact exist. Biological control strategy known as "push-pull" has been proven to reduce stem borers damage by 25 %.

g) Problems of maize production from researchers point of view

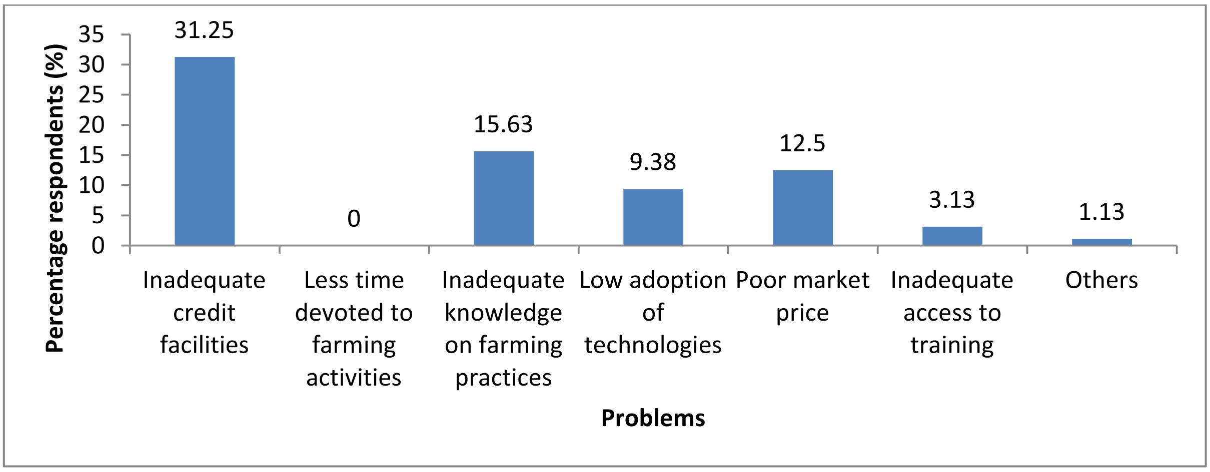


Figure 39: Problems of maize production from researchers' perspective

The outcome of the study shows that maize production is limited by a number of factors such as inadequate credit facilities 31.25%, low adoption of technologies (25%), inadequate knowledge on best farming practices (15.6%), low market price (12.5%), poor market access (9.4%) and others as demonstrated in Figure 42. Inadequate credit facilities influence the entire maize production cycle right from land acquisition through to marketing .Even adoption of technology is affected by inadequate credit facilities. Bala *et al* (2005) observed that farmer's low adoption of technology results from lack of credit. This makes the situation of inadequate credit facilities a critical production factor. A discussion of MoFA (2007) that lack of credit mostly to purchase inputs is the most prevalent constraint to agricultural development explains the significance of insufficient credit facilities. Most of the mentioned factors were noted by Lobell *et al* (*2009* as cited in Gerdien, 2012) to be causes of yield gap in maize production. The finding of low adoption of technology, poor market access, low market price, inadequate technology being a contributor to maize yield gap were also observed by Bala *et al* (2005).

4.11: Yield constraints from extension officers perspective

4.11.1: Biophysical constraints

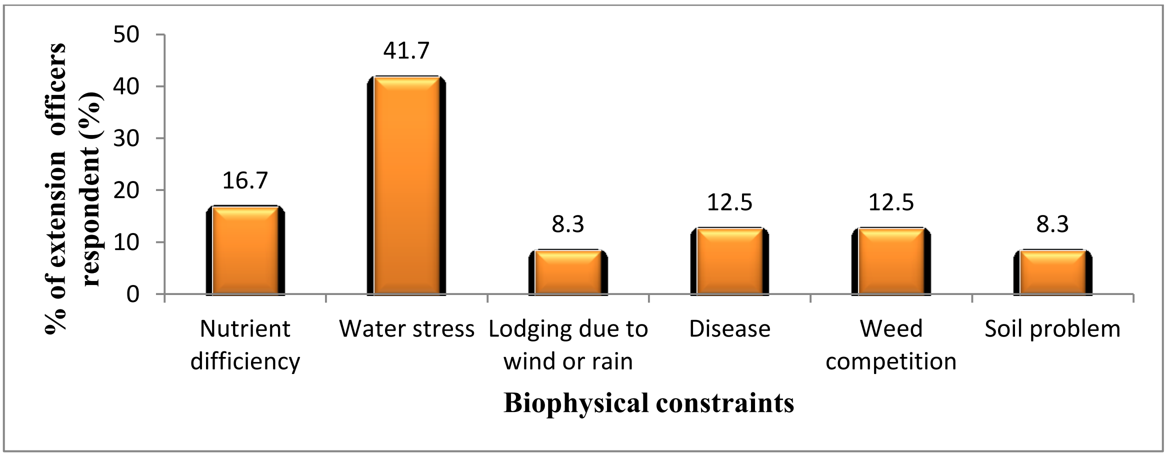


Figure 40: Biophysical constraints

According to extension officers, biophysical factors that limit higher yield of maize in the area include water stress (41.7 %), nutrient deficiency (16.7 %), pest and disease (12.5 %), weed competition (12.5%), lodging due to rain/wind (8.3%) and soil problems (8.3%). The high impact of water stress (41.7 %) that contributes to low yield of maize may be due to the fact that sufficient water is needed at critical stages of maize plant- germination period, the growth stage, vegetative stage and reproductive stage. At a stage where required water is not met, maize plant will be under stress of water and especially at silking and pollination, up to grain-filling and maturity and these negatively affect and eventually result in low yield.

Nutrient deficiency (16.7%) was recognized to be a contributory factor to low maize production. This may be due to the fact that essential macro-nutrients such as nitrogen, phosphorus and potassium as well as micro-nutrients are required in their right proportion for growth and reproduction. In the absence or inadequacies of these nutrients, yield may fall below what should have been achieved. However, fertilizers, either organic or inorganic, can boost production.

Pest and diseases (12.5%), a biophysical factor is believed to have a detrimental effect on maize yield. This is in connection with the finding that pest and pathogen influence the determination of actual yield to the highest degree (Gregory *et al.*,1991).

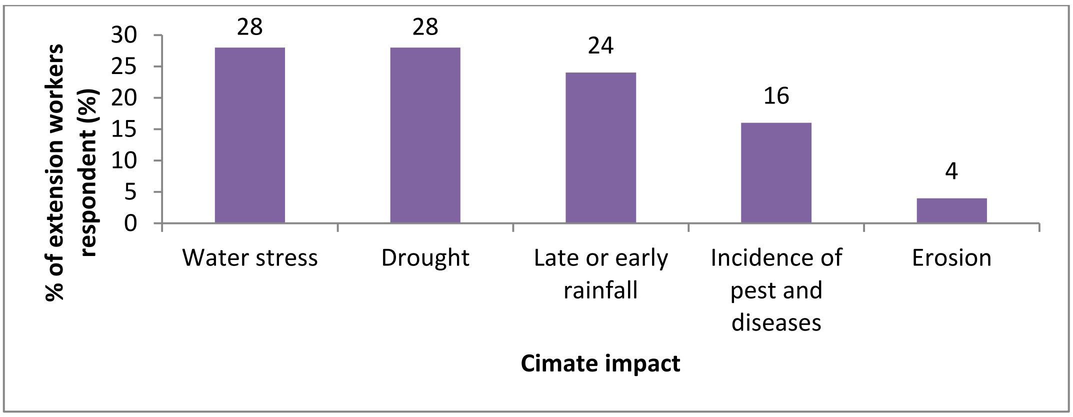


Figure 41: Climate impact on maize

The climate parameters restraining maize production identified from extension officer perspective are drought (28%), water stress (28 %), late or early rainfall (24%), incidence of pest and disease (16%) and erosion (4%). Drought (28%) has a negative effect on high yield of maize by directly impacting on planting periods, growth and development of the maize plant. This complements directly the fact that uncertainty and erratic incidence of rainfall result. in drought impact on untimely planting and harvest of seasonal crops and eventually reduces production per unit land area (Maharjan *et al*., 2010).

4.11.2: Technical factors

Technical factors considered from extension officers' perspective include maize varieties, agronomic practices to boost production and determinants of fertilizer usage.

a. Maize varieties cultivated

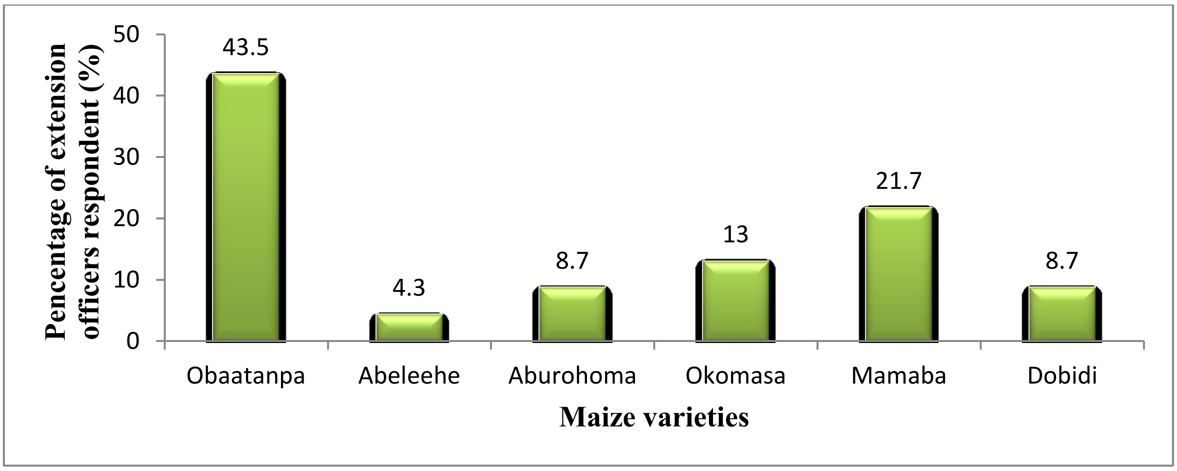


Figure 42: Maize varieties

As revealed by the research, Obaatanpa (43.5%), Mamaba (21.7%), Okomasa (13%), Aburohoma (8.7%), Dobidi (8.7%), Abeleehe (4.3 %) are maize varieties extension officers cultivate and prescribe to farmers.

Except Aburohoma (8.7 %) which is a local variety, all the varieties planted by extension officers are improved varieties. In effect, extension officers are likely to have greater harvest since majority of them cultivate improved varieties like Obaatanpa and Mamaba.

b. **Determinants of fertilizer usage**

Table 27: Determinants of fertilizer usage

Determinants	**No. of extension officers**	**Percentage**
Cost of fertilizer	3	30
Availability of fertilizer	3	30
Their belief	2	20
Late distribution of government subsidies	2	20
Total	**10**	**100**

Table 27 indicates that the use of fertilizer in the area is based on the cost of fertilizer (30 %), availability of fertilizer (30%), beliefs of the farmer (20%) and late distribution of fertilizers subsidized by the government (20%). High cost of fertilizer will lead to low patronage by farmers and vice versa. Low usage of fertilizer on continuously cropped land results in low yield since such lands reduces their productivity. Availability of fertilizer to the farmer either at farm gate or farmstead will determine accessibility and price. An input at farm gate is really expensive, most of the time beyond farmers' purchasing power/ability. Yield is likely to decrease under such conditions.

4.11.3: Socio-economic problems

a. **Farmers' attitude to investment**

Extension officers were asked to rate farmer's attitude to investment as good, fair, poor and very poor. This can give clearer notion about farmers' stance on investment.

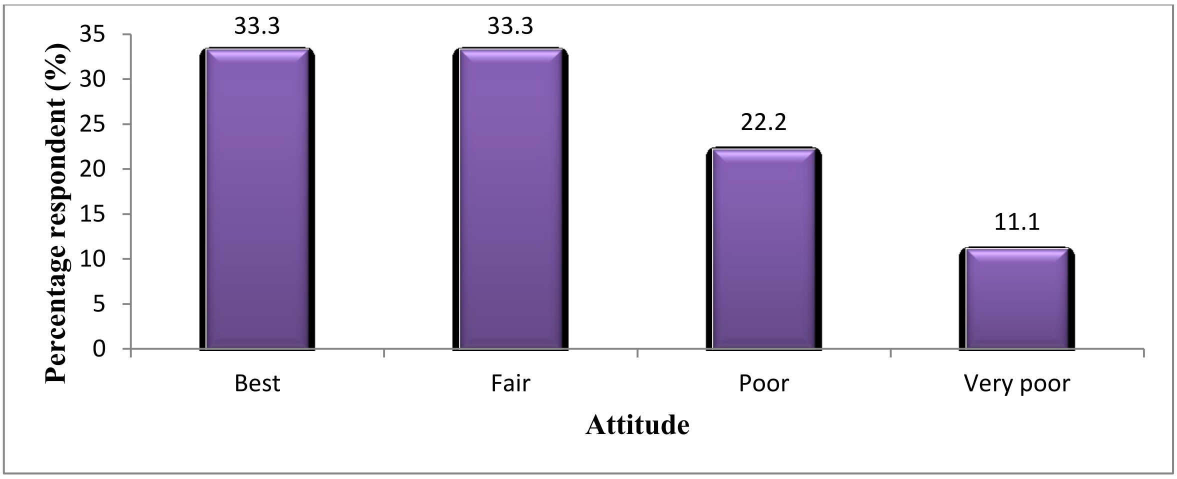


Figure 43: Farmers' attitude towards investment

According to extension officers, farmers attitude to investment are best (33.3%), fair (33.3%), poor (22.2%) and very poor (11.1%). The poor attitude of farmers towards investment as revealed by the research will in turn have negative impacts on farmer's ability to acquire credit for maize production. Credit acquisition becomes possible when farmers provide collateral. In contrast, farmers without collateral find it difficult to have access to credit to increase production.

b. Socio-economic problems

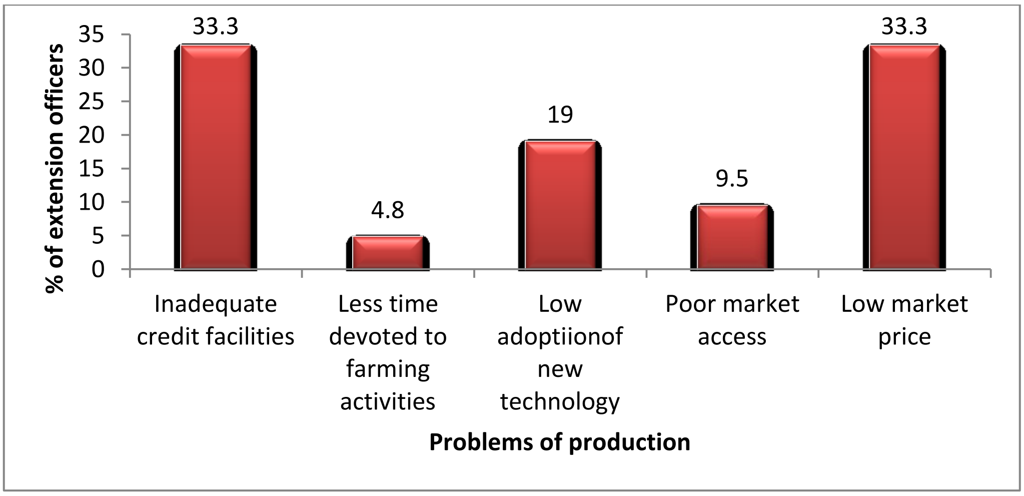


Figure 44: Problems of maize production

Socio-economic constraints to maize production identified include inadequate credit facilities (33.3%), low market price (33.3%), low adoption of technology (19%), poor market access (9.5%) and less time devoted to farming activities (4.8 %). This indicates that the issue of inadequacy of credit facilities is a serious problem facing the maize industry in the study area since this was also revealed from the farmers' perspective. Low market price of maize will discourage most people to venture into farming. Also the maize farmer will not be motivated to undertake large scale farming (commercialization).

c. Other socio-economic problems

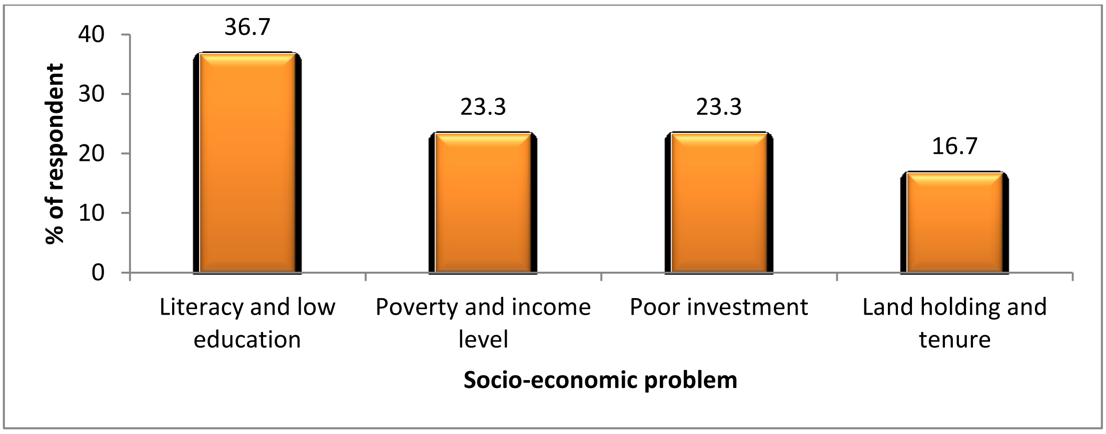


Figure 45: Socio-economic problems

Other socio-economic factors identified as constraints to maize production include literacy and low education (36.7%), poverty and income level (23.3%), poor investment (23.3%), and land holding and tenure (16.7 %). Literacy and low education affect maize production by delaying the smooth transfer of technology such as use of improved varieties, modern management practices, planting density and spacing that are prerequisite to higher yield. Badal and Singh (2001) report on the effect of farmer's educational level on maize production is seen here.

d. **Means of disseminating extension information**

Table 28: Means of disseminating extension information

Means of dissemination	**No. of extension officers**	**Percentage**
Through information centres	3	30
Cell phone	2	20
Community visit	1	10
Educating the children	1	10
AEA'S Training	1	10
Church	1	10
Community opinion leaders	1	10
Total	**10**	**100**

The outcome of the research revealed that extension ideas get to farmers through the information centres (30%), cell phone (20 %), community visits (10%) and educating the children (10%), AEA'S Training (10 %), Church (10%) and community opinion leaders (10%). These imply that extension education is done through different approaches. However, the use of the cell phone may not be effective in remote areas where most villages have communication network problems.

4.12: Yield constraints from stakeholders' perspective

Table 26 indicates the response of three stakeholders (farmers, extension officers, researchers) to the three classes of yield constraints namely technical, biophysical and socio-economic, the focused of the research. From the farmers' perspective, technical constraints identified are the use of seeds from farmer's own farm (53.6 %), poor seed selection (64.3%), poor soil fertility monitoring (100%) and no irrigation (100%). Biophysical factors are drought (92 %), pest prevalence (43 %), water stress (57 %), late or early rainfall (70 %). Socio-economic constraints were no access to credit (73 %), low market price (82%), and low profit from farming (75 %), high cost of fertilizer (66 %), literacy and low educational status (45 %), poverty and low income level (56 %) and land holding (68 %).

According to the extension officers' perception, technical constraints identified are the use of seeds from farmer's own farm (37.5 %), poor soil fertility monitoring (100%) and no irrigation (100%). Biophysical factors are drought (28 %), pest prevalence (16 %), water stress (41.7 %) and late or early rainfall (14.8 %). Socio-economic constraints are inadequate credit facilities (33.3 %), low adoption of technologies (19 %), low market price (33.3 %), low profit from farming (50 %), high cost of fertilizer (100%), literacy and low educational status (36.7%), poverty and low income level (23.3 %) and land holding (16.7 %).

Among researchers, technical constraints identified are the use of seeds from farmer's own farm (16.7 %) and no irrigation (62.5 %). Biophysical factors are drought (22.2 %), pest prevalence (50 %), water stress (14.8 %) and late or early rainfall (14.8 %). Socio-economic constraints are inadequate credit facility (31.3 %), low technology adoptions (25 %), low market price (12.5 %), low profit from farming (57.1%), poor investment (37.5%), high cost of fertilizer (60 %), literacy and low educational status (20%), poverty and low income level (35 %) and land holding (20%).

Table 29: Maize yield constraints from stakeholders' perspective from to the survey

Item	Production constraints	Site condition	Respondents					
			Farmers		Extension		Researchers	
			No.	%	No.	%	No.	%
1	Technical	Use of seeds from farmer's own farm	74	53%	6	37.5	3	16.7
		Poor seed selection	70	64.3%	-	-	-	-
		Poor soil fertility monitoring	100	100%	7	70%	-	-
		No irrigation	100	100%	10	100%	5	62.5%
2	Biophysical	Draught	92	92%	7	28%	6	22.2%
		Pest and disease prevalence	43	43%	4	16%	6	50%
		water stress	57	57%	10	41.7%	4	14%
		Late or early rainfall	70	73%	-	-	-	-
3	Socio-economic	No access to credit	73	73%	-	-	-	-
		Inadequate credit facilities	-	-	7	33.3%	10	31.25%
		Low adoption of technologies	-	-	4	19%	8	25%
		Low market price	82	82%	7	33.3	4	12.5%
		Low profit from farming	75	75%	5	50%	4	57.%
		Poor investment	-	-	7	23.3		37.5
		High cost of fertilizer	66	66%	10	100%	6	60%
		Literacy and low educational status	45	45%	11	36.7	4	20%
		Poverty and low income level	56	56%	7	23.3%	7	35%
		Land holding and tenure	68	68%	5	16.7%	2	20%

4.12.1: Seed source

Seed sources are mainly not certified since most farmers use the previous year's harvested grain as seeds in the subsequent years. Out of the total of 100 farmers, 53.6 % obtain seeds from their own farm while 37.5 % and 16.7 % out of the respective extension officers and researchers also responded that farmers use seeds from their own farm. This practice is not right since it shows seed recycling. According to Wanyama *et al* (2005) yield levels of recycled maize variety ' H614' decreased by 15.86%, 16.70%, 32.25% and 46.80% for the first, second, third and fourth recycling generations respectively and noted a progressive loss in grain when maize is recycled by farmers. Farmers should be advised not to select seed from their own farm since such seeds are not certified and may not be an improved varieties. Certified improve variety have been reported by CSIR (2011) to have attributes like drought tolerance, striga resistant three-way QPM hybrid (Mamaba) which have high yields in adverse environmental conditions. Planting a particular variety for several cropping seasons can cause a reduction in yield since that variety may not be able to resist adverse environmental conditions like drought, pest and diseases. This shows the significance of acquiring seeds from the right source. Again, 64.3% of farmers were noted to have poor seed selection since they plant local varieties like 'Aburohoma' which may have low yield potential as compared to Mamaba and other improved varieties.

4.12.2: Effects of drought

According to Ohemeng-Dapaah (1994); Kasei *et al* (1995); and Obeng-Antwi *et al* (1999) drought stress is a major constraint to Ghana's rainfed agricultural system, especially maize production. Maize production is under rain-fed condition since there is no irrigation. As a result, there is adverse effect of drought on maize yield as 92 % out of 100 farmers' responded, 28 % out of extension officers, and 22.2 % out of 27 total researcher respondents showed. Drought is a very significant factor constraining maize production in less endowed countries (Edmeads *et al.,* 1998). Because of drought, Ghana experienced 30% decline in maize production in 1982 (GGDP, 1983). However yield can increase in times of drought stress with the use of draught resistant varieties. The negative effects of drought are mitigated by drought tolerant varieties (Carrow *et al*., 1990). Cenacchi and Koo (2011) identified 12.6% average yield increase when drought tolerant variety is used across all nations and agro-ecological zones and estimation shows that drought tolerant varieties can have an average yield increase of 20.03% in humid Ghana and potential to bridge the gap by 30.78-30.71% under current climatic conditions.

It can be deduced that water supply to agriculture in the area is a factor of season and for this reason there are major and minor seasons of producing maize. In each season soil moisture determines planting periods, meaning there is no planting in times of drought. Erratic rainfalls (late/early rainfall) affect maize production by altering the cropping season. Musara *et al* (2010) attributed erratic rainfall pattern to the cause of low yield of maize encountered by small scale farmers.

Pest and diease, a biophysical factor, contributes to low yield of maize in the area. Out of the 100 farmers contacted, 43% accorded lower yield of maize to this. The stem borer is the major pest limiting high yield of maize in the study area and 50 % of researchers said so. This supports the findings that in 2010 the stem borer was recognized as an economically important pest of maize in sub-Saharan Africa with high yield loss of 40% (CIMMYT, 2010).

4.12.3: Socio-economic constraints

According to the 100 farmers surveyed, 73 % do not have access to credit. This may be as a result of inadequate credit facilities in the area. There were 33.3 % and 31.3 % respondents respectively from extensionist and researchers confirming that low yield of maize is partly due to inadequate credit facilities. This credit problem may also influence the adoption process of new technology of farmers. 19 % of extensionist and 25 % of researchers considered low adoption of technologies as a hindrance to higher yield of maize in the area.

Again, farming may be seen as unattractive business due to low profits encountered according to 75 % of farmers and 50 % of extension officers contacted during the survey. 57.1 % of researchers attributed the low profit from farming to low yield. Investment by farmers becomes poor when profit is low since they will not have any surplus after meeting household need. The problem of low investment may be explained by the lack of credit faced by a number of farmers in the area since creditors require collateral which may be a physical asset or money saved at a financial institution. Moreover, farmers' acquisition of inputs like fertilizer will be difficult due to financial challenges. High cost of fertilizers is an eminent contributor to low yield of maize in the area as the study revealed. Fertilizer is needed to boost the production level of the poor soil. Farmers' inability to purchase timely inputs causes yield to decline.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The chapter draws conclusion from the study and makes recommendations to narrow the observed yield gap in maize production.

5.2 Conclusions

In the study area, average yield was below 1.9 t/ha for the period from 1996-2011. This low yield is as a result of the adverse effects of drought, poor seeds source (use of seed from farmer's own farm) which are not improved varieties, lack of credit access and inadequate credit facilities. Other yield limitations are pest and disease prevalence, low market price, low profit from farming, high cost of fertilizers, literacy and low educational status, water stress, late or early rainfall (erratic rainfall), no irrigation, poor soil fertility monitoring, use of local varieties, low adoption of technologies, poor investment, poverty and low income level, landholding and tenure.

Maize farming is fairly profitable but farmers make low profits from farming alone to the productivity and low market prices. Credit availability and accessibility can help farmers to purchase inputs, expand production area, acquire labour, increase crop yield and provide income for the family. Therefore credit should be made available to farmers by the government. This way, poverty will be reduced and farmers' socio-economic conditions will be enhanced.

Timely distribution of government subsidized fertilizer can save farmers from the effect of high prices of fertilizers. Research has produced drought tolerant varieties to combat the effect of drought. However, farmers' adoption level is low. Intensification of extension and adoption of convenient approach to strengthens and facilitate adoption process. Farmer-extension contact has to be strengthened to realize aims of extension education. There should be a policy in place to prevent farmers from using ordinary seeds that are not recommended to encourage farmers to use the right planting material.

Possibly, an irrigation scheme should be in place since prospects exist to boost production in times of severe drought. Government interventions are needed in this direction.

The problem of yield gap needs a collaborative and holistic approach involving farmers, researchers, extensionist as well as government interventions' in order to raise production.

5.3 Recommendations

Further research can be done considering how these identified factors contribute to low yield. To reduce the risk associated with seed recycling by farmers, studies can be done on policies and regulations in the seed sector. Intensive studies on why farmers recycle should be carried out with appropriate solutions considered. Studies on institutional policies in relation to yield gap should be investigated. Farmers should be encouraged to use drought tolerant varieties in order to bridge the gap in maize production.

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APPENDICES

APPENDIX 1: FARMER QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE & TECHNOLOGY, KUMASI

DEPARTMENT OF MATERIALS ENGINEERING

TOPIC: YIELD GAP ANALYSIS IN MAIZE PRODUCTION FROM STAKEHOLDERS' PERSPECTIVE AT EJURA SEKYEDUMASE IN THE ASHANTI REGION OF GHANA

PERSONAL DETAILS/ SOCIO-ECONOMIC STATUS

Name of Farmer …………………………………………………………………………..

Age of Farmer………………………………………………………………………….

Type of farmer and literacy level

Sex of Farmer: Male () Female ( )

Educational Status: Literate ( ) Illiterate ( )

If literate, then level of education

Informal () Primary ( ) Secondary ( ) Tertiary ( )

Religion of Farmer: Traditional ( ) Christianity ( ) Islam ( ) other ( ) state..........

What else do you do for a living aside from maize farming?

…………………………………… ………………………………………….

Do you keep animals? Yes () No ( )

What type of animals do you keep? ………………………………………………….

How many animals do you have? …………………………………………………….

Do you grow other crops in addition to maize? Yes ( ) No ( )

Socio-economic status

a) **Credit facility**

1. When you have access to credit how would it help in your farm?

………………………………………………………………………….

2. Do you have access to credit? Yes ( ) No ( )

3. If yes, where do get credit from?

State Bank ( ) credit union ( ) rural bank ( ) friends ( ) others (state) ………

b) Adoption of technology

4. In what ways has extension work helped your farming activities?

………………………………..…………………………………………..

5. How do you see the service of extension personnel to you?

Extremely important ( ) very important () somewhat important () not very important ( ) not at all important ()

6. How often do extension officers visit you and where?……………………

Farm ( ) homes ( )

7. What do they teach you? ………………………………………………………...

c) **Investment**

8. What is your farm size over the years? ....

9. Which of these do you use money made from your farm for? ....

Trading ( ) keeping animals ( ) saving ( ) taking care of student. ( )

10. If saving, where? Financial institution ( ) at home ( ) others (state) …..

d) Time for farming activities

11. How many times do you go to farm in a week?………………………………………

12. Which days do you go to farm and days you don't?…………………………………….

13. Why these days?……………………………….…………………………………….

14. What do you do when you do not go to farm?…………………………………………

e) Knowledge on best farming practice

15. Do you apply fertilizer? Yes ( ) No ( )

16. What stage do you apply fertilizer?…………………….…………………………

17. How many times do you weed your farm?…………………………………………......

18. Do you plant in rows? Yes ( ) No ( )

19. How do you prepare land? ………………………………………………

20. Do you like new ideas of farming extension officers bring to you? Yes ( ) No ( )

21. List some of these ideas you have received from extension workers

…………………………………… ……………………………………………

22. Do you receive training in cropping techniques? Yes ( ) No ( )

23. How do access extension officers? They visit us ( ) we go to them ( )

24. How do market availability and accessibility affect your farming activities?…………

25. What do you do after harvesting? Sold ( ) Processed for Sale ( ) Processed for Storage ( ) others (state) …………….

26. How long does it take in storage? ……………………………………………..

27. How do you see prices when stored and not sold fresh? High ( ) low ( ) moderate ()

28. Are you able to achieve your perceive outcome every year? Yes ( ) No ( )

29. If yes, what makes you achieve your expected outcome?………………………

30. If no, what do think could cause the low productivity?...............………………………

31. What can you do to achieve your expected outcome or maximum yield potential?

……………………………………………………………………………….

f**) Utilization of maize**

42. What do you use maize for? …………………………………………………………

43. What is the size of your household? ………………………………………………….

44. What amount of maize do you consume a week? …………………………………….

CLIMATIC CONSTRAINTS

45. What have you observed about the planting season year after year?

Shifting forward () shifting backwards ( ) remain fixed ( )

46. These changes in planting season will influence maize production.

Strongly agree ( ) agree ( ) neither agree/disagree ( ) disagree ( ) strongly disagree ( )

47. How many years do you remember the rainfall was very good? … …………..

48. What was the yield in those years? Excellent () very good () good ( ) average () poor ( )

49. What indicators determine the time of land preparation in the major season?

…………………………………….. ……………………………………………….

50. What indicators determine the time of land preparation in the minor season?

……………………………………… …………………………………………….

51. How many times do you plant in a year?……………………………………………….

52. List the planting time for the past years …………………………………

53. How do you know when it is planting time?...............………………………

54. State your opinion about the contribution of variation in planting season to your maize production. ……………………………………..

55. Are you certain of the planting season/time? Yes () No ( )

56. If yes, when do you start planting each year?

a. in the major season? March ( ) April ( ) May ( )

a1. Which week of the chosen month? 1st week () 2nd week () 3rd week ( ) 4th week ()

b. in the minor season? July () August () September () October ( )

b1. Which week of the chosen month? 1st week () 2nd week () 3rd week ( ) 4th week ( )

57. If no, what makes you uncertain? Weather ( ) climate change () pest and disease ( ) soil nutrient ( ) Soil water holding characteristics ( ) land preparation ( ) readiness of planting materials (inputs)

58. Do you believe these problems can be solved? Yes ( ) No ( )

59. If yes, what do think can be done to reduce these uncertainties?

…………………………………………………………………………..

60. Water stress will have a negative impact on yield of maize.

Strongly Agree ( ) agree ( ) neither agree or disagree ( ) disagree ( ) strongly disagree ()

61. What then can you do to minimize water stress in your farm?

………………………………………..…………………………………

62. Has Floods ever taken over your maize field? Yes ( ) no ( )

63. How was the yield that season? Good ( ) fair ( ) poor () very poor ()

64. How do you see the influence of planting timing or density on yield gap of maize?

65. What maize diseases prevail in the area? ……………………………………..

66. What time did lodging (due to wind or rain) occur in your farm?

67. Have you seen new weeds you have never experienced before in your farm? Yes ( ) no( )

68. What is the nature of this weed? …………………….…………………….

69. How has seed damage been occurring in your farm?

Every planting season () don't experience () few occasions ( )

70. For how many times has erosion destroyed your maize farm?

Every planting season ( ) occasionally () not at all () others …………………..

71. Which of the following has affected your farming activities?

1) Water stress ( ) 2) drought ( ) 3) Flooding ( ) 4) lodging ( )

5) High temperature ( ) 6) late or early rainfall ( )

7) High rainfall ( ) 8) erosion ( )

72. What was the yield during such incidence?

Good () fair ( ) high ( ) low ( ) moderate ( )

73. How would you solve these problems?

Lodging ………………………… Flooding ……………………………

Erosion …………………………… Drought………………………...

TECHNICAL ASPECT

Type of maize

74. Which type of maize have you been cultivating? …………………………

75. Why the chosen type(s)

- Yield superiority ( )   Drought resistance ( )
- Good taste ( ) Disease resistance ( )
- Pest resistance ( ) Seed quality ( )
- According to the farming season ( ) Early maturity ( )

76. Are there any external agencies that supply seeds to you for planting? Yes ( ) No ()

77. If no, where do you get seed for planting?

Market () MoFA ( ) Farmers' own field ( ) Crop Research Institute ( )

78. List few of the most agricultural practices you undertake

Irrigation () fertilizing ( ) weeding ( ) pest control ( ) pruning ( )

Planting time and density ( )

Tillage practice

79. Do you till the land before planting?

Yes ( ) No ( )

80. What land preparation method (s) do you use? Slash and burn ( ) zero tillage ( ) mulch tillage () Hand hoe ( ) Machete ( ) Tractor and plough ( ) others (specify) ……………….

80. Are you involved in the following?

Ploughing () harrowing ( ) ploughing and harrowing ( ) weedicide application ( )

82. What else do you do to further prepare the land before planting? …………………

Fertilizer application

83. Do you apply fertilizer?   Yes () No ( )

84. If yes, what type of fertilizer do you encourage them to use? ………………

85. Why this type of fertilizer? …………………………….

86. What method of fertilizer application do you use?

Broadcasting () Spraying ( ) Drilling ( ) others……………… state ( )

Water Management

87. Is it necessary to irrigate maize in your area?

Yes ( ) No ( )

88. Do you irrigate your maize?

Yes ( ) No ( )

89. If yes, how is the yield compared with those who do not apply irrigation?

APPENDIX 2: RESEARCHERS QUESTIONNAIRE

KWAME NKRUMAH UNIVERSITY OF SCIENCE & TECHNOLOGY, KUMASI

DEPARTMENT OF MATERIALS ENGINEERING

Personal Details

1. Name: ……………………………………………………………………………….

2. Highest Qualification: ……………………………………………………………….

3. Department/institution……………………………………………………………….

4. Sex: Male ( ) Female ( )

5. Do you have a field for research on maize? Yes ( ) No ( )

6. What is the size of the field? ………………………….

7. What quantity of maize do you harvest per acre?

…………………………………… ……………………………………………

Technical aspect

Soil

8. How do you view the act of testing soil in order to know the state in relation to maize production?

Extremely important ( ) very important ( ) somewhat important ( )

not very important () not at all important ( )

9. Testing the soil would help bridge gap between demand and supply of maize.

Strongly agree () agree () disagree () strongly disagree ()

10. How often do you undertake soil testing?

Any time before planting () once a year () not at all ( )

11. What instrument do you use in the soil test? …………………………….

Explain why necessary? …………………………………………

12. Which of the following do you test for?

Nitrogen ( ) Phosphorus ( ) Potassium () pH ()

Electrical conductivity ( ) Salt ( ) other (state)…………

13. Why is it necessary to test for soil temperature before planting?

……………………………………………………………….

14. If yes, what are the findings?

………………………………………………………………………………

Seed source and supply

15. What type of maize variety do you plant?

……………………………………….. …………………………………………

16. Why this variety? ……………………… ………………………………………….

17. Which institution(s) supply seed in Ghana?

18. Are there any institutional arrangements and policies in place to ensure national seed sector performance? Yes ( ) no ( )

19. These institutions and policies influence the gap in yield of maize.

Strongly agree () agree () disagree () neither agree or disagree ( ) strongly disagree ()

20. In what ways do they influence? ……………………………………………………

21. What are the constraints/ problems to seed production? ……………………………….

22. What can be done to improve seed production and supply sector? ………………….

23. Which type of maize do you recommend to farmers to cultivate?

……………………………………………………..

24. Why do you recommend these type(s)

Yield superiority ( ) Drought resistance ( )

Good taste ( ) Disease resistance ( )

Pest resistance ( ) Seed quality ( )

Economic value ( ) Shelf life ( )

Others (state) ……………………..……………………………..

25. Do you supply seeds to farmers for planting? Yes ( ) No ()

26. If no, where do you think farmers get seed for planting?

Market () MoFA () Farmers' own field ( ) Crops Research Institute ( )

Grains Development Company ( ) others (state) …………………………..

27. List few of the most important agricultural practices you deem necessary to improve yield in your field.

Irrigation ( ) fertilizing ( ) weeding () pest control ( ) pruning ( )

Planting time ( ) Planting density ( )

Tillage practice

28. Do you till the land before planting?   Yes ( ) No ( )

29. What implement do you use?

Hand hoe () Machete ( ) Tractor and plough ( ) others (state) ………………….

30. Do you use slash and burn as land preparation method? Yes ( ) No ( )

31. How does slash and burn influence yield gap? ……………………………………

32. What else is done to further prepare the land before planting? …………………………

Fertilizer application

33. Do you apply fertilizer? Yes () No ( )

34. If yes, what type of fertilizer do you encourage them to use? ....

35. Why this type of fertilizer? ....

36. What method of fertilizer application do you encourage farmers to use?

Broadcasting ( ) Spraying ( ) Drilling ( ) Ring ( ) others (state)………..

Water Management

37. Is it necessary to irrigate maize in your area? Yes () No ( )

38. Have you ever irrigated your maize farm? Yes ( ) No ( )

39. What was the yield under irrigation? Fair () high () low () moderate ( )

40. If yes, how is the yield compared to those who do not apply irrigation?

…………………………………… ……………………………………………

41. Is there a mechanism in place to determine the water quality? Yes ( ) No ( )

42. If yes, what are they?

…………………………………………………………………………………………

CLIMATIC CONSTRAINTS

43. Climate change seriously influence yield gap of maize in Ghana

Strongly agree () agree ( ) neither agree or disagree () disagree ( ) strongly disagree ()

44. How would you rate the effects of climate change on maize production for the past 10 years in Ghana in the transition zone?

Fair ( ) high () low () moderate ( )

45. Impact of climate change on yield gap in maize production can be

Direct () indirect ( )

46. State your opinion about the direct effect of climate change on maize production

………………………………………………………. …………………………….

b) Indirect effect ………………………………………………………………………..

47. How do you see planting time and density in the yield gap of maize?

……………………………………………………………….

48. Which of the following climatic variables constraints maize production in the transitional zone?

1) Water stress () 2) drought ()

3) Flooding () 4) lodging ( )

5) High temperature () 6) late or early rainfall ( )

7) High rainfall ( ) 8) erosion ( )

9) Incidence of pest and disease due to climate change ( )

9) Others (state) …………………………………………………………………..

49. In what ways can we combat climatic constraints?

……………………………………………… ………………………………….

50. State your opinion about these to yield gap

…………………………………………………………………

51. Can flooding limit yield of maize? Yes ( ) No ()

52. At what growth stage can flooding can be a limiting factor?

Vegetative stage ( ) reproductive stage ( ) others (specify) ……………………….

53. What is the nature of the effect of flooding on maize production? Long term () short term ( )

54. In what other ways can flooding affect production of maize?

………………………………………………. ……………………………………………

55. Which of the following can reduce stands of maize?

Warmer condition ( ) wet condition ( ) humid condition ( )

56. What quantity of water is needed for maize best yield per season in the transitional zone? ………….… mm

57. What happens to the yield if rainfall is above the optimal range?

……………………………………… ……………………………………………

58. How can soil temperature and surface evaporation be reduced in a maize farm?

a. Practicing reduced tillage ( ) b. maximum ground cover ( ) c. applying crop residue ( )

d. others (state) …………………………………………………………….

Pests and Diseases

59. Certain diseases and pests that are constraints to maize production are associated with climate change Agree strongly ( ) agree ( ) neither agree or disagree ( ) disagree ( ) strongly disagree ( )

70. Which of such diseases and pest prevail in the transitional zone?

Stem borers ( ) cut worm () army worms () plant bug ( )

Leaf hopper ( ) leaf beetles () water weevils ( ) others (state)

71. Are there any tools to prevent pests and diseases in the area?

…………………………………………………….

72. What control measures do farmers use? ……………………………………….

Quantity of maize produced

73. What quantity of maize do you produce per acre? …………………………………..

74. What is the market price of maize? …………………………………………………

75. What is the nature of your profit? Low ( ) high ( ) medium ( )none ( )

76. What can be done to maximize profit?

…………………………………………………………………………………………...……

Socio-economic status

77. What are your opinion(s) about the following to maize production

a) Literacy and Educational status of farmers …………………………………………..

b) Type of farmer …………………………………………………………………………

c) Poverty and income level ……………………………………………………………

d) Utilization of maize …………………………………………………………………

e) Household and ethnicity ………………………………………………………………

f) Landholding and tenure ………………………………………………………………

g) Gender …………………………………………………………………………………

h) Others (state)

78. Which of the above factors contribute to yield gap in maize production in the area?

79. How do you see availability of market in relation to maize production?

Extremely important () very important ( ) somewhat important ()

not very important ( ) Not at all important ( )

80. What profits do farmers make? Low () medium ( ) high ()

81. How would you rate farmer's attitude to investment?

Good ( ) fair () poor () very poor ()

82. Which of the following is/are a problem to maize production in the area?

1) Inadequate credit facilities ( ) 2) Less time devoted to farming activities ( )

3) Inadequate knowledge on best farming practice ()

4) Low adoption of new technology ( )

5) Poor market access ( )

6) Low market price ()

(7) Inadequate access to training in cropping techniques ( )

8) Others (state) ……………………………………………………………………….

83. What is the attitude of farmers towards the use of fertilizers on maize in the area?

Best ( ) good () fair ( ) poor ( ) very poor ( )

84. What do you think can cause farmers to behave or have such attitude?

Cost of fertilize ( ) availability of fertilizer ( ) their beliefs ( ) think soil is fertile ( )

Think is not necessary ( ) others (state) ………………………………………………

85. What is in place to reduce the cost of fertilizer?

……………………………………………………. ………………………………………

……………….

86. What changes should take place to bridge the yield gap?

………………………………………………………………………..

....

....

APPENDIX 3: EXTENSION WORKERS/ TECHNICAL OFFICERS

KWAME NKRUMAH UNIVERSITY OF SCIENCE & TECHNOLOGY, KUMASI

DEPARTMENT OF MATERIALS ENGINEERING

Personal Details

1. Name: ………………………………………………………………………………

2. Qualification: ………………………………………………………………...…

3. Department: ………………………………………………………………………….

4. Sex: Male ( ) Female ( )

5. Do you have a field you cultivate?

Community(s)

1. How many communities do you visit? 1 ( ) 2 ( ) 3 ( ) 4 () 5 ( ) 6 ( )

2. If you do not visit farmers on community basis, how do disseminate information?

………………………………………………………………………………………………….

3. How often do you visit the farmers?

4. Do you undertake soil tests for farmers? Yes ( ) No ( )

If yes, what instrument do you use in the soil test?

Is it necessary to test the soil? Yes ( ) No ( )

Explain why necessary?

………………………………………………………………………………………

5. What are some of the issues you discuss with farmers?

…………………………………………………………………………………………………

1. Do farmers in your area achieve their maximum yield potential in maize production? Yes () No ()

2. If no, which of the following is likely to cause the yield gap?

Biophysical factors

(1)Nutrient deficiencies and imbalance ( ) 2) Water stress ( )

3 Floods ( ) 4) Planting time or density ( )

5) Soil problem/salinity or acidity ( ) 6) Diseases ( )

7) Lodging due to wind or rain ( ) 8) Weed pressure ()

9) Seed damage ( ) 10) Erosion

3. Which of the following climatic variables constraints maize production in the area?

1) Water stress ( ) 2) drought ( ) 3) Flooding () 4) lodging ( )

5) High temperature ( ) late or early rainfall ( )

7) High rainfall ( ) 8) erosion ( )

9) Incidence of pest and disease due to climate change ( )

4. Do you have measures to combat these climatic constraints? Yes () No ()

If yes, list the measures you have in place……………………………..

5. State your opinion about these on yield gap

…………………………………………………………………

Technical aspect

1. Do you conduct soil test before planting?

Yes ( ) No ( )

2) If yes, what do you test for?

Nitrogen ( ) Phosphorus ( ) Potassium () pH ( ) Electrical conductivity ( )

Salt ( )

3) Why is it necessary to test soil temperature before planting?

……………………………………………………………….

5 If yes, what are your findings?

………………………………………………………………………

Type of maize

1) Which type of maize do farmers cultivate? ……………………………..

2) Why the chosen type(s)

Yield superiority ( ) Drought resistance ()

Good taste ( ) Disease resistance ()

Pest resistance ( ) Seed quality ()

3) Do you supply seeds to farmers for planting? Yes ( ) No ()

4) If no, where do you think farmers get seeds for planting?

Market () MoFA ( ) Farmers' own field ( ) Crop Research Institute ( )

5) List few of the most important agricultural practices you talk to farmers about

Irrigation ( ) fertilizing () weeding ( ) pest control ( ) pruning ( )

Planting time and density ( )

Tillage practice

1) Do you till the land before planting?

Yes ( ) No ( )

2) What implement do farmers use?

Hand hoe () Cutlass ( ) Tractor plough ( ) others

3) Do farmers use slash and burn as land preparation method?

Yes ( ) No ( )

4) What else is done to further prepare the land before planting?

……………………………………………………………………………………………

Fertilizer application

1. Do you encourage farmers to apply fertilizer? Yes ( ) No ( )

2) If yes, what type of fertilizer do you encourage them to use?

…………………..............................……………………………………..

3) Why this type of fertilizer? ………………………………

4) What method of fertilizer application do you encourage farmers to use?

Broadcasting ( ) Spraying ( ) Drilling ( ) others………………………..

Water Management

1) Is it necessary to irrigate maize in your area? Yes () No ( )

2) Do you have farmers who irrigate their maize? Yes ( ) No ( )

3) If yes, how is the yield compared to those who do not apply irrigation?

…………………………………………………………………

4) Is there a mechanism in place to determine the water quality? Yes ( ) No ( )

5) If yes, what are your findings?

………………………………………………………………….

Pests and Diseases

1) Is pest and disease a constraint to maize production in your area? Yes ( ) No ()

2) If yes, which disease(s) prevail in the area?

Stem borers ( ) cutworm () army worms ( ) plant bug ( )

Leaf hopper ( ) leaf beetles () water weevils ( ) others

3) Are there anything to prevent pest and diseases in the area?

………………………………………………….

…………………………………………………

4) What control measures do farmers use?

……………………………………………………………….

Quantity of maize produced

1) What quantity of maize do farmers produce per hectare?

…………………………………………………………………………………………..

2) What is the market price of maize? ………………………………………………….

Profit from production

1) Do farmers maximize profit? Yes ( ) No ()

2) If no, what are the causes of low profit?

………………………………………. ……………………………………………

3) What can be done to maximize profit?

……………………………………………………………………………………………

Socio-economic status

1) What are your opinion(s) about the following about farmers in the area?

a) Literacy and Educational status of your farmers………………………………..

b) Type of farmer……………………………………………………………………

c) Poverty and income level…………………………………………………….

e) Household and ethnicity…………………………………………………….

f) Landholding and tenure………………………………………………………….

g) Gender ………………………………………………………………………………..

2) Which of the factors in (1) contribute to yield gap in maize production in the area?

…………………………………………………………………………………..

3) How do you see availability of market in relation to maize production?

Extremely important () very important ( ) somewhat important () not very important ( ) Not at all important ( )

4). If yes, which of the following socio-economic factors contribute to the yield gap?

5) What profits do farmers make?

Low profit ( ) moderate profit ( ) high profit ( )

6) How would you rate farmer's attitude to investment?

Good ( ) fair ( ) poor ( ) very poor ( )

7) Which of the following is/are a problem to maize production in the area?

a. Inadequate credit facilities
b. Inadequate knowledge on best farming practice ()
c. Low adoption of new technology ( )

d. Low market price ()
e. Less time devoted to farming activities ( )
f. Poor market access ( )
g. g. inadequate access to training in cropping techniques ( )

8) What is the attitude of farmers towards the use fertilizer on maize in the area?

Best () good () fair () poor () very poor ( )

9) What do you think can cause farmers to behave or have such attitude?

Cost of fertilizer ( ) availability of fertilizer ( ) their beliefs ( )

10) What do you have in place to reduce the cost of fertilizer?

.. …………………………………………………………

11) What change should take place if the yield gap is to be bridged?

....……………………...

....……………………...

....……………………...

APPENDIX 4: SAMPLE PICTURES TAKEN DURING THE SURVEY ON THE RESEARCHER'S DEMONSTRATION FIELD

APPENDIX 5: SAMPLE PICTURES TAKEN DURING MEETING WITH MOFA STAFF IN *EJURA-SEKYEDUMASE DISTRICT*