Cover Page

COMPARATIVE ECONOMIC ANALYSIS OF DROUGHT AND NON DROUGHT TOLERANT MAIZE PRODUCTION IN GOMBE STATE

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DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY, AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN AGRICULTURAL ECONOMICS

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY,

FACULTY OF AGRICULTURE

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

OCTOBER, 2015

DECLARATION

I hereby declare that the work in dissertation titled "COMPARATIVE ECONOMIC ANALYSIS OF DROUGHT AND NON DROUGHT TOLERANT MAIZE PRODUCTION IN GOMBE STATE, NIGERIA" has been performed by me in the department of Agricultural Economics and Rural Sociology is the original outcome of my research effort. The information derived from the literature were dully acknowledge and list of references provided. It was not been presented in part or full anywhere for the award of a similar degree in this or any other university.

_____ _____

Baba Dahiru Date

Student

CERTIFICATION

This dissertation titled "COMPARATIVE ECONOMIC ANALYSIS OF DROUGHT AND NON DROUGHT TOLERANT MAIZE PRODUCTION IN GOMBE STATE, NIGERIA" by BABA Dahiru, MSc./AGRIC/7470/2010-2011 meets the regulations governing the award of degree of Masters of science of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

_____ _____

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Dean, School of Post Graduate Studies

DEDICATION

This dissertation is dedicated to my family for their patience and love throughout the period of the study.

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ABSTRACT

This study compares economics of Maize production with DTMA and NDTM Maize variety. The study used farm level data to estimate Profitability, efficiency, yield gap, varietal gap, determinants of profitability and constraints to maize production in seven local government of Gombe state. A multistage sampling technique was used to collect cross-sectional data from three hundred and seventy (370) farmers, separated into 188 drought tolerant maize farmers and 182 non drought tolerant farmers, during 2014 cropping season. Farm budget analysis model was used to estimate profitability. Single stage maximum likelihood estimation method, translog stochastic frontier was used for efficiency estimates. The estimated stochastic frontier result was used to compare farmer's efficiency based on variety and location of production through metafrontier approach. The result showed that, 37% of DTMA and 32% of NDTM were within the ages of 40 - 49 years. There were no significant variations in aggregate quantity of inputs used. However, variability exists in output and yield of the two varieties. The average yield for drought tolerant maize farmers was 2.602mt per hectare whereas 1.55861mt per hectare for NDTM. The DTMA farmers spent about N45, 000 per hectare whereas for NDTM about N30,000 per hectare. Effect of variety on profitability of maize was significant at 1%. The Gross margin was N73, 416.74 per hectare for DTMA while N18, 862.61 per hectare for NDTM. Variation in profitability was 67.3% for DTMA and 59% NDTM jointly cause by variation on independent variables included in the model, like age, education, household size, land ownership, and many others. A significant relationship exists between maize variety produced and the farmer's efficiency level. Mean technical efficiency using SFA was 0.843 for DTMA, 0.628 for NDTM. Whereas under metafrontier efficiency, technical efficiency changes to 0.616 for DTMA and 0.535 for NDTM. Variability of efficiency across variety and across location was significant at 1%. Technology gap ratio was found to be 0.959 for DTMA and 0.866 for NDTM. Major constraints identified by the DTMA farmers was higher producer cost associated with low farm gate price, while for NDTM identified low extension contact as their major constraints. The survey established that DTMA farmers use average of 407 (equivalent to 69.2 man-days while 474 man-hours equivalent to 79.8man-days by NDTM of labour per hectare of maize from land clearing to harvest. It was also established that about 38.8% of maize yield was lost because of inefficiency by DTMA and 56.5% for NDTM. The study concluded that maize production was profitable even with lost in expected output resulting from farmer's inefficiency. Hence the study recommends that farmers producing maize for business should linked with companies like nestle food, for bulk marketing options, or contract farming options through their co-operative societies. Nevertheless, farmers should be informing on the proper use of herbicide through extension bulletin and guide.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background To The Study

Climatic variability and change remain a major factor affecting maize production, yield and reduced farmers income posing challenge to agribusiness enterprise. Finding adaptation strategies is a key to the success of the enterprise. Maize is an important crop in Nigerian crop mix. It is grown both for Income and household food security, it is grown as annual crops and serve as a stable food in many regions of the world serving a significant population particularly in developing countries (FAO and ILO, 1997; Ogunlade, *et al.,* 2010). Its production in Africa during the last 20 to 30 years was increasingly becoming popular as a major cereal, grown for household cash and food (Eckebil, 1994, Onyibe *et al.,* 2012). Maize is also one of the most important commodities used for food aid. Since maize is cheaper than other cereals such as rice and wheat, it is more affordable to the vast majority of the population, and therefore occupies a prominent position in the agricultural development agenda of several countries in Africa. PARA, (2009)

Maize production in Nigeria was fully established and is integrated as important component of farming system, and it remains a major determinant of the cropping pattern of the predominantly peasant farmers, especially in the Northern Nigeria (Ahmed, 1996). Nevertheless, it is grown everywhere both under irrigation and under rain fed condition in Nigeria, with over fifty million farmers growing it every year and over ninety million people employed in its processing and usage (Onyibe *et al.,* 2012). Despite the wide

production and vast ecological adaptation of the crop, yet its productivity remains comparatively low to what is obtained in other sub Saharan Africa and other parts of the world. It is worthy to note that many reports ascribed the low maize production and yield to be associated to droughts. In some cases farmers report losses of about 15% in periodic drought and dry spell, while up to 90% losses in severe or prolonged drought condition (La Rovere, *et al*., 2010; Vincent, 2013; IITA, 2013). Indeed, reasons ascribed for this low yield was mainly drought and water shortage. Sadly, in many parts of North Eastern Nigeria where Gombe is located, rainfall is unstable until around June - July and frequently less for good maize production, early season and terminal drought is experienced annually.

Consequently, launching of drought tolerant maize project in 2006 was intended to lessen the effect of drought and other constraints experienced by the crop in many sub-Saharan Africa. The project was co-jointly implemented by the Spanish International Centre for Maize and Wheat improvement (CIMMYT) and International Institute for Tropical Agriculture (IITA) in close collaboration with 13 National Programs in some countries of West, East and Southern Africa which are Benin, Ghana, Mali, Nigeria, Ethiopia, Kenya, Tanzania, Uganda, Angola, Malawi, Mozambique, Zambia, and Zimbabwe (La Rovere *et al*, 2010).

The foremost objectives of the project was to increase food security and income of small holder farmers the following activities were followed to achieve the stated goal, product development through breeding, product delivery through seed production, impact

assessment through socio economic studies, and project management. The project reported to have made progress on first and second phases (2006–2011) of the project cycle in nearly all the project objectives, and further reported to have developed and released over 100 varieties of maize to small holder farmers. In addition, the projects have an estimated 2 million farmers using the technology, not only in the target countries.

Nonetheless, it was also claimed that the varieties give significant good yields during season of poor rains and yields excellent when rains are good, These varieties were found to perform better than open pollinated varieties hence if accepted and produced in mass they will provide a safety net during dry spell and drought (Adeoye, 1986). But, upon all these claims limited empirical evidence was documented to validate their claims on the extent of difference with the other varieties of maize. As such, any effort to document this will add much to understanding of the worth of this variety compared to the other variety farmers are producing. Therefore, this work attempted to do a comparative economic analysis of drought and non drought tolerant maize production in Gombe state.

1. 2 Problem Statement

Drought remains a serious environmental problem. It is an undisputable cause of famine wherever it occurs, causing failure of crop. About 350,999 hectares of land is lost annually to drought related problem in Northern Nigeria (Abubakar, 2013). Indeed drought has continued to affect the nation's socio-economic, food security and employment opportunities in states that were seriously affected by the condition. (Abubakar, 2013). Gombe state like other state in the North is vulnerable to drought.

Vincent, (2013) and IITA, (2013) reported that drought and dry spell constitute the foremost threat to maize production and output, with reports of up to 15% loss in periodic drought and up to 90% in severe and prolong drought. In spite of the harsh environmental condition, maize remains a famous arable crop produced in Gombe state, though its production and yield is often affected by drought. The development of drought tolerant maize variety was one of the many efforts to tackle the incidence. The drought tolerant maize variety developed can tolerate extreme condition and was released coupled with bundles of incentives to encourage farmers adopt the variety. The released variety was claimed to yield up to about 6.5 to 9.0 tons per ha on research farms (Vincent, 2013) which was far above the obtainable yield from other local varieties produced by farmers which was between 1.7 – 2.3 tons per ha (NAERLS, 2009, 2010, 2011, 2012).

There has been very little attempt to document the performance of this variety as compared with the other varieties produced by the farmers. Therefore this study attempted to bridge the gap by comparing the two varieties and establish the extent of differences between them in terms of yield, profit, and efficiency and to further ascertain whether such differences are attributed to the location where the varieties are cultivated. Consequently, the following questions were addressed in the study:

i. What are the socio-economic characteristics of the farmers in the study area
ii. What are the technical relationship between inputs and output of drought and non drought tolerant maize production in the area?

iii. What are the variations on resource use efficiency within farmers in similar communities and between other communities using the two maize varieties in the state?

iv. What was the profitability of the two maize varieties in the study area?

v. What was the extent of technological and varietal gap between the two maize varieties?

vi. What are the factors influencing profitability of farmers producing the two maize varieties in the study area?

vii. What are the constraints to maize production in the area?

1.3 Objective of The Study

Broadly the study aimed to analyze and compare the economics of production of drought and non-drought tolerant maize varieties in Gombe State. The specific objectives of the study are to:

i. identify the socio-economic characteristics of the farmers in the study area

ii. Compare the technical relationship between inputs and output of drought and non drought tolerant maize production in the area.

iii. Compare resource use efficiency among farmers within communities as well as efficiency variations between communities using the two varieties in the state.

iv. Compare the profitability of the two maize varieties in the study area.

v. Compare the extent of technological and varietal gap between the two maize varieties.

vi. Identify the factors influencing profitability of farmers producing the two maize varieties in the study area.

vii. Identify the constraints to maize production in the area.

1.4 Justification

Agricultural productivity, growth and resource use efficiency are core element of sustainable crop production and profitability of farm business. Inefficient use of inputs can endanger food availability and security. Maize production in Nigeria is one area in agriculture experiencing low productivity and low yields compared to the other parts of world, and was affected gravely by drought resulting in low yield. The consequence of low yield remains a worrisome issue that requires a holistic approach to the problem. Variety of maize was developed which tolerate drought, with the aim of mitigating the effect of drought and dry spell experienced in the areas where such was a problem. Therefore providing updated information on efficiency and profitability of drought tolerant maize production will serve as guiding tools for informed decision making on the current agricultural transformation programme of federal republic of Nigeria. Similarly the output of the work will provide input to researchers, Academics , industry, and Government. So also providing empirical evidence on how this variety performs and differs with the non drought tolerant variety on farmer's farm appears to be lacking. Thus, this study established and provided empirical evidence on the variation between the two varieties thereby adding to the existing body of knowledge.

1.5 Research Hypotheses

i. Ho: Farmers' efficiency levels have no significant relationship with the maize variety produced by the farmers in the study area.

ii. Ho: There is no significant variation in profitability of DTMA and NDTM Maize variety in the study area.

iii. Ho: There are no significant differences in the efficiency level of farmer's producing the two varieties in different communities of the state.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Maize Production in Nigeria; an Overview on importance and production.

Maize *(Zea mays, L.)* remains one of the main cereal crops constituting stable food in many regions of West Africa and that of the world at large. It remains the most widely grown and important cereal food crop in Nigeria. Globally it ranked next to wheat and rice on its importance. Maize remains a miracle seed for Nigeria's agricultural and economic development. It is a basic staple diet for large population groups particularly in developing countries (FAO and ILO 1997; Oyinbe *et al,* 2012).

About 80% of it is consumed by man and animals while 20% utilized in variety of industrial processes for production of starch, oil high fructose, corn sweetener, and ethanol, cereal and alkaline (Jean du Plessis, 2003). Indeed, over 200 million peoples in developing countries consumed maize directly and serve as staple diet for them. Many people regard maize as a breakfast cereal, in Nigeria, maize remain a leading arable crop under cultivation (Onyibe *et al*., 2012).

Hassan (2011) reported that in Gombe state, maize constitutes about 34% of cultivable farmland (330,788 ha), on average each of the LGA in the state cultivates about 30,071.6 hectares of maize farmland each year. This depicts the importance of maize on the life of the people in the state.

2.2 Drought in Nigeria

Drought has been defined by many authors, as important natural disasters that show its influences slowly by time. It is one of the costly natural disasters of the world, which affects more people than any other natural disaster. The occurrence is virtually in all world climatic zones. But its characteristics vary significantly from one region to another, arid region which was generally characterized as low rainfall regions experience the wild form of the drought, Abaje, *et al*., 2013.

Although there is no universally accepted definition of drought, due to the wide variety of sectors affected by drought. The diverse geographical and temporal distribution and the demand placed on water supply by human, forced its definition to water shortage. Although others, defined it based on the nature of the water deficit. Four types of droughts were characterized by Abaje, *et al.,* 2013. The first was the meteorological droughts which occur for a period of time. The second was hydrological drought which was reduced subsurface water resources the third was agricultural drought, which, usually, refers to the failure of water resources to meet the water and demand for an economic growth of plants and Animals.

From the four definition presented, one characteristic seems to be common with all the definitions, which is a deficiency in rain for a fairly some period of time. This may cause widespread crop failure, death of livestock, water shortages, famine and other hardships and finally result to what is called “Drought”.

Shenaz (2010), defined Drought as condition that arises when there is a deficiency in the expected levels of precipitation over a prolonged period of time; or when it is observed generally, the season in previous years was generally wetter current so Parched land, dried crops, dust storms, and starving livestock are some of the scenes that people associate with the term drought.

Abaje, *et al*., (2013) observed that water scarcity due to the occurrence of droughts affects the agricultural outputs, result in food shortages emanating from an abnormal reduction in crop yield. Even the Irrigation projects which were developed to mitigate these problems were similarly affected by water shortages, most dams dry up during droughts. As such other non agricultural sectors affected were that, agro-allied industries since their raw materials might be lacking, which subsequently might leads to unemployment.

In Nigeria like many part of the world the arid parts of the country were more prone to drought and desertification. This zone forms an undulating plain at a general elevation from about 450m to 700m (Okorie, 2003). More than half of the regions were covered by ferruginous tropical soils which are highly weathered and markedly laterised. A large proportion of the region was also characterized of sandy-fixed undulating topography. The sandy soils were usually low in organic matter, nitrogen and phosphorus and may degrade rapidly under condition of intensive rainfall. When there was extensive usage, in this sandy environment, denuded patches may appear and when wind-blown sand becomes mobile. Average annual rainfall in dry land of Nigeria varies from 500mm to

1000mm in most part (Okorie, 2003). Unpredictability and unreliability characterize the pattern of rainfall, both spatially and temporally in the region. The nature of the rainfall supports mostly savannah vegetation. Thus the region was, by nature, prone to recurrent and sometimes intense and persistent periods of drought. This result in the depletion of soil and shallow ground water resources and are capable of disrupting the low level of recovery from problems of the natural ecosystems of the affected area (Okorie, 2003).

Okorie, 2013 further claimed that the vulnerability to drought incidence, frequent occurrences of drought in the zone have been largely responsible for the social backwardness and general poor quality of life especially among the less privileged ones. Droughts have also deprived natural vegetation in some parts of the region. Lack of fodder lead into a distress sale of cattle. In a long drought situation, there were exodus of people, in the location which can bring distress to neighboring areas due to excessive pressure and draining of resources.

Gombe state lies within this area and literatures have shown that, the state was challenge and was usually classified as one of the drought prone zone. According to Abubakar, (2013) who reported that, over 55 million people were estimated to be seriously affected by drought and desertification in Borno, Bauchi, Gombe, Adamawa, Jigawa, Kano, Katsina, Zamfara, Sokoto and Kebbi states; while approximately 350,999 hectares of land was lost to desertification annually. In spite of this harsh environmental condition yet Maize was an important arable crop produced in the state cultivating about 330,788 ha

annually (Hassan, 2011). Even though, the production was usually reduced by drought every year.

Drought and dry spell constitute a major hazard to maize production, yield and output especially in Northern Nigeria. In some cases farmers report up to 15% losses in periodic drought and up to 90% in severe and prolong drought (Vincent, 2013 and IITA, 2013).

2.3 Drought Tolerant maize

Shenaz M., (2010) reported that, Maize growth is sensitive to several stresses including low rainfalls and subsequent moisture stress. There have been several calls in Africa by governments, farmers, civil society and the scientific community for sustained solutions to the effects of drought on small-scale maize farmers and their families. Within this context, promoting the idea of a drought tolerant maize plant appears very attractive, especially in semi-arid regions of Africa. This is in the light of the current debates relating to climate change and the potential difficulties the region might face. However, Ogunlade *et al.,* (2013) believed that, drought remain one of the major factors affecting maize production most especially in the Northern Nigeria. Therefore Drought Tolerant Maize for Africa is needed. Because for 300 million people in sub-Saharan Africa, maize means "life" as well as nearly all African farmers rely on rainfall to grow the maize, so drought means disaster drought affected 12.5 million people in Horn of Africa, La Rovere, *et al*., 2010).

La Rovere, *et al*., 2010, is his work reported that drought tolerant maize can generate US$ 0.53 billion from increased maize grain harvests and reduced risk of drought effect, hence resulting in high and mighty traditional yield improvement because it has a a yield advantage over normal, improved maize be 3-20%, depending on the site and seasonal

conditions. He added that 34 drought tolerant varieties were released. breeder seed. He added over 20-30% of the variety was available, and varieties were provided to over 2 million smallholder farmers. Ogunlade *et al.*, (2013) reported that, the ability of local farmers to double maize yield could be raised through drought resistant varieties and varieties and hybrids in Nigeria. Several trial approaches was used for the purpose of multiplying the drought tolerant maize in Nigeria.

IITA, (2013) also has observed the limitation by drought to maize production was severe one. Framers report losses of up to 90% in severe drought condition. Bearing in mind the consequences of drought in this zone. And the importance the people of area offer to maize, researchers attempt to minimize the effect by developing a drought tolerant varieties of late, early and extra early maize. The developed maize varieties can tolerate extreme condition. It was released bundles of incentives to encourage farmers to use the varieties. These released varieties was claimed to yield up to about 6.5 to 9.0 tons per hectare (Vincent, 2013) This yield was believe to be far above the obtainable 1.7 – 2.3 tons per hectare (NAERLS, 2009, 2010, 2011, 2012).

2.4 Theoretical Framework on Production Efficiency

Economic or total efficiency was the product of technical and allocative efficiency. In the study of efficiency. Two different approaches were usually applicable; the parametric method and non parametric method. The non parametric was through using the data envelopment analysis or a piecewise regression. The parametric type use the stochastic frontier approach use better a log-linear function.

In stochastic frontier function approach, an efficient firm was said to operate on the production frontier in this all inefficient from operate under or below the production frontier. Technically efficient farm produces the maximum possible output from inputs used given cultivational and environmental constraint and it minimizes resources used for any given level of output (Rahman, 2005).

The general trend in most efficiency analysis was the assumption of similarity in technology, production sets and similarity in environmental factors. The only assumption researchers' focus was variation on the resource use efficiency i.e. how farmers utilized their limited resource. In this approach, other sources of variation even though important, but are mostly overlooked. As such, conclusions reached on such assumptions are likely to be faulty ones. It is believe that, variations in technology exist, so also variation in environmental factors. As such, assessing efficiency bearing earlier assumption mighty likely result in misleading conclusion. There was a need to study efficiency by taking into account other sources of varieties. The approach that can perform this was the metafrontier approach. Although, it was in line to review some work on the efficiency measures generally.

2.5 Type Farm Efficiency Measures

Several decisions on farm are made by the farmer in the use of resources. Mere decision making do not result in profitable farm business. Such decision must be evaluated using suitable guide or standard. These guides and standards are the measures of efficiency. Subba *et al,* (2009) had attempted to classify efficiency measures into two major types namely: - Physical efficiency measures, Financial efficiency measures.

2.5.1 The physical efficiency measures

This assesses the optimum utilization of physical inputs such as: land, labour, capital, on farms by every farmer. The principal aim of the approach was to achieve efficient utilization of these inputs. In this approach criteria and yardstick or indicators were set to quantify the efficiency of such inputs. The following are the various procedures used to express the efficiency of those physical inputs. The first was land efficiency was a ratio of actual crop yield by the farmer per average yield in the whole location in percentage. Second was the Cropping intensity which was a total cropped area for all crops during a specific year per area cropped for a particular crop also in percentage. The third measure of land efficiency was the crop yield index, measured as a ratio of production efficiency per crop acreage.

The profitability of farm, was believe to be influence by the efficient utilization of labour resource, such labour resource might be by mechanization or manual labour. Subba *et al*, (2009) had classify labour efficiency into five labour inputs efficiency namely; The first was labour efficiency as a ratio of crop acreage per adult man equivalent day (adult man equivalent day was usually computed as 6 – 8 hours of work for adult man, while for child and women 2/3 of man equivalent). The second measure was a ratio of adult man equivalent day per number of hours worked. The third was livestock labour efficiency which was a ration of number of livestock maintained per man. The fourth was an economic efficiency which was monetary return; it was ratio of Gross income per man. The last one was productive man work unit which was a ratio of total productive work unit per man equivalent day.

2.5.2 Financial efficiency measures

The physical efficiency measures resource use efficiency while the financial efficiency measures the success and failure of any farm business. Subba *et al*, (2009) further reclassified the financial efficiency measure into aggregate and ratio measures. This approach was mostly on profitability analyses, which appraise efficiency for short term investment effort. In this total capital invested, total value of production (Gross income), total expenses, net worth , net cash income, net farm income, farm earning, family labour earnings are estimated for the entire farm and comparison was made to ascertain the efficient level whichever was taking into account.

2.5.3 Ratio measures of efficiency

Other ratio measures, in investment analysis that focuses on ratio for investment either as short, medium or long term, using this approach, it reflect per unit return or cost per unit inputs involved in the organization of the farm. The major estimates in the approach were the fertilizer cost per hectare, power and equipment cost per crop area where mechanization was used. Beside the this other cost ratios include operating ratio, fixed ratio, gross ratio, solvency ratio, income ratio capital ratio are inclusive in ratio measures of efficiency (Subba *et al*, 2009). Although, cost and income measures are found to be widely used because of their instant relevance in the decision making process. They serve as a means for expansion, procurement of farm assets and inputs for future and present use.

2.6 Econometric Approaches to Efficiency Estimation

2.6.1 Stochastic frontier

Empirical estimation of parametric efficiency was typically done with stochastic frontier production function. The stochastic frontier production model has the advantage of allowing simultaneous estimation of individual technical and allocative efficiencies of the farmers as well as identifying the determinants of technical inefficiency (Battese and Coelli, 1995; Byerlee and Heisey, 1991; Ogundari and Ojo, 2006). Typically stochastic frontier has the a generalized function as seen by the equation 1.

$y = \beta' x + v$ Equation ……1

where y was the observed outcome (goal attainment), $\beta' x + v$ was the optimal frontier goal (e.g., maximal production output or minimum cost) pursued by the individual, $\beta' x$ was the deterministic part of the frontier and $v \sim N[0, \sigma_v^2]$ was the stochastic part, comprising the error(error of measurement and specification error) while the other part was the inefficiency associated with resource use allocation of the farmer. The two parts together constitute stochastic frontier, the residual of the stochastic frontier model, " the amount by which the observed individual fails to reach the optimum frontier was *u*, expressed more clearly using the equation 2

$\boldsymbol{u = |U| and\ U \sim N[0, \sigma_v^2]}$ Equation ……2

$|\boldsymbol{U}|$ This was the absolute mean deviation, or the square mean deviation $U \sim N[0, \sigma_v^2]$ from the frontier, the above equation can be change to $v + u$ for a stochastic cost frontier or any setting in which the equation was a minimization. In this context, u was the inefficiency. This was the half model which forms the basic form of the stochastic frontier model.

The idea of production function can be illustrated with a farm using n inputs: X_1, X_2, … X_n, to produce output Y. Efficient transformation of inputs into output was characterized by the production function f (X_i).The function shows the maximum output obtainable from various inputs used in production.(O'Donnell, Prasada and Battese), (2008) However, the limitation of this approach lies mainly on the assumption of homogeneity in technology, production sets, and environmental factors. This assumption of homogeneity was not common in most true situation. Therefore, a more elaborate approach was needed, so metafrontier, seems to offer a complement and provide a way in solving this panacea.

2.6.2 Metafrontier

The metafrontier function can be regarded as the envelope of commonly conceived new classical production functions. Agricultural productivity across various regions Technology or environment was defined by their metafrontier function as an envelope of the production points of the most efficient region. These variations in the technology and production limitation were associated with their respective region technology or environment. (Hung-Hung, 2004; O'Donnel, Prasada and Battese 2008; Haileselassie, and Gunnar 2010; Andrew and Ceaser, 2011;). This makes the use of metafrontier,

seems to be a useful concept for comparing efficiency of different groups, technology, regions and countries, if there was a suspicion that each of the group, operate under different technology or production sets or have different environmental condition.

Battese and Coelli, (1995) used the model for assessment of the technical inefficiency effects, in their empirical work on carp fish pond culture in South Asian countries. Similarly, Metafrontier model, was adopted by Gunar and Leung (2010) who separately studies efficiency of aquaculture farms in several countries. While, Battese, Haileselassie and Gunnar (2010) use the technique to estimate technology gap for soil conservation and small scale production in Ethopia. Thus the technique has been implemented in many places where group, regional, varietal, technological environmental variation was inherently inbuilt in the study.

Agricultural industry in several countries in European Union, also used Metafrontier analysis to compare the production efficiency, in spite of their variation in technology, weather, soil condition and production sets for comparative studies. Generally, Metafrontier assume a prior existence of difference across items to be evaluated. Metafrontier was developed to determine the extent of such differences brought about by different in technology, production sets, and environmental limitation inherently existing within item under study (O'Donnel, Prasada and Battese, 2008; Andrew and Ceaser, 2011). The output of Metafrontier was always greater than or equal to the output from individual. Since the co-efficient of the vectors of the individual frontier are fixed and if

the function are log linear in parameter, the optimization becomes the linear programming problem (O'Donnel, Prasada and Battese 2008).

Empirically, useful literatures were found beneficial on how to use the technique in order to measure technology gap or inefficiency in many countries Andrew and Ceaser 2011; and Battesse, Malik and Gill 1996).

O'Donnell, Prasada and Battese, (2008) provided a frame work for Metafrontier comparison with stochastic frontier model in efficiency measurement. Metafrontier was estimated using two major approaches, using the Data envelopment analysis (piece wise) and stochastic approach (parametric). In Metafrontier, an estimated mean efficiency scores of an item under observation were computed, and distant or difference (gap) between the individual frontier and Metafrontier were examined which gives the level of inefficiency. The Metafrontier can be used for both the technical or economic efficiency estimation.

Battese and Coelli (1993) in their studies on technology gap evaluated the extent to which bank actual cost, exceeds the efficient cost frontier. While Andrew and Ceaser, (2011) explain that Metafrontier was used in benchmarking performance by identify, best practice for improving the efficiency of resource within agricultural industry.

2.7 Farm Level Yield and Productivity Status In Nigeria

Maize yields in Africa was estimated to be an average of 1.7 tons per ha in 2006, comparatively the global average was about 5 tons per ha In India yield per hectare was 2.06 in 2009 while in Nigeria the yield was 1.52 tons per hactare (USDA, 2009).

Conversely, NAERLS (2009; 2010; 2011 and 2012) survey reports that Maize yield per ha in Nigeria was 1.58 in 2008, 1.76 in 2009, in 2010 and 2011 the yield were the same with value of 1.78 while in 2012 the yield rose to 1.859.

2.8 Factors Affecting Agricultural Production Efficiency

Productivity growth was important to the farms because more real income means that the farm can meet its (perhaps growing) obligations to the family, suppliers, inputs dealers, paid workers, and governments (taxes and regulation), and still remain competitive or even improve its competitiveness in the market place.

Kumbakhar, Gosh and McGuckin (1991) stated that technical in-efficiency significantly related to the level of education of a farmer and the size of their farming operation. Also Okike (2004) reported that farm specific factors affecting productivity in Savannah Zone of West Africa was Agricultural Intensification. Socio economic account for 76% and resource allocation account for 68% in Southern Guinea Savannah and 86% in Northern Guinea Savannah.

Another study conducted shows that credit, water and land were found to be an important factor affecting Agricultural Production efficiency under irrigation in Sri lanka Gillespie *et al*, (1997) observed that, producers experience, farm specialization and labour were found to be the major factors associated with production efficiency. Chavas *et al*, (2005) highlighted in their work that, managerial abilities, poor functioning market, labour, land, credit and poor co-operative participation were found to be the major factors. However,

Amaza *et al*, (2006) identify and linked farm size, fertilizer and hired labour to be the significant factor influencing farm specific efficiency whereas age, education, credit, extension contact and crop diversification was linked to influenced farmer specific inefficiency.

Indeed, efficiency has been improved by differential to access to subsidized credit from many sources to farms in developing countries. As a result, it was frequently suggested that rural development must originate with agricultural credit reform. However, there was little empirical evidence validating that farm production has been reticent by lack and poor access to either informal or formal government controlled credit. Generally agriculture in developing countries like Nigeria was not usually done for business, but rather for sustaining household food obligation. So credit reform may be desirable for number of reasons, but reform of other input sources and their markets might likely yield an impressive result on farm incomes than credit reforms. This might probably be linked to why many banks use to report high loan default on small scale loans given to farmers and consequently create a bottleneck for farmers assessing formal credit from banks.

It was also believed that the number of technical inputs, such as tractors and fertilizer employed in production was a significant factor in accounting for differences in agricultural productivity between developed and developing countries. However, in Nigeria, such vital inputs seems to have a serious problems of access, in many states, intermittently, government do procure and distribute tractors, yet the level of mechanization, access to fertilizer and improved seed varieties still remain unimpressive.

2.9 Empirical Application of Stochastic Frontier Production Function in Maize Efficiency Studies

Empirically, the frontier production function was a regression where the estimation of the production function was implemented with recognition of the theoretical constraints that all observations lies below it. It was all encompassing in analysis of efficiency. Many studies had shown different factors associated with efficiency and inefficiency on farm. Sadiq, *et al.,* (2013), in his study, uses stochastic frontier to examine Profitability and Production Efficiency of Small-Scale Maize Production in Niger State. Nigeria, the result revealed that output elasticity with respect to inputs like fertilizer for local seed users was 0.209 (0.00076) while hybrid seed users 0.224 (0.0011); labor for local seed users 0.300 (0.0027) while labour for hybrid seed users 0.177 (0.0063).Seed type for local seed users were 0.293 (0.0032) while seed, for hybrid seed users was 0.336 (0.0026). In the study, the major factors observed to be the causes of inefficiency were educations, family size, ownership of land; all were found to have significantly causes inefficiency in the production of the two varieties of maize.

Similarly, Ogundari and Ojo (2007) also observed that, the economic efficiency in small scale crop production in Nigeria was seriously affected by allocative efficiency which was found to be 73.07% while technical efficiency was observed to be 51.51% in their studies. The major factors causing such inefficiencies were years of schooling which was -0.073 (-0.011), farming experience -2.569(-0.004), though age of farmer 0.003 was not significant (1.265). All these studies were conducted using stochastic frontier or data envelopment analysis to assessed efficiency and factors affecting them. In all their

analysis the general assumption was they have homogenous data sets hence the only sources of variation were assumed to be that of efficiency. Limited consideration was made on existence of other sources of variation.

But, when other sources of variation were considered, a metafrontier was applied empirically to analyzed efficiency, Wang, and Hockmann, (2012) used metafrontier to examine varietal differences in rice production, similar results was found in another study, the mean technical efficiency was 55%, 58% and 57% for Ofada, Mai-Nasara and NERICA varieties, respectively. Farm size, hired labour, fertilizer, seed, age, gender, household size and amount of credit were found to be the major determinants of technical efficiency of farmers in Nigeria rice production. The average values of varietal technology difference were more than 83% in all the varieties.

Metafrontier had been used to estimate efficiency level of different locations by Andrew and Ceasar (2011) for five countries, their result revealed that mean Metatechnology ratios range from 55%, for France, up to 90%, for Poland, from their findings the UK, Germany and Italy, do not have a maximum Meta-technology ratio value of 1, indicating that they do not have farms which touch the metafrontier. The result depict that Poland was clearly closer to the metafrontier than other countries. So their high technical efficiency and Metatechnology ratio lead to high mean metafrontier scores and Poland vividly show a clear leadership in cereals when compared with other EU technology.

In this study, stochastic frontier was estimated for each group on the basis of location and the variety of maize produced by the farmers. This approach has been perform by Kumbhakar *et al,* 1991; Hung-Hung, 2004; Haileselassie and Gunnar, 2010; O'Donnel, Prasada and Battese, 2008; Andrew and Ceaser, 2011; Leuven, 2012. All these scholars have attempted to examine the efficiency in heterogeneous samples hence used the approach. It is generally believe that comparism with pooled data is only possible if two sets are similar. But where two sets are not similar comparing using the pooled data dissimilar individual is generally misleading. Because of the believe that this study have in build differences in term of variety and location. Therefore performances of the maize under this situation are likely to provide a misleading result. Hence the attempt to see how these parameters can be isolated. The work O Donnell, Prasada and Bettesse (2008) Gunnar and Leung (2010), Haileselassie and Gunnar (2010) .

The use of metafrontier was justified by Andrew and Ceaser (2011) who examined the extent of differences brought about by different in technology, production sets, and environmental limitation inherently existing within data under investigation. Therefore, since there was a suspicious of heterogeneity in this study so the use of metafrontier analysis in this study was justified. The major heterogeneity believes to be based on differences on variety and that of location of production. The attractiveness of the stochastic frontier model was its ability to simultaneously estimate causes of inefficiency level while estimating individual technical efficiency (Battese and Coelli,1995). Whereas the attractiveness of metafrontier was the ability to compare efficiency of two

differentiated observations, this was consistent with the work of O Donnell, Prasada and Bettesse (2008).

CHAPTER THREE

3.0 METHODOLOGY

3.1 The Study Area

Gombe state has a land mass of 20,265km^2, with total population 2,364,284 people as at 2006 population census. The projected population for 2014 was about 3,084,854 at 3% annual growth rate. There were more than 253,378 farm families in the 11 local government areas, with an average of 11 people per farming household (Hassan, 2011, NAERLS, 2011, 2012,).

Gombe state lies longitudes $8^0.5'$and $11^0.45' E$; Latitutes, $9^0.30' and\ 12^0.30' N$ It has lowest altitude of 793m at Deba while 2939m above sea level was the highest altitude at Kushi. It has a maximum temperature of 39.8^{0}C occurring between months of March and May, and has mean lowest temperature of 32.1^{0}C. The coldest months were between December and February. Gombe state share common boundaries with Adamawa, Bauchi, Borno, Taraba and Yobe state (Hassan, 2011). The state and has uni-modal rainfall distribution. Total annual rainfall is 1828mm with total annual rainy days of 135 days rain, and a mean 12 days per month. The state has the sizable number of rainy days, yet dry spell usually occur between July- August, in most cases, low crop yield result (NAERLS, 2012). Figure 3.1 shows the Area of study. The rainfall spread in the month of April to October. The state was characterized by savannah grass land, some woody trees of height ranging between 2m to 8.5m (Hassan, 2011).

Agriculture was the major employer of labour, employing over 80% of the State's active population. The State was blessed with abundant agricultural land, and was estimated that sixty-five 65% of the total land area was cultivable; out of which only 50% was currently under cultivation.

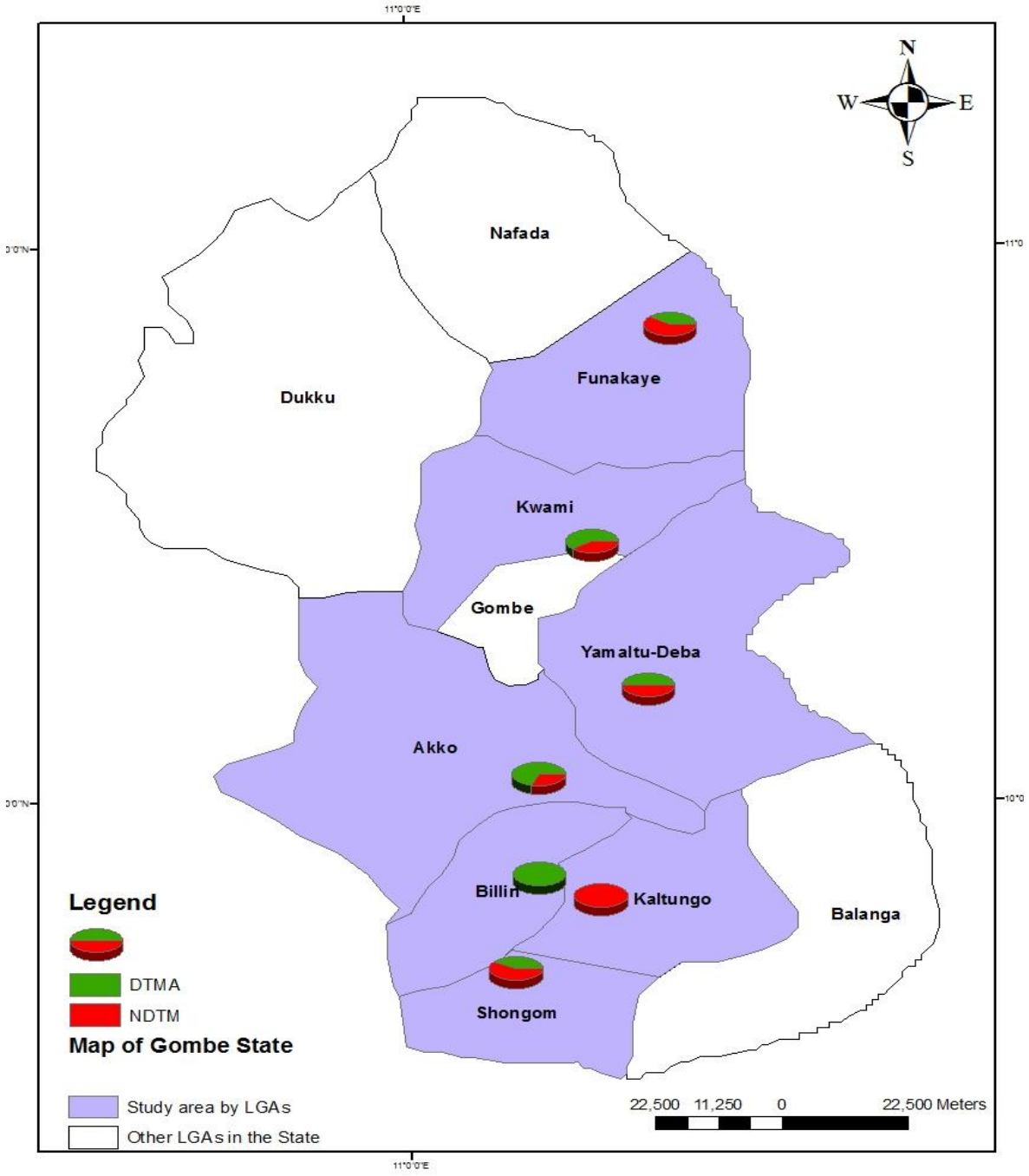


Figure 3.1 : Map of Gombe state indicating the study areas

3.2 Sampling Procedure and Sample Size

A multistage sampling procedure was conducted in all Local Governments Areas in Gombe state. This is in line with Obeka (2011) who suggested the used of a multistage

sampling procedure as most appropriate sampling when their exist heterogeneity or where sample contain multiple layers. In this study similar approach was adopted, in the first stage, a purposive selection of the five local governments that participate in the drought tolerant maize trial and seed multiplication was conducted to form a category called the drought tolerant maize (DTMA) group. The communities that make up this category are Bajoga in Funakaye, Zambuk in Yamaltu-Deba, Kufai in Billiri, Kumo in Akko and Boh in Shongom. Table 3.1 shows the selected survey areas for the study. From each of these communities 40 farmers were randomly selected through simple random sampling which constitutes 10% of the total drought tolerant maize farmers in DTMA group. This is in line with Gravetter (2006) who suggest that a number of participants for each subgroup can be determined by their number relative to the their population.

For the Non Drought Tolerant Maize (NDTM) group, all the eleven LGA's in Gombe was arranged serially. Thereafter, a simple random selection of LGA's were made to constitute a sample of NDTM group. To perform the selection a random number was generated against each LGA, then sort in descending order where another five sets of LGA'S were selected. The sampling was random selection with replacement. In each of the community, 5% of the total maize farmers in the area were selected to constitute a sample for non drought tolerant maize group thereby constituting a total sample size of 370 for the survey.

Table 3.1: Sampled LGAs in Gombe state

LGA	DTMA		NDTM		Total	
	Frequency	%	Frequency	%	Frequency	%
Akko	44	23.4	20	11.0	64	17.3
Billiri	33	17.6	-	-	33	8.9
Funakaye	33	17.6	46	25.3	79	21.4
Kaltungo	-	-	41	22.5	41	11.1
Kwami	22	11.7	15	8.2	37	10.0
Shongom	15	8.0	20	11.0	35	9.5
Y/Deba	41	21.8	40	22.0	81	21.9
Total	188	100.0	182	100.0	370	100.0

Source: Survey, 2014

3.3 Method of Data Collection

Primary data were used for this study. Data were collected using structured questionnaire and interview schedule administered by enumerators. Responses on the socio-economics, demographic characteristics, inputs, output, farm size and cost of production were obtained.

3.4 Analytical Technique and Model Specification

3.5.0 Descriptive statistics

The analytical tools employed for this study were descriptive and inferential Statistics. Descriptive statistics such as mean, standard deviation, frequency distribution were employed to describe, summarize and perform some vital parametric test to the data. The descriptive statistics were used to achieve i, and vii, as well as part of objectives iv. The inferential statistics such as stochastic frontier was used to achieved objective ii and iii, and hypothesis one and three while metafrontier model was used to achieved objective iii and v. However, Farm budget model was used to achieve objective iv whereas multiple

regression was used to achieve objectives vi and hypotheses ii. Conclusion was drawn with f-test and t-test statistics result. More specifically, f-test and t-test was used to test hypotheses i, ii and iii.

3.5.1 Analysis of relative economic performance of crop enterprise

3.5.1. Cost and return analysis

The model was shown in equation 3.

$$\mathbf{GM = Total\ Sales\ (GI) - TVC};\quad \text{Equation } \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where; GM= Gross Margin (₦/ha), GI= Total Sales (GI) (₦/ha), TVC = Total Variable Cost (₦/ha)

The Gross margin analysis was used instead of Net farm Income (NFI) in this study . It is a general believe that depreciated value of farm assets used by a households are usually negligible hence many resort to the used of gross margin instead of NFI. Similarly, all data on inputs and outputs used in this analysis were standardized per hectare basis, as such the gross margin is expected to appear on per hectare. The tool was used to achieve objective vi and hypothesis two of the study.

Never the less, another indicator used was the Return per Naira Invested (RNI). This indicator was used to identify and provide a measure of economic performance of each farm in terms of revenue accruing to a farmer on cost of inputs employed. The indicator was obtained using the:

Return on a Naira Investment $(\mathbf{RNI}) = \frac{\mathbf{GI}}{\mathbf{TVC}}$ Equation ……...……4

Using this indicator for judgment, return per naira greater than 1 was required for enterprise to be considered profitable and sustainable (Alamu and Coker, 2005).

3.5.2 The stochastic and metafrontier analysis

Two sets of inputs and output data were compiled, one set was based on the individual farmer regardless of their location or type of maize variety grown and was regarded as pooled datasets. This is because is to allow for test of heterogeneity in our datasets on both difference associated with variation on location as well as variation associated with the variety of maize grown, this method has been used by Betty, (2005), Kopsakangas, and Rauli, (2008), O'C.J. prasada.

3.5.2.1 Stochastic frontier model specification

The stochastic frontier production function with a multiplicative disturbance term of the form was specified in:

$\boldsymbol{Y_{ij} = f\left(X_{ij};\ \beta_j\right)e^{V_{ij}-U_{ij}}},\quad \boldsymbol{i = 1,2,3\ \ldots..N}$ Equation ……..5

Where *Yi* represents the possible production level for the *i*th sample farm; *f*(*Xij*; βj) was suitable function of the vector *Xi* of inputs for the *i*th farm and a vector β, of unknown parameters. The study used Cobb-Douglas type function for the analysis; *Vij* s were assumed to be independent and identically distributed normal with a random errors having mean zero and variance (σ_v^2) which were also independently distributed of *Uij*.

The *Uij*s which were the non-negative technical inefficiency effects representing management factors was assumed to be independently distributed, with mean *Ui* and variance σ^2 (Battese, Malik and Gill, 1996).

The empirical stochastic frontier Cobb-Douglas production model was specified in

$$\ln Y_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \cdots . + \beta_5 lnX_{5i} + V_i - U_i$$

Equation….. 6

Where subscripts i refer to the ith observation of jth farm,

In=Logarithm to base e,

Y= Total output of maize, standardize as grain equivalent (kg) per hectare as yield

X_1=Labour used for maize production (man days) per hectare

X_2=Quantity of Seeds used (kg) per hectare

X_3= Quantity of Fertilizer applied (kg) per hectare

X_4= Volume of Herbicide applied- if any (ltrs) per hectare

It was assumed that inefficiency effects was independently distributed, and U_i was obtained by truncation (at zero) of the normal distribution ith mean U_i and variance δ_u^2 **;**

$$U_i = \delta_0 + \delta_1 x_1 + \delta_2 x_2 + \cdots . \delta_3 x_3 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \cdots . \ldots + \delta_{10} z_{10}$$ ……7

Where subscripts i refer to the ith observation of ith farmer. For examining inefficiency level among farmers the Ui=technical inefficiency of the ith farmer, equation 3 was used for the estmiation. The residual obtained from efficiency analysis of each farmer was

compared with these factors influencing farm specific in efficiency. While for factors affecting profitability of maize variety profitability of each farmer will be compared with these variables to examine how they affect profitability.

Z_1= Age of the farmer (years)

Z_2=Years of formal education of the farmer (years)

Z_3= Household size (number of people providing unpaid family labour)

Z_4= Land ownership status (Dummy, owned = 1, otherwise =0)

Z_5= Number of crop grown in the farm

Z_6= Group membership (years of membership)

Z_7 = Previous season farm income for maize

Z_8 = Total Farm size (Ha) excluding maize

Z_9 = Total Farm size (Ha) for maize

Z_9= Extension contact (Average number of extension contact per cropping season)

Z_{10}= Amount of credit Accessed (Naira per cropping season)

Z_{11}= Distance to major town to market (Km)

Z_{12}= Amount for land hire

Z_{13} = Expenses on transportation from farm to house and vice versa

3.5.3 Metafrontier

The understanding of the existence of heterogeneity in the samples for the study it became ovious that proper approach have to be embark to truly compare the samples. This approach is the metafrontier approach. Therefore to compare efficiency across group with heterogeneity in the samples, the efficiency score for each community as well as that

of each variety of maize was compared with the most efficient farmer from within each sample. The distance between individual group frontiers with metafrontier shows the technology or technical gap ratio for each of the group. The model was to used achieve objective iii, and v of the study. The Metafrontier was estimated using the either sum of absolute difference of sum of square deviation, but in this study the sum of absolute difference was employed. Metafrontier efficiency model for farms in all the LGA's and maize varieties were expresses:

$$\boldsymbol{y = f(x;\beta^k)e^{v_i^k - u_i^k} = e^{x'\beta^k + v_i^k - u_i^k}, i = 1, 2, \ldots N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 8$$

Where β^k = vector of parameters for the metafrontier function such that $x_i\beta^k \geq x_i\beta$ this states that the Metafrontier dominates the entire LGA's or maize variety frontier. That was the Meta technology describes the unconstraint best practice according to the state of knowledge.

In deed Metafrontier production function defined as a deterministic parametric functions of specified functional form in such a way that it value was always not smaller than the deterministic components of the stochastic frontier production function of different group involve and for all group involve;

$$\boldsymbol{Y_i = e^{-u^k} \times \frac{e^{x_i\beta}}{e^{x_i\beta^*}} \times e^{x_i\beta^* + v_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

Where, the first term of the right hand side of the equation 9 was the technical efficiency relative to the stochastic frontier for the jth LGA.

$$\boldsymbol{TE} = \frac{\boldsymbol{Y_i}}{\boldsymbol{e^{x\beta+v_i}}} = \boldsymbol{e^{-u^k}}_i \quad \text{.....10}$$

The second term on the right hand side of the equation 9 was the technology gap (TGR) for the observation for the sample farm involved,

$$\boldsymbol{TGR} = \frac{\boldsymbol{e^{x_i\beta}}}{\boldsymbol{e^{x_i\beta^*}}_i} \quad \text{.....11}$$

The TGR measure the ratio of the output for the frontier production function for the jth LGA relative to the potential output, as was defined by the Metafrontier function given the observe inputs. The technology gap ratio had a values ranging between zero and one because of the equation (12) below. Although the relationship can also be estimated with Tobit regression because the Tobit has an advantage of correcting values obtained through such analysis to 1 unlike if normal regression were used which need to be corrected. The technical efficiency for the ith farm given relative to the metafrontier denoted by TE_i^* was defined in a analogous way to equation (11). It was the ratio of the observed output relative to the last term on the right hand side of the equation (10) which was the metafrontier output adjusted for the corresponding random error.

$$\boldsymbol{TE_i^*} = \frac{\boldsymbol{Y_i}}{\boldsymbol{e^{x_i\beta^*+v_i}}} \quad \text{.....12}$$

Using Equation 10 and Equation 11 implies that an alternative expression for technical efficiency relative to the metafrontier was given by

$$TE_i^* = TE_i \times TGR_i \quad \text{.....13}$$

The equation 14 used for the estimation of Yield potential as technical efficiency ratio of the i[th] farmer (farm) relative to the metafrontier was the product of the technical efficiency relative to the stochastic frontier for the given LGA and TGR.

Potential Output was estimated from yield gap which was estimated by the relation below:

$$\textbf{Yield Gap} = \frac{\textbf{100}}{\textbf{TE}} \textbf{x lnyield} \quad \text{..... 14}$$

$$\textbf{Potential yield} = \textbf{actual yield} + \textbf{yield gap} \quad \text{.....15}$$

To judge whether such differences are enough to be a difference the following relation obtained from estimated stochastic frontier from each group was used for Judgment, if the LR was greater than or equal to 1 then it was enough to be a difference but if LR was less than 1 then such differences was not enough to be a difference hence it was better to aggregate the data and run single stochastic frontier for the entire datasets.

$$\boldsymbol{LR = -2\left\{Ln\left(\frac{LH_0}{LH_1}\right)\right\} = -2\{Ln(LH_0) - Ln(LH_1)\}} \quad \text{.....16}$$

Where, $\mathrm{Ln}(\mathrm{LH}_0)$ show the value of log likelihood function for the stochastic frontier estimated by pooling the data for the two varieties and from different communities. $\mathrm{Ln}(\mathrm{LH}_1)$ Show the sum of the values of the log likelihood functions for the two stochastic production functions for varieties estimated separately. Frontier 4.1 program, (Coelli, Rao and Batesse 1998) was used for efficiency estimation, the choice of Frontier 4.1 because of its suited to the application, since the programme was essentially developed for the purpose of estimating efficiency score, parameters in both cost and production functions.

3.5.4 Hypotheses testing

T-statistics was used in this study to achieve some hypotheses, and objectives. It was expressed as:

$$t = \frac{\bar{x}_1 + \bar{x}_2}{\sqrt{\frac{var_1}{n_1} + \frac{var_2}{n_2}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 17$$

where,

$\bar{\boldsymbol{x}}_1$ =Mean value of DTMA of the objective or hypotheses in questions

$\bar{\boldsymbol{x}}_2$ = Mean value of non-DTMA/ non-DTMA of the objective or hypotheses in questions

var_1 *and* var_2 = Variance of DTMA and non-DTMA respectively

n_1 *andn*$_2$ = Corresponding sample size associated with DTMA and non-DTMA respectively

Since there are several locations to be compared to achieve the difference among locations, f-test was the best to perform such comparison, hence the generalized formula for f-test was shown as below:

$$\mathbf{f} = \frac{\textbf{variance between Location}}{\textbf{variance within Location}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 18$$

$$\mathbf{f} = \frac{\mathbf{MS_{Location}}}{\mathbf{MS_{Error}}} = \frac{\frac{\mathbf{SS_{Location}}}{\mathbf{I-1}}}{\frac{\mathbf{SS_{Error}}}{\mathbf{n_T-I}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 19$$

Where:

MS = mean square

SS = Sum of square

I = number of Locations

n_T= total number of cases to the F-distribution with

$(I - 1)$ = degree of freedom for the variance between locations

$(n_T - I)$ = degrees of freedom or the variance within locations.

CHAPTER FOUR

4.0 Result And Discussion

4.1 Socio-economic description of the respondents

The several elements surrounding farmers environment often have an influence on farming decision and output. Some of the element include farmers socio-economic characteristics, variety of maize produced; like this study thus drought tolerant maize (DTMA) and non-drought tolerant maize (NDTM) Farmers characteristics was described in this section. More specifically the farmers characteristics described the include age, gender, marital status, household size, education level, farming experience, in the tables that follows.

4.1.1. Age distribution of the respondents

Age is an important element in farming. The contribution of age in farming is important one, increases as age increases though at around 60 – 65 years of age, it begins to decline due to old age. Therefore, because of this problem, the understanding of the dynamics of farmers' age in the survey is of paramount important. Table 4.1 reported age distribution for farmers cultivating different maize variety. From the table it can be seen that 37% and 32% of DTMA and NDTM farmers fall within the ages of 40 and 49 years. The largest proportion of the respondents fall under this category in both the two group of farmers. From this result it implies that most of the farmers are in their prime stage in life. They cannot be class as young nor old. This is followed by farmers between the ages of 50 and 59 years with 23% and 28% for DTMA and NDTM respectively. For the ages of 30 and 39 years, the DTMA and NDTM had 18% and 24% respectively. The least proportion of

the respondents were those in the age category between 20 and 29 with 6% for DTMA and 7% for NDTM. This shows that limited number of youth were in maize production in Gombe state by combining farmers within 20 or 39 years the total proportion were 29% and 31% less than the proportion of farmers between 40 – 49 years but more that farmer between 50 – 59 years. .

Table 4. 1: Age distribution of the respondents

Age	DTMA		NDTM		TOTAL	
	Frequency	Percent	Frequency	Percent		
20 – 29	12	6.4	12	6.6	24	6.5
30 – 39	34	18.1	43	23.6	77	20.8
40 – 49	70	37.2	58	31.9	128	34.6
50 – 59	44	23.4	51	28.0	95	25.7
Above 60	28	14.9	18	9.9	46	12.4
Total	188	100.0	182	100.0	370	100.0

Source: Survey 2014

Similarly, the age range for DTMA household heads was between 20 – 68 years of age, the minimum age of household head was 20 years. The maximum age was 68 years, with a mean of 46 years, while in NDTM out of 182 observations, the age range remain at 20 – 68 years, with minimum age of household head was 22 years, maximum age was 68 years which gives the mean age of the household head as 45.2 years. In all the categories of the maize farmers, the respondents are in their prime and active years. This finding is in line with the finding of Wang and Hockman(2012) observed that farmers in between ages of 40-50 are classed as prime age. Generally farmers in developing countries are left

for older people, youth which are below this age category go to town in search of white colar job. This phenomenon is very detrimental to the Agricultural production.

4.1.2: Household size

By definition, a household: In this study means total number of people in a house sharing a common pot. Generally, most farmers are small scale farmers who uses manual labour for production. Therefore, the size of household influences labour availability by providing farmers with unpaid labour, although this is not always true. The household size gives a picture of how a household might likely have unpaid labour but this must be related to those contribute to the farm activities. Table 4.2 shows the distribution of household size. The survey indicated that that 41% of the DTMA and 28% of NDTM farmers have household size with 1-5 members, followed by 26% of DTMA farmers that has 6-10 members per household, similarly (24%) of NDTM have the same household members. The farmers with household size between 11 and 15 are 20% for DTMA and 22% for NDTM. The least are farmers with household members above 21 people, constituting 4% for DTMA farmers and 10% for NDTM. Never-the-less, out of the 188 observations of DTMA farmers. The maximum household size for this category was 25 people in the household; The range of the household size in the DTMA between 1 and 25, while the mean household size for the category was found to be 9 people.

Similarly, the NDTM Farmers, out of the 182 farmers in the group, their household size range, between 1 and 29. The maximum number of 29 people per household, while on average there were 10 people in a household. This is in line with Wang and Hockman

(2012) who found the mean household size to be around 8 people. But differ from Ogundari and Ojo (2007) who found the mean household size to be around 13 people.

Table 4. 2 : Household size of farmers in Gombe state

	DTMA		NDTM		Total	
Household Size	Frequency	%	Frequency	%	Frequency	%
1- 5	77	41	50	27.5	127	34.3
6 – 10	48	25.4	49	26.9	97	26.2
11 – 15	37	19.7	44	24.2	81	21.9
16 – 20	18	9.6	21	11.5	39	10.5
Above 21	8	4.3	18	9.9	26	7.1
Total	188	100	182	100	370	100

Source: Survey 2014

4.1.3: Education level of respondents

Education show how enlighten a farmer is, in terms of western education, it determine his ability to read and write, follow instruction provided on a label of materials. Although, in some societies, farmers with Quaranic education can as well read, write and communicate effectively in Arabic. Therefore they cannot be treated as un-enlighten societies, so considering this some manufacturers of many product use important information in Arabic to catch the nicthe of their customers. Education positively affect the adoption of innovation and understanding of the outside world by the farmers. The use of recommended practices, some skills are required to implement instructions, this tend to contribute to the adoption of innovation if the level of education of farmers is higher. In this study, the education level of the interviewed farmers was also examined. Table 4.3 presented the result as follows; farmers with secondary education constitute the largest

proportion of both DTMA and NDTM with 39% each. Farmers with primary education followed the DTMA by 35% and 26% in NDTM, tertiary education account for 12% for DTMA and 10% for NDTM. The least were those without any formal education, they constitute 3% for DTMA and 5% for NDTM. Although Quranic education is another important parameter it recorded 11% in DTMA and 18% in NDTM. Cumulatively Secondary education seems the prominent education level of the farmers in both groups having 39% followed by primary education with 31%. This is similar to the findings of Sadiq *et al.*,(2013). Similarly in cumulative terms, farmers with no formal education had the least with only 5%. This differs from the finding of Ogundari and Ojo (2007).

Table 4. 3 : Education Level of respondents

	DTMA		NDTM		TOTAL	
Education Level	Frequency	%	Frequency	%	Frequency	%
No formal Education	6	3.3	12	6.6	18	4.9
Quranic Education	20	10.6	33	18.1	53	14.3
Primary Education	66	35.1	48	26.4	114	30.8
Secondary Education	73	38.8	70	38.5	143	38.6
Tertiary Education	23	12.2	19	10.4	42	11.4
Total	188	100	182	100	370	100

Source: Survey, 2014

4.1.4: Membership of farmer organization

It is a general believe, that meeting farmers in group is easier than reaching them than on individual basis. They might probably possess a common resource which might facilitate their access to some vital resource in farming. Therefore, membership of group remains a cardinal point in effective extension work. Table 4.4 indicated that majority about 52%

of the DTMA farmers belong to at least one farmer organization. For the NDTM farmers majority of them did not belongs to any farmer organization, only 15% of them were members of at least one farmer organization. This finding is in line with Sadiq et al., (2013), but vary from the findings of Ogundari and Ojo (2007). Cumulatively, 67% of both the DTMA and NDTM farmers do not belong to any farmer organization, while 33% were found to be members of at least one farmer organization. From the above it is clear that farmers need to be sensitized on the group formation, so that they can pool their resources together when in group rather than as individual.

Table 4. 4: Membership of farmer organization

Membership	DTMA		NDTM		Total	
	Frequency	%	Frequency	%	Frequency	%
No	90	48.4	155	85.2	245	66.6
Yes	96	51.6	27	14.8	123	33.4
Total	186	100	182	100	368	100

Survey, 2014

4.1.5: Extension visit

Extension Contact is the number of time a farmer is getting extension advise from an extension agent or frequency for which extension agent visited the farmer for extension advise. However in some cases the farmer is the one that visit the extension agent for extension advise due to their felt need. Although, today many platfroms exist for farmers contact with extension personnel, such platforms include radio, e-extension and many others. Table 4.5 presented result on farmers extension contact, the study indicated that 92% of DTMA farmers have access to extension whereas in NDTM out of the 182

farmers selected 97 of them provide response on extension contact. Out of the responded farmers 79% NDTM have no access to extension. However, when the data were pooled (cumulated), accessibility to extension by both were found to be 68%. From this result, it is understandable that by cumulating the extension contact, the NDTM farmers were masked, showing a false indication of high extension contact in the survey communities. Nonetheless, out of the 285 farmers that responded to the number of extension visit received in last cropping season, DTMA farmers had a range between 1 and 4, with minimum of 1 and maximum of 4 visits, with a mean visit of 3 in the season. For the NDTM among only 20 farmers responded on receiving extension visit, the number of extension visit in the group had a range between 1 and 3, a minimum of 1 visit, maximum of 3 visits, while on average farmers in the group received 2 extensions visit in last cropping season. This finding differed to what Wand and Hockman (2012) discover among Farmers in Nasarawa state Nigeria.

Table 4. 5 : Farmers extension contact

Extension Contact	DTMA		NDTM		POOLED (TOTAL)	
	Frequency	%	Frequency	%	Frequency	%
No	15	8.0	77	79.4	92	32.3
Yes	173	92.0	20	20.6	193	67.7
Total	188	100	97	100	285	100

Source: Survey, 2014

4.1.6: Credits accessibility by the respondents

Credit is the money either in cash or kind used in farming. The level at which farmer have access to this important resource determined how successful the farmer might likely be in farming business. Many sources are available to support farmers, but most farmers

have limited access to them, probably because of many reasons. In this survey access to credit was shown in table 4.6, from the result out of the 188 DTMA farmer 129 of them responded on credit accessibility. 86.0% of DTMA farmers that responded to have accessed credit whereas 14.0% did not accessed credit. Out of the 182 farmers in the NDTM 8 have responded on credit accessibility. From the 8 that respondended among them, all the 100% did not accessed any formal credit facilities. Similarly when the data were pooled, accessibility to credit by both DTMA and NDTM was 81.0% for those that accessed credit, while only 19% were found to had no access from the result it is obviously seen that wrong indication of credit accessibility was manifested when accessibility was taken on pooled basis. Therefore when data on certain parameters were pooled, weak datasets were buried. This is the common error observed, as was revealed on indicator of credit accessibility and extension contact by farmers.

Table 4. 6 : Credit accessibility by the respondents

Credit Access	DTMA		NDTM		(TOTAL)	
	Frequency	%	Frequency	%	Frequency	%
No	18	14.0	8	100	26	19.0
Yes	111	86.0	0	0.0	111	81.0
Total	129	100	8	100	137	100

4.1.7: Land tenure system practice by the respondents

Land tenure system, show how farmers accessed the farm they cultivated; Different land tenureship arrangement were available in the survey communities. Some are easy while others seams difficult, some were vulnerable to extensive fragmentation. Therefore, a vivid understanding of how farmers acquire their production land provided useful insight

in any survey. The land tenure arrangement practice by the farmers in the surveyed communities, was presented in table 4.7 indicated that 34% of the DTMA farmers had a mean of 4.0ha as rented, 25% Inherited land with a means size of 3ha, 23% purchased land, with a mean size of 3 ha. On the other hand 34% of NDTM farmers acquired their production land through inheritance with a means size of 4ha, followed by 29% who acquired their production land through purchased, gift and leaseholds. They constitute the least proportion in the group with 18%.

Generally the average land holding in the surveyed area were 2.9 for DTMA and 2.6 for NDTM. Although, land tenure arrangement is not an exclusive event that a farmer might acquire only from a single source; several sources were identified in the study where some farmers had different combination of sources. This finding supported the findings of Ogundari and Ojo (2007) but vary with Sadiq *et al.*,(2013)and Wand Hockman (2012).

Table 4. 7 : Land Tenure System

	DTMA		NDTM	
Land Tenure System	Mean area	%	Mean area	%
Inherited Land	2.8	24.6	3.56	34
Purchased Land	2.6	22.8	2.99	28.6
Gift Land	2.1	18.4	1.89	18
Rental Land	3.9	34.2	2.03	19.4
Average	2.9	100	2.6	100

Survey, 2014

4.1.2 Production input used for the surveyed farmers

4.1.2.1 Land area maize cropped per farmers

Table 4.8 shows the distribution of area cropped per farmer. Forty five percent (45%) of the DTMA farmers cropped area between 4 and 6ha; 27% of them cropped between 1 and 3ha, those that cropped above 13ha were only 7%, they constitute the least proportion of

the farmers. On the other side of the farmers, the NDTM farmers, about 40% of the farmers cropped area between 1 and 3ha with maize, followed by 39% who cropped between 4 and 6ha, only 4% cropped above 13ha. Similarly the average area maize cropped from DTMA farmers had a minimum of 1.0 ha and maximum of 18ha, with a mean of 5.6 ha. For NDTM, the minimum area cropped by the farmers was equally 1ha, with a maximum of 15.0 ha, with mean of 4ha. For the average maize that was intercropped, DTMA covered minimum of 0.01ha and maximum of 13ha with 3.6 ha as the mean, whereas NDTM farmers had minimum area maize was intercropped was 0.05 ha and a maximum was 9.0 ha with the mean of 2.5ha.

Table 4. 8 : Distribution of area cropped by farmers

	DTMA		NDTM		TOTAL	
Area maize cropped	Frequency	%	Frequency	%	Frequency	%
1 – 3	50	26.6	96	52.7	146	39.5
4 – 6	85	45.2	60	33.1	145	39.2
7 – 9	25	13.3	19	10.4	44	11.8
10 – 12	15	8	5	2.7	20	5.4
Above 13	13	6.9	2	1.1	15	4.1
Total	188	100	182	100	370	100
Mean	5.33		4.16			
Minimum	0.5		3			
Maximum	18		22			

From table 4.9 on distribution of area cropped per farmer per community, it was revealed that in all the seven (7) locations that data were collected, with the exception of Kaltungo, farmers devoted sizeable land area for cultivation of drought tolerant maize. On area devoted for DTMA maize across the LGA per farmer, Kwami reported the largest area of 3.2ha, followed by Yamaltu Deba with 1.7 the rest were 1.3, 1.2, 1.2, and 1.1 for Akko, Funakaye, Shongom and Billiri respectively.

However for area devoted for other maize varieties it was found that Kwami recorded area of 6.5ha for NDTM and 2.6ha for DTMA, Funakaye followed by 5.0ha NDTM and 5.6ha DTMA, Akko had 4.5ha by NDTM and 0.90ha DTMA, 3.2ha NDTM and 2.9ha DTMA, 3.0ha NDTM, 2.9ha NDTM and 1.8ha DTMA for Yamaltu Deba, Kaltungo, and Shongom respectively, Billiri recorded land area of 5.2ha for DTMA and for NDTM. Mixed cropping is a general practice among many farmers, this is because of issue of land tenureship problem and maximum utilization of the available land. When farmers cultivated maize and cowpea on the same land the output of cowpea after sales cover over 75% of the money expend on maize and cowpea as such they can comfortably use the maize for household consumption while the cowpea be used for the next farming inputs, this is line with Rahman, (2013) who believe that farmers using mixed cropping does that for economic given.

4.1.2.2 Average maize seed used per hactre

The study established that average quantity of drought tolerant maize seed planted by DTMA farmers per hactre were 22.8kg, the minimum quantity used for the variety was 14kg whereas the maximum quantity of the seed used was 28kg per ha. NDTM, no farmer was found to try even one pieces of the variety. Generally, the DTMA farmers were also found to use other maize seed, the mean quantity of the other maize varieties were 24.9kg with minimum quantity of 14kg and a maximum was 38kg per ha whereas NDTM farmers used other maize seed varieties with mean of 26.5kg per ha, minimum of 13kg other maize seed, with maximum of 37kg. The average combined other maize and

DTMA seeds used in kg per ha showed that DTMA used minimum of 19.5kg, maximum of 35kg and the mean of 26.5kg per ha of combined varieties while NDTM used a mean of 25.4kg, a minimum of 13kg and maximum of 37kg per ha.

Similarly, in table 4.9, the seed rate per hectare across the surveyed LGAs was presented as follows; for Akko DTMA, planted on average 22.8kg per hectare; in this category, the highest seed rate found was in Kwami with 28.3kg and the lowest in Shongom with 16.8kg per hectare. For the other maize seed, the DTMA farmers had average seed rate of 24.9kg, the lowest rate was found to be in Yamaltu Deba while LGA with largest rate was Kwami. Never the less, for the other maize seed by the NDTM an average of 27kg per hectare was found to be planted across the survey areas, in this category the LGA with lowest rate was still Yamltu Deba the largest rate for the category was in Kwami. Generally for average total seed used per hectare comprising both varieties was 26.5kg for DTMA farmers. 25.4kg for NDTM Akko recorded the uppermost LGA with 27.8kg per ha, the lowest was Yamaltu Deba with 22.18kg per hectare in DTMA while the least rate in the group was similarly found in Yamaltu Deba with 17.9kg per hactare.

The recommended seed rate for DTMA was established at 15 -27kg with 75cm by 50cm and if two seeds per stand per hectare was followed. (Onyibe, *et'al.*, 2012). From the result obtained from the survey, farmers was found to plant above the recommended rate. The possible reason for the overuse might be attributed to the maximum planting density technology pushed and recommended by Sassakawa Africa. The low seed rate found in

some location was likely linked to farmers inaccessibility to extension service, as can be observed from the result in section 4.1.6 table 4.5 of the survey.

Table 4. 9 : Average seed used in kg per hectare per LGA

LGA	Total DT seed used		Total normal seed used		Total seed used	
	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Akko	22.8	-	27.3	27.88	27.78	27.88
Billiri	23.6	-	24.61	-	23	-
Funakaye	26.7	-	26.86	33.21	27.25	33.21
Kaltungo	-	-	-	26.77	-	26.77
Kwami	28.3	-	19.18	34.42	20.71	34.42
Shongom	16.8	-	33.05	21.98	26.98	21.98
Yamaltu Deba	17.7	-	18.44	17.92	22.18	17.92
Average	22.65	-	24.9	27.0	26.5	25.4

Source: Survey, 2014

4.1.2.3 Fertilizer used by farmers

Average fertilizer used by farmer in kg per ha per local government: The average fertilizer used by farmers per hacter was presented in table 4.10. The survey indicated that 83kg and 68kg of 50kg bag equivalent (1.7bags and 1.4bags respectively) of urea were found to be applied by both DTMA and NDTM farmers. Similarly, about 142kg (3bags) and 124kg (2.5bags) of NPK was equaly used by the DTMA and NDTM farmers respectively. This shows that farmers in the area used a total of 192kg (4bags) and 165kg (3bags) of both fertilizer types by DTMA and NDTM respectively. From the result on fertilizer applied by both farmers, it is without doubt that fertilizer use by the farmers was not up to the recommended rate per ha. The average fertilizer rate recommended for the North east or Sudan Savannah region was 150kg (3bags) of urea plus 400kg (8bags) of NPK (Onyibe *et al.*, 2012) the average fertilizer application was 7bags of combine NPK

& urea as against 11bags of NPK & urea. Fertilizer is a major requirement for maize. The deficit in the fertilizer use by farmers might likely be the explanation as to the reason why most farmers do not get to their potential yield expected from either of the variety or the cost of fertilizer was likely be the reason for low used . As such, there is the need for elaborate extension work for importance in the following of recommended fertilizer rate for maize.

Table 4. 10 : Average fertilizer used by farmer in kg per hectare

	Urea		NPK		Total	
LGA	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Akko	83.1	80.6	111.3	110.8	194.4	191.5
Billiri	70.2	-	118.9	-	189.0	-
Funakaye	74.6	50.2	142.2	110.9	216.7	161.2
Kaltungo	-	48.1	-	151.0	-	199.1
Kwami	83.6	46.5	174.4	122.2	258.0	168.7
Shongom	99.6	84.7	184.7	130.5	284.3	215.2
Yamaltu Deba	84.2	95.8	119.0	120.6	203.1	216.5
Average	82.6	67.7	141.7	124.3	224.3	192.0

Source: Survey 2014

Average fertilizer cost in Naira per bag: Table 4.11 presented information on cost of 50kg bag of fertilizer. 50kg bag of urea cost highest for DTMA was recorded in Shongom (₦4700), followed by Kwami, Akko, Funakaye, Billiri, and Yamaltu Deba with ₦4680, ₦4300, ₦3400, ₦3200 and ₦2800 respectively, the average cost for urea for the whole locations was ₦3700. For NDTM 50kg bag of urea, cost 4700 for Kaltungo, followed by ₦4600 (Yamaltu Deba), ₦4500 (Kwami), ₦4400 (Shongom), ₦4200 (Akko) and ₦3800 (Funakaye), with average price of ₦4400 for the whole locations. The variation in cost of

fertilizer per bag might likely be associated with the government fertilizer distribution through GESS in which the price was significantly low. Although fertlizer market was not explicitly segemented but implicitly might be segmented, transportation from one location to another implied additional cost hence makes the spartial varition of fertilizer price, similarly some farmer acquire the fertilizer from open market as such they pay higher than those that acquire from GESS.

The average price for NPK was ₦4300 for DTMAfarmers in the whole locations and ₦4600 for NDTM. Highest price for NPK as recorded for DTMA was ₦5200 in Kwami followed by ₦4900 in Shongom, ₦4700 (Akko), ₦4100 (Funakaye), ₦3700 (Billiri) and ₦3100 in Yamaltu Deba. Prices for NDTM NPK in descending order were ₦5200 (Kwami), ₦4800 (Kaltungo), ₦4700 (Shongom), ₦4300 (Akko), ₦4300(Yamaltu Deba), and ₦4100 (Funakaye). The average price for purchasing a bag of manure/poultry droppings for the whole locations for DTMA and NDTM are ₦2700 and ₦2900 respectively. With the highest price for DTMA recorded as ₦2800 for Akko, Funakaye and Kwami, the lowest price was ₦1900 recorded for Yamaltu Deba. Highest price for NDTM was witnessed in Shongom (₦3200) with the lowest price recorded as ₦2800 in Akko and Kwami.

Table 4. 11 : Average cost of fertilizer per Bag in naira per bag

LGA	Urea		NPK		Manure/Poultry Droppings	
	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Akko	4332.95	4147.5	4708	4302.5	2800	2800
Billiri	3166.67	-	3681.8	-	-	-
Funakaye	3424.24	3838.04	4060.6	4076.1	2800	2804.35
Kaltungo	-	4653.66	-	4792.7	-	2807.32
Kwami	4679.55	4530	5231.8	5163.3	2800	2800
Shongom	4753.33	4355	4900	4732.5	3200	3150
Yamaltu Deba	2840.24	4610	3056.1	4280	1937.5	2805
Average	3866.16	4355.7	4273.1	4557.9	2707.5	2861.112

Survey, 2014

Labour used per operation and cost of labour per operation: Farm labour used is usually measured in man-days and converted to man-hour. In this study, the man-hour measure was adopted. Farm labour can either be provided through hired or family, as such the labour were classified either as hired or family labour. Table 4.12 shows average hired and family labour used in man-hour per operation per hectare.

It was found that 30 man-hour was used for land clearing in DTMA per ha and 18man-hour in NDTM. Twenty two (22) man-hour was used by farmers in DTMA for plouging/ridging while 18man-hour in NDTM for the same operation. The use of hired labour on fertilizer application in DTMA was 38 man-hour and 25man-hour in NDTM. The use of hired labour in first manual weeding per ha was 47 man-hour by DTMA farmers and 26 man-hour in NDTM. The hired labour use for harvesting was 43 man-hour In DTMA and 20 man-hour in NDTM whereas hired labour in threshing per in

DTMA use 33 man-hour and 7 man hour in NDTM. For bagging in DTMA used 14 man-hour and 4 man-hour of hired labour in NDTM. For the spraying of pesticide, 4 man hour per ha was used in DTMA and 5.4 man-hour in NDTM. The use of transportation per ha was 6 man-hour in DTMA and 8 man-hour in NDTM. Cumulatively, the average hired labour used per hectare was 340 man-hour by DTMA and 219 man-hour by NDTM. Similarly, land clearing cost farmer 1200 for DTMA and 1184 for NDTM in whole total labour cost per hectare on all operations were found to be N27,286 and N21,795 per hectare for DTMA and NDTM respectively.

Table 4. 12 : Average hired and family labour used and cost of farm operation per hectare

	Average family labour used per ha		Average hired labour used per ha		Cost of labour per operation per Ha	
Farm Operation	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Land Clearing	3.9	16.9	30	17.6	1200.00	1183.85
Plouging/ Ridging	2.3	10.7	22.3	17.5	4500.00	4785.06
Planting	4	17.6	36.2	20.3	1557.18	1785.06
Fertilizer application	6.9	8.9	38.2	24.8	1300.00	2133.21
First Manual Weeding	7.3	9.8	47.3	25.5	5456.18	2234.49
Second Manual Weeding	6.5	11	50.2	28.2	3589.11	2481.36
Spraying for Chemical 1st Weeding (Herbicide)	2.2	1.7	16.9	15.2	800.00	769.77
Spraying for Chemical 2nd Weeding (Herbicide)						
Harvesting	8.7	10.4	42.9	20.3	2200.00	2143.31
Threshing	7.1	8.7	33	18.9	2300.00	1747.08
Bagging	5.2	3	13.5	17.2	1483.71	1278.66
Pesticides Spraying	4.3	1.6	3.6	5.4	500.07	443.10
Transportation	2.6	5.2	5.9	7.6	2400.00	2810.24
Total	61	105.5	340	218.5	27286.25	21795.19

Survey, 2014 NB: Not all cost were incured by the farmers,

Total labour used per hectare per LGA: Table 4.13 shows the aggregated labour used per hectare in all operation for maize production across the survey areas. Variability exist in the total labour used in farm for the production of maize. In Gombe state both family and hired labour was found to be employed in maize production. For estimation purpose, 6 hours were assumed to be the maximum hours a man can continue to work on farm actively while for children and women a total of 4 hours were inputed. It is vivid that family labour were not usually charges any cost, this study adopted to use the oppurtunity cost (this is the cost if the labour is to be paid by the farmer) as a proxy for family labour cost, which were subsequently used for computation of cost and return.

Therefore, average family labour used in all the survey areas were 46.63 for DTMA and 61.55 for NDTM, family labour across the LGA individually, family labour used by farmers across the LGAs, for DTMA in Funakaye was 147 man-hour, followed by Kwami, Billiri, Shongom and Akko with 66, 46, 17 and 4 respectively while Yamaltu Deba recorded no family labour by DTMA farmers. But the NDTM farmers was found to used 119 was obtained from Funakaye, 97 in Akko, 70 in Yamaltu Deba, 43 in Kwami, 26 in Shongom, and 14 in Kaltungo.

Never the less, hired labour was also found to be supplied in maize production across the survey LGAs in Gombe state. On average DTMA was found to use 225 unit of labour for maize production while on the other hand the NDTM was found to use 154 unit of labour. The distribution across each LGA was Akko record the highest hired labour use with 290 by DTMA and 256 by NDTM in Kwami. The least was Shongom with 115 by DTMA Farmers while Yamaltu Deba was least in NDTM with 47 unit of labour.

Cumulatively, average of 271 unit of labour was used in all the LGA for maize production by DTMA farmers while an average of 215 was used by NDTM in all the LGA. Individually Funakaye leads with 421 units for DTMA and 301 in the same Funakaye and Kwami. The LGA that recorded lowest labour was Shongom with 132 units by DTMA while Kaltungo had the least in NDTM with 129 units.

Table 4. 113 : Average family and hired labour used per LGA

	Hired labour		Family labour		Total labour per hectare	
LGA	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Akko	290.09	132.83	3.8	97.24	293.89	230.07
Billiri	254.23	-	46.33	-	300.56	-
Funakaye	274.27	182.61	147.2	118.61	421.47	301.22
Kaltungo	-	115.81	-	14.17	-	129.98
Kwami	255.82	257.74	65.6	43.41	321.42	301.15
Shongom	114.94	145.64	16.87	25.52	131.81	171.16
Yamaltu Deba	157.81	85.79	-	70.35	157.81	156.14
Average	224.53	153.4	46.63	61.55	271.16	214.95

Source: Survey 2014

4.2 Technical efficiency and stochastic frontier estimation

This section presents and discusses the results of the estimated stochastic frontier analysis (SFA). A one step process was used to estimate technical efficiency through maximum likelihood method using Frontier 4.1 computer software. There after the estimation of stochastic frontier, fitness test was conducted and found the suitability of extending efficiency comparison by metafrontier (MF) approach. Shazam professional version 9.0 was used for the estimation of metafrontier parameters and Technology gap ratio. Metafrontier was a technique use to compare efficiency when stochastic frontier was insufficient in explaining efficiency difference, due to the existence of hidden difference within the data sets, Ali, Imad and Yusuf, 2012 suggested the use of metafrontier in efficiency analysis under such situation.

Indeed, stochastic frontier can only estimate efficiencies but cannot be used to compare efficiencies between two different observation, but the estimation of metafrontier

efficiency allow for relative comparison of efficiencies across groups having different technology of production or places endowment with a peculiar characteristics. Ignoring this difference will inflate the value of technical efficiency and posing as farmers are technically efficient in their resource allocation. But in actual sense the reverse is the case.

4.2.1 Technical relationship between inputs and output

To examine the technical relationship between inputs and output of maize production in Gombe state. Stochastic frontier analysis estimation of the Cobb–Douglas production function was used to estimate both technical relationship simultaneously. The technical inefficiency effects and also generates the results of efficiency, inefficiency and their respective production parameters as was conducted by (Farrell (1957). The main variables used in the analysis were seed, fertilizer, labour and herbicide using transcendental model. In transcendental production model, each of production variable used was further squared, the interaction between them was also performed, this give the model power more than other models. Land was ignored, since all inputs and output were standardize on per ha bases. For factors influencing efficiency beside the socio-economic factors, institutional, variety, and environment also affect efficiency. Others were soil type and water, all these combined were factors related to location of production. Intuitively, LGA was assumed to capture variation in location (environment) of production.

The single stage estimation process was used as earlier mentioned. The analysis compares variation in the variety (DTMA and NDTM) and the variation on location of

production thus (environment). Hence stochastic frontier analysis parameters were estimated for pooled data sets(for all data regardless of either location if variety was considered, or variety if location was considered) to test plausibility of some assumption when conduct of efficiency studies. The assumptions regarding the estimation of technical efficiency includes: First, any deviation from normal production function is consider as noise. In this case, estimation of efficiency is best suited by the use of ordinary lease squares. The second, consider error to be zero, the available deviation is purely inefficiency. In this case, the use of data envelopment analysis in the form of deterministic efficiency estimation is best suited. The third one, is when deviation is believe to constitute both noise(error) and inefficiency then, stochastic frontier is therefore suited for the estimation.

To determine an appropriate model to use for efficiency analysis, the stochastic frontier is estimated first, since its estimated result will answer many assumption regarding efficiency estimation methods, and will further allow for subsequent analysis or otherwise, the variance parameters provide answers to all the assumption, so far stated earlier on, it also serve to judge the existence of homogeneity or otherwise in the data.

4.2.2 Variance parameters for from estimation of stochastic frontier Analysis

The variance parameters are indicators used to judge the fitness of the stochastic frontier analysis, justify suitability and choice of appropriate estimation model to use for estimating technical efficiency. These parameters include gamma, likelihood ratio (Lambda) and sigma square for error and that of inefficiency. Since stochastic frontier is

believe to capture the two composite error term. The greatest challenge is the separation of noise from the inefficiency. But such challenge is overcome if lambda is properly estimated, where from the total composite error the percentage that is believe to be that of inefficiency can be estimated so as the one that constitute the noise. All depend on the sigma squared for the restricted and that of unrestricted likelihood function. The first stage in test for plausibility of the assumption begins by examining sigma and gamma. Sigma and Gamma are related, if sigma is zero and therefore gamma is also zero in this case ordinary least squares is appropriate because the variance for error dominate that of inefficiency as such no inefficiency effect notice in the datasets. However if the inefficiency effect dominated error term effect then distribution of error is truncated hence indicate the presence of inefficiency, in this case mostly the gamma is very small close to zero positive greater than zero then this implies that deviation from estimation was purely due to random error in this case no inefficiency effect, hence deterministic efficiency estimation is appropriate using DEA(data envelopment analysis), but if gamma is larger therefore difference exist in the data set the data is not only having inefficiency but there exist grouping in the datasets. Therefore estimation of efficiency will be best suited by stochastic frontier for the each identified grouping for the estimation of the parameters of the production function for each separate group to determine efficiency in the production because heterogeneity exist between sample groups.

Table 4.14: shows the result of testing plausible assumptions underlying the estimation of the efficiency score, the first assumption tested was provided by result of likelihood ratio test. The likelihood ratio test compares the values of the likelihood functions of the sum

of the separate group estimations and the pooled data or unrestricted and restricted estimated parameters. In a simple expression, the value of the LRT statistic or called lambda (λ) equals -2{ln[L(H0)] - ln[L(H1)]}; where ln[L(H0)] was the value of the log likelihood function for the stochastic frontier estimated by pooling the data less the sum for all the values of the likelihood functions of the separate groups, or unrestricted less restricted estimated parameters.

The judgment is reached by if the likelihood ratio test rejects the pooled presentation (value lower than the tabulated chi-square value at degree of freedom). This signals that there were technological variance among farms cultivated under different technologies. Similarly, there exist a difference associated with location as such the conventional stochastic frontier is inappropriate. Hence, it is more appealing to estimate the separate stochastic frontier for the observed grouping. Subsiquently run a metafrontier to estimate the efficiency more accurately. But If the likelihood ratio test accepted the pooled presentation. Then it signals that there was no technological variance among farms cultivated under different technologies. As such, stochastic frontier is best suited for pooled and metafrontier will not be estimated because they are already homogenous.

From this study, the result of the variance parameters for the pooled location and pooled variety indicated that lambda value of location was 16.51 and 18.47 for pooled variety which shows that sigma for inefficiency term is dominant over that of normal error term. The gamma value was 0.18 and significant at 5% for location and 0.45 and significant at 5% for variety. This suggest that gamma is low for location but greater than 1 wheras for

variety, the gamma is slightly higher and so this data cannot be assume to contain no inefficiency as such using data envelopment analysis cannot be appropriate for efficiency estimation but rather with stochastic frontier estimation method. The table 4.13 From the result depicted that the group-specific frontiers are not the same. The result shows that 56.98, 46.87 for DTMA and NDTM frontier distributed as mixed chi-square. Similarly the likelihood ratio for location specific frontiers for Akko was 34.03, Funakaye was 40.82 other place include Kwami 87.20, Shongom was 76.68 and Yamaltu Deba was 67.66, Billiri was 22.34 Kaltungo with 19.90, all distributed as mixed chi-square at 14 degree of freedom.

These estimates were found to be statistically significant at 1% level, indicating that the average production frontier cannot be suitable specification for the maize production in the survey area under the current technology. Technical inefficiency effect are not random errors, except in Billiri and Kaltungo that had lower lambda value which implies that the null was rejected. This was not surprising because each of this location has only one category of farmers either DTMA alone or NDTM but other places that have both DTMA and NDTM in the same LGA showed higher values of lambda, implying the existence of heterogeneity in them.

Table 4. 14: Variance parameters of stochastic frontier analysis

Group	Lambda	In-efficiency-Sigma	Error-sigma	Gamma
Akko	36.18131	63.098	0.0482	0.632**
Billiri	28.60853	76.042	0.09291	0.73*
Funakaye	54.57344	89.05	0.0299	0.75**
Kaltungo	36.8994	56.0965	0.0412	0.78*
Kwami	54.37562	94.319	0.0319	0.62***
Shongom	33.63347	794.0192	0.70192	0.55*
Yamaltu Deba	34.27973	282.024	0.24	0.631**
DTMA	90.86334	49.702	0.00602	0.84***
NDTM	38.62781	45.0169	0.03017	0.45**
Pooled location	16.50969	22.0509	0.0809	0.18**
Pooled Varietal	18.47102	29.0309	0.08509	0.45**

Source: Survey 2014 * Significant at 10% ** Significant at 5% **** Significant at 1%

Therefore based on the result presented in Table 4.15, maize producers in the areas are not operating on the technically efficient frontier was accepted. The second assumption, the lambda values were 90.86, for DTMA and 38.62 for NDTM, on location specific frontier Akko has 36.18, Billiri 32.15, Funakaye 54.57, Kaltungo 36.90, Kwami 54.36 others are Shongom 33.63 and Yamaltu Deba 90.86. Similarly the estimated values of lambda are found to be statistically significant at 1% at 14 degree of freedom as well. From the result it clearly shows that inefficiency effects exist, therefore the assumption which said that socio-economic characteristics of maize farmers have no effect on technical inefficiency was rejected for both under DTMA and NDTM as well as location specific technologies. This is consistent with the work Wang and Hockmann (2012) on producer induced technologies but contradict the work of Battese and Coelli (1993) . Never the less, for the third postulation, the values of lambda was 16.51 for pooled location specific frontiers and 18.47 for pooled varietal specific frontiers. The result was

found to be statistically significant at 1% at 14 degree of freedom, implying that the stochastic frontier pooled base on location as well as that pooled by variety are not same hence depict heterogeneity in the data set as such since the data are not the same the estimation cannot use pooled data in both cases so assumption poolability of stochastic efficiency estimation is not appropriate is rejected, the pooled data cannot be use for the estimation. This finding supported the work of O'Donnell, Prasada and Battese,(2008).

Therefore from the result of variance parameters seen above it is better to use the estimated stochastic frontier for the group specific. But it is still in line to see the result of the estimated parameters of production frontier estimated under both pooled and separated groups. From the result number of variables that were significant in both efficiency and inefficiency serve as a pointer for the fitness and existence of heterogeneity in sampled data especially if pooled sample result was compared. In this work most of the variables determining inefficiencies and efficiency are also statistically not significant when the data were pooled, but some tend to change when the data were estimated on group basis, beside gamma and lambda, the log likelihood function and likelihood ratio test also was used to determine the heterogeneity in the dataset.

Table 4. 15 : Test of hypothesis guiding efficiency estimation

Test of Assumptions Guiding efficiency Estimation	LR test	Degree of Freedom	x^2	Decision
Akko				
$H_0: \gamma \neq 0$	34.03	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	36.18	14	29.14	Rejected H_o
Billiri				
$H_0: \gamma \neq 0$	22.34	14	29.14	Rejected H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	32.15	14	29.14	Rejected H_o
Funakaye				
$H_0: \gamma \neq 0$	40.82	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	54.57	14	29.14	Rejected H_o
Kaltungo				
$H_0: \gamma \neq 0$	19.90	14	29.14	Rejected H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	36.90	14	29.14	Rejected H_o
Kwami				
$H_0: \gamma \neq 0$	87.20	14	29.14	Accepted
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	54.36	14	29.14	Rejected H_o
Shongom				
$H_0: \gamma \neq 0$	76.68	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	33.63	14	29.14	Rejected H_o
Yamaltu Deba				
$H_0: \gamma \neq 0$	67.66	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	34.28	14	29.14	Rejected H_o
Drought Tolerant				
$H_0: \gamma \neq 0$	56.98	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	90.86	14	29.14	Rejected H_o
Non Drought Tolerant				
$H_0: \gamma \neq 0$	46.87	14	29.14	Accepted H_o
$H_0: u = \delta_1 = \delta_2 = \ldots\ldots \delta_{10} = 0$	38.62	14	29.14	Rejected H_o
Pooled location				
$H_0: \gamma \neq \beta_{k1} \neq \beta_{k2} \neq \ldots\ldots \beta_{k7} = 0$	16.51	14	29.14	Accepted H_o
Pooled Varietal				
$H_0: \gamma \neq \beta_{k1} \neq \beta_{k2} \neq \ldots\ldots \beta_{k2} = 0$	18.47	14	29.14	Accepted H_o

Survey , 2014

4.2.3 Efficiency estimate based on maize variety cultivated

Table 4.16 showed the results of the stochastic frontier model with different functional forms. The mean technical efficiency was computed for each model. The estimate

parameters for the transcendental function in different LGA and for the two maize varieties were used. DTMA, NDTM and pooled datasets were presented in the table 4.16. The transcendental production function was used in this study to estimate stochastic frontier production function and technical efficiency of farmers because of its advantage. It captures the three stages of production. Many efficiency analysis use the model because of the advantage it has, Wang and Hockmann (2012).

The result, of the estimated stochastic frontier model presented in table 4.15; the parameters for stochastic frontier in the DTMA group shows that out of the 15 variables used seven (7) were significant at 1% while only one (1) was significant at 5% four (4) variable was significant at 10%, but three(3) variables were not significant at all. The variables that were significant at 1% are intercept, Seed, labour, fertilizer, herbicide, labour square, seed-labour interaction, labour- herbicide interaction, whereas the variables that was significant at 5% include labour square. Never the less, on the NDTM side, out of the fifteen (15) variables ten (10) are significant at 1%, one (1) was significant at 5% and three (3) are not significant. From the result, it was clearly shown that more than 80% of the estimated parameters wer significant in both DTMA and NDTM. As for the sign of the variables parameters seed, herbicide, fertilizer square, herbicide square, seed-labour interaction and labour-herbicide interaction were all negative, implying a unit increase each of them result in decrease in yield by value of co-efficient in DTMA while for NDTM only (6) herbicide, fertilizer square, herbicide square, seed-labour, seed-fertilizer, labour-herbicide, fertilizer-herbicide had a negative

sign of the co-efficient, meaning that a unit increase in each of them imply reduction in the yield by proportionate value each parameter co-efficient.

Table 4. 16: Stochastic and Metafrontier co-efficient for the Drought and Non-Drought Tolerant Maize in Gombe state

	DTMA			NDTM			Meta-frontier
Variables	co-efficient	SE	t-value	co-efficient	S.E	t-value	co-eff
Intercept	24.182	4.23	5.7168***	6.138	2.788	2.201***	0.517
Seed	-3.567	0.899	-3.968***	0.161	0.039	4.12821***	0.386
Labour	2.064	0.829	2.4897***	0.279	0.083	3.36145***	0.469
Fertilizer	2.155	0.799	2.6971***	1.315	0.377	3.48806***	-0.696
Herbicide	-3.687	0.982	-3.755***	-0.802	0.996	-0.8052 NS	0.554
Seed2	0.402	0.244	1.6475*	0.37	0.126	2.93651***	0.146
Labour2	0.714	0.309	2.3107**	0.21	0.051	4.11765***	0.357
Fertilizer2	-0.056	0.183	-0.306 NS	-0.898	0.45	-1.99556*	0.975
Herbicide2	-0.76	0.871	-0.873 NS	-0.761	0.399	-1.90727*	-0.112
Seed*Lab	-0.053	0.016	-3.313***	-0.27	0.052	-5.1923***	-0.335
Seed*Fert	-0.633	0.329	-1.924*	-0.896	0.139	-6.4460***	-0.653
Seed*Herb	0.33	0.198	1.6667*	0.304	0.097	3.13402***	0.13
Lab*Fert	0.652	0.478	1.364 NS	0.997	0.382	2.60995***	0.333
Lab*Herb	-0.086	0.037	-2.324***	-0.186	0.253	-0.7352NS	-0.637
Fert*Her	0.445	0.245	1.8163*	-0.191	0.137	-1.3942 NS	0.758

Survey, 2014 NB: P<0.05

The parameter co-efficient metafrontier after each farmer category was analyzed separately and they were compared. It was found that the number of significant variables increased only two (2) variables were not significant, implying 86.7% of the variables were significant. The remaining thirteen (13) were all significant, which was an indication of existence of classes in the pooled since when the pooled sample was used, only six variables were significant. However, estimating stochastic frontier on the

segregated form shows that in DTMA category only three (3) variables were not significant, so also, in the NDTM category contrary to using pooled sample, the number of variable that were significant decreases as can be seen in the table 4.16 above.

4.2.4 Stochastic frontier estimate base on location of production

When each local government area were segregated and stochastic frontier was estimated individually, the co-efficient for stochastic frontier were observed as follows; fifteen (15) variables including intercept were reported in table 4.17, out of the fifteen (15) variables, eight (8) and two (2) variables were significant at1% and 5% respectively in Akko, while five (5) variables were not significant. But in Billiri, five (5) variables were significant at 1% . All the remaining were not significant. In Funakaye, all the fifteen (15) variables were significant at 1 and 5% , in Kaltungo, only five (5) variables were not significant the remaining ten (10) were all significant, In Kwami, nine (9) out of the fifteen are significant six (6) are not, while in Shongom, eleven (11) variables were significant, four (4) were not, similarly in Yamaltu Deba, nine (9) out of fifteen variables were significant, but when the pooled sample were used only six (6) variables were significant. Intuitively, from the table of the estimated co- efficient of Stochastic frontier analysis, out of the 15 Variables 66.7% of them were statistically significant at different confidence level in Akko. Whereas, Billiri, Funakaye, Kaltungo, Kwami, Shongom, Yamaltu Deba had 33.3%, 100%, 66.7%, 60%, 73.3%,60% respectively.

However, when the data were pooled together number of variables that was statistically significant was lower than when they were estimated separately in pooled dataset. Only

40% of the variables were statistically significant but after they were separately estimated, table 4.18 showed the meta frontier result estimated for the locations. The number of statistically significant variables increases for metafrontier. Almost 80% of the variables were statistically significant. From this result, it was concluded that the pooled datasets are not homogenous but rather a heterogeneous one. The implication here was, variation in number of significant variables on efficiency estimates was associated with heterogeneity in datasets. This was supported by the work of Wang and Hockmann (2012), Wongchai and Liu (2012). Therefore disregarding the heterogeinity in the dataset might likely mislead conclusion in farmers level of efficiency. By pooling the data, important variation in the dataset might likely be buried. However, when they were estimated separately, then the variation within each sample will surely be expressed so when metafrontier was applied. The individual differences within each sample remains but yet provide a more reliable basis for their comparism. That was why stochastic frontier analysis do not provide a good estimated result for the pooled sample because some classification were buried in the dataset, this was clearly depicted when each of the LGA were estimated separately the estimates demonstrate a better fit with many significant variables compared to the stochastic frontier estimates.

Generally, if a variable was observed not to be significant, it was expected that such variable contributed less in the efficiency or yield, whereas if a variable was significant then its contribution was considered important, therefore removing might inflate the result downwards or upwards, depending on the degree of importance and confidence exhibited by the variable through it p-value or t-value.

Table 4. **17**: Stochastic frontie analysis co-efficient in different LGA in Gombe state

	Akko		Billiri		Funakaye		Kaltungo		Kwami		Shongom		Yamaltu Deba	
Variables	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er
Intercept	1.458	1.01	3.007	0.963***	1.768	1.0*	0.733	0.436*	1.478	0.388***	0.728	0.349**	3.692	1.348***
Seed	0.776	0.367**	-1.465	0.288***	1.798	1.006*	-2.141	0.998**	3.586	0.992***	2.642	0.992***	-1.683	0.5***
Labour	-0.169	0.04***	0.281	0.203	2.906	1.011***	2.681	0.996***	2.173	0.986**	3.028	0.991***	1.171	0.5**
Fertilizer	1.428	0.332***	2.261	0.759***	-5.304	1.012***	2.209	0.995**	2.359	0.984***	-0.916	0.992	1.787	1.01*
Herbicide	-0.901	0.999	0.064	0.972	-1.936	1.001**	-2.003	1.10**	-0.529	0.3	2.044	0.997**	5.115	1.01***
Seed-square	0.833	0.39**	0.516	0.459	0.949	0.165***	3.089	1.375**	0.719	0.304**	0.141	0.408	2.355	0.84***
Labo-square	0.094	0.016***	0.102	0.109	0.099	0.016***	1.022	0.131***	0.907	0.674	1.006	0.288***	0.139	0.041***
Ferti- square	0.057	0.009***	0.607	0.684	1.906	0.943**	0.016	0.102	-0.095	0.093	2.023	0.934**	-0.013	0.009
Herb-square	-0.537	0.995	0.458	0.098***	0.92	0.2***	-0.082	1.01	-1.021	0.996	1.06	0.927	0.458	0.999
Seed*Labour	-0.342	0.07***	0.407	0.161***	-0.463	0.095***	2.05	0.871**	-2.028	0.756***	1.063	0.137***	1.098	0.322***
Seed*Fertiliz	0.317	0.058***	0.0001	0.001	-0.14	0.017***	1.038	1.093	-0.007	0.082	-0.015	0.029	0.173	0.162
Seed*Herbic	0.859	0.937	-0.012	0.07	0.891	0.382**	2.326	1.011**	-0.013	0.918	3.633	0.904***	-0.172	0.986
Lab*Fertili	-0.055	0.031*	0.0001	0.001	0.008	0.004**	-0.037	0.106	0.424	0.163***	0.47	0.161***	0.001	0.027
Lab*Herbici	-0.722	0.845	-0.003	0.021	-0.623	0.273**	-0.101	0.922	-3.019	0.632***	2.051	0.212***	1.087	0.811
Ferti*Herbic	0.779	0.472*	0.003	0.006	2.116	1.139*	2.118	0.779***	0.728	0.52	1.107	0.626*	2.019	0.594***

Source: Survey 2014 P<0.05

Table 4. 18 Metafrontier co-efficient Gombe state

Variables	Metafrontier co-efficient
Intercept	0.236
Seed	-1.214
Labour	0.453
Fertilizer	0.891
Herbicide	0.945
Seed-square	0.516
Labo-square	0.605
Ferti- square	-1.854
Herb-square	-0.819
Seed*Labour	0.448
Seed*Fertilizer	0.347
Seed*Herbicide	1.235
Lab*Fertilizer	0.413
Lab*Herbicide	0.435
Ferti*Herbicide	-0.225

4.2.5 Determinant of technical inefficiency in Maize production in Gombe state

Determinants of inefficiency parameters were together estimated using one stage stochastic frontier analysis estimation. In the stochastic frontier analysis not only the parameters co-efficient technical efficiency are present but including those factors that influence in-efficiency in maize production, from the result in table 4.19 commulatively the estimated in-efficiency parameter co-efficient for DTMA revealed that 67% of the variables include in the model were statistically significant. While for NDTM the out of the fifteen variables included 53% were Significant.

Indeed, for the pooled sample used, out of the fifteen variables only 33% of the variables are statistically significant. Specifically the seven (7) variables that were significant in the DTMA include relative household size, number of crop grown by the farmer, total firm

size excluding area for maize, extension contact, farms size for maize, number of years growing maize, this is contary to the findings of Rahman and Haque (2008) location (LGA) and the type of maize grown were significantly found to affect farmers inefficiency, land ownership, membership of farmer association, amount of access , amount paid for land rent all were not significantly affecting efficiency among DTMA farmers in Gombe state.

However, for NDTM education, membership of association, number of extension contact, amount of credit accessed, years in maize farming, variety of maize cultivated all significantly affect farmers efficiency the finding is consistent with findings of Rahman and Haque (2008) other variables that do not significantly affect efficiency include age, relative household size, number of crops grown, total farm size excluding maize, nonfarm activities engage, land rent and location (LGA). None the less, in the Pooled dataset, eight (8) variables were found to significantly affect efficiency while seven (7) were not significant. Generally from the result, the number of variables that are significant is less compared to when metafrontier was estimated, after the estimation of metafrontier the number of variables that were significant improves this was because of the heterogeneity in the dataset, this is supported by Wang, and Hockmann, (2012), Wongchai,. and Iiu, (2012). In metafrontier estimate all variable are positive and significant except household size, total farm size excluding maize area, nonfarm activities and land rent were not significant. This suggest that their inclusion in the metafrontier estimate of technical efficiency is not worthwhile. Wang, and Hockmann, (2012), Wongchai,. and Iiu, (2012).

Never the less when metafrontier was estimated the significant in the parameters co-efficient improve to 73 %. It was interesting to note that inefficiency model provide results that require government intervention. The negative and significant value for DTMA and NDTM for education reveals that as education level changes inefficiency decrease this implies that with more extension farmers inefficiency can be minimized this was consistent with Kumbakhar, Ghosh and McGuckin (1991), Parikh *et al.,* (1995) who found that education decreased inefficiency while Rahman and Haque (2008), showed that inefficiency was greater for educated farmers. While farm sizes was inversely related to inefficiency in DTMA but Positively related in NDTM with inefficiency although both are significant moreso extension contact was positively related with inefficiency in DTMA but negatively related in NDTM though both are significant although the findings from the survey contradict the work of Ephraim, (2007).

Table 4. 19: Determinants of technical inefficiency Parameters on variety.

	DTMA		NDTM	
Variables	coeff	Std Error	coeff	Std Error
Age	-0.05	1.000	-0.100	1.000
Education	0.12	1.001	-0.192	0.100*
House Hold Size	-0.03	0.247	-0.488	0.826
Land Ownership	-2.48	0.998***	0.190	1.000
Number Crop Grown	-0.06	0.997	-0.373	0.199*
Membership	0.82	0.370**	-0.970	0.578*
Total Farm Size Without Maize	-0.92	0.542*	0.059	0.929
Non Farm Act.	-0.85	0.399**	0.146	0.999
Extension Cont	-0.32	0.911	0.966	0.399***
Maize Farm size	0.93	0.400**	-0.774	1.000
Credit Accessed	0.32	0.133**	0.720	0.227***
Land Rent	0.26	0.085***	-0.270	1.997
Experience	-0.89	0.285***	-0.746	3.000
LGA	0.26	0.090***	-0.380	-0.35
Cultivated	-0.89	0.29***	-0.75	0.3***

Survey, 2014 $P<0.05$

Similarly table 4.20 looked at determinant technical inefficiency for pooled sample, the proportion of variables that were found to significantly affect efficiency was 56% at different confidence level. However segregating each LGA, 94% of Parameters determining inefficiency in Akko were found to be significantly affect efficiency, 75% in Billiri, 81% in Funakaye, 56% in Kaltungo, 68.8% in Shongom, while 81% in Yamaltu Deba. The result obtrain after segregation seems contrary to what was experience in pooled sample because the number of variable that were significant are more in segregated sample than in pooled sample this suggest the heterogenity in the pooled sample. None the less, when Metafrontier was estimated to the same variables the number of statistically significant variables improve where up to 75% were statistically significant This is consistent with the work of Wang, and Hockmann, (2012), Wongchai,. and Iiu, (2012) but contradict the work of Hung-Hung, (2004).

The results further shows that education was significant and positive in Akko, Shongom and Yamaltu Deba areas that were significant but negative include Billiri, Funakaye, Kaltungo and Kwami. While LGA was all significant except Shongom, variation in LGA specifically shows that Funakaye and Yamaltu Deba are significant and Positive, but Akko, Billiri Kaltungo Kwami was significant but negative.From the result those variables that are positive implies that they decrease efficiency by respective magnitude of the parameters while the negetive sign implies increasing the efficiency by the respective magnitude.

Table 4.20: Determinants of Technical inefficiency for stochastic frontier base on LGA

	Akko		Billiri		Funakaye		Kaltungo		Kwami		Shongom		Yamaltu Deba	
Variables	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er	co-ef	std.-er
Age	0.72	1.01	0.001	0.99	-0.59	0.3*	1.51	1.01	-0.26	0.13*	-1.21	0.39***	-0.84	0.24***
Education	-0.95	0.37***	0.02	0.96	-0.92	0.3***	-0.35	1.101	0.68	0.12***	-0.01	1.01	8.01	4.0**
Household size	-0.66	0.31**	0.54	0.8	-0.97	0.11***	-0.28	2.58	-0.79	0.32***	2.11	0.92**	3.24	0.51***
Land Ownership	0.81	0.5	2.46	1.01***	0.73	0.44*	-2.58	1.01***	-0.91	0.5*	-1.11	1.01	3.33	1.1***
Number of C. Grown	0.94	0.5*	-1.86	0.92**	-0.96	0.33***	0.01	1.1	-0.91	0.4**	4.06	0.85***	0.83	0.23***
Membership	0.22	0.03***	-2.07	0.47***	-0.51	0.12***	-2.33	1.46	-0.21	0.2	2.27	1.31*	2.51	0.99***
Far Size Exc. Maize	-0.99	0.2***	-0.3	0.05***	-1.24	0.51***	2.75	1.03***	-0.65	0.64	2.03	0.52***	-2.63	0.96***
Non-Farm Activities	0.46	1.1	0.49	0.3*	1.01	1.01	-3.4	1.01***	0.25	0.1***	2.09	0.77***	1.11	0.35***
Extension Cont	0.89	0.4**	0.5	0.29*	-1.83	0.87**	-1.13	1	-0.85	0.5*	-0.2	1.11	0.05	1.01
Maize F Size	0.81	0.4**	-0.75	0.3***	-1.72	0.98*	-3.63	1.79**	-0.15	0.88	-0.09	0.79	0	1.01
Credit Accessed	0.8	0.18***	0.34	0.05***	-0.02	0.01***	-9.53	6.02	0.79	0.13***	3.01	0.85***	1.15	0.63*
Land Rent	-0.53	0.99	-0.93	0.48*	1	0.27***	-3.9	1.01***	-0.2	0.1**	2.23	1.72	2.03	1.00**
Experience	0.53	1	0.99	0.41***	-0.56	0.38	4.02	1.01***	-0.46	0.2**	3.07	0.82***	-0.02	0.99
LGA	-0.63	0.39	-0.93	0.48*	1	0.27***	-3.9	1.01***	-0.2	0.1**	2.23	1.72	2.03	1.00**
Cultivated	0.53	0.32*	0.99	0.41***	-0.56	0.28**	4.02	1.00***	-0.46	0.2**	3.07	0.82***	-0.02	0.99

Survey, 2014 P<0.05

4.3 Mean technical efficiency

As stated earlier, technical efficiency of the ith farm was calculated from the following. $TE = exp^{-u_i}$ *100 (TE was converted into a percent by multiplying this equation by 100) Technical efficiency was calculated using the conditional expectation of the above equation, by assuming the existence of composed error term ($e_i{}^{v_i - u_i}$). The word Composite error term means the error term comprises both inefficiency resulting from farmer practice or environment and the random error associated with distribution of each variable..

The mean technical efficiency across the survey areas were found to be as follows: The LGA with least technical efficiency was Yamaltu Deba with a mean technical efficiency of 0.822 for the DTMA group. This mean that about 18% is loss to inefficiency, indeed the data spread widely. The spread was found to be 0.231, minimum score was 0.167 and maximum score was 0.969, whereas the Standard error was 0.036, for the DTMA farmers. On the NDTM group Akko has the least technical efficiency Score with 0.746. Similarly, the standard deviation was 0.197, the minimum score was 0.364 and maximum technical efficiency was 0.969, with a standard error of 0.034. The LGAS that follows in DTMA group were Shongom and Billiri with mean technical efficiency of 0.824 each. Though both LGA has same mean technical efficiency but vary interms of their standard deviation and other Parameters. Shongom has 0235, Billiri has 0.197 standard deviation, while Shongom has minimum score of 0.265, Billiri has 0.365 on maximum score. Shongom has 0.968 whereas, Billiri has 0.969. Standard error for Shongom was 0.061, while Billiri has 0.034. The findings was consistent with the findings of Binam,

Gockowski and Nkamleu, (2008) that two different places might have same technical efficiency but diffirent standard error and standard deviation, cause due to the distribution of the data sets.

None the less, on the DTMA group, similar trend was identified to the LGAS that has the highest score, as it was reported in table 4.21. Funakaye and Kwami has slightly similar mean technical efficiency 0.868 and 0.856, meaning 14% is loss to inefficiency similarly they have same mean technical efficiency but different other parameters their standard deviation were 0.194 for Funakaye, 0.213 for Kwami, minimum score of 0.260 for Funakaye, 0.262 for Kwami. While the maximum of 0.969 and 0.968 standard error was 0.034 for Funakaye, 0.045 for Kwami. Billiri and Shongom are close and have similar environmental features while Funakaye and Kwami was also near each other. They share common environmental features, as such, it is not out of place for them having same mean. This is a clear indication of similarity and variability of the environmental features. The result was also consistent with the findings of Rungsuriwiboon and Xianbing (2007) in their work on recent evidence on agricultural efficiency and productivity in China.

Table 4.21: Estimated mean resource use efficiency score for Stochastic frontier analysis

Parameters	PLD	*Akko*		*Billiri*		*Funakaye*		*Kaltungo*		*Kwami*		*Shongom*		*Yamaltu Deba*	
		DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Sample	370	44	20	33	No Sample Collected	33	46	No Sample Collected	41	22	15	15	20	41	40
Mean	0.838	0.856	0.746	0.824		0.868	0.799		0.830	0.868	0.844	0.824	0.839	0.822	0.908
Stand. Dev.	0.218	0.209	0.297	0.197		0.194	0.272		0.221	0.213	0.180	0.235	0.231	0.231	0.111
Variance	0.048	0.044	0.088	0.039		0.038	0.074		0.049	0.045	0.033	0.055	0.053	0.053	0.012
Min.	0.154	0.263	0.154	0.364		0.260	0.157		0.258	0.262	0.459	0.265	0.258	0.167	0.557
Max.	0.969	0.968	0.960	0.969		0.969	0.964		0.962	0.968	0.959	0.968	0.963	0.969	0.963
Stand. Err	0.011	0.032	0.066	0.034		0.034	0.040		0.034	0.045	0.047	0.061	0.052	0.036	0.018

Source: Survey, 2014

Generally earlier production efficiency focuses on the estimation of technical efficiency by assuming technologies that were similar across farms and similar between varieties. But later it was discovered that the assumption was misleading as such a more flexible approach to efficiency analysis was presented and term as metafrontier. Metafrontier was flexible that can accommodate the possibility of heterogeneity in production technology caused by differences in variety and or location of production or environmental factors. The metafrontier have been introduced to facilitate comparisons of performance of farms using different technologies, products, heterogeneous in nature or regions. Therefore estimating efficiency with heterogeneous data set often result in misleading efficiency score hence this study after examining the number at the number of variables parameters that were not significant in the Pooled data set imply the existence of heterogeneity in the dataset, this prove that technical efficiency in the pooled dataset present a misleading result (Greene, 2005).

Consequently, to escape from the problems stated earlier, a more appealing method of estimating technical efficiency for each category of indices for variation (in this study variety and or location) Linear programming was used to compare and estimate the efficiency by this way the heterogeneity was maintained while at the same time achieve more acceptable efficiency score. The concept of metafrontier evolves for the purpose of studying differences in productivity across different regions and groupings.

This argument seems true and indisputable when refer to some assessment made where pooled data masked the actual segregated observations in the descriptive section 4.1.1.5 and 4.1.1.6 in tables 4.5 and 4.6. The metafrontier represents the overall state of

knowledge that was only partially revealed by the frontiers from different regions. Since efficiency in a region (or a in a sub-group) was assessed against its own frontier. The Meta-production function concept was based on the hypothesis that all producers in different units/group or location have potential access to the same technology. However, each producer may choose to operate on a different part of it depending on circumstances such as natural endowments, relative prices of inputs, and the economic environment. Therefore violation of this assumption will biased estimation of technical efficiency of farmers. As such a more realistic approach is provided, thus metafrontier approach (Rungsuriyawiboon and Xianobing, 2007).

4.3.1 Mean technical efficiency score

The study further attempt to classify the metfrontier score into five classes and found that, thus DTMA and NDTM as well as the pooled sample. in table 4.22 and 4.23 reported for the pooled data, DTMA and NDTM, the highest falls within the class with 26% of the farmers falls within metfrontier score of 0.4501- 0.6000. indicating an optimum technical efficiency for the two varieties, 25% of the farmers falls in the 0.6001-0.7500 then 13% of the farmers falls to the class 0.9001-1.0000 which a high efficiency level. The lowest proportion of farmers ie 0.3% of farmers falling under the class 0.0000-0.1500. However for the DTMA mean technical efficiency for DTMA farmers shows that 62.2% of the farmers falls between 0.7501-0.9000 followed by 13.3% of the farmers that falls in the class of 0.9001-1.0000. For the NDTM, 50% of the farmers had the highest score that fall under technical efficiency class of 0.3001-0.4500, then 31%, of the farmers falls in the of class 0.1501-0.3000, the lowest was 0.0% in class 0.0000-0.1500.

Table 4.22 : Estimated efficiency score on maize variety cultivated by farmers

Efficiency Score	DTMA	NDTM	Pooled
0.0000 - 0.150	0.5	0.0	2.7
0.1501 - 0.300	2.1	30.8	5.4
0.3001 - 0.450	5.9	50.0	2.79
0.4501 - 0.600	8.0	13.7	43.2
0.6001 - 0.750	8.0	1.6	37.8
0.7501 - 0.900	62.2	2.8	5.4
0.9001 - 1.000	13.3	1.0	2.7
Total	100.0	100.0	100.0

The technical efficiency for the pooled data shows that, 26% falls to the range 0.4501-0.6000, 26% falls to the class 0.6001-0.7500 efficiency, followed by the class 0.7501-0.9000 with 25%, class of 0.9001-1.000 with 12%, 10% for the class 0.3001-0.4500, followed by 1% for class 0.1501-0.3000 and the least was 0.5% for class 0.0000-0.1500. The technical efficiency for Akko farmers 43.2%, of the them fall under the class of 0.4501-0.6000 technology efficiency as the highest frequency followed by 37.8% for those in a frequncy class of 0.6001-0.7500 technical efficiency, the least recorded class was those having 2.7%. they fall under a class of 0.9001-1.0000 technical efficiency. Generally the distribution for Akko seems to have a normal distribution.

Technical efficiency for Funakaye from the figure the distribution was negatively skewed which implies that many farmers had lower technical efficiency because about 34.2% and 18% of them falls under the class of 0.1501 - 0.3000 and 0.000 - 0.15000 respectively when summed up it became almost upto 52.2% of the total respondent are within these two class the remaining 47.8% are distributed within the other 5 classes.

The distribution of technical efficiency for Kaltungo was shown on table in table 4.20 that 63.4%, of the farmers fall in technical efficiency class of 0.3001 - 0.4500. Although the distribution is shown to be normal distribution technical efficiency for Kaltungo with bell shaped but it is generally low. Similarly the technical efficiency for Shongom was shown in in table 4.19 it 23% and 23% of the farmers are in the class of 0.1501 – 0.3000 and 0.3001 – 0.4500 technical efficiency, the highest proportion of the farmer about 31.4% are in the class of technical efficiency of 0.4501- 0.6000. But Technical efficiency for Yamaltu Deba. 3.7% of the farmers have technical efficiency between 0.1501 – 0.3000, 18.5 are in technical efficiency between 0.3001 - 0.4500 then 19.8 of the farmers had technical efficiency between 0.4501 – 0.6000, while 39.5% of the farmers had technical efficiency of 0.6001 – 0.7500 then drops to 17.3% for those between 0.7501 - 0.9000.

Table 4.23: Estimated efficiency score for all LGA

Efficiency Score	Akko	Billiri	Funakaye	Kaltungo	Kwami	Shongom	YDeba	Pooled
0.0000 - 0.1500	2.7	3.0	19	2.4	2.7	0.0	0.0	0.5
0.1501 - 0.3000	5.4	3.0	34.2	7.3	10.8	22.8	3.7	1.2
0.3001- 0.4500	2.7	12.2	19	63.4	8.2	22.9	18.5	9.7
0.4501 - 0.6000	43.2	27.3	11.4	17.2	13.5	31.4	21	26.2
0.6001- 0.7500	37.8	27.3	5.1	2.4	27	22.9	39.5	25.7
0.7501- 0.9000	5.5	24.2	8.8	4.9	37.8	0.0	17.3	25.1
0.9001 - 1.000	2.7	3.0	2.5	2.4	0.0	0.0	0.0	11.6
Total	100	100	100	100	100	100	100	100

4.3.2 Hypothesis one: Farmers efficiency level have no significant relationship with the maize variety produced by the farmers in the study area

This study had hypothesis that, there is no significant relationship between farmer's efficiency level and maize variety produced by the farmers in the study area. Therefore, after study the hypothesis was tested, from the result obtained, relationship was found to exist between variety of maize produced by farmers and their efficiency scores as was reported in table 4.24. The indicator for the existance of this relationship was presented by the Pseudo R-Square which was found to be 0.857 and was significant at 1%. This implies that variation in variety produced is directly related to metafrontier efficiency but inversely related to stochastic frontier efficiency.

This means that, the model illustrated that 86% of the variation was explained by the two variables included. The likelihood rate increases in metafrontier efficiency from NDTM to DTMA by 1.70, while that for stochastic frontier decreases by 1.40. More so the likelihood of varying location decreases by 0.09. The rationale for having abnormal sign in stochastic frontier is because of the heterogeneity in data pooled data used to estimate stochastic frontier hence cannot predict accurately but when the data were segregated for different location the correct sign were observe as was represented in table 4.21 in metafrontier score. Therefore, estimating efficiency with stochastic frontier in heterogeneous data is likely to provide a misleading inference. This is consistent with finding of Schure and Wagenvoort (1999).

From the test of relationship the likelihood ratio (LR) result which usually represent calculated chi square shows that LR for the analysis was 439.71 greater than Chi Square tabulated value which was 11.34 this implies that the null hypothesis stating that no significant relationship exist between farmers efficiency and maize variety produce was rejected.

Table 4. 24: Result of test in the resource use efficiency difference within and between communities producing the two maize varieties in the state

Variety	Co-efficient	Std. Err.	t-value	Decision
Metafrontier efficiency score	1.698	0.246	6.9***	Null is
Stochastic frontier Analysis	-1.373	0.195	-7.03***	Rejected
Location	-0.088	0.175	-0.5NS	
Intercept	1.882	0.255	7.37***	
Pseudo R2	0.857***			
LR chi2(3)	439.71			
Chi -square Critical at 1% , df(3)	11.34			

4.4 Cost and Return Analysis in Maize Production in Gombe state

4.4.1 Gross margin estimation

The analysis of gross income was carried out, to determine the level of profits for maize production in Gombe state. The gross income approach was adopted, because, the study considers only one production cycle. Never the less, most of the survey farmers are small scale farmers, who use limited or no machineries and therefore the depreciation of their local tools is very insignificant as to affect the cost and return for production. The study examines cost and returned across different communities as well as across two maize varieties use, thus the DTMA and NDTM thereby exploring two ways variability analysis.

The study, examined the cost and return for the production of maize, across farmers of the two maize varieties, it was revealed that, the major cost items for maize production are fertilizer cost. Fertilizer cost constitute 44% of the total cost of maize production by DTMA farmers whereas the same inputs take 29% for NDTM. Seed cost take 14% of the total cost of maize in DTMA while 16% in NDTM. Labour cost constitute 35% of DTMA and 52% for the NDTM group. This revealed that NDTM used labour intensive technology than the DTMA counterpart, this can be justified from the herbicide used by both group. The cost of herbicide by DTMA was 7% of the total cost while 2% was seen in NDTM total cost, this explained limited use of herbicide by this group.

4.4.2 Seed cost across the communities

As shown from Table 4.25 the average cost of seed for DTMA was ₦6592 while for NDTM was ₦5482. The cost of seed across the LGA shows that the seed cost highest for DTMA per hectare in Funakaye at ₦7531, the lowest for same maize variety was recorded as ₦5861 in Yamaltu Deba. NDTM maize recorded the highest seed cost in Funakaye with a value of ₦6478 per hectare, and the lowest was witnessed as ₦4590 in Akko. By way of comparing the seed cost, DTMA maize was more costly than the NDTM probably due to the fact that, DTMA maize has to undergo series of processes before reaching the hands of the farmer which was a process for value addition. While in most cases the NDTM was obtained from previous harvest or taken from the one to be consumption at home.

4.4.3 Fertilizer cost across the communities

The average cost of fertilizer for DTMA was ₦21,750 while that of NDTM was ₦9,714 Table 4.22 presented the fertilizer cost across the survey LGAs. The DTMA recorded ₦31,943 in Kwami as the highest recorded cost for fertilizer and the lowest price for same variety was ₦12,925 in Funakaye. For NDTM, highest price for fertilizer per hectare was recorded in Shongom as ₦11,064 and the lowest was ₦8,809 in Funakaye. By implication it means that DTMA farmers supply more fertilizer than NDTM.

4.4.4 Labour cost across the communities

The average cost of labour for DTMA was found to be ₦17,347 per ha while that of NDTM was ₦17,336 nearly the same but marginal difference, figure 4.1 depict the cost of labour across the LGAs. DTMA farmers had the highest cost for labour at about ₦18,158 in Kwami and for NDTM was ₦19,345 in Shongom, for the least labour cost for DTMA was recorded at ₦16,458 in Shongom and NDTM as ₦15,675 for Yamaltu Deba.

4.4.5 Herbicide cost across the communities

Average herbicide cost for DTMA was ₦3,259 for DTMA while for NDTM the cost was very low at N802. DTMA maize farmers spend much on herbicide than NDTM. Herbicide cost across the LGAs shows that DTMA maize spend ₦3,735 as the highest for herbicide cost, in Kwami and ₦2,992 as the lowest recorded for Shongom. The highest cost for NDTM maize was ₦1,155 (Shongom) and the lowest was ₦664 Kaltungo.

4.4.6 Total cost

The average total cost for maize production by DTMA farmers was reported in Table 4.22 and was found to be ₦48,950 while for the NDTM cost ₦33,334. The figure summaries the average total cost for each inputs used in maize production across the survey LGAs for both the DTMA and NDTM. In an elaborate form Maize production is costlier in Kwami where farmers expend almost ₦60,600 per ha by DTMA whereas Shongom spends more among the NDTM farmers where farmers spends up to ₦38,000 per ha. Similarly Funakaye farmers was found to spend less for DTMA they spend about ₦40,727 per ha by the DTMA while for the NDTM Kaltungo spend about ₦31,736.

Table 4.25 Average Cost and Return for Maize Production in Gombe State

COST	DTMA	NDTM
Seed Cost	6592.30	5482.32
Fertilizer Cost	21750.33	9713.51
Labour Cost	17347.82	17336.05
Herbicide Cost	3259.03	801.91
Total Cost	48949.49	33333.75
Average	12237.37	8333.44
Revenue	121428.10	72755.75
Gross Margin	72478.53	39421.98
Return per Naira	2.52	2.19

Table 4. 26 : Cost and Return Analysis of Maize Production in Gombe State in naira per hectare(₦/ha)

Cost and Return	Akko		Billiri		Funakaye		Kaltungo		Kwami		Shongom		Yamaltu Deba	
	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Seed	6460.23	4590.1	6467.41		7530.83	6477.39		4817.26	6758.33	5905.91	6476.21	6316.69	5860.8	4786.55
Fertilizer	19521.28	9191.23	18539.5		12924.5	8809.06		9661.47	31942.6	10047.1	31595.58	11063.5	15978.5	9508.72
Labour	17796.4	18346.3	17930.5	No Sample Selected	17019.5	16013.8	No Sample Selected	16593.4	18158	18041.1	16457.6	19347.2	16724.9	15674.5
Herbicide	3015.46	717.75	3429.24		3252.73	681.41		664.02	3734.77	812	2992	1155	3130	781.25
Total	46793.37	32845.3	46366.6		40727.6	31981.6		31736.1	60593.8	34806	57521.39	37882.5	41694.2	30751
Average	11698.34	8211.33	11591.7		10181.9	7995.41		7934.03	15148.4	8701.51	14380.35	9470.62	10423.5	7687.75
Revenue	118757.7	66077.5	121209		106559	70827.3		73143.9	134157	72106.2	123681.9	81891.7	124204	72487.9
G. Margi	71964.29	33232.2	74842.5		65831.8	38845.6		41407.8	73562.8	37300.2	66160.51	44009.2	82509.3	41736.9
Return per Naira	2.54	2.01	2.61		2.62	2.21		2.3	2.21	2.07	2.15	2.16	2.98	2.36

Survey, 2014 NB : dash implies that no farmer sampled using the variety

4.4.7 Revenue

Gross revenue was used for assessment of profitability in the study. Table 4.25 and Table 4.26 show that DTMA maize was more profitable than NDTM; this is consistent with the result for yield, because it also showed that DTMA maize yield more than NDTM. Indeed, the lowest revenue recorded for DTMA maize was still greater than the highest revenue recorded for NDTM. The highest average total revenue from maize production by DTMA farmers was ₦121,428 while for NDTM ₦72,756 as seen in table 4.23 The total revenue across the LGA per hectare was recorded for DTMA as ₦134,157 in Kwami and for NDTM ₦81,891 was realized in Shongom. The gross revenue after all variable cost were deducted was ₦72,478 per ha for DTMA while N39,422 was for NDTM farmers. The highest gross revenue across the survey areas was ₦82,509 in Yamaltu Deba DTMA and for ₦44,009 NDTM recorded in Shongom. The lowest average gross revenue as recorded for DTMA and NDTM are ₦65,832 in Funakaye and ₦33,232 for Akko respectively. For return per naira DTMA recorded highest with ₦2.98 in Yamaltu Deba and its lowest as ₦2.15 in Shongom while for NDTM the highest reads ₦2.36 in Yamaltu Deba and the lowest as ₦2.01 in Akko. The implication of this was that for every one naira invested in DTMA it pays back ₦3 and ₦2.2 as recorded for the highest and lowest respectively, this was equivalent to 190% and 110% pay back for DTMA. For NDTM, for every ₦1 spent it pays back ₦2.36 and ₦2.01 for the highest and lowest respectively, and 130% and 100% in percentage.

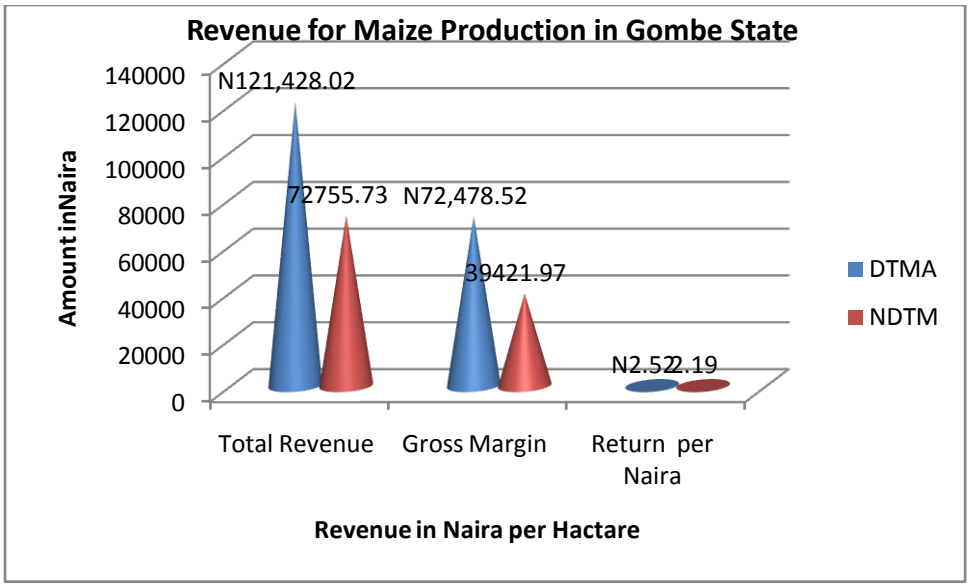


Figure 4.1 : Return for Maize Production in Gombe state

4.4.8 Hypothesis two: There is no significant variation in profitability of DTMA and NDTM in the study area

The result of the test of hypothesis signifies that maize production is a profitable enterprise. Table 4.27 present the mean profit (Gross margin) for DTMA as ₦73,416.74 while NDTM had ₦18,862.61 per hectare of maize, the suggest that a farmer cultivating DTMA earn as four times in DTMA than in NDTM (in the ratio of 80:20), the total spread of the distribution of the gross margin among farmer which was represented by standard deviation for the mean, for DTMA was ₦18,862 while for NDTM was ₦10,323. Similarly the standard error represent the total variation between farmer to farmer in relation to mean was higher in DTMA than in NDTM, the DTMA had ₦1,375.70 while NDTM has ₦765 this implies that there is wide variability in profit this is because of difference in efficiency among the farmers as well as location for the maize production. But in NDTM the variability is small probalby because of variety. This means that

DTMA was found to produced more in certain location at improve allocative efficiency than NDTM. The test indicated that t calculated-value was 21.17 while tabulated t-value is 3.34 since the calculated is greater than tabulated hence the hypothesis is rejected implying that variety has significant effect on profitability of maize business in Gombe state. Therefore, there is need for massive investment in the input sector (fertilizer, seeds multiplecation and herbicide) of the maize industry which constitutes about 70 % of the cost of maize production. The finding from this work supported the work of Mazvimavi, *et al*. (2012), Sadiq, *et al* (2013).

Table 4.27: Effect of variety on profitability of maize production business in Gombe state

Variable	DTMA	NDTM	Decision
Mean	73416.74	18862.61	Null Hypothesis
Standard deviation	18862.61	10323.11	Rejected
Standard error	1375.70	765.20	
Observation	188	182	
t-value		21.17	
t - critical		3.34	

4.5. Metafrontier

Farms in different location, regions and/or producing different commodities, face different production opportunities. Technically, they make choices from different sets of feasible input output combinations. The so-called technology sets differ, because of differences in available stocks of physical, human and financial capital such as type of machinery, size and quality of the labour force, access to improve variety), economic infrastructure (e.g., extension contact, access to credit, access to markets), resource endowments (e.g., quality of soils, availability of water and other climate related

infrastructures). Other characteristics of the physical, social and economic environment in which production takes place, in which farmers harnessed them for his production. Such differences have led the estimation of separate production frontiers for different groups of combination or group, if differences are notice or assumed to exist (Rungsuriyawiboon and Xianobing, 2007).

Consequently, the primary interest is to measure performance of farmers across groups, thereby comparing efficiency levels of farmers cultivating different crop varieties or raising different livestock breads. Unfortunately, such comparisons are only meaningful, in the limiting special case where frontiers for different groups are identical. Therefore, in this study after taking environmental and varietal variation into account, a more realistic assessment was made through Metafrontier technique. Never the less, after estimation base on location or based on variety then the metafrontier technical efficiency was computed for each of farmer category DTMA or DTM. Moreso, each LGA are disaggregated into two (DTMA or NDTM) and seven LGA where the data are collected. From the result in table 4.25 the minimum estimated metafrontier technical efficiency for DTMA was 12.3%, the maximum of 77.4% and the mean was 62.2% with a standard deviation of 19 percent. For the NDTM category the minimum efficiency was 3.3% and a maximum of 65.5% with a standard deviation of 17.7% and mean of 53.5%. This was interpreted as follows: in the short run, there was a scope for increasing DTMA maize production by 38.8% and 56.5% by adopting the production of DTMA maize variety couple with all techniques used by the best practice maize farms. This suggests that, on

average; about 38.8% DTMA and about 56.5% for NDTM of maize yield was lost because of inefficiency this finding is consistent with the work of Rahman, (2013).

The result was presented as in table 4.128 The LGA with highest metafrontier score for the DTMA was Kwami with 0.655 followed by Akko with 0.635. The standard deviation of Kwami was 0.195 while that of Akko was 0.189 minimum score of 0.111 Kwami and 0.114 for Akko maximum score of 0.778 for Kwami with 0.765 for Akko standard error 0.042 and 0.029. For the NDTM Yamaltu Deba records the highest metafrontier Score of 0.603 with standard deviation of 0.098 minimum Score of 0.305 and a maximum score of 0.654 standard error of 0.015. The least score was in Akko with 0.459 standard deviation of 0.288 minimum of 0.036 and max of 0.641 the standard error was 0.031 by looking at the whole mean score for metafrontier across the LGAS and between the maize varieties, it is clearly shown that variability was apparent this entail that metafrontier estimate the actual efficiency, this is in line with the findings of Ali, Imad and Yusuf, 2012. Every variety perform differently in a particular location that differences exist in the production technology and environment, which justifies estimation of a metafrontier in the estimation of efficiency studies if there is an fore knowledge of differences as supported by (Battese and Rao, 2002; Battese and Coelli, 1996, Ali, Imad and Yusuf, 2012).

But when efficiency was estimated with stochastic frontier assuming locations and variety were same or identical the effect of location and the variety was masked and hidden. Hence the violation of this assumption biases the technical efficiency estimates, as output differentials emanating from technology differentials were treated as technical

efficiency differentials and farms with higher technology appear more efficient as they are, this is consistent with the observation of O'Donnell, Prasada and Battese, 2008; Heilesassie, 2010.

However, with the analysis of technical efficiency using a metafrontier model gives a better overview of the comparability of technical efficiency scores across groups with different variability factor. Hence the closeness of group frontier to metafrontier is a measure of the metatechnology ratio for the different groups under consideration. This ratio is of interest for policy formulation, because they measure potential improvement in performance resulting from changes in production environment. Government can invest in physical, financial and human capital and trainings by the co-efficient of the gap.

Table 4.28 : Estimated score for Metafrontier in the state

Parameters	PLD	*Akko*		*Billiri*		*Funakaye*		*Kaltungo*		*Kwami*		*Shongom*		*Yamaltu Deba*	
		DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Sample	370	44	20	33	No Sample Selected	33	46	No Sample Selected	41	22	15	15	20	41	40
Mean	0.581	0.635	0.459	0.599		0.624	0.511		0.539	0.655	0.549	0.611	0.550	0.609	0.603
St. Dev.	0.190	0.189	0.228	0.178		0.169	0.213		0.180	0.195	0.151	0.211	0.189	0.207	0.098
Var.	0.036	0.036	0.052	0.032		0.028	0.045		0.032	0.038	0.023	0.044	0.036	0.043	0.010
Min.	0.036	0.114	0.036	0.198		0.111	0.040		0.093	0.111	0.229	0.141	0.092	0.062	0.305
Max.	0.781	0.765	0.641	0.781		0.771	0.652		0.651	0.778	0.654	0.775	0.678	0.774	0.654
Stand. Err	0.010	0.029	0.051	0.031		0.029	0.031		0.028	0.042	0.039	0.054	0.042	0.032	0.015

4.5.1 Technology Gap Ratio

This measure the ratio of the output of the frontier production function for the jth farm group relative to the potential output that was defined by the metafrontier function given the available inputs sets. The technology gap ratio indicates the technology gap for the given group according to currently available technology in that group, relative to the technology available in the whole group or categories. This ratio and the technical efficiencies (and, hence, the technical efficiency ratio) can be estimated for each individual farmer. It has a value between zero and one. The higher the average value of the TGR for a group the more advanced the production technology the group adopts. The mean technology gap give additional explanation compared with the analysis based only on stochastic frontier functions for the different groups. The technology gap ratio plays an important part in explaining the ability of the farmers in one group to compete with other from different groups in terms of efficiency of production. This ratio provides an estimate of the technology gap between the farmer using similar technology and the others using another technology.

In this study values of the TGR were computed for all farmers producing the DTMA and NDTM in the different location. Basic summary statistics for these measures are presented in table 4.29. The seven LGA and the pooled sample have productivity TGR ranging between 0.766 to 1. These values can be interpreted as the technological gap faced by maize farmers in the survey areas, their performances are compared with the technology available to both the Maize farmers producing the DTMA and NDTM in Gombe state. The mean values of the technology gap ratio vary from about 0.851 for

Funakaye in DTMA to 1 in Kwami. While for NDTM Funakaye rank highest with 0.956 followed by Yamaltu Deba in the NDTM with 0.896. These results imply that, in Akko from the DTMA group farmers produce on average, about 98% of the potential output given the technology available to DTMA farmers. However, farmers in Billiri, Yamaltu Deba and Funakaye produce respectively on average, about 97%, 97% and 85% of the potential output.

Table 4. 29: Technology Gap Ratio of DTMA and NDTM farmers in Gombe state

	Akko		Billiri		Funakaye		Kaltungo		Kwami		Shongom		Y. Deba		Pooled	
	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Samples	44	20	33	No Sample Selected	41	33	No Sample Selected	41	22	15	15	20	41	40	188	182
Mean	0.981	0.766	0.968		0.851	0.956		0.851	1.00	0.866	0.979	0.858	0.974	0.896	0.98	0.845
St. Dev.	0.087	0.139	0.065		0.091	0.075		0.091	0.093	0.062	0.083	0.094	0.093	0.036	0.08	0.099
Var.	0.008	0.019	0.004		0.008	0.006		0.008	0.009	0.004	0.007	0.009	0.009	0.001	0.01	0.01
Min.	0.433	0.23	0.545		0.359	0.421		0.359	0.424	0.499	0.532	0.358	0.369	0.547	0.37	0.23
Max.	0.79	0.669	0.806		0.679	0.796		0.679	0.806	0.682	0.805	0.705	0.805	0.681	0.81	0.705
St. Err	0.013	0.031	0.011		0.014	0.013		0.014	0.02	0.016	0.021	0.021	0.015	0.006	0.01	0.007

Survey, 2014

For the Technology gap ratio in maize production in Gombe state similar result. The results of the Technology gap ratio (TGR) estimated when the metafrontier was estimated. It was believe that because of the difference in variety and location the assumption of heterogeneity in the data set was therefore assumed, consequently for each LGA and variety the SFA was estimated separately to allow to capture other differences that are usually buried in doing SFA alone and metafrontier was estimated from it, then technology gap ratio was further estimated for each group. For drawing conclusion when TGR equal to one (1) implies farmers uses the best technology available, but when the value was the closer TGR value to one (0) implies farmers are using poor technology available. Although this assertion might likely be debated because Diagne (2010) in his observation on low rate of adoption asserted that low rate of adoption and poor use of technology in sub-saharan Africa attributed to largely due to lack of awareness on the technology or on how to use the technology as bundled by the researchers.

4.5.2 Potential Yield and Yield Gap

Yield potentials and yield gap was estimated between the two maize varieties across the survey areas. Potential yield was an indicator of technology/environmental gap between farmers cultivating different or similar variety of crops or are in different location. Potential yield was calculated for either each farm or aggregate for variety or location and the results are presented by the criteria under consideration. Therefore, the yield gap of a crop grown in a certain location and certain cropping system was the difference between the yield under optimum management and the average yield achieved by farmers. Yield under optimum management was labeled as potential yield with fully irrigated conditions

or water-limited yield under rain-fed conditions, table 4.30 summarizes the results from the calculation of potential yields. using the expression shown in equation 14 and 15.

Table 4. 30: Potential yield and yield gap for two maize varieties in different location in Gombe state estimated under stochastic and metafrontier

			Stochastic frontier				Metafrontier			
	Actual Yield		Yield Gap		Potential Yield		Yield Gap		Potential Yield	
LGA	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM	DTMA	NDTM
Akko	2575.49	1430	1033.9	1952.6	3609.39	3382.6	808.17	771.89	3383.7	2201.9
Billiri	2510.41	-	1029.9	-	3540.34	-	805.07	-	3315.5	-
Funakaye	2271.92	1537.1	1016.4	1972	3288.36	3509.1	794.52	779.58	3066.4	2316.7
Kaltungo	-	1585.6	-	1980.8	-	3566.3	-	783.04	-	2368.6
Kwami	2820.8	1591.3	1043.7	1981.7	3864.5	3573	815.83	783.41	3636.6	2374.7
Shongom	2748.49	1615	1040.8	1985.6	3789.28	3600.6	813.55	784.94	3562	2399.9
Yamaltu Deba	2685.15	1589.6	1039.2	1981.4	3724.31	3571	812.28	783.3	3497.4	2372.9
Average	2602.04	1558.1	886.28	1693.4	3116.6	3028.9	692.77	669.45	2923.1	2005

Survey, 2014

4.5.3 Estimated potential yield by Local Government Areas

Comparing difference in productivity between two varieties of maize. Several issues were considered. It is belive that farms within same location are belive to have similar environmental features so also same maize variety is likely to perform simingly the same across location, but farmers are not guaranteed to have the same production function. Different farmers from different location or producing different variety may have been bounded by different choices of production. As a result, they may combine their input-output in different ways which give them difference in efficiency. So comparing two separate varieties that are inherently different in their location of production a more realistic approach is conducted which is metafrontier approach.

To compare the two varieties both Stochastic frontier was estimated the table 4.32 were presented for both actual yield. Potential or maximum yield which could be reached by a crop in a given environments, in other word it was the highest possible yield obtainable with ideal management, soil, and weather. Potential yield was maximum yield. In deed potential yield was associated with specific soil and weather conditions that can change. Usually farmers obtained some yield which was called the actual yield while potential yield was the maximum yield to be obtained in a specific environment under good management practice and disease free environment. Yield potential was defined as the yield of a crop variety when grown in environments to which it was adapted, with nutrients and water non-limiting, pests and diseases effectively controlled.

4.5.4 Yield gap

In the estimation of the yield gap, the efficiency Score of each farmer is compared relative to the actual yield observed by the farmer, the result discovered that, on average DTMA farmers has a yield gap of 886Kg whereas, the NDTM had a gap of 1693kg, implying that the DTMA on average has limited yield gap than NDTM which requires additional effort to close the gap. The yield gap across the LGA shows that Funakaye has the lowest yield gap of 1016kg in the DTMA group then Billiri followed with 1030kg. The LGA with higher gap was Kwami with 1044kg, on the other hand the, NDTM group the LGA with lowest yield gap was Akko with 1953kg followed by Funakaye with 1972kg.

The yield gap was used to estimate the potential yield, the result shows that on average the DTMA have a potential yield of 3117kg while that of NDTM had 3029kg across the

survey areas. Billiri has the least yield potential of 3540kg from the DTMA group while Akko is the least from the NDTM group with 3383kg. The LGA with highest yield potential in DTMA group was Shongom with 3789kg but for NDTM the highest remain in Shongom with 3600kg. The potential yield is an indicator of the performance of maize variety under getting the required inputs and good management. Some crops do not reach their potential because of poor management or poor environmental condition. But improving management and supplying the right inputs at the rate of application the chances of getting the potential yield is likely to improve. Table 4.31 and Table 4.32 report estimated potential yield and yield gap using stochastic frontier and under metafrontier.

4.5.5 Hypothesis three: There are no significant differences in the efficiency level of farmers producing the two maize varieties in different communities of Gombe state

There are no significant differences in the efficiency level of farmer's producing the two varieties in different locations in the state. The result on table 4.31 revealed that the F-calculated was 103.76 was greater than f-critical 3.05 on f-table and was significant at 1% probability level. Therefore the null hypothesis stating that no significant difference in efficiency level of farmers producing the two varieties was rejected. This indicate that there were variation between variety and location, the efficiency score tend vary by 15% across variety and location but the value for efficiency difference is marginal about 0.15% within variety and within location hence limited variation is observed within variety and within location. This means that variety performed well though subject to location of production.

Table 4. 31: Test of variability of efficiency across variety and location

Efficiency variability	Stochastic Frontier		Metafrontier	
	DTMA	NDTM	DTMA	NDTM
Mean efficiency variability	0.8429	0.6277	0.6163	0.5352
Variance	0.0004	0.0029	0.0005	0.0023
Variation between varieties and locations				0.4513
Variation within variety and location				0.0319
Total Variation				0.4832
Mean square between varieties and Locations				0.1504
Mean square within variety and locations				0.0015
Observation				25
F-Calculated				103.76****
F-Critical				3.05

*** Significant at 1% If Fcal->Ftab significant at 1%

4.6 The Determinants of profitability

A Multiple regression model was used to examine the determinants of profitability in Maize Production; the result was presented as follows in table 4.34. The variables included were, age, education, land ownership, experience, household size, maize farm size, number of crop grown, land rent, amount of credit access, extension contact, location where the variety is cultivated, variety of maize cultivated, yield, seed cost, fertilizer cost, labour cost, herbicide cost.

The estimation was first performed assuming no difference between variety and location, but such factors were included as dummy variables and nominal variable. In this model, household size, membership of co-operative and constant term, all were not founds to be significantly contributed to the profitability of maize, beside them all other variables

mentioned ealier were significant at varying level. From the study, all variables except household size were found to be significantly affect profitability among DTMA Farmers but for NDTM, ten(10) variables were found to significantly contributed to profitability at 1% those variables include: herbicide cost, labor cost, fertilizer cost, Seed Cost, yield. However LGA, co-operative membership, number of extension contact by a farmer in the last cropping season and credit accessed, number of crop grown, were not significant among the NDTM farmers whereas, other variables such as education, maize farm size, age of farmers were significant at 5% and 10% respectively.

Nevertheless, the adjusted R-square were 0.673 for DTMA while for NDTM it was 0.586. This shows most of the variation were examined, in all the 2 models limited was not explained by the models.

Table 4.32: Determinants of Profitability of Maize Production in Gombe state

	DTMA				NDTM			
Gross Margin	Coef.	Std. Err.	t-value		Coef.	Std. Err.	t-value	
Age	83.983	48.741	1.723	*	0.462	0.234	1.972	*
Constant	-1.899	0.649	-2.923	***	-8.199	8.129	-1.009	
Education	0.458	0.125	3.676	***	-1.908	0.887	-2.150	**
Land_ownership	2.158	1.086	1.987	**	-1.232	0.391	-3.146	***
Experience	-1.340	0.719	-1.863	*	1.417	0.528	2.683	***
Household size	58.500	98.864	0.592		9.335	3.663	2.549	***
Maize farm size	0.300	0.154	1.944	*	1.988	1.060	1.876	*
Number crop grown	-1.232	0.513	-2.402	**	-0.080	0.358	-0.223	
Land Rent	-3.755	1.073	-3.500	***	-0.642	0.076	-8.445	***
Credit Accessed	3.644	2.121	1.718	*	-3.688	1.392	-2.650	***
Extension contact	-2.490	1.230	-2.024	**	0.704	1.358	0.519	
Co-ops Membership	-3.459	1.462	-2.366	**	0.142	0.171	0.830	
LGA	-0.548	0.222	-2.474	**	-0.251	0.254	-0.990	
Yield	4.814	2.174	2.215	**	4.593	0.497	9.242	***
Seed Cost	-1.142	0.345	-3.309	***	-1.159	0.242	-4.797	***
Fertilizer cost	-1.097	0.265	-4.137	***	-0.935	0.145	-6.445	***
Labour Cost_ha	-0.897	0.115	-7.774	***	-0.947	0.078	-12.079	***
Herbicide cost	4.850	1.273	3.811	***	12.276	0.695	17.671	***
Adj R-squared			0.673				0.586	

Source: Survey 2014 P<0.05

4.7 Constraints to Maize Production in Gombe state

Generally farmers experience many obstacle preventing them from obtaining the optimal yield, several factors contribute to such, although it differ from farmer to farmer as well as from location to location. In this study from the result in Table 4.33: Constraints affecting Maize Production in Gombe state. The study identified 9 major constraints on maize production. The DTMA farmers, rank high cost of inputs and low producer price as the first constraints while the NDTM farmers, rank low extension contact as the

highest constraint. The second constraints identified by DTMA was low access to credit by farmers which rank next to the first one in the group with 26(8.9%) while for NDTM they rank high cost of production with low producer price as their second constraints, high incidence of adulterated fertilizers in the market was identified as the third constraint by DTMA farmers with 26(8.9), in the NDTM the third constraints was low access to credit by farmers with 18(6.2%). The least constraints specified by the DTMA farmers was high incidence of adulterated seed from government supply seed while high incidence of striga infestation rank the least in NDTM with 73(9.4%).

The high production cost and low producer price, generally farmers spend a lot of money to cultivate a hactre of maize but unfortunately when they take their produce to market the price offered by the market is relatively low. Farmers buy a bag of NPK fertilizer at about ₦4500 to ₦5500 at open market though if purchased from GESS the price is relatively lower than that, whereas in last production season maize price per bag is not more ₦4000 in urban cities therefore in rural areas where the road is not motorable the price might not be more than ₦2500. This apparently makes maize production less attractive to farmers yet they most produce for their household needs.

Therefore, if a farmer need the recommended quantity of fertilizer, he need about 11bags for his hacter. Therefore, he need upto ₦49,000, for him to get that sum he will sale about 20bags from his maize output. Linked to this, is low access to fartilizer by farmers, although, government do provide 1bag of Urea + 2bags of NPK through e-wallet. The reality is that, this is far from the recommended rate, therefore farmer consider using the

limited available quantity given to them sometime buy 1 or 2bags to complement. Sometime farmers observed that the fertilizer purchased from market are adultrated with sand or some materials that are not really fertilizers. Moreover, access to credit among farmers is conversome and filled of with extensive adminstrative bottleneck while in some cases arrived late. The low access to extension, NAERLS, 2014 in its executive summary reported the wide gap in extension staff between ten years in Nigeria this is a serious area of concern most states in Nigeria have aged extension staff and even at that they keep on retiring day by day without employing new and young ones. Other constraints specified by the farmers are poor yield, incident of striga infestation and incident of adultrated seed from government supply seed. In this situation, if a farmer plant such a seed, they will definitely experience all the stated obstacles above.

Table 4.33: Constraints affecting Maize Production in Gombe state

Constraints to Maize Production	DTMA			NDTM		
	Frequency	%	Rank	Frequency	%	Rank
High Production Cost with low Producer Price	162	55.5	1st	146	18.7	2nd
Low Fertilizer Access to farmers	26	8.9	2nd	78	10.0	5th
High adulterated Fertilizers in the Market	26	8.9	2nd	84	10.8	4th
High Incidence of Diseases and Pest	25	8.6	4rd	68	8.7	7th
Low extension Contact by Farmers	20	6.8	5th	173	22.2	1st
Low Access to Credit by Farmers	18	6.2	6th	118	15.2	3rd
Poor Maize Yield	9	3.1	7th	23	3	8th
High Incidence of Striga infestation	4	1.4	8th	16	2.1	9th
High Incidence of Adulterated seed from Govt. Supply Seed	2	0.7	9rd	73	9.4	6th
Total	292	100		779	100	

Source: Survey 2014

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary

Comparative economic analysis of drought and non-drought tolerant maize production in Gombe state was conducted. The broad objective of the study was to compare and contrast the similarities and differences of overall production associated with the two maize varieties. From the Survey the major findings were as follows: The study found that, 18% of the total respondents in DTMA have tertiary education level while for NDTM only 9.9% has tertiary education in the group. This was not surprising because from the survey 23.5% of DTMA respondents were civil servants, while only 21.2% were civil servants from NDTM respondents.

Extension visit was very important in adoption of any technology, in this study the survey also found that, 3 and 2 farm visits were common for DTMA and NDTM respectively. Furthermore 52% of DTMA farmers belong to at least one farmer association as against 33.4% for NDTM farmers. Access to credit remains a serious challenge where 86% of DTMA access credit as against the 100% of NDTM who do not access any form of credit.

DTMA farmers planted about 26.5kg per hectare and NDTM planted 24.4kg per hectare of maize seed. The average area where maize was intercrop with other crop by DTMA was found to be 4.0 hectare while on similar cropping system by NDTM was found to be only 3.0 hectares. Never the less, DTMA maize was found to yield about 2.6ton per

hectare as against the NDTM which on average yields 1.60ton per hectare. Furthermore, about 271 man-hours were utilized for Maize production in DTMA category while 215 man-hours were utilized by NDTM. DTMA farmers used 192kg equivalent to (4bags) per hectare of fertilizer while NDTM applied 165.7kg per hectare equivalent to (3bags). The level of fertilizer utilization might likely be the reason for differential yield between the two maize varieties. Similarly the survey found that, on average 3.2 litres herbicide was applied per ha by DTMA while 0.8 litres by NDTM.

The DTMA farmer's sale up to 10.7 metric ton of maize from their total annual harvest as against 5.5 metric ton of maize by NDTM. The total maize output realized on average in the whole production season per farmer by the DTMA farmers was 13.7 metric ton while for NDTM was 6.2 metric ton, showing a difference of 7.5 metric ton twice of what NDTM produced annually.

Inputs cost as percentage of total cost. Maize production seed was found to have 13.5% and 16.4% for DTMA and NDTM farmers respectively, fertilizer cost was 44. 4% and 29.1% for DTMA and NDTM farmers. Labour was 35.4% of cost maize production for NDTM as compared to 52.0% for DTMA. Herbicide takes 6.7%f for DTMA and 2.4% for NDTM. However, taking different dimension, input cost as proportion of profit for maize production were, maize seed accounted for 9.1% for DTMA and 13.9% in NDTM, fertilizer account for 30% for DTMA as compared to 24.6% for NDTM, this is slightly different from the findings of Ogunlade, *et al* (2010) who observed that fertilizer constitute 50% of the constraints affecting drought tolerant maize, labour was 23.9%

relative to 44% for DTMA and NDTM respectively, finally herbicide was 4.5% and 2.0% for DTMA and NDTM respectively.

Technical efficiency was examine with stochastic frontier and metafrontier the parameters, technical efficiency identified, seed was found to significantly change yield of DTMA farmer's by 3.5 i.e. a unit increased in seed resulted in 3.5kg increased in yield of DTMA Maize variety at 1% Confidence level, similarly seed significantly changed yield of NDTM by any unit increased in seed resulted in 0.16Kg increased in yield at 1% confidence level, though a unit increased in seed resulted in 0.04Kg increased using metafrontier approach at 1% level of confidence. Labour showed that a unit increased in labour by 1 man day significantly resulted in a 2.6 kg increased in kg of maize at 1% level at significant of DTMA farmers while one unit increased in NDTM labour resulted in 0.3kg increased in yield at 1% level of significant.

From the survey fertilizer indicated that for 1Kg increase on fertilizer will significantly resulted in 2.2kg increased of Maize for DTMA farmers while for NDTM 1kg increased in fertilizer will significantly resulted in l.3kg increased in maize. Similarly 1 kg increase in fertilizer significantly increased Maize yield at metafrontier by 0.005 kg increase at 1% confidence level. For herbicide, litre increased only resulted 3.7, 0.8, 0.06 yield reduction in DTMA, NDTM and metafrontier 1% respectively. The rational for this abnormal finding was associated with low used of herbicide by the farmers in the area.

Beside differences in varieties, location of production also was found to exhibit

differences between LGAS as well as affected input use. Seed was fond to significantly affected yield in Akko, Funakaye, Kwami, and Shongom but reduced Yield in Billiri Kaltungo Yamaltu Deba and Metafrontier. Labour significantly increased yield in Billiri, Kaltungo, Kwami, Shongom, Yamaltu Deba and Metafrontier but reduced yield in Akko. But fertilizer was found to increased yield in Akko 1.42 at 1%, Billiri 2.3 at l%, Kaltungo 2.2 at 1% Kwami 2.4 at 1%, Yamaltu Deba 1.79 at 5% Metatechnology 0.89 at 1% but reduced yield Significant by 5.3 at 1% in Funakaye.

The major determinant of technical inefficiency when DTMA and NDTM were compared showed that, within DTMA farmers, age, household size, number of crop grown, total farm size excluding maize area, extension contact, experience, Local government area, variety cultivated significantly affect efficiency at 1% confidence level, while land ownership, maize farm size, significantly affected yield at 5% and education was significant at 10%, the remaining membership association, nonfarm income, credit access, were not significant, But for NDTM within the variety credit access, experience, variety of maize cultivated were significantly affected technical efficiency this contradict the work of Mazvimavi, *et al* (2012). However, comparing DTMA and NDTM, education, land ownership, number of crop grown, extension contact, maize farm size, non-farm income, credit access, experience, LGA, and variety cultivated significantly affected technical efficiency of maize farmers at 1% level of confidence, while age, membership of association, were significant at 5%, household size, total farm size excluding maize area, nonfarm activities, were not significant at all.

Technology gap ratio of DTMA was 0.75 while NDTM was 0.37. In terms of location, Akko indicated a yield gap of 2217.5 Kg from potential yield for the same place with TGR of 0.63, Billiri's Yield gap was 2510.1Kg with TGR 0.6. But Funakaye had yield gap of 1844.1 with 0.35 TGR. But Kaltungo had 1585.6 Kg with TGR 0.37 Kwami 2322.4kg with 0.67 Shongom 2100.8kg with 0.59 PLD 2077.25kg with 0.69

5.2 Conclusion

Conclusively, a major problem associated with the inefficiency was farmers' inaccessibility to credit and extension. The study established that about 38.8% of DTMA and 56.5% of NDTM maize yield was loss because of farmers both allocative and technical inefficiency. Yet Farmers make a sizable profit and maize production remain profitable enterprise that can increase household income and sustain the means of livelihood of many farming household, regardless of whether a farmer use DTMA or not but tend to earn more if DTMA variety was produced.

5.3 Recommendations

The following recommendation was made base on the data collected, interaction and observation during the survey:

i. Drought tolerant maize variety was established to yield 2603.04kg/ha on farmers farm compared to the Non drought tolerant maize variety which yield 1558.10kg/ha. Therefore is a need to extend this study to cover the hold country by NAERLS DTMA Project and assessed the contribution to livelihood and household food security and Income.

ii. The study also found low access to credit among farmers as constraint to maize production in the area, hence farmers should be guided to pool their resources together in order to assist themselves through group formations, self help through credit revolving schemes.

iii. There were low and in appropriate used of herbicide by both farmers. Therefore, farmers need to be informed on the proper use of herbicide through extension bulletin and guide.

iv. There was high producer cost associated with low producer price in Maize production, therefore farmers producing maize for business should be assisted with wide market option through linkage with companies like nestle food, for bulk marketing options, or contract farming options through their co-operative societies.

v. Age was found to be an important factor affecting efficiency hence young farmers with higher education level should be engage in agricultural business through government intervention on workable school leaver and graduate agricultural programmes.

vi. Farm ownership and cultural practices (number of crop grown) was found to affect efficiency so farmers should be enlighten to streamlines the number of crop grown on their farm lands, farm renting should be encourage since little cost was associated with land rent to enhanced access to farm land.

5.4 Contribution to knowledge

i. The study was able to establish that DTMA farmers realized ₦121,428.10 while the NDTM realized ₦72,755.75 per a hectare of maize as their gross sales with

₦72,478.52, ₦39,421.97 for DTMA and NDTM respectively as gthier gross margin per hectare.

ii. The survey also established that on every naira spend NDTM farmer obtained ₦2.19 while DTMA farmers realized ₦2.52 per every naira spends.

iii. The study established that DTMA variety had actual yield 2603.04kg/ha on farmers farm while the NDTM variety had actual yield of 1558.10kg/ha. Moreover, the survey determined the potential yield for stochastic frontier for DTMA to 3116.60kg/ha and 3028.94 kg/ha in NDTM, but Potential yield after metafrontier was estimated was found to 2923.10kg/ha for DTMA and 2004.9kg/ha for NDTM.

iv. The study also established that DTMA farmers use average of 407 while NDTM used average of 474 man-hours (equivalent to 69.2 man-days to 79.8man-days) was utilized per hectare of maize from land clearing to harvest.

v. The study established that about 38.8% of DTMA and 56.5% of NDTM of maize yield was lost because of inefficiency by the farmers in the state.

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APPENDIX I: Sample Shazam code used to estimate metafrontier and technology gap for DTMA&NDTM

1. Instruction files for estimation Metafrontier and Technology Gap Ration for DTMA and NDTM

```
* parm.txt contains estimated parameters of regional frontiers
* dtm.txt contains 182 data observations for group 1
* ndtm.txt contains 188 data observations for group 2
* pld.txt contains 370 data observations for group 3
* READ ESTIMATED PARAMETERS OF REGIONAL FRONTIERS
smpl 1 15
read (parm.txt) parm / rows = 15 cols = 3
do # = 1,3
  dim b# 15
  copy parm b# / fcols=#;# tcols = 1;1
endo

* READ DATA (and construct matrices and vectors)
smpl 1 370
read (dtm.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 183 370
read (ndtm.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 1 370
genr one = 1
MATRIX  x = one|lx1|lx2|lx3|lx4|lx11|lx12|lx13|lx14|lx22|lx23|lx24|lx33|lx34|lx44
dim x1 182 15 x2 188 15 x3 370 15
copy x x1 / frows=1;182 trows=1;182
copy x x2 / frows=183;370 trows=1;188
copy x x3 / frows=1;370 trows=1;370
do # = 1,3
   matrix yhat# = x#*b#
endo
matrix b = -(yhat1' |yhat2' |yhat3'  )'
* OBTAIN AND PRINT PARAMETERS OF THE METAFRONTIER
stat x  / means = xbar
matrix c = ((-xbar' )|xbar' )'
matrix A = (-x) |x
lp c A b / iter = 5000 primal = bstar
```

```
dim beta1 15 beta2 15
copy bstar beta1 / frows=1;15 trows=1;15
copy bstar beta2 / frows=16;30 trows=1;21
matrix beta =  (beta1-beta2)**2
print beta

* OBTAIN AND PRINT TECHNOLOGY GAP RATIOS
do # = 1,3
  matrix xbeta# = x#*beta
  matrix tgr# = exp(yhat#)/exp(xbeta#)
  stat tgr#
endo
matrix tgr = (tgr1'|tgr2'|tgr3' )'
stat diagnos tgr# / boostrap
print tgr
stop
```

APPENDIX II: Sample Shazam Code used to estimate metafrontier and technology gap for locations

2. Instruction files for estimation Metafrontier and Technology Gap Ration between LGAs

```
* parm.txt contains estimated parameters of regional frontiers
* sfa1.txt contains 64 data observations for group 1
* sfa2.txt contains 33 data observations for group 2
* sfa3.txt contains 79 data observations for group 3
* sfa4.txt contains 41 data observations for group 4
* sfa5.txt contains 37 data observations for group 5
* sfa6.txt contains 35 data observations for group 6
* sfa7.txt contains 81 data observations for group 7
* READ ESTIMATED PARAMETERS OF REGIONAL FRONTIERS
read (parm.txt) parm / rows = 15 cols = 7
do # = 1,7
dim q# 15
copy parm q# / fcols=#;# tcols = 1;1
endo
* READ DATA (and construct matrices and vectors)
smpl 1 370
read (akk1.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 65 97
read (bill2.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 98 176
read (funa3.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 177 217
read (kalt4.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 218 254
read (kwa5.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 255 289
read (shong6.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 290 370
read (yamal7.txt) group t ly lx1-lx4 lx11-lx14 lx22-lx24 lx33-lx34 lx44
smpl 1 370
gen one = 1
MATRIX x = one|lx1|lx2|lx3|lx4|lx11|lx12|lx13|lx14|lx22|lx23|lx24|lx33|lx34|lx44
stat x / means = xbar
dim x1 64 15 x2 33 15 x3 79 15 x4 41 15 x5 37 15 x6 35 15 x7 81 15
copy x x1 / frows=1;64 trows=1;64
```

```
copy x x2 / frows=65;97 trows=1;33
copy x x3 / frows=98;176 trows=1;79
copy x x4 / frows=177;217 trows=1;41
copy x x5 / frows=218;254 trows=1;37
copy x x6 / frows=255;289 trows=1;35
copy x x7 / frows=290;370 trows=1;81
do # = 1,7
matrix yhat# = x#*q#
endo
* OBTAIN AND PRINT PARAMETERS OF THE METAFRONTIER
matrix c = ((-xbar')|xbar')'
matrix A = (-x)|x
matrix q = -(yhat1'|yhat2'|yhat3'|yhat4'|yhat5'|yhat6'|yhat7')'
lp c A q / iter = 5000 primal = qstar
dim beta1 15 beta2 15
copy qstar beta1 / frows=1;15 trows=1;15
copy qstar beta2 / frows=16;28 trows=1;21
matrix beta = (beta1-beta2)**2
print beta
* OBTAIN AND PRINT TECHNOLOGY GAP RATIOS
do # = 1,7
matrix xbeta# = x#*beta
matrix tgr# = exp(yhat#)/exp(xbeta#)
stat tgr#
endo
matrix tgr = (tgr1'|tgr2'|tgr3'tgr4'|tgr5'|tgr6'tgr7')'
stat diagnos tgr# / boostrap
print tgr#/ boostrap
```

APPENDIX III: Sample Questionnaire used in the survey

Questionnaire Number:_____

Enumerator's Name_____ Phone Number_____

Date: _____

Geographical Location

Agro-ecological Zone	LGA	Community/ Village	GPS coordinates		
			Longitude	Latitude	Altitude

Section A: Farm Household Head characteristics

1. Name _____Phone Number: _____
2. Age :_____ Gender: Male [ ] Female [ ]
3. Marital status : Married [ ] Single [ ] Widow [ ]
4. Total Household members who are involved in Maize farming a. Number of Adult _____
   b. Both Male and Female Children_____ c. Adult Women:_____
5. Select Highest Educational Status of the household head from the options below (only 1 option is to be selected):
   a. Quranic Education [ ]
   b. Primary School Education [ ]
   c. Secondary School [ ]
   d. Tertiary Education [ ]
   e. Others (Specify) [ ]_____
6. Specify the total number of years spent in formal education_____
7. Select Primary occupation from the options below (only 1 option is to be selected)::
   a. Farming [ ]
   b. Civil Servant [ ]
   c. Trading [ ]
   d. Processing/Milling [ ]
   e. Crafts work [ ]
   f. Others (Specify) _____
8. Select secondary occupation from the options below(only 1 option is to be selected):
   a. Farming [ ]
   b. Civil Servant [ ]
   c. Trading [ ]
   d. Processing/Milling [ ]
   e. Crafts work [ ]
   f. Others (Specify) _____

9. Are you a member of Maize farmer organization? Yes [ ] No [ ] If Yes Specify number of Farmer organizations Belong to _____
10. If 9 is yes, Number of Years in prominent Maize farmer organization _____
11. Select any benefits derived from being a member of the group(s)? (multiple options can be selected)
    a. Loan /Credit [ ]
    b. Inputs(Fertilizer, Seed, labour [ ]
    c. Education [ ]
    d. Bulk Marketing [ ]
    e. Others (Specify) _____
12. Do you engage in other nonfarm activity? Yes [ ] No [ ] if Yes Name the none farm activity _____
13. Income from Other Secondary Occupation Income per:
    Day [ ] week [ ] Month [ ] Year [ ] in Naira _____please select appropriately and fill in the gap provided above for income.
14. Are you a maize farmer? Yes [ ] No [ ]
15. Which of the following reasons why you produce Maize?
    a. for household consumption [ ]
    b. Doing Maize farming as a business [ ]
    c. For Trial [ ]
    d. For Seed Multiplication [ ]
16. What is the maize output for previous season?

Maize output in previous season?	Maize			
	Sold	Retain for Consumption	Gift out	Retain as seed

17. What is your total farm size including area for maize? _____ Select from the following unit that explain the farm size.
    Hectare [ ] Bull Ridges [ ] Tractor Ridges [ ]
18. What is the total land size cultivated for maize only? _____
    Hectare [ ] Bull Ridges [ ] Tractor Ridges [ ]
19. What is your total farm size where maize is intercropped with another crops:_____
    Hectare [ ] Bull Ridges [ ] Tractor Ridges [ ]

Section B: Production

20. Specify number of Years in Maize farming (……..yrs)

21. Owned personal farm? Yes [ ] No [ ]
22. If Yes to 21, Total farm size owned (m^2 or ha) ……..…. Select from the following unit that use to explain the farm size.

    Hectare [ ] Bull Ridges [ ] Tractor Ridges [ ]
23. Total farm ownership by status- fill in where applicable to your ownership status

Tenural status	Land Area
i. Inheritance	
ii. Purchase	
iii. Gift	
iv. Rent	
v. Others (specify)	
Total	

24. If Not personally owned, amount paid for Rent_____ Size of Farm Rent_____
25. When do access credit last _____ [ ] If Yes What is total amount access last _____
26. If Accessed, What is the source of your credit access:_____
27. Do you have extension contact? Yes [ ] No [ ] If Yes Number of extension visit for last cropping season _____
28. What is your distance from Market source from your house? _____

Farm Received

29. Crop mixture grown with maize in the same pieces of land: Please fill in the appropriate Maize crop mixtures in table below, state total farm area for crop produced:

Maize Crop Mixtures	Land area dedicated for the mixtures
Maize and Cowpea	
Maizeand Groundnut	
Maize and Bambara nut	
Maize and Sorghum	
Maize and Rice	
Maize and Cotton	
Maize and Millet	
Maize and Soybean	

30. Quantity of Output obtained: _____ _____

Maize Crop Mixtures	Maize	Other Mixture

Maize and Cowpea		
Maizeand Groundnut		
Maize and Bambara nut		
Maize and Sorghum		
Maize and Rice		
Maize and Cotton		
Maize and Millet		
Maize and Soybean		

Unit of measurement: _____

(NB: Measured by bags, Basket, Kg, Mudu, or Tiya)

Size of standard Bag in Tiya/Mudu:_____

Price per Unit: _____

(NB All unit of measurement must be converted to SI unit for each material used) using appropriate conversion factor) or the unit use should be stated to allow for conversion later

Farm Expenses

31. Fertilizer use

Type Crop applied	Total land area cropped	Fertilizers			
		Type	Source	Qty in Bags / Mudu	Price per bag/ Mudu
		Urea			
		NPK			
		Manure			

32. Quantity of seed planted in Bag/Tiya/Mudu: _____

Unit of measurement: _____

Price per unit: _____

33. Name of seed (Hybrid/Farmer seed):_____

Quantity of Seed utilized:_____

34. Name of Herbicide: _____

35. Total volume of herbicide applied:_____

Unit of measurement: _____

36. Name of Pesticide: _____

    Volume of Pesticide applied: _____

    Unit of measurement: _____

37. Do you pay Cost of transportation from home to Farm? Yes [ ] No [ ] If Yes What is the cost of transportation from farm to home on average per trip_____

38. Number of times taken per farm operation like planting, weeding, e.t.c

(NB All unit of measurement must be converted to SI unit for each material used) using appropriate conversion factor)

Hired Farm labour

Type of Farm operation	Number of people work	Number of days taken for the work	Amount paid	Gender of Worker		Price per man day	Children
				M	F		
Land clearing							
Ploughing/ Ridging							
Planting							
Fertilizer application							
Weeding Manual (First)							
Weeding Manual (Second)							
Spraying for Chemical weeding- labour – (if used)							
Harvesting							
Threshing							
Bagging							
Pesticide Spraying – Labour							
Transportation							
Others Specify							

39. Family Labour

Type of Farm operation	Number of people work	Number of days taken for the work	Gender of Worker		Children
			M	F	
Land clearing					

Ploughing/ Ridging					
Planting					
Fertilizer application					
Weeding Manual (First)					
Weeding Manual (Second)					
Spraying for Chemical weeding- labour					
Harvesting					
Threshing					
Bagging					
Pesticide Spraying –Labour					
Transportation					
Others Specify					

40. Consumption and Sales of Outputs:

Maize Crop Mixtures	Maize				Other Mixture			
	Sold	Retain for Consumption	Giftout	Retain as seed	Sold	Retain for Consumption	Giftout	Retain as seed
Maize and Cowpea								
Maizeand Groundnut								
Maize and Bambara nut								
Maize and Sorghum								
Maize and Rice								
Maize and Cotton								
Maize and Millet								
Maize and Soybean								

41. Farm Assets

Asset	Number	Year Purchased	Amount Purchased
Land Clearing tools a. _____ b. _____			

c. _____ d. _____			
Ploughing tools a. _____ b. _____ c. _____ d. _____			
Planting tools a. _____ b. _____ c. _____ d. _____			
Weeding tools a. _____ b. _____ c. _____ d. _____			
means of transport for commodity a. _____ b. _____ c. _____ d. _____			
Other Mechanical Machinery a. _____ b. _____ c. _____ d. _____			

SECTION C: DROUGHT TOLERANCE

42. Are you aware of maize variety that can do better if dry spell or drought occurs? Yes [ ] No [ ]
43. Do you cultivate drought tolerant maize variety Yes [ ] No [ ]
44. If No why? _____

_____

45. If Cultivate drought tolerant maize, What is the size of you land cultivated with drought tolerant maize variety?_____

46. Select from the following unit Hectare [ ] Bull Ridges [ ] Tractor ridges [ ]
47. Which of the following reasons that drives you to produce drought tolerant Maize variety?
    a. for household consumption [ ]
    b. Sales to earn money [ ]
    c. For Trial [ ]
    d. For Seed Multiplication [ ]
48. If yes how much quantity of seed you planted for drought tolerant maize_____
49. How much quantity of seed of normal maize planted _____
50. How much quantity of output of drought tolerant maize _____
51. What is the total area planted with Drought tolerant _____
52. Area planted with Normal Maize _____
53. What is your Source of seed?
    a. Seed Company [ ] Quantity access form the source :_____
    b. Friend [ ] Quantity access from the source:_____
    c. Previous Harvest [ ] Quantity access from the source:_____
    d. Research Institute [ ] Quantity access from the source:_____
    e. Govt. [ ] Quantity access from the source:_____
    f. Market [ ] Quantity access from the source:_____

    (Please tick appropriate from the options provided may tick more than 1 option if applicable to you and fill in the quantity access from each source selected)
54. In this area do you experience drought in the last 3 - 4 years? Yes [ ] No [ ] Tick only 1 option
55. What is the approximate number of days experience without rain in the last cropping seasons _____
56. If experience does it lead to replant at early stage? Yes [ ] No [ ]
57. What stage of growth when drought occur
    a. Planting /Germination [ ]
    b. Weeding first [ ]
    c. Second weeding [ ]
    d. Fertilizer application [ ]
    e. Flowering [ ]
    f. Seed formation [ ]
58. If experienced please estimate maturity stage in number days from planting _____
59. When the drought occur what happens to the plant? Affected [ ] Stunted growth [ ] Normal growth[ ]
60. When the drought happen how does the husk Cover of cops at harvest? Poor [ ] Fair [ ] Remain Good [ ]
61. Did the crop wilted after the drought occurs? Yes [ ] No [ ]
62. What happens to grain yield at harvest? V. Poor [ ] Poor [ ] Good [ ] Excellent [ ]

63. Did number of ear per plant during growth become Few [ ] Normal [ ]
64. What happens to Flowering interval? No interval [ ] varied interval [ ] Uniform [ ]
65. Did the crop exhibit ability to stay green after exposure to drought or dry spell? Yes [ ] No[ ]
66. What are the constraints affecting maize production in your area?_____

    _____

    _____

Thank you for your time please