ECONOMIC ANALYSIS OF COTTON PRODUCTION AND SUPPLY TREND ESTIMATION IN ZAMFARA STATE, NIGERIA.

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JUNE, 2015

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS.

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JUNE, 2014

DECLARATION

I hereby declare that this dissertation titled **"Economic Analysis of Cotton Production and Supply Trend Estimation in Zamfara State, Nigeria"** has been written by me and it is a record of my research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed ideas have been acknowledged in the text and a list of references provided.

…… ……

Victor Olatunji Odedokun (Student) Date

CERTIFICATION

This Dissertation titled **"Economic Analysis of Cotton Production and Supply Trend Estimation in Zamfara State, Nigeria**" carried out by Victor Olatunji Odedokun meets the regulations governing the award of the degree of Doctor of Philosophy in Agricultural Economics of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to Almighty God the creator of the universe. Also, to my late parents, my wife and children and the entire members of my family both immediate and extended.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACGSF – Agricultural Credit Guarantee Scheme Fund

ADENI – Agricultural Development in Nigeria

ADP's – Agricultural Development Projects

AE – Allocative Efficiency

AFS – African Fertilizer Summit

ATA – Agricultural Transformation Agenda

ATAP – Agricultural Transformation Action Plan

BCGA – British Cotton Growers' Association

Bt Cotton – *Bacillus thuringiensis* (Bt) Cotton

DEA – Data Envelopment Analysis

DFRRI – Directorate of Food Road and Rural Infrastructure

EE – Economic Efficiency

FAO – Food and Agriculture Organisation

FARA – Forum for Agricultural Research in Africa

ICAC – International Cotton Association Committee

IFDC – International Fertilizer Development Council

LBA's – Licensed Buying Agents

NACB – NigerianAgricultural and Co-operative Bank

NAERLS – National Agricultural Extension and Research Liaison Services

NALDA – National Agricultural Land Development Authorities

NCEMA – Nigeria Centre for Economic Management

NCMB's – Nigerian Commodity Marketing Boards

NIRSAL – Nigerian Incentive based Risk Sharing Agricultural Lending

NPC – National Population Commission

NRCRI – National Root Crop Research Institute

RUSEP – Rural Sector Programme

SFA – Stochastic Frontier Analysis

TE – Technical Efficiency

UNFPA – United Nations Population Fund

USAID – United States Agency for International Development

USDA – United States Development of Agriculture

WACOT – West African Cotton Company

ZADP – ZamfaraState Agricultural Development Project

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ABSTRACT

The focus of this thesis was on economic analysis of cotton production and supply trend estimation. The specific objectives described socio-economic characteristics, predicted cotton production trends, described resource utilisation and production technologies and determined profits among cotton farmers. Also, the study estimated the levels of technical, allocative and economic efficiencies, examined the constraints to cotton production and estimated response of cotton supply to price changes in the study area. Primary and secondary data were used for the study. Structured questionnaire was used to collect information from farmers. The list from reconnaissance survey from Zamfara State Agricultural Development Project was used to randomly select 15% of farmers from selected villages of the four Local Government Areas to give a sample size of 220 farmers. The analytical tools used to achieve the stated objectives were descriptive statistics, grafted polynomial models, net farm income model, stochastic frontier models and models with lagged variables. The study found that the mean age of the farmers was 39 years and 30% of the farmers had no formal education while about 74% were married. Also, about 90% were males and having a mean of about 12 years of experience in farming. In resource utilisation and production technologies, about 35% used seed retained from previous planting while 36% procured fertilizers from Agricultural Development Projects. About 41% owned their land through inheritance, 53% used self-financing for their production while 54% used hired labour. The production trends showed that the values of the grafted (mean) function of 123,000 tons were closer to the observed values of 129,000 tons resulting in smaller difference during the sub-period under consideration when compared to the linear values of 137,000 tons. Analysis of net farm income showed a profit of ₦ 51, 414.51/ha if all labour were valued and the returns per man-day of ₦ 966.80 while the returns to investment showed that a farmer gains ₦ 1.11 per Naira invested in cotton production. The input-output analysis showed that the average yield of cotton produced was 773.319kg/ha while return to scale (RTS) was 0.791 depicting a positive decreasing returns to scale and at stage II of the production function. The average technical, allocative and economic efficiency scores were 0.67, 0.64 and 0.44 respectively. The results of cotton production constraints showed that majority of the farmers faced inadequate soil fertility, inadequate loan and credit supply and inadequate market and marketing facilities. The application of models with lagged variables revealed that the coefficients of the explanatory variables in the analysis (P_t), (P_{t-1}) and (P_{t-2}) were significant at 1% and 10% levels of probability for the Nerlovian Adaptive Expectation Model and the Constant Elasticity Adjustment Model. The study showed that socio-economic characteristics and production technologies had meaningful bearings on production. The grafted model gave a satisfactory result since the grafted mean values were closer to the observed values than the linear values while cotton production was profitable and farmers' productivities were above average. The response of cotton supply to price changes was elastic and satisfactory. It was recommended that adequate and intensive research and extension service delivery programme should pursue a consistent and systematic campaign for cotton production. Efficiency of cotton farmers should be supported by government through timely distribution of inputs. An enabling marketing policy should be instituted by government. This could be achieved through Product Marketing Corporation which would serve as a clearing house for cotton marketing in Nigeria.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

In Nigeria, the agricultural sector has been invaluable in supporting economic growth and development since independence in 1960. Indeed, before the discovery and exploration of petroleum, the Nigerian economy depended on funds generated from agricultural export expansion for the development of other sectors of the economy. Due to its important role in nation building, the agricultural sector has continued to be a target of government policies overtime (Eyo, 2008). In other words, agriculture has traditionally been characterised as the mainstay of the Nigerian economy in spite of the growing importance of oil exploration in Nigeria. Nigeria has remained essentially an agrarian economy. In the context of the Nigerian economy, agriculture is tied to the various sectors and is essentially for generating broad-based growth and development. Agriculture is therefore fundamental to the sustenance of life and has become the bed-rock of economic development as it still accounts for significant share in Gross Domestic product (GDP), total exports and employing the bulk of the total labour force (Jimaza and Sanni, 2003).

In this regard, cotton has been chosen to form the focus of this study. Cotton as a sub-sector of the crop production sector has been playing similar roles in the economy. Alam *et al.* (2013) asserted that cotton (*Gossypium Spp*) remains by far the most important natural fibre, it represents 38% of the fibre market. Cotton is crucially important for income, raw materials and employment provided its production and processing is adequate. In Nigeria, prior to the oil boom, cotton was one of the main source of foreign exchange and second largest employer of labour after the public sector. Indeed, the contribution of the crop production sub-sector is one of the indicators

of the roles played by agriculture. This is in terms of some cash crops particularly cocoa cotton, groundnuts and some other staple food crops contributing to the expansion of the economy of the country.

In the same vein, Oji-Okoro (2011) was of the opinion that agricultural resource has been an important sector in the Nigerian economy since 1960's and is still a major sector despite the oil boom; basically it provides employment opportunities for the teeming population, eradicates poverty and contributes to the growth of the economy. Ogen (2007) noted that a strong and efficient agricultural sector would enable a country to feed its growing population, generate employment, earn foreign exchange and provide raw materials for industries. The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multifunctional nature of agriculture. In the same vein, Ega (2010) asserted that agriculture provides about 90% of nation's total food requirements and merits priority attention from policy makers not only because of its economic significance but also because of its importance in the war against hunger and poverty and its significance in rural development.

At independence, the contribution of agriculture to the GDP was about 25% between 1975 and 1977. This was partly due to the phenomenal growth of the mining and partly as a result of the disincentives created by macroeconomic environment, (NBS) (2011). Similarly, the growth rate of agricultural productivity exhibited a downward trend during the period. Thus, between 1970 and 1982 agricultural productivity stagnated at less than one percent annual growth rate at a time when the population growth rate was 2.5 to 3.0% per annum (Adubi, 2001). According to the National Bureau of Statistics (NBS) (2011), the *percent* share in the GDP of the crop sub-sector between 1981 to1990

had been fluctuating between 28.37% and 22.99% and did not register any significant increase. This trend continued as the contribution of the crop sub-sector was almost stagnant at about 36% from 1994 to 1997 and from 2003 to 2006. Also, the Central Bank of Nigeria CBN, (2011) in its annual report indicated the *per cent* share in total of the contribution of the agricultural sector to the GDP at 1990 constant basic prices. From 2007 through 2012, the share has been declining from 42% of the total GDP to 40.2%. The place of the crop production sub-sector in the total GDP have shown similar trend with a decline from 37.5% to 35.8% between the same period. Despite this marginal decline in recent years, the demand for many agricultural products outweighs the supply.

Therefore, there has not been any meaningful impact of agriculture in achieving its target of self-sufficiency in food production and meeting the desired need of supplying raw materials for agro-based industries, sustainable food security programme and exporting the marketable surpluses to earn foreign exchange for the country. This problem has been attributed by agricultural policy makers to the neglect of agricultural sector as a result of oil boom which led to a fall in food and export or cash crop production. The fluctuating pattern was more prominent and salient with respect to fibre and oil crops such as cotton and groundnuts. It is with respect to this that cotton was chosen to form the basis of this study. With regards to fibre crop, cotton is an important crop in the world, it ranks first followed by jute, kenaf and sisal in the world production of fibres. It is noticeable from the performance of the cotton production industry that since 2003/2004 cropping season, there has been a fall and fluctuating pattern in the production trends in cotton. According to United State Department of Agriculture (USDA, 2011), the production trend in cotton had not witnessed remarkable

improvement between 2007/2008 cropping year while the 2010-2012 cropping seasons experienced a decline.

This phenomenon revealed a glaring disparity between demand and supply thereby creating a gap in the cotton production industry. Batterham, (2000) asserted that supply is yet to satisfy the level of demand for cotton. This has caused great concern in the textile cotton fibre supply situation in the local market and export profile in the country thereby having a declining effect in its contribution to the agricultural economy of the country. According to Raw Material and Research Development Council (RMRDC) (2004) consumption of cotton lint by textile industry in Nigeria is about 100, 000 metric tons plus or minus 15%. Textile mills are therefore forced to import 15, 000 metric tons of cotton in order to cover the shortfall in local supply and for certain specific requirements for finer yarns such as 30-40 inches, which is not grown locally. It is therefore clear that the local supply is not enough to meet the demand of the product.

However, government attention has been directed towards the agricultural sector of the economy. Therefore, from 1971 onwards, government explored policies and strategies to circumvent various problems confronting agricultural production. These policy measures served as impetus and were aimed towards restoring the role of agriculture and increased productivity in the agricultural sector. Some of these policies and programmes relevant to the food sector and cotton fibre production industry include:

i. Nigerian Commodity Marketing Boards (NCMBs) of 1975
ii. Agricultural Development Projects (ADPs) of 1976 (World Bank Assisted Project) rendering agro-services to farmers.
iii. Land use decree (No. 6) of 1978.

iv. Agricultural Loan and Credit Systems such as, Nigerian Agricultural and Co-operative Bank (NACB) and Agricultural Credit Guarantee Scheme Fund (ACGSF) of 1978 and 1977 respectively.

By 1986, government deemphasized the direct food production policy and adopted an integrated approach that combined agriculture with rural development. As a result of this new agricultural development thrust, government established;

v. National Agricultural Land Development Authorities (NALDAs) of January, 1991.

vi. Directorate of Food, Road and Rural Infrastructure (DFRRI) of 1986 and a preponderance of various Rural Sector Programmes (RUSEP) in the present political dispensation in 1999 till date.

These policies were conceived, planned and implemented to solve some problems militating against agricultural production. Instead, the contribution of agriculture and crop production sector in particular has not been meaningful or significant in the agricultural economy of the country. This is evident in the downward trend of the agricultural sector in Nigeria. In order to further ameliorate these problems in the cotton-fibre production industry, the Federal Government's transformation agenda on cotton was instituted recently. Some of the policy guidelines are those enshrined in the Agricultural Transformation Action Plan (ATAP) and the Federal Government Partnership with West African Cotton Company (WACOT).

1.1.1 Agricultural transformation action plan (ATAP) of 2012 on cotton

This is the most recent agricultural policy that is geared towards reviving the agricultural sector in Nigeria. It is achievable through mass involvement of private sector, economic experts, researchers, government and its agencies. According to

Adeshina (2012) the transformation agenda is an all inclusive policy that is designed to generate 3.5million employment, provide enough food by adding 20 million tonnes of food to the supply chains, move Nigeria from being an importer of food to a self-sufficient country in food production and also become one of the exporting countries so as to earn foreign exchange.

In the ATAP, the Federal Government signed a memorandum of understanding (MoU) with the West African Cotton Company (WACOT) to revive the dwindling fortunes of this sector. The partnership of the Federal Government with WACOT would help in how best to resuscitate cotton production and the urgent need to restore the past glory of the cotton industry in Nigeria. The following policy instruments contained in the public gazette covered by people's daily newspaper of 4th September, (2012) (www.peoplesdaily-online.com) are highlighted as follows:

i. WACOT proposed a four year quality seed multiplication and distribution plan to enhance remunerative price for farmers through the use of appropriate packaging and cotton grading.

ii. The government plans to generate 3.5million employment through the resuscitation of farmers' groups, garment producers, cotton merchants, functional ginneries and spinners throughout the country.

iii. Government will initiate growth enhancement support scheme and make available more hectares of land for cotton cultivation. About 105,307 cotton farmers across the targeted cotton producing states would benefit from seed, fertilizers and agro-chemicals at subsidised rates.

iv. Government had taken measures towards eliminating illegal textile importers thereby checking the depletion of the country's foreign reserves.

v. In order to encourage cotton production, the Bank of Industry (BoI) has earmarked ₦70 Billion for disbursement as loan to cotton farmers so as to forestall endemic shortage of finance among cotton farmers.

vi. The Federal Government establishes Regional Cotton Research Centre at the Institute of Agricultural Research (IAR), Ahmadu Bello University Zaria, to serve as capacity building and encourage cotton cultivation.

vii. Measures have been taken to provide more extension materials, training of farmers and strengthening of cotton related associations. This will make Nigeria to be self-sufficient in cotton in terms of satisfying the demand of local industries as well as exporting surplus.

1.2 Problem Statement

The phenomenon of downward trend in the Nigerian agricultural sector since 1970's has been a matter of concern in the country. This had caused great concern among researchers, agricultural administrators and policy makers in the Nigerian Agricultural Sector. The cotton production industry as a sub-sector of the crop production sector has experienced similar downturn over the years (CBN, 2011). This was clearly demonstrated through its persistent decline and a conspicuous fall in its level of output at various time periods. This had undermined its role in providing raw materials for fabric and textile industries, decline earning in foreign exchange through export and in providing cotton seed for the extraction of oil and supply of cotton seed cake for poultry and livestock feed mills in the country (USDA 2011).

In fact, the cotton production industries have not met the demand for the required lint and cotton seed. The Raw Material and Research Development Council (RMRDC)

(2004) reported that against a total demand of about 80, 000 MT of lint per annum (240,000 MT of seed cotton) by textile mills, the total production of lint has been less, thus resulting in a gap between demand and supply. It is expected that this gap will widen further as the steps taken by government to revive the textile industry may lead to increase in capacity utilisation, thus resulting in higher demand for cotton. The phenomenon was clearly revealed by the fact that most ginneries across the country have to operate below capacity. This claim was substantiated by Adeshina (2012) who asserted that, the industries contribution to the value addition of cotton had dropped significantly from 25% in 1980 to 5% presently. He said, out of the 51 ginneries in operation in the 80's, only 10 ginneries were currently functional at low capacity. In addition, inadequate production of local textile and fabric materials has led to importation to satisfy the domestic demand thereby reducing the foreign exchange reserve portfolio of the country.

The United State Department of Agriculture (USDA, 2011) in its statistics unveiled that cotton production has been on the decline since demand outweighs supply of the crop in the textile industry. In other words, the low level of supply could not meet the local demand and cotton was not exported from Nigeria. From 2002 to 2012, cotton production had not significantly increased. According to Onu and Okunmadewa (2008), the deregulation of the cotton market served as a thrust towards liberalizing its pricing mechanism when the organized statutory commodity marketing boards were abolished in Nigeria in January, 1986. These were boards through which farmers could offer their crops such as cotton, groundnuts, grains and other cash crops for sale and subsequently for exports. The deregulation of cotton market was seen as disincentive to cotton

farmers in terms of organised market prices, inputs and output culminating in declining production and output profile in Nigeria.

Indeed, the decline in cotton production among cotton farmers has been an endemic problem associated with the characteristics of most traditional farmers. This is in terms of low productivity of resources and economic efficiency. However, in productivity and economic efficiency studies, there are many factors that have serious implications on the level of output produced by farmers in agricultural production industry. It is presumed that some of the factors attributed to farmers' efficiency and productivity are associated with the method and cultural practices used in inputs allocation and utilisation. This depends on the existing institutional framework and the prevailing socio-economic conditions of farmers. This determines farmers' ability to make profits and operate their cotton production enterprises with the desired level of economic efficiency attainable among cotton farmers.

In this regard, the study aimed at investigating the problems associated with the downward trend and low productivity of cotton with the anticipation of detecting and unveiling the basis of this decline and low productivity among farmers. It is based on this credence that the following research questions were addressed by this study:

i. What are the socio-economic characteristics of cotton farmers?
ii. What are the patterns of production trends for cotton in the state?
iii. What are the patterns of resource utilization in cotton production?
iv. Is there profit or otherwise in cotton production in the state?
v. What is the level of economic efficiency in cotton production in the state?
vi. What are the constraints to cotton production in the state?

vii. What is the response of cotton supply to price changes in the cotton market in the state?

1.3 Objectives of the Study

The broad objective of the study is to carry out economic analysis of cotton production and supply trend among cotton farmers in the study area. The specific objectives of the study are to;

i. describe the socio-economic characteristics of farmers in the study area;
ii. estimate and predict cotton production trends in the state;
iii. examine the pattern of resource utilization and production technologies in cotton production;
iv. determine the level of profit in cotton production;
v. estimate the levels of technical, allocative and economic efficiencies among cotton farmers;
vi. examine the constraints to cotton production, and
vii. estimate the response of cotton supply to price changes in the cotton market.

1.4 Research Hypotheses

These are tentative statements which state the expected possible relationship between variables by being conjective on the direction of research findings. They make possible explanation of what the study is attempting to find out. According to Rasaq and Ajayi, (2000) hypothesis is a good instrument for testing the validity and reliability of the research findings as it is often claimed that the most important characteristic of a good hypothesis is testability. Some of the hypotheses that were tested were stated in null forms as follows:

$H0_{1;}$ Cotton farmers are not technically, allocatively and economically efficient in cotton production in the study area.

$H0_{2;}$ There is no significant relationship between socio-economic characteristics of farmers and the technical, allocative and economic efficiencies in the study area.

$H0_{3}$; There is no significant difference between cost and returns in cotton production in the study area.

$H0_{4;}$ There is no significant difference between the trend in supply and prices (P_t, P_{t-1} and P_c) of cotton trends in the study area.

1.5 Justification for the Study

This study is essential because the contribution of cotton to the agricultural sector of the country has been declining. The increasing demand for cotton lint and seed to make the textile and oil processing industries sustainable made the research to examine the circumstances that led to the fluctuation in the first instance and examine factors that would lead to improvement in the production of the crop in another instance. It was important to identify and examine socio-economic attributes of cotton farmers so as to determine their effects on seed cotton output in the study area. The study examined production constraints, resource use and utilization pattern and estimate cost and returns among cotton farmers. Also, the study examined economic efficiency and productivity of cotton farmers in the study area.

In economic time series, the problem of paucity of data and their availability has always been a matter of concern when attempting to make appropriate forecasts and predictions in agricultural production. This problem is most salient in agriculture due to vagaries of weather, biological and government policy variables such that future levels of output,

inputs and their respective prices cannot be accurately predicted. In this regard, adequate information and knowledge about production trends, price trends and the response of cotton supply to price changes in the market are required. This is to provide insight into proper predictions and forecasts into the future of cotton production so as to enhance better decisions on planning and investment. This will enhance formulation of relevant policy that would assist farmers and improve growth in this sub-sector. This could be made possible by providing such information for farmers producing cotton so as to enable them consider various choices in production as a viable option in the farming enterprise. It is as a result of this that this aspect of forecasting production trends was undertaken.

On the whole, the result would be of national importance for policy makers who design and institute policy measures for a prospective cotton industry specifically and the agricultural sector as a whole. The study would be a versatile tool for researchers who wish to investigate into all facets of problems in cotton production and other related studies in agricultural research. It was also envisaged that the result of this study would make valuable contributions for analysts, technologists and students who are willing to source and utilise information for their academic pursuits and advancement in learning.

1.6 Organisation of the Study

Chapter I presents introduction of the study on background to the study, problem statement, objectives of the study, research hypotheses and justification for the study. Chapter II of this study deals with review of literature on origin and development of cotton, importance of cotton in the Nigerian economy, production and marketing trends in cotton and resource productivity, efficiency and measurement in agriculture. Others

include cotton production constraints, production technologies, resource use and utilization pattern among cotton farmers and a review of previous studies on some empirical econometric analysis related to the study. Chapter III provides the methodology for analyzing the data collected. Chapter IV is the presentation of results and discussion while chapter V includes the summary, conclusion and recommendations.

1.7 Scope and Limitations of the Study

The study covered some of the facets that made up the economic analysis and supply trend estimation of cotton in Zamfara State, Nigeria. The study empirically investigated the socio-economic attributes of farmers growing cotton, farmers' ability to procure, allocate and utilise inputs in cotton production efficiently and make profits in their cotton production enterprises. Also, the study relied solely on the information and cross-sectional data collected from the field as primary data based on 2012/2013 cropping season using structured questionnaire and the supply trend estimation was restricted to the period between 1995 and 2013 based on secondary data from various sources. On the whole, inadequate fund to expand the extent of the research work was a limitation to the study. Also, insufficient time was a restriction to the study which had limited the coverage of more study areas.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Conceptual Framework

The conceptual aspects that were covered in this section includes the concept of historical overview and development of cotton, economic importance of cotton in the Nigerian economy, production and marketing trends in cotton, cotton production constraints and production technologies and resource use pattern in cotton production.

2.1.1 The concept of historical overview and development of cotton

The English word cotton came from the Arabic word Qutun or Kutun. Cotton is the most important cash crop in areas where the production is quite significant and vast. Cotton is the most important of all fibrous plants used by man for clothing. The time cotton fibre was first used by man is not known. The oldest archaeological record of cotton textiles dated back to about 3,000 B.C which were found in the valley of the Indus River in West Pakistan (Fisher, 1969). The existence of cotton in the Indus civilization dated back to about 3,000 B.C and the pre-Columbian civilization. Americans grew their own species of new world cotton. When the true-to-type cotton was cultivated and most of those found wild can be identified as escapes from cultivation. The earlier botanist regarded the cultivated farms as having been domesticated from wild cotton species (Prentice, 1972). The exact origin of the crop is not known. According to Cooper (1990) cotton might have originated from central and south America. Commercial cotton production started in Nigeria in the year 1902 by the British Cotton Growing Association popularly known as BCGA. The BCGA was set up to assist in finding new sources of cotton to supply the Lancashire cotton industry

and was financed by labour organization in Lancashire and by the United Kingdom Government.

In Nigeria, the association commenced operation in the South with the idea of plantation production of cotton. Moor plantation in Ibadan was acquired for this purpose but this concept was abandoned as unworkable and small farm production was developed to replace it. Indeed, it was finally discovered that, the humidity was high coupled with the scenario of heavy rainfall pattern towards the maturity period of cotton. Hence, Moor plantain was found to be unsuitable for cotton production. Thereafter, the association moved Northwards to locate suitable ecological zones in Northern Nigeria where cotton could be extensively cultivated. The association undertook to provide seed, establish buying centres and purchase cotton at guaranteed minimum price as well as build ginneries and carryout experimental work on the crop. While at the state, development was slow, cotton growing spread Northwards with improvement of communications particularly the railways and departments of agriculture were established partly due to cotton development requirement (Jones, 1969).

2.1.2 The concept of economic importance of cotton in the Nigerian economy

Agriculture constitutes one of the most important sectors of the Nigerian economy. The sector is particularly important in terms of employment generations and its contribution to the gross domestic product (GDP) and export earnings. However, the sector has been characterised since 1970 by declining productivity and increase dependence on import of food and raw materials (Manyong *et al.,* 2005). Efforts have been made by various governments to reverse the trend by diversification of the productive base through increase production of cash crops such as cotton, groundnuts, palm oil, rubber, cocoa

and coffee. These crops were the main export crops of the country where large revenue have been generated in the 60's (Idem, 1999). However, the role of generating revenue through exports had experienced decline. The decline in total food and fibre crop production and astronomical rise in input prices derived it legitimacy from the major consequences of neglect of the agricultural sector in Nigeria during the oil boom years of between 1970 and 1980's. These general problems of agricultural sector also affect the cotton industries which has hitherto played an important role in the economy.

Cotton is a vital raw material for the country's textile industry. Initially, protection of the textile industry created demand for Nigerian cotton. Total demand for lint is stagnating because of the difficulties the Nigerian textile industry encounters to maintain their sales both within and outside Nigeria. Due to the relatively poor quality, the only outlet that exists for the national production is the textile industry. But now the competition from the world market is very fierce and textile industry is collapsing. This is not a desirable situation and therefore additional outlets must be found. So, Nigerian cotton sector will have to rely more on exportation to sustain its development. However, Nigeria's cotton lint is being rated as poor quality and it attracts 20-40% price discount in the international market because of its high trash content and polypropylene fibre contamination. If the Nigerian cotton sector has to compete with other international suppliers of cotton, it should improve on its cotton quality to be able to match international quality standard for lint cotton.

In cotton production, the main product is lint. For nearly 75% of producers and consumers after the saw ginning machine was invented, cotton seed was regarded as a waste product. For purpose of processing into usable items, cotton seed is divided into

five main products namely; cotton lint, cotton seed, cotton seed oil, cotton seed cake or meal and cotton seed hulls. Cotton is an important and a strategic product that feeds many industries. It can be considered both as a fiber crop and an oil crop. After the ginning process of raw cotton, the fiber is used mostly in textile industry, and its crust is used as an animal food (oil, cake and pulp). It is also used as cotton seed to be processed in oil industry, as crude oil to produce refined oil such as margarine oil and refined liquid, and soap stock, and as litter to feed bed and filling industry, war industry and cellulose chemical industry. Although its share in world merchandize trade is insignificant (0.10 to 0.15 % from 1990 to 2008), cotton is a significant crop to a number of developing countries with its substantial contribution to the labor industry and hence, to gross domestic production (GDP). For example, in Turkey, it provides about two million employments from textile to agriculture (Solakoglu *et al., 2013*).

The lint is the soft hair around the seed called floss. It is made of cellulose which serves as raw material in the textile industries to manufacture large proportion of adsorbent fabric for clothing as a natural textile fibre (Gwandi *et. al.*, 2010). Despite the declining trend of cotton share in textile fibres since 1970s, cotton still remains the most important natural fibre of the 20th century and it represents 30% of the fibre market in the early 2000's (Horton and Mackay, 2003). The lint is used extensively to produce thread after spinning. This forms the basis of the textiles and fabric industries which lie in the fact that, they are dependent on mass utilisation of thread to weave and produce fabric and cloths. Cotton is versatile in all aspects of human existence. Goreux (2003) asserted that cotton accounts for more than half of all fibre used in clothing, household furnishings and offices. Idem (1999) substantiated that, despite the competition from synthetic fibres cotton supplies about 80% of natural fibres and constitutes 50% of the

primary materials in the textiles materials throughout the world. The bonding of the fibres makes cotton ideal for making cloth and interlock when spun into long strands that can be easily dyed.

Cotton is used to manufacture a wide range of fabric materials. It is used for making cloth, sewing threads, rugs, cordage, papers, towels, cellulose products and tents. It can also be milled to make currency; seeds are crushed to extract vegetable oil and can also be woven after spinning to make fish nets (Sabo *et al*., 2009). Cotton is also used widely in hospitals, medical centres and clinics in cleaning and dressing wounds in surgical operation and other orthopaedic cases. At home, it is used domestically as bedding and cushioning materials. The lint is also used as wick when soaked in oil to serve as illuminant in the rural areas. The oil known as gossypol is the most important of the by-products. It is used in cooking, preparation of Salad, Mayonnaise, and Margarine, carrier in some drugs and in preparing vegetable oil that is packaged for sale. The by-product of cotton seed oil extraction is the cotton seed cake. It is one of the ingredients needed in the formulation and compounding livestock feeds because it is quite rich in protein. Low grade waste products and fuzz are consumed in the production of felts or bathing materials. It is used in matresses and other bedding products, writing papers, upholstery, rayons, photographic material and x-ray films and in the production of explosives.

2.1.3 Concept of cotton production and marketing trends in Nigeria

Cotton has a relatively long history in Nigeria. The cultivation of the crop started well before the colonial era even though it was not produced in commercial quantities until the onset of the activities of the British Cotton Growers' Association (BCGA) in 1903

as earlier stated. Since then, considerable attention and resources have been devoted to the improvement of cotton production and utilization by both public and private organizations. Cotton is grown as a cash crop by about 0.8 million farmers on a total estimated area ranging from 0.8-0.9 million hectares (NBS, 2011). The major feature of cotton production in Nigeria is that about 80% of total production is by peasant farmers under rain-fed conditions with simple farm tools and animal drawn implements (Onu and Atala, 1992., Adeniji, 2002). This implies that, cotton growers are small-scale, resource-poor farmers cultivating between 1 and 3 hectares under rain-fed conditions. Characteristically, most field operations are not mechanized and farmers are resource-poor and illiterate (Federal Office of Statistics, FOS, 2009).

Unfortunately, total production remains far below the national requirements of the textiles and the oil mills. This is as a result of low average yield of the crop on farmers plot of about 400 – 500kg seed cotton per hectare which is below the genetic yield potential of about 2.5 – 3.0 tons seed cotton per hectare of the varieties being grown and also yield that are obtainable on research plots of 1.5 – 2.5 tons ha^{-1} (Ogunlela, 2004). In other words, the level of production or supply of cotton is quite low and could not meet up with the level of consumption or demand both in the local market and for export. In the same vein, (FOS) (2009) reported that, the total consumption of cotton in Nigeria is about 80,000MT of lint annually or 240,000MT seed cotton. Production in 2003 was 32,000MT which was less than half of the demand.

According to Mshelia, (1991) cotton production in the country has taken a downward trend as the gap between demand and supply is becoming wider every year because the supply does not equate with demand. If such situation persists, it means that the demand

for the raw material cannot be met by the local industries. According to United State Agency for International Development (USAID 2012), the current cotton production in Nigeria as reported by USAID is 120,000 tons in the year 2012. This had endangered the future of the Nigerian textiles thereby causing an unnecessary drain of the country's foreign exchange. This problem was further exacerbated by the Structural Adjustment Programme (SAP) in the Nigerian economy that led to the scrapping of the commodity marketing boards by the Federal Government in January 1986.

In Nigeria, the cotton marketing board is the monopoly and institutionalised market geared towards marketing cotton for local consumption by textile industries, feed mills and for export. The cotton marketing board had its headquarters in Funtua. According to Onu and Okunmadewa (2008) the deregulation of the cotton market was a major reform policy which sought to reduce distortion in the structure of the market through reduction in government intervention. This was a process referred to as the market liberalisation. Market liberalisation portends to make farmers offer their cotton for sale to buyers directly by removing adverse impact of marketing agents. This has helped to check the excesses of middlemen, unscrupulous behaviour of cotton merchants and marketing agents and the resultant effect of extra marketing charges and costs which has been responsible for reducing farmers' share and profit.

Despite the measure on cotton marketing, it was reported that the deregulation of cotton market has made it absolutely impossible to effectively monitor the movement of seed cotton, lint and seed (Ogunlela and Echekwu, 1989). Also, the scrapping of the cotton marketing board which is an organized marketing system for cotton had thwarted its pricing mechanism. Food and Agricultural Organisation (FAO) (2008) revealed that,

pricing of cotton has been a subject of controversy, since the government deregulated the cotton market. Consequently, the trading price of cotton is determined in the open market. Between 2002 and 2004, the average price of cotton lint was ₦135, 000.00 metric tons. The crash in the world market price of cotton lint has discouraged production, although elsewhere, the price has since appreciated. Deregulation of the price of cotton lint in the international market has led to an unstable but high market price. Significant increase in cotton price during the 2003 cropping season was attributed to government policy which removed bottlenecks in export of the crop (FAO, 2008).

2.1.4 Production technologies, resource use and utilisation pattern among cotton farmers

These are technological packages employed and pattern of resource use and utilisation in cotton production activities. Such technological packages may be traditional cultural practices common among farmers while some are new through adoption and innovation or modified new technologies. Some of these technological packages are categorized broadly into cultural practices and cropping systems adopted, input procurement methods and agro-services that cotton farmers employed in cotton production.

It is important for farmers to make rational use and utilization of various resources available to them in the farm. These resources are recommended technological packages which are needed to be adopted in order to increase productivity. Atala and Kuchinda (2012) asserted that generation and adoption of new improved technologies are the fundamental triggers of “Green Revolutions”. Any future green revolution would also be spurred by generation and adoption of new improved agricultural technologies.

According to Emea and Eugene (1998) land is a fundamental factor of production in the agricultural sector. It has an essential role to play in increasing as well as sustaining agricultural production. The extent to which this role is performed is determined in part by method of land acquisition and arrangements for the ownership and use of land. According to Ekong (2005) farmers could be indifferent in utilizing new technologies if the land tenure system does not allow personal ownership to execute the technology. Among the farming population in Nigeria, land acquisition and utilisation in most cases is through inheritance, allocation and gifts, sales, pledges, lease, purchase and loans, (Ekong 2005., Ajayi and Ogunlola, 2006).

Furthermore, farmers prefer to allocate small portion of land to cotton because of poor marketing of the crop and food scarcity. Due to shortage of food crops, farmers prefer to grow more food crops and less of cotton. Ogunlela (2004) substantiated this fact by asserting that farmers preferred to plant food first at the expenses of labour for planting cotton. This reduces seed cotton yield due to delayed planting. Cotton farmers utilised various technological packages as evident in recommended practices offered to them for adoption and innovation. Some of the recommended technological packages offered to farmers were timely land preparation such as ploughing, harrowing and ridging, timely planting, close spacing, timely fertilizer application and timely weeding. All these packages were disseminated by agricultural extension agents. The ultimate aim of extension services is to enhance farmer's ability to efficiently utilize resources in their crop production activities.

According to Atala and Kuchinda, (2012) over half of the 17 cotton production technologies were adapted/modified by 50-96% of the farmers who produce cotton. The technologies that were modified by the highest number of farmers were;

i. Sowing date of mid-June (96%); ii. Calcium Ammonium Nitrate (CAN) fertilizer application (96%); iii. Boronated Single Super Phosphate (SSP) fertilizer application (96%); iv. These were followed by; v. Chemical spraying regime (6 sprays at weekly interval 95%), vi. Ridging across slopes/crossing in alternate furrows (86%) and vii. Sourcing seed from accredited sources (66%). The technologies least modified by the farmers were; viii. Cutting/removing/burning of all cotton stalks known as cotton close season; ix. Weed control; x. Avoiding contamination with dirt and thrash.

In order to acquire and utilize these recommended and improved technologies, there is need for financial assistance through agricultural loan and credit. Increased amount of credit available to farmers to use as enhancing factor has led to adoption of improved and modern technologies. Agbamu *et al.* (1996) reported that, credit is vital to agricultural transformation. It contributes to social welfare of farmers, enhances production and helps in capital formation and sustainability of income. They also identified problems emanating from unavailability of credit to include low productivity, inability to adopt recommended practices, poor marketing and distribution arrangement.

In terms of labour inputs required in farmers' production activities, cotton production requires copious amount of labour at the "peak period" of labour demand. This is because cotton requires constant spraying and frequent pickings at the period of harvest.

(Odoemenem, 2007, Adeniji, 2007) attested to this fact, since they opined that labour intensiveness and capital investment associated with cotton production render it a disadvantaged crop among the competing crops such as cereals and pulses which are also grown by farmers. Therefore, the tendency is that more labour is devoted to relatively high yield obtained from cereals requiring less labour and other investment.

Ahmed *et al.* (2012) conducted an experiment during 2011 cropping season to evaluate suitable weed control treatments for large scale cotton production system in which land preparation and appropriate agronomic practices were applied. The results revealed that, the post emergence herbicide treatment produced higher seed cotton yield than the other treatments used in the farm. From this result, it is rational to subsume that weed control is an important cultural practice and production technological package enhancing increased productivity in cotton farms.

2.2 Cotton Production Constraints

It is important to provide insight into some of the cotton production constraints in Northern Nigeria. As it is with most food and fibre crops, a number of constraints beset cotton production in most producing areas. These constraints are divided into two main categories namely Environmental and Institutional constraints. According to Onyenweaku (2000) farmers are beset with a lot of constraints that prevent them from adopting improved and recommended practices and enhance farmers to increase their level of productivity and efficient use of resources. Environmental constraints are conceptualized here as all ecological factors affecting the performance, growth and yield of cotton. Some of the environmental constraints are soil and climatic constraints, genetic constraints and pest and disease constraints.

2.2.1 Soil and climatic constraints

Soils in cotton producing areas that is, Northern Sudan savanna ecological zones of Nigeria are sandy soils or sandy-loam which are poor in fertility. Therefore, fertilizer application particularly Nitrogen, Phosphorus and Potassium (N.P.K.) and Single Super Phosphate (S.S.P.) to provide nitrogen, phosphorus and potassium are required by farmers to replenish soil fertility and increase level of production. In some cases, cotton is grown sole but peasant cotton farmers prefer to grow cotton in mixture with groundnuts, maize, cowpea, sorghum and so on. This helps in augmenting soil fertility through improved cropping system and averts risk of soil depletion as one of the soil constraints in cotton production.

It was asserted that, fertilizer application is low among farmers. Fertilizer use is estimated to average 8 kg/ha per annum, compared to 100–200 kg/ha in developed agricultural economies. Improved crop varieties exist, but realization of yield potential requires a leap in the level of fertilizer use. As elsewhere in Nigeria, low fertilizer use is a serious constraint to agricultural productivity growth in Nigeria, where fertilizer use averages 10–15 kg/ha (International Fertilizer Development Council) (IFDC), 2006).

Furthermore, climatic elements have remarkable influences on some soil properties such as soil moisture, soil air, soil porosity and soil temperature which militate against cotton production. Such climatic problems include fluctuations in annual rainfall, too low or too high temperature, unavailable sunlight due to cloud cover; day length differences, air movement and circulation are all basic natural constraints to cotton production.

2.2.2 Genetic constraints

Genetic attributes of most crops are influenced by the environment. Genetic potential of cotton varieties serve as impediments to improved cotton productivity. Genetic traits or attributes such as high yielding varieties, pest and disease resistance, early maturity and ability to adjust and adapt to the environment are required by farmers. The inability of farmers to cultivate improved varieties constitutes a serious bottleneck. SAMCOT 8, 9 and 10 were three promising cotton varieties of short staple released by the Institute for Agricultural Research (IAR) to farmers as an action to ameliorate this cotton production constraint. The potential yield of these varieties range from 1,000-1,500 kg/ha.

2.2.3 Pest and disease constraints

Pest and disease occurrences are quite inevitable on most cotton farms. According to Adeniji (2007) cotton as a crop is susceptible to attack by numerous insects and diseases throughout the life cycle and effective control is inevitable if reasonable yield is expected. The most important and prevalent group of insects in terms of economic threshold or cost is the boll worm. He further asserted that apart from their inability to reduce yield, certain crop pests can also cause reduction in cotton lint quality *(Dysdercus spp)* causes discoloration of the lint which automatically represent serious decline in quality and substantial reduction in price.

Many institutions are important when considering agricultural production activities. Institutional constraints are those that had various forms of impact on production among farmers. This is because agricultural production and related activities such as processing, transportation, storage and marketing of agricultural products do not operate

in a vacuum. They serve many interrelated and interdependent functions. Institutions in their conceptual framework refer to socio-economic factors which determine the level of economic development achieved by any community or nation. With particular reference to cotton production, institutions that were reviewed here are those closely related to agriculture in a poor and agriculturally dominated economy as in Nigeria.

2.2.4 The land tenure constraints

The communal system of land ownership prevails among most ethnic groups in which individual ownership of land is embedded in group or kinship ownership Philip *et al.*, (2009). As it is the case in most Nigerian agrarian system and communities, land fragmentation is also an important problem in cotton producing areas. This has made farmers to operate small holdings on their cotton farms thereby hampering their ability to expand production.

In order to ensure that the problem of land is arrested, the land use decree (No. 6) of 1978 which was enshrined in the 1979 constitution of the Federal Republic of Nigeria was promulgated. This was introduced as a state intervention to modify some of the anomalies that have resulted from the principles and tenets guiding the land tenure system and land use pattern in Nigeria. Philip *et al*. (2009) asserted that communal ownership of land in Nigeria has been associated with such problems as limited tenure security, restrictions on farmers' mobility, and the inevitable fragmentation of holdings among future heirs. In addition, group ownership restricts access rights of community members outside the owning group, a situation that limits the use of land as collateral for agricultural credit. But communal ownership has also been credited with preserving

traditional land use practices such as bush fallowing, which has helped retard problems of land degradation.

2.2.5 Research and extension constraints

The intensification of research into technology and extension services into all facets of cotton production is to evolve ways of improving traditional practices through technical means and also extend this technical break-through by way of a well co-ordinated extension services. This ultimate objective may be addressed and executed through research institutions and agricultural policies and programmes. These constraints can be circumvented through the creation of more awareness for farmers by virtue of more extension advice and the desire for researchers to come to the farm to have on the spot assessment of their problems and also rehabilitation of farm service centres. This needs adequate funding in to research and extension.

Philip *et al.* (2009) posited that when research is poorly funded, agricultural technologies cannot be improved, and there will be no downstream farm income increase, rural employment generation, reduction in food prices, establishment of agro-based industries, and economic growth. Indeed, the absence of new technologies in agriculture will slow the growth of agricultural productivity and the reduction of rural poverty. Therefore, the participation of government and other stakeholders need to be improved.

Agricultural research in Nigeria has been primarily funded by the federal government. Funding, However, has become somewhat unstable since the early 1980s. Private-sector involvement in agricultural research has remained negligible to date. Some 59 higher

education agencies were involved in some form of agricultural research by 2000 (Beintema and Ayoola, 2004). In this regard, private sector participation in research and extension programmes in Nigeria will be a laudable approach. This will help in mainstreaming research and extension activities to be result oriented thereby serving as incentive for farmers the target beneficiaries.

2.2.6 Marketing constraints

Cotton production is accomplished and completed only if the product reaches the ultimate hand of buyers when consumption takes place. Marketing of the agricultural products begin at the farm gate when the farmers plan to meet the needs of the buyers . According to Philip *et al*. (2009) agricultural marketing efficiency in Nigeria is dismally low. First, transportation costs are high. In addition, road conditions are poor, which limits access to purchased inputs, credit, and output markets as well as reducing the transmission of key market signals. In the process of marketing, most cotton farmers suffer in the hands of unscrupulous middlemen who often exploit and deprive them of the benefits of their effort. The problem is compounded by lack of interference by government on matters affecting marketing and pricing of cotton. The scrapping of commodity marketing boards in Nigeria of which cotton marketing board was also affected made cotton marketing system to meet with unhealthy experiences and pronounced marketing constraints. By implication, Nigeria has liberalized its commodity markets and cotton is one of the freely traded. The dissolution of the marketing boards in January, 1986 allows supply and demand forces to determine cotton prices in the competitive market. This disrupted the organizational framework of cotton production, processing, marketing and finance.

2.2.7 Loan and credit constraints

Cotton farmers are usually faced with endemic financial, loan and credit constraints. Adeniji (2007) identified delay in payment for cotton purchased by buyers as another constraint. Farmers may be compelled to sell to ginners and cotton merchants on credit, either for financial problem or otherwise. Most often, they would not be paid and by the time such payment is made, it is possible it might have lost its value. Hence, the ability to earn income, save and invest in order to expand cotton production frontier becomes a constraint.

Therefore, cotton farmers of small-scale holdings are caught in a "vicious circle of poverty" from which it is very difficult to escape without outside financial assistance. Based on this premise, Awe (2013) asserted that in order to increase productivity, there is the need to mobilize more financial resources to enhance and boost agricultural productivity in Nigeria through the provision of modern technologies and mobilization of financial resources for re-positioning the agricultural sector in Nigeria.

2.3 Empirical Studies on Resource Productivity, Efficiency and Measurement in Agriculture

The concept of resource productivity and economic efficiency in agriculture is versatile in agricultural production and economic growth. It is one of the most pressing challenges of economic take-off, progress and transformation. This is because it serves as pre-requisite and pre-condition at both the early stages of economic development as well as in the permanent process of reinforcing the production instruments of any nation. This will help to evolve a sustainable economic growth upon which subsequent developments are predicated.

Productivity measures how well operators combine inputs to produce output. It is an indicator of the efficiency of production processes. Productivity growth is the rate of improvement on previous years' productivity and may be influenced by a wide range of factors, including changes in farm size, the rate of uptake of new technologies, the rate of technological discovery, policy settings, market forces and climate variation. (Mallawaarachchi *et al.,* 2009). Since one of the main objectives of any society is the attainment of an optimal level of living with a given amount of effort, any increase in the productivity of resources employed in farm production amount to growth. According to Omolehin *et al. (2014)* the efficiency of an economic unit is a 'holistic measure', in that it takes account of all resources used and all outputs produced in determining how well' or 'how effectively' the decision making unit combines inputs to produce output.

In essence, part of the output could be offered for sale to earn income. The income could be saved and invested thereby expanding the economic base of productivity of resources employed in production. Resource productivity is described in terms of individual resource inputs or in terms of combinations of them. For instance, labour productivity is defined as the ratio of total output to labour inputs. From this definition, maximum resource productivity implies obtaining maximum possible output from minimum possible set of inputs. Therefore, optimal productivity of resources implies efficient utilisation of resources in production.

There are a number of factors affecting the productivity of farmers such as age, cropping patterns, years of farming experience, and lack of access to credit which tend to impact negatively on productivity and efficiency. Despite all human and material

resources devoted to Nigerian agriculture, the productive efficiency of farmers for most crops still fall below 60%. The inefficiency problem is attributed to factors such as use of low input technologies, lack of knowledge of high input technologies and poor farm management skills, poor extension services, unavailability and high cost of inputs (Obasi, 2005, Anyanwu and Obasi, 2010a, Anyanwu and Obasi, 2010b). Previous studies on efficiency of resource utilisation and productivity showed that there are wide variations in the levels of productivity and productive efficiency for the major food crops, and the levels are far from the optimum. Therefore, this indicates that ample opportunities exist for the farmers to increase their productive efficiency (Moses and Adebayo, 2006; Oluwatosin, 2006; Ike and Ogba, 1996).

Farrel, (1957) in his case identified three forms of efficiency in agricultural production:

i. Technical Efficiency

According to him is the ratio of total output to total inputs. For a perfectly efficient firm, this ratio is unity. The larger the amount of input per unit of output, the smaller the size of this ratio becomes.

ii. Price Efficiency

This is defined by the tangency of the price line to the isoquant. This tangent depicts that a minimum possible amount of each input is being used to produce a unit of output at given level of prices

iii Economic Efficiency

This is a product of technical and price efficiencies. These measures of efficiency assume that a standard efficient production function exists which could be set up as a yardstick for measuring individual firms' performance.

Omolehin *et al.* (2014) asserted that technical efficiency involves a comparison between observed and optimal values of outputs and inputs while allocative reflects the

ability of the farmer to use inputs, or produce output, in the most profitable manner, given their respective prices and the production technology. Economic efficiency provides a measure for whole farm comparisons independent of the level of inputs used, or output produced, and can be used as a benchmark to make comparisons across many producers.

However, Productivity measures are broadly classified as estimates of total factor productivity involving all inputs or estimates of partial productivity involving a specific input or groups of inputs. The most commonly used productivity measurement is total factor productivity (TFP). The TFP estimates are simply the ratio of the total quantity of outputs produced by a farm to the total quantity of inputs used by that farm. TFP measurement illustrates trends occurring in productivity and can be used to isolate the factors that might be causing these trends, but it does not demonstrate how or why these factors are important. Trends in TFP are often a trigger for more detailed investigation into how productivity may be improved (Mallawaarachchi *et al*., 2009).

Agricultural productivity is measured as the ratio of final output, in appropriate units, to some measure of inputs. However, measures of productivity can be divided into partial or total measures depending on the number of inputs under consideration. Total output as a ratio of some measure of labor quantity, usually man days in developing countries, is called labor productivity (LP) and provides some notion of output per worker; while output per area of land planted is land productivity (Wiebe *et al.,* 2003; Zepeda 2001). The two previously mentioned measures are examples of single factor productivity (SFP), defined as the ratio of a measure of output quantity to the quantity of a single input used (Diewert and Nakamura 2005). Partial measures of productivity can be

misleading because they ignore the role of other inputs in any observed output changes (Zepeda 2001). As a result of this shortcoming, a total measure of productivity was developed. Total factor productivity (TFP) is defined as the ratio of a measure of total output quantity to a measure of the quantity of total input (Wiebe *et al.,* 2003; Zepeda 2001).

In the same vein, Forum for Agricultural Research in Africa (FARA), (2006) defines agricultural productivity as a measure of value of output for a given level of inputs. Agricultural productivity is affected by two broad factors. These are conventional inputs and non conventional inputs. Non-conventional inputs capture the impact of macroeconomic factors such as public investment and agro-ecological specific factors, while conventional inputs are traditional choice variables in the farmers' production decisions process. Conventional inputs could include labour intensity, fertilizer use, tractor use intensity and stock of livestock. While non-conventional inputs include land quality, irrigation, agricultural research, calorie availability, agricultural export growth and agricultural export instability (Frisvold and Ingram, 1994). However, under this study socio-economic factors and farm specific factors are envisioned to have an influence on efficiency. Increasing agricultural productivity requires one or more of the following: an increase in output and input with output increasing proportionately more than inputs; an increase in output while inputs remain the same; a decrease in both output and input with input decreasing more; or decreasing input while output remains the same (Adewuyi 2002., Oni *et al.,* 2009).

Productivity, as the rate of output per unit of input, may be influenced by a wide range of factors. In the agricultural context, the primary inputs of production include land,

labour, capital and material inputs, while outputs include crop and livestock products. Agricultural productivity levels are determined by the scale, output mix and technical efficiency of farms as well as and the state of available production technology, and are therefore influenced by factors such as: seasonal conditions, enterprise mix, farm size and farm operator human capital namely age, education/training, gender, experience ,household size, access to credit and marital status.(Mallawaarachchi *et al., 2009).*

Notable problems associated with low crop productivity on cotton farms include inappropriate decisions on how best to allocate resources, inadequate use of corresponding production inputs and inadequate adoption of improved technologies by farmers. Also, farmers might use resources rationally but not at the optimal level of efficiency (Gwandi *et al.,* 2010). All these contribute to low output or productivity among farming households. Iheanacho *et al.* (2000) used production function to estimate efficiency of resource use in crop production systems and determined the optimal resource utilization for adjustment in resource allocation. They reported that there is inefficiency in the use of resources. Hence, adjustment in resource allocation for economic optimum was required in order to meet the needed percentage change based on the quality of marginal value products and marginal factor costs of inputs. This is the economic efficiency involved in production.

The assessment and estimation of production efficiency of a farm business relative to other farm enterprises is still an important area of economic study. It is generally measured in terms of the efficiency with which input such as land, labour, seeds, fertilizers, herbicides, pesticides, tools, equipment and so on are converted to output within the production process (Umoh and Yusuf, 1999).

It is also a measure of the quantity of agricultural output produced when certain quantity of inputs are employed in production. This is a physical relationship between output and inputs used for producing specific agricultural commodity. It can also be measured in units such as kg, tons, bales, heads of livestock, litres of milk and so on. These quantities can be valued in monetary terms and appropriate measures adopted. Such measures include cost-returns analysis, input-output analysis, determination of resource use efficiency at optimal level when marginal value product (MVP) equals marginal factor costs (MFC) and other parametric and non-parametric models. These models can be evolved to determine productivity and resource use efficiency.

Furthermore, productivity can also be measured based on partial measure such as the amount of a single output per unit of a single input as in tons of crop per hectare of land. Also, it could be measured in terms of an index of multiple outputs divided by an index of multiple inputs. For example, the values of all farm outputs divide by the value of all farm inputs used in production can be used to measure productivity. Land productivity on one hand, helps in determining the amount of land needed to meet future world food needs and thus the potential level or pressure on land currently providing other environmental services. Labour productivity on the other hand, helps to determine the incomes and welfare of people employed in agriculture including the majority of rural people in developing countries. Hence, increased agricultural productivity will enhance the well-being of the national economy as a whole and improve the standard of living of the people.

2.4 Empirical Studies on Stochastic Frontier Analysis

Increased level of output cannot be obtained only by new or modern and recommended production practices on cotton farms but also through efficient use of these new technologies. As a result of paucity of information from extension agents to farmers, inadequate technical- know-how and low level of enlightenment, most farmers of small holdings may still be allocating and utilizing production inputs in less appropriate way. This will make them not to move towards the desired frontier level of technical, allocative and economic efficiencies in production.

Indeed, some studies have been carried out to estimate technical efficiency, allocative efficiency and economic efficiency of traditional farmers in various crop production enterprises but there is no preponderance of direct study related to the measurement of technical efficiency in Nigeria for cotton farmers. In this regard, empirical work on technical efficiency for cotton producers in Nigeria is quite limited and scanty. Therefore, due to lack of literature on technical efficiency on cotton production, this part aims at reviewing recent studies on stochastic frontier estimation.

However, part of this work has been based on technical efficiency approaches implemented by: Coelli (1996), Seyoum *et al.* (1998), Battese and Coelli (1992), Battese (1992) and Tzouvelekas *et al*. (2002). The technical efficiency of a given farm (at a given time period) is defined by Battese and Coelli, (1992) as the ratio of its mean production (conditional on its level of factor inputs and farm-effects) to the corresponding mean production if the farm utilises its levels of inputs most efficiently.

According to Farrell (1957) the efficiency of a farm is defined as the actual productivity of a farm relative to a maximal potential productivity. The maximal potential productivity is defined by a production frontier. Mohammad (2009) asserted that measurement of efficiency involves measurement of distances from observed data points to that of frontier. The measurement of productive efficiency has important implications for neoclassical theory of production economics and economic policy (Tietenberg, 2006). Measuring productivity efficiency allows one to test competing hypotheses regarding sources of efficiency or differentials in productivity (Farrell, 1957., Rios and Shively,2005). This will help us to take appropriate decision on whether to accept or reject such hypothesis for policy purpose. Furthermore, such measurements permit quantification of potential increases in output that might be associated with an increase in efficiency (Rios and Shively, 2005). The literature suggests several alternative approaches to measuring productive efficiency. Hence a technically efficient producer could produce the same output with less of at least one input, or could use the same inputs to produce more of at least one output.

2.4.1 Technical efficiency measurement

In accordance with assertion by Ogundele and Okoruwa, (2006), the pioneer work on efficiency was initiated by Farrell (1957) to which the present estimation method originated. Overtime, estimation of the production frontier has tended to follow two general paths; the full frontier where all observations are assumed to be along the frontier and the deviation from the frontier considered being inefficient. The other path has been the stochastic frontier estimation where the deviation from the frontier is attributed to the random component reflecting measurement error and statistical noise and an inefficiency component

The estimation of full frontier has been based on either non-parametric approach where technical efficiency is estimated by solving the linear programming for each individual farm/firm or through parametric approach where the estimation is by statistical techniques. Under the parametric approach, there are two methods namely; deterministic and stochastic frontier method. The deterministic method just like the non-parametric approach envelops all of the data of the farm (Neff *et al.,* 1993). The major drawback of these methods is that since it forces all outputs to a frontier it is sensitive to outliers that, if large, distort efficiency measurements (Ogundele and Okoruwa, 2006).

The stochastic parametric method however incorporates the random error of regression. Therefore random error captures the effect of unimportant left out variables and errors of dependent variables as well as the farm specific inefficiencies. It is because of this decomposition of error that makes this method of estimation superior to others. It provides the farm efficiency estimates with much lower variability than any other method due to the error term decomposition (Neff *et al.,* 1993). What should have been its major weakness as opposed to non-parametric measurements was its inability to construct different frontier for every observation (Neff *et al.,* 1993, Ogundele and Okoruwa, 2006). This method adopted a stochastic frontier approach for efficiency analysis but did not consider institutional factors because they are sometimes elusive (Kirsten and Vink, 2006).

2.4.2 Allocative efficiency measurement

Allocative efficiency is the ability of a farm to use inputs in optimal proportion, given their respective prices and the production technology. The use of an input is allocatively efficient if the value of marginal product is equal to its price (Mohammad, 2009).

Allocative inefficiency arises when factors of production are used in proportion that does not minimize the cost of producing a given level of output. For the farm to realise allocative efficiency, the following questions need to be answered;

i. What is the optimal combination of inputs so that output is produced at minimal cost?

ii. How much profit could be increased by simply reallocating resources?

Therefore, the farm has to choose a combination of inputs to be used in right proportions and technically efficient at low prices so that output is produced at minimal costs (Shahooth, *et al*., 2006). This results into profit maximization. Though there are new methods used to estimate allocative efficiency, traditionally it has been hard to estimate allocative efficiency without input and output prices. Based on this argument, some scholars like Farrell called it price efficiency, referring to the ability of a farm to choose the optimal combination of inputs given input prices (Badunenko, *et al*., 2006).

Thus, the allocatively efficient level of production is where the farm operates at the least-cost combination of inputs. Most studies have been using gains obtained by varying the input ratios based on assumptions about the future price structure of products such as cotton output and factor markets. Chukwuji *et al*. (2006) reviewed assumptions used by farmers to allocate resources for profit maximization. Such assumptions included, farmers choose the best combination (low costs) of inputs to produce profit maximizing output level; there is perfect competition in input and output markets; producers are price takers and assumed to have perfect market information; all inputs are of the same quality from all producers in the market.

Allocative efficiency can also be defined as the ratio between total costs of producing a unit of output using actual factor proportions in a technically efficient manner, and total costs of producing a unit of output using optimal factor proportions in a technically efficient manner (Inoni, 2007). Thus for the farm to maximize profit, under perfectly competitive markets, which requires that the extra revenue (Marginal Value Product) generated from the employment of an extra unit of a resource must be equal to its unit cost (Marginal Cost = unit price of input) (Chukwuji, *et al*., 2006). In summary, if the farm is to allocate resources efficiently and maximize its profits, the condition of marginal value product equals marginal factor cost should be achieved.

Inoni, (2007) carried out the study to examine efficient resource utilization in pond fish production in Delta State, Nigeria. The estimated allocative efficiency of production resources employed were 3.22, 0.0025, 0.00064, –0.00017, and 0.00025 respectively for pond size, feed resources, fingerlings, labour, and fixed costs. With exception of pond size which was under-utilized, all inputs used in fish farming were said to be over-utilized implying sub-optimal resource allocation in fish production. Based on results, fish farmers in Delta state of Nigeria needed to reduce the use of over-utilized resources to achieve optimal resource allocation and this would raise productivity of resources, increase output and hence increase revenues and net returns.

In the same vein, Chukwuji, *et al*. (2006) carried a quantitative study to determine allocative efficiency of broiler production in Delta state of Nigeria. Results from this study estimated allocative efficiency for stock size, feed expenses, variable expenses and fixed capital inputs as 24.9, 24.8, – 4.6 and 11.9 respectively. In accordance with these results, farmers were said to be allocatively efficient and needed to increase the

quantity of the inputs to enable them to maximize profits since marginal value product was greater than marginal costs or unit price of inputs. Other studies carried out included Bravo-Ureta and Pinheiro (1997) to estimate economic, technical and allocative efficiencies of peasant farming in the Dominican Republic. Results indicated that farmers were 0.44 efficient in resource allocation. These results were said to be in line with a 0.43 allocative efficiency for a sample of wheat and maize farmers in Pakistan, though peasant farms in Paraguay were said to be more efficient with 0.70 and 0.88 allocative efficiency compared with peasant farmers in the Dominican Republic.

2.4.3 Economic efficiency measurement

Economic efficiency has technical and allocative components. It is determined by multiplying technical and allocative efficiency. A farm/firm which is both technically and allocatively efficient is said to be an economically efficient farm/firm. The measurement of technical efficiency is important. Farrell (1957) in his pioneering work defined efficiency as the ability to produce at a given level of output at the lowest cost. Technical efficiency is the ability of the farm to produce a maximum level of output given a similar level of production inputs. Allocative efficiency is the extent to which farmers equate the marginal value product of a factor of production to its price. Economic efficiency combines both allocative and technical efficiency. It is achieved when the producer combines resources in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative) (Chukwuji, *et al.,* 2006).

If the farm is technically and allocativelly efficient, then that farm is said to be cost effective (Chukwuji, *et al.,* 2006). In order to promote commercialization of Agriculture

from subsistence farming, these farmers have therefore to be both technically and allocatively efficient. The ultimate goal of training farmers to be both allocatively and technically efficient is to boost their incomes by maximizing profits especially in poverty pressed countries. Indeed, most of the studies on efficiency measurement were aimed at knowing whether there is efficiency or not that will transform agriculture from subsistence to commercial agriculture.

2.5 Analytical Review of Econometric Methods

A number of empirical econometric models can be employed in the analysis of economic variables for making plausible and meaningful conclusions for policy purpose. This is the thrust of research work so as to help researchers evolve ways of alleviating obstacles in the agricultural sector. Many econometric methods such as cost and return analysis, stochastic frontiers production function, grafted models, models with lagged variable namely Nerlovian Model and Constant Elasticity Adjustment and others have been widely used in econometrics. Some of these models that were applied in previous studies and which this study employed were as follows:

2.5.1 Net farm income analysis

The net farm income is the difference between gross income (GI) and the total cost (TC) of production (Olukosi and Erhabor, (2005). It is specified as;

$$NFI = GI - TC \quad \text{.....(1)}$$

Where;

NFI = Net farm income

GI = Gross income

TC = Total cost

The gross income (GI) is the total return or total value product (TVP) which is the total output m ultiplied by the price per unit of produce that is,

$$\boldsymbol{TVP = Q * P_y} \quad \text{.....(2)}$$

Where;

$Q = quantity\ of\ output\ or\ TPP$ (Total Physical Product)

$P_y = Price\ per\ unit\ of\ output.$

The total cost (TC) of production is given by;

$$\boldsymbol{TC = TVC + TFC} \quad \text{.....(3)}$$

Where:

TVC = Total variable costs such as seed, labour, chemicals and fertilizers.

TFC = Total fixed cost which include depreciation of farm tools such as cutlasses, ox-drawn ploughs, sprayers, hoes, interest on capital and cost of land rent.

2.5.2 Stochastic frontier model

Furthermore, Shehu *et al.* (2007) applied the Cobb-Douglas stochastic frontier production function to study technical efficiency among rainfed upland rice farmers in Northwest agricultural zone of Adamawa state, Nigeria. The empirical results indicated that more than 88% of the sampled farmers attained greater than 80% technical efficiency level. The model specified in the analysis of technical efficiency is specified as;

$$TE_i = \frac{f(x_i,\beta)e^{vi}e^{-ui}}{f(x_i,\beta)e^{v}} \quad \text{.....(4)}$$

Where;

TE_i = Technical efficiency

X_i = Quantity of inputs (used)

β = Vector of parameter to be estimated.

$e_i = v_i - u_i$ (composite error terms)

vi = Random error outside farmers' control such as weather, luck. It is either negative or positive which cannot be captured in the model.

u_i = Random variable within farmers' control. They are mostly socio-economic variables (such as age of farmers, experience of farmers, major occupation, gender, level of education and access to credit) which can be captured in the model. They are usually non-negative.

Ogundari and Ojo, (2006) applied the technical, economic and allocative efficiencies to 200 cassava farmers in Osun State of Nigeria. The results revealed an average level of technical, allocative and economic efficiencies equal to 90%, 89% and 81% respectively. This confirms that peasant settings are efficient in their resource allocation behaviour given their operating circumstances. The allocative efficiency and economic efficiency models specified in their study is of the Cobb-Douglas functional form. The models are expressed as;

$$AE_i = \frac{f(px_i,\lambda)e^{vi}e^{ui}}{f(px_i,\lambda)exp.vi+exp.ui} \quad \text{.....(5)}$$

Where;

AE_i = Allocative efficiency of ith farmer.

PX_i = Price of variable inputs

λ = Vector of parameter to be estimated

e^{v_i} = Exponent of random error

e^{u_i} = Exponent of random variable

$f(\ )$ = Function of

$$EE = TE \times AE \quad \text{.....(6)}$$

Where;

EE = Economic efficiency

TE = Technical efficiency

AE = Allocative efficiency

In the same vein, Eheke (2008) applied the Cobb-Douglas stochastic frontier production function using the data from 160 cassava farmers in Southeastern Nigeria. The result of the study revealed that the technical efficiency of farmers ranged from 52 – 95% with a mean technical efficiency of 77%. This implies that, ample opportunity exists from the farmers to enhance their productivity and income through more efficient resource use and utilization.

Rahman *et al.* (2005) in their study determined technical efficiency for five popular sorghum-based cropping systems in Soba Local Government Area of Kaduna State. The overall technical efficiency for five popular Sorghum-based cropping systems ranged between 58 – 74 percent. Contribution of land and labour in increasing crop production was also observed to be more prominent in all the Sorghum-based cropping systems.

Therefore, crop output could be improved through any means of land consolidation and use of improved labour device.

2.5.3 Grafted model

The use of grafted models to predict and forecast crop production and price trends has been adopted widely in econometrics. Rahman (2001) opined that, the estimation of models to forecast the probable future values of an economic time series is one of the econometric methods of information management. He further asserted that, the maize production trend predicted with the grafted function is closer to the observed trend or values when compared to that of the linear function because it resulted in smaller difference. This is because, the grafted function incorporated and infused all the major observed local trends in the forecasting framework.

The grafted model was used in forecasting maize production trend in Nigeria. The general form of the linear trend model which was improved in the study is represented as;

$Y = a + b_t$ ……..(7)

where;

$Y = level\ of\ maize\ output,$

$a\ and\ b = structural\ coefficients$

$t = trend\ variable$

The preliminary graphical representation of the time series indicated three time segments (L-Q-L) with the following trend functions.

$Y = a_o + a_1 t,\ for\ 1970 \leq t \leq 1977$

$Y = b_o + b_1 t + b_2\, t^2,\ for\ 1977 \leq t \leq 1983$

$$Y = c_o + c_1 t, \ for\ t > 1984$$

$Where,$

$$a's,\ b's \quad and \quad c's\ are\ the\ structural\ coefficients.$$

The grafted (mean) function is expressed as,

$$Y = C_o X_o + C_1 X_1 + b_2 X_2 \text{.....(8)}$$

This type of forecasting technique may be useful for policy making in planning for future crop production based on the available information of the past periods.

According to Rahman and Damisa (1999) their study estimated a grafted model (Quadratic-Quadratic-Linear) to forecast cowpea price for the periods outside the sample for estimation. Forecasts were generated from linear model to evaluate the predictive performance of the estimated grafted model. This study revealed that, the estimated grafted model performed better than linear because its forecasts were closer in values to observed values on trend. The grafted model was used in forecasting its performance on cowpea price in Zaria area of Kaduna State, Nigeria. The linear equation to be improved is stated as;

$$P = a + b_t \text{ .....(9)}$$

$Where;$

$$P = price\ of\ cowpea,$$

$$a\ and\ b = structural\ coefficients,$$

$$t = time\ variable$$

The preliminary graphical representation of the observed time series data indicated three (3) time segments with the suggested trend functions illustrated below;

$$P = a_o + a_1 t + a_2 t^2 \ \ for \ \ t \leq k_1$$

$$P = b_o + b_1 t + b_2 \, t^2, \ for \ k_1 \ < t \leq k_2$$

$$P = c_o + c_1 t, \ for \ t > k_2$$

$Where,$

$a's, \ b's \quad and \quad c's \ are \ the \ structural \ coefficients.$

$P \ is \ the \ price$

$t \ is \ the \ time \ variable$

The grafted (mean) function is expressed as;

$$P = C_o X_o + C_1 X_1 + a_2 X_2 + b_3 X_3 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(10)}$$

This was used for ordinary least squares (OLS) regression. Therefore, it is better to fuse all the observed major local trends in the forecasting framework to achieve a more relevant time series prediction for policy purpose.

2.5.4 Models with lagged variables

A number of models with lagged variables have been used and applied by many researchers and authors in response studies and trend analysis to estimate supply response of various agricultural commodities. The empirical framework enshrined in the Nerlovian model is to study and analyse supply response which enhances the analysis of price and price expectations over various time lags (Nerlove, 1979). Other factors on which expectations of prices could be built to justify supply response of various agricultural commodities that are implicitly embedded in the model were specified in equation (11).

$Q_{t=}f(Q_{t-1}, A_{t-1}, w_i, P_t, T_i, C_t, P_{t-1}, P_c, V_t)$……..(11)

Where;

Q_{t-1} = Previous crop yield lagged one period,

A_{t-1} = Acreage planted previous year lagged one period,

W_i = Weather index,

P_t = Ruling price in the market,

T_i = Prevailing technology,

C_t = Level of capital stock,

P_{t-1} = Previous price lagged one period,

P_c = Price of competing crop,

V_t = Error term.

Of all the econometric models used to estimate commodity supply response, the Nerlovian model is considered one of the most influential and successful, judged by the large number of studies which utilize this approach (Braulke, 1982). The Nerlovian adaptive expectation model is a dynamic model, stating that output is a function of expected price, output (area) adjustment and some exogenous variables stated above. According to Gujarati and Porter (2012) a model is described as dynamic if the time path of the dependent variable is explained by its previous values.

Leaver (2003) measured the supply response functions of tobacco which revealed that an estimation of the price elasticity of supply of tobacco output in Zimbabwe when she used adapted Nerlovian model gave a short run elasticity of + 0.34 and a long run elasticity of + 0.81. This suggests that tobacco farmers are highly unresponsive to price changes in the tobacco market. These estimates are similar to those obtained for tobacco in supply response studies in other developing African countries.

Most of the econometric models reviewed indicated that they can be used to improve on future production status among farmers. This could enhance recommendations and adoption of various production technologies in order to make farmers more economically efficient in resource utilization and increase their productive potentials. It is envisaged that this study will also proceed to evolve more salient and appropriate econometric methods of information analysis to facilitate and enhance adequate agricultural knowledge among farming population. This will be useful for policy making in planning for subsequent future crop production activities based on the results of this study.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

Zamfara State was chosen for this study. This is because cotton is one of the largely produced major crops in the state. The state lies between latitudes 10^0 50`N and $13^0$ 38`N and longitudes 4^o16`E and $7^o$18`E. The state is located in the Sudan Savanna ecological zone of Nigeria with a land area of 39,762km^2. Figures 3.1 and 3.2 illustrate the location of Zamfara State in the map of Nigeria and the local government areas in the state respectively. Zamfara state shares common borders with Sokoto and the Republic of Niger to the north, Katsina and Kaduna states to the east, Niger and Kebbi states in the south (Yakubu 2005., www.zamfarastate.net, 2010). The state has a population of about 3,259,846 people in 2006 according to the National Population Commission (NPC.,2006). This is projected as population estimate in 2011 to be 3,838,160 people based on 3.2% annual growth rate in population (UNFPA, 2013).

The climate is essentially that of tropical climate. The climate is generally characterised by alternating dry and wet seasons. The rains usually commence in May/June and ends in September/October. The effective rainy season in the study area is restricted from July to mid September (Yakubu, 2005). The mean annual rainfall ranges from 969mm to 1,086mm. Relative humidity varies between 24% in January and rises to 85% in September. The mean annual temperature also varies from 29^0C to 37^0C (www.zamfarastate.net, 2010).

The state is in the Northwestern part of the country. Carved out of Sokoto state, the state at the inception had twelve local government areas (LGA's) namely Anka, Bakura,

Bungudu, Bukkuyum, Gusau, Kaura-Namoda, Gummi and Maru. Currently there are fourteen LGA's with the creation of Shinkafi and Birnin Magaji LGAs. The main ethnic groups in these areas are Hausa, Beriberi, Zamfarawa, Fulani, Buzzaye Kamuku, Gwari, Kambari, Dukawa and Zabarma ethnic communities. Indeed, agriculture forms the main occupation of the entire population. This constitutes the bulk of those involved in traditional farming, fishing, hunting and nomadic pastoralism.

Majority of the farmers are resource poor and small-scale traditional farmers combining arable crop production with cotton production over the years. Cotton production is predominantly rain-fed. In some instances, cotton is grown in crop mixtures with other food crops such as millet, sorghum, maize, cowpea, groundnut and soybean among others in order to diversify their production enterprises. Other farmers cultivate cotton as sole crop. In sole cropping, improved and recommended cotton production practices are adopted or adapted on their farms which help in increasing the level of output. (ZADP, 2010).

Also, mixed faming is practiced predominantly among the nomadic pastoralists. The cropping system had proved promising since the soil fertility level is replenished on seasonal basis thereby enhancing higher yields of both cotton and other food crops that are cultivated. There has been cotton production in Zamfara state for decades and it has been a life-long business of the farmers in villages especially in the North-western part where the climatic conditions are more favourable. In some cases, farmers organised themselves into groups and associations that assist them in input procurement, production, management and marketing of their products. (ZADP, 2010).



Figure 3.1: Map of Nigeria showing location of Zamfara State

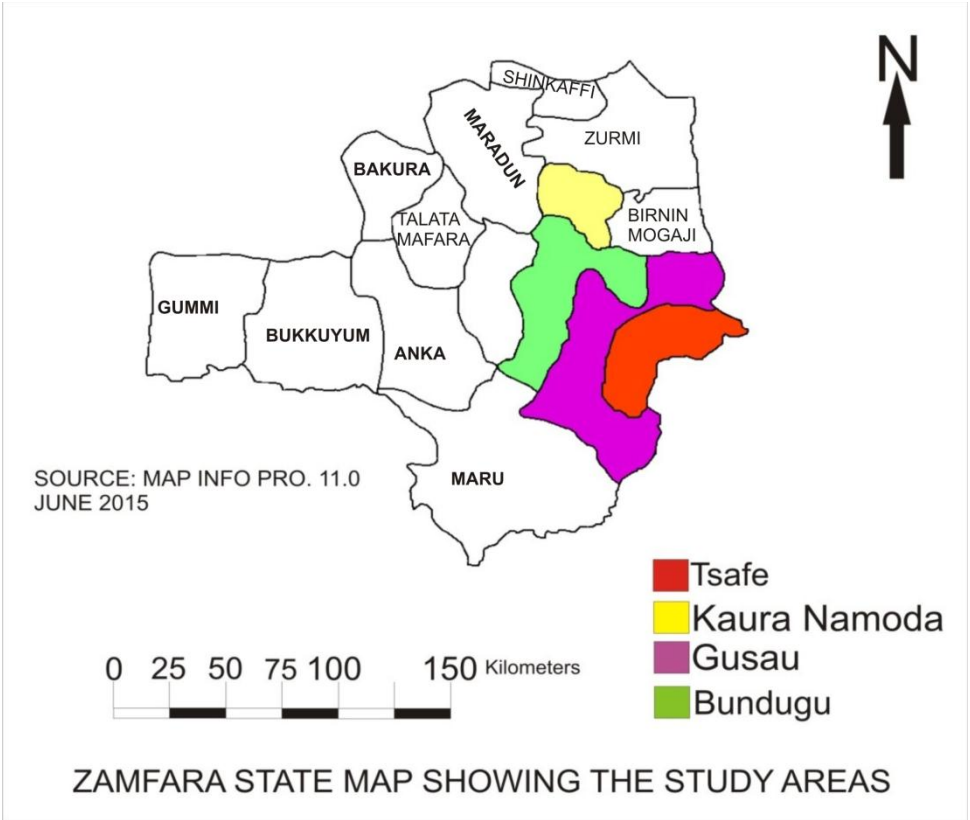


Figure 3.2: Map of Zamfara State indicating the Local Government Areas (LGA's)

3.2 Sources and Types of Data

Primary and secondary sources of data were used for this study. The primary data from cross-sectional survey were collected for the study during 2012/2013 cropping year. Structured questionnaire was used and administered to the farmers provide information on socio-economic characteristics of farmers, resource procurement, utilisation pattern and production technologies, costs and returns variables and inputs and output variables. Secondary data were also collected on cotton output and prices in the state for various years from Central Bank of Nigeria (CBN annual reports), Food and Agriculture Organizations (FAO) production yearbook, Quarterly Bulletin of Statistics, Federal Office of Statistics (FOS), National Agricultural Extension and Research Liaison Services (NAERLS) Wet Season Production Report, Bulletin of Prices, internet and the Zamfara State Agricultural Development Project (ZADP).

3.3 Sampling Procedures and Sample Size

List from reconnaissance survey of farmers conducted by Zamfara State Agricultural Development Project (ZADP) was used for this study. The ZADP conducts survey of farmers seasonally so as to enhance adequate preparation for appropriate cotton production technologies and agro-services they intend to render to groups, associations and individual farmers who produce cotton and other crops. The identified cotton growers served as the sampling frame. Therefore, the sampling population was cotton growers in the study area. The population of cotton farmers in Kaura, Gusau, Tsafe, Bungudu, Maru, Birnin Magaji and Zurmi were 391, 330, 367, 383, 248, 270 and 300 respectively based on the reconnaissance survey conducted by the Zamfara State Agricultural Development Project.

A multistage sampling technique was employed in selecting the farmers. The first stage was purposive sampling of four Local Government Areas (LGA's). These were Kaura, Gusau, Tsafe and Bungudu in the south-western part of the state. These were chosen because of the prevalence of cotton farmers, their homogeneity and their involvement in cotton production. Also, there is a wider coverage by the Farming System Research and Extension Programme /Recommended Cotton Production Practices (RCPP) intervention of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria among cotton farmers in the state.

The second stage was a random selection of two villages known for cotton cultivation from each of the selected Local Government Areas. Hence, a total of eight villages were selected for the study. The third stage involved using the list of cotton farmers obtained from the reconnaissance survey to randomly select 15% of farmers from each of the eight villages to give samples of 26, 33, 23, 26, 33, 22, 31 and 26 farmers from Kasuwa-Daji, Kabarawa, Danba, Magami, Tsafe, Kucheri, Kwatarkwashi and Tashar-rawaya villages respectively. Thus, giving a total of 220 out of 1471 farmers.

Table 3.2: Distribution of Respondents in selected LGA's from a Reconnaissance Survey

Selected LGA's	**Villages**	**Registered cotton growers (sample frame)**	**15% Sample frame (sample size)**
Kaura LGA	i. Kasuwa Daji	170	26
	ii. Kabarawa	221	33
Gusau LGA	iii. Danba	155	23
	iv. Magami	175	26
Tsafe LGA	v. Tsafe	220	33
	vi. Kucheri	147	22
Bungudu LGA	vii. Kwatarkwashi	207	31
	viii. Tashar Rawaya	176	26
Total	**8**	**1471**	**220**

Source: ZADP Reconnaissance Survey, (2010).

3.4 Analytical Techniques

The analytical techniques that can be used in farm production and management are many. The choice and application of a particular technique depends essentially on the type of data, data availability and the use to which the results are intended. The analytical tools used to achieve the stated objectives in this study are;

i. Descriptive statistics;

ii. Net farm income;

iii. Stochastic frontier models;

iv. Grafted models and

v. Models with lagged variables.

3.4.1 Descriptive statistics

Descriptive statistics are the statistical procedures used for organizing, describing and interpreting characteristics, parameters and variables in production in concise and meaningful quantifiable terms. Simple descriptive statistics was used to achieve objectives (i), (ii), (iii) part of (iv) and (vii). Some of the simple descriptive statistical tools used include frequency, mean and percentage.

This enabled us to measure variables relating to socio-economic characteristics such as household size, sex, farming experience, age of farmers and so on. Other variables that were measured include production technologies and resource utilization pattern, production constraints, cost and return variables associated with cotton production, stochastic frontier analysis and production constraints in cotton production in the study area.

3.4.2 Grafted polynomial model

Grafted polynomial model was used to achieve objective (ii). This was used to estimate production trends of cotton in the study area. Grafted models are used in econometrics to embark on economic analysis involving time series. This was based on available data collected from different secondary sources. In trend analysis, it is the quadratic and linear functions that are most commonly used. This gave rise to a situation in which both the quadratic and linear are estimated as grafted polynomial functions so as to give better estimates of the parameters and variables. It was assumed that different functional forms may fit different segments of a time series or response studies. Segments of polynomials can be used to approximate production surfaces or frontiers and to forecast time series. The segment required to approximate production surfaces must terminate in a quadratic form while the one to be used to forecast time series as in trend analysis must end in a linear form (Fuller, 1969; and Philip, 1990).

These segmented curves are restricted to be continuous and differentiable at the joined points. This aspect of the study focused specifically on predicting or forecasting cotton production trends into the immediate future. This will provide adequate information on what will happen in the future about the phenomenon under study with respect to cotton. Subsequently, this will help us to proffer and recommend some policy measures that will help in sustaining cotton production industry in Nigeria.

3.4.2.1 Quadratic-quadratic- linear polynomial function

The quadratic-quadratic-linear (Q-Q-L) function is of a graphical form shown in figure 3.3.

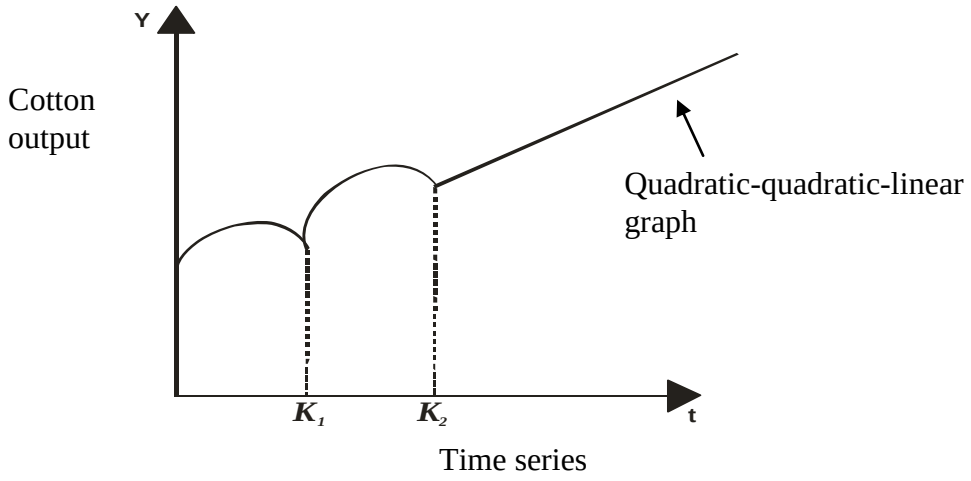


Figure 3.3: Quadratic-quadratic- linear polynomial function

The general equation of the linear trend model used in forecasting along with the mean function is of the general form;

$$Q_t = a + bt \quad \text{.....(24)}$$

This is an observed time series that do not relate linearly to trend as shown in the graph above. The three segments of the functional relationship can be expressed as functions of the form;

$$Q_t = a_0 + a_1 t + a_2 t^2, \text{ for } t \leq k_1 \quad \text{.....(25)}$$

$$Q_t = b_0 + b_1 t + b_2 t^2, \text{ for } k_1 < t \leq k_2 \quad \text{.....(26)}$$

$$Q_t = c_0 + c_1 t, \text{ for } t > k_2 \quad \text{.....(27)}$$

In this model, we are assuming that the mean function is to be continuous, linear in parameters and differentiable at the joined points (k_1 and k_2) as contended by Fuller,

(1969); and Philip, (1990). In other words, we need to derive a mean function which encompasses all the key local trends observed in the time series Q_t. Thus, it is imperative that the following restrictions must hold. There are four restrictions namely; two continuities and two differentiabilities.

At continuity, the following expressions hold.

$$a_0 + a_1k_1 + a_2k_2^2 = b_0 + b_1k_1 + b_2k_1^2 \text{.....(28)}$$

$$b_0 + b_1k_2 + b_2k_2^2 = c_0 + c_1k_2 \text{.....(29)}$$

At differentiability, we derive these expressions as shown in equations (30) and (31).

$$a_1 + 2a_2k_2 = b_1 + 2b_2k_1 \text{.....(30)}$$

$$b_1 + 2b_2k_2 = c_1 \text{.....(31)}$$

It is noticeable that there are eight parameters namely a_0, a_1, a_2, b_0, b_1, b_2, c_0, and c_1. There are also four restrictions on the mean function. In other words, this implies that only four parameters can be estimated. The parameters to be estimated depend upon the motive of generating or formulating the mean function which is to forecast. For forecasting, it is highly important to retain the coefficient in the terminal trend function and this is usually linear. Thus c_0, c_1, a_2 and b_2 are to be retained for subsequent estimation while a_0, a_1, b_0 and b_1 are to be dropped and eliminated.

For ease and simplicity, it is better to start the derivations with equation (31) and making b_1 the subject of the formular. From equation (31).

$b_1 + 2b_2k_2 = c_1$

$b_1 = c_1 - 2b_2k_2$……..……(32)

from equation (30)

$a_1 + 2a_2k_1 = b_1 + 2b_2k_1$

$a_1 = b_1 + 2b_2k_1 - 2a_2k_1$

Substitute for b_1

$a_1 = c_1 - 2b_2k_2 + 2b_2k_1 - 2a_2k_1$

$a_1 = c_1 - 2b_2 (k_2 - k_1) - 2a_2k_1$ ……..……(33)

From equation (29)

$b_0 + b_1k_2 + b_2k_2^2 = c_0 + c_1k_2$

Substituting for b_1

$b_0 + (c_1 - 2b_2k_2) k_2 + b_2k_2^2 = c_0 + c_1k_2$

$b_0 + c_1k_2 - 2b_2k_2^2 + b_2k_2^2 = c_0 + c_1k_2$

$b_0 = c_0 + c_1k_2 - c_1k_2 + 2b_2k_2^2 - b_2k_2^2$

$b_0 = c_0 + b_2k_2^2$ ……(34)

From equation (28),

$a_0 + a_1k_1 + a_2k_1^2 = b_0 + b_1k_1 + b_2k_1^2$

Substituting for a_1, b_0 *and* b_1

$a_0 + [c_1 - 2b_2k_2 + 2b_2k_1 - 2a_2k_1] k_1 + a_2k_1^2 = c_0 + b_2k_2^2 + (c_1 - 2b_2k_2) k_1 + b_2k_1^2$

$a_0 + c_1k_1 - 2b_2k_2k_1 + 2b_2k_1^2 - 2a_2k_1^2 + a_2k_1^2 = c_0 + b_2k_2^2 + c_1k_1 - 2b_2k_2k_1 + b_2k_1^2$

$a_0 + b_2k_1^2 - a_2k_1^2 = c_0 + b_2k_2^2$

$a_0 = c_0 + b_2k_2^2 - b_2k_1^2 + a_2k_1^2$

$= c_0 + b_2 (k_2^2 - k_1^2) + a_2 k_1^2$

$a_0 = c_0 + b_2 (k_2^2 - k_1^2) + a_2 k_1^2$ ……(35)

From equation (25)

$Q_t = a_0 + a_1 t + a_2 t^2$

Substituting for a_0 *and* a_1

$Q_t = [c_0 + b_2(k_2^2 - k_1^2) + a_2 k_1^2] + [c_1 - 2b_2(k_2 - k_1) - 2a_2 k_1]t + a_2 t^2$

$= c_0 + b_2(k_2^2 - k_1^2) + a_2 k_1^2 + [c_1 - 2b_2 k_2 + 2b_2 k_1 - 2a_2 k_1]t + a_2 t^2$

$= c_0 + b_2 k_2^2 - b_2 k_1^2 + a_2 k_1^2 + c_1 t - 2b_2 k_2 t + 2b_2 k_1 t - 2a_2 k_1 t + a_2 t^2$

$= c_0 + c_1 t + a_2 t_1^2 - 2a_2 k_1 t + a_2 k_1^2 + b_2 k_2^2 - b_2 k_1^2 - 2b_2 k_2 t + 2b_2 k_1 t$

$= c_0 + c_1 t + a_2 (t_1 - 2k_1 t + k_2) + b_2 (k_2^2 - k_1^2 - 2k_2 t + 2k_1 t)$

$= c_0 + c_1 t + a_2 (t - k)^2 + b_2 [(k_2^2 - k_1^2) - 2(k_2 - k_1)t]$……(36)

Equation (36) Q_t can be transformed as

$Q_t = c_0 x_0 + c_1 x_1 + a_2 x_2 + b_2 x_3$……..……..……(37)

For simplicity, equation (37) can be represented as;

$Q_t = \propto_o x_o + \propto_1 x_1 + \propto_2 x_2 +$

$\propto_3 x_3$……(38)

Where;

$x_0 = 1$; for all t,

$x_1 = t$; for all t, time variable in trend for k

$x_2 = (t - k_1)^2$; for $k \leq t$, time variable in trend for k_1

$= 0$ otherwise

$x_3 = (k_2^2 - k_1^2) - 2(k_2 - k_1)\, t$ for $k_1 \leq t$, time variable in trend for k_2

$= (t - k_2)$; for $k_1 < t \leq k_2$

$= 0$

Equation (37) represents a grafted continuous (mean) function which encompasses all the key local trends indicated by the set of restrictions in equations (25), (26) and (27). Equation 37 is the empirical (grafted) model suitable for computing an Ordinary Least Squares (OLS) regression.

3.4.3 Stochastic frontier models

This technique was used to achieve objective (iv) of the study. The Stochastic Frontier Approach (SFA) is parametric analytic technique which uses econometric method by employing the production function of Cobb-Douglas form. It specifies a functional form for the production relationship, cost and profits associated with output, input and other factors. It is one of the methods for estimating frontier functions and usually employed to measure efficiency of production. The model deals with the existence of two or composite independent error terms in a production function.

3.4.3.1 Stochastic frontier production function

The Stochastic frontier function was estimated using Maximum Likelihood Estimation (MLE) technique to obtain farm specific technical efficiency. Using the SFA, it is suitable to apply a generalized likelihood ratio test to ascertain whether the cotton production enterprises were technically efficient or not.

This approach was taken up by Aigner and others which subsequently resulted in the development of this method in econometric studies. Aigner and Chu (1968), Aigner *et al.,* (1977) and Meeusen and Broeck van de (1977) considered the estimation of a parametric frontier production function which was later improved and applied by

Battese and Coelli (1995). The Stochastic frontier production function model is specified as:

$$Y_i = f(x_i, \beta)\, e_i \quad \ldots\ldots (13)$$

Where,

Y_i = Output

X_i = Quantity of input used

$f(X_i, \beta)$ = the production frontier

β = Scalar parameter (Vector) to be estimated

e_i = Error term

$e_i = V_i - U_i$ => composite error term.

This V_i's are random variables which account for random variation in output due to factors outside farmers control such as weather, disease and measurement error in production. The random error (V_i's) are assumed to be independently and identically distributed $N(\sigma^2 v)$ and independent of U_i's. It constitutes noise or disturbance error (V_i's). The U_i's are random variables that account for technical inefficiency of the farm as reflected in the socio-economic characteristics and other variables within farmers' control. The U_i's are assumed to be non-negative truncation of the half-normal distribution $N(\sigma^2 U)$.

$$TE = Y^a / \hat{Y} = \text{actual output / frontier output}$$

$$= f(X_i, \beta)\, e^V e^{-U} / f(X_i, \beta) e^V \quad \ldots\ldots (14)$$

$$TE = e^{-U} \quad \ldots\ldots (15)$$

TE = Technical efficiency

X_1 = Farm size (ha)

X_2 = Seed (kg/ha)

X_3 = Family labour (man-days/ha)

X_4 = Hired labour (man-days/ha)

X_5 = Fertilizer (kg/ha)

X_6 = Agro-chemicals (liter/ha)

$\beta_1 - \beta_6$ = vector parameters to be estimated

β_o = Intercept term

$e_i = V_i - U_i$ (Composite error term)

This is the technical efficiency which is defined as the ratio of observed output to maximum feasible output which is called frontier output. The empirical stochastic frontier was specified by Cobb-Douglas production function by taking the logarithm form, the model can be written as;

$$\text{Log } Y_i = ß_0 + \sum \text{Log } X_n + (V_i - U_i) \qquad (16)$$

$$\text{Log } Y_i = ß_0 + ß_1 \text{Log } X_1 + ß_2 \text{Log } X_2 + ß_3 \text{Log } X_3 + ß_n \text{Log } X_n + (V_i - U_i) \qquad (17)$$

When $TE_i = 1$ it shows that a farm obtains the maximum feasible output while $TE_i < 1$ provides measures of shortfall of the observed output from the frontier output. Therefore, there is need for estimation.

In this study, the production function specified in equation (14) above is amenable, tractable and compatible by been transformed in its logarithm form. According to Coelli (1995) a logarithmic transformation provides a model which is linear in the log of inputs and hence, easily used in econometric estimation. Aigner *et al.* (1977) and Meeusen and Broeck van de (1977) independently proposed the stochastic frontier production

function in which an additional random error V_i is added to the non-negative random variable U_i. Its most attractive feature is its simplicity.

3.4.3.2 Stochastic frontier cost function

The Stochastic frontier cost function is of Cobb-Douglas functional form. The allocative efficiency can be estimated through the stochastic cost frontier function. In other words, the stochastic frontier cost function was estimated in order to arrive at allocative efficiency. The allocative efficiency of cotton farmers is defined in terms of the ratio of the predicted minimum cost (C_i^*) to the observed or actual cost (C_i). It is expressed as the process involved in minimising cost without reducing the level of output realised in the production frontier. Hence, EE is the inverse of the cost frontier function. The allocative efficiency is part of objective (iv) of the study.

It is specified as follows;

$C_i = f(Px_i, \lambda)\ \exp.\ (v_i+u_i),\ i = 1,2,\ldots n$…………………………………………..(18)

Where,

C_i = total input cost (₦) of the ith farmer

f = functional form represented by Cobb-Douglas production function.

Px_1 = Price of land (₦)/unit

Px_2 = Price of seed (₦) /unit

Px_3 = Price of fertilizers (₦) /unit

Px_4 = Price of family labour (₦) /unit

Px_5 = Price of hired labour(₦) /unit

Px_6 = Price of Agro-chemicals (₦) /unit

$\lambda_1 - \lambda_6$ = Unknown parameters (scalar) to be estimated

λ_o = Intercept term

$e_i = V_i + U_i$ = random errors (composite error term).

The allocative efficiency of the individual farmer is defined in terms of the ratio of the predicted minimum cost (C_i*) to the observed cost (C_i) that is,

$AE_i = C_i^*/C_i$

$AE_i = f(Px_i, \lambda)\, e^{Vi}\, e^{Ui} / f(Px_i, \lambda)$ exp. v_i + exp. u_i. ……..….(19)

$AE_i = \exp(u_i)$

The allocative efficiency scores index for each farmer also ranges between 0 and 1. Hence, the specification of the cost frontier function is in accordance with the Cobb-Douglas function illustrated in the allocative efficiency expressed below;

$LogC_i = \lambda_0 + \lambda_1 logPx_1 + \lambda_2 logPx_2 + \lambda_3 logPx_3 + \lambda_4 logPx_4 + \lambda_5 logPx_5 + \lambda_6 logPx_6 + v_i + u_i$..... (20)

3.4.3.3 Economic efficiency function

Economic efficiency function is the product of technical efficiency (TE) and allocative efficiency (AE) of the individual cotton enterprises. Therefore, the economic efficiency (EE) is given as;

EE = TE x AE……..... (21)

3.4.3.4 Technical inefficiency model

The assumption in the technical inefficiency model is that the technical inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution with mean U_{ij} and the variance σ^2. The specific variables involved are closely associated with socio-economic factors of the farmers and other factors within

farmers' control. The determinant of technical inefficiency and allocative inefficiency effects (U_{ij}) is specified as:

$U_{ij} = \gamma_0 + \sum \gamma_{ij} Z_{ij}$

$U_{ij} = \gamma_0 + \gamma_1 Z_1 + \gamma_2 Z_2 + \gamma_3 Z_3 + \gamma_4 Z_4 + \gamma_5 Z_5 + \gamma_6 Z_6 + \gamma_7 Z_7 + \gamma_8 Z_8 + \gamma_9 Z_9$……..(22)

Where;

U_{ij} = Farmers' technical inefficiency

γ_0 = Intercept term

γ_1 - γ_9 = Unknown parameters (vectors) to be estimated

Z_1 - Z_9 = Socio-economic variables

Z_1 = Major occupation (farming =1, 0 = otherwise)

Z_2 = Age of farmers in years

Z_3 = Level of education in years

Z_4 = Marital status (married =1, single =0)

Z_5 = Household composition (number of household members)

Z_6 = Experience in years (years of cotton production)

Z_7 = Access to credit facilities (amount of credit received)

Z_8 = Membership of cooperative (years of membership)

Z_9 = Extension contact (number of contact)

These variables were included in the model to indicate their possible influence on the technical inefficiencies of cotton farmers. The $\gamma_1 - \gamma_9$ are the scalar parameters to be estimated. The variances of the random errors $\sigma^2 V$ and that of technical inefficiency effects $\sigma^2 U$ and the overall variance of the model σ^2 are related as follows:

$\sigma^2 = \sigma^2V + \sigma^2U$…… (23)

and the ratio;

$\gamma = \sigma^2V/\sigma^2$

Equation 23 measures the total variance of output which can be attributed to technical inefficiency (Battese and Corra, 1977). Its value is expected to be between 0 and 1. Hence, there is need for estimation.

The values of γ indicate the relative magnitude of the variance associated with the distribution of the inefficiency effects which can be captured by the stochastic frontier analysis in the model that is, $\mu_i's$. If μ_i in the stochastic frontier are not present or alternatively if the variance parameter γ associated with the distribution of μ_i has zero value, then σ^2U_i in equation (17) and (22) is zero. Then, the model reduces to a traditional production function with variable inputs which are included in the production function or variables that are devoid of any stochastic (disturbance or noise) which implies that inefficiency effects are not stochastic.

In econometric analysis of stochastic frontier, there is availability in recent years of computer software such as the LIMDEP econometric package (Greene 1992) and the FRONTIER 4.1 programme in (Coelli 1992, 1996a). They automate the maximum likelihood (ML) method for estimation of the parameters of stochastic frontier models. The maximum likelihood estimate (MLE) of ß and γ coefficients in equations 17 and 22 respectively were estimated simultaneously using the computer software programme FRONTIER 4.1 (Coelli, 1996).

3.4.4 Net farm income analysis

In any production process, various levels of inputs are employed to produce a given level of output. It is rational for farmers to allocate and utilise inputs at minimum cost in order to maximise the level of profits accruing to them. This is a measure of profitability. There are many methods that can be used in order to estimate the level of profits made by farmers in their farming enterprises. One of such techniques is the net income analytical model. This analysis was applied to achieve objective (iii) of the study. The tool was used to determine the net farm income accruing to cotton farmers and hence estimate the average rate of return per naira invested in the cotton production enterprises. According to Olukosi and Erhabor, (2005), the net farm income is a very useful tool in determining the profitability of farm enterprises.

The net farm income for any farm production enterprise is given as;

$$NFI = \sum_{i=1}^{n} P_i Y_i - \sum_{j=1}^{m} P_i X_j + \sum_{k=1}^{K} FK \quad \text{.....(12)}$$

Where;

NFI =Net farm income in cotton production enterprises.

∑PiYi = Total farm income (value) of cotton produced or gross farm income. (₦).

Y_i = Cotton output, (kg).

P_i = Price of output or inputs, (₦).

∑PiXj = Total variable cost used in cotton production enterprise, (₦).

X_j = Quantity of variable inputs used, (kg or litres). Such as seed, fertilizers, labour and agro-chemicals

∑Fk = Cost of fixed inputs in cotton production enterprise, (₦). Such as ox-drawn plough, sprayers, hoes, interest on capital and cost of land rent.

∑ = Summation.

Net farm income by definition is the difference between gross income and the total cost associated with cotton production in naira (₦) value. It is a useful tool required to identify costs, returns and profits or otherwise of cotton production in the study area.

∑PiYi = Gross income. This is computed by multiplying total output by average price of cotton prevailing in the area.

ΣPiXj= Total variable cost which varies according to output and are incurred on variable inputs employed in production. Such inputs include seed, seed dressing chemicals, agro-chemicals, fertilizers, labour inputs, cost of clearing and land preparation and so on. These inputs vary in proportion to the level of output.

ΣFK= Total fixed costs are those costs incurred on fixed inputs which cannot be used up during one production process. Examples include land, buildings, fences, road and so on. Costs incurred on fixed inputs are in the short run considered sunk and unchanged. They are considered as being gradually converted into products during the production process and as such, they depreciate over time.

However, depreciation was computed using the straight line method (SLM) on working capital and fixed assets which depreciate over time. In this case, some fixed costs include depreciation of farm tools such as hoes, ox-drawn ploughs, cutlasses, sprayers, interest on capital and cost of renting land. On the whole, the model shows that for a given level of output, increase in net return is possible either by an increase in the level of total farm income or a decrease in total variable costs used in production.

3.4.5 Models with lagged variables

In economic time series, past values could influence present values and present values could influence future values. The variables with such properties are called lagged variables. There are lagged variable models to address problem constituted by lagged variables. In the model with lagged variables such as Nerlovian Adaptive Expectation Model, there is expected price in various time periods t_{-1}, t_{-2}, t_{-3} and so on as against the previous years. In the adjustment models such as the Constant Elasticity Adjustment Model, expected prices in various time periods are not reflected. These two models were used to validate and estimate the response of cotton supply to price changes in the cotton market stated in objective (vi).

3.4.5.1 Expectation model

Theoretically, the supply curve of a commodity is a relationship between the quantity of a commodity that farmers are willing to offer and various ruling market prices. It is in this vein that, farmers are assumed to build their expectations of prices for their products based on what was realised as income from last year's or previous prices. Hence, cotton supplied, price, and price expectations at different time periods were used in the regression analysis to see how these variables behaved. This will give credence to the fact that farmers' decisions on how much cotton to supply to the market is a more direct response to the expected price of cotton. The Nerlovian adaptive expectation model was used to analyse the response of cotton supply to price changes in the cotton market.

According to Nerlove (1958), the model assumes that, supply of any agricultural commodity is a function of expected price for that commodity. This is expressed as;

$$Y_t = f(P_t^e) \quad \text{.....} \quad (39)$$

This means that;

$Y_t = \alpha_0 + \alpha_1 P_t^e + ut$ ……...…. (40)

Where;

$Y_t =$ Acreage planted in year t

$\alpha_0 =$ Intercept term

$\alpha_1 =$ Coefficient of Regression

$P_t^e =$ Expected price in year t.

The assumption in the Nerlovian case is that, the expected price is expressed as;

$P_t^e = P_{t-1}^e + \beta(P_{t-1} - P_{t-1}^e)$…… (41)

Where;

$P_t^e =$Price expected this period

$P_{t-1}^e =$ Price expected last one period

$(P_{t-1} - P_{t-1}^e) =$ Forecast error

$\beta =$ Adaptation expectation coefficient

For this hypothesis to hold, the value of ß must lie between 0 and 1.

If $\beta = 0$, $P_t^e = P_{t-1}^e$, expected price last year and this year is the same.

If ß $= 1$, $P_t^e = P_{t-1}^e$, expected prices are the same for both year.

If the value of ß lies between 0 and 1 how can we estimate the model?

From equation (41) we derive the following expressions

$P_t^e = P_{t-1}^e + \beta(P_{t-1} - \beta P_{t-1}^e)$

$P_t^e = \beta P_{t-1} + P_{t-1}^e - \beta P_{t-1}^e$

$P_t^e = \beta P_{t-1} + (1 - \beta)P_{t-1}^e$ ……..…….. (42)

Applying lag operator to equation (42) gave the following expressions;

$\beta P_{t-1} = P_t^e - (1 - \beta)LP_t^e$

$\beta P_{t-1} = [1 - (1 - \beta)L]\, P_t^e$

$$P_t^e = \frac{\beta P_{t-1}}{[1 - (1 - \beta)\, L]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (43)$$

Substitute equation (43) into supply function expressed in equation (40) to give;

$$Y_t = \alpha_0 + \alpha_1 \left[\frac{\beta P_{t-1}}{1-(1-\beta)\, L} \right] + ut \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (44)$$

Clear fraction by multiplying through by [1 – (1 – ß) L].

$Y_t[1 - (1 - ß)\, L] = \alpha_0[1 - (1 - ß)\, L] + \alpha_1 ß P_{t-1} + u_t[1 - (1 - ß)\, L]$

$Y_t - (1 - ß)\, Y_{t-1} = \alpha_0 - \alpha_0(1 - ß) + \alpha_1 ß P_{t-1} + u_t - (1 - ß)u_{t-1}$

$Y_t = \alpha_0 - \alpha_0 + \alpha_0 ß + (1 - ß)\, Y_{t-1} + \alpha_1 ß P_{t-1} + u_{t-1}(1 - ß)u_{t-1}$

$Y_t = \alpha_0 ß + (1 - ß)\, Y_{t-1} + \alpha_1 ß P_{t-1} + u_{t-1}(1 - ß)u_{t-1}$ ……………………………… (45)

For estimation,

$Y_t = a_0 + a_1 Y_{t-1} + a_2 P_{t-1} + v_t$…………………………………………………… (46)

Where;

$a_0 = \alpha_0 ß$

$a_1 = (1 - ß)$

$a_2 = \alpha_1 ß$

$v_t = ut_{-1}(1 - ß)\, u_{t-1}$.

Equation (46) is the empirical model which is in a linear form suitable for Ordinary Least Squares (OLS) regression to obtain a_0, a_1, a_2 and v_t.

If $a_1 = 1 - ß$

$ß = 1 - a_1$

3.4.5.2 Adjustment model

In the adjustment model, the basis of the model lies in the fact that the nature of farmers' responses evolve round the biology and economics of agricultural production, both of which are usually influenced by future occurrences whose probability distribution cannot be determined empirically or otherwise in advance. It is on this credibility that, farmers are assumed to adjust and reallocate their currently available resources and to adopt or discard as the case may be, packages of improved inputs and cultural practices in the face of changes in market prices. This is the thrust of adjustment model which was used in this analysis. The assumption under this is that,

Y_t^* = f(Y_t)……..……(47)

Where;

Y_t = Acreage planted in year t;

Y_t^* = Acreage planned in year t.

But,

Y_t = f (P_t^e), expected price that period

Y_t^* = f (P_{t-1}), expected price last one period

Y_t is the acreage a farmer plants which is a function of price the farmer is expecting this year.

Also, Y_t^* this is the acreage a farmer is planning which is a function of last year's price. Another model that was used in the analysis of farmers' responses to cotton supply in the cotton market is the constant elasticity adjustment model.

This hypothesis assumes that,

$$\frac{Y_t}{Y_{t-1}} = \left[\frac{Y_t^*}{Y_{t-1}}\right]^{\lambda} \cdot e^{ut} \quad \text{..... (48)}$$

Where;

Y_t^* $= \alpha P_t^{ß}$

$\frac{Y_t^*}{Y_{t-1}}$ = Constant elasticity adjustment

λ = Adjustment coefficient

Therefore, our expression for constant elasticity adjustment will be,

$$\frac{Y_t}{Y_{t-1}} = \left[\frac{\alpha P_t^{\beta}}{Y_{t-1}}\right]^{\lambda} \cdot e^{ut} \quad \text{..... (49)}$$

$$Y_t = \left[\frac{\alpha P_t^{\beta}}{Y_{t-1}}\right]^{\lambda} \cdot e^{ut} \cdot Y_{t-1}$$

Hence,

$$Y_t = \frac{\alpha^{\lambda}}{Y_{t-1}^{\lambda}} \cdot P_t \lambda_{\beta} \cdot e^{ut} \cdot Y_{t-1}$$

$$= \alpha\lambda \cdot P_t \lambda^{\beta} \cdot e^{ut} \cdot \frac{Y_{t-1}}{Y_{t-1}^{\lambda}}$$

$$= \alpha\lambda \cdot P_t \lambda^{\beta} \cdot e^{ut} \cdot Y_{t-1}^{(1-\lambda)}$$

$$Y_t = \alpha\lambda \cdot Y_{t-1}^{(1-\lambda)} \cdot P_t \lambda^{\beta} \cdot e^{ut} \quad \text{..... (50)}$$

$$Log\ Y_t = Log\left[\alpha\lambda \cdot Y_{t-1}^{(1-\lambda)} \cdot P_t \lambda^{\beta} \cdot e^{ut}\right]$$

$$Log\ Y_t = Log\alpha\lambda + Log\ Y_{t-1} + Log\ P_t \lambda^{\beta} + Log\ e^{ut}$$

$$Log\ Y_t = \lambda Log\alpha + (1-\lambda) Log\ Y_{t-1} + \lambda\beta Log\ P_t + utLoge$$

Then, $Y_t = \lambda Log\alpha + (1-\lambda) Log\ Y_{t-1} + \lambda\beta Log P_t + ut$ ..... (51)

Let $a_0 = \lambda Log\alpha$, $a_1 = (1-\lambda)$ and $a_2 = \lambda\beta$

Hence, $Log\ Y_t = a_0 + a_1\ Log Y_{t-1} + a_2 Log\ P_t + ut$..... (52)

Equation (52) is linear and Ordinary Least Squares (OLS) can be applied based on supply function to get our regression coefficients.

If $a_1 = 1 - \lambda$

$\lambda = 1 - a_1$

This is the adjustment coefficient which must be between 0 and 1. That is, a value of λ should not be o and 1.

If $\lambda = 0,\ Y_t = Y_{t-1}$

If $\lambda = 1,\ Y_t = Y_t^*$

For the model to hold, λ must not be 0 or 1. This is the basis for adjustment so as to estimate the response of cotton supply to changes in price in the cotton market. These two lagged models were used to achieve objective (vi) of the study which estimated the response of cotton supply to price changes in the cotton market.

3.5 Definition of Variables Used in the Analysis

In farm survey where cross-sectional data are needed for econometric analysis, information that are specifically required were collected from farmers. Variables on which data were collected include socio-economic variables, resource procurement and utilization pattern, and production constraints. Other variables include input-output, cost-returns and production techniques of farmers involved in cotton production. Structured questionnaire was used for this purpose. Specific information that was collected from the field for analysis are outlined below:

3.5.1 Farm size (X_1)

This was measured in hectares. Relevant information with respect to this variable include size of plots in hectares, location, distance from house, number of plots devoted to cotton and other crops in crop mixtures. Land was used as farm size indicating

continuous area or portion in specific locations on which cotton was grown. Those plots in acres were converted to hectares for the purpose of this study.

3.5.2 Seed (X_2)

Information needed in this regard include type and quantity of cotton seed in kilogram, source of seed, price per unit and variety of cotton seed.

3.5.3 Fertilizer (X_3)

Fertilizer is required in order to augment soil fertility level. Information required here include brand of fertilizer or type used, cost per unit or bag, quantity applied per unit area of cropped farm, source of procurement. Fertilizer requirement is measured in kilogram or any other local measures namely mudu or tier which were converted to kilogram in the analysis.

3.5.4 Farm labour (X_4 and X_5)

This input is one of the most frequently used in the farm. Therefore, information was collected based on number of workers, type of workers namely(family labour, hired labour, communal labour) category of workers as determined by age, gender, the type of farm task to be accomplished such as clearing, ridging, planting, spraying, weeding, fertilizer application, picking of cotton and time spent on the farm operations. This is usually measured in man-hours or man-days per farm operation carried out and total cost incurred in farm labour. In Northern Nigeria, manual labour is the most frequently employed in carrying out farm tasks. The pattern and nature of labour range from hired labour, family labour or communal labour or a combination of those types of labour.

Norman (1973) developed the time schedule for labour inputs employed in man-days on most traditional farms in Northern Nigeria. This was adopted in computing the labour input in cotton production. The assumption is that, the time schedule for labour is same since it is applicable to the cultural system and cropping pattern prevailing in the study area. Accordingly, labour was broadly divided into family labour and hired labour categories. Within each categories, labour was further subdivided into three namely;

a. Children (< 15 years old);
b. Adult females (> 15 years);
c. Adult males (> 15 years).

Indeed, work rates can be influenced by certain factors inherent among workers and the magnitude and intensity of work to be carried out. It is in accordance with this notion that Spencer (1972) evolved a conversion factor so as to ameliorate these anomalies. Female and children's hours will be converted to man-hours equivalent using the respective weights of 0.75 and 0.50. This is because work rates could be influenced by age and sex of the worker as well as the farm job being carried out in the farm.

3.5.5 Agro-chemicals (X_6)

Information that was collected here includes type of chemicals such as herbicides, pesticides and insecticides. Seed dressing chemicals such as apron-plus, fernasan-D among farmers that use them. Also, costs of such chemicals were collected including source of agro-chemicals in litres per hectare.

3.5.6 Yield or output (Y_i)

Information collected in this regard include total number of bags harvested from plot(s) which were converted to kilogram per hectare, gifts, home use or utilization, quantity

offered for sale and those marketed to cotton seed oil processors. The yield or output is ideally the total physical product (TPP).

3.5.7 Specification of cost and return on variables

Proper specification of cost and return were carried out with respect to inputs used in production and the net farm income accruing to the farmers after sales and marketing. Other variables such as home use, gifts, seed retention, sales to oil mills and livestock feed mills were adequately valued and added to gross returns. The variables included here are stated below.

All costs on inputs such as tools, equipment, machinery and other farm structures were regarded as costs of production. In cotton production, costs namely cost of seed, seed dressing, herbicides, fertilizers were identified. Other costs required in the information include costs incurred on working capital namely tools, implements, tractors, sprayers, planters, and so on. Also, fixed costs were valued at the purchase price stated by the manufacturers or marketers or other sources such as agricultural development projects (ADP's), market prices and so on. For fixed costs incurred, depreciation was derived using the straight line depreciation method. Specific information relevant here include, cost of land preparation such as clearing, ridging, types of labour used namely family labour, hired labour, communal labour, method of land preparation adopted such as tractor, hoe-ploughing, ox-drawn plough and so on.

3.5.8 Gross farm income

Total quantity of cotton produced by farmers in physical terms such as kg, bags, bales etc. multiplied by the average ruling price in the market in accordance with the unit

adopted in measurement is the total value of the product (TVP). This is also called total revenue (TR). The Net Farm Income (NFI) was computed by the deduction of total cost from the gross farm income. This determines the level of profits accruing to farmers in the study area.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Cotton Farmers

Socio-economic characteristics that were investigated during the farm survey are those relevant to increasing farmers' efficiency in cotton production in the study area. These socio-economic factors are farmers' major occupation, age distribution, level of education, marital status, gender distribution, and experience in farming, household composition and access to credit. Some of the findings in the study area are presented below. This aspect of analysis was used to achieve objective (i) of the study.

4.1.1 Major occupation of cotton farmers

The result revealed that majority of the respondents considered farming as their major occupations while a negligible proportion pre-occupied themselves in some other minor occupations during the off-season such as fishing, livestock rearing, hunting, blacksmithing and petty trading. Occupation is an important socio-economic attribute determining farmer's livelihood, level of income, wealth and ability to invest in agricultural production. It also serves as a basis to procure, utilise and adopt improved modern technologies that will enhance efficient use of resources and increase productivity in their cotton production enterprises. Major occupation prevalent among the respondents was farming.

4.1.2 Age of cotton farmers

From Table 4.1 majority of the respondents were within the young and active age group while others were found to be in other categories of 41 years of age and above. This revealed that more than half of the cotton farmers were in the middle age group of

between 31-40 years in the study area. The middle age group is the active age range when farmers' performances are more meaningful. Hence, it can be concluded that the productive age group constitutes a large proportion of the respondents which depends largely on the mental and physical labour productivity of cotton farmers in the study area.

Table 4.1: Distribution of cotton farmers by their age

Age range (Years)	**Frequency**	**Percentage**
21 – 30	13	7.72
31 – 40	140	63.64
41-50	40	18.18
51-60	13	5.91
≥ 61	10	4.55
Total	**220**	**100**
Mean = 39.09 Minimum = 21 Maximum = 70 Standard deviation = 10.69		

Age is a socio-economic attribute upon which farmers' abilities and physical disposition in planning, organizing, controlling resources and accomplishing production activities and farm tasks are based. From the sampled farmers, the average age was about 39 years. This depicts that most of the farmers are within the middle age and are able-bodied to produce cotton. These result concords with the farm survey conducted by Onu and Edon (2009) who reported a significant relationship between farmers' age and efficiency. They further stated that younger farmers have the tendency to operate more efficiently on the farm than the older ones because the younger farmers are more agile and energetic to work on the farm.

The average age range is in accordance with Idiong *et al.* (2007) findings who asserted that majority (75%) of farmers in Cross River State were within the age of adulthood and middle age with the likelihood of high productivity in their farms. This determines the number of man-hours or man-days farmers could devote and spend when carrying out farm activities per day during the cropping season and production period. Similarly, Alam *et al.* (2013) asserted that the predominance of younger people in cotton production could be because of the labour intensive nature of its production, which requires young and energetic farmers. The reason could be that young farmers are more agile, aggressive, energetic and capable of making good production decision and have the potential for productivity; hence they are likely to be more efficient in cotton production than the older farmers.

4.1.3 Level of education among cotton farmers

In Table 4.2, the study showed that a significant proportion of cotton farmers had no formal education, some attended primary school but did not complete while others completed primary school. Those who attended primary school but did not complete were able to communicate in English while some could write. A reasonable number of cotton farmers had secondary education while few pursued further studies in the tertiary institutions. From this result, it is clear that, majority of cotton farmers constituting the largest proportion of the total sampled farmers were not educated.

Table 4.2: Distribution of cotton farmers by their level of education

Level of Education	Frequency	Percentage
No formal education	66	30.0
Attended Primary School but did not complete	30	13.60
Completed Primary School	42	19.10
Had Secondary Education	50	22.70
Above Secondary Education	32	14.60
Total	**220**	**100**

The level of education attained by an individual is a powerful determinant regarding the capacity to produce goods and services in the society. It also enhances ability of farmers to co-ordinate inputs in agricultural production. Hence, level of education is an important socio-economic variable enhancing agricultural production. Education will help in increasing farmers' level of production, income, savings and investment in their agricultural production activities which will enhance farmers' ability to increase their production frontiers. Muhammed Lawal *et al.* (2009) in their studies asserted that level of education is expected to influence farmers' adoption of agricultural innovations and decisions on various aspects of farming. They were of the opinion that, education is highly important for sustainable agricultural growth and of the agricultural programme, participants had some form of formal education. Indeed, formal education is a veritable attribute enhancing farmers to be able to innovate, adapt and adopt improved recommended production practices.

4.1.4 Marital status of cotton farmers

The study indicated that a large proportion of the sampled farmers were married, some were single while a small proportion were divorced and some were found to be widows (Table 4.3). The implication of large proportion of married farmers is that they will

have various family sizes in the household which help in contributing labour input in most farm operations in the traditional setting. Marital status is an indispensable socio-economic factor in agricultural production. It relevance lies in its contribution to the development of the traditional farming system through adequate supply and utilisation of labour among the farming population to accomplish farm tasks.

Table 4.3: Distribution of cotton farmers by marital status

Marital Status	**Frequency**	**Percentage**
Married	162	73.64
Single	35	15.91
Divorced	13	5.91
Widowed	10	4.54
Total	**220**	**100**

Indeed in the traditional farming system, family labour is substitutable for hired labour or communal labour. In some cases, family labour constitutes a more significant source of labour while hired labour or communal labour serve as supplementary sources of labour in the farm.

4.1.5 Sex of cotton farmers

From the survey, most of the farmers who produce cotton were males. The female respondents were small proportion of the sampled farmers. The study revealed that in the North-Western part of Nigeria, majority of farmers were men while their female counterpart pre-occupied themselves with other minor vocations. This findings agreed with the result of Alam *et al. (2013)* that majority (89%) of the respondents were males while about 11% of them were females indicating that there are more males in cotton production than their female counterparts in Taraba State, Nigeria.

Based on this premise, religion and culture are the major sources of influence on the socio-economic life styles of women in the study area. The area is Hausa-Moslem-dominated zone and the socio-economic life styles of women in the Moslem communities are strictly guided by Islamic doctrines and principles. Keeping women in harem (seclusion) is quite pronounced in the area. This had compelled women to housekeeping, food processing activities at homes and subsequently with less time for accomplishing farm tasks.

The result of this study agreed with that of Rahman (2008), that division of labour in rural agricultural activities may be gender specific. It is probably believed that in the Moslem-dominated community in Northern Nigeria, the obligations of men and women are clearly defined. Jackson (1986) asserted that secluded Moslem women do not farm. Cotton production is capital intensive and involves tedious and hard labour this gives credence to the dominance of males in cotton production activities than females.

4.1.6 Experience in farming among cotton farmers

Majority of the sampled farmers had experience of above 15 years while some had experience of between 11-15 years. A small proportion of cotton farmers had been farming for a period of 6-10 years and 1-5 years among cotton farmers in the study areas respectively. The mean year of experience among cotton farmers was 12 years while the minimum and maximum years of farming experience were 1and 14 years respectively

Table 4. 4: Distribution of farmers by their farming experience

Level of Experience	Frequency	Percentage
1 – 5 years	35	15.91
6 – 10 years	43	19.55
11 – 15 years	65	29.54
≥15 years	77	35.00
Total	**220**	**100**
Mean = 12.18 Minimum = 1 Maximum = 14 Standard deviation = 0.73		

In this regard, cotton farmers have various depths of experiences in their farming activities. Experience is described as the process of gaining knowledge and skill in carrying out certain farm operations. It enhances professional disposition in the art of carrying out some jobs in the farm. The more the number of years spent on production by a farmer, the greater is the knowledge and skill gained in that production enterprise. This agreed with the findings by Ajani (2000), on productivity in food farming in Northern area of Oyo State, Nigeria. The study showed that year of farming experience may increase agricultural productivity among farming households in Nigeria.

4.1.7 Household composition of cotton farmers

The result shows that adult males and females above 14 years constitute a large proportion of cotton farmers. The numbers of male and female children below 14 years were small proportion of the respondents. From this result, it implies that there are more adult females above 14 years than adult males above 14 years in the household in the study area. Also, the disabled males and females were a small proportion of the number of persons in a household. This means that their contribution in the supply of family

labour for accomplishing farm tasks may not have any significant impact and quite negligible. (Table 4.5).

Table 4.5: Distribution of cotton farmers by age, sex and household composition

Age and Sex	**Frequency**	**Percentage**
Adult males above 14 years	825	39.55
Adult females above 14 years	916	43.91
Children		
(Male below 14 years)	131	6.28
(Female below 14 years)	180	8.63
Disabled		
(Male)	20	0.96
(Female)	14	0.67
Total	**2086**	**100**
Mean= 9		

Household composition depicts the number of persons in a family living together in a house. This determines the family size of individual farmer interviewed. The average number of persons per family was found to be 9. However, the absolute number of persons in a particular household cannot be used to justify the possibility of increased labour supply and consequent potential for productive farm work. This is because labour supply for accomplishing farm tasks depends on four important factors namely age, health status, sex and interest. In accordance with the findings of Okoruwa and Ogundele (2006), large family size does not necessarily translate to higher use of family labour because some of the young able-bodied family member may create preference for other jobs than farming.

4.1.8 Access to credit facilities among cotton farmers

Result revealed that about half of cotton growers had access to credit facilities from various statutory financial institutions while slightly above half of the farmers had no access to credit facilities. This implies that slightly more than half of cotton farmers had no access to credit facilities that would have enhanced adopting improved technologies and expand production of cotton.

Agricultural credit facilities are essential in order to circumvent and overcome the problem of shortage of capital among cotton farmers. This is because most cotton farmers operate small holdings which subject them to vicious circle of poverty of low productivity, low output, low income, low savings and low investment. As a result, it is difficult for them to increase their ability to save and invest on capital intensive technologies in their cotton production enterprises.

Therefore, there is need to increase the level of funding in order to transform cotton production in Nigeria. ATA (2011) asserted that, this could be achieved through integration of agriculture value chains with agricultural lending. This would be facilitated by Nigerian Incentive-based Risk Sharing for Agricultural Lending (NIRSAL). NIRSAL is a new, dynamic, holistic approach that tackles together both the agricultural value chains and the agricultural financing value chains. Therefore, NIRSAL breaks with tradition by doing two things at once:

i) Fixes the agricultural value chains, so that banks can lend with confidence into cohesive and complete value chains; and

ii) Encourages banks to lend into the agricultural value chains by offering them strong incentives.

This funding measure in agricultural lending will help in overcoming frequent shortages of cash flowing into agricultural production and marketing thereby affording farmers the opportunity to procure inputs timely in their production activities. This is an incentive for cotton farmers to improve value chains in marketing their products both in the domestic markets and international markets as well.

4.2 Forecasting Cotton Production Trends in Zamfara State, Nigeria

This part of the study is to forecast cotton production trends with the application of a grafted polynomial function from 1995 to 2013 in Zamfara State, Nigeria. This analysis was used to achieve objective (ii) of the study.

4.2.1 Application of grafted model in forecasting cotton production trend

The forecasting model that was applied to estimate cotton production trends is a grafted polynomial function "quadratic-quadratic-linear" function. A graphical representation of Q_t in Figure 4.1 clearly showed that observed time series fluctuate and do not relate linearly to trend 't' over the entire sample period. This is as a result of some economic, biological, environmental and other observed key and major local trends entrenched in the production system. The cotton production trend in Zamfara State between (1995 and 2013) was illustrated in figure 4.1. In 1995, cotton production was about 125,000 metric tons which rose appreciably to 175,000 metric tons in 1996 implying that cotton production witnessed an upturn. In 1998, cotton production experienced a downturn from 175,000 metric tons to about 110,000 metric tons. Cotton production experienced a slight increase of about 160,000 metric tons in 1999. This increase was sustained from 1999 to 2002 when cotton production rose to about 210,000 metric tons. Between 2003 and 2005, cotton production trend stagnated while it experienced a fall to 160,000 metric tons in 2006. There was a sharp rise to 225,000 metric tons in 2007 while

between 2008 and 2013 cotton production trend fairly stagnated at about 110,000 metric tons during which no significant increase or decrease was observed.

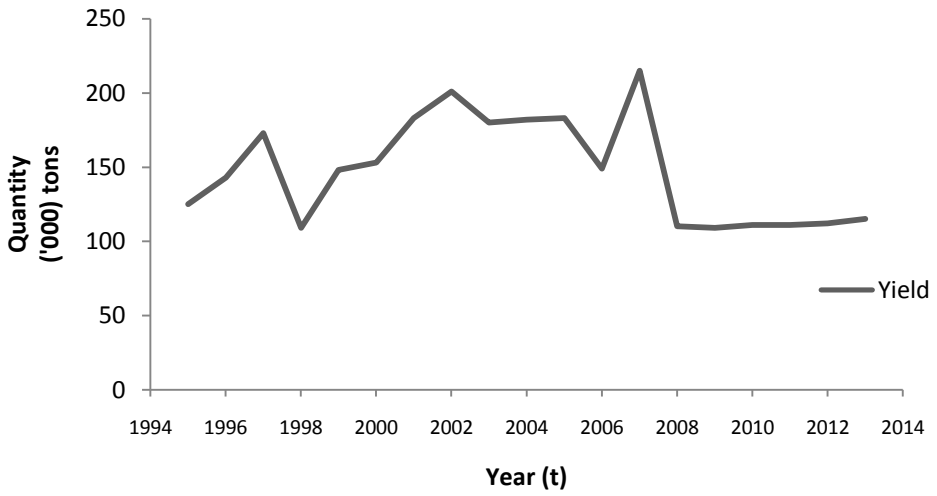


Figure 4.2: Cotton Production Trends in Zamfara State, Nigeria (1995 – 2013)

Source: Zamfara State Agricultural Development project (ZADP) and other secondary sources.

Therefore, this section attempted to improve upon the linear model represented by equation (24) by dividing the available time series into segments. Different functional forms were used for the segments and the best functional form was adopted to estimate the already observed future values and appropriate inferences were taken from the results. The major database for this analysis was the observed trend in cotton output in Zamfara State from 1995 to 2013. A preliminary graphical representation of the observed time series data in Figure 4.1 indicates three (3) time segments and the quadratic-quadratic-linear trend function were hence suggested. From this three time segments, a mean (grafted) functional model was derived in which the objective was to entrench and absorb all the key and major local trends in the time series Q_t. The mean function in equation (37) required for the forecasts was obtained by substituting for a_o, a_1, b_o and b_1 in equations (28)-(31). This was summarised in appendix (II).

The mean function is now continuous, differentiable and linear in all parameters and structural coefficients. Since the objective is to predict cotton production trends over the years, it is quite imperative to retain the coefficients at the terminal trend function which is usually linear and it is quite congruent and suitable for ordinary least squares (OLS) estimation. The linear function and the mean functions represented in equations (24) and (37) were utilized in the analysis using the ordinary least squares method. The results of the regression analysis and the estimates of the structural parameters are presented in Table 4.6. The data for the 2006 - 2013 sub-periods were retained for the *ex-post* evaluation or forecast of the estimated equation. Also, equation (24) was estimated in order to purposely evaluate the predictive performance of equation (37).

Table 4.6: Estimates of the structural parameters in predicting cotton production trend in Zamfara State, Nigeria.

Variable	**Linear trend**	**Grafted (Mean) trend**
Intercept	168***	314***
	(10.12)	(5.79)
X_1	-2	-12.4***
	(-1.38)	(-3.25)
X_2	-	0.30
		(0.09)
X_3	-	-1.53**
		(-2.08)
R^2	0.10	0.504
Adjusted R^2	0.048	0.39
df.	18	16

*** = P < 0.01 **= P < 0.05

Figures in parenthesis are the T-values.

The computed T-value corresponding to the estimate of the coefficient on X_1, for the linear trend model was statistically insignificant. Only the calculated T-value corresponding to the estimated coefficient on X_2 was statistically insignificant for the

grafted trend model (Table 4.6). The calculated T-values for the grafted function in the trend model for both X_1 and X_3 were statistically significant at 1% and 5% levels of probability. The variables, x_1 is the time variable in trend for k., x_2 is the time variable in trend for k_1 and x_3 is the time variable in trend for k_2. This suggests that the mean trend model must have captured and infused all the observed key and major local trends in the model. Unlike the mean trend model, the linear trend model failed to explain the desired variation observed in cotton production trend. This is because time series do not always correlate linearly to trend during the entire sample period.

The estimates of the linear and grafted functions in Table 4.6 were utilized to obtain ex-post forecasts of cotton production in the study area. The numerical ex-post values of cotton production were used to forecast the trend over the 2006-2013 sub-periods as retained in the analysis. This was based on the linear and grafted models. The result of ex-post forecast revealed that the grafted function provided better estimates of cotton production during the sub-period. The values for the grafted function were closer to the observed values resulting in smaller difference during the sub-period under consideration. This is due to the fact that, the grafted (mean) function entrenched the major observed local trends in the forecasting framework which has enhanced a more relevant time series prediction over the entire sample period. This type of forecasting may be useful for policy makers and agricultural administrators in planning for future cotton production based on the available information of the past periods (Table 4.7).

Table 4.7: *Ex-post* forecasts of cotton production in Zamfara State, Nigeria (2006 – 2013).

Year	Observed Cotton Production ('000 tons)*	Forecasts using the Grafted Function ('000 tons)	Forecast using the Linear Function ('000 tons)
2006	149	165.20	144
2007	215	161.20	142
2008	110	140.40	140
2009	109	128.0	138
2010	111	115.60	136
2011	111	103.20	134
2012	112	90.80	132
2013	115	78.40	130
Total	**1032**	**982.8**	**1096**
Mean	**129**	**123**	**137**

* The observed cotton production trend was obtained from ZADP and other secondary sources.

The result of this work agrees with that of Rahman and Damisa (1999) in forecasting performance of a grafted model on cowpea price in Zaria area of Kaduna State, Nigeria. The result revealed that, the mean trend model predicted better than the linear model because the mean trend model was built on the principle that past local trends in the observed time series (linear, quadratic, exponential etc.) have been incorporated into the body for forecasting immediate future values. This had helped to achieve a more relevant time series prediction that provided appropriate flexible and useful policy guide especially in cases where forecasts are obtained based on estimation.

In the same vein, the result of this analysis is in agreement with the work of Oyakhilomen *et al.* (2013) who estimated the numerical ex-post forecast of rice consumption in Nigeria. The structural parameters of the linear and grafted models were used to determine their predictive performance with the linear model utilised as a benchmark. The result of their work showed that, the estimates of the grafted model

were closer to the observed rice consumption trend in comparison with the estimates of the linear model.

4.3 Resource Procurement methods, Utilisation and Cotton Production Technologies

Among cotton farmers, there are various patterns of resource use and utilisation in the production process. On one hand, inputs are procured through agro-services which are combined at various levels in order to accomplish production. On the other hand, inputs are organised and utilised through available cultural practices and various cotton production technologies at their disposal. This part of analysis was used to achieve objective (iii) of the study. Inputs are procured through various sources among cotton farmers. Some of these inputs were provided by various agro-service agencies such as National Seed Service, non-governmental agencies such as West African Cotton Company (WACOT), Ministry of Agriculture and Natural Resources (MANR), Agricultural Development Projects (ADP's) and other Agro-service Agencies. Some of the inputs procured through these agencies include seed, fertilizers, agro-chemicals, sprayers, hoes, ox-drawn ploughs and cutlasses.

4.3.1 Source of seed used in cotton production

Table 4.8 indicates that majority of the farmers relied on seed that was retained from previous harvest for planting. Some of the farmers sourced their seed for planting from Ministry of Agriculture and Natural Resources (MANR) or the Agro-service Centres (ASC's) of the Agricultural Development Projects (ADP's) nearest to them.

Some of the farmer's preferred certified seed from the National Seed Service Centres while some planted seed procured from the open market in their domain. The source of

seed from the open market may not be desirable due to the fact that, the genetic attributes of such seed may not be known. Therefore, it is strictly advised and recommended that sources of seed required for planting need to be known and should be such that will be suitable and adaptable to the environment with high yielding potential. This is shown in Table 4.8. Idem (1999) opined that, it is very essential that well adapted cotton varieties are planted in various cotton growing zones.

Table 4.8: Distribution of cotton farmers by their source of seed

Source of Seed	**No of respondents**	**Percentage**
MANR/ADP*	53	24.00
Seed retention	77	35.20
National Seed Service	46	20.80
Market	44	20.00
Total	**220**	**100**

* Ministry of Agriculture and Natural Resources/Agricultural Development Project, Zamfara State.

Improvement in cotton production depends on source of cotton varieties used in its production complemented by other cultural practices. Good and sanitized source of seed for planting determines the success and productivity of cotton among farmers. Availability of improved seed which are certified with high yielding genetic potential, pest and disease resistance with ability to adapt and adjust to the environment is required by cotton farmers.

4.3.2 Source of fertilizers used in cotton production

Most of the farmers sourced their fertilizers from the Ministry of Agriculture and Natural Resources (MANR) or the Agro-service Centres (ASC's) of the Agricultural Development Projects (ADP's) nearest to them. Some financial institutions helped in the supply of fertilizers to farmers as part of their credit delivery packages of which

some of the farmers benefitted from such programme. Some of the farmers procured their fertilizer inputs from the open market and cooperative societies. Also, a small proportion of the farmers used the Ministry of Agriculture and Natural Resources (MANR) or Agricultural Development Projects (ADP's), Co-operative Societies, financial institutions and open market to procure the fertilizers used in their cotton production activities.

Table 4.9: Distribution of cotton farmers based on source of fertilizer

Source of Fertilizer	**Frequency**	**Percentage**
MANR/ADP	80	36.36
Co-operative Society	60	27.27
Financial Institution	20	9.09
Market	50	22.73
All of the above	10	4.55
Total	**220**	**100**

Fertilizer is one of the inputs used in cotton production to replenish the fertility of the soil among cotton farmers in the study area. Hence, availability of mineral nutrients for crop use is made possible through application of various brands of fertilizer. It is important for farmers to have prompt and timely access to this input to enhance their production activities. This is because fertilizer is required in most savanna soils to upgrade the fertility status and improve physiological performance of the crop and its productivity.

4.3.3 Brand of fertilizers used in cotton production

Majority of the farmers applied all the three brands of fertilizer namely N.P.K, boronated Single Super Phosphate (SSP) and Calcium Ammonium Nitrate (CAN) at

different split doses in their cotton farms (Table 4.10). Certain proportion of the farmers applied N.P.K, boronated (SSP) and (CAN) in their cotton production farms.

Table 4.10: Distribution of cotton farmers by brand of fertilizers utilised

Brand of Fertilizer	**Frequency**	**Percentage**
N.P.K	60	27.27
S.S.P (Boronated)	19	8.60
C.A.N.	30	13.6
All of the above	111	50.53
Total	**220**	**100**

Different brands of fertilizer were required by farmers in cotton farms to augment the level of soil fertility thereby enhancing productivity. The supply of different brands of fertilizer containing different forms of nutrients required by cotton plant will enhance provision of adequate mineral nutrients in the soil. This will be made available and ready for crop use thereby increasing yield and productivity of cotton among farmers in the study area. The Federal Government in its agricultural transformation agenda noted that for cotton production to thrive in Nigeria, a specific blend of fertilizer is required, which unfortunately is not available locally. Thus, importation of this blend of fertilizer becomes inevitable. It is estimated that 27,000MT of fertilizer needed in 2011 would be increased to 70,000MT by 2015 to meet the targeted cultivable land area of 350,000ha (ATA, 2011). This measure is a right step in the right direction that will help in revamping cotton production industry.

4.3.4 Method of fertilizer application adopted by cotton farmers

In adopting method of fertilizer application, some proportion of the sampled farmers used top dressing. While a small number of the farmers adopted broadcasting as one of the recommended cotton production practices. Broadcasting method of fertilizer

application was used in order to enhance wider coverage of the farm and proper incorporation of the fertilizer into the soil for efficient crop use especially if it is done before land preparation. Majority of the farmers adopted spot method of application which is the most common method especially at the later stage of crop growth while some of the farmers used side dressing method of fertilizer application (Table 4.11).

Table 4.11: Distribution of cotton farmers by method of fertilizer application

Method of fertilizer application	**Frequency**	**Percentage**
Top dressing	39	17.72
Broadcasting	20	9.09
Spot application	100	45.46
Side dressing	61	27.73
Total	**220**	**100**

Appropriate methods of fertilizer application are required by farmers in the process of applying fertilizer to cotton in their farms. This is because specific methods are adopted depending on the brand, different stages of crop growth and at different location of ecological zone or soil. This will help to optimise the utilisation of this input in the farm.

4.3.5 Method of land acquisition and land ownership among cotton farmers

Land acquisition, ownership and land tenure pattern was investigated in the farm survey among cotton farmers in the study area. In Table 4.12 most of the farmers acquired their farms through inheritance. This is the most common way of acquiring land for cotton production in the study area. Some owned their land through gift and leasing. A small proportion of the farmers used co-operative and communal land for producing cotton in their farms. Those that rented their farmland for cotton production are quite

insignificant while those that purchased their land were also small proportion of the total sampled farmers.

Table 4.12: Distribution of cotton farmers by their mode of land acquisition and ownership

Method of Land Ownership	**Frequency**	**Percentage**
Inheritance	90	40.91
Gift	58	25.45
Leasing	26	11.82
Co-operative land	16	7.27
Communal land	15	6.82
Rented land	9	4.09
Purchased land	8	3.64
Total	**220**	**100**

Land is an indispensable and a valuable input as a factor of production in agriculture. It is one of the salient assets required in agricultural production. This finding was substantiated by ATA (2011) that due to cotton's relatively low yields, 300kg to 500kg per Ha, there is that need to bring significant quantum of land into cotton production. The North-western and North-eastern part of the country being most suitable for cotton production will be the regions of focus. The projection is to increase cotton from 113,000MT in 2011 to 350,000 MT by 2015 then improvement in productivity and access to improved cotton varieties and practices can be a better substitute for land expansion.

4.3.6 Source of finance among cotton farmers

The result in Table 4.13 shows that majority of cotton farmers financed their production activities through personal savings. This implies that most of them do not seek for

external sources of finance such as formal credit or loans from banks, co-operative societies or other statutory financial organisations to produce cotton. Some of the farmers sourced funds from co-operative banks while others got funds from co-operative societies. A small proportion of the sampled farmers sourced funds from the so-called money lenders.

Table 4.13: Distribution of cotton farmers according to source of finance

Source of finance	**Frequency**	**Percentage**
Personal savings	117	53.18
Credit through		
co-operative banks	47	21.36
Co-operative societies	50	22.73
Money lenders	6	2.73
Total	**220**	**100**

Adequate and timely source of fund is required to ameliorate shortage of funds for acquiring inputs needed for production of cotton in the farm. The amount of fund available for use in the farm justifies the quantity of agricultural product that can be produced with adequate and rational combination of other inputs. In a similar study conducted by Alam *et al.* (2013), they reported that inadequate funds (67.7%) hindered farmers in expanding the cotton farming business, which could be the reason why majority of the cotton farmers (91%) were small scale farmers in Taraba State Nigeria.

4.3.7 Amount of loan granted to cotton farmers

The amount of loans for funding cotton production activities vary from one farmer to another. According to the result in Table 4.14, most cotton farmers did not seek for formal loan but used their personal savings. Some of the sampled farmers were granted loan of between ₦70, 000 - ₦100, 000 while some obtained loans of between ₦101, 000

- ₦200, 000., ₦201, 000 - ₦300, 000 and ₦301, 000 and above required to produce cotton in their farms. The minimum and maximum amount of loan granted were ₦54, 540.00 and ₦374, 500.00 respectively while the mean loan granted was ₦182, 254.82

Table 4.14: Distribution of cotton farmers based on amount of loan granted

Amount of Loan received (₦)	**Frequency**	**Percentage**
70,000 – 100,000	28	12.73
101,000 – 200,000	25	11.36
201,00 – 300,000	27	12.27
301,000 and above	34	15.50
No Loan granted	106	48.20
Total	**220**	**100**
Mean = ₦182,254.82 Minimum = ₦54,540.00 Maximum = ₦374,500.00 Standard deviation = ₦73,345.65		

The essence of obtaining loan from various sources is to overcome shortage of fund. This will help farmers to source, procure and utilise various inputs timely in cotton production. The amount of loan secured by farmers serves as an enhancing factor to invest into all aspects of production activities if such loan is properly utilised. Farmers sourced loans from various sources in order to accomplish the task of agricultural production.

4.3.8 Source of labour used in cotton production

The result revealed that more than half of the labour used in accomplishing farm tasks in cotton farms were sourced by hiring. Family labour was also used while some of the farmers used communal labour for carrying out various tasks in the farm. Since most farm operations were executed using traditional methods, a small proportion of the

farmers mechanised almost all operations with the exception of cotton picking in the farm.

Table 4.15: Distribution of cotton farmers according to source of labour

Source of Labour	Frequency	Percentage
Family labour	57	25.91
Hired labour	119	54.10
Communal labour	23	10.45
Mechanical labour	21	9.50
Total	**220**	**100**

Labour is a crucial factor of production as it is the case in most labour intensive traditional farms. Labour input is applied by activity based on the task to be accomplished in the farm. The most frequently demanding in terms of labour input in cotton production are planting, thinning, manual weeding, spraying and picking or harvesting. ATA (2011), attested to this fact that one of the more labour intensive aspects of cotton is in the harvesting process; hence the expectation is that with increased yields there will be a dramatic increase in labour requirement not only for new farms but existing farms as well.

Labour constitutes the main input in the small scale farm operation in cotton production in the study area. There were three types of labour that were frequently used in cotton production. These were hired labour, family labour and communal labour. Hired labour and family labour sources were widely used while few of the farmers indulged in using communal labour in their farms which was regarded as an equivalent source to family labour in the study area.

4.3.9 Source of agro-chemicals used in cotton production

Majority of the sampled farmers sourced their agro-chemicals from Ministry of Agriculture and Natural Resources (MANR) or Agricultural Development Projects (ADP's) nearest to them. Those who procured their agro-chemicals through co-operative societies represent a substantial number of the respondents while some purchased their own through open market (Table 4.16).

Table 4.16: Distribution of cotton farmers by their source of agro-chemicals

Source of Agro-chemicals	**Frequency**	**Percentage**
MANR/ADP	87	39.55
Co-operative society	73	33.18
Open market	60	27.27
Total	**220**	**100**

This implies that majority of cotton farmers obtained their agro-chemicals through the ADP's in their domain while others reaped the benefit of co-operative societies of which they are members. Agro-chemicals comprise of herbicides and pesticides used to produce healthy and vigorous cotton plants when applied at appropriate and regular time intervals and at correct dosage. Agro-chemicals were used to control and eradicate weeds, pests and diseases on cotton farms so as to increase yield and productivity. The new voucher system of inputs delivery introduced by ATA (2011) will serve as an impetus to alleviate the problem of inputs supply, procurement and utilisation in crop production. This will serve as an incentive to encourage farmers in cotton production in Nigeria.

4.3.10 Pest control methods adopted in cotton production

Pest control methods were applied so as to control pests of cotton at various stages of growth. From the sampled farmers, nearly half of the respondents applied pesticides while some proportion of the farmers used cultural measures such as appropriate cotton close season, adequate land preparation, timely planting, close spacing and timely weeding. Only a small number of the sampled farmers employed physical control measures such as burying of pests during weeding, hand picking and tillage operations. Those farmers that applied a combination of all the three methods namely cultural methods, physical methods and application of insecticides known as chemical control measure were also a small proportion of the sampled farmers in the study area.

Table 4.17: Distribution of cotton farmers by pest control methods adopted

Pest Control Method	**Frequency**	**Percentage**
Cultural method	86	39.1
Physical method	11	5.0
Chemical method (Pesticides)	105	47.72
All of the above	18	8.18
Total	**220**	**100**

This implies that timely pest control using appropriate method or a combination of methods will help in reducing the disastrous impacts of pests on the roots, stems, leaves, buds, flowers, bolls and lint thereby increasing the level of cotton output.

4.3.11 Interval of sprays of cotton farms

Consistent and periodic spraying of cotton farms at regular intervals is essential to produce high yield. In Table 4.18, certain number of cotton farmers sprayed their cotton

farms at 3-sprays fortnightly and 4-sprays at weekly interval respectively. Those who sprayed their farms at 5-sprays at weekly intervals represent nearly a quarter of the sampled farmers. On the whole, slightly more than half of the farmers sprayed their farms at 6-sprays at weekly interval.

Table 4.18: Distribution of cotton farmers by interval of sprays of cotton farms

Interval of Spray	**Frequency**	**Percentage**
3 – Sprays fortnightly	28	12.71
4 – Sprays at weekly interval	25	11.36
5 – Sprays at weekly interval	50	22.73
6 – Sprays at weekly interval	117	53.20
Total	**220**	**100**

Indeed, these intervals of spraying cotton farms are subjective because the farmers need to take congnisance of insect pests on cotton at different phenologic growth stages. According to Onu (2012) it was recommended that spraying and control of pests should be at the phenologic growth of interest namely flowering, squaring, boll formation and boll maturation stages. This will help in controlling pests that can degrade cotton lint and reduce its quality such as cotton stainer known as *Dysdercus superstitiosus.*

4.3.12 Land preparation technologies adopted by cotton farmers

Many cultural practices for cotton production were investigated among cotton farmers. Various cultural practices commonly adapted, adopted and used by farmers to produce cotton include land preparation, cropping system, seed varieties planting, weeding practices, agricultural extension services and co-operative societies or cotton growers' association in the study area.

Land preparation is an essential pre-requisite determining successful production among cotton farmers. Land preparation was found to be prevalent among cotton farmers in the study area. In Table 4.19, some of the farmers adopted hoe-ploughing and ox-drawn plough to prepare their land while certain number of the sampled farmers used a combination of hoe-plouging and ox-drawn ploughing to prepare their land for cotton production on various plots. A small proportion of the farmers used tractor in their farms. This result implies that majority of the farmers used ox-drawn ploughing in the study area which is faster than hoe-ploughing using direct manual labour. The use of tractor by cotton farmers was not pronounced due to the fact that most of the cotton farmers were small-scale farmers. Sabo *et al.* (2009) attested that the use of ox-drawn plough and tractor-drawn plough were frequent in land preparation (ploughing and harrowing) while zero-tillage was least practiced.

Table 4.19: Distribution of cotton farmers according to land preparation technologies adopted

Land Preparation method	**Frequency**	**Percentage**
Hoe-ploughing	67	30.45
Ox-drawn ploughing	72	32.73
Tractor	40	18.18
Hand and ox-drawn plouging	41	18.64
Total	**220**	**100**

It is evidently clear that, a significant proportion of the farmers used hoe and ox-drawn plough to prepare their farmland. This is due to the fact that farmers have their farm holdings operated using traditional practices.

4.3.13 Cotton seed varieties planted

The use of good seed variety determines the yield if accompanied by other recommended cotton production practices. From field survey, a significant number of respondents used the varieties of cotton through seed retention from their farms. Majority of the sampled farmers used improved varieties while some farmers cultivated newly certified cotton seed varieties from various sources. A small proportion of the sampled farmers planted cotton seed from both retained and improved varieties on different plots (Table 4.20).

Table 4.20: Distribution of cotton farmers by cotton seed varieties planted

Seed variety	Frequency	Percentage
Cotton seed retention	67	30.45
Improved cotton seed	90	40.91
Newly certified seed	52	23.64
Retained and improved varieties	11	5.01
Total	**220**	**100**

Improved recommended cotton seed varieties were Samcot 8, Samcot 9 and Samcot 10. Samcot 8 has maturing period of 120 – 130 days and potential yield of 1,500 $kgha^{-1}$, while Samcot 9 and 10 mature at 120 days with potential yield of 2,500 – 3000 $kgha^{-1}$. (Idem 1999., Adeniji *et al.*, 2007). Accordingly, Onu *et al.*, (2012) investigated seven cotton genotypes for two years to ascertain their level of resistance or tolerance to leaf roller (*Sylepta derogata*) and the agronomic performance. The genotypes screened were Samcot-8, Samcot-9, Samcot-10, Samcot-11, Samcot-12, Samcot-13 and CL07. It was evident from the results that all the varieties showed various levels of infestation to cotton leaf rollers except CL07 that showed zero infestation.

4.3.14 Weeding practices adopted by cotton farmers

The result showed that weeding was one of the dominant practices among cotton farmers in the study area. Table 4.21 revealed that slightly less than half of the sampled farmers used manual weeding method. Also, a large proportion of the respondents applied various forms of herbicides to control weeds while a small number of the sampled farmers used both manual and chemical methods in their farms. This could be attributed to the fact that some chemicals were not effective in controlling all weeds that might have emerged. Therefore, supplementary manual weeding was required. A small number of the sampled farmers indicated that no weeding was done at various stages of cotton production.

Table 4.21: Distribution of cotton farmers based on weeding practices adopted

Weeding methods	**Frequency**	**Percentage**
Manual weeding	100	45.45
Chemical weeding	90	40.91
Manual and chemical weeding	20	9.10
No weeding	10	4.54
Total	**220**	**100**

Weed control is one of the essential cotton production practices aimed at enhancing adequate utilization of other inputs and increased yield and productivity. Weeding is desirable at regular intervals for a good crop of cotton so as to allow for proper genetic expression in terms of yield, pest, disease resistance and adaptation to the environment. According to Vissoh *et al.,* (2004), yield losses in farmers' fields due to weeds range from 25% to total crop failure because farmers are unable to perform the necessary weeding at the optimal times. Weeds are perceived by most smallholder farmers as the greatest yield-limiting constraint. In the same vein, Idem (1999) pointed out that, cotton

does not compete favourably with weeds especially during the early period of growth. Cotton fields should be kept weed-free until bolls are beginning to mature.

This implies that, cotton farms that are kept weed-free will be able to produce vigorous and healthy cotton plants with high cotton lint yield. Also, the lint will be free from adulterants such as grasses and dry weeds thereby producing high quality lint of better grade. In other words, cotton farms infested by weeds will be subjected to low crop growth performance, competition for soil nutrients and hence low cotton yield and productivity. Ahmed *et al.* (2012) conducted cotton zonal herbicide trial to evaluate suitable herbicides for cotton production system. The results showed that all the herbicides rates resulted in significantly reduced weed cover more than the hoe-weeded control and the weedy check treatments.

4. 3. 15 Cropping system adopted by cotton farmers

In the study, cropping system was investigated among sampled farmers in the study area. In Table 4.22 less than half of the sampled farmers adopted sole cropping system in which cotton was planted as the sole crop cultivated. Those who adopted "Gicci" system[1] were small proportion of the sampled farmers while some practiced the formal mixed cropping system. A small proportion of the sampled respondents adopted all the three methods namely sole cropping, gicci and mixed cropping system on various plots in their farms.

[1] Gicci system is a mixed crop modeling pattern in which a selected food crop is inter-planted with a major crop across the ridges at definite but wider intra and inter-row spacing so as to maximize the use of inputs and increase yield.

Table 4.22: Distribution of cotton farmers according to cropping system adopted

Cropping system	Frequency	Percentage
Sole cropping	70	31.82
Gicci (with groundnut /soybean)	53	24.10
Mixed (with cotton, soybean, groundnut)	76	34.50
Sole, gicci and mixed	21	9.58
Total	**220**	**100**

Cropping system in the context of this study is defined as the cultivation of crops in a given pattern comprising of cotton as sole crop or in mixtures with other crops for some part of the cropping season. Most small cotton farm holders in the traditional farming systems adopted various forms of cropping systems. This is done by integrating other crops which serve as staple food thereby ensuring food security and meeting other needs at family level. In other words, cotton farmers embark on diversification by producing other crops as an insurance measure against risks. Some of the risks include crop failure in the event of natural hazards such as serious incidence of pests, weeds and diseases, weather hazards such as flood, drought, storms and frost.

In a survey conducted by Adeniji (2007) he attested to this fact in his report that cotton is one of the major crops grown in the area of study. The crop is grown as sole and in mixture with maize, sorghum, groundnuts, cowpea and so on. The study further revealed that, about 73% of the respondents planted cotton in mixtures. The average hectare of the sole crop cotton was 1.46 ha.

The primary aim of farmers is to diversify production activities thereby taking advantage of maximum and efficient utilization of various inputs such as land and labour. It is believed that this will enhance increase in the level of output, income and food per unit area cultivated. This finding agrees with Idem (1999) that cotton production in Nigeria is not done in isolation, small holders produce many crops of interest to them. The primary aim or priority is to meet the food needs of the household and secondarily the surplus is sold to acquire goods and services.

4.3.16 Visits by agricultural extension agents to cotton farmers

There are various recommended cotton production technologies available for innovation, adoption and adaptation by farmers on their cotton farms. Most farmers acknowledged that agricultural extension agents contacted them to disseminate new practices in cotton production. Few cotton farmers claimed that, there was no visit by agricultural extension agents in their farms.

The dissemination of new and improved technologies in cotton production for adoption is an important measure enhancing effective resource utilization and increased productivity among farmers. A well articulated research and extension network system is needed to ameliorate the constraints in operating agricultural production using traditional methods. According to Obwona (2000) extension service is very essential to the improvement of farm productivity and efficiency among farmers. This agrees with Cherry *et al.,* (2000) who in their findings asserted that the adoption of new technologies is often influenced by the frequency of visits of the extension agents to farmers to disseminate information on new and improved recommended cotton production practices.

The ultimate aim of agricultural extension services is to enhance farmers' ability to innovate and adopt new practices by increasing their level of awareness about the existence and usefulness of such technologies. This is based on improving the "researchers-extension agents-farmers" linkages through frequent contacts to farmers by extension agents and using appropriate methods to teach them various technologies they intend to offer the farmers. Some of the recommended cotton production technological packages offered to farmers by extension agents revealed by farmers were many.

Atala and Kuchinda (2012) reported that the more wholesome the adoption of improved technology package, the higher the productivity of cotton. A vast number of farmers, including those that are also pro-technology bias do not wholesomely adopt the technologies owing to circumstantial factors. They partially adopt technologies or technological packages. The adaptation are modifications or adjustments which are often logical actions taken in order to be within the economic, social, cultural and environmental situations in which farmers find themselves. Adaptation is only partial success or progress towards adoption that it is better than non-adoption or rejection of improved technologies.

4.3.17 Membership of co-operatives/cotton growers' associations

From field survey, slightly less than half of cotton farmers did not belong to any co-operative society or cotton growers' association while more than half were members of various cotton growers' groups. Co-operative organisations or cotton growers' associations were formed by farmers sharing common interests and goals. These groups are carved out by farmers in specific locality to improve their welfare and mobilize resources for enhanced cotton production. They are statutorily registered and recognised

to perform some functions which are beneficial to farmers. Most of these groups were operated based on democratic principles such as one man one vote, member can vote and be voted for and deriving common benefits as members.

4.3.18 Type of cotton growers' associations

There are some groups of cotton growers that are known to make group effort in alleviating some problems encountered by cotton farmers in the study area. From Table 4.23 few numbers of the sampled farmers belong to cotton growers' associations and young farmers' group. A small proportion of the respondents were members of co-operative societies while some of the farmers were those that belong to farmers' support clubs rendering some agro-services and supports to cotton farmers. Majority of the farmers claimed that they did not belong to any cotton growers' group.

Indeed, Co-operatives, farmers' associations and groups embark on group efforts in harnessing farm inputs in their production activities. They are important vehicles in economic growth and development. Majority of the farmers did not belong to these cotton growers' groups which imply that most of the benefits of cotton growers' membership that will enhance their production activities will not be realised by non-members.

Table 4.23: Distribution of cotton farmers according to type of cotton growers' associations

Type of Group	Frequency	Percentage
Cotton growers' association	30	13.63
Young farmers' group	27	12.27
Co-operative society	44	20.0
Farmers' support club	20	9.10
Do not belong to any	99	45.0
Total	**220**	**100**

Therefore, necessary steps need to be taken to intensify formation of co-operative societies, cotton growers groups or associations. The role of some voluntary organisation and government encouragement to effect formation of these groups are essential. This will help to raise farmers' expectations in terms of securing loans from formal sources as a group, timely supply and distribution of production inputs, prompt evacuation of cotton from the farms, sale of cotton in organised markets and many other benefits farmers can derived from those groups.

4.3.19 Benefits derived from group or association of cotton growers

The benefits derived from such groups were investigated during the field survey. Table 4.24 indicates that some of the sampled farmers benefitted from the group in terms of procuring of inputs for members. A small proportion of the farmers were assisted in the process of marketing their cotton while some proportion of the farmers had access to loans or credits approved and disbursed by the group. Also, a small proportion of the sampled farmers benefitted from procurement of inputs, marketing of output and granting of loans or credits. These benefits had enhanced farmers who are co-operative

members or members of any cotton growers' group to overcome some constraints in these regard. Those who did not belong to any group and derived no benefit from the group constituted slightly less than half of the sampled farmers in the study area.

Table 4.24: Distribution of cotton farmers according to benefits derived from group

Benefits from Group	Frequency	Percentage
Procurement of inputs	45	20.45
Marketing of output	37	16.82
Granting of loans/credits	28	12.73
All benefits	10	4.45
No benefit	100	45.45
Total	**220**	**100**

There are some benefits inherent in belonging to cotton farmers' groups or co-operative societies. The benefits derived from such groups depend on the functions performed by the group. Some of the functions they perform include securing loans, procuring inputs, rendering some agro-services and sales of output on behalf of members. This will help farmers in proper planning and timely utilisation of inputs in cotton production.

4.4 Determination of Costs, Returns and Profitability of Cotton Production

Cotton is a cash crop that is commercially produced primarily for sale. This shows that cotton production enterprise can be seen as an economic unit organised by farmers purposely for profits or economic returns. Based on this premise, the expected net farm income is an important factor in cotton production planning and organisation at farm level. This section deals with the pattern and magnitude of cost incurred and income accruing from cotton production enterprises. This analysis is predicated on data collected with specific reference to cost incurred on inputs namely labour, fertilizers, seed, agro-chemicals and depreciation of farm tools, equipment and maintenance,

income variable and subsequently profits associated with cotton production. This aspect was used to achieve objective (iv) of the study.

4.4.1 Specification of inputs utilised in cotton production

The specification of inputs utilised are those that are relevant in cotton production namely, farm size, labour, seed, fertilizers and agro-chemicals. Each of them are discussed in subsequent sections below.

4.4.1.1 Farm size

Various plots were devoted mainly to sole cotton or crop mixtures. The average farm size cultivated was 1.8ha. In this study, farmers were categorised into five groups based on sizes of farm holdings. The distribution of various farm sizes is presented in Table 4.25. Some of the farmers had more than one plots situated at various locations around the farming zones in their respective villages. These were aggregated together to give the total farm size cropped by each household in the study area. Size of farm is a justification of the scale of operation of cotton farms. In most traditional farming systems, production was undertaken by small scale farmers with few of them operating at medium scale in cotton production. This is comparable with previous study by Adzawla *et al*., (2013) that cotton farmers cultivated the crop with a land holding of 1.22acres in the 2011/12 cropping season.

The study revealed in Table 4.25 that less than half of the sampled farmers operated cotton farms which are less than 1ha. These were small farms employing traditional methods of production. Majority of farmers cultivated between 1ha-1.5ha representing slightly less than half while some of the farmers cultivated between 1.6ha- 2.0ha of

cotton farms. Those who produce cotton using 2.1ha and above of farm sizes represent a small proportion of the entire sampled farmers. The minimum and maximum farm sizes cultivated by cotton farmers were 0.47ha and 5.25ha respectively. The mean farm size cultivated was 1.8ha in cotton production. This implies that majority of cotton farmers operated small-scale farms to produce cotton due to small holdings. Hence, the level of income will be low thereby retarding the rate of savings and investment. Operating larger farms serves as a basis to gain advantage of economies of scale which may help in efficient utilisation of inputs and increasing productivity among cotton farmers.

Table 4.25: Distribution of farm size cropped among cotton farmers

Farm Size	**Frequency**	**Percentage**
Less than 1 ha	63	28.63
1 ha – 1.5 ha	92	41.82
1.6ha – 2.0ha	46	20.91
2.1ha and above	19	8.64
Total	**220**	**100**
Mean = 1.8ha Minimum = 0.47ha Maximum = 5.25ha Standard deviation = 0.914ha		

4.4.1.2 Labour

In most labour intensive traditional farms, labour input is a factor of production as it is the case in agricultural production. A mean value of 53.18 man-days was used in cotton production. However, slightly above half of the sampled farmers came from family sources while slightly below half came from hired labour. The labour input employed by activity in cotton production/ha is in Table 4.26. This Table indicates that the largest proportion of labour inputs was devoted to picking, land preparation or ridging and spraying in cotton production activities. These were the operations that demanded more labour inputs during the production period in cotton farms.

Table 4.26: Labour inputs by activity in Cotton Production (man-days/ha)

Activity	**Family labour (Man-days/ha)** $(\overline{X})$	**Hired labour (Man-days/ha)** $(\overline{X})$	**Total labour input (Man-days/ha)** $(\overline{X})$	**% of total labour input**
Land preparation and ridging $(\overline{X})$	6.5	6	12.5	23.51
Planting$(\overline{X})$	2.1	2	4.1	7.71
Fertilizer application$(\overline{X})$	2.16	3	5.16	9.70
Weeding$(\overline{X})$	4	4	8	15.04
Spraying$(\overline{X})$	4	5.42	9.42	17.71
Harvesting/Picking$(\overline{X})$	8	6	14	26.33
Total	**26.76**	**26.42**	**53.18**	**100**
%	**50.32**	**49.68**	**100**	

4.4.1.3 Seed

The average seed rate was approximately 20.87kg/ha. This is the quantity of seed required by farmers to plant the average farm size in cotton production. Seed was planted using various methods. The planting date in the study area was between mid-may and lasted towards mid-June for better cotton yield.

4.4.1.4 Fertilizers

The minimum quantity of fertilizer used was about 8kg/ha while a maximum of 1,200kg/ha was applied with an average of about 100kg/ha. The methods of application

recommended include top placement, broadcasting, spot application and side dressing. All the farmers interviewed planted their cotton with the use of fertilizers in their farms.

4.4.1.5 Agro- chemicals

Agro-chemicals were utilised as one of the inputs required in cotton production. Some of the chemicals include herbicides and pesticides for the control of weeds and pests respectively. In most cotton farms, these recommended practices were used in order to forestall damages of cotton plants by weeds, pests and diseases so as to improve yield and productivity. The minimum dosage of agro-chemicals (herbicides and pesticides) used was about 5litres/ha and a maximum of 107litres/ha with an average of about 10litres/ha. In terms of weeding, some of the farmers used chemical weed control with supplementary manual weeding. Regular and appropriate interval of sprays of cotton farms against pests and diseases were adopted.

4.4.2 Costs and gross farm income

Costs and gross farm income were estimated based on the variable inputs enumerated above. In order to make profits in cotton production there is need to minimise cost incurred in production. However, the subsequent sections described various costs and returns associated with cotton production.

4.4.2.1 Costs

The cost used in this analysis include all costs incurred on variable inputs such as seed, fertilizer, labour, agro-chemicals and depreciation on fixed or working assets possessed by the farmers. Depreciation and other charges namely maintenance and replacement were calculated so as to reflect total cost of production (Table 4.27).

Table 4. 27: Average cost per hectare associated with cotton production

Variable Inputs Employed	Quantity ($\bar{X}$)	Cost (₦) ($\bar{X}$)	Percentage
Labour	53.18 man-days	25,844.41	55.72
Seed	20.87 kg/ha	1,968.46	4.24
Fertilizer	91.28kg/ha	8,211.55	17.70
Agro-chemicals	9.84L/ha	10,176.59	21.94
Depreciation of tools and implements			
- Maintenance and repairs		52.15	0.112
- charge on rented equipment		72.64	0.156
- Replacement cost		61.47	0.132
Total		**46,387.27**	**100**

The average wage rate in the study area was ₦485.98/man-day. It was assumed that family labour is perfectly substitutable for hired labour. Hence, it is implied that, it will attract the same remuneration if it were to be remunerated. Cotton seed was valued at ₦94.32/kg while fertilizer input was valued at ₦89.96/kg. The average cost involved in producing one hectare of cotton was ₦46, 387. 27. Labour input accounted for about 56% of the average cost per hectare associated with cotton production. This is a clear indication that most cotton production activities on traditional farms are labour intensive and hence attracted more costs which accounted for more than half of the average costs in cotton farms.

Furthermore, 4% of the costs were incurred on cotton seed while 18% accounted for the cost of fertilizers. Also, 22% was spent on various agro-chemicals used in spraying cotton farms. Depreciation of tools and other charges accounted for about 0.40% of the total cost of production. These are costs which include depreciation of farm tools namely ox-drawn ploughs, hoes, cutlasses, interest on capital and cost of renting land.

During the period of study, it was estimated that the minimum cost a cotton farmer incurred was ₦12, 520. 40/ha while the maximum cost incurred was ₦95, 428.43/ha. In accordance with this, Mshelia (1991) noted that high cost of farm inputs (19.29%) may be connected with the low or underutilisation of inputs especially fertilizers and pesticides which directly affects yields negatively as compared to yield of 1500 kg – 2000 kg/ha of intensified inputs by Afcott cotton out growers scheme in Adamawa State, Nigeria.

With regards to distribution of average cost on cotton farms in Table 4.28 majority of the farmers incurred between ₦50, 001- ₦80, 000 while less than half of the sampled cotton farmers produced cotton with cost of ₦80, 001 - ₦ 110,000 on their farms. Those who produce their cotton with between ₦5, 000- ₦20, 000 and ₦110, 001- ₦140, 000 represents small proportion of the respondents. This signifies that, majority of the farmers were small-scale farmers producing cotton with labour intensive practices. These farmers represent more than half of the respondents in the study area. In the same vein, the minimum and maximum cost incurred in cotton farms were ₦12, 520.40/ha and ₦ 95, 428.43/ha respectively while the average cost incurred in cotton production was ₦ 46, 387.27/ha

Table 4. 28: Distribution of average cost per hectare on cotton farms

Range of Cost (₦/ha)	Frequency	Percentage
5,000 - 20,000	15	6.82
20,001 - 50,000	13	5.90
50,001 - 80,000	117	53.20
80,001 - 110,000	65	29.54
110,001 – 140,000	10	4.54
Total	**220**	**100**

Mean = ₦ 46, 387.27/ha
Minimum = ₦12,520.40/ha
Maximum = ₦ 95, 428.43/ha
Standard deviation = ₦ 27,721.90/ha

4.4.2.2 Gross farm income

In Table 4.29 the average gross farm income per hectare accruing to farmers was ₦93, 144.95. It is noticeable among cotton farmers that the minimum gross farm income after sale of cotton was ₦46, 115. 22 while the maximum was ₦136, 700 per hectare. Some of the farmers had an average gross farm income in the range of ₦50, 000 - ₦70, 000 accruing to them. Furthermore, less than half of the farmers realised an average gross farm income between ₦70, 001- ₦90, 000 while a small proportion realised an average gross farm income of between ₦90, 001- ₦110, 000, ₦110, 001- ₦130, 000 and above ₦130, 000. From these findings, it is evident that a small proportion of cotton farmers obtained larger average gross farm income while majority realised an average gross farm income of between ₦70, 001- ₦90, 000. This means that majority of the farmers were operating small scale farms. This will reduce farmers' ability to expand production on a large scale. At higher level of income, farmers will be able to plough back some

part of income which can be saved and invested in production thereby increasing production frontier and take advantage of economies of scale.

Table 4.29: Distribution of average gross farm income per hectare in cotton production

Gross Farm Income Range	Frequency	Percentage
50,000 - 70,000	50	22.72
70, 001- 90,000	86	39.10
90,001 -110,000	36	16.36
110,001 - 130,000	27	12.27
Above 130,000	21	9.55
Total	**220**	**100**
Mean = ₦ 93,144.95/ha Minimum = ₦ 46,115.22/ha Maximum = ₦ 136,700.00/ha Standard deviation = ₦ 40,711.78/ha		

4.4.3 Net farm income estimation

The analysis of net farm income was carried out so as to determine the level of profits associated with cotton production. The profitability of an agricultural production enterprise is defined as total farm income realised from cotton minus total cost incurred in cotton production. Land was taken as fixed input and data were expressed on per hectare basis among sampled cotton farmers. Major variables that were estimated include costs, gross farm income and the level of profits or net farm income realised by farmers in their farms. The cost and returns associated with the production of one hectare of cotton are described in Table 4.30. Earlier, we have specified that family labour is perfectly substitutable for hired labour. By implication, family labour would attract the same wage rate if it is valued.

The analysis in the table revealed that the net farm income realised was ₦64, 419.33 when only hired labour was valued. When all labour (family labour and hired labour) were valued in the analysis, the estimated net farm income reduced to ₦51, 414.51. This is a clear indication that family labour contributed immensely in the reduction of cost of labour which if it were to be paid for, would have led to an increase in cost of producing one hectare of cotton thereby reducing farmers' net farm income.

Table 4.30: Cost and returns associated with cotton production

Item of Description	**Amount (₦)**
Cotton yield (kg/ha)	773.32
Cotton value (₦/ ha) [a]	97,801.78
Labour input (man-days/ha)	
1. family labour	26.76
2. hired labour	26.42
3. Total	53.18
Input cost other than labour (₦/ha)	
1. seed[b]	1,968.46
2. Agro-chemicals[c]	10,176.59
3. Fertilizers[d]	8,211.55
4. Depreciation of tools and implements[e]	186.26
Labour cost (₦/ ha)[f]	
1. Hired labour	12,839.59
2. All labour	25,844.41
3. Total cost (including hired Labour only) (₦)	33,382.45
4. Total cost (including all labour) (₦)	46,387.27
Net farm income (NFI) (₦)per Ha	
1. Costing only hired labour	64,419.33
2. Costing all labour	51,414.51
3. Returns per man-day (all labour)	966.80
4. Returns per ₦ invested	1.11

a. Cotton is valued at ₦126.47/kg in the study area.
b. Seed is valued at ₦94.32/kg in the study area.
c. Agro-chemicals were valued at ₦1,073.48/L average price from various sources.
d. Fertilizer is valued at ₦89.96/kg. This is the average price from various sources.

e. Depreciation of tools and implements are valued at ₦186.26/ha.
f. Labour is valued at ₦485.98/man-day.

These findings agreed with the work of Alam *et al.,* (2013) that cotton production was profitable. Their study revealed that the average net farm income was ₦21, 172.12. The study further revealed that, returns on Naira invested by farmers was ₦0.56 this implies that a farmer gains 56 kobo in every one naira invested in cotton production. Similarly, Ibrahim (2008) conducted a research on the economics of sole cotton production in Lau Local Government Area of Taraba State and came out with a similar result of returns on investment of ₦0.76.

4.4.3.1 Labour productivity

Labour productivity is an important parameter that justifies if labour is adequately utilised in most agricultural production enterprises or not. In order to estimate the productivity of labour, the net farm income for all labour (family labour and hired labour) was calculated. The productivity of all labour was obtained by finding the quotient of net farm income using all labour in man-days. The result showed a return of ₦966.80/man-day. When this value was compared with the average wage rate of ₦485.98/man-day in the study area, it shows that labour is productive.

This implies that, it is more rewarding for family labour and hired labour to make their own contributions in carrying out farm tasks. This will enhance cost effectiveness thereby increasing the level of net farm income accruing to farmers. This is because the farm tasks to be carried out will be accomplished within a short period and at stipulated time at the given cost. The return per naira invested was also computed. It was revealed that returns per naira invested were ₦1.11 in cotton production. This shows that a

farmer will make one naira and eleven kobo in every naira invested in cotton production. This revealed that cotton production is a profitable enterprise.

*4.4.3.2 Test of hypothesis on net farm income (**H0$_3$**)*

Test of hypothesis for net farm income associated with cotton production was carried out based on the result of the analysis of net farm income estimates of the parameters in Table 4.31. The test indicated that the computed T-value of the profit function was 18.74 which far exceed the T-critical value at 1% level of significance. Hence, the null hypothesis which states that cotton production is not profitable in the study area was rejected.

Table 4 .31: Statistical significance of net farm income associated with cotton production

Estimates	**Revenue (₦)**		**Total cost (₦)**
Minimum	46,115.22		12,520.40
Maximum	136,700.00		95,428.43
Average	97,801.78		46,387,27
S.D	40,711.78		7,721.90
Profit		51,414.51	
Standard error		2,744.29	
T-value		18.74***	

*** = P<0.01

The result of the test of hypothesis signifies that cotton production is a profitable enterprise. Therefore, there is need to increase the level of awareness of the would-be cotton farmers about the profitability of this enterprise through adequate extension services and education in this regard. The would-be cotton farmers need to be adequately informed about the profitability of this production enterprise so that they will also take to cotton production in their farm production and investment plan.

Furthermore, agricultural administrators and policy makers need to take cognisance of this fact and utilise it for policy purpose. This is in terms of timely provision of production facilities and inputs such as improved and certified seed, fertilizers, agro-chemicals and market incentives that will encourage cotton farmers and the would-be cotton farmers to produce. Adequate attention by government, stakeholders, researchers, extension agents and agro-service agencies will help farmers to place emphasis on cotton production. This will attract more farmers and the would-be cotton farmers to incorporate and integrate cotton production into their farming system thereby restoring the lost glory in the cotton production industry in Nigeria.

4.5 Estimation of Technical, Allocative and Economic Efficiencies among Cotton Farmers

This section deals with the stochastic frontier analysis as a parametric method that computes the parameter estimates by iteratively maximizing a non-linear function of the unknown parameters in the model subject to the constraints. Ajibefun (2008) highlights parametric methods to include production, cost, profit and revenue functions as alternative methods of describing the production technology and estimating efficiency of production. The functional form for the stochastic frontier is defined by a modified version of a Cobb-Douglas model. It permits different levels of productivity associated with different proportions of variable inputs employed in production. This analytical tool was used to achieve objective (v) of the study.

4.5.1 Input-output levels in cotton production

In any production process, inputs are required to produce a given level of output. Inputs that were used in cotton production include land, seed, fertilizers, family labour, hired

labour and various agro-chemicals. Table 4.32 shows various levels of inputs employed in production while land was reduced to per hectare basis and held constant. The minimum and maximum seed rate used for planting one hectare of land were 5kg/ha and 22kg/ha respectively with a mean seed rate of 20.87kg/ha. The average quantity of fertilizer used in cotton production was 91.28kg/ha while the minimum and maximum quantity of fertilizers used were 7.69kg/ha and 1,200 kg/ha respectively.

Table 4.32: Input and output levels in cotton production per hectare

Input/output	**Minimum**	**Maximum**	**Average**	**Standard Deviation**
Seed (kg/ha)	5.2788	21.513	20.87	17.3291
Fertilizer (kg/ha)	7.6944	1200	91.2882	95.5569
Family labour (man-days/ha)	4.6400	116.67	26.7603	20.3419
Hired labour (man-days/ha)	4.9107	148.33	26.4218	21.9505
Agro-chemical (litre/ha)	5.118	107.33	9.8372	7.4178
Yield (kg/ha)	391.3043	900	773.3191	640.40

Both family labour and hired labour were applied in cotton farms in the study area with average of 26.76 man-days/ha and 26.42 man-days/ha respectively with an average labour of 53.18 man-days/ha. The minimum and maximum levels of both labour inputs were about 4.64 man-days/ha and 116.67 man-days/ha for family labour and 4.91 man-days/ha and 148.33 man-days/ha for hired labour respectively. The average agro-chemicals used was 9.8372 litres/ha while the minimum and maximum levels of agro-chemicals that was applied were 5.11 litres/ha and 107.33 litres/ha respectively.

Indeed, the level of output of cotton a farmer produces is a justification of how rational the inputs were utilised and adoption of improved cultural practices and management skill such farmer possesses. This premise necessitates variation in the level of output among cotton farmers. The average output of cotton in the study area was 773.31kg/ha. The minimum and maximum output levels among cotton farmers were about 391.30kg/ha and 900kg/ha respectively (Table 4.32).

The recommended seed rates show that about 15-20kg of cotton seed per hectare is required (Idem, 1999). When this was compared with average seed rate of 20.87 kg/ha, it revealed that the farmers have followed the recommendation with an increase of 02.87 kg/ha above the recommended seed rate. About 120kg/ha of Nitrogen, Phosphorus and Potassium (N.P.K), were recommended as against an average fertilizer rate of 91kg/ha or about 2 bags. Farmers were using a lower rate of fertilizer when compared to the recommended rate.

Also, the amount of labour employed varies depending on source and location while the recommended rate of herbicides and pesticides application is 12L/ha compared to an average dose of 10L/ha as shown in the table. The level of output of about 773kg/ha was less than half of the recommended cotton output of different cultivars ranging from 1,5000 kg/ha to 2,000 kg/ha or more in research farms. This implies that farmers' level of output produced in cotton farms were less than half of the recommended cotton output in research farms. This may be attributed to inadequate application of recommended cotton production practices offered to them by extension agents.

4.5.2 Input-output relationship in cotton production

Stochastic Frontier Production Function of the Cobb-Douglas form was estimated so as to examine the pattern of input-output relationship in cotton production and determine technical efficiency. The result showed that the estimated coefficients for most inputs were positive except for family labour and hired labour which were negative. Farm size and family labour were significant at 1% level of significance. The insignificance of hired labour may be attributed to the use of family labour by cotton farmers as substitutes for hired labour. This is shown in Table 4.33.

Table 4.33: Maximum likelihood estimation results of stochastic frontier production function

Variable	**Coefficients**	**Standard error**	**T-value**
Constant (β_0)	6.468	0.589	10.981***
Farm Size (X_1)	0.477	0.0664	7.186***
Seed (X_2)	0.219	0.092	2.383**
Fertilizers (X_3)	0.393	0.419	0.939
Family labour (X_4)	-0.355	0.053	-6.670***
Hired labour (X_5)	-0.137	0.109	-1.256
Agro-chemicals (X_6)	0.194	0.107	1.812*
Variance Parameters			
Sigma squared (σ^2)	13.622	3.962	3.437***
Gamma (γ)	0.997	0.005	181.5***
LR test = 193.75***			
Log likelihood function = -193.37***			

$\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\gamma = \sigma_u^2 / \sigma^2$ *** = P < 0.01, ** = P < 0.05, * = P < 0.10

This implies that increase in farm size, seed and agro-chemicals would result to an increase in output level in cotton production in the study area. Indeed, a unit increase in farm size, seed and agro-chemicals would result in 0.47, 0.219 and 0.194 increases in

output respectively. Seed and agro-chemicals were significant at 5% and 10% levels of probabilities respectively. In a similar study by Muhammad-Lawal *et al*., (2009) who determined the technical efficiency of youth participating in agricultural programme in Ondo State, reported that farm size was positively related to output and significant. They further claimed that an increase in farm size would increase output level of farmers.

The coefficients of seed and agro-chemicals were significant at 5% and 10% levels of probabilities respectively. By implication, there exists a direct relationship between seed, agro-chemicals and cotton output produced by farmers. Seed is a crucial input employed in agricultural production which if over-utilised or under-utilised as an input could affect total output level of farmers in their production activities. The diagnostic statistics entrenched in the results of the maximum likelihood estimates (MLE's) of the production function showed that the estimated sigma squared ($\boldsymbol{\sigma}^2$) was (13.622). This value was significantly different from zero at 1% indicating a goodness of fit and the correctness of the specified distributional assumption of the composite error term. Also, the result of the gamma (γ) statistics of (0.99) is attributable to farmers' inefficiency factors. The result revealed that technical inefficiency factors were present in cotton production in Zamfara state, Nigeria. The generalized likelihood ratio (LR) statistics was (193.75). This ratio exceeds the critical value at 1% level of significance implying that the model expressed a goodness of fit of the data used in the estimation. The log likelihood function of (-193.75) showed the goodness of fit of the model. The parameter represents the value that maximises the joint densities in the estimated model.

4.5.3 Elasticity of production and returns to scale

Elasticity of production is a useful guide that enhances farmers to be prudent and rational when allocating and utilising inputs in production. In the Cobb-Douglas production of stochastic frontier model, the coefficient of regression is an indication of the degree of responsiveness or elasticity of production to the inputs employed. From the regression coefficients, it is noticeable that the coefficients of all variable inputs were inelastic since the coefficient of regression with respect to each input employed, holding all other inputs fixed resulted in less than 1% increase in cotton output.

The degree of responsiveness of output in relation to the sum of coefficients of variable inputs used in production indicates the nature and pattern of returns to scale. In other words, the sum of these elasticities justifies the returns to scale. The sum of the elasticities derived from Cobb-Douglas equation was 0.791. This depicts that when all inputs were increased by 1% the output increased by 0.79% showing that resources employed in cotton production were inelastic. The equation exhibits decreasing returns to scale. Returns to scale (RTS) is used to determine the stage of the overall production process in the production possibility frontier. When $0 < RTS < 1$ that is RTS is between 0 and 1, it shows that production is in stage II. This is a stage of positive decreasing returns to scale where every farmer strives to be so as to maximise profit and minimise cost of production. This is because the phase of positive decreasing returns to scale is a more efficient production phase where resource allocation and utilisation can be adequately adjusted and subsequently profit can be fully maximised in the production possibility frontier (Table 4.34).

Table 4.34: Elasticity of production and return to scale in cotton production

Variables	Elasticity of Production
Farm Size (X_1)	0.477
Seed (X_2)	0.219
Fertilizer (X_3)	0.393
Family labour (X_4)	-0.355
Hired labour (X_5)	-0.137
Agro chemicals (X_6)	0.194
Returns to scale (RTS)	**0.791**

Farmers' technical, allocative and economic efficiency indices were estimated using Cobb-Douglas model of the stochastic frontier analysis. Inefficiency model analysed the influence of some socio-economic variables or random variables which were within farmers' control namely age, major occupation, level of education, access to credit, marital status, gender, experience in farming, membership of co-operative and extension contact.

4.5.4 Farmers' technical efficiency indices

The result in Table 4.35 shows the frequency distribution of technical efficiency in cotton production. The study showed that a small proportion of the farmers had technical efficiency score indices ranging between 0.10 - 0.2., 0.21 - 0.30 and 0.91 - 1.0 in the study area. Those whose technical efficiency range were between 0.81 - 0.90 also represents certain proportion of the sampled farmers. The minimum technical efficiency was 0.11 while the maximum technical efficiency score index was 0.97 with a mean technical efficiency score index of 0.67. This implies that farmers could increase their level of output by improving on their efficiency index of input allocation and utilisation through adoption of recommended technological packages by 33%. Therefore, there is

existence of opportunity for farmers to increase their level of output or productivity through increased efficiency in the use of available inputs.

Table 4.35: Frequency distribution of technical efficiency estimates

Technical efficiency range	Frequency	Percentage
0.10-0.20	6	2.73
0.21-0.30	12	5.45
0.31-0.40	8	3.64
0.41-0.50	6	2.73
0.51-0.60	24	10.91
0.61-0.70	45	20.45
0.71-0.80	59	26.82
0.81-0.90	49	22.27
0.91-1.0	11	5.00
Total	**220**	**100.00**
Average = 0.67		
Maximum = 0.97		
Minimum = 0.11		

In a similar study by Adzawla *et al.* (2013) in estimating technical efficiency of cotton production in Yendi Municipality, Northern Ghana, it was reported that the average technical efficiency level of 0.88, ranging from 0.70 and 0.99 were observed. This is comparable to that of many studies (Mohammed-Yusuf, 2005, Tsimpo, 2010, Neba *et al.*, 2010). The wide difference in technical efficiency among least practice and best practice farmer indicates an opportunity for efficiency improvement.

The mean efficiency observed by Adzawla *et al.* (2013) among farmers implies that on the average, 88% of output was obtained from the given mix of production inputs by farmers. This is an indication that cotton output had fallen by 12%, otherwise, there is a potential of increasing output by 12% through the adoption of efficient farming practices. In the same vein, Mohammed and Roujman (2008) in analysing the technical performance of cotton farmers in developing countries in Burkina Faso reported that,

the computed average technical efficiency was 90.4%, ranging from a minimum of 61.3% to a maximum of 98.4%. Given the present state of technology and input levels, this result suggests that farmers in the sample are producing on average at 90.4% of their potential.

4.5.5 Test of hypothesis on technical efficiency model and inefficiency model

Estimates of the parameters of the technical efficiency model were statistically significant with the null hypothesis that, $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$. The test of hypothesis for parameters of production function model revealed that farmers were technically, allocatively and economically efficient in cotton production in the study area. The value of the likelihood ratio test statistic shown in Table 4.36 is 193.75 which are more than the critical at 0.01 levels of probability. Hence, the decision is to reject the null hypothesis.

Table 4.36: Test of hypothesis for stochastic frontier production function and frontier inefficiency function

	Null Hypothesis	**Log Likelihood Ratio/T-ratio**	**Critical Value**	**Decision**
Production function	$\beta = 0$	193.75	2.40	Reject $H0_1$
Inefficiency function	$\gamma = \sigma_u^2 = 0$	Significant	2.40	Reject $H0_2$
• Gender		-2.559***		
• Membership of Cooperative		-2.588***		
• Access to credit		-3.295***		
• Marital status		-3.196***		

*** P<0.01

Hence, cotton farmers were technically, allocatively and economically efficient in cotton production. By implication, they were rational in the allocation and utilisation of

inputs required to produce cotton. However, there is need for them to proceed in the utilisation of inputs so as to attain the desired production frontier level and maximise profits. Also, the outcome of this test will be useful for policy makers in the cotton production industry. This is in terms of timely distribution of inputs such as improved seed, fertilizers, agro-chemicals, extension visits and market incentives in order to assist farmers in the adoption of recommended cotton production technologies and improve on productivity and efficiency. Also, test of hypothesis was conducted on the stochastic inefficiency models. The T- test for parameters of the stochastic frontier inefficiency models that is, $\gamma = \sigma_u^2 = 0$ showed that there were significant relationship between socio-economic characteristics of farmers shown in Table 4.36 and the technical, allocative and economic efficiencies of farmers in the study area. Decisively, the null hypothesis was rejected since the value of the T-test statistics were significant in most cases at 0.01 level of probability illustrated in Tables 4.37, 4.40 and 4.42 respectively.

The result of test of hypothesis on the stochastic frontier inefficiency model implies that most of the random variables had meaningful and direct bearing on farmer's productivity and efficiency. This is an outcome that may be required by farmers, agro-service agencies and government when planning for production and investment in the cotton production industry. This may include formation of cotton growers' groups and cooperative organisations that will help farmers to improve on productivity and efficiency. This is possible through provision and timely distribution of inputs that will help farmers in cotton production and dispose output promptly.

4.5.6 Determinants of technical inefficiency

The result of technical inefficiency model in Table 4.37 showed that age, gender, membership of co-operative and extension contact variables were significant. Age of

farmers was negative and significant at 10% level of probability. This means that, as age increases among farmers, technical inefficiencies decrease. Gender and membership of co-operative were negatively related and significant at 1% level of significance while extension contacts were negative and significant at 5% level of significance. This means that, as these socio-economic variables improve in status, farmers' technical inefficiencies decrease. Hence, farmers' technical efficiencies were enhanced and improved by these variables.

Table 4. 37: Socio-economic factors influencing technical inefficiency

Variable	**Coefficients**	**Standard error**	**T-value**
Constant (Z_0)	2.422	1.581	1.531
Age (Z_1)	-0.064	0.036	-1.774*
Major occupation (Z_2)	-1.117	1.085	-1.084
Education (Z_3)	-0.619	0.381	-1.622
Access to credit (Z_4)	-0.635	0.901	-0.704
Marital status (Z_5)	0.081	0.587	0.139
Gender (Z_6)	-3.802	1.485	-2.559***
Farming experience (Z_7)	-0.610	0.469	-1.299
Membership of cooperative (Z_8)	-0.144	0.500	-2.888***
Extension contact (Z_9)	-0.744	0.333	-2.223**

*** = P < 0.01, ** = P < 0.05, * = P < 0.10

Extension contact is also a precursor for improving efficiency and reducing inefficiency because it is assumed that the more a farmer interacts with the extension officers, the more efficient that farmer would be. FARA (2006)., Gerdin (2003)., Uaiene and Channing (2009), Nyagata *et al.* (2010) and Mohammed (2009) found the extension services variable to have a positive coefficient in relation to technical efficiency. This implied that technical efficiency increases with the number of contacts made to the farm

household by extension officers. Extension officers play a central role in informing, motivating and educating farmers about available technologies.

4.5.7 Stochastic frontier cost function

Stochastic frontier cost function of Cobb-Douglas form was used to estimate the cost of cotton production in order to determine the relationship between cost and level of output produced. Table 4.38 shows that cost of land was positively related but insignificant in cotton production. This is probably because the cost of acquiring land is proportionally negligible to cost of producing cotton since most of them inherited or got their farmland on lease. Also, cost of agro-chemicals was positively related and significant at 1% level of probability. A unit increase in agro-chemicals resulted in 0.124 increases in output produced. This shows that agro-chemicals had impact on production of cotton since they are important in the cost of production. This input is influencing the level of output in the production process. It is important that attention need to be given to its utilisation since it is contributing to production.

Table 4.38: Maximum likelihood estimation results of stochastic frontier cost function

Variable	**Coefficients**	**Standard error**	**T-value**
Constant (β_0)	7.698	0.876	8.781***
Cost of land (X_1)	0.064	0.052	1.236
Cost of seed (X_2)	0.109	0.065	1.676*
Cost of fertilizer (X_3)	0.047	0.031	1.478
Cost of family labour (X_4)	0.138	0.053	2.611***
Cost of hired labour (X_5)	0.108	0.046	2.339***
Cost of agro-chemicals (X_6)	0.124	0.032	3.851***
Variance Parameters			
Sigma squared (σ^2)	13.92	2.96	4.689***
Gamma (γ)	0.998	0.005	175.7***
LR test = 264.69***			
Log likelihood function = -170.19***			

$\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\gamma = \sigma_u^2 / \sigma^2$ *** = P < 0.01, ** = P < 0.05, * = P < 0.10

Cost of family labour and hired labour were positively related with respect to their coefficients and they were significant at 1% level of significance. Unit increases in family and hired labour inputs lead to increase in cotton output by 0.138 and 0.108 respectively. Seed was also positively related and significant at 10% level of probability. Therefore, seed, family labour, hired labour and agro-chemicals are inputs that increase cost of production. In this regard, there is need to reduce costs that are incurred on procurement and utilisation of these inputs in order to minimise cost. In other words, all input costs must be positively related since no negative cost is incurred when inputs are employed in production. This is why in stochastic frontier cost function; we calculate economic efficiency as the inverse of frontier cost function.

The maximum likelihood estimates (MLE's) of the stochastic frontier cost function revealed that the estimated variance parameter, sigma squared ($\boldsymbol{\sigma}^2$) was (13.92). The value was significantly different from zero at 1% level of probability. This indicates a goodness of fit and the correctness of the specified distributional assumption of the composite error term in the model. The gamma ($\boldsymbol{\gamma}$) statistics of (0.998) was due to farmers' inefficiency factors. The result showed that technical inefficiency factors were present in cotton production in Zamfara state, Nigeria. The generalized likelihood ratio (LR) test was (264.69). This ratio exceeds the critical value at 1% level of significance implying that the model expressed a goodness of fit of the data used in the estimation. The log likelihood function of (-170.19) expressed the goodness of fit of the model. This vector represents the value that maximises the joint densities in the estimated model.

Also, the inefficiency effects in cost frontier are positively correlated and must be added to the cost of production instead of being subtracted as in the case of the production frontier. Hence, the production function represents maximum output while the cost function represents minimum cost. On the whole, the goal of the farmer is to strive on how to minimise cost without reducing the level of output so as to maximise profit at that minimum cost. This is the essence of allocative efficiency in stochastic frontier analysis. The estimation of the stochastic frontier cost function is needed in order to arrive at the estimation of the allocative efficiency in the production process. This is possible since the inverse of the stochastic frontier cost function is equal to economic efficiency.

4.5.8 Farmers' allocative efficiency indices

In allocative efficiency in cotton production, the frequency distribution showed that some of the farmers had allocative efficiency range between 0.01 - 0.10 while a small proportion had allocative efficiency range between 0.11 -0.20. Majority of the sampled farmers operated their farms with the allocative efficiency range of 0.71-0.80 while those that operated their farms with efficiency range of 0.91-1.0 were a small proportion of the respondents. The minimum allocative efficiency score index was 0.02 while the maximum allocative efficiency score index was 0.97. The mean allocative efficiency score index was 0.64 in cotton production (Table 4.39). From this result, there exists ample opportunity for farmers to embark on rational allocation and utilisation of inputs by 0.36 so as to minimise costs and maximise profits in their cotton production enterprises.

Allocative efficiency is a measure of how an enterprise uses production inputs optimally in the right combination to maximise profits (Inoni, 2007). According to Kibirige (2008) for a farm to be allocatively efficient, the following questions need to be answered;

i. What is the optimal combination of inputs so that output is produced at minimal cost?

ii. How much profit could be increased by simply reallocating resources?

Therefore, the firm has to choose a combination of inputs to be used in right proportions and technically efficient at low prices so that output is produced at minimal costs. This results into profit maximisation. Though, there are new methods used to estimate allocative efficiency, traditionally it has been hard to estimate allocative efficiency without input and output prices.

Table 4. 39: Frequency distribution of allocative efficiency estimates

Allocative efficiency range	**Frequency**	**Percentage**
0.01-0.10	26	11.82
0.11-0.20	6	2.73
0.21-0.30	9	4.09
0.31-0.40	1	0.45
0.41-0.50	3	1.36
0.51-0.60	4	1.82
0.61-0.70	19	8.64
0.71-0.80	85	38.64
0.81-0.90	63	28.64
0.91-1.0	4	1.82
Total	**220**	**100.00**
Average = 0.64		
Maximum = 0.97		
Minimum= 0.02		

Based on this argument, some scholars such as Farrell (1957) called it price efficiency, referring to the ability of a firm to choose the optimal combination of inputs given input prices.

4.5.9 Determinants of allocative inefficiency

The result of allocative inefficiency model is in Table 4.40. The coefficients of age, access to credit, marital status and extension contact were negatively related and they were significant at 1% level of significance. This implies that these socio-economic variables reduce allocative inefficiency among farmers in cotton production. Major occupation was also negatively related while it was significant at 5% level of probability. Hence, farming as a major occupation reduces allocative inefficiency among farmers involved in cotton production in the study area. The coefficient of marital status was negative and significant at 1% level of significance. This shows that allocative inefficiency is decreasing among cotton farmers. By implication married farmers were allocatively efficient compared to farmers who are otherwise. This could be attributed to their ability to afford and have access to family labour as married farmers tend to have larger household sizes that could provide labour for farm operations. Access to credit was found negative and significant at 1% which showed that this variable reduces allocative inefficiency. Access to credit may reduce liquidity constraints as noted by Oyewole (2012) and this will enhance farmers' access to production inputs thereby increasing allocative efficiency.

Table 4. 40: Socio-economic factors influencing allocative inefficiency

Variable	Coefficients	Standard error	T-value
Constant (Z_0)	2.566	2.247	1.141
Age (Z_1)	-0.283	0.016	-17.634***
Major occupation (Z_2)	-1.252	1.194	-2.110**
Education (Z_3)	-0.034	0.222	-0.156
Access to credit (Z_4)	-4.258	1.292	-3.295***
Marital status (Z_5)	1.870	0.585	-3.196***
Gender (Z_6)	-123	1.020	-0.120
Farming experience (Z_7)	-0.091	0.738	-0.123
Membership of cooperative (Z_8)	0.105	0.079	1.334
-Extension contact (Z_9)	-1.422	0.333	-4.263***

*** = P < 0.01, ** = P < 0.05, * = P < 0.10

In the same vein, extension contact and visits by agricultural extension agents was negatively related with allocative inefficiency and significant at 1% level. Hence, extension contact had a resultant increases in allocative efficiency by enhancing farmers' awareness about the existence of improved cultural practices in their domain. The adoption of improved cultural practices serves as innovation for farmers to improve on productivity and efficiency in cotton production. Indeed, extension programme as an institutionalised socio-economic variable is a vital vehicle that transforms the traditional rural agriculture to a modern, efficient and productive agricultural system.

4.5.10 Farmers' economic efficiency indices

The frequency distribution of economic efficiency ratios as indicated in Table 4.41 showed that some of the respondents had economic efficiency score between 0.01-0.10 while those that operated between 0.11 - 0.20 economic efficiency ratios constitute a small proportion of the respondents. A small sample of the respondents had economic efficiency score indices of 0.71-0.80 and 0.81-0.90 among cotton farmers. Majority of the respondents had economic efficiency indices between 0.51-0.60. The minimum economic efficiency score index was 0.01 while the maximum economic efficiency score index was 0.81 with the mean of 0.44 which is slightly below average of the economic efficiency. The study revealed that farmers can improve on their economic efficiencies through efficient allocation and utilisation of inputs by 0.56 or 56%. This will make farmers to be cost effective and maximise profits.

Table 4.41: Frequency distribution of economic efficiency estimates

Economic efficiency range	Frequency	Percentage
0.01-0.10	31	14.09
0.11-0.20	15	6.82
0.21-0.30	16	7.27
0.31-0.40	11	5.00
0.41-0.50	34	15.45
0.51-0.60	56	25.45
0.61-0.70	45	20.45
0.71-0.80	11	5.00
0.81-0.90	1	0.45
Total	**220**	**100.00**
Average = 0.44 Maximum = 0. 81 Minimum = 0.01		

On the whole, Kabwe (2012) in his study on factors affecting efficiency of smallholder cotton producers in Zambia reported that, the overall mean of technical efficiency scores of cotton farmers varied from 0.09 to 1 with a mean of 0.46. While the overall mean of allocative efficiency scores of cotton farmers varied from 0.07 to 1 with a mean of 0.37. While the overall mean of economic efficiency scores of cotton farmers varied from 0.01 to 1 with a mean of 0.20.

4.5.11 Determinants of economic inefficiency

Some socio-economic factors determining economic inefficiency were estimated. This is shown in Table 4.42. The result of this estimation showed that, age was negatively related with economic inefficiency at 1% level of significance. This means that age increases economic efficiency among the respondents. Also, extension contact and visits by agricultural extension agents was negatively related and significant at 1% level of probabilty. This implies that extension contact reduces economic inefficiency. This is because farmers were made to be aware of the existence of improved recommended

cotton production technological packages which upon adoption by farmers help in increasing their economic efficiency in resource allocation and utilisation.

Table 4.42: Socio-economic factors influencing economic inefficiency

Variable	Coefficients	Standard error	t-value
Constant (Z_0)	0.282	0.138	2.03***
Age (Z_1)	-0.005	0.001	-4.28***
Major occupation (Z_2)	0.041	0.059	0.69
Education (Z_3)	0.008	0.011	0.71
Access to credit (Z_4)	-0.057	0.028	-2.01**
Marital status (Z_5)	-0.041	0.015	-2.70**
Gender (Z_6)	0.039	0.048	0.82
Farming experience (Z_7)	-0.004	0.014	-0.30
Membership of cooperative (Z_8)	0.002	0.005	0.46
Extension contact (Z_9)	-0.158	0.017	-14.80***

***P < 0.01, **P < 0.05,

Access to credit and marital status were both negatively related and significant at 5% level of probability. These socio-economic factors reduce economic inefficiency of farmers who produce cotton in the study area. Access to credit could make farmers to procure the necessary inputs needed in production at appropriate time and affordable costs which will enhance rational allocation and utilisation of such inputs. This result agrees with that of Mohammed (2009) who found that access to credit can influence the efficiency of farmers positively. He said that, a negative relationship was established between access to credit and inefficiency in cotton-wheat system and also in rice-wheat system. This means that, farmers accessing credit were more likely to be more efficient than those that did not access any credit. Also, marital status could be beneficial in improving the household status and composition of farmers thereby contributing to source of family labour in their production activities and farm operations. This will enhance economic efficiency among cotton farmers in the study area.

4.6 Cotton Production Constraints

There are many constraints militating against cotton production in the study area. Onyenweaku (2000) was of the view that, farmers are beset with a lot of constraints that prevent them from adopting improved recommended practices. This section was used to achieve objective (vi) of the study. In Table 4.43, multiple responses were allowed in the examination of constraints faced by cotton farmers in the study area. Environmental constraints experienced by cotton farmers are ecological factors impinging on the growth, performance and yield of cotton. Some of the ecological factors include climatic, soil, pests, diseases as biotic constraints and genetic constraints while others are institutional namely land tenure system, loan and credit supply, extension services and marketing institutions.

4.6.1 Climatic constraints faced by farmers

Climatic constraints constitute one of the salient problems confronting cotton production in the study area. In Table 4.43, majority of the sampled farmers had inadequate rainfall affecting cotton production in terms of growth rate and good physiological performance of cotton. Some of the farmers expressed that excessive rainfall hampers cotton production which tend to soak cotton lint. Some proportion of the sampled farmers stated that high intensity of sunshine and excessive wind especially at harvest period could degrade cotton lint at maturity. Others were of the opinion that inadequate rainfall, excessive rainfall, high intensity sunshine and excessive winds ranked 9^{th}, 17^{th}, 19^{th} and 11^{th} respectively. As a result of climatic fluctuation and variation, severe climatic stress may impinge disastrous effect on cotton production at every stage of their phenological growth and development. For instance, at the reproductive stage of cotton, intensive sunshine and inadequate rainfall may affect

flowering and boll formation. In the same vein, excessive rainfall and wind may impair lint quality which may not meet the desired quality and standard in the cotton market. In this regard, prompt forecast of weather by research stations are required. This will alert farmers through appropriate extension services and contacts on measures to be adopted in order to overcome these constraints and increase efficiency of production.

4.6.2 Soil constraints faced by cotton farmers

Some soil constraints faced by farmers were investigated during the field survey. In Table 4.43, majority of the farmers encountered inadequate soil fertility in their farms. Low fertility level renders cotton to show some nutrient deficiency symptoms and impaired physiological growth and low yield. This is the most severe constraint faced by cotton farmers. In the savanna, the problem of soil fertility is prevalent and pronounced. This compelled cotton farmers to use various doses of inorganic fertilizers to augment and improve the status of soil fertility in the area. Some proportion of the sampled farmers had severe environmental degradation and erosion menace respectively in their farms. Inadequate soil fertility ranked 1st as one of the soil constraints in cotton production which means it is the most severe constraints encountered among farmers. Adequate and timely fertilizer procurement and application will help in circumventing this constraint in cotton production. Severe environmental degradation and erosion menace ranked 22nd and 18th respectively. In situations where technology is affordable, poor knowledge may lead to over-use of agrochemicals such as fertilizers, which may precipitate environmental problems. The immediate concern today in Nigeria is under-usage of fertilizers as a result of high costs. Fertilizer application rates have decreased in Africa at 1.1 *percent* per annum since the 1990s (Africa Fertilizer Summit) (AFS), (2006).

Severe environmental degradation could affect cotton production activities by impairing movement of inputs and evacuation of output through bad road network system. Also, erosion menace interrupts availability of mineral nutrients in cotton plants thereby reducing farmer's productivity. Adequate control measures such as constructing of drainages, cover cropping to reduce surface run-off and retain soil nutrients for crop use and providing good road networks to enhance adequate transportation of inputs and output are essential. This could be undertaken through community development efforts, agro-service agencies and the government in order to alleviate these constraints.

4.6.3 Biotic constraints encountered by cotton farmers

This is one of the environmental constraints investigated in the study area. In Table 4.43, some of the farmers had problem with respect to pest invasion while some experienced disease incidence in their cotton farms ranking 10^{th} and 13^{th} in the list of constraints encountered by cotton farmers respectively. Some of the sampled farmers faced the menace of weed infestation which ranked 24^{th} in the list of constraints. This implies that cotton farmers took prompt decision and action to ensure that farms were kept at minimum level of weed infestation. This enhanced improved productivity on cotton farms. Pests attack on the bolls, lint and buds is a common problem and a range of bacterial diseases and fungal infection attacking leaves and stems. Also, weed infestation leads to competition for space, light, soil nutrients and soil air between the weeds and cotton plants. These tend to reduce yield significantly in cotton farms.

Alam *et al.*, (2013) in their reports stated that, pest and disease infestation constituting 68.8% is another major constraint. This conformed to findings of International Cotton Association Committee (ICAC), (2001) which indicated that pest and disease infestation

are important factors in cotton production which could in most cases result in the failure of the cotton farm business. In accordance with this, Onu, (2012) opined that management of cotton biotic constraints is a major practice that should not be overlooked if economic yield of the crop is to be realised. The surest way to prevent the vagaries of broad range of insect pests is through chemical control.

4.6.4 Genetic constraints faced by cotton farmers

Some of the genetic constraints identified among cotton farmers during the field survey are expressed in Table 4.43. Some of the farmers had inadequate improved seed varieties to plant constituted ranking 15th in the order of listed constraints while some of the farmers planted seed that was not certified which ranked 12th in the order of identified genetic constraints. Some proportion of the farmers expressed their inability to procure seed due to its cost ranking 8th while some expressed improper storage of seed meant for planting which ranked 7th in the order of identified constraints. Genetic expression of cotton depends on environmental factors. These are ecological factors that determine the performance, growth and productivity of cotton. Therefore, adequate expressions of genetic potential of cotton are demonstrated based on soil and climate. Genetic traits such as early maturity, pest and disease resistance, high yielding varieties and ability to adjust and adapt to the environment are needed by farmers when deciding and selecting seed to be cultivated. The inability of cotton growers to select and cultivate improved varieties of cotton constituted a major constraint.

Therefore, it is suggested that private sector input distribution voucher system needs to be encouraged. This will enhance timely distribution of inputs such as seed, fertilizers and agro-chemicals for farmers to procure them for cotton production in their farms.

Also, *Bt* cotton varieties have been introduced in some developing countries such as China and India for cultivation. This is a recent technological package which needs to be introduced in Nigeria as well if cotton production industry is to be transformed. According to (Agricultural Transformation Agenda) (ATA), (2011) at present, Nigeria is yet to release a *Bt* Cotton (improved) variety that has revolutionalised cotton production across the globe. These cotton varieties are however critical to attaining rapid productivity growth in the cotton sector. The current goal is to fast track the release of *Bt* Cotton in Nigeria enabling farmers to double or triple their yields in a short period of time.

Mendelsohn *et al., (2003)* asserted that *Bt* Cotton have been genetically engineered to produce proteins from the soil bacteria *Bacillus thuringiensis* (B_t) that kill some key caterpillar and beetle pests of these crops. B_t toxins cause little or no harm to most non-target organisms including beneficial insects, wildlife, and people. B_t crops produce B_t toxins in most of their tissues. These B_t toxins kill susceptible insects when they eat B_t crops. This means that *Bt* crops are especially useful for controlling pests that feed inside plants and that cannot be killed readily by sprays, such as the European corn borer (*Ostrinia nubilalis*), which bores into stems, and the pink bollworm (*Pectinophora gossypiella*), which bores into bolls of cotton.

4.6.5 Institutional constraints among cotton farmers

Many institutional factors can be considered to determine the success of any agricultural production enterprise. This is due to the fact that agricultural production and related activities such as harvesting, processing, grading, storage and marketing do not operate in isolation, they perform many interrelated and interdependent functions. Some of

these institutions are statutory governmental organisations such as ministries, departments and agro-service agencies and some institutionalised non-governmental organisations required in cotton production.

Some of the institutional problems affecting cotton production were investigated. In Table 4.43, Majority of the farmers faced problem of land acquisition while some experienced inadequate loan and credit supply system. Extension services are required to increase farmers' level of awareness about the existence of improved cotton production technological packages. Some of the aspects of extension constraints showed that about some of the farmers complained of inadequate extension services offered to them ranking 23rd in the order of constraints indicated. Some proportion of the sampled farmers complained of the complexity of some technological packages hampering adoption. Also, majority had insufficient fund to enhance adoption of improved technologies. In order to increase the level of extension contacts made to farmers, appropriate extension administration, teaching methods and extension programme management need to be introduced among cotton farmers. This will help farmers in improving the rate of adoption of recommended cotton production technologies.

Marketing constraints were investigated among cotton producers in the study area. The result in Table 4.43 shows that, inadequate market and marketing facilities posed some problems among farmers representing nearly half of the sampled farmers. Some were offered poor farm gate price and pricing of cotton. This tends to reduce farmers' share and level of profit accruing to them. Similar study was conducted by Alam *et al*., (2013) which showed that about 73% of their respondents claimed that they experienced low price of seed cotton offered to them in the market. This result is in consonance with the

report of Fortucci (2002) which stated that West and Central Africa is vulnerable to cotton world price.

Some proportion of the farmers experienced inadequate processing and transportation facilities. Those farmers who were faced with problem of long marketing distances ranked 5th in order of constraints faced by the sampled farmers. Production is accomplished and completed if the product reaches the hands of ultimate consumers or users. Movement of cotton to the market is one of the physical functions of marketing in making cotton available to the final users. In this regard, organised statutory marketing institution can play crucial roles in overcoming most of the identified marketing constraints identified in the study. The restoration of institutionalised marketing bodies by government, the participation of viable cotton companies and private sector concerns will help to resuscitate cotton production industry in Nigeria.

In accordance with this, (Agricultural development in Nigeria) (ADENI), (2005) Project was instituted and aimed at improving farmers' incomes through improved access to markets opportunities and development services. The identification of appropriate and relevant strategies for enhancing farmers marketing position for cotton requires a comprehensive analysis of farmers marketing environment. Commodity Chain Analysis (CCA) provides the analytical framework for identifying farmers' constraints and assessing the economic viability of proposed solutions to overcome these constraints.

Recently, ATA (2011) noted that the scrapping of marketing boards during the structural adjustment, without any institutions to replace them or play their functions, has left many farmers in a precarious situation. Lack of market access, price

uncertainties and volatility are great challenges which leave them at the mercy of middlemen. There is no developed country with such institutional abandonment of farmers. In this regard, the Federal Government promised to revamp the functions performed by the marketing boards and ensure that a non-viable or over-bureaucratic institution that tax farmers like the old marketing boards is not built. Marketing corporations with remarkable contribution to the performance of private sector in agricultural transformation and economic development will be enhanced. The marketing corporations will be owned by agricultural value chains, run as private sector-led (but government enabled) institutions and empower farmers and the value chain actors to generate value and will coordinate the production and/or export of cotton.

As a result of inadequate marketing facilities and incentives, cotton has to be transported through various distances in search of market and attractive price. Transportation is one of the constraints since it is a cost the farmers need to incur in cotton production. The distance to the market where cotton may be disposed varies by location and chosen market from their farms or villages. The farther the market from the point of production or the village, the more is the cost of transportation and subsequently the cost of production. In accordance with this, farmers are not necessarily confined to certain village or local markets in order to sell their cotton. Some of the farmers seek various urban and commodity exchange markets to speculate for better or higher prices for cotton. Adequate access to organised market where cotton can be sold determines the tendency of farmers to produce cotton. The step taken by the government in the agricultural transformation agenda to reorganise and reconstitute commodity marketing system in Nigeria will help in revamping and revitalising cotton production and marketing in Nigeria.

Table 4. 43: Distribution of farmers by constraints faced in cotton production

Constraints	Frequency *	Percentage	Rank
Climatic constraints			
Inadequate rainfall	67	30.45	9th
Excessive rainfall	54	24.54	17th
High intensity of sunshine	48	21.82	19th
Excessive wind at harvest	63	28.64	11th
Soil constraints			
Inadequate soil fertility	115	52.27	1st
Erosion menace	52	23.64	18th
Severe environmental degradation	41	18.64	22nd
Biotic constraints			
Pest invasion	65	29.55	10th
Disease incidence	60	27.27	13th
Weed infestation	38	17.27	24th
Genetic constraints			
Inadequate improved seed variety	57	24.91	15th
Costly seed to procure	69	31.36	8th
Seed is not certified	62	28.18	12th
Seed is not properly stored	70	31.81	7th
Institutional constraints			
Problem of land acquisition	98	44.55	3rd
Inadequate loan/credit supply	45	20.45	21st
Inadequate extension services	40	18.18	23rd
Insufficient funds for production	92	41.82	4th
Complexity of some technologies	58	26.36	14th
Inadequate market and marketing facilities	100	45.45	2nd
Poor farm gate price and pricing	72	37.73	6th
Inadequate processing facilities	30	13.64	25th
Poor transportation facilities	56	25.45	15th
Long marketing distances	75	34.10	5th

* Multiple responses were allowed

4.7 Estimation of Response of Cotton Supply to Price Changes in the Cotton Market

The response of cotton supply to price changes in the cotton market between 1995 through 2013 in Zamfara state was estimated. This is to ascertain that the response of farmers in the supply of cotton depends on the ruling price, price expectations, previous price profile, price of competing enterprise and some impinging non-economic factors determined by the ecology and biology of cotton production in the state. It is based on this premise that farmers respond and decide on the amount of cotton to produce in a

current year using last year's market prospects as a basis for decision at farm level thereby justifying the level of profits accruing to them. The lagged models namely Nerlovian Adaptive Expectation Model and Constant Elasticity Adjustment Model were used to estimate the response of cotton supply to price changes in the cotton market in the state. The models were used to achieve objective (vii) of the study.

4.7.1 Nerlovian adaptive expectation model

The assumption in the Nerlovian Adaptive Expectation Model is that, supply of an agricultural product is a function of the expected price for that commodity; in this case cotton was used in the estimation. The derivation of the linear trend relationship between output and price at various time periods is summarised in appendix (III). The equation that was used to determine the response of cotton supply to price changes in the cotton market is expressed in equation 45 while P_C is price of a competitor to cotton such as groundnuts. In the double log functions, the values of R^2 and $\bar{R}^2$ showed the performance of cotton supply to price changes in the domestic market between 1995 and 2013 shown in Table 4.44. In the analysis, the LEAD equations were chosen as the best fit in the multiple regression analysis of the response of cotton supply to price changes in the cotton market. The equations in this regard were the double logarithm functions of Nerlovian Adaptive Expectation Model and the Constant Elasticity Adjustment model in which the dependent and the explanatory variables were logged.

Table 4.44: Regression analysis for cotton supply to price changes in the cotton market (1995 – 2013)

Variable	**Nerlovian adaptive expectation model**	**Constant elasticity adjustment model**
Dependent variable	(Y_t)	(Y_t)
Constant	4.341***	4.337***
Term	(2.40)	(2.32)
Regression coefficients		
Y_{t-1}	0.3351	0.3225
	(1.27)	(1.18)
P_t	0.3718*	0.8320***
	(1.79)	(2.96)
P_{t-1}	-1.0395***	0.4291*
	(-3.92)	(1.75)
P_{t-2}	-0.0307***	-1.3604***
	(-4.09)	(-3.453)
P_{t-3}	0.9829	-0.1141
	(1.59)	(-0.38)
P_c	-0.3876	-0.3848
	(-1.16)	(-1.12)
R^2	0.589	0.597
F	2.87	2.02
$\bar{R}^2$	0.383	0.254

Figures in parentheses are the T-values
*** = p< 0.01 * = p < 0.10

Hence, the explanatory power of R^2 was about 58.90% of the supply of cotton in the domestic market which was explained by the explanatory variables between the periods under consideration. For P_{t-1} and P_{t-2} showing the T-values of (-3.92) and (-4.09) respectively were significant at 1% level of probability while P_t with T-value of (1.79) was significant at 10% for the Nerlovian model. This implies that the response of cotton supply to price changes in the domestic market was dramatic and impressive within the period. The R^2 for double-log function was above average in explaining the relationship between the explanatory variables and the dependent variable in the time series. This means that the powers of the explanatory variables were expressed in consonance with the dependent variable. Therefore, the response of cotton supply to price changes in the domestic markets in the study area was responsive and satisfactory.

Also, the analysis revealed that the competitor to cotton that is groundnuts (P_c) had negative coefficient of regression. These have credence for the case of any competitive enterprise in which a fall in price of cotton will enhance an increase in the level of production of the alternative enterprise (groundnuts) where the price is more attractive, profitable and stable. In this case, inputs will be diverted to the production of the profitable alternative enterprise.

4.7.2 Constant elasticity adjustment model

The essence of this is that, farmers respond to supply of cotton based on the dictate of changes in prices of cotton in the market. This is because market price determines the level of income accruing to farmers which is a direct relationship of the amount of profit made in cotton production. This justifies farmers' ability to adjust and re-organise their currently available resources in the process of decision making at farm level. Therefore, packages of improved technologies and cultural practices can be adopted or discarded as the case may be in their cotton production enterprises. This is the basis of adjustment model which was used to analyse farmers' responses in the supply of cotton in the market in the study area.

The summary of the derivation of the linear regression equation in appendix (IV) was used in this analysis to ascertain the validity of the response of cotton supply to price changes in the cotton market using constant elasticity adjustment model in equation (52) while Pc is price of a competitor to cotton such as groundnuts. The regression analysis for cotton supply to price changes using Constant Elasticity Adjustment Model is shown in Table 4.44.

The estimated value of R^2 was 59.7% revealing the performance of cotton supply to price changes in the cotton market. The estimates were slightly above average implying that the values were able to explain the level of cotton supply during the period under consideration. The regression coefficients with respect to $P_{t,}$ and P_{t-2} indicating the T-values of (2.96), and (-3.53) respectively were significant at 1% level of probability while P_{t-1} showing the T-value of (1.75) was significant at 1% level of probability. Hence, the performance of cotton supply to price changes in the cotton market was elastic and satisfactory.

The Nerlovian Adaptive Expectation Model and Constant Elasticity Adjustment Model were chosen because of the type and nature of data used in the analysis. Lagged models are used in analysing time series data and data with lagged variables. Therefore, they were the choice criteria because the models can accept time series data and data with lagged variables used to estimate the response of cotton supply to price changes in the cotton market in the state.

The phenomenon of elasticity and responsiveness of cotton supply to price changes in the cotton market can be attributed to the profitability of the cotton production enterprise in the study area. Presently, most cotton markets are still freely traded and there is no statutorily organised cotton market in existence within the immediate reach of cotton farmers. In order to improve on the performance of cotton production among cotton farmers there is need for institutional intervention by the government. The commodity marketing boards were scrapped and abolished in January, 1986. In this regard, registered cotton merchants, agent middlemen and licensed buying agents (LBA's) ceased to exist thereby hampering cotton to be traded in organised markets

through appropriate marketing channels. Availability of organised markets and guaranteed market prices of cotton may serve as an important indicator for farmers' decisions to increase cultivation of the crop. This will improve the response of cotton supply by farmers and generate employment for more would-be cotton farmers and the textile mills in the study area. According to Adeshina, (2012) employment generation from the textile industry fell from 700,000 persons in 1980's when the industry was flourished with more than 175mills in operation throughout the country to only 25,000 persons currently. This led to the downward trend of textile industries in Nigeria.

4.7.3 Test of hypothesis on the response of cotton supply to price changes

In Table 4.45, Test of hypothesis for the response of cotton supply to price changes in the cotton market was carried out using the result of analysis of trend in Table 4.44. The null hypothesis states that $H0_4 : P_t = P_{t-1} = P_{t-2} = 0$ stating that there is no significant difference between supply and prices in the study area. The results of the analysis in Table 4.45 shows that the calculated T-values of (-3.92) and (-4.09) for the Nerlovian Model and (2.96) and (-3.53) for the Constant Elasticity Adjustment Model were above the T- critical value and significant at 1% level of probability in both models. Hence, the null hypothesis $H0_4$ was rejected. Thus, there is significant relationship between cotton supply and seed cotton prices $P_t,\ P_{t-1}\ and\ P_{t-2}$ in the study area.

Table 4. 45: T-Test of hypothesis for the response of cotton supply to price changes in the cotton market

	Null Hypothesis	Calculated T-value		Critical t-value	Decision
Price function	: $P_x = 0$			2.40	
	$P_t =$	$-$	$(2.96)^{***}b$		Reject $H0_4$
	$P_{t-1} =$	$(-3.92)^{***}a$	$-$		Reject $H0_4$
	$P_{t-2} =$	$(-4.09)^{***}a$	$(-3.53)^{***}b$		Reject $H0_4$

Figures in parentheses are the T-values
*** = p < 0.01
a = calculated T-values from Nerlovian Model
b = calculated T-values from Constant Elasticity Model

Since this hypothesis was rejected that there is no significant relationship between cotton supply and prices, there are some implications that can be deduced for production planning and investment in the cotton production industry. In most cases, output levels from cotton enterprises are relatively low which tend to discourage farmers when compared to the level of recommended output. In order to overcome this problem, farmers need to plan their investments in cotton production by adopting improved recommended cotton production practices. Also, sufficient incentives in terms of inputs and output prices will encourage farmers to improve production while organised cotton markets are needed to absorb cotton produced by farmers in the economy.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study was on economic analysis of cotton production and supply trend estimation in the study area. A multi-stage sampling technique was used in selecting the study farmers from whom primary data were collected using structured questionnaire. Secondary data were also used in the study. Descriptive statistics, grafted polynomial models, net farm income analysis, stochastic frontier analysis and models with lagged variables were the analytical tools used in achieving the stated objectives of the study.

The study provided insight into the socio-economic characteristics, resource procurement and utilisation, cotton production technologies, profitability and economic efficiency involved in cotton production. Most of the socio-economic characteristics investigated had meaningful bearings on the farmers' ability to procure, utilise and adopt cotton production practices that led to increased productivity. The ex-post forecast of cotton production using the grafted (mean) function was 123,000 tons and was close to the observed values of 129,000 tons during the sub-period (2006-2013). The linear estimation of 137,000 tons was far from the observed values. Farmers were able to make profits of ₦51, 414.51/ha if all labour costs are calculated and the returns per man-day of ₦966.80 while the return to investment shows that a farmer gains ₦1.11 per naira invested in cotton production.

The input-output analysis indicated that farmers operated their farms with different levels of efficiencies. The average yield of cotton produced was 773.319kg/ha with yield ranging from 391.30kg/ha to 900kg/ha. The return to scale (RTS) was 0.791

showing positive decreasing returns to scale and in stage (II) of the production function. The average technical, allocative and economic efficiency scores were 0.67, 0.64 and 0.44 respectively. Some constraints encountered by cotton farmers were identified to include inadequate soil fertility, inadequate market and marketing facilities, problem of land acquisition and insufficient funds for production. The Nerlovian and Constant Elasticity Models showed that the response of cotton supply to price changes in the cotton market from 1995 to 2013 were significant at 1% and 10% levels of probability. Hence, the response of cotton supply to price changes in the domestic market was above average and impressive.

5.2 Conclusion

The results of socio-economic characteristics, sources of input procurements and utilisation; and production technologies showed that they exert direct influence on increased cotton productivity. The grafted model provided a better forecast of the production trend over the entire sampled period. Also, the analysis of the net farm income indicated that cotton production was a profitable enterprise in the study area. The results of the stochastic frontier analysis revealed that cotton production was above average with respect to technical and allocative efficiency. Cotton farmers were beset with various constraints in cotton production. Farmers who belong to cotton growers' group or co-operative societies were able to overcome some of the constraints promptly. The responses of farmers' supply of cotton to price changes in the domestic market since 1995 were satisfactory.

5.3 Contribution of the Study to Knowledge

The study revealed that cotton production is a worthwhile production enterprise which farmers need to explore in order to increase their level of income and improve economic welfare. Based on this credence:

i. The estimation of supply trend revealed how economic time series data can provide opportunity to forecast and predict future events. The grafted model provided closer mean estimates of 123,000 tons when compared to the observed mean value of 129,000 while 137,000 tons of the linear model was farther away from the observed value.

ii. The response of cotton supply to price changes in the cotton market gave insights into how data with lagged variables can be used to measure farmers' responses in the supply of cotton to price changes based on past records. The application of models with lagged variables from 1995 to 2013 revealed that the coefficients of the explanatory variables p_t, p_{t-1} and p_{t-2} their corresponding T-values of (1.79), (-3.92) and (-4.09) for the Nerlovian model and (2.96) (1.75) and (-3.45) for the Constant Elasticity model were significant indicating that farmers' response to cotton supply was satisfactory and impressive.

iii. The efficiency and productivity of farmers were beset with various constraints which hindered farmers' ability to be productive. Inadequate soil fertility ranked first with 52.27%, inadequate market and marketing facilities ranked second with 45.45% while Problem of land acquisition ranked third with 44.55%. Those who were co-operative members or those that belong to cotton growers' group reaped benefits of membership which contributed immensely in overcoming such constraints and improve on production efficiency.

5.4 Recommendations

Based on the above conclusions, some policy recommendations and suggestions that will help in improving upon the level of growth in cotton production and circumventing most of the identified constraints in the study are proffered.

i. Most socio-economic attributes of farmers investigated had meaningful bearings on farmers' ability to procure and use inputs to produce cotton. Hence, government and agro-service agencies should distribute inputs timely and at affordable prices so as to enhance productivity among cotton farmers.

ii. The production and supply trends should be considered as a basis to assess the performance of cotton production industry overtime. Hence, in planning for production and investment, government should provide production facilities that will and enhance improvement on farmers' productivity overtime.

iii. Adequate and intensive research and extension service delivery programme should pursue a consistent and systematic campaign for cotton production by government. Increased use of recommended production practices such as improved cotton varieties, timely weeding, spraying and fertilizer application are recommended.

iv. Cotton production is a profitable enterprise with an average profit of ₦51, 414.51/ha. Therefore, agro-service agencies and government should encourage cotton farmers and the would-be cotton farmers in its production by providing price incentives for cotton lint, cotton seed, cottonseed oil and cotton seed cake.

v. The average technical, allocative and economic efficiency scores of 0.67, 0.64 and 0.44 were below the optimum levels respectively. Efficiency of cotton farmers should be supported by government through motivation and other

supportive services such as supply of credit facilities required in adopting the best and modern technologies by cotton farmers.

vi. The results indicated that co-operative societies increased farmers' efficiencies and overcome various constraints in cotton production. Those who are non-members should join and harness their resources to improve their level of financing. Government and Government sponsored Community-based agro-support agencies should render more services to enable more farmers form and operate co-operative societies.

vii. The response of cotton supply to price changes in the market was above average. An enabling marketing policy should be instituted by government to increase and sustain cotton supply in the market. This could be achieved through Product Marketing Corporation which will serve as a clearing house for cotton marketing.

5.5 Suggestions for Further Study

The depth and scope of the study was limited by insufficient fund and time restrictions which necessitates the need to embark on further research on similar studies or topics related to the study. Therefore, it is suggested that future studies on economic analysis of cotton production and supply trend estimation should cover more production states or cotton based production zones in the country.

REFERENCES

Adeniji O.B., Voh, J. P., Atala. T.K. and Ogungbile A.O. (2007). Adoption of improved Cotton Production Technologies in Katsina State, Nigeria. *Journal of Applied Sciences*, 7: 397 – 401.

Adeniji, O. B. (2002). Adoption of Improved Technologies for Cotton Production in Katsina State, Nigeria. Unpublished Ph.D Thesis Submitted to the Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria.

Adeniji, O. B. (2007). Constraints to Improved Cotton Production in Katsina State, Nigeria. *Journal of Applied Sciences*, 7:1647-1651.

Adeshina, A. (2012). Agricultural Transformation to Create 3.5 million Jobs, Adds 20 million Tonnes of Food. www.leadership.ng. Accessed Nov. 18th 2012.

Adeshina, A. (2012). Reviving Cotton Production in Nigeria. www.peoplesdaily-online.com. Accessed Nov. 18th 2012.

Adewuyi, S. A.(2002). "Resource Use Productivity in Food Crop Production in Kwara State, Nigeria." Phd Thesis Submitted to the Department of Agricultural Economics, University of Ibadan, Ibadan, Nigeria.

Adubi, A. A. (2001). *Agriculture in the Nigerian Economy.* Being a Paper Presented At the Workshop on Planning and Management of Agriculture Sector, August 14 – 25, Organized by Nigeria Centre for Economic Management. (NCEMA), Ibadan, Nigeria.

Adzawla, W., Fuseini, J., and Donkoh, S.A. (2013). Estimating Technical Efficiency of Cotton Production in Yendi Municipality, Northern Ghana. *Journal of Agriculture and Sustainability*. 4: 115-140.

Africa Fertilizer Summit (AFS) (2006). http://www.africangreenrevolution.com Accessed July, 2014.

Agbamu, J. U., Fujita, Y., Idowu, I. and Lawal. A. (1996). Effect of Socio-Economic Factors on Adoption of New Varieties of Maize and Cassava: A Case Study of Ogun State in Nigeria. *Journal of Agricultural Development*. Tokyo, Pp. 8-16.

Agricultural Development in Nigeria (ADENI), (2005). *Commodity Chain Analysis of Cotton Sector in Nigeria* . A Report Submitted to ADENI Project/National Agricultural Extension and Research Liaison Services, Ahmadu Bello University, Zaria, Nigeria. 1/47.

Ahmed, B., Dadari, S. A. and Shinggu, K. C. (2012). *Weed Control in Mechanised Cotton Production.* Cropping Scheme Meeting and Zonal Refill Workshop. Farming System Research and Extension Programme. Institute for Agricultural Research; Ahmadu Bello University, Zaria, Nigeria.

Ahmed, B., Dadari, S. A., Ishaya, D. B. and Shinggu, K. C. (2012). *Cotton Zonal Herbicide Trial.* Cropping Scheme Meeting and Zonal Refill Workshop. Farming System Research and Extension Programme. Institute for Agricultural Research; Ahmadu Bello University, Zaria, Nigeria.

Aigner, D. J., and Chu, S. F. (1968). On Estimating the Industry Production Function. *American Economic Review*, 58, 826-839.

Aigner, D. J., Lovell, C. A. K. and Schmidt, P. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics*. 6: 21-37.

Ajani, O.I.Y. (2000). Resource Productivity in Food Farming in Northern Area of Oyo State, Nigeria. Unpublished Ph.D Thesis, Department of Agricultural Economics, University of Ibadan, Nigeria. Pg. 167.

Ajayi, M.T., and Ogunlola, J. O. (2006). Farmers' Perceived Agricultural Input: Factor Influencing Adoption and Production of Crops in Akure Area of Ondo State, Nigeria. *Nigerian Global Approaches to Extension Practice*. 2 (1), 1-8.

Ajibefun, I.A. (2008). An Evaluation of Parametric and Non-parametric Methods of Technical Efficiency Measurement: Application to Small Scale Group Production in Nigeria. *Journal of Agricultural Science* 4: 95 -100.

Alam, M.K., Aboki, E. and Gidado E.H. (2013). An Economic Analysis of Cotton Production in Selected Local Government Areas of Taraba State, Nigeria. *Journal of Agricultural Science*, 4 (1): 27-31.

Alam, M.K., Aboki, E. and Gidado E.H. (2013). An Economic Analysis of Cotton Production in Selected Local Government Areas of Taraba State, Nigeria. *Journal of Agricultural Science*, 4 (1): 27-31. Cited in Gbadegesin J, Uyovnisere K .(1994). *Cotton Production in Nigeria.* Kaduna: Baraka Press and Publishers Ltd.

Alvarez, A. and Arias, C. (2004). Technical Efficiency and Farm Size: A Conditional Analysis. *Agricultural Economics* 30: 241-250.

Anyanwu, S. O. and Obasi P. C. (2010b). Comparative Analysis of Aggregate Agricultural Productivity Between Low and High External Input Technology Farms in Nigeria. *African Journal of Biotechnology.* 9 (34):5530–5534.

Anyanwu, S.O. and Obasi P. C. (2010a). Comparative Analysis of Land Productivities in low and High External Input Technology Agriculture in Imo State, Nigeria. *Acta Agronomica Nigeriana.* 10 (1):15–21.

Atala, T. K. and Kuchinda, N. C. (2012). *Factors Influencing Adoption of Recommended Cotton Technology Package by Small Holder Farmers.* Cropping Scheme Meeting and Zonal Refill Workshop. Farming Systems Research and Extension Programme, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

Agricultural Transformation Agenda (ATA),(2011). *We will Grow Nigeria's Agricultural Sector.* Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

Awe, A. A. (2013).Mobilization of Domestic Financial Resources for Agricultural Productivity in Nigeria. *Australian Journal of Business and Management Research*. 2 (12): 01-07.

Badunenko, O., Fritsch, M. and Stephan, A.(2006). What Determines the Technical Efficiency of a Firm? The Importance of Industry, Location and Size. Jenaer Schriften zur Wirtschaftswissenchaft 33/2006. Friedrich-Scchiller-Universität Jena.

Battese, G. E. and Corra, G. S. (1977). Estimation of a Production Frontier Model; with Application to the Pastoral Zone of Eastern Australia. *Australian Journal of Agricultural Economics,* 21:167-179.

Battesse, G. E, (1992). Frontier Production Functions and Technical Efficiency: a Survey of Empirical Applications in Agricultural Economics. *Agricultural Economics*, (7): 185- 208.

Battese, G.E., and Coelli, T. J.(1992). Frontier production functions, technical efficiency panel data: With applications to paddy farmers in India. *Journal of productivity analysis. 30: 153-169.*

Battese, G..E. and Coell, T. J. (1995). A Model for Technical Inefficiency Effects in a Stochastic Frontier Production for Panel Data. *Empirical Economics*, 20:325-332.

Beintema, N. M. and. Ayoola, G. B. (2004). *Agricultural Science and Technology Indicators, Nigeria,* ASTI Country Brief No. 10.

Braulke, M. (1982). A Note on the Nerlove Model of Agricultural Supply Response. *International Economic Review*, 23 (1): 241- 246.

Bravo-Ureta, E. B. and Pinheiro, E. A. (1997). Technical, Economic and Allocative Efficiencies in Peasant Farming: Evidence from the Dominican Republic. *The Developing Econ*omics. 34: 48-67.

Central Bank of Nigeria (CBN), (2011). *Gross Domestic Product at 1990 Constant Basic Prices*. Central Bank of Nigeria. Annual Report.

Central Bank of Nigeria (CBN), (2011). Estimated Output of Major Agricultural Commodities. Annual Report.

Cherry, R. D. and Michael, L. M. (2000). How Does Gender Affect the Adoption of Agricultural Innovation? The case study of Maize Technology in China: Women Agricultural and Rural Development. Findings of FAO study in Africa. In: Adepoju, S.O., Umar, G. and Agun, J.O. An Appraisal of Participation of Women in Kano Agricultural and Rural Development Authority (KNARDA). Extension Delivery Programmes. *Journal of Agricultural Extension*, 10: 207-217.

Chukwuji C. O., Inoni, O. E., Ogisi, D. and William J. O. (2006): A Quantitative Determination of Allocative Efficiency in Broiler Production in Delta State, Nigeria. Department of Agricultural Economics and Extension, Delta State University, Asaba Campus, Asaba. Delta State, Nigeria: *Agriculturae Conspectus Scientificus, 71(1): 21-26.*

Coelli, T J. (1995). Recent Development in Frontier Estimation and Efficiency Measurements. *Australian Journal of Agricultural Economics.* 39:219-245.

Coelli, T. J. (1996). A Guide to FRONTIER Version 4.1: A Computer Programme for Coulibaly, O., Mbila, D., Sonwa, D. J., Adesina, A. and Bakala, J. (2006); Integrated Pest Management Reviews. *Springerlink Journal*. 7 (3):165-175.

Coelli, T. J. (1992). A Computer Program for Frontier Production Function Estimation: FRONTIER Version 2.0. *Economics Letters*. 39: 29-32.

Coelli, T. J. (1996a). A Guide to FRONTIER Version 4.1*: A Computer programmes for Frontier Production Function Estimation.* CEPA Working Paper 96/07, Department of Econometrics, University of New England, Armidale.

Coelli, T. J. and Batasse, G. E. (1996). Identification of Factors which influence the Technical efficiency of Indian Farmers. *Australian Journal of Agricultural Economics*. 40 (1): 19-44.

Coelli, T. J., Rao, D. S. P. and G. E. Battese (1998). *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers, Boston.

Cooper, E. I. (1990). *Agricultural Science: Fundamentals and Application.* Peter Publishers. Inc. Ibadan, Nigeria. 46pp.

Diewert, W. and Nakamura, A.(2005). *Concepts and Measures of Productivity: An Introduction. In Services, Industries and the Knowledge Based Economy,* edited by Lipsey and Nakamura. University of Calgary Press.

Ega, L. A. (2010), Land Holding Patterns and Related Problems of Agricultural Development in Zaria Villages. *Samaru Journal of Agricultural Research 14 (1and2).*

Eheke, O. R. (2008). Technical Efficiency of Cassava Farmers in Southeastern Nigeria: Stochastic Frontier Approach. *Agricultural Journal* 3 (2): 152-56.

Ehui, S. K. and Spencer, D. S. C. (1990). In Umoh, G. S. and Yusuf, S. A. (1999). An Empirical Analysis of the Poverty Status and productivity of Rural Farmers in Obubra Cross River State, Nigeria. *Nigerian Journal of Economics and Social Studies*.4 (2): pp. 259-271.

Ekong, E. E. (2005). *Introduction to Rural Sociology. An Introduction and Analysis of Rural Nigeria, Ugo, Nigeria*. Dove Education Publishers, Revised Edition.

Emea, A. O. and Eugene, C. O. (1998). Multidimensional analysis of land tenure system in eastern Nigeria. *Land Reform bulletin* 1997/2. Rome: FAO.

Eyo, E. O. (2008). Macroeconomic Environment and Agricultural Sector Growth in Nigeria. *World Journal of Agricultural Sciences* 4(6): 781-786.

Farrel, M. J. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistical Society,* 120:254-289.

Food and Agriculture Organisations Statistics (FAO), (2008). (FAOSTAT. Data Results).

Food and Agriculture Organisation (FAO). Production Year Book .(Various issues).

Forum for Agricultural Research in Africa (FARA), (2006).*Framework for African Agricultural Productivity* .Accra, Ghana.72 pp.

Federal Office of Statistics. (FOS), (2009). National Agricultural Sample Survey.

Fisher, J. F (1969). *The World's Major Fiber Crops: Their Cultivation and Manuring*. Switzerland. P. 11.

Fortucci, P. (2002). *The Contribution of Cotton to Economy and Food Security in Developing Countries.* A paper presented at the Conference of Cotton and Global Trade Negotiation, Ibadan, Nigeria. 20th September. pp. 5-8.

Frisvold, G. & Ingram, K. (1994). Source of Agricultural Productivity Growth and Stagnation in Sub-Saharan African. Agricultural Economics, 13(1): 51-61.

Fuller, W. A. (1969). Grafted Polynomials as Approximating Functions: *In Australian Journal of Agricultural Economics.* 35-46.

Gerdin, A. (2002). Productivity and Economic Growth in Kenyan Agriculture, 1964-1996. *Agricultural economics.* 27(1):7-13.

Goreux, L. M. (2003) *Cotton Production in Africa vis-à-vis US and EU subsidies.* Prelude to the Cacun Negotiations. European Parliament, Brussels.

Greene, W. H. (1992). LIMDEP Version 6.0 User's Manual and Reference Guide. *Econometric Software Inc*. New York.

Gujarati, D. N. and Porter, D. C. (2012). *Basic Econometrics*. 3rd Edition, New York: *McGraw- Hill* Companies.pp.155.

Gwandi, O., Balla, M. and Danbaki, J. W. (2010). Resource Use Efficiency in Cotton Production in Gassol Local Government Area of Taraba State, Nigeria. *Journal of Agriculture and Social Sciences.* 6: 87-90.

Gwandi, O., Balla, M. and Danbaki, J. W. (2010). Resource Use Efficiency in Cotton Production in Gassol Local Government Area of Taraba State, Nigeria. *Journal of Agriculture and Social Sciences*. 6: 87-90. Cited in Batterham, R. (2000). *The Chance to Change*. Discussion Paper by the Chief Scientist Camberra, African Summit, Abuja, Nigeria.

Horton, D. and Mackay, R. (2003). Using Evaluation to Enhance Institutional Learning and Change. Recent Experience with Agricultural Research and Development. *Agricultural System*. 78:127-142.

Ibrahim, E. J. (2008). Economics of Sole Cotton Production in Lau Local Government Area of Taraba State, Nigeria. Unpublished M.Sc. Thesis Department of Agricultural Economics, Federal University of Technology, Yola.

Idem, N .U .A. (1999). *Cotton Production in Nigeria*. Baraka Press and Publishers Ltd. Kaduna, Nigeria.

Idiong, C. I., Onyeweaku, E. C., Domian, I. A. and Susan, B. O. (2007). A Stochastic Frontier Analysis of Technical Efficiency in Swamp and Upland Rice Production System in Cross River State, Nigeria. *Medwell Agricultural Journal,* 2(2): 299-305.

Iheanacho, A. C., Olukosi, J. O. and Ogungbile, A. O. (2000). Economic Efficiency of Resource Use in Millet Based Cropping Systems in Borno State of Nigeria. *Nigeria Journal of Tropical Agriculture*. 2:33-42.

Ike, C. P. and Ogba, A. (2004*). Resource Use Efficiency by Cassava Women Farmers: Evidence from Enugu State, Nigeria.* Proceeding of 39th Conference of the Agricultural Society of Nigeria, Benin, October. 9-13.

Inoni, O. E. (2007). Allocative Efficiency in Pond Fish Production in Delta State, Nigeria: A Production Function Approach. *Agricultura Tropica Et Subtropica* 40 (4) .

International Cotton Association Committee (ICAC), (2001). *An Overview of the Performance of Extension Services to Cotton Farmers in the Northern Cotton Producing Zone*. Proceedings of the Cotton Production and Marketing in Nigeria. 10-11 November. Held at Federal Secretariat Conference Hall, Bauchi, Nigeria.

International Fertilizer Development Corporation (IFDC), (2006). Nigerian Company re-opens only Urea Fertilizer Plant in Sub-saharan Africa to meet summit call for African Green Revolution. www.ifdc.org/New Design. Accessed July, 2014.

Jackson, C. (1986). *The Kano River Irrigation Project*. West Hartford; Kumerian Press.

Jimaza, M. and Sanni, E. I. (2003). Agricultural Production and the Economic Development of Nigeria. *Journal of Development and Society*, 1(4), 126-143.

Johnston, J. (1984). *Econometric Methods*, Third Edition, New York: McGraw-Hill.

Jones, T. S. (1969). *Commonwealth Development Corporation.* Nigeria Investigation Part III, London Pp. 3.

Kabwe, S. (2012). Factors Affecting Efficiency of Smallholder Cotton Producers in Zambia. A Dissertation Submitted to the University of Zambia in Partial Fulfillment of the Requirements of the Degree of Master of Science in Agricultural Economics.

Kibirige, D. (2008). Analysis of the Impact of the Agricultural Productivity Enhancement Programme on the Technical and Allocative Efficiencies of Maize Farmers in Masindi District. An M.Sc Thesis, School of Graduate Studies Makerere University, Kampala.

Kirsten, J. and Vink, N.(2006). Farm Size, Productivity and Returns to Scale in Agriculture Revisited: A Case Study of Wine Production in South Africa. *Agricultural economics Blackwell*, 19(1-2): 175-180.

Leaver, R. (2003). *Measuring the Supply Response of Tobacco in Zimbabwe*. Paper Presented at the 41st Annual Conference of Agricultural Economic Association of South Africa (AEASA). Pretoria, South Africa.

Mallawaarachchi, T., Walcott, J., Hughes, N., Gooday, P., Georgeson, L. and Foster, A. (2009). *Promoting Productivity in the Agriculture and Food Sector Value Chain: issues for R&D Investment*, ABARE and BRS Report to the Rural R&D Council, Canberra.

Manyong, V. M., Ikpi, A., Olayemi, J. K., Yusuf, S.A., Omonona, B.T., Okoruwa, V. and Idachaba, F.S. (2005). *Agriculture in Nigeria: Identifying Opportunities for Increased Commercialization and Investment.* IITA, Ibadan, Nigeria, Pp. 159.

Mendelsohn, M., Kough, J., Vaituzis, Z. and Matthews, K. *(2003).* Are Bt crops safe? *Nature Biotechnology, 21: 1003–1009.*

Meeusen, W. and Broeck van de, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. *International Economic Review*, 18: 435-444.

Mohammad-Yusuf, T. (2005). *The Effects of Market Reforms on Cotton Production Efficiency. The case of Tajkistan.* Asian Pacific School of Economics and Governments Working Paper 05-5.

Mohammed, I. J. (2009). Efficiency Analysis of Cotton-wheat and Rice-wheat systems in Punjab, Pakistan. *The Lahore Journal of economics.* 14(2): 97-124.

Mohammed, S. and Roujman, S. (2008). Analysing the Technical Performance of Cotton Farmers in Developing Countries: The Case of Burkina Faso. B.Sc. Thesis Submitted to the Department of Economics Uppsala University, Burkina Faso.

Moses, J. and Adebayo, E. F. (2006). Efficiency of Factors Determining Rain-fed Rice Production in Ganye LGA, Adamawa State, Nigeria. *Journal of Sustainable Development in Agriculture and Environment.* 3:20-30.

Mshelia, S. I. (1991). Economic Analysis of Cotton Production in Nigeria. A case study of Afcott Out-growers Scheme in Adamawa State. Unpublished M.Sc.Thesis, Department of Agricultural Economics, University of Ibadan, Nigeria. Pp. 45-47.

Muhammed-Lawal, A., Omotesho, O. A. and Falola, A. (2009). Technical Efficiency of Youth Participation in Agricultural Programme in Ondo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment.* 5(1): 20-26.

National Bureau of Statistics (NBS), (2011). Nigeria Gross Domestic Product at 1990 Constant Basic Prices.

National Population Commission (NPC), (2006). Population Census of the Federal Republic of Nigeria. *Analytical Report* at the National Population commission, Abuja, Nigeria.

Neba, C., Ngassam, S. and Nzomo, J. (2010). *The Determinants of Technical Efficiency of Cotton Farmers in Northern Cameroon.* MPRA Paper No.24814.

Neff, D. L., Garcia, P. and Nelson, C. H. (1993). Technical Efficiency: A Comparison of Production Frontier Methods. *Journal of Agricultural Economics.* 44 (3): 479-489.

Nerlove, M. (1958). *The Dynamics of Supply: Estimation of Farmers' Responses to Price*. John Hopkins Press.

Nerlove, M. (1979). The Dynamics of Supply: Retrospect and Prospects. *American Journal of Agricultural Economics*. 61 (5): 874-888.

Norman, D. W. (1973). An Economic Analysis of Agricultural Production and Labour Utilization among the Hausas in the North of Nigeria. *Samaru Research Bulletin*, No. 91.

Nyagata, O. D., Obare, A. G., Omiti, M. J. and Nguyo, W. (2010). Technical Efficiency in Resource use: Evidence from Smallholder Irish Potato Farmers in Nyandarua North District, Kenya. *African Journal of Agricultural Research* 5 (11): 1179-1186.

Obasi, P. C. (2006). Application of Trans-log Function to Productivity Estimation in Imo State, Nigeria. *International Journal of Agriculture and Rural Development* (IJARD). 6:26–33.

Obwona, M. (2000*). Determinants of Technical Efficiency among Small and Medium Scale Farmers in Uganda: A case Study of Tobacco Growers*. Final Report at the AERC Biennial Research Workshop, Nairobi, Kenya.

Odoemenem, U. I. (2007). Capital Resource Mobilization and Allocative Efficiency by Small-scale Cereal Crop Farmers of Benue State, Nigeria. A Ph.D Dissertation Submitted to the Department of Agricultural Economics, Management and Extension, Ebonyi State University, Abakaliki, Nigeria.

Ogen, O. (2007). The Agricultural Sector and Nigeria's Development: Comparative Perspective from the Brazilian Agro-industrial Sector Economy (1960-1995). *Nebula March @Noble World Archives.*

Ogundari, K. and Ojo, S. A. (2006). An Estimation of Technical, Economic and Allocative Efficiencies of Small Farms: The Case Study of Cassava Farm in Osun State of Nigeria. *Journal of Central European Agriculture*, (3): 423-432.

Ogunlela, V. B. (2004). *Improved Techniques for Increased Production in Nigeria*: Proceedings of the Train the Trainer Workshop on Presidential Initiative on Vegetable Oils, Cotton and Groundnut Production. Lake Chad Research Institute, May 10^{th}-12^{th}, Maiduguri, Nigeria.

Ogunlela, V. B. and Echekwu, C. A. (1989). *Long Staple Cotton as a Raw Material for the Nigerian Textile Industry. Present Status and Prospects.* Proceedings of the First Meeting of the Action Committee on Raw Materials. Raw Materials Research and Development Council Lagos, Nigeria. April 3-7. Pp.94-99.

Oji-Okoro, I. (2011). Analysis of the Contribution of Agricultural Sector on the Nigeria Economic Development. *world review of business research*, 1(1): 191 – 200.

Okoruwa, V. O. and Ogundele , O. O. (2006). Technical Efficiency Differentials in Rice Production Technologies in Nigeria. *African Economic Research Consortium*. Research paper No. 154.

Olukosi, J.O. and Erhabor, P.O. (2005). *Introduction to Farm Management Economics*: *Principles and Applications*. Agitab Publishers. Pp. 43-44.

Oluwatosin, F. M. (2006). Resource Use Efficiency among Maize Grower Households in Ekiti State, Nigeria. *Agricultural Journal*. 3(2):134–141.

Omolehin, R. A., Nmadu, J. N. and Ogidan, I. O. (2014). Profitability and Resource Use Efficiency of Poultry Egg Production in Abuja, Nigeria. *Kasetsart Journal of Social Science.* 35 : 134 - 146.

Oni, O., Pender, J., Phillips, D. and Kato. E. (2009). *Trends and Drivers of Agricultural Productivity In Nigeria*. Nigeria Strategy Support Program (NSSP) Report 001: IFPRI.

Onu, J. I. and. Atala, T. K. (1992*). An Overview of the Performance of Extension Services to Cotton Farmers in the Northern Cotton Producing Zones*.

Proceedings of the Seminars on Cotton Production and Marketing in Nigeria. 10th - 11th November, 1992. Held at the Federal Secretariat Conference Hall, Bauchi, Nigeria.

Onu, J. I. and Okunmadewa, F. Y. (2008). What Does the Conduct of the Cotton Market in Nigeria Reveal? *World Journal of Agricultural Sciences* 4(4): 521-526.

Onu, J. I. (2012). *Chemical Control of Cotton Insect Pests*. Cropping Scheme Meeting and Zonal Refill Workshop. Farming System Research and Extension Programme. Institute for Agricultural Research; Ahmadu Bello University, Zaria, Nigeria.

Onu, J. I., Abdullahi, Y. and Mohammed, M. S. (2012). *Population Improvement Through Inheritance of Resistance to Cotton Leaf Rollers (Sylepta derogata).* Cropping Scheme Meeting and Zonal Refill Workshop. Farming System Research and Extension Programme. IAR., ABU, Zaria, Nigeria.

Onu, J. I. and Edon, A. (2009). Comparative Economic Analysis of Improved and Local Cassava Varieties in Selected Local Government Areas of Taraba State, Nigeria. *Journal of Social Science,* 19(3): 213-217.

Onyenweaku, C. E. (2000). *Policy Issues and Strategies for Agricultural Production in Nigeria.* Proceedings of the National Workshop on Enhancing Research and Development in Agriculture and Root Crops Towards Poverty Alleviation and Rural Development in Nigeria. NRCRI, Umudike, Nigeria.

Oyakhilomen, O., Rekwot, G. Z and. Saliu, H . O . (2013). Assessment of the Suitability of Grafted Model in Forecasting Rice Consumption Trend in Nigeria. *Journal of Management and Science*. 3(1): 116-118.

Oyewole, S .O. (2012). Analysis of Income Diversification and Food Security among Farmers in Oyo State. An M.Sc. Thesis, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria.

Philip, D. O. A. (1990), Grafted Polynomials as Forecasting Functions: Application to Cotton Production in Nigeria 1(1): 103-108.

Phillip, D., Nkonya, E., Pender, J. and Oni, O. A. (2009*). Constraints to Increasing Agricultural Productivity in Nigeria: A Review.* Nigeria Strategy Support Program (NSSP). Background Paper No. NSSP 006.

Prentice, A. N. (1972). *Cotton with Special Reference to Africa* .(Printed in Great Britain by Williams Clowes and Sons. London) P.1.

Rahman, S. A. and Damisa , M. A. (1999). Forecasting Performance of a Grafted Model on Cowpea Price in Zaria Area of Kaduna State, Nigeria. *Nigerian Journal of Rural Economics and Soc*iology. 1 (5): 24-28.

Rahman, S. A. (2001). The Use of Grafted Polynomial Function in Forecasting Maize Production Trend in Nigeria. *Nigeria Journal of Biosciences.* 1 (1): 69-73.

Rahman, S. A. (2008). Women's Involvement in Agriculture in Northern and Southern Kaduna State, Nigeria. *Journal of Gender Studies*. 17(1): 17-26.

Rahman, S. A., Ajayi, F. A. and Gabriel, J. (2005). Technical Efficiency in Sorghum-based Cropping Systems in Soba Area of Kaduna State, Nigeria. *Journal of Research in Science and Management.*3(1): 100-104.

Rasaq, B. and Ajayi, O. O. S. (2000*). Research Methods and Statistical Analyses*. Haytee Publishers, Ilorin, Nigeria.

Raw Material and Research Development Council (2004). *Report on Survey of Selected Agricultural Raw Materials in Nigeria*. Federal Ministry of Agricultural, Abuja FCT, Nigeria.

Rios, A. R. and G .E. Shively. (2005). *Farm Size Non-parametric Efficiency Measurements for Coffee Farms in Vietnam.* Proceeding. America Agricultural Economics Association Annual Meeting. 24-27 July, Providence, Rhode Island.

Sabo, E., Daniel, J. D. and Adeniji, O. T. (2009). Economic Analysis of Cotton Production in Adamawa State, Nigeria. *African Journal of Agricultural Res*earch. 4(5): 438-444.

Seyoum, E., Battese, G. E. and Fleming, E. M. (1998). Technical Efficiency of Maize Production in Eastern Ethiopia: A Study of Farmers within and outside the Sassakawa-global 2000 Project. *Agricultural economics*, 19:341-348.

Shahooth, K. and Hussein, B.A. (2006). Using Data Envelopment Analysis to Measure Cost Efficiency with an Application on Islamic Banks. Scientific Journal of Administrative Development, 4:134-156.

Shehu, J. F., Mshelia, S. I. and Tashikalma, A. K. (2007). Analysis of Technical Efficiency of Small Rainfed Upland Rice Farmers in the Northwest Agricultural Zone of Adamawa State, Nigeria. *Journal of Agriculture and Social Sciences*, 3 (4): 133-134.

Solakoglu ,E. G., Er, S. and Solakoglu, M. N. (2013). Technical Efficiency in Cotton Production: The Role of Premium Payments in Turkey. *Transit Study Review* 20:285–294.

Spencer, D. C. (1972). *Micro-level Farm Management and Production Economics Research among Traditional African Farmers.* Lesson from Sierra Leone. Rural Employment Paper No. 3, Michigan State University, East Lasing.

Tietenberg, T. H. (2006). *Emissions Trading: Principles and Practice*. 2nd.Edition. Washington D.C.

Tsimpo, C. N. (2010) *Technical Efficiency and Optimal Farm Size in the Jajik's Cotton Sector.* MPR: 35192.

Tzouvelekas, V., Rozakis, S. and Pantzios, C. J. (2002). *Assesing the Perspectives of European Union (EU) Cotton Farming: Technical and Scale Efficiencies of Greek Cotton Growers,* European Association of Agricultural Economists International Congress, Zaragoza, Spain, August 28-31, pp. 1-21.

Uaiene, R. W. and Arndt, C. (2009). *Farm Household Technical Efficiency Frontier Analysis in Maputo, Mozambique.* Paper Presented at the International Association of Agricultural Economists Conference, 16-22 August, Beijin, China.

Umoh, G. S. and Yusuf, S. A. (1999). An Empirical Analysis of Poverty Status and Productivity of Rural Farmers in Obubra, Cross River State, Nigeria. *Nigerian Journal of Economics and Social Studies.* 4(2): 259-271.

United Nations Population Fund (UNFPA), (2013). Available on-line @http: Nigeria. unfpa.org/zamfara.html. Retrieved: 05/12/2013.

United State Agency for International Development (USAID), (2011). *Global Cotton Production Trend.* http//www.usaid. Retrieved: January, 2013.

United State Department of Agriculture. (USDA), (2011). *Nigeria Cotton Production by year*. http://www.indexmundi.com Accessed, 02/09/2011.

Vissoh, P. V., Gbehounou, G., Ahanchede, A., Kuyper, T. W. and Roling, N. G. (2004). Weeds as Agricultural Constraint to Farmers in Benin: Results of a Diagnostic Study. *Nigeria Journal of Agricultural Science.* 52(3/4):305-329.

Wiebe, K., Soule, M. J., Narrod, C. and Brenneman, V. E. (2003). *Resource Quality and Agricultural Productivity: A Multi-country Comparison in Land Quality, Agricultural Productivity and Food Security: Biophysical Processes and Economic Choices at Local, Regional and Global Levels.* Edward Elgar publishing, 2003.

Yakubu, A. A .(2005). Risk and Risk Management in Cotton Production among Farmers in Zamfara State, Nigeria. Unpublished M.Sc. Thesis, Department of Agricultural Economics, Usman Dan Fodio University, Sokoto, Sokoto State, Nigeria.

Zamfara State Agricultural Development Project (ZADP), (2010). Reconnaissance Survey.

Zamfara State (2010). www.zamfarastate.net Accessed Jan. 2013.

Zepeda, L.(2001). *Agricultural Investment, Production Capacity and Productivity.* In Agricultural Investment and Productivity in Developing Countries : Food and Agriculture Organisation *(*FAO) : Rome.

APPENDICES

Appendix I: Farmers' Questionnaire

SECTION A

BACKGROUND INFORMATION

1. Name of District/Local Government……
2. Name of Village……
3. Name of Farmer (optional)……...
4. Age of Farmer/Age Distribution
   - i. 18 – 39 [ ]
   - ii .40 – 59 [ ]
   - iii. 60 and above [ ]
5. What is your major occupation?
   - i. Farming [ ]
   - ii. Others (specify) [ ]
6. What is your level of education?
   - i. No formal education [ ]
   - ii. Attended Primary School but did not complete [ ]
   - iii. Completed Primary School [ ]
   - iv. Attended Secondary School [ ]
   - v. Attended Tertiary Institution [ ]

7. Do you have access to credit facilities?
   - i. Yes [ ]
   - ii. No [ ]
8. Marital Status of Farmer
   - i. Married [ ]
   - ii. Never married [ ]
   - iii. Divorced [ ]
   - iv. Separated [ ]
   - v. Widowed [ ]

9. Sex of Farmer

   i. Male [ ]

   ii. Female [ ]

10. For how long have you been farming (years)

   i. 1 – 5 years [ ]

   ii. 6 – 10 years [ ]

   iii. 11 – 15 years [ ]

   iv. Above 15 years. [ ]

11. If married what is the total size of your household

   i. Adult males above 14 years [ ]

   ii. Adult females above 14 years [ ]

   iii. Children [ ]

   iv. Disabled [ ]

SECTION B

RESOURCE UTILIZATION PATTERN AND COTTON PRODUCTION TECHNOLOGIES

I. Input Procurement and Resource Utilization Pattern.

12. Source of seed used in cotton production

   i. MANR/ADP [ ]

   ii. Seed retention [ ]

   ii. Market [ ]

   iii. National Seed Service/Certified [ ]

13. What is the source of fertilizer you used?

   i. MANR/ADP [ ]

   ii. Co-operative Society [ ]

   iii. Financial Institution [ ]

   iv. Market [ ]

   v. All of the above [ ]

14. What are the brands of fertilizer you used?

i. N.P.K. [ ]

ii. S.S.P. (Boronated) [ ]

iii. CAN [ ]

iv. All of the above [ ]

15. What is the method of fertilizer application adopted?

i. Basal application [ ]

ii. Broadcasting [ ]

iii. Spot application [ ]

iv. Side dressing [ ]

16. What method of land ownership did you encounter in acquiring your farmland?

i. Land tenure by inheritance [ ]

ii. Freehold title [ ]

iii. Leasing [ ]

iv. Co-operative/Communal land [ ]

v. Purchased/Rented [ ]

17. What is the total size of your farm land in hectare?.....

i. Less than 1ha [ ]

ii. 1ha – 1.5ha [ ]

iii. 1.6 – 2.0ha [ ]

iv. 2.1ha and above [ ]

18. What are the sources of financing your production activities?

i. Self financing/personal savings [ ]

ii. Credit through co-operative bank [ ]

iii. Co-operative societies [ ]

iv. Money lenders [ ]

v. Others (specify) [ ]

19. If commercial or co-operative bank, how much were you granted as loan and at what interest rate?

i. ₦70,000 - ₦100,000 [ ]

ii. ₦101,000 - ₦200,000 [ ]

iii. ₦201,000 - ₦300,000 [ ]

iv. ₦301,000 and above [ ]

At what interest rate……..?

20. What is the type and source of labour you employed?

i. Family labour [ ]

ii. Rented labour/Hired labour [ ]

iii. Communal labour [ ]

iv. All operations are mechanized [ ]

v. Others (specify) [ ]

21. What is the source of your pesticides?

i. MANR/ADP [ ]

ii. Co-operative Society [ ]

iii. Open Market [ ]

iv. Others (specify) [ ]

22. What type of pest control/method did you apply?

i. Cultural control measures [ ]

ii. Physical control measures [ ]

iii. Application of insecticides [ ]

iv. All of the above [ ]

23. At what intervals did you spray your cotton farm?

i. 3 sprays at bi-weekly interval [ ]

ii. 4 sprays at weekly interval [ ]

iii. 5 sprays at weekly interval [ ]

iv. 6 sprays at weekly interval [ ]

24. Kindly complete the table below on type/variety, sources, quantity (kg) or litre, total cost of seed, fertilizer, pesticides, and other inputs used.

S/No	Inputs	Sources	Type/Variety	Quantity(kg) or Litre	Total Cost
1.	Land				
2.	Labour				
3.	Seed				
4.	Fertilizer				
5.	Insecticides/Pesticides				
6.	Herbicides				
7.	Transportation				
8.	Empty Bags				
9.	Others (Specify)				

II. Cultural Practices and Cotton Production Technologies

25. What type of cropping system did you adopt?
    i. Sole cropping [ ]
    ii. Gicci [ ]
    iii. Mixed [ ]
    iv. Sole, Gicci and Mixed [ ]
    v. Others (specify) [ ]

26. What are the recommended practices you adopt?
    i. Ridging [ ]
    ii. Timely planting [ ]
    iii. Close spacing [ ]
    iv. Timely fertilizer application [ ]
    v. Timely weeding. [ ]

27. State the type of seed variety you used for planting
    i. Local Variety [ ]
    ii. Improved Variety [ ]
    iii. Certified seeds [ ]
    iv. i and ii [ ]
    v. Others (specify) [ ]

28. How many times did you weed your plots?
    i. Once [ ]
    ii. Twice [ ]
    iii. Thrice [ ]

    a. First weeding……weeks after planting
    b. Second weeding……weeks after planting

29. What are the weeding practices you adopt?
    i. Manual [ ]
    ii. Chemical [ ]
    iii. Manual and Chemical [ ]
    iv. No weeding [ ]

30. How did you prepare your land?
    i. Hand ploughing [ ]
    ii. Ox-drawn ploughing [ ]

iii. Tractor [ ]

iv. Hand and ox-drawn ploughing [ ]

31. If (i) what are your reasons?

i. Plot is too small [ ]

ii. Hiring tractor or oxen is expensive [ ]

iii. Others (specify) [ ]

32. Reasons for using oxen…….

……..

33. Reasons for using tractor……..

34. Source of tractor

i. ADP/ASC [ ]

ii. MANR [ ]

iii. Local Government [ ]

iv. Co-operative Society [ ]

v. Others (specify) [ ]

35. Did agricultural extension agents visit you to disseminate new technologies on cotton production to you?

i. No [ ]

ii. Yes [ ]

36. If yes, use the list below to indicate what technologies were offered.

i. Timely land preparation [ ]

ii. Timely planting/close spacing [ ]

iii. Timely herbicides application [ ]

iv. Fertilizer application at regular intervals [ ]

v. Pesticides application [ ]

vi. Adoption of improved varieties [ ]

vii. Timely picking/harvesting of cotton lint [ ]

viii. Cotton close season [ ]

37. How often did the extension agents visit you to disseminate new technologies to you?

i. Once a week [ ]

ii. Fortnightly [ ]

iii. Once in a month [ ]

iv. Once in two months [ ]

v. Quarterly [ ]

38. Do you belong to any co-operative or cotton growers' association?

i. No [ ]

ii. Yes [ ]

39. State the name/form of group you belong to:

i. Cotton growers association [ ]

ii. Farmers group [ ]

iii. Co-operative society [ ]

vi. Farmers' support club [ ]

v. Others (specify) [ ]

40. State the benefits derived from the group.

i. Procurement of inputs [ ]

ii. Marketing of output [ ]

iii. Granting loans or credit [ ]

iv. Others (specify) [ ]

SECTION C

COTTON PRODUCTION CONSTRAINTS

41. State the type of climatic constraints you frequently encountered in cotton production.

i. Inadequate rainfall [ ]

ii. Excessive rainfall [ ]

iii. High Intensity of Sunshine [ ]

iv. Excessive wind [ ]

v. Low relative humidity [ ]

42. Mention other environmental problems you faced in cotton production.

i. Pest invasion [ ]

ii. Disease incidence [ ]

iii. Weed Infestation [ ]

iv. Inadequate soil fertility [ ]

v. Erosion menace [ ]

vi. All of the above [ ]

43. What are the genetic constraints affecting your cotton production activities.

i. Inadequate improved seed variety [ ]

ii. Seed is not certified [ ]

iii. Seed is costly to procure [ ]

iv. Seed is not properly stored [ ]

44. State some of the institutional problems affecting cotton production.

i. Problem of land procurement and acquisition [ ]

ii. Inadequate Loan and Credit Supply [ ]

iii. Poor farm gate price and pricing system [ ]

iv. Inadequate Storage and Transportation facilities [ ]

v. Inadequate extension services [ ]

45. What are some of the extension constraints encountered?

i. Inadequate visits and dissemination of improved technologies. [ ]

ii. Complexity of some technological packages hampering adoption. [ ]

iii. Insufficient fund to enhance adoption of improved technologies [ ]

iv. Others specify [ ]

46. What type of market did you use to sell your cotton?

i. Contract/Local market [ ]

ii. Village market [ ]

iii. Urban market [ ]

iv. Organized statutory market [ ]

v. Others (specify) [ ]

47. Is there any organized statutory marketing institutions through which you sell your cotton?

i. Marketing agents/co-operative market [ ]

ii. Commodity exchange market [ ]

iii. Licensed marketers [ ]

iv. Buying agents/Contract buyers [ ]

v. Other (specify). [ ]

48. What problem did you encounter in marketing your cotton?

i. Low price [ ]

ii. Inadequate storage facilities [ ]

iii. Inadequate processing facilities [ ]

iv. Inadequate transportation. [ ]

49. Do you have any co-operative market or organisation for marketing cotton?

i. Yes [ ]

ii. No [ ]

50. Through which distance did you transport your cotton for sale?

i. 10 – 50 km [ ]

ii. 51 – 70 km [ ]

iii. 71 – 100 km [ ]

iv. 101 – 200 km [ ]

v. 201km and above [ ]

vi. Others (specify) [ ]

SECTION D

QUESTIONS ON LABOUR RECORDS/COST OF LABOUR, COTTON YIELD AND CAPITAL ACQUISITION

51. **Please kindly complete in table below the number of people employed and the total number of man-days or man-hours spent in each farm operation.**

Note: AM = adult male, AF = adult female, CH = child, Mh = Man-hour, Md = Man-day.

S/No	OPERATION	FAMILY LABOUR						HIRED LABOUR						COMMUNAL LABOUR						TOTAL
		AM		AF		CH		AM		AF		CH		AM		AF		CH		
		No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	No	Mh/ Md	
1.	Land clearing																			
2.	Ploughing																			
3.	Ridging																			
4.	Planting																			
5.	First fertilizer application																			
6.	Second fertilizer application																			
7.	First weeding																			
8.	Second weeding																			
9.	Third weeding																			
10.	Pesticides application at weekly interval																			
11.	Harvesting/picking																			
12.	Bagging/baling																			
13.	Transportation																			

52. How much did you pay on labour for farm operations per man-hour or man-day?

S/N	Operation	AM		AF		CH		Total	Amount
		Wage (₦)	Food (₦)	Wage (₦)	Food (₦)	Wage (₦)	Food (₦)	Wage (₦)	Food (₦)
1.	Land clearing								
2.	Ploughing								
3.	Ridging								
4.	Planting								
5.	First fertilizer application								
6.	Second fertilizer application								
7.	First weeding								
8.	Second weeding								
9.	Third weeding								
10.	Harvesting/ Picking								
11.	Bagging								
12.	Transportation								

53. Provide in the space below information on your crop yield (output)

Crop	Total Output (Bags)	Farm Size (Ha)	Output/Ha
Cotton			
Others (specify)			

54. What is the amount (₦) or value (₦) of the cotton you produced /sold from your farm?

i. ₦…… per kilograms

ii. ₦……..... per bag/bale

iii. ₦……per tonne

55. State the type of capital or combinations of capital you utilized in production.

a. Working capital [ ]

b. Rented equipment [ ]

c. Fixed capital (if any) [ ]

56. How much did you pay for maintenance ₦…….

57. How much is the total cost of each capital item?

    a. Working Capital ₦……

    b. Rented equipment ₦……..

    c. Fixed Capital (If any) ₦……

58. Transportation of harvested/picked cotton to the nearest buying centre.

Field A

S/N	Mode of Transport	Qty (kg)	Distance (km)	Cost (₦)
1.	Head Porterage			
2.	Animals			
3.	Hired Vehicles			
4.	Commercial vehicles			
5.	Others			

Field B

S/N	Mode of Transport	Qty (kg)	Distance (km)	Cost (₦)
1.	Head Porterage			
2.	Animals			
3.	Hired Vehicles			
4.	Commercial vehicles			
5.	Others			

Field C

S/N	Mode of Transport	Qty (kg)	Distance (km)	Cost (₦)
1.	Head Porterage			
2.	Animals			
3.	Hired Vehicles			
4.	Commercial vehicles			
5.	Others			

Field Name	Plot Number	Number of Days	Men No. of hours	Women No. of Hours	Children No. of hours

Appendix II: Grafted Polynomial Model

This summary presents the derivation of the reduced form of expressions in coefficients a_o, a_1, b_o and b_1 in the grafted polynomial model. These were presented earlier in the study as equations (28) – (31). For ease and simplicity, it is convenient to start our derivations with equation (29) and making b_1 the subject of the formula.

$b_1 + 2b_2k_2 = c_1$

$b_1 = c_1 - 2b_2k_2$……(i)

From equation (30);

$a_1 + 2a_2k_1 = b_1 + 2b_2k_1$

$a_1 = b_1 + 2b_2k_1 - 2a_2k_1$

Substitute for b_1

$a_1 = c_1 - 2b_2k_2 + 2b_2k_1 - 2a_2k_1$

$a_1 = c_1 - 2b_2 (k_2 - k_1) - 2a_2k_1$ ……..……(ii)

From equation (29);

$b_0 + b_1k_2 + b_2k_2^2 = c_0 + c_1k_2$

$b_0 + c_1k_2 - 2b_2k_2^2 + b_2k_2^2 = c_0 + c_1k_2$

$b_0 = c_0 + c_1k_2 - c_1k_2 + 2b_2k_2^2 - b_2k_2^2$

$b_0 = c_0 + b_2k_2^2$

$b_0 = c_0 + b_2k_2^2$ ……(iii)

*From equation (*28),

$a_0 + a_1k_1 + a_2k_2^2 = b_0 + b_1k_1 + b_2k_1^2$

Substituting for a_1, b_o and b_1

$a_0 + [c_1 - 2b_2k_2 + 2b_2k_1 - 2a_2k_1] k_1 + a_2k_1^2 = c_0 + b_2k_2^2 + (c_1 - 2b_2k_2) k_1 + b_2k_1^2$

$a_0 + c_1k_1 - 2b_2k_2k_1 + 2b_2k_1^2 - 2a_2k_1^2 + a_2k_1^2 = c_0 + b_2k_2^2 + c_1k_1 - 2b_2k_2k_1 + b_2k_1^2$

$a_0 = c_0 + b_2k_2^2 - b_2k_1^2 + a_2k_1^2$

$= c_0 + b_2 (k_2^2 - k_1^2) + a_2 k_1^2$

$a_0 = c_0 + b_2 (k_2^2 - k_1^2) + a_2 k_1^2$ ……(iv)

From equation (25)

$Q_t = a_0 + a_1 t + a_2 t^2$

Substituting for a_o and a_1

$Q_t = [c_0 + b_2(k_2^2 - k_1^2) + a_2 k_1^2] + [c_1 - 2b_2(k_2 - k_1) - 2a_2 k_1]t + a_2 t^2$

$= c_0 + b_2(k_2^2 - k_1^2) + a_2 k_1^2 + [c_1 - 2b_2 k_2 + 2b_2 k_1 - 2a_2 k_1]t + a_2 t^2$

$= c_0 + b_2 k_2^2 - b_2 k_1^2 + a_2 k_1^2 + c_1 t - 2b_2 k_2 t + 2b_2 k_1 t - 2a_2 k_1 t + a_2 t^2$

$= c_0 + c_1 t + a_2 t_1^2 - 2a_2 k_1 t + a_2 k_1^2 + b_2 k_2^2 - b_2 k_1^2 - 2b_2 k_2 t + 2b_2 k_1 t$

$= c_0 + c_1 t + a_2 (t_1 - 2k_1 t + k_2) + b_2 (k_2^2 - k_1^2 - 2k_2 t + 2k_1 t)$

$= c_0 + c_1 t + a_2 (t - k)^2 + b_2 [(k_2^2 - k_1^2) - 2(k_2 - k_1)t]$……(v)

Equation (v) can be transformed as;

$Q_t = c_0 x_0 + c_1 x_1 + a_2 x_2 + b_2 x_3$……..……..……....(vi)

This is amenable and compatible with OLS and can be represented as;

$Q_t = \propto_o x_o + \propto_1 x_1 + \propto_2 x_2 + \propto_3 x_3$……(vii)

Where;

$x_0 = 1$; for all t,

$x_1 = t$; for all t

$x_2 = (t - k_1)^2$; for $k_1 \leq t$

$= 0$; otherwise

$x_3 = (k_2^2 - k_1^2) - 2(k_2 - k_1)\, t$ for $k_1 \leq t$

$= (t - k_2)$; for $k_1 < t \leq k_2$

$= 0$

Appendix III: Nerlovian Adaptive Expectation Model

Summary of the derivation of the Ordinary Least Squares (OLS) equation from the Nerlovian Adaptive Expectation Model. This was used to estimate the response of cotton supply to price changes in the cotton market in Zamfara State, Nigeria.

The model is expressed in equation (39) as;

$$Y_t = f(P_t^e) \quad \text{.....(i)}$$

This mean that;

$$Y_t = \alpha_0 + \alpha_1 P_t^e + ut \quad \text{.....(ii)}$$

The assumption in the Nerlovian case is represented as;

$$P_t^e = P_{t-1}^e + ß\,(P_{t-1} - P_{t-1}^e) \quad \text{.....(iii)}$$

For this hypothesis to hold, the value of ß must lie between 0 and 1. From equation (iii), we derived the expression that,

$$P_t^e = ßP_{t-1} + (1 - ß)P_{t-1}^e \quad \text{.....(iv)}$$

Applying lag operator to equation (iv) the expression becomes;

$$P_t^e = \frac{ßP_{t-1}}{[1 - (1 - ß)\,L]} \quad \text{.....(v)}$$

Equation (v) is substituted into supply function expressed in equation (ii) to give,

$$Yt = \alpha_0 + \alpha_1 \left[\frac{ßPt_{-1}}{1 - (1 - ß)\,L}\right] + ut \quad \text{.....(vi)}$$

Clear fraction to derive a linear expression suitable and tractable for Ordinary Least Squares (OLS) regression.

Hence,

$$Yt = \alpha_0 ß + (1 - ß)\,Yt_{-1} + \alpha_1 ßPt_{-1} + ut_{-1}(1 - ß)ut_{-1} \quad \text{.....(vii)}$$

This is suitable for OLS estimation,

$Y_t = a_0 + a_1 Yt_{-1} + a_2 Pt_{-1} + vt$……..…….(viii)

Where;

$a_0 = \alpha_0 ß$

$a_1 = (1 - ß)$

$a_2 = \alpha_1 ß$

$vt = ut_{-1}(1 - ß)\ ut_{-1}$.

Appendix IV: Constant Elasticity Adjustment Model

The model assumes in equation (47) that,

$Y_t = f(Y_t^*)$……(i)

But,

$Y_t = f(P_t^e)$, expected price that period

$Y_t^* = f(P_{t-1})$, expected price last one period

Hence, constant elasticity adjustment model assumes that,

$$\frac{Y_t}{Y_{t-1}} = \left[\frac{Y_t^*}{Y_{t-1}}\right]^{\lambda} . e^{ut} \quad \text{……..……..……..} \text{ (ii)}$$

Since $Y_t^* = \alpha P_t^{ß}$, the expression for constant elasticity adjustment will be,

$$\frac{Y_t}{Y_{t-1}} = \left[\frac{\alpha P_t^{ß}}{Y_{t-1}}\right]^{\lambda} . e^{ut}$$

Clear bracket and multiply through by λ

$$Y_t = \frac{\alpha^{\lambda}}{Y_{t-1}} . P_t \lambda^{ß} . e^{ut} . Y_{t-1}$$

$Y_t = \alpha\lambda . Y_{t-1}^{(1-\lambda)} . P_t \lambda^{ß} \cdot e^{ut}$ ……..…… (iii)

Then,

$\text{Log } Y_t = \lambda \text{Log}\alpha + (1 - \lambda) \text{Log}Y_{t-1} + \lambda ß \text{Log}Pt + ut$

Let $a_0 = \lambda \text{Log}\alpha$, $a_1 = (1 - \lambda)$, and $a_2 = \lambda ß$.

Hence,

$\text{Log } Y_t = a_0 + a_1 \text{Log}Y_{t-1} + a_2 \text{Log}P_t + ut$……..……..……(iv)

Equation (iv) is linear in all the parameters and tractable to Ordinary Least Squares (OLS) which was used based on supply function to obtain the regression coefficients.