ECONOMICS OF SIZE IN IRRIGATED TOMATO (*Lycopersicum esculentum* Mill) PRODUCTION UNDER KANO RIVER IRRIGATION PROJECT (KRIP) PHASE I, KANO STATE, NIGERIA

BY

Bashir Sa'ad AHMED
(MSc /AGRIC /32267 /2012-13)

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

DEPARTMENT OF AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY
ZARIA, KADUNA STATE
NIGERIA

MAY, 2016

DECLARATION

I hereby declare that this dissertation titled **"Economics of Size in Irrigated Tomato Production under Kano River Irrigation Project (KRIP) Phase I, Kano 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 in this or any other institution. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

_____ _____

Bashir Sa'ad AHMED **Date**
Student

CERTIFICATION

This dissertation titled **"Economics of Size in Irrigated Tomato Production under Kano River Irrigation Project (KRIP) Phase I, Kano State, Nigeria",** by Bashir Sa'ad Ahmed meets the regulations governing the award of the Degree of Master of Science in Agricultural Economics of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

_____ _____

Prof B. Ahmed Date
Chairman, Supervisory Committee

_____ _____

Dr O. Yusuf Date
Member, Supervisory Committee

_____ _____

Prof Z. Abdulsalam Date
Head of Department

_____ _____

Prof K. Bala Date
Dean, School of Postgraduate Studies

DEDICATION

This dissertation is dedicated to my parents Alhaji Sa'adu Kankarofi and Hajiya Maimunatu Adamu

ACKNOWLEDGEMENT

I glorify the exalted name of Almighty Allah (SWT), the cherisher and sustainer of the universe, for His mercy, assistance and protection especially for successfully seeing me through this programme. I specially wish to express my deep appreciation and sincere gratitude to my supervisors, Prof B. Ahmed and Dr O. Yusuf for their invaluable assistance, close supervision, constructive criticisms, useful suggestions and pieces of advice that aided the completion of this research work. My appreciation also goes to the Prof Z. Abdulsalam, the Head of Department for his kind support and sincere encouragement, May Allah in His infinite mercy bless him and his family. I also appreciate the PG Coordinator, Dr M. A. Damisa for his sincere assistance and efforts in making sure that we not only acquire knowledge but also discipline. My appreciation goes to Dr B. A. Babaji of Department of Agronomy for his assistance and Dr N. H. Kura also of Agronomy and Head of Seed Programme IAR/ABU for his concern and encouragement.

My thanks go to the staff of Kano River Irrigation Project (KRIP), Phase I especially Malam Abdullahi Sambo, Head of Irrigation and Drainage for their immense contributions toward the success of this research, and the Secretary of Water Users Cooperative Society (WUCS), Malam Mustapha Mudawa for providing a comprehensive list of irrigated tomato farmers in the study area. The interest shown and time given by the farmers in the process of acquiring information is highly appreciated.

Let me also use this opportunity to thank Kano State Government and the Management of Kano State College of Arts, Science and Remedial Studies, Kano (CAS, Kano) for allowing me to further my studies. I also wish to express my gratitude and appreciation

to my brothers, sisters and friends for their prayers. My thanks go to my sister Hajiya Hadiza Sa'ad Ahmed for her financial support and the patience, the support and prayers of my wife are highly appreciated. At this juncture, I sincerely express my gratitude to all students and the staff of the department. Finally, may the peace and blessings of Allah be upon His noble Prophet Muhammad (S.A.W), his household, companion and those on their foot-path till the day of reckoning.

TABLE OF CONTENTS

Content **Page**

Title Page……..... i

Declaration ……...…… ii

Certification……..... iii

Dedication……..……... iv

Acknowledgement…….……... v

Table of Contents..... vii

List of Tables…….……... xi

List Figures.....xii

List of Appendices……xiii

Abstract……..xiv

CHAPTER ONE…….....1

1.0 **INTRODUCTION**……....1

1.1 Background to the Study……1

1.2 Problem Statement**…**……....3

1.3 Objectives of the Study…….5

1.4 Justification of the Study……..6

CHAPTER TWO……8

2.0 **LITERATURE REVIEW**……..…….....8

2.1 Economic importance of tomato.....8

2.1.1 Tomato production in the study area……..…….....9

2.1.2 Irrigation and tomato production…….....9

2.1.3 Seasonality and price instability of tomato…….11

2.1.4 Farm size and productivity…….……11

2.1.5 Patterns of farm size across countries and time……13

2.1.6 Scale of production…….13

2.1.7 Concept of economics of size…….....14

2.1.8 Economies of scale……..15

2.1.9 Concept of production efficiency in agricultural production……..17

2.1.10 Factors that affects efficiency…….....19

2.1.11 Effects of exogenous variables in the analysis of technical efficiency……...21

2.1.12 Profitability analysis in crop production…….23

2.2 Review of Analytical Tools…….24

2.2.1 Descriptive statistics……24

2.2.2 Budgeting techniques……..24

2.2.3 Data envelopment analysis (DEA) approach to efficiency measurement……...27

2.2.4 Regression analysis……...……...33

2.3 Review of empirical studies……..……...33

2.3.1 Descriptive statistics/Budgeting techniques…….....33

2.3.2 Data envelopment analysis (DEA)……35

CHAPTER THREE…….....38

3.0 **METHODOLOGY**……..38

3.1 Description of the Study Area…….....38

3.2 Sampling Procedure and Sample Size……41

3.2.1 Classification of the farm sizes……...41

3.3 Data Collection…….....42

3.4 Analytical Techniques……43

3.4.1 Descriptive statistics……43

3.4.2 Budgeting techniques ……43

3.4.3 A two-stage Data envelopment analysis…….....46

3.5 Measurement of Variables……...48

CHAPTER FOUR…….……...51

4.0 **RESULTS AND DISCUSSION**…….....51

4.1 Socio-Economic Characteristics of the Irrigated Tomato Farmers……51

4.1.1 Age distribution ….……51

4.1.2 Educational level……52

4.1.3 Farming experience……53

4.1.4 Extension service……53

4.1.5 Farm size……..54

4.1.6 Sources of finance……..……55

4.2 Level of Inputs and Outputs in Irrigated Tomato Production Based on the Sizes of Production……. ……55

4.2.1 Land.....55

4.2.2 Seed.....56

4.2.3 Labour.....56

4.2.4 Fertilizer.....57

4.2.5 Pesticide.....57

4.2.6 Tomato yield (supply level).....58

4.3 Cost and returns analysis…….....60

4.3.1 Gross returns.....60

4.3.2 Cost of production.....61

4.3.3 Cost of seed.....61

4.3.4 Cost of fertilizer.....61

4.3.5 Labour costs.....61

4.3.6 Pesticide costs.....61

4.3.7 Cost of empty basket.....62

4.3.8 Total variable cost.....62

4.3.9 Total fixed costs.....62

4.3.10 Gross Margin.....62

4.4 Estimate of Technical, Allocative and Economic Efficiencies Based on the three Sizes of Production in the Study Area.....64

4.4.1 Estimate of technical efficiency based on the sizes of production in the study area……...69

4.4.2 Estimate of allocative efficiency based on the sizes of production in the study area……70

4.4.3 Estimate of economic efficiency based on the sizes of production in the study area……72

4.4.4 Determinants of technical efficiency of irrigated tomato producing farms……...73

4.5 Constraints to Irrigated Tomato Production in the Study Area……...77

CHAPTER FIVE…….....80

5.0 **SUMMARY, CONCLUSION, AND RECOMMENDATIONS**……..80

5.1 Summary……80

5.2 Conclusions…….....82

5.3 Recommendations…….....83

5.4 Contribution to Knowledge……..... ……84

REFERENCES…….....86

LIST OF TABLES

Table **Page**

Table 2.1: Irrigated tomato production for three seasons in the study area…….. 9

Table 3.1: Summary of sampling procedure in the study area……. …… 42

Table 4.1: Socio-economic characteristic on age, educational level and farming experience of irrigated tomato farmers in the study area.……52

Table 4.2: Socio-economic characteristic on extension service, farm size and source of finance of irrigated tomato farmers in the study area……54

Table 4.3: Result of the level of inputs and outputs in irrigated tomato production based on the sizes of production in the study area..…….. 60

Table 4.4: Result of average cost and returns per hectare of irrigated tomato production based on the sizes of production in the study area..... 64

Table 4.5: Efficiency measures and descriptive statistics for irrigated tomato producing farms according to sizes of operation in the study area..... 65

Table 4.6: Distribution of tomato farms according to types of return among different sizes of operation in the study area…… 68

Table 4.7: Frequency distribution of technical efficiency estimates based on the sizes of operation in the study area……. 70

Table 4.8: Frequency distribution of allocative efficiency estimates based on the sizes of operation in the study area……..71

Table 4.9: Frequency distribution of economic efficiency estimate based on the sizes of operation in the study area……73

Table 4.10: Result of the factors influencing technical efficiency of irrigated tomato-producing farms in the study area…….……... 74

Table 4.11: Constraints to irrigated tomato production in the study area….……78

LIST OF FIGURES

Figures I: Map of Kano State showing the study area..... 40

LIST OF APPENDICES

Appendix **Page**

Appendix I: Questionnaire……...98

Appendix II: Some approximations/averages used in this research.....104

ABSTRACT

The broad objective of the study was to examine the economics of size in irrigated tomato production under Kano river irrigation project (KRIP) phase I, Kano state, Nigeria. Primary data were collected from 213 irrigated tomato farmers, using multi-stage sampling techniques in three local government areas covered by KRIP. Data were collected during the 2014/2015 irrigation farming season using well-structured questionnaire. Data collected were analysed using descriptive statistics, budgeting techniques, two-stage data envelopment analysis (DEA) and regression models. The result indicates that majority (53%) of the irrigated tomato farmers were in their active years and approximately 57% had some form of formal education. Majority of the farmers(93%) had been in tomato production for 8 to 31 years and 71% of the farmers had less than 1.0 hectare of farmland. Majority of farmers (78%) had no contact with extension workers while 76% used personal savings for production. It was found that only seed was over-utilised by medium and large scale farmers with average usage of seed above recommended rate resulting to output far below the potential yield of 40tonnes/ha. Irrigated tomato production was found to be profitable with an estimated total cost of ₦89,935.60/ha, ₦115,171.80/ha and ₦135,575.80/ha for small, medium and large farms respectively, and a gross margin of ₦135,040.90, ₦169,257.00 and ₦207,027.40 for small, medium and large farms respectively. The irrigated tomato production was profitable among the three sizes of production but more profitable in the large farms with the highest returns of 85 kobo for every ₦1 invested. The study found that most of the farms irrespective of size of holding have some technical inefficiency problems. The medium farmers, in terms of Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS), had the best measures of technical efficiency 13.6% and 72.7% compared to 16.5% and 21.2% for small farms and 27.3% and 45.5% for large farms. Though large farms have been found efficient, with higher yields (6750kg/ha), it is the medium and large scale farms that emerged as farms with price-efficiency in terms of higher unit profit (0.43) respectively. Findings further revealed that none of the sampled irrigated tomato farmer reached the frontier threshold. However, the average economic efficiency of the irrigated tomato farms was 67%. The mean technical efficiency was 85%. This indicates that irrigated tomato farms were economically inefficient. Also, factors such as age, household size, farming experience, sources of finance, sex and cooperative society were responsible for 59% total variation in technical efficiency among the three categories of irrigated tomato farms. Majority of the irrigated tomato farmers complained of poor output price as the foremost constraint faced. It was therefore recommended that farmers should form a production clusters through the formation of producer groups or cooperatives with an advisory committee trained in various aspects of marketing to have access to up-dated pricing information and make it available to farmers on time this could improve their market intelligence and controlled irrigated tomato production per season.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop in many parts of the world. It is one of the most important vegetables grown for its edible fruits in virtually every part of Nigeria. It is also one of the most widely cultivated crops in the world. It is an important source of vitamins and an important cash crop for small - holder and medium scale commercial farmers (Shankara *et. al.,* 2005). The tomato fruit is an essential component of the diet of man and also an important industrial commodity (Jaliya *et. al.,* 2007).

Egypt is the leading producer in Africa with the production of 8.5 million metric tonnes and Nigeria is the fourth in Africa and leads in West African sub region, with an estimated output of 1.10 metric tonnes and average yield of 10 metric tonnes per hectare. This is lower than average yield of 13.5 metric tonnes per hectare in tropical Africa and world average of 22.0 metric tonnes per hectare (FAO, 2010; Anons, 2010). The United States of America is the leading importer of fresh tomato (25% of the world output). Due to lower yield and expansion in consumer population in Nigeria, demand for tomato paste continues to grow, resulting in expanded import in to the country. According to Global Trade Atlas (GTA), Nigeria became Italy's second largest export market for tomato paste in 2003, with shipments value at $50 million dollars (Ewulo *et. al.,* 2008).

There is no general definition on "scale" of enterprise in scientific literature. Different national and international institutions have their own definitions. The history of industrial revolution in developed and developing countries have shown that small and medium scale enterprises are the driving force of industrial development. The attentions of the national governments all over the world have, therefore focused on funding and supporting small and medium scale enterprise activities (Adamu, 2005). In Nigeria, small scale, resource poor farmers, the majority of who are engaged in subsistence or near subsistence farming produce the majority of aggregate agricultural output via rudimentary farming systems (Oviasogie, 2005; Ajibolade, 2005). Farm holdings across Nigeria are generally small with less than 5 hectares on average and are often inherited rather than purchased (Adeyemo *et. al.,* 2010). Irrigated agriculture has played a major role in expanding the level of food production leading to the attainment of food self sufficiency and the overall agricultural development in many developing countries (Pierce, 1990; Ibabu *et. al.,* 1996). In addition to reducing the uncertainty in yields of rain-fed crops due to climatic variability, it has also contributed to general increase in productivity of crops enabling the farmers to generate substantial income and to be gainfully employed all year round (Frederick, 1992). Today it is essential to note that Fadama farmers are responsible for supplying food to millions of people in Nigeria (Muhammad *et al.* 2011).

The major issues limiting agricultural productivity in Nigeria include low yields due to the use of low technology inputs, poor yielding seeds and livestock, lack of or poor adoption of improved production technologies, poor infrastructure, poor access to finance and poor marketing structures. Thus, to raise productivity and stimulate the sector, these problems need to be mitigated through adequate research and provision of

technologies which would lead to competitive production (CBN, 2010). Increased output and productivity are directly related to production efficiency which arises from efficient input usage given the state of technology (Maurice, 2004). Increasing agricultural productivity requires one or more of the following: an increase in output 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). Production of vegetables is profitable; nevertheless is labour intensive. Thus, it provides income support especially to small farmers and employment opportunity for landless labourers in rural areas.

1.2 Problem Statement

In development economics, on-going debate on farm size and productivity "inverse relationship" (IR) exists. Before it was argued that small farm holdings were more efficient. However, the "inverse relation" was challenged with time (Maqbool *et al.* 2012).

Nigeria in her quest to be among the world 20 largest economy by the year 2020 has to fight poverty among its citizenry and empower them economically to collectively improve the economy of the nation. Despite the rapid pace of urbanization taking place in Nigeria, half of Nigerians (approximately 70 million individuals) still in rural areas; most of them engaged in small-holder semi-subsistence agriculture (Lenis e*t. al*., 2011). Agriculture remains a crucial sector in the Nigerian economy, being a major source of raw materials, food and foreign exchange; employing over 70% of the Nigerian labour force and serving as a potential vehicle for diversifying the Nigerian economy.

However, there are no rigorous studies that explain productivity in this sector. Most small-holder farmers produce significantly below their frontiers. As a result, they produce less than optimal levels of output as revealed by studies (mostly land productivity) while many farming enterprises are profitable, profit margins are generally low (Lenis e*t. al*., 2011).

Profit maximization and maximum yield are common objectives of business enterprises and is grossly dependent on how best production resources are harnessed (Afolabi *et. al.*, 2013). Profitability in tomato production depends on how effectively a farmer can manage inputs costs in such a way that least cost is achieved without sacrificing production efficiency. Research findings have shown that some of the works have been done on small size farming with less or no comparison to medium and large sizes, especially in the production of vegetables like tomato under irrigated condition.

In 1980s agricultural production had become more diversified into high value commodities. Old cropping patterns had improved for example, from cereals to cash crop, from crop to horticulture and livestock products, in which small farms again started to gain comparative advantages over the large farms. Furthermore, big farms are input (fertilizer, agro chemicals etc) intensive that led to the degradation of their natural resource. Considering these externalities, large farms are no longer in lead in productivity and efficiency as compared to small farms (Maqbool *et. al*., 2012).

Therefore, there is the need to assess the economics of size in irrigated tomato production in term of small farm size, medium and large size to see which of the sizes give higher productivity and more profit than the other in Kano River Irrigation Project

(KRIP). Based on this background, the following research questions were addressed by the study:

i) What are the socio-economic characteristics of farmers in the study area?

ii) What are the levels of inputs and outputs in irrigated tomato production based on the sizes of production in the study area?

iii) What are the costs and returns associated with irrigated tomato production based on the sizes of production?

iv) What are the technical, allocative and economic efficiencies in irrigated tomato production based on sizes of production in the study area?

v) What are the constraints being faced by irrigated tomato producers in the study area?

1.3 Objectives of the Study

The broad objective of the study in the study area was to examine the Economics of Size in Irrigated Tomato Production under Kano River Irrigation Project (KRIP), Nigeria. More specifically the study achieved the following objectives:

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

ii) describe the levels of inputs and outputs in irrigated tomato production based on the sizes of production in the study area.

iii) determine the costs and returns in irrigated tomato production based on the sizes of production in the study area.

iv) estimate the technical, allocative and economic efficiencies based on the sizes of production in the study area.

v). identify and describe the constraints to irrigated tomato production in the study area.

1.4 Justification for the Study

Africa is the only developing region where crop output and factor productivity growth are lagging seriously behind population growth (Byiringiro, 1996). The inverse relationship between size of land holding and agricultural productivity has taken an important place in the literature of agricultural economics and agricultural development in recent decades. For various reasons farmers face different productivities of inputs as the size of their holding vary and thus, making their output/input ratios vary systematically with the size of their farms. The debate persists because no fully agreed upon consensus has yet emerged on what is the exact implication of the observed relationship and because of the possible (and sensitive) policy implication that is engenders (Bardhan, 1973; Barrett, 1994). For example, if it is due to a higher efficiency of small farms (low opportunity cost of labour, decreasing returns to scale), then addressing issues of land reform would be the straight forward implication. However, if it is a consequence of imperfect factor markets (smaller farms confront different factor prices from larger farms i.e smaller farms face a low opportunity cost of labour and high prices of land and capital which is an inverse pattern for that of larger farms) then attention should be directed toward the institutional framework and the functioning of the rural economy.

In the face of the scarcity of farmland and constraints of extensive farming, the significance of increasing productivity may not be taken too lightly. Higher agricultural productivity will lead to quicker growth, rural jobs and resources for industrial progress along with food supply to ever-increasing population. As a consequence, raising agricultural productivity is an important policy goal for concerned governments and development agencies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Economic Importance of Tomato

Large scale processing of tomato into various canned and bottled products such as puree, ketchup and juice for human consumption is done. They are also consumed raw, as dessert or cooked into stews and served with meals. The seeds of tomato contain fat, which can be extracted and used as salad oil, and in the manufacture of margarine and soap. After oil extraction the residual cake is used as livestock feed and manure. Tomato fruit is a good source of many essential nutrients and vitamins. Proximate analysis showed that 100g of tomato fruit contains; 94.5mg of water, protein 1g, negligible fat, 4g carbohydrate, 0.6g fibre,5mg calcium, iron 0.4mg, 0.4mg vitamin A, 0.7mg nicotinamide, 25mg ascorbic acid, 0.06mg thiamine and 0.04mg riboflavin. Tomato is therefore an important source of vitamin A, Iron and Calcuim which are critical to the nutrition of children and pregnant women and essential for healthy growth and protection against diseases (Anons, 2010; Anons, 2011).

Tomato also has medicinal properties as it removes disease particles and opens natural channels of the body. It is gentle natural stimulant for kidneys and helps to wash away the toxins which contaminate system and cause diseases. Vitamin C content increases as they ripen. Tomato juice is probably one of the most widely used juices. Fresh, raw tomato juice is most beneficial and has an alkaline reaction when digested in concentrated form. Its pulp when applied liberally and regularly on the face and left for an hour and then washed with warm water give good complexion and remove ugly-looking pimples within a short time (Anons, 2000; Anons, 2010).

2.1.1 Tomato production in the study area

Large scale tomato production has been taken up along the important rivers in Kaduna State (Galma, Kuzuntu, Shika), Kano State (Kano River Irrigation Project) Sokoto State (Rima River), Kwara State (Asa River near Ilorin) and Upper and Lower Benue River basin areas (Olanrewaju and Swarup, 1983).

As a result of tomato production under the KRIP, a 1500 tonnes per day tomato processing plant is being constructed in the area. Also a specialised market at "Kwanar Gafan" in Garun Malam Local Government Area was well established. The production also provides employment to thousands of the tomato merchants and brokers in local processing and marketing of the commodity (HJRBDA, 2013).

Table 2.1: Irrigated tomato production for three seasons in the study area

Dry Season (Year)	Area Covered (Hectares)	Average Yield (Tonnes/Ha)	Production (Metric Tonnes)
2009/2010	1,200.00	15.0	18,000.00
2010/2011	7,736.00	15.0	116,040.00
2011/2012	4,798.13	17.5	83,967.28
2012/2013	300.00	15.0	4,500.00

Source: HJRBDA (2013/CPV 2014)

2.1.2 Irrigation and tomato production

Adequate and timely application of water to crops under irrigation is a prerequisite to optimum growth and development. The frequency and amount of applied water is a function of weather condition, soil water retention capacity, irrigation system, crop variety, stage of growth, rooting characteristics and crop management practices (Phene *et. al.*, 1989). Early in the growing season, tomato needs abundant light and frequent irrigation. As growth progresses, the water requirement increases at less frequent intervals

and allow the water to penetrate deeply in to the soil by flooding the field for absorption by the deeper roots. The flowering and fruiting period is the most critical time to maintain soil moisture. The goal is to keep the soil moist, but not water logged (Anons, 2003).

Various research works show that water requirement of tomato varies with the crop growth stages. Research works conducted by various research had shown that irrigation interval significantly influenced growth characters and yield. Martin (1966) reported that excessive irrigation delayed crop maturity. Sajjapongose *et. al.* (1989) confirmed that frequent irrigation delays maturity and observed that drier plots mature earlier and were ready for harvest compared to their frequently irrigated counterparts. Alibury and May (1970) indicated that long irrigation interval exposes the plant to moisture stress resulting in poor growth and development. Nwadukwe (1986) evaluated tomato cultiva Ife-1 under three irrigation schedules of 1,2 and 3 weeks intervals at Kadawa and found that one week interval provided an optimum condition for root development under low water table, while are two weeks interval was found to be optimum under a high water table condition. However, Deidda and Marrias (1973) recommended 7 or 8 days irrigation interval for best growth and yield of tomato on clay soils. While Caliandro (1978) reported that the number and size of fruit as well as yield of unmarketable fruits were increased significantly at irrigation interval beyond 8 days. However, in a trial on the effect of irrigation interval and plant density on two varieties of tomato, Umar (1999) found that 5 days irrigation gave higher marketable yield of tomato at Samaru were variety TI106 had higher yield than TI539. Amans and Nwadukwe (1993) reported that the 10 days irrigation intervals gave better growth and higher yield than more frequent (5 days) or less frequent (20 days) intervals. In contrasts, Jaliya *et. al.* (2007) reported an increase in number of leaves and branches per plant at 4 days irrigation interval compared to 8 and 12

days interval at Kadawa. Sama'ila *et. al.* (2011) recorded increase in fruit diameter and reduced number of unmarketable fruits by extending irrigation interval from 5 to 10 days while 15 days interval enhanced the fruit firmness. Similarly, Martin (1966) showed that long irrigation interval reduced the yield and solid content of tomato fruits. Pill *et. al.,* (1980) reported a decrease in fruit counts with increase soil dryness.

According to Imtiyaz *et. al.* (2000) water application by means of irrigation increased the higher marketable yields in tomato due to increase in freshness of fruits as compared to rain fed tomato. The bulk of tomato production lies in the Northern part of the country especially areas around Jigawa and Kano States (Abba and Shehu, 2007).

2.1.3 Seasonality and price instability of tomato

In a study carried out by (Abba and Shehu, 2007) on the supply of fresh tomato within a year and the magnitude of dried and canned tomato consumption among urban consumers in the country, between January and April the supply of fresh tomato is adequate and thus consumer's rarely used the other forms. However, from April to September the supply of fresh tomato drastically declined and thus representing the off –season period for the crop and during such period consumers turns to the other two forms (dried and canned) of tomato. Seasonality of the fresh tomato product courses price to fluctuate and thus affecting consumption patterns of the consumers. Generally consumers used other forms of tomato when the fresh is not very much available due to seasonality and or the product is very expensive.

2.1.4 Farm size and productivity

Despite its importance in agricultural development, the observed inverse relationship between farm size and land productivity in developing countries has received very

limited attention in Africa. In a research carried out by Byiringiro (1996) in Rwanda, he confirmed the existence of an inverse relationship between farm-size and land productivity.

He found that smaller farms have a lower opportunity cost of labour and a higher shadow price of land compared to larger farms. These disparities are the results of constraints faced by smaller farms to access land and labour market opportunities. The observed relationship is affected by land quality proxied by erosion (average annual soil loss), percentage of area fertilized, investment in soil conservation and by share of high value crops in gross value of output.

The existence of an inverse relationship between farm productivity has been observed by agricultural and development economists for some time. Crop yields per unit area cultivated that decline with size of holdings follow from regular observations of more intensive labour use on small farms than large (Berry and Cline, 1979, Cornia, 1985 and Sen 1981). This common empirical finding has drawn several different explanations, with important implications for both policy and theory. The most popular rely on labour market dualism with a distinctly chayanovian flavour. Small, peasant households are believed to face a lower opportunity cost of labour than large, commercial farms. Consequently, small farms apply their own labour in such quantities that the expected marginal value product of house hold labour applied to homestead cultivation is less than a market wage-based measure of the opportunity cost of labour (Chayanov, 1966, Hunt, 1979 and Sen 1966, 1975).

2.1.5 Patterns of farm size across countries and time

Countries with higher per capita GDP tend to have larger average farm size and fewer small farms (Eastwood *et. al.*, 2006). Also, as GDP per capita grew through the latter parts of the twentieth century, farms tended to become larger in the advanced countries but smaller in Asia and perhaps, Africa. Thus mean farm size has diverged internationally. The share of family workers in total farm labour does not vary systematically with GDP per capita; indeed, in many advanced countries the family is still the main source of farm labour. However, in the few low-income African countries with FAO data, little hired labour is recorded (Eastwood *et. al.*, 2006).

In the FAO farm censuses, land area of holdings is available for most countries, but no other potential measure of scale is widely available. In Europe and North America farm sizes have been increasing on average since 1950. In Africa and Asia, by contrast, farm sizes seem to have been declining in the 20th century. In South America there is no clear long run trend. Average farm size is very small in parts of sub-Saharan Africa and South-east and East Asia, e.g. Democratic Republic of the Congo, Bangladesh, China, Egypt, Indonesia, India and Korea. In these countries the great majority of farms are less than two hectares. In contrast, western European countries have the medium holding mostly above ten hectares.

2.1.6 Scale of production

The scale of production refers to the amount of factors use, the quantities of product produced, and the techniques of production adopted by the producer. Production may be carried on a small scale by a firm when a firm operates by using less capital and small quantities of other factors of production, the scale of production is said to be small. On

the other hand a firm using more capital and larger quantities of other factors is said to be large. A firm expand its scale of production for the purpose of earning profits and thereby derives many economies of large scale production which, in turn, help it in lowering the cost of production and increasing its productive efficiency (Jhingan, 2007).

2.1.7 Concept of economics of size

The history of industrial revolution in developed and developing countries have shown that small and medium scale enterprises are the driving force of industrial development. According to Baumback (1983), attempts made to defined small business in terms of employment, asset value or sales volume have proved unsatisfactory because, a firm in one industry may loom large relative to its competitors, yet be small in employment, assets and sales relative to firms in other industries and in some circumstances, the firm may be small on the basis of employment and large in assets and sales or vice versa.

The concept of size of enterprise may vary from one country to another, depending on the scope and range of activities covered by them and the amount of capital required of them to finance their operations in a particular market economy they are setup. Particularly the level of a country`s development largely determines the scope and range of activities and the capital base requirement of the size of the enterprises operating there- in (Adamu, 2005). There is no general definition for size of enterprises in scientific literature. Different national and international institutions have their own definitions.

2.1.8 Economies of scale

Economies of scale can occur for several reasons. Expanded operation generally permits greater specialisation of resources. Technology advance equipment, like mainframe computers, can be used, and more highly skilled workers can be employed. Expansion may also permit improvements in organisation, like assembly-line production. As firm increase its scale of operation, indivisibility or unavailable excess capacity or resources declines. The important point is that by spreading the higher cost of additional plant and equipment over a larger output level the firm can reduced the average cost of production.

Economies of scale are cost savings associated with the expanded use of resources. To realise such savings, however, a firm must expand its output. Economies of scale do not last forever. That is to say, a firm cannot increase its use of resources indefinitely and expect its average total cost to continue to fall. At some point a firm will confront diseconomies of scale cost increase that stem from an expanded use of resources. Diseconomies of scale may occur because of the communication problems of large firms.

Economies of scale is the economies of growth resulting from expansion of the scale of productive capacity of a firm or industry, leading to increases in its output and decreases in its cost of production per unit of output. By economies of scale economist mean the advantages that large scale production brings to firms. They usually lead to a reduction in the per-unit cost of production. They are often divided into two:

a. **The Internal economies of scale:** These arise within the firm itself and include Technical, Managerial, Financial, Marketing, Research and Welfare Economies.

Internal economies which accrue to a firm when it expands are caused by two factors:

i. **Indivisibility**- many fixed factors of production are indivisible in the sense that they must be used in a fixed minimum size. Such factors of production can be most efficiently employed at a fairly large output, but work less efficiently at small outputs because they cannot be divided into smaller units. Thus as output increase the indivisible factors which were being used below capacity can be utilised to their full capacity thereby reducing costs. Such indivisibilities arise in the case of labour, machines, marketing, finance and research.

ii. **Specialisation-** Division of labour which leads to specialization of another cause of internal economies. When a firm expands in size, not only its production increases, but the quantity of raw materials and the number of workers also increase. This necessitates division of labour whereby each worker is assigned one particular job, and the splitting up of process into sub-process for greater efficiency.

b. **The External economies of scale:** these are advantages that arise in the locality around where ancillary firms contribute to make a particular firm efficient in its operations. External economies may be divided into Economies related to a particular industry, industrialization in general and to the society. External economies benefit all firms within the industry as the size of the industry expands. Such economies accrue to firms when the industry is localised in a particular area, makes inventions and evolves specialisation of production

process. These external economies are concentration, Information, Welfare and Specialisation Economies.

2.1.9 Concept of production efficiency in agricultural production

Production is defined as the transformation of goods and services into finish products (that is input-output relationship) and this is applied to every production process, tomato production inclusive (Oyewo *et. al.*, 2009). The production technology can be represented in the form of cost function. The cost function represents the dual approach in the technology and is seen as a constant towards the optimisation behaviour of firms (Chambers, 1983). In the context of the cost function any error of optimisation is taken to translate into higher cost for the producers. However, the stochastic nature of the production frontier would still imply that theoretical minimum cost frontier would be stochastic.

The pivotal role of efficiency in accelerating agricultural productivity and output has been applauded and investigated by numerous researchers within and outside Africa. The decreased output of food crop production over the years may not only be connected with deviations of farmers' practices from technical recommendations but also with the use of resources at sub-optimal levels which ultimately leads to technical and allocative inefficiencies (Coelli and Bettese,1996). An underlying premise behind much of the research in efficiency is that farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output (Belbase and Grabowski, 1985; Adeleke *et. al.*, 2008).

There is a large literature on the need to increase the quantity and quality of input in agriculture in developing countries as well as the need to increase access to resources to finance these inputs. However, it is also possible to increase output even given current levels and quality of inputs by increasing overall economic efficiency of farmers (Bravo –Ureta and Pinheiro, 1997). The concept of efficiency is critical in developing country agriculture. Given the level and quality of inputs available, how well farmers are able to utilise these inputs is an important determinant of the quality of output they are able to produce. Recent measurement of farmer efficiency has been based on the seminar paper by Farrell (1957), who decomposed economic efficiency into its technical and allocative components.

Technical efficiency refers to the ability of a producing unit to obtain maximum (optimal) output from a given amount of inputs. Formally, the level of technical efficiency is measured by the distance of farm production from the optimal production frontier. A firm that sits on the production frontier is said to be technically efficient (Henderson, 2003). Allocative (or price) efficiency refers to the ability of the firm to choose its inputs in a cost-minimising manner (Murillo-Zamorano, 2004; Chavas and Aliber, 1993). For allocative efficiency to hold, farmers must equalise their marginal returns with true factor market prices. Thus, technical inefficiency is related to deviations from the frontier isoquant, while allocative inefficiency reflects deviations from the minimum cost input rations (Bravo-Ureta and Pinheirro, 1997). In addition to technical and allocative efficiency, Farell (1957) also defined the concept of overall efficiency renamed economic efficiency by later literature. Economic efficiency refers to the "capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology" and is derived by multiplying the technical and

allocative components of efficiency (Bravo-Ureta and Pinheiro, 1997). All three measures are bounded between zero and one (Murillo- Zamorano, 2004).

Parametric and non-parametric methods are often utilised to measure economic efficiency. The most common specifications are the stochastic frontier models, which has been extensively specified in Nigeria for a wide variety of crops (Ajibefun, 1998; Fasoranti, 2006; Amos *et. al.,* 2004; Adejoh *et. al.,* 2009; Ojo *et. al.,* 2009). Parametric method assume that the functional form of the production function is known, while non-parametric methods do away with the restrictive functional form assumptions, instead relying on the data to specify the production frontier. Data Envelopment Analysis (DEA) models are the most commonly used forms of non-parametric models (Ajibefun, 1998, 2008). Using either methodology parametric and non-parametric, it is possible to estimate technical efficiency and allocative efficiency for each observation in the data set. Most studies that report mean levels of technical and allocative efficiency for the sample under observation. Studies that have applied both methodologies report no substantive differences in estimates of efficiency (Ajibefun, 1998, 2008).

2.1.10 Factors that affects efficiency

There is a large literature on the factors that affect the levels of efficiency of Nigerian farmers. Variables that have an unambiguous positive impact on efficiency include having male household head (Otitoju and Arene, 2010), educational attainment of farmers (Fasoranti, 2006; Oladeebo, 2006), land ownership and farming systems (Fasoranti, 2006), contact with extension agents (Ojo *et. al.,* 2009; Ebong *et. al.,* 2009), membership of co-operative societies (Shehu *et. al.,* 2010; Idiong *et. al.,* 2009) and access to credit (Ogundari, 2006 and Oluwatosin, 2011). There are other factors that

have a more ambiguous impact on efficiency. While some studies find that age and years of farming experience improve efficiency as a result of "practice makes perfect" (Otitoju and Arene, 2010; Adeyemo *et. al.*, 2010); Ebong *et. al.*, 2009; Ekunwe *et. al.*, 2008 and Idiong *et. al.*, 2009), many other studies find that both factors have negative impacts on efficiency as older farmers are less likely to adopt new technologies. Consequently, the aging of the farming population is a source of concern (Ajibefun, 1998; Ogundari, 2006; Oladeebo, 2006; Ogunniyi, 2011; Amos *et. al.*, 2004; Ojo *et. al.*, 2009; Ebong *et. al.*, 2009; Idiong *et. al.*, 2009; Oviasogie, 2005 and Ekunwe *et. al.*, 2008).

Finally, high cost of inputs including fertilizers and herbicides negatively affects the efficiency levels of small- holder farmers (Adeyemo *et. al.*, 2010), as does the pollution of land-holdings in the south – south (Idumah, 2006). Another important factor is farm size. The inverse relationship between farm size and efficiency is well documented and could be attributed to the higher labour intensities on small farms due to lack of off-farm employment opportunities (Masterson, 2007). Labour is the most important factor of production in small-holder Nigerian agriculture (Adewuyi, 2002) as it is usually dominated by family labour, (Ojo, 2005). Labour often accounts for more than half of the costs of production (Oladejo, 2005 and Oviasogie, 2005). There is evidence that farmers are allocatively inefficient in the use of labour, over-utilising this factor in the production process (Ojo, 2005). Household size is an important predictor of efficiency for similar reasons, as it is the source of the most important factor of production on small-holder farms, namely, family labour. Some studies find that household size has a negative impact on efficiency, implying that individuals in these households act as a

drain on household resources instead of a source of labour supply (Ebong *et. al.,* 2009 and Idiong *et. al.,* 2009).

2.1.11 Effects of exogenous variables in the analysis of technical efficiency

The non-parametric method of DEA permits the technical efficiency score to be estimated for a sample of farms. A second, important task in this kind of analysis is the identification of the common features of the most efficient farms in order to estimate the impact on efficiency of variables under (or not) the farmers' control.

The literature refers to two different approaches to account for the effects of these variables the first is one-stage procedure that directly includes the exogenous variables in the estimation of the efficiency score. The second is a two-stage procedure that first estimates the efficiency using inputs and outputs and then analyse the effect of exogenous variables by means of regression analysis or analysis of variance. This second approach is more useful for political analyses because it provide an easy and clear evaluation of the relations between efficiency and its determinants. Testing which of them are significant and which are positive or negative, it is possible to highlight which aspects of the farms should be targeted in order to improve farm efficiency.

In agricultural studies, the variables usually taken into account to explain the farm efficiency level are the location and size, the farmer's age, qualifications, experience and specialisation, the use of services and combination of inputs. So, together with the structural and socio-economic variables, other variables representing the quality of the production factors are often included in this analysis. The agricultural literature refers to some difficulties in collecting this kind of information and, in many cases, additional

surveys may be necessary (for example questionnaires and specific surveys). To regress the single variables (or group of variables) in the two-stage process, the ordinary least squares (OLS) method is commonly used. In addition to the previously described variables, another group of factors that can affect farm performance are the long-term aspects connected with the farm strategic management. Many authors have found relationships between strategy and farm performances. Although the literature on strategic management is about large organizations, it is also applicable to farms.

Generally speaking, there are different levels of farm environmental influencing strategy. These are: External environmental – macro-economic conditions, Operational environment – situation on the market, internal environment – the resources under direct control of the farmer and Micro – social environment – the social environment in which the farm operates. The first two factors are generally considered in terms of geographical location; apart from differences like soil quality and climate different geographical regions may be characterized by differences in business culture (Cesaro *et. al*., 2009).

In the second-stage the obtained overall technical efficiency scores of the first-stage are regressed on the environmental variables. The advantages of the two-stage analysis include: It accommodates more than one variable, it accommodates both categorical and continuous variables, it does not make prior assumptions regarding the direction of the influence of the categorical variables and It is easy to calculate, simple and therefore transparent (Boame, 2004).

2.1.12 Profitability analysis in crop production

Despite the numerous constraints faced by farmers in the production process like the small size of farm holdings and the use of rudimentary inputs, studies of farming establishments across the country show that farming is generally a profitable enterprise for small scale farmers. Profitability measures the ability of farmers to cover their costs and is an important concept, because it provides incentives for entry into and longevity in the farming business. While many studies of Nigerian farms across the country report profitability, profit margins are often very small. In general, Nigerian farmers can be described as rational profit maximisers who respond to price instruments (Ajani, 2000). A regional analysis of the efficiency of farmers revealed that most farmers were producing significantly below their production frontiers. However many farming enterprises were found to be profitable, even though profit margins were generally low.
According to Olukosi and Erhabor (1988), gross margin is a very useful planning tool in situation where fixed cost is negligible portion of the farming enterprise as in the case of subsistence agriculture. It is easy to compute and represents the most relevant economic indicator to draw the attention of the farmer to the problem of his farm and offer solution to them.

According to Canadian Agric-Food Policy Institute (2009); farm profitability and performance can be measured using techniques such as gross margin concept, operating profit margin, net income, operating expense ratio and return on equity. Also Olukosi and Erhabor (1988) have postulated the use of Gross Margin (GM) Analysis as a tool of measuring profitability of farm enterprise, the tool use to estimate the costs and returns base on total cost and total revenue with the assumption that fixed cost in small scale

farming is negligible. The difference between the total revenue and total cost is the Gross Margin (GM)

2.2 Review of Analytical Tools

2.2.1 Descriptive statistics

Descriptive statistics is a phase of statistics that seek to describe and analyse a give group without drawing any conclusions or inferences about a larger group. Descriptive statistics is the term given to the analysis of data that helps describe, show or summarise and characterise data in a meaningful way, such that, for example patterns might emerge from the data and allows simpler interpretation of the data. Some tools to use here include mean, frequency distribution and percentage.

2.2.2 Budgeting techniques

The budgeting techniques include:

A. Gross Margin Analysis which is the difference between the Gross Farm Income (GFI) and the Total Variable Cost (TVC) (Mshelia *et. al.*, 2005: Olukosi and Erhabor, 1988).

The technique was used to determine cost and return associated to production. It is mathematically expressed as:

$$GM = GFI - TVC \ldots\ldots\ldots\ldots(1)$$

Where:

GM = Gross Margin (₦/Ha)

GFI = Gross Farm Income (₦)

TVC = Total Variable Cost (₦/Ha)

B. Net Farm Income (NFI) which is the difference between gross margin and fixed cost:

$$NFI = GM - FC \text{ ....(2)}$$

Where:

NFI = Net Farm Income (₦/Ha)

FC = Fixed Cost (₦/Ha)

Net farm income measures the return to unpaid family labour, operators land, labour, capital and management.

i. Gross Ratio: is the total cost of production divided by the gross income. A less than 1 ratio is desirable for any farm business. The lower the ratio the higher the return per naira invested.

ii. Operating Ratio: is the total variable cost divided by gross income. It shows the proportion of the gross income that goes to pay for the operating costs. The lower the ratio the higher the return on investment.

iii. Return on capital investment: is the gross Margin divided by total variable cost.

Profitability Index Analysis

Cost-return analysis, usually form the basis for farm profitability analysis. This involves itemising costs and returns of production and using them to arrive at such estimates as the return to one unit of the resources used, the gross margin, as well as the gross and net returns. In some cases, these values are subjected to test of statistical significance to verify differences between them. Gomez (1975), developed a farm level model to evaluate alternative cropping mixtures and patterns. These include:

i. Profitability, measured as the difference between value of yields and cost of production

ii. net return, defined as the difference between value of yields and as input costs, including hired labour, land and family labour. In choosing economic indicators on the basis of production factors affected by potential innovation, Werner (1993) suggested the used of :

(a). the gross margin and returns to variable cost, where only capital is affected;

(b). yield and labour ratio, where only labour is affected; and

(c). gross margin, return to variable cost and monetary return to labour, where capital and labour is affected.

The major problems associated with cost-return analysis as basis for profitability assessment are:

i. it does not indicate the relative importance of each of the resources in production; and

ii. its location bound and specific in applicability due to use of money as common unit of measurement and the prevailing price for the estimates.

Gomez (1975), said that in spite of the limitations, cost and return analysis is a useful tool in enterprise comparison and in indicating a profitable pattern of aggregate input use.

The Business Resources (2013) identified three measures of profitability as follows:

i. Gross Margin = Net sales – The cost of goods sold ……. (3)

where Net Sales = Gross Sales less any returns and discount

ii. Operating Profit = Gross margin – Selling and administrative expenses……..…(4)

iii. Net Profit = Operating Profit – Additional expenses – Taxes ……..… (5)

2.2.3 Data envelopment analysis (DEA) approach to efficiency measurement

The DEA technique uses linear programming methods to construct a non-parametric piece-wise surface (or frontier envelopment) for all sample observations, which provides a yardstick for all Decision Making Units (DMUs) in a sample. This surface is determined by those units that lie on it, that is the efficient DMUs. Efficiency measures are then calculated relative to this surface. A unit on the efficient frontier is given a score of 1. Units that do not lie on that surface can be considered as inefficient and an individual inefficiency score will be calculated for each one of them, given a score between 0 and 1 (Charnes *et al.*,1978).

Data Envelopment Analysis (DEA) is a mathematical programming approach for the development of production frontiers and the measurement of efficiency relative to the development frontiers (Charnes *et. al.*, 1978). It is also able in handling multiple inputs as well as multiple outputs. DEA is considered as deterministic function of the observed variables, and no specific functional form is required. Other main advantages of using DEA are that it performs well with only small number of observations and it does not require any assumption to be made about the distribution of inefficiency.

Avkiran (1999) stated that DEA allows the researchers to choose any kind of input and output, regardless of different measurement units (Sufian, 2007). On the other hand, the short-comings of DEA are that it assumes data to be free of measurement error and is

sensitive to outliers. DEA uses the term decision making unit (DMU) to refer to any entity that is to be evaluated in terms of its abilities to convert inputs into outputs. If there are 'n' DMUs to be evaluated then each DMU consumes varying amounts of 'm' different inputs to produce's' different outputs. Specifically, DMU_j consumes amount xij of input i and produces amount yrj of output r. we assume that $xij \geq 0$ and $yrj \geq 0$ and further assume that each DMU has at least one positive input and one positive output value.

The original formulation of the DEA model introduced by Charnes *et. al.*, (1978), denoted Charnes, Cooper and Rhodes (CCR). The ratio of outputs to inputs is used to measure the relative efficiency of the DMU_j = DMUO to be evaluated relative to the rations of all the j = 1,2, . . . , n DMU. This basic DEA model implied the assumption of Constant Returns to Scale (CRS). Using Charnes-Cooper transformation and dual formulation under CRS, then

θ^* = Minimum θ

Subject to

$$\sum_{j}^{n} = i \quad \lambda j \, Xij - \theta io \leq 0 \qquad i = 1, \ldots, m$$

$$\sum_{j}^{n} = i \qquad \lambda j \, y_{rj} - Y_{jo} \geq 0 \qquad r = 1, \ldots, s$$

$$\lambda j \geq 0 Aj$$

The optimal solution, θ^*, yields an efficiency scores for a certain DMU. The process is repeated for each DMU. DMUs for which $\theta^* < 1$ are inefficient, while DMUs for which $\theta^* = 1$ are boundary points or efficient. This model is sometimes referred to as the "Farrel Model" (Cooper *et. al.*, 2004). CRS is appropriate only when all firms are operating at an optimal scale. A bank exhibits constant return to scale if a proportionate

increase or decrease in inputs or outputs move the bank along or above the frontier. The efficiency measure derived from the model reflects the technical efficiency (TE).

DEA has proven to be a valuable tool for strategic, policy and operational problems, particularly in the service sector and non-profit sectors. Its feature is adopted to provide an analytical, quantitative comparison tool for measuring relative efficiency (Barr, 2002). Technical efficiency (TE) refers to ability to produce the maximum outputs at a given level of inputs (output-oriented), or ability to use the minimum level of inputs at a given level of outputs (input-oriented). Due to imperfect competition or constraint in finance then not all banks are able to operate at the optimal scale. In that condition, Banker *et. al.*, (1984) suggested the use of variable return to scale (VRS), denoted as Banker, Charnes and Cooper (BCC) hereafter that allows the calculation of efficiency leads to decomposition of technical efficiency into scale efficiency (SE) and pure technical efficiency (PTE) components. The BCC model is together with additional constraint that captures return to scale characteristics.

$$\sum_{j=i}^{n} \lambda j = 1$$

Then, the efficiency estimates obtained in the BCC model is not of the contribution of scale economies and therefore is referred to as 'pure' technical efficiency and also as the managerial efficiency. A DEA model can be constructed either to minimise inputs or maximise outputs. An input orientation aims at reducing the input amounts as possible while keeping at least the present output levels, while an output orientation pint towards at maximising output levels without increasing use of inputs (Cooper *et. al.*, 2004).

Scale efficiency can be defined as the proportional reduction of input use to be obtained under CRS. A measure of scale efficiency (SE) is simply the ratio of TE and PTE. DEA method is computationally simple and has the advantage that it can be implemented without knowing the algebraic form of the relationship between outputs and inputs (ie we can estimated the frontier without knowing whether output is a linear, quadratic, exponential or some other function of inputs). Essentially the DEA techniques evaluate "the performance of peer units by constructing a surface over the data that allows the observed behaviour of a decision-making unit to be compared with best observed practices" (Cooper *et. al.*, 2004).

The piece-wise-linear convex hull approach to frontier estimation, proposed by Farrell (1957), was considered by only a few authors in the two decades following Farrell`s paper. The mathematical programming method did not receive wide attention until the paper by Charnes *et. al.* (1978), in which term Data Envelopment Analysis (DEA) was first used. These authors proposed a model that had an input orientation and output orientation under assumption of Constant Returns to Scale (CRS) and how both models follows from different fractional programming models. Some popular extensions of the basic DEA (CRS and VRS) models so far involve non-discretionary variables, environmental variables, weights restrictions, super efficiency and bootstrap methods.

For the estimation of technical efficiency, several methods like Ordinary Least Squares (OLS) regression, Stochastic Frontier Analysis (SFA) and Total Factor Productivity (TFP) indices using Price-based Index Numbers (PIN), are used. The OLS methods are well known and easy to implement, however, it has been documented that it requires the specification of a functional form for the production technology and provides

information about the average performance rather than frontier performance. SFA is an econometric technique that addresses the latter problem, by specifying a composed error-term, with one part capturing data noise and the other, inefficiency. However, SFA methods still require a functional form to be specified, plus distribution forms for its composed error structure (Coelli and Battese, 1996). PIN methods, such as the popular Tornqvist TFP index, suffer from the problem that it requires access to the reliable price information (which is often difficult to obtain) and it does not explicitly accommodate scale effects. Of late, the popular method of estimating the maximum possible output has been the Data Envelopment Analysis (DEA) advocated by Charnes *et. al.* (1978) which over comes most of these limitations. The uncontrolled or discretionary variables are an important weakness of model developed in Charnes *et. al.* (1978). Some variables are outside the control of the manager. Maximisation of equi-proportionate contraction should be made by omitting these variables to obtain more precise efficiency scores. However, in order to get more realistic individual efficiency scores, one might isolate in some way this type of variable, known as non-discretionary variables and their effects on the final performance of the observed units. Banker and Morey (1986) adapt the mathematical programming treatment of DEA models to allow a partial analysis of efficiency on the basis of what they initially termed exogenously and non-exogenously fixed inputs and outputs.

Adjusting for the environmental variables is another extension of the basic for DEA model to evaluate some factors that could influence the efficiency of a firm, where such factors are not traditional inputs and are assumed not under the control of the manager. There are a number of possible approaches to the consideration of environmental variables such as the “three-stage” method proposed by Charnes *et. al.*, (1981), the

possible method is to include the environmental variable(s) directly into the linear programming formulation (Ferrier and Lovell, 1990). The "two-stage" approach involving a DEA problem in the first stage analysis and regressing the efficiency score from the first stage in the second stage by OLS or Tobit regression is recommended in most cases. Some considerable advantages of this approach are that both continuous and categorical variables can be easily accommodated in the second step and hypothesis test to see if the variables have a significant influence upon efficiencies can be conducted.

The flexibility of the frontier that is constructed using DEA is one of the advantages of this method. However, this aspect of the method can also create problems, especially when dealing with small data sets. One can find that the weights assigned to the various input and output variables are not realistic for some firms since they are too large or too small. A variety of methods have been proposed to remedy this. Among them, the most relevant are the Assurance Region (AR) method developed by Thompson *et. al.* (1989) and Charnes *et. al.* (1990). The AR approach deals with the existence of large differences in input/output weights from DMU to another by imposing additional constraints on the relative magnitude of the weights for some particular inputs/outputs into the initial DEA model. More general than the AR method, the cone-ratio approach extends the Charnes *et. al.* (1978) model by using constrained multipliers, which are constrained to belong to closed cones (Murillo-Zamorano, 2004).

Super efficiency relates to a DEA model which firms can obtain efficiency scores greater than one. To calculate a super efficiency score for the ith firm, the data for the ith firm is removed from matrixes of inputs and outputs. Thus, when running the LP, if the ith firm was a fully-efficient frontier firm in the original standard DEA model, it

may not have an efficiency score greater than one. This method was originally proposed by Andersen and Petersen (1993). The problem of infeasibility in that model has been discussed and removed by Lovell and Rouse (2003); Zhu (2004); Chen (2005). Other extension to the DEA basic model include the measurement of allocative efficiency on the basis of price information and the assumption of a behavioural objective such as cost minimisation in Ferrier and Lovell (1990), revenue maximisation in Fare *et. al.* (1985) or profit maximasation in Fare *et. al.* (1997); treatment of panel data by means of the window analysis developed in Charnes *et. al.* (1985) or the Malmquist index approach of Fare *et. al.* (1994).

2.2.4 Regression analysis

Regression describes the form of relationship between two factors X and Y. It tells at what rate the two factors that are significantly correlated (with α equals 1 or close to 1) are associated by means of a regression line. It enables one to estimate or predict the value of one variable from a given value of the other variable.

2.3 Review of Empirical Studies

2.3.1 Descriptive statistics/budgeting techniques

A study to analyse the profitability of small scale dry season tomato production in Adamawa State, Nigeria was carried out by Usman and Bakari (2013) in the 2011/2012 cropping season. The result indicates that majority of the respondents were male (85%) and married (76%) while most of them were in their active years, with family size of six people and above. Tomato production was found to be profitable with an estimated total cost of production and gross margin of ₦137, 092, 86 and ₦136,970.46 respectively. There is an estimated gross and operation ratios of 0.56 and 0.43 respectively, while the

return on naira invested was 1.33, thus indicate profitability of tomato production in the study area. The study also identified the major constraints associated with tomato production. They are pests and diseases, (16%), inadequate farm credit (14%) poor storage and processing facilities (13%), while shortage/high cost of irrigation facilities has been the least.

In a study carried out by Haruna *et. al.* (2012) to analyse economics of fresh tomato marketers in Bauchi metropolis in Bauchi State, Nigeria. The costs and returns analysis revealed variable cost (99.99%) and fixed cost (0.01%) of the total cost of tomato marketing with acquisition cost (87.46%) and cost of empty baskets (4.37%) constituting the highest. The findings of returns per naira invested of 1.20k disclosed that the enterprise is profitable. The cost of marketing was ₦68,670.00, total revenue was ₦80,000.00 and the net income of ₦11,330.00 was realised, indicating highly profitable.

Other findings by some scholars revealed that tomato production is profitable. A study conducted by Ojo *et. al.*, (2009) using Gross Margin Analysis revealed that tomato production is profitable with net income of ₦85,306.92/ha. Omonona *et.al*. (2010) also reported an enterprise economic efficiency of 1.17, implying that for every ₦1.00 spent by the farmers on cowpea production, 17kobo was realised as profit. Zalkuwi *et. al*. (2012) revealed that tomato production is profitable in both short and medium term owing to the positive gross margin and net income/ha of ₦90,113.78 and ₦68,296.26 respectively.

2.3.2 Data envelopment analysis (DEA)

A great variety of applications of DEA have been conducted in many of studies to investigate technical, allocative cost and scale efficiency by applying input and output oriented models in many different activities in many different contexts in many different countries. Areas where DEA applied are hospitals, universities, cities, courts, business firms, banks and others, including the performance of countries, regions etc. There is a number of efficiency studies applying DEA conducted on agricultural sector in many countries.

A study carried out by Murthy *et. al*. (2009) estimated the technical and scale efficiencies of tomato production regions of Karnataka, India under three production situations, viz small, medium and large farms. DEA and log linear regression models have been used for estimating the technical efficiency and its determining factors respectively. The study has indicated that most of the farms irrespective of size of holding have shown technical inefficiency problems. The medium farmers have been observed with best measure of technical efficiency, which has been explained by factors such as the land and labour productivity and education. Though medium farmers have been found efficient, with higher yields, it is the small farmers who have emerged as price-efficient producers in terms of lower cost on production (Rs 1.72/kg compared to Rs 2.01 in medium farms and Rs 1.85 in large farms) and higher unit profit. Most of the farms have been observed to have potential to expand production and productivity, increasing technical efficiency as majority has been performing with increasing return to scale.

Using a weight-restricted DEA technique, Kaliba and Engle (2006) estimated the technical, allocative and cost efficiency of a sample of small- and medium-sized catfish farms in Chicot County, Arkansas. These authors then regressed the cost efficiency score in Tobit model on operator characteristics, farm practices and institutional support services to determine whether these factors lead to a higher level of efficiency. An important finding of this research is the authors found that higher cost efficiency of catfish farm efficiency in Chicot County, Arkansas, can be achieved by adjusting inputs used in production to optimal levels rather than by adjusting the scale of operation.

Also using a two-step DEA procedure, Cinemre *et. al*. (2006) measured the cost efficiency of trout farms and explored determinants of cost inefficiencies in the Black sea Region, Turkey. The decomposition of the technical efficiency measure showed that pure technical inefficiency was the primary cause of technical inefficiency in the sample of trout farms. Research results also suggested that there were positive relationships between cost efficiency and pond tenure, farm ownership, experience of the operators, contact with extension services, off-farm income and credit availability while feeding intensity, pond size and capital intensity had negative effects on cost efficiency.

Ferdous and Murshed-e-Jahan (2008) employed DEA technique in evaluating the resource allocation efficiency of prawn-carp polyculture systems by making use of the data of 105 farmers of Bangladesh. The results showed that 50% of prawn-carp farmers displayed full technical efficiency whereas only 9% were cost efficiency. Technical and Allocative efficiencies showed a positive and negative correlation with pond size respectively. Labour, fingerlings and feed were over used while organic and inorganic fertilizers were under used in general.

In a research conducted by Buile (2009) on the relationship between farm financial exposure and technical efficiency in the Pangasius farming in Vietnam, a non-parametric DEA approach was applied to estimate technical and scale efficiency scores of 61 Paragasius farms in 2008 and a mean technical efficiencies under assumption of constant returns to scale (CRS) and variable returns to scale (VRS) and scale efficiency were measured to be 0.595, 1.058 and 0.580respectively. The decomposition of the technical efficiency measure shows that scale inefficiency is the primary cause of technical inefficiency in the case of Pangasius farming as about 92% of the sample Pangasius farms exhibit increasing returns to scale (IRS). Then, estimated technical efficiency (TE) scores under assumption of VRS are used in a regression analysis to investigate the relationship between the efficiency measures and different farm characteristics, including financial consideration.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

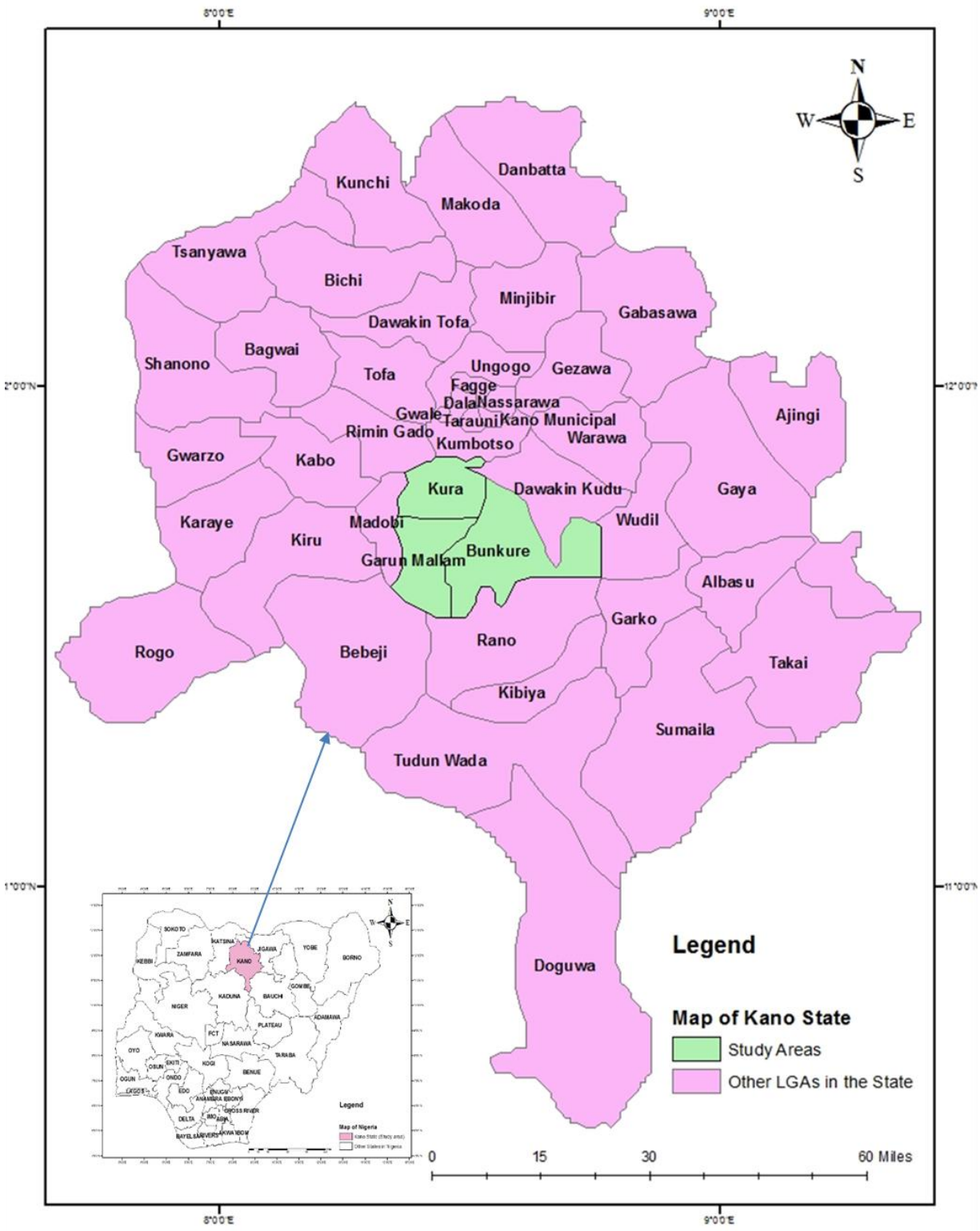
The Study was carried out in Kano State, Nigeria. Kano lies between latitude 12^0 $37^{'}$ North and 9^0 $33^{'}$ South and longitude 9^0 $29^{'}$ and 7^0 43' West. It shares boundary with Jigawa state to the North-East, Katsina state to the North-West and Kaduna State to the south. Kano state consists of two agro-ecological zones namely, Northern Guinea Savannah (NGS) and the Sudan Savannah (SS). The southern part of the state is in the NGS, which has an annual rainfall of 600-1,200mm. The central and northern parts are in the SS, with an annual rainfall of 300-600mm (Kano State Government 2012).

The state comprises of 44 local government areas with population of 9,383,682 (NPC, 2006). The projected population in 2012 with national growth rate of 3.2% is 11,710, 553. The predominant ethnic groups are Hausa and Fulani.

Agriculture is the major employer of labour in the state with many citizens involved in farming, animal husbandry and fishery (Muhammad and Atte, 2006). The cropping system is mostly undertaken under rain-fed condition and majority of the farmers are small scale holders with less than 2.5 hectares per farming household and either resources are meager (KNARDA, 2002). The upland crops commonly grown are millets, sorghum, cowpea and maize, while the low land/Fadama crops grown in the state includes tomato, onion, and pepper with rice and wheat grown in the flood plains and irrigated areas. The Research was specifically conducted under Kano River Irrigation Project (KRIP) because of large scale cultivation and highest number of tomato farmers in the state.

The KRIP is one of the largest and successful projects, not only in Nigeria, but in West African sub-region. It is unique in its design in that the entire water distribution network operates on gravity. Water is conveyed from Tiga Dam to the project site through 18km long main canal, which splits into East (Bunkure) and West (Garun Malam and Kura) Branches. These are then further broken into lateral canals, distributaries canals, field channels and finally to the farm for the crops to be irrigated. Crops cultivated include tomato, wheat, onion, maize, rice, garlic, cucumber, potatoes, millet, guinea corn and melon (HJRBDA, 2013).

The KRIP Phase I is currently providing all year round direct employment to about 41,250 farmers and their families. Over 5.0 million man days of employment are being generated as indirect employment to communities within and outside the project area annually. Farmers produce an average of 200,000 metric tonnes of food and cash crops valued at over ₦2.7 billion annually, thereby contributing significantly toward enhancing national food security (HJRBDA, 2013).


8°0'0"E
9°0'0"E
12°0'0"N
11°0'0"N
N
W
E
S
Kunchi
Danbatta
Makoda
Tsanyawa
Bichi
Minjibir
Gabasawa
Dawakin Tofa
Bagwai
Shanono
Tofa
Ungogo
Gezawa
Fagge
Dala
Nassarawa
Gwale
Tarauni
Kano Municipal
Rimin Gado
Warawa
Kumbotso
Ajingi
Gwarzo
Kabo
Kura
Dawakin Kudu
Gaya
Karaye
Madobi
Wudil
Kiru
Bunkure
Garun Mallam
Albasu
Garko
Rogo
Bebeji
Rano
Takai
Kibiya
Sumaila
Tudun Wada
Doguwa
Legend
Map of Kano State
Study Areas
Other LGAs in the State
0
15
30
60 Miles

3.2 Sampling Procedure and Sample Size

Kano state comprises of three agricultural zones, namely Danbatta, Rano and Gaya zones. Rano zone was purposively selected because of its highest number of irrigated tomato farmers. The major irrigated tomato producing local government areas in the zone are Bunkure, Garun-Mallam and Kura which are covered by Kano River Irrigation Project (KRIP) Phase I, (HJRBDA, 2013). Large scale tomato production has been taken up along KRIP (Olanrewaju and Swarup, 1983). Two villages with the highest number of large scale irrigated tomato farmers from each of the three local government areas were purposively selected. Finally, random number sampling was employed to select **10%** of the total population **(**2122**)** of the purposively selected villages, to prepare a sample size of 213.

Classification of the sizes:

To the irrigated tomato farmers (WUCS, 2014) under KRIP, the following is how they classify themselves in terms of size and also the one used for the purpose of this research. This is also based on the categorisations of Haruna (2004) in his work on "Prospects and Problems of Vegetables Production under Irrigation in Bauchi State, Nigeria" and Usman and Bakari (2013) in their study on "Profitability of Small Scale Dry Season Tomato Production in Adamawa State, Nigeria":

i. all farmers with farm size of less than a hectare are small scale farmers **(<1.0ha)**

ii. all farmers with one hectare to less than three hectares are medium scale farmers **(1.0ha to 2.9ha)**

iii. all farmers with three hectares and above are large scale farmers (**3.0ha and above**)

Table 3.1: Summary of Sampling Procedure (n=**213)**

Local Govt. Area	**Village**	**Sampling frame**			**Sample size (10%)**		
		S	**M**	**L**	**S**	**M**	**L**
Bunkure:	Gafan	342	68	32	34	7	3
	Dorayi	129	50	18	13	5	2
Garun Mallam:	Bangaza	62	27	35	6	3	4
	Agalawa	133	38	20	13	4	2
Kura:	Bugau	466	44	118	47	4	12
	Dakasoye	392	133	15	39	13	2
	Total:				**152**	**36**	**25**

Source: KRIP-WUCS (2014)

Note: 1. The villages were purposively selected based on high number of large size irrigated tomato farmers for the sampling.

2. S, M and L stand for Small, Medium, and Large sizes respectively.

3.3 Data Collection

Primary data were used for this study. The data collected was based on 2014/2015 irrigation farming season with the aid of structured questionnaire through the assistant of field enumerators in a manner that allows the collection of relevant data on specific variables that were investigated. Information was collected on the following variables among others: age, sex, marital status, educational status, household size, access to extension contacts, farming experience, farm size, sources of finance, cooperative membership, type and cost of labour (both family and non-family), access to market, type and cost of inputs used per hectare, revenue, water rate, produce prices, and problem faced by the farmers.

3.4 Analytical Techniques

3.4.1 Descriptive statistics

Descriptive statistics was used to achieve objectives (i) (ii) and (v) of the study. Simple Descriptive statistics such as percentage frequency distribution, mean, minimum and maximum, coefficient of variation and ratios were used to describe the socio-economic characteristic of the farmers, levels of inputs and outputs and the constraints related to production of irrigated tomato by the small, medium and large size farmers in the study area.

3.4.2 Budgeting techniques (gross margin, net farm income (NFI) and profitability index analysis)

Gross Margin, Net farm income (NFI) and Profitability index Analyses were used to achieve objective (iii). They were used to determine the costs and returns and net profits that accrue to the small, medium and large size farmers of irrigated tomato in the study area. These tools were used to determine the profitability of the three types of farm operations. The model for estimating the net farm income is represented by:

$$NFI = GR - TC \quad \ldots\ldots (6)$$

Where:

Gross Revenue (GR) = Price (P) × Quantity (Q)

$$\text{Total cost (TC)} = TVC + TFC \quad \ldots\ldots (7)$$

$$\text{Profitability index or return to scale} = \frac{NFI}{GR} \quad \ldots\ldots (8)$$

The model can further be simplified to as:

$$\sum_{i=1}^{n} P_1 Y_i - \sum_{j=i}^{m} P_j X_j - \sum_{k=1}^{k} FK \quad \ldots\ldots (9)$$

Where:

NFI = Net farm income (Per ha)

Y_i = Output (kg)

P_i = Unit price of product (₦/ha)

X_1 =Seed (kg)

X_2 =Fertilizer (kg)

X_3 = Pesticides (L)

X_4 = Labour (man/day)

P_j = Price per unit variable input (₦/ha)

FK = Cost of fixed input (where k = 1,2,3, ……………. k fixed input)

$\sum$ = Summation (Addition) sign

Depreciation

Depreciation is on fixed assets like hoes and classes. It forms the fixed cost component. The straight line method of evaluating depreciation was used to obtain fixed cost for the durable farm tool(hoe). The straight line depreciation method is specified as:

$$D = \frac{P-S}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Where:

D = Depreciation on production asset

P = Original cost of production asset

S = Salvage value of asset

N = Number of years of life of the asset

Profitability Index Analysis

i. Rate of Return to Investment (RRI):

Rate of Return to Investment (RRI) is a measure of return on a unit amount of money invested in the farm business. It is expressed as a percentage and hence allows easy comparison with the same values from other farms within a given locality. It is computed as:

$$RRI = \frac{NFI}{TC} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (11)$$

This ratio was used to determine the profitability of the farm by comparing it with return on investment from farms (Kay *et. al.,* 2008).

ii. Operating Profit Margin Ratio (OPMR):

Operating Profit Margin Ratio (OPMR) computes the operating profit as a percentage of total revenue. It shows the percentage of the income that is required to cover the operating expenses, excluding the principal and interest payments. It was computed as

$$OPMR = \frac{Operating\ Expense}{Total\ Revenue} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (12)$$

The ratio was used to determine the farm business performance of the small, medium and large size irrigated tomato production and see which the best among them is. Variable costs that were considered are; cost of inputs like costs of seed, fertilizer, agrochemicals, and labour costs of land preparation, nursery preparation, transplanting, fertilizer application, watering, pesticides application, weeding, irrigation, harvesting and transportation. The total revenue was estimated by multiplying the total quantity of produce (kg), output by the prevailing market price of the output (₦/ha).

For this study, fixed cost was mainly on depreciation of hoes. The straight line method of evaluating depreciation was used to obtain fixed cost for the hoes. Kay *et al.* (2008) observed that the Net Farm Income should be a starting point for analysing farm profitability, rather than used as the only measure of farms profitability.

3.4.3 A two-stage data envelopment analysis

A two-stage Data Envelopment Analysis (DEA) was selected to achieve objective (iv). In the first stage the technical efficiency was determined using the non-parametric DEA, while in the second stage the factors influencing the producer level of technical efficiency was determined by regressing the efficiency indices from model against some socio-economic characteristics of the farmer. The technical efficiency indices was used as proxy for technical efficiency. The technical efficiency model is implicitly expressed as:

$$Y = f\,(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, U_i), \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

Where:

Y_i = technical efficiency (technical efficiency indices)

X_1 = age of farmer (years)

X_2 = farming experience (years)

X_3 = level of education of farmer (years of formal education)

X_4 = household size (numbers)

X_5= sex of the farmer (male or female)

X_6 = number of extension contact

X_7 = group membership (years of membership)

X_8 = source of finance (value in Naira)

X_9 = marital status (married=1, unmarried=0)

$\alpha_1 - \alpha_9$ = parameters to be estimated.

U_i is expected to be negatively related to the level of inefficiency in irrigated tomato production under small, medium and large sizes.

Subscript i indicate ith farmer in the sample.

The functional forms (Linear, Semi-Log, double-log, and Exponential) were tried and the lead equation (semi-log, one with the highest coefficient of determination R^{-2} value) was selected.

DEA method has a disadvantage that it does not explicitly accommodate the effects of data noise. In the present case, the DEA method was preferred because data noise was less of an issue as most of the variables in tomato production were included and because of its ability to readily produce rich information on technical efficiency, scale efficiency and peers (Murthy *et. al.,* 2009).

Various constraints under financing of inputs, technological and institutional considerations may cause the farmers to operate at non-optimal scale hence the assumption of using Variable Return to Scale (VRS).

In order to derive the economic efficiency of the firm, the model is solved:

Subject to $\min \theta, w_i' x_i^*$

$$-yi + Y\lambda \geq 0,$$

$$X^*I - X\lambda \geq 0$$

$$N1 \grave{} \lambda = 1$$

$$\lambda \geq 0$$

$$\theta \in (0, 1]$$

Where w_i represent firm i's vector of inputs prices and X*I is the cost-minimizing input bundle faced by the firm i. The economic efficiency for firm i is then solved by the following computation.

$$EE_i = \frac{w_i' x_i^*}{w_i' x_i} \qquad (14)$$

That is, the observed cost is compared to the minimum cost the firm would face if using the optimal input bundle. Furthermore, the allocative efficiency (AE) firm i can be calculated as follows:

$$AE = \frac{EE}{TE} \qquad (15)$$

3.5 Measurement of Variables

i. **Age** - This refers to the number of years from birth of the respondent as given at the time of data collection.

ii. **Gender** - This was measured as sex of the respondent. It was recorded as a dummy (male = 1, female = 0).

iii. **Household size** - This means that total number of people in the house which includes the wives, children and dependants who reside within the same family house and eat from the same pots.

iv. **Educational status** - This refers to the acquisition of knowledge. This was measured by educational level (ie non-formal, primary, secondary or tertiary).

v. **Farming experience** - This refers to the numbers of years the farmer has actively engaged in irrigated tomato production and was measured in years.

vi. **Source of finance** - This refers to source of credit from both formal and informal source. It was measured in Naira.

vii. **Number of extension contacts** - This refers to the number of limits access to government extension services by the respondents in the production cycle. It was measured as 1, 2, 3 ……. n^{th} times.

viii. **Group membership** - This refers to membership with common interest in relation to the irrigated tomato production. It was measured as dummy (1 = membership, 0 = non-membership).

ix. **Quantity of seed (X_1)** - It is included in the model to examine how variability in output is affected by seed used. It was measured in kilogram (kg).

x. **Farm size (X_2) -** It is included in the model to determine the extent to which variability in output is affected by farm size. It was measured in hectares.

xii. **Quantity of fertilizer (X_3) -** It is included in this model to examine the extent to which variability in quantity of fertilizer used affects output. It was measured in kilogram.

xi. **Quantity of agrochemical (pesticides) (X_4)** - It is included to examine the extent to which variability in pesticide will affect output. It was measured in litres.

xii. **Labour (X_5) -** This consist of family and hired labour. It was included to determine how variability in labour used to affects variability in output. Labour was measured in man-days.

xiv. **Irrigated water rate** - The rate at KRIP is fixed at ₦5000 hectare per season by the Hadejia Jama`are River Basin Development Authority (HJRBDA 2014).

xv. **Transportation** - This is a charge for transportation of tomato to markets and other farm inputs. It was measured in Naira.

xvi. **Output (Y)** - This is the product harvested from sampled fields. It was measured in kilogram.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Irrigated Tomato Farmers in the Study Area

In this section, the general socio-economic characteristics of the irrigated tomato farmers are provided. These include age, educational level, farming experience, extension service, farm size and source of finance as shown in Table 4.1 and 4.2 below.

4.1.1 Age distribution

The results in Table 4.1 revealed that the mean age for respondents was 47 years of age. It implies that the farmers were within the active and productive working ages. This also agrees with the findings of Usman and Bakari (2013) in their work on "Profitability of Small Scale Dry Season Tomato Production in Adamawa State" where they found that irrigated tomato production was dominated by farmers who are within their active and productive working ages.

Table 4.1: Socio-economic characteristic on age, educational level and farming experience

Characteristics	Frequency	Percentage
Age		
20-29	7	3
30-39	29	14
40-49	83	39
50-59	62	29
60-69	32	15
Mean	47	
Min.	20	
Max.	66	
Std. Dev.	10.14	
Educational Level		
Non Formal	91	43
Primary	56	26
Secondary	46	22
Tertiary	20	9
Farming Experience		
0-7	10	5
13-15	78	37
16-23	52	24
724-31	68	32
32-39	5	2
Mean	19	
Min.	4	
Max.	35	
Std. Dev.	7.8	

4.1.2 Educational level

It was found that about 26% of the respondents had primary education, while 22% had secondary education. Also, approximately 9% of the respondents had tertiary education. Majority (57%) of the respondents had some form of formal educational qualification, while, 43% of the respondents had non-formal educational qualification. This is an indication that more than half (57%) of the respondents are educated. Consequently, they could access information necessary to help them improve on their farming activities. Level of education of the irrigated tomato farmers' household is important in

determining the household's ability to access, process and implement information on agricultural technologies (Zbinden and Lee, 2005).

4.1.3 Farming experience

It was found that on the average respondents have been cultivating irrigated tomato for 19 years of experience. This implies that the production is dominated by vast experienced adults who are in active years of their life. It is therefore, expected that farmers will achieve high level of productivity. The finding supports the findings of Maurice (2004) ,who reported a positive and significant relationship between farming experience and technical efficiency.

4.1.4 Extension service

The result in Table 4.2 revealed that majority (78%) of the respondents had no services of the extension workers at all during this cropping season and therefore the farmers are likely to be technically less efficient. Limited extension contact may reduce farmers' access to information on improved farm technologies. Mbanasor and Kalu (2008) in their study found that number of extension visits had a significant positive relationship with economic efficiency of commercial vegetable farmers in Akwa Ibom state, Nigeria.

Table 4.2: Socio-economic characteristics on extension service, farm size and source of finance

Characteristics	Frequency	Percentage
Extension Service		
Yes	47	22
No	166	78
Farm Size		
<1.0	152	71
1-2.9	36	17
3.0 and Above	25	12
Mean	1.09	
Min.	0.10	
Max.	10	
Std. Dev.	1.34	
Source of Finance		
Personal saving	213	22
Personal saving and family/friends	202	21
Money lender	195	20
Personal saving and bank	176	18
Personal saving and cooperative	186	19
Total	980*	100

* Multiple response

4.1.5 Farm size

The result in Table 4.2 revealed that the mean farm size was 1.09. Possession of small farm size could be due to mode of land acquisition in the study area which is predominantly through inheritance. This implied that maximum mechanized farm production among the respondents could not be feasible. This findings agrees with Okunlola and Adekunle, (2000) that majority of the Nigerian farmers are the small scaled.

4.1.6 Sources of finance

The result in Table 4.2 revealed that 22% of the respondents used their personal savings in the irrigated tomato production while 21% used their personal savings and family/friend's credit to finance production. This shows that most of the farmers cannot have access to some improved farm inputs and ability to expand their production. This agrees with the findings of Isah (2012) who also reported that lack of credit facilities affect production. Ekong (2003) asserts that credit is a very strong factor that is needed to acquire or develop any enterprise; its availability could determine the extent of production capacity.

4.2 Level of Inputs and Outputs in Irrigated Tomato Production Based on the Three Sizes of Production

The inputs utilized in tomato production among the three scales of farm in the study area were land, seed, fertilizer, labour and pesticide. Table 4.3 shows the levels of input used as well as the output (yield) realized in tomato production.

4.2.1 Land

Land is one of the limiting resources for tomato production among the three scales of farm in the study area. The average sizes of land used for tomato production were 0.5ha, 2ha and 4ha by small, medium and large scale farms, respectively (Tables 4.3). The maximum land size put into production was 0.98ha, 2.4ha and 10ha for small, medium and large scale farms while the minimum were 0.1ha, 1.0ha and 3ha for small, medium and large scale farms, respectively. The inclusion of land or farm size in the study is important because output is a function of farm size (ceteris paribus) and this will translate into determination of the farmer's income and his ability to pay his loan and interest obligation as at when due. This would allow for meaningful investment and returns to scale on food security and productivity.

4.2.2 Seed

The seeds used by the farmers in the study areas were either bought from certified seed company, out growers or obtained the seeds from previous year harvest. The maximum and minimum for small scale farms were 0.6 kg/ha and 0.1 kg/ha with an average of 0.3 kg/ha, medium scale farms were 1.0 kg/ha and 0.2 kg/ha with an average of 1.0 kg/ha while large scale farms were 4.8 kg/ha and 0.8 kg/ha with an average of 2.0 kg/ha, respectively. The average seed rate used by small scale farm was close to the recommended seed rate while medium and large scale farms were above the recommended rate of 0.35kg/ha (USAID, 2009) meaning that the seed was underutilized by small scale farms and with other recommended agronomic practices increasing the seed to the recommended rate will increase output that will translate into increase in profit.

4.2.3 Labour

In the study area, labour is obtained from both the family and hired farmers. It was observed that farmers used a combination of family and hired labour for their farm operations. Hired labour was mainly used for land preparation, weeding and harvesting to compliment the family labour. The average labour used in the study area by small, medium and large scale farms were 36, 48 and 51 man-day, respectively. The maximum minimum labour used by small, medium and large scale farms were, 68, 72 and 120 man-day and 12, 16 and 36 man-day, respectively. The large scale farms (36 man-days) uses more labour than medium scale farms (16 man-days) and this could be as a result awareness in the use of modern farming technologies by medium scale farms. However, the minimum labour was 48 and 51 man-days for farmers among medium and large scale farms, respectively. The recommended labour usage man-hour per tomato

production cycle/ha using 5 men for eight (8) hours in ten (10) operations is 400man-hour (Elizabeth, 2010). This is equivalent to 400/8= 50 man-day. It was found that only the large scale farm used recommended labour. It implies that labour is overutilised by large scale farm and therefore decreasing the amount of labour for large scale farm would decrease the variable cost and by implication their profit would increase as well as income.

4.2.4 Fertilizer

The amount of fertilizer used was limited by the high price of the commodity. Maximum and minimum quantity used per hectares was 120, 275 and 325 kg and 50, 20 and 20kg by small, medium and large scales farm, respectively. The average quantities used per hectare were 38 kg, 95 kg and 115 kg by small, medium and large scales farm, respectively. The recommended fertilizer application rate per production/ha is 200Kg/ha equivalent to 4 bags (Oyinlola, 2005). From the result none of the three categories of farms used the recommended rate. This implies that fertilizers were underutilized by the small scale farms probably due to the hike in price, unavailability and subsidy diversion in the study areas. The effect of this underutilization of fertilizer is that output (yield) obtained would be low, because tomato is a high fertilizer demanding crop.

4.2.5 Pesticide

Pesticide was used to control weeds to give the tomato a luxurious growth. The average pesticide used by small, medium and large scales farm, respectively were 3.4, 8 and 13 litres/ha respectively. The maximum were 20, 25 and 16 litres/ha while the minimum were 1, 2 and 2 litres/ha for the three groups of farmers' respectively. The level of pesticide used is not unconnected with the high price of the input in the market.

4.2.6 Tomato yield (supply level)

It was shown that the average quantity of tomatoes harvested by the three groups of farmers (small, medium and large scale farms) per ha were 1705kg, 2140 kg and 2549kg respectively. The maximum output for small, medium and large scale farms were 3070, 5600 and 6750 kg/ha while the minimum output were 456, 220 and 375kg/ha respectively. The difference in output between the three classes of farmers might be due to enlightenment and adoption of modern farming technologies. However, the output obtained from the three categories of farmers were far below the potential or recommended yield which is 40tonnes/ha (NAERLS, 1989). This could be due to shortage or inadequate of capital in the study areas which ultimately lead underutilization of resources.

The Coefficient of Variation (CV) of each variable input used and output realised are presented in Table 4.3. The higher the coefficient of variation, the greater the dispersion in the variable while the lower the ratio of standard deviation to mean return, the better your risk-return trade-off. The coefficient of variation for a model aims to describe the model fit in terms of the relative sizes of the squared residuals and outcome values. The lower the coefficient of variation, the smaller the residual relative to the predicted value. This is suggestive of a good model fit.

The law of coefficient of variation is a reflection of reliability (precision) of the result (Johnson and Welch, 1939). Johnson and Welch (1939) reported that for a normal distribution, the ratio of mean to standard deviation should be of order of three or more. They mentioned that 33% is often stated as the permissible upper fiducial limit of coefficient of variation (CV).

The Table 4.3 shows that the coefficient of variation of all the variable inputs such as the farm size, seed, fertilizer, labour and pesticides in percentage were 46, 46.67, 61.9, 80.4 and 37.1 for small scale farms, 26.2, 42.4, 54.9, 28.1 and 65.00 for medium farms while 31.4, 43.3, 28.5, 31.4 and 44.5 for large farms respectively. The high coefficient of variation of variable inputs implies high level of variation in the use of variable inputs among irrigated tomato farmers across the three sizes of operation in the study area. However, the coefficient of variation for inputs use was lower in medium and large farms compared to inputs used by small scale irrigated tomato farmers. The variation in input used by the farmers could be attributed to the fact that they differ in purchasing power, size of production and technical know-how.

The coefficients of variation in irrigated tomato yield in the small, medium and large farms were 37.1%, 86.7% and 70.6% respectively. The coefficient of variation of irrigated tomato yields among the categories of farms were above the permissible upper fiducially limit of 33% mentioned by Johnson and Welch (1939). This implies inconsistency or variability in yield level among three categories of irrigated tomato farms in the study area. The instability in the yields among the categories of irrigated tomato farms could be attributed to inconsistency of use and inadequacy of variable inputs among the farmers in the study area.

Table 4.3: Result of the level of inputs and outputs in irrigated tomato production based on the three sizes of production in the study area

Input	Max.	Min.	Average usage	Std. dev.	CV
Small scale					
Land(ha)	0.98	0.1	0.5	0.23	46.6
Seed(kg/ha)	0.6	0.1	0.3	0.14	46.7
Fertilizer(kg/ha)	120	50	38	23.70	61.9
Labour(man-day)	68	12	36	28.69	80.4
Pesticide(L/ha)	20	1	3	2.79	82.1
Yield(kg/ha)	3070	456	1705	632.37	37.1
Medium scale					
Land(ha)	2.4	1	2	0.42	26.2
Seed(kg/ha)	1	0.2	1	0.26	42.4
Fertilizer(kg/ha)	275	20	95	52.18	54.9
Labour(man-day)	72	15.8	48	13.37	28.1
Pesticide(L/ha)	25	2	8	4.99	65.0
Yield(kg/ha)	5600	220	2140	1855.88	86.7
Large scale					
Land(ha)	10	3	4	1.34	31.4
Seed(kg/ha)	4.8	0.8	2	0.79	43.3
Fertilizer(kg/ha)	325	20	115	32.72	28.5
Labour(man-day)	120	36	51	16.10	31.4
Pesticide(L/ha)	16	2	13	6.00	44.5
Yield(kg/ha)	6750	375	2549	1800.02	70.6

4.3. Costs and Returns Analysis

The costs, returns and profitability analysis of irrigated tomato production by small, medium and large scale farms are presented on Table 4.4. The following items were considered in estimating the costs and returns: gross returns, cost of seed, fertilizer, labour, pesticides, empty and basket.

4.3.1 Gross returns

The gross return was computed by multiplying the total yields from the sampled farmers by the average price of tomato at the time of data collection. The average price was varied considerably over the time. For instance, the prices dropped from ₦10, 000 per 40kg basket before harvest to ₦5, 000 at harvest time. This price

considered for this study was ₦5, 000 per 40kg basket. The average price of ₦5000/basket (i.e. ₦ 125/kg) was computed and used to determine return.

4.3.2 Cost of production

In estimating the total cost of production, the variable and fixed costs component, were considered. The variable inputs used were seeds, fertilizer, labour and pesticides.

4.3.3 Cost of seed

The seeds used by the farmers in the study areas were either bought from certified seed companies, out growers or obtained the seeds from previous year harvest. The average market price of ₦200 per 10g sachet for seed was used. Meanwhile, the weight of the sachet being negligible was not used in computing the average market price of the seed.

4.3.4 Cost of fertilizer

The average cost of fertilizer in the study area was ₦4700 per 50 kg bag.

4.3.5 Labour costs.

The labour cost includes the cost of land preparation, fertilizer application, planting/transplanting, pesticide application, irrigation and harvesting. The wage rate varied depending on the operation that was performed. The average wage rate was ₦500 per man-day.

4.3.6 Pesticide costs

The cost of pesticides in the study area was ₦1250 per 2kg sachets. The average market price of ₦625/kg was used for this study.

4.3.7 Cost of empty basket

The average cost of empty basket at ₦300 per basket was used, giving average cost of empty basket to be ₦54,500, ₦60,500 and ₦66,360 by small, medium and large scale farms, respectively.

4.3.8 Total Variable Cost.

The total variable costs of production consist of the costs of fertilizers, seeds, pesticide and labour. The high cost of production could be said to be responsible for the under utilisation of the inputs by small scale farmers in the study area.

4.3.9 Total fixed costs

Fixed assets component were rent value on land and depreciations on farm tool (hoe). Depreciation was determined using the straight line method with no salvage value for the item. The total costs of fixed inputs incurred on irrigated tomato production were ₦11,844.7, ₦16,950 and ₦23,944 by small, medium and large scale farms, respectively.

4.3.10 Gross Margin.

The gross margin represents the difference between the total returns (Gross returns) and the total variable cost. The average rate of return i.e. the gross return divided by the total variable cost. The revenue and production costs incurred for tomato production by small, medium and large scale farms were presented on Table 4.4. The amounts invested in tomato production (TVC) by small, medium and large scale farms were ₦78, 091/ha, ₦ 98,222/ha and ₦111, 632/ha respectively, while the total revenue realized were ₦ 213,131.8/ha, ₦ 267,478.8/ha and ₦ 318.659.2/ha respectively, while the return on naira invested were 1.73, 1.72 and 1.85 for small, medium and large farms

respectively. Thus, indicated profitability of irrigated tomato production in the study area. It is profitable among the three sizes of production but more profitable in the large farms with the highest returns of 85 kobo for every ₦1 invested. The results further revealed an estimated gross ratio of 0.42, 0.43 and 0.43 and operation ratio of 0.37, 0.37 and 0.35 for small, medium and large farms respectively; since the large scale farms had the lowest ratios is desirable for any farm business. The findings of this study is similar to the findings by Usman and Bakari (2013) who reported that an estimated gross and operation ratios of 0.56 and 0.43 respectively while the return on naira invested was 1.33; thus indicate profitability of tomato production in the study area. This shows that despite the inadequacy of good storage and processing facilities to take care of large productivity, irrigated tomato farming among the three scales of production still remain a profitable venture in the study area. This finding is collaborated by the findings of Omonona *et al.* (2010) who reported an enterprise economic efficiency of 1.17. Implying that for every ₦1 spend by the farmer on Cowpea production, 17 kobo was realized as profit and Zalkuwi *et al*. (2012) who reported that tomato production is profitable in both short and medium term owing to the positive gross margin and net income per/ha of ₦ 90,113.78 and ₦ 68,296.26 respectively. This finding also agrees with the findings of Sani and Haruna (2010) who concluded that the cost and returns analysis of vegetable crop production was economically viable and sustainable. Also Lenis *et. al*., (2011) mentioned that despite numerous constraints faced by farmers in production process like the small size of farm holdings and the use of rudimentary inputs, studies of farming establishments across the country show that farming is generally a profitable enterprise for small scale farmers.

Table 4.4: Result of average costs and returns per hectare of irrigated tomato production based on the three sizes of production in the study area

Items	Small scale	Medium scale	Large scale
	Total value (₦/ha)	Total value (₦/ha)	Total value (₦/ha)
1. Gross returns(GR)			
Average yield(kg/ha)	213,131.8	267,478.8	318,659.2
2. Variable costs (VC)			
Seed	60	200	400
Fertilizer	3600.2	8930	10810
Labour	17850	23802.1	25632
Pesticide	2121.7	4791.7	8429.8
Cost of empty basket (₦)	54,459	60,498	66,360
3. Total variable cost(TVC)	78,091.0	98,222.0	111,632.0
4.Fixed cost (FC)			
Rent on land	9044.7	13200	18544
Depreciation on fixed asset	2800	3750	5400
Total fixed cost (TFC)	11,844.7	16,950.0	23,944.0
Total cost of production(TCP)	89.935.6	115,171.8	135,575.8
GM (GR-TVC)	135,040.9	169,257.0	207,027.4
NFI (GM-TFC)	123,196.2	152,307	183,083.4
GR (TCP/GR)	0.42	0.43	0.43
OR (TVC/GR)	0.37	0.37	0.35
RNI (GM/TVC)	1.73	1.72	1.85

4.4 Estimate of Technical, Allocative and Economic Efficiencies Based on the three Sizes of Production in the Study Area

Technical Efficiency Scores

Employing the output-oriented DEA under constant returns to scale (CRS) and variable returns to scale (VRS) models, technical efficiency and scale efficiency for the three sizes of irrigated tomato farms were estimated. The summary statistics for technical efficiency under constant returns to scale, technical efficiency variable returns to scale and scale efficiency are presented in Table 4.5 below for the three sizes irrigated tomato farms, respectively. The mean technical efficiency (CRS), technical efficiency (VRS) and scale efficiency for small size irrigated tomato farms were 16.5%, 21.2% and 62.3%, respectively.

Table 4.5: Efficiency measures and descriptive statistics for irrigated tomato producing farms according to size of production in the study area

Scale of operations	Efficient farms(θ≥0.90)		Efficiency measures			
	Freq.	%	Mean	Standard deviation	Max	Min
Small farms						
Technical efficiency (CRS)	35	16.5	0.66	0.23	1	0.18
Technical efficiency (VRS)	45	21.2	0.70	0.24	1	0.19
Scale efficiency (SE)	132	62.3	0.95	0.09	1	0.41
Medium farms						
Technical efficiency (CRS)	3	13.6	0.33	0.29	1	
Technical efficiency (VRS)	16	72.7	0.83	0.18	1	0.47
Scale efficiency (SE)	3	13.6	0.39	0.30	1	0.05
Large farms						
Technical efficiency (CRS)	6	27.3	0.44	0.35	1	0.07
Technical efficiency (VRS)	10	45.5	0.85	0.12	1	0.66
Scale efficiency (SE)	6	27.3	0.50	0.34	1	0.08

The estimated mean TE measure for the sample small scale farms is 70% for the VRS DEA model and 66% for the CRS DEA model. This result reveals inefficiency in the use of inputs, which means that the current level of output can be produced using 30% (34%) less inputs on average than are applied by farmers under VRS assumption (respectively, CRS). In terms of TE, 21% of the 152 farms investigated are fully efficient under the VRS model. Under the CRS model, only 17% farms are fully efficient. The difference between the VRS and CRS measures further indicated that many farms among the small scale farmers did not operate at an efficient scale and that adjusting the scale of operation could improve the efficiency.

Similarly, the estimated mean TE measure for the sample medium scale farms is 83% for the VRS DEA model and 33% for the CRS DEA model. This result reveals efficiency in the use of inputs under CRS assumption, which means that the current

level of output can be produced using 17% less inputs on average by farmers under VRS assumption. In terms of TE, 73% of the 36 farms investigated are fully efficient under the VRS model. Under the CRS model, only 14% farms are fully efficient. The difference between the VRS and CRS measures further indicated that many farms among the medium scale farmers did operate at an efficient scale under VRS assumption and that adjusting the scale of operation could improve the efficiency. Also, TE for large scale farms is 85% for the VRS DEA model and 44% for the CRS DEA model. This result reveals efficiency in the use of inputs, which means that the current level of output can be produced using 15% less inputs on average by farmers under VRS assumption. In terms of TE, 46% of the 25 farms investigated are fully efficient under the VRS model. Under the CRS model, only 27% farms are fully efficient. The difference between the VRS and CRS measures further indicated that many farms among the large scale farmers did operate at an efficient scale under VRS assumption and that adjusting the scale of operation could improve the efficiency. This improvement from the VRS model was mainly due to the inclusion of scale efficiency, which the CRS model did not take into account (Murthy *et. al.*, 2009). Therefore, the results show that inputs, especially among large scale farms could be saved without harming their production. These results reconcile a sustainable management water resource. In fact, the overexploitation in the irrigated area is about 20% (Ben Allaya et al., 2009). This strategy decreases the overexploitation of the groundwater and goes with a sustainable use of the resource.

The results show that size of the farms does have an impact on the efficiency of tomato output. Furthermore, the corresponding mean scale efficiency of 95% for small size farms and 85% for large size farms suggests that by operating on an optimal scale a

further increase in output can be achieved beyond their projected value by as much as 5% and 15%, respectively. This implies that there is room for additional increase in domestic irrigated tomato output from existing hectares if efficiency of irrigated tomato production is enhanced. This observation is in agreement with Ataboh (2007) and Okuruwa *et al*. (2009) who reported that there is room for additional increase in domestic rice output from existing hectares if efficiency of rice production is enhanced. Although the above results show that small size farms were more efficient, the technical and scale efficiency scores did not differ much from the corresponding estimates for large farms. This could probably be attributed to under-utilization of input such as fertilizer and agrochemical (pesticides) by the irrigated tomato farmers. This is in agreement with Ayinde *et. al*. (2009) who reported that farmers in Nigeria are yet to adopt the optimum fertilizer rate. Thus, embracing the use of fertilizer alone may not be the key to increasing tomato production levels in Nigeria, if farmers are not encouraged to adopt the optimum fertilizer rate. This can be accomplished through educating farmers as suggested by some studies (Llewelyn and Williams 1996; Dhungana *et. al.,* 2004).

Regions of Operations in the Production Frontier

In addition to knowing about the number of efficient farms, extent of inefficiency and optimum scale of operation, it is also important to understand the distribution of farms in the three regions of production frontier, i.e. how many farms are under increasing, decreasing or constant returns. These were estimated using the equations given under methodology and the results have been presented in Table 4.6.

Table 4.6: Distribution of irrigated tomato farms according to types of return among different sizes of production in the study area

Return to scale	IRS		DRS		CRS		Total
	Freq.	%	Freq.	%	Freq.	%	
Small farms	84	55	31	20	37	24	152
Medium farms	33	92	0	0	0	0	36
Large farms	10	76	0	0	6	24	25

Approximately 55% of the farms in the small farm category were found operating in the region of increasing returns or the suboptimal region. The production scale of these farms could be increased by decreasing the costs, since they were performing below the optimum production scale. Approximately 20% of irrigated tomato farms for the small farms category, who were found in the decreasing returns region, could increase their technical efficiency by reducing their production levels. This region is also called as supra-optimal, i.e. the farms were performing above the optimum scale of production. In the constant region of frontier, i.e. optimum scale of production, only 24% of the small farms were found operating. Approximately 92% of the farms for the medium farm category were found operating in the region of increasing returns or the sub-optimal region. The production scale of these farms could be increased by decreasing the costs, since they were performing almost at the optimum production scale. None of tomato farms in the medium farms category were found in the decreasing returns region. In the constant region of frontier, i.e. optimum scale of production, only 8% of the medium farms were found operating. Approximately 76% of the farms for the large farm category were found operating in the region of increasing returns or the sub-optimal region. The production scale of these farms could be increased by decreasing the costs, since they were performing almost at the optimum production scale. None of tomato farms in the large farms category were found in the decreasing returns region. In

the constant region of frontier, i.e. optimum scale of production, only 24% of the large farms were found operating. Given that majority of the irrigated tomato farms were operating under IRS suggests that irrigated tomato farms in general were scale inefficient, since scale inefficiency is usually due to the presence of either IRS or DRS. This is in agreement with (Sharma *et. al.*, 2003; Nasiru, 2010; Benjamin *et. al.*, 2011). Although in the short run, farms may operate with increasing returns to scale (IRS) or decreasing returns to scale (DRS), in the long run however, irrigated tomato farms must shift towards constant returns to scale (CRS) to be efficient in order to achieve the desired increase in irrigated tomato production in Nigeria.

4.4.1 Estimate of technical efficiency based on the three sizes of production in the study area

The frequency distribution of the technical efficiency estimates for irrigated tomato farmers in the study area as obtained from the Data Envelopment Analysis model is presented in Table 4.7. Result revealed that 49%, 56% and 64% of the small, medium and large farms respectively operated within a technical efficiency range of 0.61 and less than 1.00. While, approximately 39% for all farms operated within a technical efficiency range of 0.20-0.40. The implication of this result is that majority of the irrigated tomato farmers are not technically efficient in the use of production resources. This maximum possible level attainable may be due to inefficiency and hence results to low productivity.

Table 4.7: Frequency distribution of technical efficiency estimates based on size of operation in the study area

Technical Efficiency	Small Farms	Medium Farms	Large Farms
<0.20	2	0	0
	(1)	(0)	(0)
0.20-0.40	49	4	0
	(32)	(11)	(0)
0.41-0.60	26	12	9
	(17)	(33)	(36)
0.61-0.80	75	20	16
	(49)	(56)	(64)
0.81-1.00	0	0	0
	(0)	(0)	(0)
Mean	0.763	0.826	0.854
Min	0.316	0.474	0.656
Max	1	1	1

The study also reveals that technical efficiency among the irrigated tomato farmers varied substantially ranging between 0.316 and 1.00 for small farms, 0.474 and 1.00 for medium farms and 0.656 and 1.00 for large farms with a mean technical efficiency of 0.763, 0.826 and 0.854 for small, medium and large farms respectively. This result suggests that the farmers are not utilising their production resources efficiently, indicating that they are not obtaining maximal output from their given inputs. In other words, technical efficiency among the irrigated tomato farmers can be increased by 23.7%, 17.4% and 14.6% for small, medium and large farms respectively through better use of available production resources such as fertilizers and pesticide given the current state of technology. This finding agrees with (Asogwa *et. al.*, 2011) that Nigerian rural farmers did not obtain maximum output from their given quantum of inputs.

4.4.2 Estimate of allocative efficiency based on the three sizes of production in the study area

The frequency distribution of allocative efficiency estimates for irrigated tomato farmers in the study area as obtained from the Data Envelopment Analysis result

presented in Table 4.8. Results revealed that majority of the irrigated tomato farmers (35%) of the small farm size operated within an allocative efficiency range of 0.41-0.60. Approximately 39% of the medium farm size operated within an allocative efficiency range of 0.20-0.40, while 64% with large farm size operated within an allocative efficiency range of 0.61-0.80. The implication of this result is that majority of the irrigated tomato farmers are not allocatively efficient in the use of production resources. This can result to the utilisation of inputs in the wrong proportions, given input prices, and hence higher costs of input combination and reduced return to capital. The study also suggests that allocative efficiency among the irrigated tomato farmers varied widely ranging between 0.252 and 1.00 for small farms, 0.034 and 1.00 for medium farms and 0.36 and 1.00 for large farms with a mean allocative efficiency of 0.65, 0.54 and 0.77 for small, medium and large farms respectively.

Table 4.8: Frequency distribution of allocative efficiency estimates based on the sizes of production in the study area

Allocative efficiency	**Small farms**	**Medium farms**	**Large farms**
<0.20	15	9	6
	(10)	(25)	(24)
0.20-0.40	52	14	3
	(34)	(39)	(12)
0.41-0.60	53	10	0
	(35)	(28)	(0)
0.61-0.80	32	3	16
	(21)	(8)	(64)
0.81-1.00	0	0	0
	(0)	(0)	(0)
Mean	0.646	0.543	0.769
Min	0.252	0.034	0.36
Max	1	1	1

This result revealed that the farmers are utilising the inputs in the wrong proportions, given input prices. In other words, about 35% of small farms, 46% of medium farms and 23% of large farms resources are inefficiently allocated relative to the best-

practiced farms producing the same output and facing the same technology in the study area. This implies that allocative efficiency among the respondents could be increased by 35% for small farms, 46% for medium farms and 23% for large farms through better utilisation of resources in optimal proportions given their respective prices and given the current state of technology. This finding is at variance with (Okoye *et. al.,* 2009) who observed that the most allocatively inefficient farmer will have an efficiency gain of 89.6 % in cocoyam production if he or she is to attain the efficiency level of most allocative efficient farm in the state. It also agrees with the findings of (Asogwa *et. al.,* 2011) that Nigerian rural farmers are not utilising production inputs in the optimal proportions, given input prices.

4.4.3 Estimate of economic efficiency based on the three sizes of production in the study area

The results in Table 4.9 revealed that 41%, 47% of the irrigated tomato farmers with small and medium farm sizes in the study area operated within an economic efficiency range of less than 0.20 (<0.20). While, majority (52%) of the irrigated tomato farmers with large farm size operated within an economic efficiency range of 0.61-0.80. Implication of this result is that majority of the irrigated tomato farmers are not economically efficient in the use of production resources. This can result to higher costs per unit of output for a farm firm and hence the inability of the farmer to maximise profit. Result revealed that economic efficiency among the irrigated tomato farmers varied widely ranging between 0.134 and 1.00 for small farms, 0.034 and 1.00 for medium farms and 0.257 and 1.00 for large farms with a mean economic efficiency of 0.50, 0.446, and 0.674 for small, medium and large farms respectively.

Table 4.9: Frequency distribution of economic efficiency estimate based on the sizes of production in the study area

Economic Efficiency	Small Farms	Medium Farms	Large Farm
<0.20	63	17	6
	(41)	(47)	(24)
0.20-0.40	48	11	4
	(32)	(31)	(16)
0.41-0.60	20	6	2
	(13)	(17)	(8)
0.61-0.80	21	2	13
	(14)	(6)	(52)
0.81-1.00	0	0	0
	(0)	(0)	(0)
Mean	0.5	0.446	0.674
Min	0.134	0.034	0.257
Max	1	1	1

This indicates that irrigated tomato farms were economically inefficient and are not able to minimize the cost of production. The implication is that overall economic efficiency among the irrigated tomato farms could be increased by 50%, 55% and 33% for small, medium and large farms respectively in the area through the reduction in production costs that would occur if production were to occur at the allocatively and technically efficient point given the current state of technology. This agrees with the observation of (Benjamin *et. al.*, 2011) and (Asogwa *et. al.*, 2011) that Nigerian rural farmers do not produce at the allocatively and technically efficient point given the current state of technology.

4.4.4 Determinants of technical efficiency of irrigated tomato producing farms

In assessing the factors influencing the technical efficiency of irrigated tomato-producing farms in the study area, (Table 4.10) four functional forms (linear, semi-log, double-log and exponential) were estimated. The semi-log model was chosen as the lead equation due to the higher coefficient of determination (R^{-2}) value, the

significance number of explanatory variables and the conformity of estimates to a priori expectations.

Table 4.10: Result of the factors influencing technical efficiency of irrigated tomato producing farms in the study area

Variable	**Small Farms**		**Medium Farms**		**Large Farms**	
	B	t-value	B	t-value	B	t-value
Constant	0.996	16.306	0.477	0.700	1.878	3.970
Age	0.688***	93.024	0.902***	5.838	-0.328*	-1.931
Household size	0.246***	13.630	0.100*	1.748	-0.163***	-2.487
Education	0.00001	0.431	0.0001	0.413	-0.000005	-0.046
Farming experience	0.00002*	1.884	-0.010	-0.168	0.348***	2.714
Amount of credit	-0.019***	-2.688	0.001***	3.656	-0.0002	-1.413
Extension contact	0.000004	0.396	-0.0001	-0.532	0.001***	4.972
Cooperative societies	0.00003**	2.438	-0.004***	-27.001	0.0001	0.930
Sex	-0.000003	-0.402	0.038	0.173	-0.621***	-3.133
Marital status	0.006	0.296	0.191	0.613	-0.118	-1.249
R^2	0.686		0.489		0.743	
Adjusted R^2	0.585		0.423		0.689	

Note: *** P < 0.01, ** P < 0.05 and * P < 0.10

Result from Table 4.10 revealed that the factors influencing technical efficiency were age, household size, farming experience, amount of credit, extension contact, cooperative societies and sex for all the three categories of farms.

The coefficient of age was significant for all the three categories of farms. It implies that 1% increase in their age could influence the efficiency to the extent of 0.69% increase in small farms, 0.90% increase in medium farms and -0.33% decrease in large farms. Coefficient for age was found to be positive for age among small and medium scale farms. It implies that as the age of farmers increases their experience in acquiring and

handling inputs increases thereby making them more efficient. On the other hand, coefficient for age was negative among the large scale farm but significant at 10%. It implies that older farmers have acquired more human capital through their experiences, but they also may be less willing to adopt new ideas to tomato productions which could reduce efficiency. Abdullai and Huffman (1998) found that older rice farmers in Northern Ghana were less efficient than younger farmers while Coelli et. al., (2002) found that younger rice farmers in Bangladesh were more efficient than older rice farmers.

Also, it was found that the coefficient of household size was significant for all the three categories of farms. It implies that 1% increase in their household size could influence the efficiency to the extent of 0.25% increase in small farms, 0.10% increase in medium farms and -0.16% decrease in large farms. It implies that larger the household size the more available labour help in farm work. The size of the household in a society usually influences the rate of population growth of that society, which in turn can determine the labour force. It is assumed that the larger the size of the household of a farming community, the greater the availability of hands to offer help in farm work (Okafor *et. al*., 1994).

Farming experience was also found to significantly influence the technical efficiency in the two categories of farms (small and large scale farms). It implies that 1% increase in their farming experience could influence the efficiency to the extent of 0.35% increase in large farms and 0.00002% increase in small farms. Most experienced farmers know cropping practices to employ for optimum yield which is likely to have higher productivity. Oluyole *et. al.* (2009) also reiterated that an experienced farmer is likely to

have higher productivity and hence be able to provide more food for his household members.

It was found that source of finance significantly influence the technical efficiency in the two categories of farms (small and medium scale farms). It implies that 1% increase in their amount of credit received could influence the efficiency to the extent of -0.02% decrease in small farms and 0.001% increase in medium farms. Suggesting that households with access to credit facilities would be economically empowered to divert incomes and access food in adequate quantity and quality. However, the result indicated negative coefficient for small scale farms. This may likely be attributed to the bureaucratic process(s) involved in credit acquisition, nature and type of collateral etc.

Extension contact and sex were found to significantly influence the technical efficiency in large scale farms. It implies that 1% increase in their contact with the extension agent and sex could influence the efficiency to the extent of 0.001% increase and in -0.62% decrease in large farms, respectively. The regression produced a negative coefficient for sex indicating the tendency for female headed households to have lower efficiency scores. This could be because women are more aware or concerned with the food requirements of the family (Thomas 1990).They may therefore be more likely than men to recognize the advantages of cost saving technologies and are hence able to produce at lower costs. In addition female household heads are normally members of farmer groups and are more likely to regularly attend meetings organized by extension workers. This makes them more knowledgeable and certain to adopt new technologies. Frequent extension contacts expose the farmer to new and improved farming practice, enhances the level of adoption and general farm output. This implies that the higher the number

of extension contacts per cropping season, the higher the probability of increased productivity

It was found that cooperative society was also found to significantly influence the technical efficiency in the two categories of farms (small and medium scale farms). It implies that 1% increase in their membership in cooperative society could influence the efficiency to the extent of 0.00003% increase in small farms and -0.004% decrease in medium farms. Active participation in cooperative activities tend to attract benefits in terms of helping members in mobilizing resources within society for agricultural operations and marketing, access to inputs (essential manufactured goods) at cheaper rates, enables members take advantage of economies of scale in production, processing and marketing of agricultural produce. Also, it assists in the training and education of members in modern agricultural practices and use of agricultural inputs.

4.5 Constraints to Irrigated Tomato Production in the Study Area

The result in Table 4.11 showed the constraints faced by the irrigated tomato farmers. Although, returns to irrigated tomato farming among the three scale of farm were profitable, it appears opportunities still exist for improving them if the constraints as highlighted by the respondents are adequately addressed. The result revealed that 28% of small scale, 30% of medium scale and 33% of large scale irrigated tomato farmers ranked poor output price of tomato which are highly perishable as the foremost constraint faced. An insight into the price movement during the irrigation season indicated that the prices of tomato fluctuate widely. They were generally highest at the beginning of the season but decreased rapidly until they reached their lowest values at

the peak of harvest period (period of harvest around April to September), and farmers are forced to sell their product at low prices, after which the prices began to rise again.

Table 4.11: Constraints to irrigated tomato production in the study area

Constraints	Small scale			Medium scale			Large scale		
	Freq.	%	Rank	Freq.	%	Rank	Freq.	%	Rank
Poor output price	152	28	1st	25	30	1st	35	33	1st
Pests and disease	93	17	4th	17	20	3rd	27	25	2nd
Poor storage and processing facilities	76	14	5th	20	24	2nd	21	20	3rd
High cost of input	109	20	3rd	9	11	5th	15	14	4th
Inadequate farm credit	119	22	2nd	13	15	4th	9	8	5th
Total	549*	100		84*	100		107*	100	

*Multiple response

Also, 22% of small scale, 15% of medium and 8% of large scale farmers ranked inadequate farm credit as the second, fourth and fifth constraining factor, respectively. This is in line with the study by Usman and Bakari (2013) , who reported inadequate capital hinders tomato farmers from expanding their business. About 20% of small, 11% of medium and 14% of large scale farmers ranked high cost of inputs such as fertilizer, pesticide, labour as the third, fifth and fourth constraining factor, respectively. This most likely, explains the under-utilization of this inputs. This is in line with the report of Afolami (2002) noted high inputs cost among tomato farmers in Ogun State. In addition, 17% of small, 20% of medium and 25% of large scale farmer's ranked attack on tomato production through the effect of pests and diseases as the fourth, third and second constraining factor, respectively. Tomato are subjected to a variety of pests and diseases such as cutworms and white flies that can reduce yield and quality of the tomato (Ibrahim, 2005). Fagade (2001) attribute potential crop losses of 10% to 100% to pest and disease problems. Agricultural

pesticides to control these problems are costly for farmers to purchase. Therefore, diseases and pests can limit the economic benefits of small-scale irrigation activities in the study area. Also, 14% of small, 11% of medium and 20% of large scale farmer's ranked poor storage and processing facilities as the fifth, second and third constraining factor, respectively. This problem causes the price of tomato to fluctuate with season. Farmers are either forced to sell their produce at harvest at a very low price or to use local methods to preserve tomato despite its perishability. This implies that there will be greater percentage of post-harvest loses of tomato which may discourage farmers from increasing their production (Usman and Bakari (2013); Oyekanmi (2010).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study focused on the Economics of Size in Irrigated Tomato Production under Kano River Irrigation Project (KRIP), Phase I in Kano State, Nigeria. Two villages each based on higher number of large size farms were purposively selected from three Local Government Areas covered by the project and 213(10%) of total population of 2122 irrigated tomato farmers were randomly selected for this research. The purpose of the study was to examine the economics of size in irrigated tomato production under Kano River Irrigation Project (KRIP), Phase I in Kano State, Nigeria. The specific objectives were: to describe the socio-economic characteristics of irrigated tomato farmers, to describe the level of inputs and outputs in irrigated tomato production based on the sizes of production, to determine the costs and returns in irrigated tomato production based on the sizes of production, to estimate the technical, allocative and economic efficiencies based on the sizes of production and to describe the constraints to irrigated tomato production in the study area.

Primary data were collected with the aid of structured questionnaire and the data were analyzed using Descriptive Statistics, Budgeting Techniques (Gross Margin Analysis, Net Farm Income and Profitability Index) and two-stage Data Envelopment Analysis.

The results of the socio-economic analysis show that (53%) of the irrigated tomato farmers' fall within the age range of 30-49years, majority of the farmers (57%) had some formal educational qualification. Approximately 93% of the irrigated tomato

farmers' have been cultivating tomato for 16-23 years. Majority of the farmers, (76%) used their personal savings in tomato production.

The average costs incurred and revenue obtained per hectare for irrigated tomato production were estimated to determine the profitability of irrigated tomato production in the study area (Table 6). The total variable costs per hectare were ₦78,091.00, ₦98,222.00 and ₦111,632.00 with a fixed cost of ₦11,844.70, ₦16,950.00 and ₦23,944.00 and the total cost (TVC + TFC) was ₦89,935.60/ha, ₦115,171.80/ha and ₦135,575.80/ha for small, medium and large farms respectively. The average revenue generated by irrigated tomato farmers in the study area were ₦213,131.80, ₦267,478.80 and ₦318,659.20 with a gross margin of ₦135,040.90, ₦169,257.00 and ₦207,027.40 for small, medium and large farms respectively. While the return on naira invested were 1.73, 1.72 and 1.85 for small, medium and large farms respectively. Thus, it could be concluded that irrigated tomato production was profitable among the three sizes of production, but more profitable in the large farms with the highest returns of 85kobo for every ₦1 invested.

It was found that medium and large scale farms used seed above the recommended rate of 0.35kg/ha (USAID, 2009), the large scale farms used more labour than medium scale farms. Also, from the result none of the three categories of farms used the recommended rate of fertilizer application of 200Kg/ha equivalent to 4 bags. However, the output obtained from the three categories of farmers were far below the potential or recommended yield which is 40tonnes/ha.

It was observed that 21% of the 152 small scale farms investigated were fully efficient under the VRS model, also, about 73% of the 36 farms investigated were fully efficient under the VRS model while for large scale farms 85% were fully efficient under the VRS DEA model. It was revealed from the study that majority of the irrigated tomato farmers (49% of the small, 56% of medium and 64% of large farms) operated within a technical efficiency range of 0.61 and less than 1.00. Approximately 64% and 52% of the large farm size operated within an allocative and economic efficiency range of 0.61-0.80.

In assessing the factors influencing the technical efficiency of irrigated tomato-producing farms in the study area, of the four functional functions analysed, the semi-log model was chosen as the lead equation due to the highest coefficient of determination (R^{-2}) value, the significance number of explanatory variables and the conformity of estimates to a priori expectations. As regards to factors influencing technical efficiency, age, household size, farming experience, amount of credit received, extension contact, cooperative society, and sex collectively contributed 59% to the total variations in technical efficiency in all the three categories of farms. Finally, among the constraints identified in the study area, majority 28%, 30% and 33% of small, medium and large scale irrigated tomato farmers attested to the fact that poor output price as the major constraint faced.

5.2 Conclusion

Based on the findings of this study, it can be concluded that irrigated tomato farming is profitable at various sizes of production with large size being more profitable and can be an important cash crop for both full and part-time farmers in the study area and Nigeria at large. Being an essential component of the diet of man and also an important

industrial commodity, any attempt to increase its productivity would be a right step in the right direction for economic development. Given the current level of technical efficiency (CRS and VRS) at the disposal of the irrigated tomato farmers, they have a scope of improving the efficiency by using 30%, 17% and 15% less inputs on average by small, medium and large scale farms under VRS assumption, respectively without altering the input quantities used.

5.3 Recommendations

From the findings of this study, the following recommendations are made:

i. Majority of the irrigated tomato farmers complained of poor output price as the foremost constraint faced. Therefore, there is a need to improve the pricing system of tomato. Farmers should form a production clusters to improve their market intelligence. This could be achieved through the formation of producer groups or cooperatives. In each group there should be an advisory committee trained in various aspects of marketing which will be able to have access to up-dated pricing information and make it available to farmers on time.

ii. Since the farms were not allocatively efficient, farmer-education should be encouraged by extension agents through effective and efficient dissemination of information.

iii. Since majority of the farmers financed their production through personal savings which are mostly not adequate for appreciable production. Agricultural loan facilities by banks and non-governmental organization should be made easily accessible to the farmers to ensure timely and adequate procurement and utilisation of agricultural inputs to improve farm production efficiency.

iv. Since cooperative membership was a significantly determinant of technical efficiency, irrigated tomato farmers should join cooperative societies, so as to be able to benefit from the government and non-governmental organization through increased credit access, input supply and farm advisory services.

5.4 Contribution of the Study to Knowledge

i. The study revealed that small, medium and large irrigated tomato farms were profitable with returning 73, 72 and 85 kobo, respectively to every ₦1.00 spent. But large irrigated tomato farms were more profitable with returning 85 kobo to every ₦1.00 spent in the study area.

ii. It was revealed that all the three categories of irrigated tomato farms were economically inefficient (50% and 45% for small and medium irrigated tomato farms, respectively) with large irrigated tomato farms having the highest economic efficiency of 67% in the study area.

iii. The study revealed that small, medium and large irrigated tomato farms in the study area achieved technical efficiencies of 76%, 83% and 85 % respectively.

iv. The study revealed that large scale farms could potentially expand output by 73% and 54% compared to 86% and 27% for medium size farms and 83% and 79% for small size farms without altering the input quantities used

v. The study revealed that the mean scale efficiency of 95% for small scale farms and 85% for large scale farms suggests that by operating on an optimal scale a further increase in output can be achieved beyond their projected value by as much as 5% and 15%, respectively.

vi. The socio-economic factors influencing technical efficiency of small irrigated tomato farms were age (1%), household size (1%), farming experience (10%), amount of credit received (1%) and cooperative society (5%).

REFERENCES

Abba, A. and Shehu, M. (2007). Commodity Chain Analysis of Tomato: Case Study of KRIP Area, Kano State. Agricultural Development in Nigeria Programme. A collaborative Programme of NAERLS/ABU, Zaria and Embassy of France Abuja.

Abdullai, A. and Huffman, W.E. (1998). An examination of profit inefficiency of rice farmers in Northern Ghana. Staff paper, Swiss Federal Institute of Technology, Department of Agricultural Economics.

Adamu, B. I. (2005). Small and Medium Industries Equity Investment Scheme (SMEESIS): Pro or Anti-Industrialization; *Bullion*, 29(4): 32.

Adejoh, S. D. (2009). Analysis of Production Efficiency and Profitability of Yam-Based Production System in Ijunmu L.G.A of Kogi State M.Sc. Thesis Department of Agricultural Economics and Extension, Ahmadu Bello University, Zaria.

.

Adeleke, O. A, Matanmi, H. and Ogunniyi, L. T. (2008). Application of the Normalized Profit Functions in the Estimation of the Profit Efficiency among Small-Holder Farmers in Atiba Local Government Area of Oyo State, Nigeria. *Journal of Economic Theory*. 2(3): 71-76.

Adewuyi, S. A. (2002). Resource-Use Productivity in Food Crop Production in Kwara State, Nigeria. Ph. D. Dissertation, Department of Agricultural Economics University of Ibadan, Ibadan.

Adeyemo, R. J, Oke T. O. and Akinola A. A. (2010). Economic Efficiency of Small Scale Farmers in Ogun State, *Nigeria Tropiculture.* 28(2).

Afolabi, O. I, Adegbite, D. A, Ashaolu, O. F. and Akinbode, S. O. (2013). Profitability and Resource-Use Efficiency in Poultry Egg Farming in Ogun State, Nigeria. *African Journal of Business Management.* 7(16): 1536-1540.

Afolami, C. A. and Ayinde, I. A. (2002). Economics of Tomato Production in Yewa North Local Government Area of Ogun State, Nigeria. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension.* l (1&2):17 - 23.

Ajani, O. I. Y. (2000). Resource Productivity in Food Crop Farming in the Northern Area of Oyo State, Nigeria. Ph. D. Dissertation, Department of Agricultural Economics University of Ibadan, Ibadan.

Ajibefun, I. A. (1998). Efficiency of Small Scale Food Crop Farms in Ondo State, Nigeria. An Application of Parametric and Non-Parametric Frontier Production Functions. Ph. D. Dissertation, Department of Agricultural Economics and Extention, FUTA, Akure.

Ajibefun, I. A. (2008). An Evaluation of Parametric and Non- Parametric Methods of Technical Efficiency Measurement: An Application to Small Scale Food Crop Productivity in Nigeria. *Journal of Agriculture and Social Sciences.* 4(3).

Ajibolade, E. O. (2005). Effects of Land Acquisition for Large Scale Farming on the Productivity of Small Scale Farming in Okitipupa L.G.A, Ondo State. Unpublished M. Sc. Thesis, Department of Agricultural Economic and Extension, FUTA, Akure.

Alibury, F. D. and May, O. (1970). Irrigation Schedule and Production of Processing Tomatoes. *California Agriculture.* 24(8): 10-11.

Amans, E. B. and Nwadukwe, P. D. (1993). Effect of Irrigation Interval, Plant Density and Yield Performance of Tomato in Northern Nigeria. *Terminal Report Submitted to the Irrigation Research Programme*, IAR/ABU, Zaria.

Amos, T. T, Chikwendu, D. O. and Nmadu, J. N. (2004). Productivity, Technical Efficiency and Cropping Patterns in the Savannah Zone of Nigeria. *Journal of Food, Agriculture and Environment*. 2: 173-176.

Andersen, P. and Petersen, N. C. (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Management Science*. 39(10): 1261-1264.

Anonymous, (2000). Guide to Commercial Staked Tomato Production in Alabama, Cooperation Extension System (ACES). http://www.aces.edu/counties.

Anonymous (2003). University of Idaho Bulletin at: http://uidaho.edu/homegard.asp.

Anonymous, (2010). Tomato en.wikipedia.org/wiki/tomato.

Anonymous, (2011). Petomech li.www.southafrica.net.

Asogwa, B. C. Ihemeje, J. C. and Ezihe, J. A. C. (2011). Technical and Allocative Efficiency Analysis of Nigerian Rural Farmers: Implication for Poverty Reduction, *Agricultural Journal.* 6(5): 243-251.

Ataboh, E. (2007). Technical and Allocative Efficiency of Rice Production in Kogi State, Nigeria Unpublished M. Sc. Dissertation. Department of Agricultural Economics University of Agriculture, Makurdi, Benue State.

Avkiran, N. K. (1999). An Application Reference for Data Envelopment Analysis in Branch Banking: Helping the Novice Researcher. *International Journal of Bank Marketing.* 17(5): 206 – 220.

Ayinde, O. E, Adewumi, M. O. and Omotosho, F. I. (2009). Effect of Fertilizer Policy on Crop Production in Nigeria. *The Social Science.* 4(1): 53-58.

Banker, R. D. and Morey, R. (1986). The Use of Categorical Variables in Data Envelopment Analysis. *Management Science.* 32(12): 1613-1627.

Banker, R. D, Charnes, A. and Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science*. 30 (9): 1078 – 1092.

Bardhan, P. K. (1973). Size, Productivity and Returns to Scale: An Analysis of Farm-Level data in Indian Agriculture *In: Journal of Political Economy*. 81(6): 1370-1386.

Barr, R. S.; Killgo, K. A.; Siems, T. F. and Zimmel, S. A. (2002). Evaluating the Productive Efficiency and Performance of United States Commercial Banks, *Managerial Finance*. 28(8): 3 – 25.

Barrett, C. B. (1994). On Price Risk and the Inverse Farm Size-Productivity Relationship. Department of Agricultural Economics and Economics, University of Wisconsin-Madison.

Baumback, C. M. (1983). *Basic Small Business Management:* Prentice-Hall, Engelwood Cliffs, New Jersey.

Belbase, K. and Grabowski, R. (1985). Technical Efficiency in Nepalese Agriculture. *Journal of Development Agriculture.* 19:515-525.

Benjamin, C. A, Simon, T. P. and Wuraola, L. L. (2011). Application of Data Envelopment Analysis to Evaluate Farm Resource Management of Nigerian Farmers. *Journal of Agricultural Science*. 2(1): 9-15.

Berry, R. A. and Cline, R. C (1979). *Agrarian Structure and Productivity in Developing Countries*. (Baltimore: Johns Hopkins University Press).

Boame, A. K. (2004). The Technical Efficiency of Canadian Urban Transit Systems: *Transportation Research*, Part E. 40(5): 401 – 415.

Bravo-Ureta, B. and Pinheiro, E. (1997). Technical, Economic and Allocative Efficiency in Peasant Farming: Evidence from the Dominican Republic: *The Developing Economics*. XXXV-1: 48-67.

Buile, T. H. (2009). Impact of Financial Variables on the Production Efficiency of Pangasius Farms in AnGiang Province, Vietnam. M.Sc Thesis in Fishery and Agriculture Management and Economics (30ECTS). Norwegian College of Fisheries Science, University Of Toromso, Norway & NhaTrang University, Vietnam.

Business Resources (2013). How to Analyse Profitability. Retrieved from http://zionbusiness.resources centre.com.

Byiringiro, F. and Thomas, R. (1996).Farm Productivity in Rwanda: Effects of Farm Size, Erosion and Soil Conservation Investments. *Agricultural Economics*. 15(2):127-136.

Caliandro, H. H. (1978). The Effect of the Volume of Water Applied Annually as a Function of Irrigation Frequency on the Yield of Tomatoes. *Rivita Di Agromi*. 51: 215-222.

Canadian Agrifood Policy Institute (CAPI) (2009). Measuring Farm Profitability and Financial Performance. Retrieved July 7th, 2013 from http://www.capi-icpa.ca/pubs.html.

Central Bank of Nigeria (2010). *Annual Report and Statement of Accounts*, Abuja.

Cesaro, L, Marongiu, S, Arfini, F. and Capelli, M. G. (2009). Methodology for Analysing Competitiveness, Efficiency and Economy of Scale: Use and Applications of DEA FACEPA Deliverable, No. D5. 1.3.

Chambers, R. G. (1983). *Applied Production Analysis: A Dual Approach Cambridge:* Cambridge University Press.

Charnes, A.; Cooper, W. W. and Rhodes, E. (1981). Evaluating Program and Managerial Efficiency: An Application of Data Envelopment Analysis to Programme Follow Through. *Management Science*. 27(6): 668-697.

Charnes, A.; Clark. C. T.; Cooper, W. W. and Golany, B. (1985). A Developmental Study of Data Envelopment Analysis in Measuring the Efficiency of Maintenance Units in the United States Air Forces In: R.G Thompson and R.N. Thrall, eds., *Annals of Operations Research*. 2: 95-112.

Charnes, A, Cooper, W. W, Sun, D. B. and Huang, Z. M. (1990). Polyhectal Cone-Ratio Models with an Illustrative Application to Large Commercial Banks. *Journal of Econometrics*. 46: 73-91.

Charnes, A, Cooper, W. W.and Rhodes, E. (1978). Measurement of the Efficiency of Decision Making Units. *European Journal of Operational Research*. 2(6): 429-444.

Chavas, J. and Aliber M. (1993). An Analysis of Economic Efficiency in Agriculture: A Non-Parametric Approach. *Journal of Agricultural and Resource Economics*. 8(1): 1-16.

Chayanov, A. V. (1966). *The Theory of Peasant Economy* (Homewood, IL: Richard Irwin.

Chen, Y. (2005). Measuring Super-Efficiency in DEA in the Presence of Infeasibility. *European Journal of Operational Research*. 161: 545-551.

Cinemre, H. A, Ceyhan, V. K, Demiryurek, M. and Bozoglu K. O. (2006). The Cost Efficiency of Trout Farms in the Black Sea Region, Turkey. *Aquaculture*. 251: 324-332.

Coelli, T. J. and Battese, G. E. (1996). Identification of Factors Which Influence the Technical Efficiency of Indian Farmers. *Australian Journal of Agricultural Economics.* 40(2): 103-128.

Coelli, T.J., Rahman, S. and Thistle, C. (2002). Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: A non-parametric approach. *Journal of Econometrics.* 53(3): 607-626.

Cooper, W. W, Seiford, L. M. and Zhu, J. (2004). Data Envelopment Analysis: History Models and Interpretations In: *Handbook on Data Envelopment Analysis,* eds Cooper, W. W, Seiford, L. M. and Zhu, J. Chapter 1: 1- 39 Boston: Kluwer Academic Publishers.

Cornia, G. A. (1985). Farm Size, Land Yields and the Agricultural Production Function: An Analysis for Fifteen Developing Countries. *World Development*. 13(4): 513-534.

Crop Production and Value 2014. Kano River Irrigation Project.

Deidda, M. and Marras, G. (1973). Determining Interval and Volume of Watering for Canning Tomatoes as a Function of Soil Humidity. *Horticultural Abstract.* 21(2): 793-804.

Dhungana, B. R, Nuthall, P. L. and Nartea, G. V. (2004). Measuring the Economic Inefficiency of Nepalese Rice Farms Using Data Envelopment Analysis. *The Australian Journal of Agricultural and Resource Economics*. 48(2): 347–369.

Eastwood, R, Lipton, M. and Newell, A. (2006). Farm Size. Paper Prepared for Volume III of the Handbook of Agricultural Economics, University of Sussex.

Ebong, V. O, Okoro, U. S. and Effiong,E. O. (2009). Determinants of Technical Efficiency of Urban Farming in Oyo Metropolis of Akwa Ibom State, Nigeria. *Journal of Agriculture and Social Science.* 5: 89-92.

Ekong, E. E. (2003). *Rural Sociology: An Introduction and Analysis of Rural Nigeria*. Dove Educational Publishers, Uyo, Akwa Ibom State, Nigeria, Pp 34.

Ekunwe, P. A, Orewa, S. I. and Emokaro, C. A. (2008). Resource-Use Efficiency and Yam Production in Delta and Kogi States of Nigeria. *Asian Journal of Agricultural Research.* 2(2).

Elizabeth, J.Z. Robinson and Shashi L. Kolavalli (2010). The Case of Tomato in Ghana: "*Productivity*". GSSP Working Paper.19:9.

Ewulo, B. S, Ojeniyi, S. O. and Akanni, D. A. (2008). Effect of Poultry Manure on Selected Soil Physical and Chemical Properties, Growth, Yield and Nutrient Status of Tomato. *African Journal of Agricultural Research.* 3(9): 612-616.

Fagade, S. O. (2001). Yield gap and productivity decline in rice production in Nigeria. In Yield gap and productivity decline in rice production. Proc. of Expert consultation, Rome 5-7 Sept.2000, p. 357-377, FAO, Rome, Italy.

Fare, R, Grosskopf, S. and Lovell, C. A. K. (1985). *The Measurement of Efficiency of Production* Boston: *Kluwer Academic Publishers*.

Fare, R, Grosskopf, S, Lindgren, B. and Roos, P. (1994). Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach In:Data Envelopment Analysis: Theory, Methodology and Applications, A. Charnes, W.W. Cooper, A.Y. Lewin and Seiford, L.M. (eds). Boston:*Kluwer Academic Publishers:* Pp 253-272.

Fare, R, Grosskopf, S. and Weber, W. (1997). The Effect of Risk-Based Capital Requirements on Profit Efficiency in Banking. *Discussion Paper Series No. 97-112,* Department of Economics, Southern Illinios University, Carbondale.

Farrell, M. J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society,* Series A, General. 120(3): 253-290.

Fasoranti, M. M. (2006). A Stochastic Frontier Analysis of Effectiveness of Cassava-Based Cropping Systems in Ondo State, Nigeria. Ph. D. Dissertation, Department of Agricultural Economics and Extension, FUTA, Akure.

Ferdous A. and Murshed-e-Jahan, K. (2008). Resource Allocation Efficiency of the Prawn-carp Farmers of Bangladesh. *Aquaculture Economics and Management*. 12(3): 188-206.

Ferrier, G. D. and Lovell, C. A. K. (1990). Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence. *Journal of Econometrics*. 46: 229-245.

Frederick, K. D. (1992). Managing Water for Economic, Environment and Human Health. In: Damstadfer, J. (ed). Global Development and Environmental Perspectives on Sustainability: Resources for the Future, Washington D.C. Pp 67-68.

Food and Agriculture Organisation (2010). Food and Agriculture Organization *Bulletin of Statistics* htt/fao.org.

Gomez, A. A. (1975). Optimising Crop Production in Small Farms. Paper Presented at a Thursday, 2nd October. International Rice Research Institute (IRRI) Los banus, Phillipenes. Pp 26.

Haruna, U, Sani, M. H, Danwanka, H. A. and Adejo, E. (2012). Economic Analysis of Fresh Tomato Marketers in Bauchi Metropolis, Bauchi State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*. 8(3): 1-8.

Haruna, U. (2004). Prospects and Problems of Vegetable Production under Irrigation in the Fadama Areas of Bauchi State, Nigeria. Horticultural Society of Nigeria, Proceedings of the 22nd Annual Conference.

Henderson, D. (2003). The Measurement of Technical Efficiency Using Panel Data. Mimeo State University of New York at Binghamton, New York.

Hadejia Jama'are River Basin Development Authority (HJRBDA, 2013). Brief on Kano River Irrigation Project (KRIP), Phase I.

Hadejia Jama'are River Basin Development Authority/Federal Ministry of Water Resources and Rural Development, 2014 Crop Survey.

Hunt, D. (1979). Chayanovs Model of Peasant Household Resource Allocation, *Journal of Peasant Studies.* 6: 247-285.

Ibabu, S. C, Nwas, B. T. and Traxer, G. J. (1996). Irrigation Development and Degradation in Developing Countries: A Dynamic Model of Investment Decisions and Policy Options. IFPRI Paper. 337: 1-15.

Ibrahim, N. D. (2005). Insect infestation and control of thrips in onion in Sokoto State, Nigeria. A Ph.D. thesis submitted to the Department of crop protection, faculty of Agriculture, University of Ilorin, Ilorin, Nigeria.

Idiong, I. C. Agom, D. I, Effiong, E. O. and S. B. Ohen, S. B. (2009). Analysis of Technical and Economic Efficiencies in Rice Production Systems in the Niger Delta Region of Nigeria. In: Sustaining Agricultural Growth to Meet National Economic Development Goal *Proceedings of The 23rd Annual Conference of The Farm Management Association of Nigeria (FAMAN).*

Idumah, F. O. (2006). Productivity Differentials among Food Crop Farmers in the Niger Delta. Ph. D. Dissertation Department of Agricultural Economics University of Ibadan, Ibadan.

Imtiyaz, M, Mgalda, N. P, Chepete, B. and Manase, S. K. (2000). Response of Six Vegetable Crops to Irrigation Schedule. *Agricultural Water Management.* 45: 331-342.

Isah, H. (2012). Efficiency of Sole-Cowpea Production in Gombi Agricultural Development Programme Zone of Adamawa State, Nigeria. Unpublished M. Sc. Thesis. Department of Agricultural Economics and Extension, Modibbo Adama University of Technology, Yola, Nigeria. Pp. 24 - 25.

Jaliya, M. M, Sani, B. M, Lawal, A. O. and Murtala, G. B. (2007). Effect of Irrigation Frequency on Productivity of Heat Tolerant Tomato Varieties at Samaru, Zaria, Agricultural Engineering and Irrigation Programme, NAERLS/ABU, Zaria *13th National Irrigation and Drainage Seminar, Minna*. Pp. 105-108.

Jhingan, M. L. (2007). *Micro Economic Theory,* 6th Edition. Pp 307-311.

Johnson, N. L. and Welch, B. L. (1939). *Biometrika*. 31: 362-389.

Kaliba, A. R. and Engle, C. R. (2006). Productive Efficiency of Catfish Farms in Chicot County, Arkansas. *Aquaculture Economics and Management.* 10: 223-243.

Kano Agricultural and Rural Development Authority (KNARDA). 2002 Kano State Estimated Crop Production. Monitoring and Evaluation Unit.

Kano State Government (2012). Brief on Kano State. kano.gov.ng/new/index.php/2012-02-28-03-51-05/brief. Accessed on 10th January, 2013.

Kay, R. D, Edward, W. W. and Duffy, P. A. (2008). *Farm Management, Sixth Edition*, McGraw-Hill Companies, Inc. New York. International Edition, Printed in Singapore.

KRIP-WUCS (2014). Kano River Irrigation Project-Water Users Cooperative Society: Hadejia-Jama`are River Basin Development Authority, Kura Office.

Lenis, S. L, Oluyemisi, K. and Akeem, A. (2011). A Review of Literature on Agricultural Productivity, Social, Capital and Food Security in Nigeria: National Strategy Support Programme (NSSP), International Food Policy Research Institute (IFPRI), Washington D. C, USA. NSSP *Working Paper* No. 21.

Llewelyn, R. V. and Williams, J. R.(1996). Non-Parametric Analysis of Technical, Pure Technical and Scale Efficiencies for Food Crop Production in East Java, Indonesia. *Agricultural Economics*. 15: 113–126.

Lovell, C. A. K. and Rouse, A. P. B. (2003). Equivalent Standard DEA Models to Provide Super-Efficiency Scores. *Journal of the Operational Research Society*. 54: 101-108.

Maqbool, H. S, Shahid, I. and Sheik, A. D. (2012). Farm Size-Productivity Relationship: Evidence from Central Punjab. *Pakistan Economic and Social Review.* 50(2): 139-162.

Martin, P. E. (1966). Irrigation of Tomatoes in a Single Harvest Programme. *California Agriculture.* 20: 12-14.

Masterson, T. (2007). Productivity, Technical Efficiency and Farm Size in Paraguayan Agriculture. *The Levy Economics Institute Working Paper No. 490*.

Maurice, D. C. (2004). Resource Productivity in Cereal Crops Production Among Fadama Farmers In Adamawa State, Nigeria. Unpublished M. Sc. Thesis Submitted to the Department of Agricultural Economics and Extension, University of Maiduguri, Nigeria.

Mbanasor, J. A. and Kalu, K. C. (2008). Economic Efficiency of Commercial Vegetable Production System in Akwa Ibom State, Nigeria: A Stochastic Frontier Cost Function Approach. *Tropical and Subtropical Agrosystems*. 8(3): 313-318.

Mshelia, S. I, Iheancho, A. C. and Iliyasu, A. (2005). Economic Analysis of Paddy Rice Processing in Adamawa State, Nigeria. *Journals of Sustainable Development in Agriculture and Environment*. 1: 19-21.

Muhammad, L.A. and Atte, O.A. (2006) Analysis of Agricultural production in Nigeria. African Journal of General Agriculture, Vol.2, No.1. Nigeria.

Muhammad, H.U., Umar, B. F., Abubakar, B.Z. and Abdullahi, A.S. (2011). Assessment of Factors Influencing Beneficiary Participation in Fadama II Project in Niger State, Nigeria. *Nigerian Journal of Basic and Applied Science,* 19 (2): 248-252.

Murillo-Zamarano, L. (2004). Economic Efficiency and Frontier Techniques. *Journal of Economic Survey*. 18(1): 33-77.

Murthy, D. S, Sudha, M, Hegde, M. R. and Dakshina, M. (2009). Technical Efficiency and its Determinants in Tomato Production in Karnataka, India: Data Envelopment Analysis (DEA) Approach. *Agricultural Economics Research Review.* 22: 215-224.

National Agricultural Extension Research Liaison Service (NAERLS) (1989). "Production of Tomato", *An Extension Bulletin of National Agricultural Extension Research Liaison Service* No. 20.

Nasiru, M. O. (2010). Microcredit and Agricultural Productivity in Ogun state, Nigeria . *World Journal of Agricultural Sciences. 6(3): 290-296.*

National Population Commission (NPC) (2006). Population Census of the Federal Republic of Nigeria. *2006 Census Report* National Population Commission, Abuja.

Nwadukwe, P. O. (1986). Tomato Root Growth and Distribution as Affected by Irrigation, Frequency and Ground Water Table Depth. Unpublished M. Sc. Thesis Presented to School of Postgraduate Studies, Ahmadu Bello University, Zaria. Pp 88.

Ogundari, K.; Ojo, S. O. and Ajibefun, I. A. (2006). Economics of Scale and Cost Efficiency in Small Scale Production: Empirical Evidences from Nigeria. *Journal of Social Sciences*. 13(2):131-136.

Ogunniyi, L. T. (2011). Economic Efficiency of Leafy Vegetable Production in Oyo State, Nigeria. *Report and Opinion* 3(1) http://www.sciencepub.net/report.

Ojo, A. (2005). Economic Analysis of Irish Potato Production Innovations among Contract Farmers In Plateau State. M. Sc. Thesis, Department of Agricultural Economics and Extension, Ahmadu Bello University, Zaria.

Ojo, M. A, Ibrahim, O. A. and Mohammad, U. S. (2009). Profitability and Production Function of Small Scale Irrigated Tomato Production in Niger State, Nigeria. *Continental Journal of Agricultural Economics.* 3: 16-22.

Okafor, F. C. and Andrew, G. O. (1994). *Rural Systems and Land Resources Evaluation for Africa*. Benin: The Benin Social Series for Africa, pp. 75-86.

Okoruwa, V. O.; Akindeinde, A. O. and Salimonu, K. K. (2009). Relative Economic Efficiency of Farms in Rice: A Profit Function Approach in North Central Nigeria. *Tropical and Subtropical Agro-systems.* 10: 279-286.

Okoye, B. C.; Asumugha, G. N. and Mbanasor J. A. (2009). *Cost and Return analysis of Cocoyam Production at National Root Crops Research Institute, Umudikwe, Abia State, Nigeria.* Pp 17363. http://mpra.ub.uni-muenchen.de/17363.

Okunlola, J. O. and Adekunle, O. A. (2000). Indigenous Knowledge Approach for Rice Pests and Disease Control by Rice Farmers in Niger State, Nigeria for Sustainable Environmental Management.

Oladeebo, J. O. (2006). Economic Efficiency of Rain-Fed Upland Rice Production in Osun and Oyo States of Nigeria Ph. D. Dissertation. Department of Agricultural Economics and Extension, FUTA, Akure.

Oladejo, O. B. (2005). *Food Crop Production in Selected Local Government Areas of Kwara State.* B. Sc. Project Submitted to the Department of Agricultural Economics OAU, Ile-Ife, Osun State, Nigeria.

Olanrewaju, D. and Swarup, V. (1983).Tomato Cultivation and it's Potential in Nigeria. National Horticultural Research Institute, Idi-Ishin, Ibadan, Nigeria, *Occasional Paper* No. 10 ISSN 0795-4123.

Olukosi, J. O. and Erhabor, P. O. (1988). *Introduction to Farm Management: Principles and Applications* Agitab Publishers, Zaria, Nigeria. Pp 77-80.

Oluwatosin, F. M. (2011). Measuring Technical Efficiency of Yam Farmers in Nigeria: A Stochastic Parametric Approach. *Agricultural Journals.* 6(2).

Oluyole, K.A., Oni, O.A., Omonona, B.T. and Adenegan, K.Q. (2009). Food Security among Cocoa Farming Households of Ondo State, Nigeria. *ARPN Journal of Agriculture and Biological Science.* 4(5):7-14.

Omonona, B. T, Egbetokun, O. A. and Akanbi, A. T. (2010). Farmers Resource-Use and Technical Efficiency in Cowpea Production in Nigeria. *Economic Analysis and Policy*. 40(11).

Oni, O, Pender, J, Phillips, D. and Kato, E. (2009). Trends and Drivers of Agricultural Productivity in Nigeria. *Nigeria Strategy Support Programme* (NSSP) Report 001:IFPRI.

Otitoju, M. and Arene, C. J. (2010). Constraints and Determinants of Technical Efficiency in Medium Scale Soyabean Production in Benue State, Nigeria. *African Journal of Agricultural Research.* 5(17): 2276-2280.

Oviasogie, D. I. (2005). Productivity in Yam-Based Farming System in Edo State, Nigeria. M. Sc. Thesis, Department of Agricultural Economics, FUTA, Akure.

Oyekanmi, M.O. (2010). Determinants of post-harvest losses in tomato production. *Journal of Life and Physical Science.* ACTA SATCH 3(2): 1418.

Oyewa, I. O, Rauf, M. O, Ogunwole, F. and Balogun, S. O. (2009). Determinants of Maize Production among Maize Farmers in Ogbomoso South Local Government Area Oyo State. *Medwell Agricultural Journals*. 4(3): 144-149.

Oyinlola, E.Y. and I.A. Aliyu, (2005). *Effect of Town Waste and Fertilizer on Tomato Plant. Chem class Journal.* 2:32-35.

Phene, O. J, Devias, K. R, Hunmacher, R.B. and Pierro, J. D. (1989). Water Fertility Management for Surface Drip for Irrigated Tomatoes. *Proceedings of The International Symposium on Integrated Management Practice*, (AVRDC), Shenhua, Taiwan. Pp 323-338.

Pierce, J. T. (1990). *The Food Resource: Themes in Resource Management*, Longman Group Ltd. London, U.K. Pp 226.

Pill, W. G. and Lambeth, V. N. (1980). Effect of Soil Water Regime and Nitrogen Form on Blossom and Rot, Yield Relation and Elemental Composition of Tomato. *Journal of American Society of Horticultural Science*. 105(5): 730-735.

Sajjapongose, A, Ota Y, Roam, Y.C. and Wu, C.C. (1989). Some Aspects of Management in Tomato. *Tomato and Pepper Production in the Tropics, AVRDS*, Taina. 354: 209-211.

Sani, M. H. and Haruna, U. (2010). Planning Model for Sustainable Vegetable Crop Production in the Eastern Part of Kogi State, Nigeria. *Journal of Agronomy*. 9(1): 17-22.

Samaila, A. A, Amans, E. B. and Babaji, B. A. (2011). Yield and Fruit Quality of Tomato (*Lycopersicum esculentum* Mill) as Influence by Mulching, Nitrogen and Irrigation Interval. *International Research Journal of Agricultural Science*. 1(3): 90-95.

Sen, A. K. (1966). Peasants and Dualism With or Without Surplus Labour. *Journal of Political Economy*. Pp 74.

Sen, A. K (1975). *Employment, Technology and Development*. Oxford: ILO and Clarendon Press.

Sen, A. K. (1981). Market Failure and Control of Labour Power: Towards an Explanation of Structure and Change in Indian Agriculture. *Part I Cambridge Journal of Economics*. 5: 201-228.

Shankara, N, Joep Van Lidt, D. J, Marja, D. G, Martin, H. and Barbara, V. D. (2005). Cultivation of Tomato: Production, Processing and Marketing, *Agrodok 17, Agromisa Foundation and CTA*, Wageningen.

Sharma, P. V, Staal, S, Delgado, C. and Singh,R. V. (2003). Policy, Technical, Environmental and Implication of Scaling-up of Milk Production in India. *Annex in Research Report of International Food Policy Research Institute (IFPRI)*, Food and Agriculture Organisation. Livestock Industrialisation Project Phase II, Washington D. C.

Shehu, J. F, Iyortyer, J. T, Mshelia, S. I. and Jongur, A. U. (2010). Determinants of Yam Productivity and Technical Efficiency among Yam Farmers in Benue State Nigeria. *Journal of Social Science.* 24(2).

Sufian, F. (2007). Bank Mergers Performance and the Determinants of Singapore Banks Efficiency. *Gajah Mada International Journal of Business.*9 (1):19–29.

Thomas, D. 1990. Intra-Household Resource Allocation an Inferential Approach. *Journal of Human Resources 25 (4): 635-64.*

Thompson, R. G, Singleton, F, Thrall, R. and Smith, B. (1989). Comparative Site Evaluations for Locating a High-Energy Physics Laboratories in Texas. *Interfaces*. 16(6): 35-49.

Umar, R. L. (1999). Effect of Irrigation Interval and Plant Density on the Growth and Yield of Two Tomato Cultivars at Samaru, Nigeria. Unpublished M. Sc. Thesis Presented to School of Post-Graduate Studies, Ahmadu Bello University, Zaria Pp 65.

Usman, J. and Bakari, U.M. (2013).Profitability of Small Scale Dry Season Tomato (*Lycopersicon esculentum* Mill.) Production in Adamawa State, Nigeria. *ARPN Journal of Science and Technology*.3 (6):604-612.

United States Agency for International Development (USAID) (2009) Extension Guide on Pesticide Application. PP 1-5.

Werner, J. (1993). Participatory Development of Agricultural Innovations: Procedures and Methods On-farm Research, GTZ, Eshborn, Germany. Pp 251.

Zbinden, S. and Lee, D. R. (2005). Paying for Environmental Services: An Analysis of Participation in Costa Rica's PSA Program. *World Development.* 33: 255-272.

Zhu, J. (2004). Super-efficiency and Data Envelopment Sensitivity Analysis. *European Journal of Operational Research*. 129: 443-455.

Zalkuwi, J., Maurice, D.C., Garba, A., and Usman, J. (2012). Profitability of small-scale Dry Season Tomato Production in Guyuk Local Government Area of Adamawa State, Nigeria. *Journal of Technology and Education Research* (JOTER). 5(1): 2006-3148.

APPENDIX I: RESEARCH QUESTIONNAIRE

Dear Sir/Madam,

I am a post graduate student ((M.Sc) of the above named department carrying out a research on the topic: ECONOMICS OF SIZE IN IRRIGATED TOMATO PRODUCTION UNDER KANO RIVER IRRIGATION PROJECT (KRIP) Phase I. Please I will be grateful if you will prove the following information. Information given would be treated with utmost confidentiality and for the purpose of this research only. Thank you for the cooperation.

Village/Community…… L.G.A …….

Enumerator`s Name…….....G.S.M No. ……..

Kindly tick (√) or fill in the blank space as appropriate:

A. SOCIO –ECONOMICS CHARATERISTICS

1. Name of farmer…….. G.S.M No. (If available) ……

2. Sex: Male ( ) Female ( )

3. Age (years)……..

4. Marital status: Married ( ) Single ( )

5. Highest level of Education:

   (a) Non Formal Education ( ) (b) Primary school Education ( ) (c) Secondary School Education ( ) (d) Tertiary Education ( )

6. Family Size (All the number of the people depending on you for living)…….

   (a) No. of Adult Male ( ) (b) No. of Adult female ( ) (c) Children 16yrs and above ( ) (d) Children 1-15yrs ( )

7. How long have you been in irrigated tomato farming? (Years of experience)……

8. Do you belong to any Co-operative/Association? Yes ( ) No ( )

9. If yes, (Years of participation) ----------

10. What benefit did you derive as a member? ……..

11. What is your major source of capital for irrigated tomato farming?

    a .Personal savings ( ) b. Credit (borrowing) ( ) c. Gift from friends and family ( ) d. Money Lenders ( )

12. If you borrow, what was/were the source(s) of the credit?

    a. Commercial Bank ( ) b. Bank of Agriculture ( ) c. Cooperative Society ( ) d. Money Lenders ( ) e. Friends and Family ( ) f. Others (specify)……

13. How much did you borrow to finance last production? (Fill for the source you indicated in Q .12)

SOURCE OF LOAN	AMOUNT(₦)	INTERST RATE (%)
Commercial Bank		
Bank of Agriculture		
Cooperative Societies		
Money Lenders		
Friends And Family		
Others (Specify)		

14. Have you been visited by an Extension Agent? Yes ( ) No ( )

15. If Yes, How many times in last one year?.....

16. What activities did the agent teaches you? .....

17. Of what benefit were the techniques learnt by you to the success of your farm?

……

18. Have you been trained on irrigated tomato farming? Yes ( ) No ( )

19. If Yes, which organization conducted the training?.....

20. Was the training beneficial to you?

a. Not beneficial ( ) b. somehow beneficial ( ) c. beneficial ( ) d. very beneficial ( )

21. Any other assistance from government or private organisation? Yes ( ) No ( )

22. If 21 above is yes, what kind of assistance …….

23. How do you source your seedlings?

a. by self production ( ) b. by buying from other producers ( )

24. If the answer above is (b), how much do you buy a basin and how many basins did you buy?

B. INFORMATION ON INPUTS

(I) Information on Farm:

(i) What is the size of your tomato farm? .....

(ii). How did you acquire your land? *(Tick below):*

Mode of Acquisition					
(a) Inheritance	(b) Lease	(c) Borrowed	(d) Gift	(e) Purchased	(f) Hiring

(II) Variable inputs (Last production Cycle):

(i)Seed (Kg):

Quantity of Seed(Kg)	Cost (₦)

(ii).Fertilizer:

Fertilizer type	Quantity(Kg)	Cost(₦)

(iii).Agrochemicals:

Agrochemical type	Quantity(litres)	Cost(₦)

(iv) Labour input:

(a) Land preparation/Seedling of Nursery (if applicable):

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

(b)Sowing of seeds in Nursery (if applicable):

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

(c) Fertilizer Application to Nursery (if applicable):

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

(d) Weeding in the Nursery (if applicable):

Number of weeding	Hire Labour			Family Labour		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost(₦)
1st						
2nd						
3rd						

(e) Land preparation (Main farm):

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

How much is tractor hiring in your area per hectare?.....and how many times did you hire a tractor?.....

(f)Transplanting to Main field:

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

(g) Weeding in the Main field:

Number of weeding	Hire Labour			Family Labour		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost(₦)
1st						
2nd						
3rd						

(h)Fertilizer Application to Main field:

Number of applications	Hire Labour			Family Labour		
	No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)
1st						
2nd						
3rd						

(i).Replacement/Thinning of seedling planted:

Hire Labour			Family Labour		
No of people	No of Hours	Cost (₦)	No of people	No of Hours	Cost (₦)

(j)Irrigation:

Labour			
No. of people	No. of hours	No. of times of irrigation	Cost(₦)
`			

(K) Spraying:

Labour			
No. of people	No. of hours	No. of times of spray	Cost(₦)
`			

(I) Information

Number of times of Harvest	No. of output produced(Basket)	Total Qty sold	Price (₦)
1st			
2nd			
3rd			
4th			
5th			
6th			
7th			
8th			
9th			
Total of baskets			

25. What does it cost to rent one Hectare of land per irrigation season in your village? ....…..... Naira

26. When do you sell your produce?

a. immediately after harvesting ( ) b. Few months after harvest ( ) c. Off season ( )

27. Where do you sell your produce?

a. Farm gate ( ) b. Rural market ( ) c. Urban market ( )

28. How much do you sale the farm debris/remains per hectare?

29. How much is tax per basket to rural market? …….. and to urban market? …….

30. How many baskets did you take to rural market? ……. and to urban market? ……

31. How much do you pay for transporting a basket to rural market?..... and to urban market?

32. Any cost incurred during transfer of seedlings to the main field? If yes, how much……..

33. Please kindly indicate the farm tools/implements you own and use and provide other related information

S/N	Farm Tool/Implement	Cost of Purchased (₦)	Date Purchased	Current Value (₦)	Value of Renting/month (₦)

34. Constraints faced by irrigated tomato farmers:

S/N	Constraint	Ranking according to severity 1=least severe, 2=moderately severe, 3= severe, 4= more severe, 5= most severe.	Coping Strategy
1			
2			
3			
4			
5			
6			

Thank You For Your Attention

APPENDIX II: SOME APPROXIMATIONS/AVERAGES USED IN THIS RESEARCH:

i. Weight of "Kano Basket" with tomato	40kg
ii. Price of "Kano Basket" with Tomato	₦2,000
iii. Sachet of 10gram tomato seed	₦200
iv. Cost of labour per day	₦500
v. Bag of fertilizer (50kg)	₦4,700
vi. One litre of pesticide	₦1,250
vii. Cost of empty basket	₦300
viii. Cost of Hoe	₦1,600
ix. Cost of harvesting per basket	₦150
x. One hectare of farm debris/remains sold to cattle rearers	₦10,000