ECONOMIC ANALYSIS OF WATERMELON *(Citrillus lanatus)* PRODUCTION IN SELECTED LOCAL GOVERNMENT AREAS OF KANO STATE, NIGERIA

By

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

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DECLARATION

I hereby declare that this thesis titled "**Economic Analysis of Watermelon (*Citrillus lanatus*) Production in Selected Local Government Areas of Kano State, Nigeria"** has been written by me and it is a record of my own research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed ideas have been duly acknowledged in the text and a list of references provided.

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Student

CERTIFICATION

This thesis titled**: "Economic Analysis of Watermelon (*Citrullus lanatus)* Production in Selected Local Government Areas of Kano State, Nigeria"** by Muhammad Babatunde Adeniyi **ALFA-NLA,** meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my parents; Sheikh Musa, Alfa-Nla of blessed memory and Alhaja Amina Iya'gba who both have been my source of inspiration.

I also dedicate this to my dear loving wife, Hajia Rasheedah Tinuke, who has been very understanding and supportive as well as my kids who have always been encouraging.

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My foremost sincere appreciation and gratitude are due to Almighty Allah, the one without a partner, the creator of the universe for His blessing, protection and guidance which has successfully seen me through up till today.

"Say: "Nothing shall ever happen to us (nothing can ever be achieved) except what Allah has ordained for us. He is our '***Maula'*** (Lord, Helper and Protector)." And in Allah let the believers put their trust."   At-Taubah, Ch 8: V 51

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ABSTRACT

This study estimated the costs and returns, the input-output technical relationship, as well as constraints associated with watermelon production in some selected Local Government Areas of Kano State of Nigeria. Field survey was conducted in four local government areas (Bunkure, Kura, Wudil and Bichi) where structured questionnaires were administered to 200 respondents to generate the data used. The data were analyzed by the use of descriptive statistics, gross margin analysis and stochastic frontier production function. The results showed that, the average net farm income per hectare for watermelon was ₦25,422.98k and the average rate of return was 1.46 showing that, watermelon production is profitable in the study area. The inputs of farm size, seed, fertilizers and agrochemicals were positive and significant at 1% level of probability, while labour was negative and not significant. The socio-economic variables of age, education, years of farming experience and credit were significant at 5% level of probability. The major constraints to watermelon production were lack of improved seeds, activity of middlemen, lack of credit facilities and high cost of inputs.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Watermelon (*Citrullus lanatus*) is one of the most widely cultivated crops in the world at large. According to FAO (2011) statistics, China is the world's leading producer of watermelon. The top twenty leading producers of watermelon produced a collective volume of approximately 92.7 million metric tonnes in 2011, of which China produced 75%. Turkey, Iran and Brazil commanded a production share (of the 20 leading producers) of 4.7%, 3.5% and 2.4% respectively in 2011. Nigeria produced more watermelons in 2011 (139,223 tons) than the leading fresh produce African exporter, Kenya, which produced 66,196 tons and South Africa that produced 77,993 tons (This Day Live, 2014). There are over 1,200 varieties of watermelon worldwide and quite a number of these varieties are also cultivated in Africa (Zohary and Hopf, 2000). The global consumption of the crop is greater than that of any other cucurbit.

Watermelon is a tender, warm season vegetable belonging to the family Cucurbitaceae. It is enjoyed by many people across the world as fresh fruit. It is highly nutritious and thirst-quenching and also contains vitamins C and A in the form of disease-fighting beta-carotene. Watermelon is rich in carotenoids, some of the carotenoids of which include lycopene, phytofluene, phytoene, beta-carotene, lutein and neurosporene. Lycopene and beta-carotene work in conjunction with other plant chemicals not found in vitamin/mineral supplements. Potassium is also available in it which is believed to help in the control of blood pressure and possibly prevention of stroke (De Lannoy, 2001). Lycopene is what gives watermelon its rich, red colour and is associated with reduced risk of developing muscular degeneration, prostate challenges, and a variety of other degenerative conditions. Beta carotene is another powerful antioxidant that can help to protect body cells against damage by free radicals (Kim, 2008).

Watermelon seeds are excellent sources of protein (both essential and non-essential amino acids) and oil. The largest production of the crop comes from the northern part of Nigeria where suitable agro-ecology is found. The potentials of watermelon as a cash-producing crop are enormous for farmers, especially those residing near the urban areas (Adekunle *et al.*, 2003).

1.2 Problem Statement

Recent reports indicated that exotic fruits such as watermelon production generate higher profit and provide more employment and income to the farmers than those of indigenous vegetables. Food supply in Nigeria has not been able to keep pace with population growth. Shortages of horticultural produce especially fruits are often very acute because of low levels of technology in production, harvesting and storage as well as increasingly high demand for fruits arising from rapidly improving standard of living (Ndubizu, 2008). Production of fruit crops such as watermelon has been low despite its nutritional and commercial value. This low production of watermelon calls for a close examination of the profitability of producing the crop and analysis of the resources used in its production.

The following research questions were raised by this research:

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

ii. What are the costs and returns in watermelon production?

iii. What is the technical relationship between inputs used and the resultant output and the determinants of technical inefficiency in watermelon production?

iv. What is the distribution of technical efficiency in watermelon production?

v. What are the constraints to watermelon production in the study area?

1.3 Objectives of the Study

The broad objective of this study was to examine the economics of watermelon production in the study area. The specific objectives were to:

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

ii. estimate the costs and returns in watermelon production;

iii. determine the input – output technical relationship in watermelon production and the determinants of technical inefficiency in watermelon production;

iv. describe the distribution of technical efficiency in watermelon production; and:

v. identify and describe the constraints to watermelon production in the study area.

1.4 Justification of the Study

The resultant objective of this study is to provide necessary framework for present watermelon producers by critically examining their mode of production and profitability, so as to improve on their profit margin. Watermelon has the potential of not only increasing the income and standard of living of the producers but also contributing to the nation's GDP. However, its overall production inefficiency can seriously affect the production and realization of its potential. The profitability of this agricultural enterprise could only be improved upon if the current level of productive activities is known. Moreover, the absence of good data about the operations of the smallholder watermelon farmers may have prevented prospective large-scale farmers from venturing into this business. Therefore, estimating the farm level production efficiency can provide an understanding of the level of technical and economic efficiencies which can assist in policy formulation. This study therefore, will generate information that will serve as a database for both present and prospective watermelon producers on inputs that positively affect watermelon production and its profitability, as well as assist policy makers in formulating efficiency-based policies with better production plan. The study will contribute greatly to the existing body of knowledge on watermelon production with a view to improving its production and also serve as a baseline for further research work.

1.5 Limitations of the Study

The survey experienced several problems common to many fieldwork experiences. The most serious problems were:-

(i) Lack of record keeping by the farmers – The culture of farm record keeping is not practised by the respondents. All the farmers interviewed provided the needed information from memory.

(ii) Financial constraints on the side of the researcher – This has limited the researcher to only 4 LGAs out of the 44 LGAs in the State and only 200 respondents out of the population of watermelon farmers in the state. The researcher is fully aware that the larger the sample size, the more the representativeness of the population and the more accurate the parameters of the population will be estimated.

(iii) Some farmers' unwillingness and reluctance or even providing false answers to some questions might be a kind of limitation in getting good and accurate information.

CHAPTER TWO

LITERATURE REVIEW

2.1 Origin and Distribution of Watermelon

Watermelon (C*itrullus lanatus*) belongs to the family Cucurbitaceae (Schippers, 2000). Its centre of origin has been traced to both the Kalahari and Sahara deserts in Africa (Jarret *et al*.,1996) and these areas have been regarded as points of diversification to other parts of the world (Schippers, 2000). In Nigeria, though there are no official figures recorded for its production, the crop has a wide distribution as a garden crop, while as a commercial vegetable production; its cultivation is confined to the drier savanna regions of Nigeria (Anon, 2006).

Watermelon is grown in more than 96 countries worldwide. China is the world's leading producer of watermelon, with 70.3 % of the total production in 2003. Other leading countries are Turkey (4.7 %), Iran (2.3 %), the United States (2.2 %) and Egypt (1.7 %), (FAO 2003).

2.2 Historical Review of Watermelon

Watermelon is thought to have originated in the Kalahari Desert of Africa. The first recorded watermelon harvest occurred nearly 5,000 years ago in Egypt and is depicted in Egyptian hieroglyphics on walls of their ancient buildings. Watermelons were often placed in the burial tombs of kings to nourish them in the afterlife (Produce Pete, 2008).

From there, watermelons spread throughout countries along the Mediterranean Sea by way of merchant ships. By the 10th century, watermelon found its way to China, which is now the world's number one producer of watermelons.

Watermelon is a vine-like (scrambler and trailer) flowering plant originally from southern Africa. Its fruit, which is also called watermelon, is a special kind referred to by botanists as a pepo, a berry which has a thick rind (exocarp) and fleshy center (mesocarp and endocarp). Pepos are derived from an inferior ovary, and are characteristic of the Cucurbitaceae. The watermelon fruit, loosely considered a type of melon – although not in the genus Cucumis - has a smooth\exterior rind (usually green with dark green stripes or yellow spots) and a juicy, sweet interior flesh (usually deep red to pink, but sometimes orange, yellow, or white).

Watermelon belongs to Cucurbitaceae family, which consists of nearly 100 genera and over 750 species (Yamaguchi, 1983). They are widely distributed in the tropics and subtropics, and a few species occur in the temperate region. Watermelon grows well in alluvial and sandy soils, even in arid regions and coastal saline areas. In the gigantic plains, early sowing is done in November and extended up to February; in South and Central India watermelon is grown almost throughout the year. Watermelon is a major cucurbit crop that accounts for 6.8% of the world's area (second behind tomato) devoted to vegetable production in 2005. A rough estimate of annual world value of watermelon exceeds $ 15 billion. The total production of cucumber, melon and watermelon has increased more than fourfolds in the last 40 years (FAO, 2006).

Watermelon is the most popular cucurbits, followed by cucumber, and melon (FAO, 2005). Watermelon is originally from Africa and grown in more than 96 countries worldwide. China is the world's leading producer of watermelon, with 70.3% of total production in 2005. Other leading producer countries are Turkey (4.7%), Iran (2.3%), United States (2.2%) and Egypt (1.7%). Watermelon is an economically important fruit crop and valuable alternative source of water in desert areas.

The long and general culture of the watermelon from North Africa to middle Asia led to the view that it was of Asiatic origin, although it had never been found wild in Asia or elsewhere. Finally, however, about a hundred years ago, the great missionary-explorer, David Livingstone, settled the question of its origin. He found large tracts in central Africa literally covered with watermelons growing truly wild (Boswe ll, 2000).

2.3 Areas of Watermelon Production

In Africa, watermelon is grown not only in dry, low altitude tropical areas like Cape Verde, Mali, Mauritania, Chad, Senegal and Nigeria, but also in equatorial countries like Gabon and Democratic Republic of Congo (De Lannoy, 2001). In Nigeria, watermelon production has increased significantly in the last one decade with the major production areas being located in the Sahel, Sudan and Guinea agro-ecological zones. In recent times, its cultivation has extended down to the forest belts of southwestern Nigeria (NIHORT, 2006). However, the northern fringes of the Sudan and Sahel savanna ecological zones and the shores of the Lake Chad remain the major production areas (NIHORT, 2000).

2.4 Nutritional Value of Watermelon

Watermelon is 92% water and 8% sugar. It is rich in lycopene, an antioxidant that gives it its characteristic color. It is fat free (Medicine Net, 2004). Watermelon can be processed and used for juice syrups and sweets. From the seeds it is possible to extract oil rich in vitamin D. Their sugar content boosts our energy so we are more positive in any aspect. High water content cleans human organism and does well for our urinary and digestive system. It is obvious that using watermelons in our regular diet is very healthy as it has positive curing effect on coronary, liver, gold bladder and kidney patients. Half kg of fruit can satisfy our daily need in vitamin C. Other than 85% water content it contains 7-15% of sugar, also minerals, vitamins and little bit of proteins as well. Vitamins present are carotenes, vitamin B complex and traces of C vitamin. Mineral content present are potassium, magnesium, phosphorus, calcium, zinc, iron, and cuprum. It is a good source of carotenes and lycopens as well. Apart from nutrient value, it is also important as natural medicine source (Ignjatovic, 2005).

Watermelon is rich in carotenoids. Some of the carotenoids in watermelon include lycopene, phytofluene, phytoene, beta-carotene, lutein and neurosporene. Lycopene makes up the majority of the carotenoids in watermelon. The carotenoid content varies depending on the variety of the watermelon. Depending on the variety, carotenoid content in red fleshed watermelon varies from 37 – 121 mg/kg fresh weight, where as lycopene varies from 35 – 112 mg/kg fresh weight (HonCod, 2008).

Not only is watermelon packed with thirst-quenching water and natural sweetness, it is an excellent source of two powerful antioxidants: lycopene, and beta carotene. Lycopene is what gives watermelon its rich, red colour and is associated with reduced risk of developing muscular degeneration, prostate challenges, and a variety of other degenerative conditions. Beta carotene is another powerful antioxidant that can help to protect your cells against damage by free radicals (Kim, 2008).

Watermelon seeds are excellent sources of protein (both essential and non-essential amino acids) and oil. Watermelon seed is about 35% protein, 50% oil, and 5% dietary fiber. Watermelon seed is also rich in micro- and macro-nutrients such as magnesium, calcium, potassium, iron, phosphorous, zinc etc (HonCod, 2008).

The seeds are eaten as a snack or added to other dishes and may be roasted and seasoned. The rind is edible and may be stir-fried, pickled or even grilled. Beyond these values, the watermelon plant provides aesthetic delight and the fruit appeals to the senses of taste, sight and touch. Ecologically, the watermelon flowers provide a source of nectar and pollen for bees (New World Encyclopedia, 2008).

In some African cuisines, however, watermelons are served as a cooked vegetable. Watermelon seeds are ground into flour and baked as bread in some parts of India. In addition, watermelon is also used as feed for livestock. The seeds and flesh are used in cooking (Robinson and Decker-Walters, 1997; Rubatzhy and Yamaguchi, 1997).

Watermelon has the highest lycopene content among fresh fruits and vegetables; watermelon contains 60 % more lycopene than tomato. Lycopene in the human diet is associated with prevention of heart attacks and certain cancers. Watermelon rind contains an important natural compound called citrulline, an amino acid that the human body makes from food. Citrulline is found in high concentration in the liver, and is involved with athletic ability and functioning of the immune system (Perkins-Veazie *et al*. 2001).

2.5 Watermelon Varieties

Watermelon is grown in more than 96 countries worldwide (Produce Pete, 2008). There are about 1200 varieties of watermelon grown worldwide; giving consumer's a wide choice to choose from. There is great variation within varieties ranging from small bitter inedible fruits to large succulent sweet fruits. The varieties vary in vigour, earliness and productivity; shape, colour and marking of fruits; thickness and texture of rind; colour, texture, flavour and sugar content of flesh; size, colour and number of seeds (Purseglove, 1972). Watermelon varieties fall into three broad classes based on how the seed was developed: open-pollinated, F_1 hybrid and triploid (seedless).

Open-pollinated varieties are developed through several generations of selection. The selection can be based upon yield, quality characteristics and disease resistance. Open-pollinated varieties have true-to-type seed (seed saved from one generation to the next will maintain the same characteristics) and are less expensive than F_1 hybrid varieties.

F_1 hybrids are developed from two inbred lines that have been self-fed for several generations and then crossed, with the subsequent seed sold to growers. F_1 hybrid seed will exhibit increased uniformity of type and time of harvest compared with open-pollinated seed and can exhibit as much as a 20 percent to 40 percent increase in yields over open-pollinated varieties grown under similar conditions. The disadvantages of F_1 hybrid seed are cost and availability. F_1 hybrid seed will be as much as five to 10 times as costly as open-pollinated seed, and available F_1 hybrid varieties will change from year to year.

The third type is triploid or seedless watermelon. These are developed by creating watermelon plants with double the usual chromosome number and crossing them with normal watermelon plants. The resulting plants have one-and-a-half times the normal chromosome number. Because they have an odd number of chromosomes, they cannot form viable seed. In addition, they produce very little pollen; therefore, normal watermelon must be planted with triploid watermelon as a source of pollen. Although triploid watermelons are referred to as seedless, they are not truly seedless but rather have undeveloped seeds that are soft and edible. Triploid seeds will be even more expensive than F_1 hybrid seeds (Boyhan, *et al.,* 2008) Melons weighing 25 to 40 pounds are most popular in America; there are other varieties such as Baby Delight, Northern Sweet, and Sweet Siberian grown in different parts of the world (Boswell, 2000).

"Seedless" watermelons have been produced experimentally in recent years by two wholly different methods, neither of which appears practical as yet for use by farmers and gardeners (Boswell, 2000).

Seeded varieties such as Sangria and Fiesta are popular as well as all-sweet hybrids that are oblong and dark green with broken light green stripes. The flesh is bright red with black seeds. Calsweet, the most popular open-pollinated variety, has striped skin and red flesh. Also grown is the hybrid Royal Sweet, with striped skin and dark pink flesh. Sultan is an early-maturing, high-yielding hybrid. Icebox watermelon varieties grown in the northern San Joaquin Valley include Sugar Baby, Baby Doll, and Tiger Baby (Mayberry, *et al.,* 2008). Grattidge *et al.,* (2001) summarized the different varieties of watermelon in a tabular form as given in Table 2.1.

Table 2.1: Varieties of watermelon

Large Types	Mini Melons	Yellow Champagne	Seedless
Red Tiger	Gemini	Yellow Doll	Honey heart (yellow)
Bengal Tiger	Minilee (O.P.)	Orange Dragon	Raven (red)
Phantom	Baby lee	Champagne	Dragon Heart (red)
Pharaoh	Baby Tiger		Triple Heart (red)
Red Dragon	Sugar Baby		Banquet (red)
Genghis			Golden acre (yellow)
Hercules			Seedless 1600

2.6 Economic Importance and Uses of Watermelon

In certain semi-desert districts, the watermelon is an important source of water to the natives during dry periods; even today there are districts in Africa where it is cultivated for that purpose (Boswell, 2000).

Greatly oversized watermelons have no sound market value. They are too difficult to handle without damage or wastage; most customers do not want them; and they are likely to be inferior in quality to those of normal size. Modern emphasis is upon high quality of garden products rather than mere size (Boswell, 2000).

The watermelon is used almost entirely as a dessert, to be eaten fresh-and cold. The rind, however, is made into preserves or sweet "pickles". The seeds are used in Nigeria only for planting (Boswell, 2000). In some cultures, it is popular to bake watermelon seeds and eat them (Produce, 2008).

In Europe, beer is made from watermelon juice, or the juice may be boiled down to heavy syrup like molasses for its sugar. In Iraq, Egypt and elsewhere in Africa, the flesh of the melon is used as a staple food and animal feed as well as a source of water in some dry districts. In the Old World, particularly Asia, the seeds are roasted, with or without salting, and eaten. Orientals also preserve watermelon by salting or brining large pieces or halves in barrels (Boswell, 2000)

2.7 Review of Analytical Tools

2.7.1 Net farm income (NFI)

Net farm income is the difference between gross income (revenue) and total cost of production (Olukosi and Erhabor, 2005).

Gross Income: This is also called total return or total value product (TVP) which is defined as the total output multiplied by the price per unit of produce.

The net farm income is used to show the levels of costs, returns and net profit that accrue to farmers involved in production. The technique emphasizes the (fixed and variable) costs and returns of any production enterprise. Olukosi and Ogungbile (1989) have examined two major categories of cost involved in crop production. These are fixed and variable costs. Fixed costs (FC) refers to those costs that do not vary with the level of production or output while variable costs (VC) refers to those costs that vary with output. The total cost (TC) is the sum of total fixed cost (TFC) and total variable cost (TVC).

Net Farm Income (NFI) = Gross Income (GI) – Total Cost (TC) of production.

Therefore;

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

Where:

NFI = Net Farm Income

GI = Gross Income

TC = Total Cost of Production

Total Cost (TC) of production = Total Variable Cost (TVC) + Total Fixed Cost (TFC).

The Total Variable Cost (TVC) includes items such as labour, fertilizer, herbicide and or insecticide and seeds. The Total Fixed Cost (TFC) includes depreciation of farm tools such as cutlasses and hoes, interest on capital and cost of renting land. The straight-line method, which assumes a constant rate of annual depreciation, will be used to calculate the depreciation on farm tools.

2.7.2 Previous researches using net farm income

Several researchers have used Net farm income as a tool for determining the profitability of crop production. Yusuf *et al*. (2008) assessed the profitability of Egusi melon under sole and intercropping systems in Okehi local government area of Kogi state of Nigeria and found out that the average net farm income per hectare for sole melon and two, three and four crop mixtures were ₦1, 328.68, ₦915.77, ₦887.27 and ₦414.57 respectively; the total gross return per hectare for melon (pooled data) averaged ₦12, 638.61 while the total cost of production was ₦8,838.74 on the average and the total net farm income per hectare for both sole and mixed (pooled data) melon was ₦3,799 on the average, implying that Egusi melon production was profitable in the study area.

Ayinde *et al*. (2011) examined resource use efficiency and profitability of fluted pumpkin and found the net farm income to be ₦116, 891.39 per hectare. Anselm and Ubokudom (2010) also found the net farm income of waterleaf production in Akwa Ibom State of Nigeria to be ₦322,413 per hectare and rate of return to be 1.2. Simonyan and Balogun (2010) found the net farm income of sesame production in Okene local government area of Kogi state to be ₦17,811.56 per hectare which indicates that sesame production was profitable in the study area.

2.8 Efficiency Analysis

The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or a certain level of output at least cost (Amaza, 2000). Efficiency can be defined as the relative performance of the processes used in transforming input into output (Lissita and Odening, 2005). It could also be defined as the attainment of production goals without waste (Ajibefun *et al*., 2002).

The pivotal role of efficiency in accelerating agricultural productivity and output has been applauded and investigated by numerous researchers within Africa and outside Africa alike. 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 economic inefficiencies (Coelli and Battese,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; Huynh, 2008; Adeleke, 2008).

Technical inefficiency occurs when the level of production for the firm is less than the frontier output and it arises when timing and methods of application of production inputs are mismanaged (Bashkh, 2007).

2.8.1 Measurement of production efficiency

Broadly, two quantitative approaches are developed for measurement of production efficiency: parametric and non-parametric approaches.

The parametric which is the stochastic frontier approach is sensitive to the choice of functional forms and accounts for random errors. In this approach, all deviations from the frontier are due to random effects and inefficiency (Coelli *et al*., 2002).

The data envelopment analysis (DEA) which is non-parametric has no fixed functional form and does not account for noise in the data. Thus, all deviation from the frontier will be accounted for as inefficiencies (Johansson, 2005). The measurement of efficiency is important because it leads to substantial resource savings (Bravo-Ureta and Rieger, 1991).

2.8.2 Stochastic frontier approach

For a long time, econometricians have estimated average production functions. It is only after the pioneering work of Farrell (1957) that serious considerations were given to the possibility of estimating the so-called frontier production functions in an effort to bridge the gap between theory and empirical work (Aigner *et al*, 1977).

The modeling, estimation and application of stochastic frontier production functions to economic analysis assumed prominence in econometrics and applied economic analysis during the last two decades. Early applications of stochastic frontier production functions to economic analysis include those of Aigner *et. al*., (1977) in which they applied the stochastic frontier production functions in the analysis of the United States agricultural data. Battese and Corra (1977) applied the techniques to the pastoral zone of Eastern Australia. And more recently, empirical applications of the technique in efficiency analysis have been reported (Ojo and Ajibefun, 2000; Ojo, 2003; Maurice, 2004; Dawang, 2006; Idiong, 2007; Usman, 2009; Adejoh, 2009).

The stochastic frontier production function was independently proposed by Aigner, *et al*., (1977) and Meeusen and Van den Broeck (1977) and is defined by

$$Y_i = f(X_i; \beta) + e_i \quad \ldots\ldots (2)$$

$$e_i = V_i - U_i \quad \ldots\ldots (3)$$

Where:

Y_i represents the output level of the i-th sample farm; f ($X_i; \beta$) is a suitable function such as Cobb-Douglas or translog productions of vector, X_i, of inputs for the i-th farm and vector, β, of unknown parameters. e_i is a compound error term made up of two components: V_i is a two sided ($-\propto < v < \propto$) normally distributed $N(0,\delta^2 v)$ random error that captures stochastic effects outside the farmer's control e.g. weather, measurement error, topography and lucks. U_i is a one sided ($u \geq 0$) efficiency component that captures the technical efficiency of the farmer. It measures the shortfall in output Y from its maximum value given by the stochastic frontier $f(X_i;\beta) + V$. It is assumed to be independently and identically distributed u~ N (0, σ^2_u). N represents the number of firms involved in the cross-sectional survey.

The stochastic frontier production function model is estimated using the maximum likelihood estimation procedure (MLE) (Bakhsh, 2007). The technical efficiency (TE) is empirically measured by decomposing the deviation into a random component (V) and an inefficiency component (U). The technical efficiency of an individual firm is defined in terms of the observed output (Y_i) to the corresponding frontier output (Y_i*) given the available technology.

$TE_i = Y_i/Y_i^*$ ………………………………………………………………………………… (4)

$TE_i = F(X_i;\beta) \exp(V_i - U_i)/F(X_i;\beta) \exp(V_i) = \exp(-U_i)$ ………………………………….. (5)

So that $0 \leq TE_i \leq 1$

Therefore, the technical inefficiency is equal to $1 - \widehat{TE}$

The stochastic cost frontier function which is the basis for estimating the technical efficiency of the farms is specified as follows:

$C_i = g(P_i; \alpha) \exp(V_i + U_i)$……………………………………..……………………………. (6)

Where:

C_i = represent the total input cost of the i^{th} farms

g = is a suitable functional form

p_i = represents input prices employed by the i^{th} farm

α = parameters to be estimated

V_i *and* U_i = are the random error terms defined earlier.

However, inefficiencies are assumed to always increase costs, error component have positive signs.

The strength of the stochastic frontier approach is that it deals with the stochastic noise and permits statistical test of hypotheses pertaining to the structure and degree of inefficiencies. However, the limitations of the stochastic frontier approach are:

(i) There is no *a priori* justification for the selection of any particular distribution for the technical inefficiency effects, *Ui*.

(ii) Efficiency measures may still be sensitive to distributional assumptions.

(iii) The Cobb-Douglas has constant input elasticities and returns to scale for all firms.

(iv) The elasticities of substitution for the Cobb-Douglas function are equal to one.

2.8.3 Previous researches using the stochastic frontier approach

Stochastic frontier approaches have found wide acceptance within the agricultural economics literature because of their consistency with theory, versatility and relative ease of estimation. The measurement of efficiency (technical, allocative and economic) has remained an area of important research both in the developing and developed countries, where resources are meager and opportunities for developing and adopting better technologies are dwindling (Kibaara, 2005).

A study carried out by Usman (2009) on farm planning and resource-use efficiency of sesame farmers in Jigawa State of Nigeria, found the mean technical efficiency to be

57%. This is showing that there is a scope of increasing sesame production by 43% by adopting the technology and techniques of the best sesame farmers.

In a study carried out on technical efficiency of cassava farmers in Oluyole and Akinleye Local Government Areas of Oyo State by Adeleke *et al*. (2008), the mean technical efficiency was found to be 65.98%. Thus, in the short run, an average cassava farmer has the scope of increasing his/her cassava production by about 34.02% by adopting the technology and techniques used by the best cassava farmers. Huynh (2008) studied the analysis of productive efficiency of soya bean production in the Mekong River of Vietnam and found that the average levels of technical, allocative and economic efficiencies were 74%, 51% and 38%, respectively.

Idiong (2007) studied the farm-level technical efficiency in small-scale swamp rice production in Cross River state of Nigeria. The result indicated mean efficiency of 77% and thus the presence of 23% inefficiency level. Udoh and Etim (2007) studied the application of stochastic production function in the estimation of technical efficiency of cassava- based farms in Akwa Ibom State of Nigeria and found the mean technical efficiency to be 0.74. Bakhsh (2007) examined the profitability and technical efficiency of growing potato, carrots, radish and bitter gourd in Punjab, Pakistan. The mean level of technical efficiency was 82% for radish, 72% for carrots, 70% for potato and 66% for bitter gourd, indicating that there exist potentials to increase vegetable production by using existing resources more efficiently.

Ogundari and Ojo (2006) studied the technical, allocative and economic efficiencies of small-scale farms in Osun State of Nigeria. The result showed mean technical, allocative and economic efficiencies of 0.90, 0.81 and 0.89 respectively, implying that technical efficiency appears to be more significant than allocative efficiency as source of gain in economic efficiency. Pius and Odjuvwvederhie (2006) investigated the determinants of yam production and economic efficiency among small holders in south-eastern Nigeria. The result showed the mean technical efficiency of 0.41, implying inefficiency in resource use of yam farmers in the study area. However, the result also showed a wide gap between the efficiency of the best economically- efficient farmer (0.85) and that of the average farmer (0.41).

Amaza and Maurice (2005) investigated the technical efficiency in rice- based production among *fadama* farmers in Adamawa State of Nigeria. The result showed an efficiency of 80% among the rice farmers. Kibaara (2005) studied the technical efficiency in maize production in Kenya and found out that the technical efficiency was 49%.

Belen *et al.* (2003) made an assessment of technical efficiency of horticultural production in Navarra, Spain. They estimated that tomato- producing farms were 80% efficient while those that raised asparagus were 90% efficient. They concluded that there exist a potential for improving farm incomes by improving efficiency. Gautam and Jeffrey (2003) used a stochastic cost function to measure efficiency among small - scale tobacco farmers in Malawi. Their study revealed that large tobacco farms are less cost- efficient.

Rahji (2003) studied the technical, allocative and economic efficiencies of broiler farms in Ibadan, Oyo State of Nigeria. The result showed average technical, allocative and economic efficiencies of 80.3%, 74.9% and 60.3% respectively. This means that the sampled broiler farms would be able to reduce their cost by 31% by operating at technical and allocative efficiency levels. Ojo (2003) studied the productive and technical efficiency of poultry egg production in Nigeria using the stochastic frontier production analysis. The result showed a mean technical efficiency of 76%.

Amaza (2002) used the stochastic frontier Cobb-Douglas Production function to estimate technical inefficiency in food production in Gombe State of Nigeria. The study revealed variability in technical efficiency among farmers, ranging between 0.13 and 0.89 and a mean technical efficiency of 0.69. Awudu and Richard (2001) used a translog stochastic frontier model to examine technical efficiency in maize and beans in Nicaragua. The average efficiency levels were 69.8% and 74.2% respectively. In a study by Wilson *et al*. (2001), a translog stochastic frontier and joint estimate technical efficiency approach was used to assess efficiency. The technical efficiency among wheat producers in eastern England was between 62% and 98%.

Liu *et al*. (2000) in a study on technical efficiency in post-collective Chinese agriculture found 76% and 48% of technical inefficiency in Sichuan and Jiangsu respectively could be explained by inefficiency variables. They use a joint estimation of the stochastic frontier model. Ben-Belhassen (2000) estimated the technical efficiency in Missouri hog production. The result revealed a mean technical efficiency of about 82% implying that 18% of production is due to farm specified production inefficiencies.

2.8.4 Socio-economic variables affecting efficiency

Several studies have identified numerous socio-economic variables that influence efficiency of inputs use. These factors include age, education, and farmer's experience, farm size and access to credit.

Awudu and Richard (2000) reported that efficiency increased with age until a maximum efficiency was reached. Alene and Hassan (2003) reported that technical efficiency of Ethiopian farmers were positively and significantly influenced by education, credit and contact with extension workers. Ogunyinka and Ajibefun (2003) observed that education and membership of farm association were the most important factors increasing efficiency.

Educational level and farming experience have been reported to have a positive and significant impact on technical efficiency (Adewuyi and Okunmadewa, 2001; Bayacag, 2001). Extension contact has been reported to have a positive and significant relationship with efficiency (Amaza, 2002). Therefore, farmers that have had extension contacts are likely to be more efficient than those without any extension contacts.

Greater family size increases efficiency (Bayacag, 2001). This can be explained by the fact that readily available family labour will allow for the timely execution of important farm activities such as fertilization and weeding, thus, contributing to higher yields. Besides, most farmers are financially constrained and thus, the availability of family labour will ease hiring of labour. Farm size has been reported to have a positive and significant relationship with technical efficiency (Rahman, 2003).

Latruffe *et al.* (2005) identified low educational attainment as the source of inefficiency in Polish dairy farms. Similarly, Kibaara (2005) identified level of education, age of the household head and gender of the household head to be associated with technical efficiency. Kibaara also reported that access to credit, and off- farm income reduce technical inefficiency. Furthermore, Liu (2006) argued that financial constraints affected technical efficiency because, besides the quantity of input used, the timing of input usage also influences farm output.

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

The study was carried out in Kano State. The state is located in North-Western Nigeria and was created on May 27, 1967 from the Northern Region. Kano state borders Katsina State to the north-west, Jigawa State to the north-east and Bauchi state to the south-east and Kaduna state to the south-west. The state originally included Jigawa State which was made a separate state in 1991. The capital of Kano State is Kano.

Kano State is located between latitudes 11°59′47”N and longitudes 8°31′0”E. The State has a land mass of about 20,760 square kilometers (NAERLS, 2008). Based on National Population Commission (2006), the State has a projected population of 10,885,071.12 as at 2011. The State is considered to be agrarian as more than 65% of the working adults engage in farming and related activities as a means of livelihood. It is the most extensively irrigated state in the country and the average annual rainfall is 700mm over a period of 90-110 days, depending on location, from the end of May to mid-September with the mean daily maximum and minimum temperature of 35°C and 19°C respectively. The major crops in the State include cereals like rice, maize, millet and wheat; legumes like groundnut, cowpea and bambara nuts and vegetables like pepper, onion, tomatoes, amaranthus, watermelon, etc (NAERLS, 2008).

3.2 Sampling Techniques

A multi stage random sampling technique was used to obtain a sample of 200 watermelon farmers. In the first stage, two major and two non - major watermelon - producing Local Government Areas (Bunkure, Kura, Wudil and Bichi respectively) were purposively selected out of the forty four Local Government Areas in the state. Secondly, two accessible and major watermelon - producing villages were also purposively chosen from each Local Government Area. Finally, a total of 200 watermelon farmers from the sampling frame of each village were proportionally selected. The numbers of watermelon producers in the villages were estimated with the Local Government agricultural extension agents of the Kano State Agricultural and Rural Development Authority (KNARDA). The distribution of the watermelon farmers in the selected villages are presented in Table 3.1.

Table 3.1: Distribution of Watermelon Farmers in the Study Area

Local Govt. Area	**Village**	**Estimated population of watermelon farmers**	**Approximate Number of farmers selected (10%)**
Bunkure	Gurjiya	348	35
	Zango Buhari	284	28
Kura	Dan Hassan	319	32
	Karfi	247	25
Wudil	Wudil pilot	201	20
	Garun Dau	207	21
Bichi	Yallami	203	20
	Yanbuntu	194	19
Total		2003	200

3.3 Method of Data Collection

Primary data were collected from the selected watermelon farmers in eight villages located in the four selected local government areas, using structured questionnaires designed in English and orally administered to the farmers in their local language (Hausa). The questionnaires sought the input-output data of the farmers for both the production and cost function analyses.

The data generated included the socio-economic characteristics of the farmers such as sex, age, marital status, household size, access to credit, farm size, level of education, and farming experience.

The data for the output included the total value of the watermelon produced, the quantity consumed as well as those given out as gift inclusive. The input cost data include land area cultivated (ha), labour (man/day), quantity of seeds (kg), quantity of fertilizers used (kg) and quantity of insecticide (agrochemicals) used (litres). Other costs included are costs of farm tools such as pumping machine and its accessories (for irrigation), sprayers, hoes, cutlass and other simple farm implements. Information source for this study is based on the 2011/12 farming season

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3.4 Analytical Techniques

The following analytical tools were used to achieve the objectives of this study.

i. Descriptive statistics

ii. Net Farm Income

iii. Stochastic frontier Production function

3.4.1 Descriptive statistics

To actualize objectives i and v, descriptive statistics were used which include measures of central tendencies such as mean, frequency distribution and percentages grouping the farmers into a number of classes with respect to socio-economic characteristics as well as use of measures of dispersion.

3.4.2 Net farm income (NFI)

The net farm income was used to actualize objective iii of the study to show the cost and return of the watermelon farmers as well as to determine the profitability of the farm.

NFI = GI – TC ………………………………………………….……………… *(7)*

But:

TC = TVC + TFC ……………………………………………….……………................ *(8)*

Where:

NFI = Net Farm Income

TC = Total Cost of Production

TVC = Total Variable Cost

TFC = Total Fixed Cost

The Total Variable Cost (TVC) includes costs of items such as seed, fertilizer, agro-chemical and labour (for land preparation, planting, weeding, fertilizer application, spraying and irrigation). The Total Fixed Cost (TFC) includes depreciation of farm tools such as cutlasses, hoes, sprayer and pumping machine, its accessory as well as cost of renting land. The straight-line method, which assumes a constant rate of annual depreciation, was used to calculate the depreciation on farm tools. The Gross Income (Total Revenue) includes Total Output (kg/ha) multiplied by the price per unit (₦ /kg) of produce which was based on the prevailing market price of 2011-2012 production season.

3.4.3 Stochastic frontier production function

Estimating the stochastic production frontier function and predicting individual farm's technical efficiency determine production efficiency. In a stochastic frontier production model, output is assumed to be bounded from above by a stochastic production. The essential idea behind the stochastic frontier model is that error term is composed of two parts, a systematic and a one sided component. Stochastic frontier is an econometric analytical technique, which allows for variation of output of individual producers from the frontier of maximum achievable level to be accounted for by the firm (Battese, *et al.*, 1997).

The stochastic frontier production function was used to achieve objectives ii and iv. The model in its implicit form is as follows:

$$Y = f(X_i;\beta) + e_i \quad \ldots\ldots (9)$$

$$e_i = V_i - U_i \quad \ldots\ldots (10)$$

Where:

Y = quantity of output (kg)

X_i = vector of the inputs used by the i^{th} farm

β = a vector of the parameter to be estimated

e_i = composed error term

V_i = random error beyond the control of *producers*

U_i = technical inefficiency effects

$f(X_i;\beta)$ = appropriate functional form of the vector.

A general Stochastic Frontier Production model following Aigner, *et al.,* (1977) is expressed implicitly as:-

$$\ln Y_i = \beta_0 + \sum \beta_j \ln X_{ji} + V_i - U_i \quad \ldots\ldots (11)$$

The stochastic frontier model for estimating the technical efficiency of watermelon farmers is specified by the Cobb- Douglas frontier production function, which is defined by:

$$InY_i = \beta_0 + \beta_1 Inx_1 + \beta_2 Inx_2 + \beta_3 Inx_3 + \beta_4 Inx_4 + \beta_5 Inx_5 + v_i - u_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

Where:

In = natural logarithm to base e

Y_i = Output of watermelon (kg)

β_0 = constant or intercept

β_1 - β_5 = unknown scalar parameters to be estimated

x_1= farm size (ha)

x_2= labour used (man days)

x_3= quantity of seeds (kg)

x_4= quantity of fertilizers used (kg)

x_5= quantity of agrochemicals (litres)

v_i = random errors

u_i = Technical inefficiency effects predicted by the model

Subscript i indicate the i^{th} farmer in the sample.

The technical inefficiency effects U_i is affected by socio-economic characteristics of the farmers and is defined by:

$$U_i = \alpha_o + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \quad (13)$$

Where:

U_i = technical inefficiency effects

Z_1 =age of the ith farmer in years

Z_2 = household size

Z_3 = education level

Z_4 = farming experience

Z_5 = credit accessibility in dummy of one if ith farmer accessed credit and zero otherwise

α_1 - α_7 are unknown scalar parameters to be estimated

α_o = constant or intercept

These were included in the model to indicate their possible influence on the technical efficiency of the farmers.

Battese and Coelli (1995) stated that the TE of a farmer is between 0 and 1 and is inversely related to the level of the technical inefficiency. Technical efficiency is defined as the ratio of observed output to maximum feasible output. $TE_i = 1$ shows that the ith firm obtains the maximum feasible output, while $TEi < 1$ provides a measure of the shortfall of the observed output from maximum feasible output. It is estimated as;

TE_i = Observed Output / Frontier Output

$$\text{Technical inefficiency} = 1 - \widehat{TE} \quad \text{……………………………………………….…….. } (15)$$

3.5 Variables as measured in the model

i. Farm size (x_1) –This is the cultivated farm size for watermelon, it was included in the model to determine its expected relationship with output. It was measured in hectares.

ii. Labour (x_2) -This consists of family and hired labour. It was included to determine how variability in labour used affects variation in output. It was measured in man-days.

iii. Quantity of seed (x_3) - It was included in the model to examine how variability in quantity of seed used will affect output. It was measured in kilogram (kg).

iv. Quantity of fertilizers (x_4) -It was included in the model to examine the extent to which variability in quantity of fertilizer used affects output. The major fertilizer used by the farmer in the area is NPK. It was measured in kilogram.

v. Quantity of agrochemicals (x_5) –The pesticide used was included to examine the extent of its relationship with the output. It was measured in litres.

vi. Age (Z_1) - was the number of years from birth of the respondent as given at the time of data collection.

vii. Household size (Z_2) - was the total number of people in the house which include the farmer, his wives, children and dependants who reside within the same family house and eat from the same pot.

viii. Educational status (Z_3) - was the acquisition of knowledge by farmers through formal schooling. This was measured by the number of years spent in school.

ix. Farming experience (Z_4) – was the number of years the farmer has actively engaged in watermelon production.

x. Access to credit (Z_5) -was to determine the effect of credit accessibility of the farmers' from both formal and informal sources to the output variability.

It is a dummy variable which takes the value of unity if the farmer has access to credit and zero otherwise.

xi. Output (Y)-This is the product harvested from sampled fields (kg). The output was measured by separating the entire produce into various sizes, from the biggest to the smallest consumable ones which form five heaps. One ball is selected from each heap and weighed. The average weight was used to estimate the quantity of the total output.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of the Respondents

The general socio-economic characteristics of the watermelon farmers in the study area are availed in this section. This includes variables such as age, level of education, experience in watermelon farming, household size, farm size, land tenure and labour utilization.

4.1.1 Age

The survey of the sampled farmers shows in Table 4.1 that farmers between the age range of 20 – 29 years were about 16%, between 30 – 39 years were about 35%, those between 40 – 49 years were about 39% and those between 50 – 59 years were about 7%. The mean age of the farmers was 44 years. This shows that, the farmers are strong and agile and would be more efficient than the aged farmers in agricultural production. This is in support of the findings of Maurice (2004) and Yusuf (2005) that, farmers of this age group can influence the adoption of improved agricultural practices, which can equally influence a high level of watermelon productivity.

Table 4.1: Age distribution of Respondents

Age (Years)	No. of Respondents	Percentage
20 – 29	31	15.50
30 – 39	69	34.50
40 – 49	77	38.50
50 – 59	13	6.50
60 – 69	10	5.00
Total	**200**	**100**

Mean age of respondents is 44 years

4.1.2 Household size of the respondents

From Table 4.2, a good number of the farmers surveyed (49.5%) had a household size of between 1 – 10 persons, 40.5% had between 11 – 20 persons and 1.5% had between 31 - 40 persons in their households. The average household size was 9 persons, implying that there is appreciable source of family labour. According to the report of Bayacag (2001), there is a positive and significant relationship between household size and farmers' efficiency in production. Since the production of the crop is not mechanized, farmers depend solely on human labour which is an important variable in agricultural production. The household size determines the available labour force to be employed in carrying out production activities. The major source of labour supply in peasant farming system, which is labour-intensive, is family labour.

Table 4.2: Household size of the Respondents

Household Size	**No. of Respondents**	**Percentages**
01 – 05	45	22.5
06 - 10	54	27.0
11 - 15	50	25.0
16 – 20	31	15.5
21 – 25	07	3.5
26 – 30	10	5.0
31 – 35	02	1.0
36 – 40	01	0.5
Total	**200**	**100**

Mean household size is 9 persons

4.1.3 Educational status

Table 4.3 shows that a good number of the farmers had formal education, ranging from adult education (15%), primary (9%), secondary (10%) and post-secondary education (2.5%), while 12% of them had no formal education. However, more than half of them (103) representing 51.5% had Quranic education as the farmers are predominantly Muslim. This equally assists them to read guides and or pamphlets written in their language but with Arabic alphabets (*Anjami*). As reported by Amaza (2000), Adewuyi and Okumadewa (2001), education has positive and significant impact on farmers' efficiency in production. This literacy level will greatly influence the decision making and adoption of innovation by farmers, which may bring about increase in production of the crop.

Table 4.3: Educational Status of Respondents

Educational Status	Frequency	Percentage
No Formal Education	24	12.00
Quranic Education	103	51.50
Adult Education	30	15.00
Primary education	18	9.00
Secondary education	20	10.00
Post-Secondary Education	5	2.50
Total	**200**	**100**

4.1.4 Farming Experience

The farming experience of the farmers (Table 4.4) shows that the majority (54%) had farming experience of 2 – 9, about 24% had 10 – 17 years experience, 18% had 18 - 25 years experience, while 4.5% of the farmers had between 26 - 33 years experience of watermelon production. The mean years of farming experience was 9 years. This is an indication that more farmers are embracing production of the crop due to its profit advantage.

Table 4.4: Numbers of years of Farming Experience

Experience (Years)	No. of Respondents	Percentage
02 – 09	108	54.00
10 - 17	47	23.50
18 - 25	36	18.00
26 – 33	9	4.50
Total	200	100

Mean years of farming experience is 9 years

4.1.5 Farm size of the respondents for watermelon production

The production of watermelon in the study area is carried out predominantly by small-scale farmers. The size of farm holdings of the respondents for watermelon production is shown in Table 4.5, where 69% of the farmers had between 0.1 – 3.0 hectares of land, about 24% had 3.1 – 6.0 hectares and 1.5% had between 9.1 – 12.0 hectares. The average farm size is 2.4 hectares. This implies that the production of watermelon in the study area is carried out predominantly by small-scale farmers.

Table 4.5: Farm size distribution for watermelon production by Respondents

Farm Size (Hectares)	No. of Respondents	Percentages
0.1– 3.0	138	69.00
3.1 – 6.0	47	23.50
6.1 – 9.0	12	6.00
9.1 – 12.0	3	1.50
Total	**200**	**100**

Mean farm size is 2.4 hectares

4.1.6 Land tenure system

Table 4.6 shows that, 84 of the respondents (representing 42%) acquired their land through inheritance, 16% got theirs through lease, 23% purchased their land while 10.5% obtained theirs through gift. Very few of them, 8.5% were using the land on permission from the community head and were observed to be the non-indigene farmers. This may mean that, there is the opportunity for people that might want to go into commercial production of this crop with 23% of the respondents being able to purchase their own land.

Table 4.6: Distributions of Respondents Based on Land Tenure System

Land Tenure	No. of Respondents	Percentage
Inheritance	84	42.00
Purchased	46	23.00
Leased	32	16.00
Gift	21	10.50
Community Permission	17	8.50
Total	**200**	**100**

4.1.7 Credit accessibility

The survey revealed that more than half of the farmers surveyed do not have access to credit, only 34% of the farmers had access to credit. The performance of an enterprise such as agriculture in Nigeria, as noted by Nwaru (2006) can be greatly influenced by credit accessibility.

4.2 Cost and Return Analysis for Watermelon Production

Table 4.7 indicates that watermelon farmers obtained a net income of ₦25,422.98k per hectare which implies that watermelon production in the study area is profitable. The average rate of return was calculated to be ₦1.46k implying that, *ceteris peribus* for every naira invested; there was a profit of 46k

Table 4.7: Average Gross Margin from watermelon production in Kano State (₦/ha)

Variables	**Average quantity / ha**	**Unit price (₦)**	**Value (₦)**
1.Gross Returns:			
a)Average yield (kg)	1,351.42	60	**81,085.20**
2.Inputs			
i. Variable inputs			
a) Seeds (kg)	0.79	150	118.50
b) Fertilizer (kg)	48.75	63.68	3,104.40
c) Chemicals (ltr)	2.54	1,100	2,794.00
d) Land (ha)	1	6,000	6,000.00
e) Labour (man/day)	65.46	400	26,184.00
ii. Fixed inputs (Depreciation)			
a)Cutlass			98.45
b)Hoe			238.87
c)Sprayer			4,907.00
d)Pumping Machine			8,278.00
e)Siphon			3,939.00
3.Total input costs{2(i)+2(ii)}			**55,662.22**
4.Net Farm Income (NFI) (1 - 3)			**25,422.98**
5.Average Rate of Return (1/3)			**1.46**

4.3 Estimates of the Technical Efficiency of Farmers

The maximum likelihood estimates (MLE) of the parameters of the stochastic frontier production function and inefficiency model were estimated using LIMDEP version 7.0 (Greene, 1998). The MLEs of the Cobb-Douglas stochastic frontier model with the half-normal distributional assumption made on the efficiency error term are reproduced in Table 4.8. The table contains estimates of the parameters for the frontier production function, the inefficiency model and the variance parameters of the model. The estimate of gamma (γ) is a measure of level of the inefficiency in the various parameters and it ranges from 0 to 1. From the table, γ is estimated to be 0.980 and is significant at 1% indicating the amount of technical inefficiency of the farmers. This can be interpreted that 98% of random variation in farmers output is due to difference in technical efficiency. The variance parameter of Sigma (δ^2) was 2.590 which is significant at 5% indicating a good fit and correctness of the distributional form assumed for the composite error term.

The average technical efficiency for the farmers is 0.92 implying that, on the average the respondents are able to obtain 92% of potential output from a given mix of production inputs. Thus, in a short run, there is a minimal scope (8%) of increasing the efficiency, by adopting the technology and techniques used by the best watermelon farmer.

The estimated coefficient for farm size was 0.065 which is positive and statistically significant at 1% level. The 0.065 elasticity of farm size with respect to watermelon output is inelastic in line with the findings of Adeoti and Olayemi (2003); Adejoh (2009) and Ukun *et al*. (2010).

Table 4.8: Maximum likelihood Estimates of the Stochastic Frontier Production Function for Watermelon Production in Kano State

Variables	Parameter	Standard Error	Coefficient	T-value
Stochastic frontier				
Constant	β_0	0.236	7.031*	29.750
Farm size (lnX_1)	β_1	0.025	0.065*	2.601
Labour (lnX_2)	β_2	0.039	-0.001*	-0.286
Seed (lnX_3)	β_3	0.030	0.295*	9.762
Fertilizer (lnX_4)	β_4	0.035	0.160*	4.511
Agrochemical (lnX_5)	β_5	0.031	0.174*	5.586
Inefficiency model				
Constant	δ_0		-4.756	-1.319
Age of farmer (Z_1)	δ_1	0.052	0.124*	2.365
Household size (Z_2)	δ_3	0.071	-0.103	-1.441
Education level (Z_3)	δ_4	0.141	-0.297**	-2.101
Farming experience (Z_4)	δ_5	0.053	-0.105**	-1.991
Credit accessibility (Z_5)	δ_6	0.166	-0.338**	-2.032
Model diagnostics				
Sigma squared	σ^2		0.127**	2.590
Gamma	γ		0.980*	76.511
Log likelihood function			204.118	
Mean Tech. efficiency	$\overline{TE}$		0.92	
Number of observations	N		200	

** P<0.05; *P<0.10

The estimated coefficient for seed was 0.295 positive and statistically significant at 1%. The estimated 0.295 elasticity of seed implies that increasing seed by 1% will increase watermelon output by less than 1% which means, all things being equal the output is inelastic to changes in the quantity of seeds. The significance of seed quantity is however, due to the fact that seed determines to a large extent the output obtained. If correct seed rates and quality seeds are not used, output will be low even if other inputs are in abundance. This is consistent with the findings of Ajibefun and Daramola (2001) and Shehu *et al*. (2010). The estimated coefficient of labour was -0.001which is negative and not significant. This implies that increasing labour will decrease technical efficiency of farmers. This is because, labour is mostly excessively used as a result of its abundance in traditional farming.

The production elasticity of output with respect to quantity of fertilizer was 0.160 which is positive and statistically significant at 1%. This implies that a 1% increase in fertilizer will increase output by 0.16%. Fertilizer is a major land-augmenting input because it improves the quality of land by raising yields per hectare. This study is in agreement with the works of Maurice (2004) and Oladiebo and Fajuyigbe (2007). The elasticity estimate of agrochemicals (0.174) is positive and statistically significant at 1%. This implies that 1% increase in the use of agrochemical will increase output of watermelon by 0.174%.

The inefficiency model estimates are contained in Table 4.9. Generally, a negative sign on a parameter means that the variable reduces technical inefficiency (increases technical efficiency), while a positive sign increases technical inefficiency (decreases technical efficiency).

The result shows that number of years of farming experience, level of education, household size and access to credit have a negative sign, and therefore reduce technical inefficiency (or increase technical efficiency).

The variable for age of farmers has positive estimate and statistically significant at 1%, therefore decreases technical efficiency. Although farmers become more skillful as they grow older, the learning by doing effect is attenuated as they approach middle age, as their physical strength starts to decline. This finding is consistent with studies by Awudu and Huffman (2000), Ojo (2003) and Kudi (2005).

The estimated coefficient for the household size was negative, although not significant. This indicates that the household size of the farmers increases technical efficiency. This could be explained by the fact that small scale farming is characterized by family labour which is supplied by the household members of the farmers. This finding is supported by the report of Bayacag (2001) and Ibrahim (2011).

The negative sign on estimate for the years of farming experience variable indicates that an increase in the number of years of experience in watermelon production decreases technical inefficiency. This finding is consistent with the studies by Ojo and Ajibefun (2000), Usman (2009) and Ibrahim (2011).

The estimated coefficient for the variable, level of education (literacy), has a negative sign and statistically significant at 5%. This indicates that literacy of the farmers increases technical efficiency. This could probably be explained by the fact that education exposes and encourages the desire for farming and adoption of new technologies. Therefore, the farmers probably used their educational level as opportunity to develop their production capability and invariably would be ready to adopt innovations and technologies for improved productivity.

4.4 Frequency Distribution of Technical Efficiency Estimates of Watermelon Farmers

The frequency distribution of the technical efficiency estimates for watermelon farmers in the study area as obtained from the stochastic frontier model is presented in Table 4.9. It was observed from the study that 80% of the farmers had TE of 0.9 and above while only 9% of the farmers operate at less than 0.8 efficiency level. The mean technical efficiency for the 200 sampled farmers in the study area was 0.92. The farmer with the best practice has a technical efficiency of 0.99 while 0.62 was for the least efficient farmer. This implies that on the average, output fall by 8% from the maximum possible level due to inefficiency. Also 91% of the farmers were estimated to have technical efficiency exceeding 0.80, indicating that there are some 20% technical inefficient farmers in the study area.

The study also suggest that for the average farmer in the study area to achieve technical efficiency of his most efficient counterpart, he could realize about 8 percent [(1-0.92/0.99)x100] cost savings while on the other hand, the least technically efficient farmer will have about 38 percent [(1-0.62/0.99)x100] cost savings to become the most efficient farmer.

Table 4.9: Frequency Distribution of Technical Efficiency Estimates from the Stochastic Frontier Model

Efficiency	Frequency	Percentage
0.60 – 0.69	6	3
0.70 – 0.79	12	6
0.80 – 0.89	22	11
≥0.90	160	80
Total	**200**	**100**

4.5 Problems Associated with Watermelon Production in the Study Area

Production of watermelon in the study area within the period of this survey is not without constraints. The major constraints observed during the study are ranked and presented in Table 4.10. Lack of credit facility, lack of improved seed, activity of middlemen and high cost of inputs were the most prominent constraints of watermelon production in the study area. There were multiple responses to the problems by the farmers. Only 200 farmers were surveyed, but the frequency of the respondents to the problems is more than double.

Lack of improved seed is ranked first (23.4%) as majority of the farmers confessed that they make use of seeds from their previous harvest which is not reliable and can jeopardize improved and sustainable productivity.

Activity of the middlemen ranks second (22.4%). Some of the farmers in the study area transport their output to the major markets within the State or outside the State, while majority of them dispose their output either at the farm gate or both at the farm gate and in the local market. The middlemen scout for the produce on the farm where they bargain and eventually buy the output for onward transportation to the major markets in the cities. This activity reduces the profit accruable to the farmers.

More than 21% of the respondents indicated inadequacy of capital and credit facilities which ranked third. This affects watermelon production in the study area, because the meager savings the farmers might have made or the funds generated from relatives is not sufficient to satisfy various activities in watermelon production. The study also revealed that about 17% of the respondents indicated inadequate inputs such as improved seeds, fertilizers, agrochemicals which affect watermelon production in the study area. Transportation problem (5%), pests and diseases (2.3%) and storage and preservation (0.6%) were also indicated as constraints in the study area.

Table 4.10: Problems Associated with Watermelon Production

Problems	**Frequency***	**Percentage**	**Rank**
Lack of improved seed	113	23.4	1st
Activity of middlemen	108	22.4	2nd
Lack of credit facilities	102	21.2	3rd
High cost of inputs	85	17.6	4th
Transportation problem	60	12.5	5th
Pests and diseases	11	2.3	6th
Problems of storage and preservation	3	0.6	7th
Total	**482**	**100**	

***** Multiple responses allowed

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The broad objective of this study is to examine the economics of watermelon production in the study area. The specific objectives were to describe the socio-economic characteristics of watermelon farmers, estimate the costs and returns in watermelon production, determine the input – output technical relationship in watermelon production and the determinants of technical inefficiency, describe the technical efficiencies of the watermelon farmers, and describe the constraints to watermelon production in the study area.

To achieve these objectives, primary data were collected with aid of questionnaire administered on the respondents. A multi-stage sampling technique was employed in selecting the respondents for this study. Four (two major and two non-major) watermelon- producing Local Government Areas were purposively selected and two villages were purposively chosen from each of them. Finally, a simple random sampling technique was then employed to select 10% of the farmers cultivating the crop as sole and under irrigation (dry season) from the population of each selected village for enumeration. A total of 200 farmers formed the sample size for the study and each respondent was interviewed. The analytical tools used to analyze the data included, descriptive statistics, net farm income and stochastic frontier production function.

The results indicated that over 90% of the respondents were between the active ages of 25 and 54 years. About 50% had household size of between 1–10% persons. As high as 64% of the respondents had no formal education. About 54% had 2– 9 years of farming experience. About 69% had 0.1–3.0 hectares of land. Land acquisition was mainly through inheritance (42%).

The gross margin analysis results indicated that watermelon production had a total revenue of ₦81, 085.20k per hectare, with ₦55, 662.22k as total cost of production, and the net farm income was ₦25, 422.98k per hectare. The average rate of return was 1.46.

The stochastic frontier production function was estimated. Farm size, seed, fertilizer and agro-chemicals were positively and significantly related with output. Age of farmers was positively and significantly related with technical inefficiency, while education level, farming experience and access to credit were negatively and significantly related with technical inefficiency at 5% level of probability.

A mean technical efficiency of 92% was achieved by watermelon farms in the study area. This means that there is a scope for increasing watermelon production by 8% in the study area.

Finally, the major problems associated with watermelon production identified by the respondents in the study area were lack of improved seed, activity of the middlemen, lack of credit facilities, high cost of inputs and transportation problem.

5.2 Conclusion

The study observed that technical efficiency of watermelon farmers varied due to the presence of technical inefficiency effects in watermelon production. This shows that there is a great opportunity for farmers to increase their level of efficiency in watermelon production. The cost and return analysis revealed that watermelon production in the study area was profitable with the net farm income of ₦25,422.98k per hectare, despite the problems identified.

5.3 Contribution of the study to Knowledge

i. The results from this study indicate that watermelon production is a profitable agricultural venture in the study area with net farm income of ₦25,422.98k and an average rate of return of 1.46

ii. The results of stochastic frontier production model showed farm size, seed, fertilizers and agro-chemicals to be positively and significantly related with output watermelon.

iii. The results of the determinants of technical inefficiency in watermelon production showed age, education, farming experience and credit to be significantly related with technical inefficiency.

iv. The most important constraints to watermelon production were lack of improved seed (23.4%), activities of middlemen (22.4%), lack of credit facilities (21.2%), and high cost of inputs (17.6%).

5.3 Recommendations

Based on the findings of this study, the following recommendations are hereby put forward for improving efficiency as well as sustaining watermelon production in the state.

i) Considering the economic potential of watermelon production at 92% level of technical efficiency, there is the need for the state government to address the problems (such as lack of improved seeds, lack of credit facilities *etc*.) observed in the study area in order to sustain the potential of the crop.

ii) Farmers should be encouraged to form cooperative or group through which they can be easily reached by the government. The grouped farmers can also empower themselves through group benefits such as group lending, group marketing and group procurement of inputs.

iii) In view of the crop's profitability with the farmers producing in small scale, there is the need to encourage them to produce on large scale so as to further increase the production level which may probably result in the crop's exportation.

iv) Lastly, farm inputs such as fertilizer, pesticides and improved seed varieties should be made available by the appropriate body in time and at affordable prices to avoid the under utilization of the inputs.

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APPENDIX I: QUESTIONNAIRE

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TOPIC: Economic Analysis of Watermelon Production in Kano State, Nigeria.

Questionnaire No……………. Village……………………L.G.A…………………….

Date of administration……………………………………………………………….

A. **DEMOGRAPHIC DATA**

1. Sex: Male ( ) Female: ( )
2. Age…………………………years
3. Number of wives: ……………………………………………………………
4. Number of children: …………………………………………………………
5. Number of other dependant(s):
   (a) 1 ( ) (b) 2 ( ) (c) 3 ( ) (d) 4 ( ) (e) >4 (specify)…..
6. Do you have access to credit? Yes ( ) No ( )
7. What are your sources of credit?
   (a) Formal institutions (b) Friends/relatives
   (c) Cooperative society (d) Others:………………………………………..
8. How much credit did you receive last farming season? ………………………
9. What is your level of education?
   i. No formal education ( )
   ii. Primary education ( )
   iii. Secondary education ( )
   iv. Post secondary education ( )
   v. Adult education ( )
   vi. Quranic education ( )
10. How long have you been farming watermelon? ……………………………….

B. **INPUT DATA**

i. **Land**

11. What is the size of your watermelon farm? ……………………………………

12. How did you acquire the land? ……………………………………………………

a. Inheritance	( )	b. Lease	( )
c. Gift	( )	d. Purchase	( )
e. Joint ownership	( )	f. Others (Specify) ……………………	

13. If you were to rent a hectare of land, how much will you get it? ....

14. In what form do you produce the crop watermelon?

i. Irrigated ( )

ii. Rain-fed ( )

15 The crop watermelon is cultivated as:

i. Sole ( )

ii. Mixed ( )

ii. Labour

16. What were your sources of labour?

a. Family labour ( ) b. Hired labour ( )

c. Both family and hired labour ( )

d. Others (specify) ………………………………………………………………...

17. Please fill the table below for the farm operations and the type of labour used.

Operation	**Type of labour**	**Number of people used**	**Number of hours spent**	**Number of days spent**
Land preparation				
Planting				
Fertilizer application				
Weeding				
Irrigation				
Sprayer				
Harvesting				

18. How much do you pay hired labour? ..../day

iii. **Other inputs:**

a) Variable inputs

19. Please fill the following table below:

Input used	**Quantity used**	**Cost/Quantity (#)**	**Total Cost (#)**
Seed	Kg		
Fertilizer(s) i) ii) iii)	Kg		
Herbicide	(ltr)		
Insecticide	(ltr)		

b) Fixed inputs

20. Which of the following tools do you use for the cultivation and production of watermelon?

a) Cutlass ( )
b) Hoe ( )
c) Sprayer ( )
d) Pumping machine ( )
e) Siphon ( )

C. **OUTPUT DATA**

21. How do you measure your output, since they are not of the same size? ....
……………………………………………………………………………………..
……………………………………………………………………………………..

22. What is the total number of watermelon balls harvested from your farm last year? ………………………..…….

23. What is the total amount realised from the sales of the harvested watermelon last year? ……………………………..

24. What is the worth of the watermelon harvested consumed by your family? ……………………

25. What is the worth of the watermelon harvested given out as gift? ……………

26. Where do you sell the watermelon after harvest?

    a. Farm gate ( )
    b. Local market ( )
    c. Urban market ( )
    d. Both farm gate and market ( )

27. How much do you spend in transporting the watermelon from the farm to;

    a. Local market? ……………………………………………………….
    b. Urban market? ……………………………………………………….

D. **CONSTRAINTS**

28. What were the problems you encountered in the production of watermelon?

    a. Lack of credit facility ( )
    b. Pest and diseases ( )
    c. Lack of improved seeds ( )
    d. Transportation problem ( )
    e. High cost of input(s) ( )
    f. Storage/preservation problem ( )
    g. Others (specify) …………………………………………………………