

**TECHNICAL EFFICIENCY AND PROFITABILITY OF FARMS  
ADOPTING SAWAH RICE TECHNOLOGY IN KEBBI STATE, NIGERIA**

**BY**

**ADELALU, Olubusayo Kazeem**

**B. Tech (Agricultural Economics), M.Tech (Agricultural Economics)**

**(LAUTECH, Ogbomosho)**

**MATRIC NO: 12/68AJ001**

**A Ph.D. Protocol Submitted to the Department of Agricultural Economics  
and Farm Management, Faculty of Agriculture, University of Ilorin, Nigeria.**

**November, 2019**

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background to the study

In many developing countries including Nigeria, agriculture plays a vital role in promoting economic growth and development. The importance of agriculture in Nigeria is evidenced by its share of GDP (20%), its employment generation (80%), proportion share of export earnings (70%) and providing about 70% raw material for the industries in the country NBS, (2017)

Nigeria is blessed with varied climatic zones and enormous land resources and potentials for the production, processing, marketing, and export of various agricultural commodities (Ayodele *et al.*, 2016 and USDA Foreign Agricultural Service GAIN Report (2019)). One of the major staple food crops in Nigeria is rice a member of the Cereals family. In 2013/14 main crop season, cereals were cultivated on 9.9 million hectares of land producing 22 million tons of food grains, with rice accounting for 75% of food grains production in the country. (Community Supported Agriculture (CSA), 2014)

Rice constitutes one of the major crops produced in Nigeria. Osagie, (2016) asserted that rice is the fourth major cereal in Nigeria after sorghum, millet and maize in terms of output and cultivated land area, it is a major staple and most popular cereal crop of high nutritional value grown and consumed in all ecological zones of the country.

Rice production in Nigeria is dominated by smallholder farmers using traditional methods which are associated with drudgery. Individual farmers cultivate between 0.5 - 2.0 hectares on average. Generally, farmers depend on natural flooding to cultivate and produce rice (Osagie, 2016).

Rice is a basic food for most people in sub-Saharan African and West Africa in particular. In Nigeria, the demand for rice has been increasing since mid-1970s (Ayodele *et al.*, 2016). It has moved from being a luxury food which it was in the 1960s, to a major source of calories for most Nigerians. The per capita consumption of rice in Nigeria is currently about 32 kg, down from an average of 34kg over the past five years. In spite of rice contribution to the food requirements of the Nigerian population, it's production in the country is considerably low, about 5.8 million tones as against a demand of 7.1 million metric tonnes (USDA Foreign Agricultural Service GAIN Report (2019)). The overall trend of production and area shows that yield has witnessed sluggish growth rate and the increase in rice production has primarily been due to area expansion (FOA, 2015). To what extent area expansion can continue remains a question. Therefore, the question of gaining higher yield through other means remains concern for Nigeria's agriculture system.

Nigeria is said to be Africa largest producer of rice among the top 15 globally. The country is endowed ecologically to produce enough rice to satisfy domestic demand and has the potential to export to other countries considering its vast agricultural land and suitable climatic conditions; however, in spite of this advantage the efficiency of production and productivity of rice is very low because of lower utilization of improved agricultural technologies (Babafada, 2003 and USDA Foreign Agricultural Service GAIN Report (2019)).

## **1.2 Statement of the Problem**

Available statistics reveals a deficit of about 3 to 3.5 million metric tones per annum in rice production in Nigeria (FAO, 2016). Research on yield Gap and productivity in rice production by FAO have recognized that there is a sizable rice yield Gap between attainable and actual farm yields. For instance, as at 2005 in Kebbi State, the rice cultivation method was still largely traditional, with a mean yield of about 1.2 tonnes per hectare which is far

from a potential yield of 5-7 tonnes per hectare. (Kebbi State Agricultural development programme (KESADEP, 2018). For the states to be self-reliant in rice production farmers need to find a way to improve on the average yield per hectare. It is no doubt worrisome that most Nigerian States have not been able to source for better technology that could help improve the average yield of rice per hectare. The National Centre for Agricultural Mechanization (NCAM) therefore introduced a new technology to rice farmers called Sawah Rice technology. The technology is said to be capable of successfully generating 6-7 tonnes per hectare. A number of communities in Kebbi State have taken up the use of sawah rice technology since its introduction in 2005. However, not much information exist on the success or otherwise of the technology transfer to the benefitting communities in the proposed study area. In the light of the foregoing, this study intends to provide answers to the following research questions:

- i. What is the level of compliance to sawah rice technology adoption by farmers in the study area?
- ii. What are the drivers of adoption of sawah rice technology in the study area?
- iii. Does sawah technology have any effect on the profit of rice farmers in the study area?
- iv. How does sawah rice technology impact on technical efficiency of rice farms?
- v. Does sawah rice technology have any impact on cost efficiency in the study area?
- vi. What are the constraints militating against the use of sawah rice technology in the study area.

### **1.3 Aim and Objectives of the Study**

The aim of the study is the investigation of the technical efficiency and profitability of sawah rice technology in Kebbi State Nigeria.

The specific objectives are to:

- i. determine the level of compliance to sawah rice technology adoption by farmers in the study area;
- ii. identify the drivers of adoption of sawah rice technology in the study area;
- iii. analyze the effect of sawah rice technology on the profit of rice farmers in the study area; and,
- iv. estimate the technical efficiency of rice farms using sawah technology in the study area
- v. estimate the cost efficiency of rice farms using sawah rice technology in the study area.
- vi. examine the constraints militating against the use of sawah rice technology in the study area.

### **1.4 Justification of the Study**

The limited capacity of the Nigerian rice farmers to meet the domestic demand has raised a number of pertinent questions among the policy makers and researchers. For example what are the factors explaining why domestic production lags behind the demand for the commodity in Nigeria? One major factor that may account for this production lag is the issue of efficiency of the rice farmers in the use of resources (Okoruwa and Ogundele 2006; Akanbi, 2012) and perhaps, the issue of sustainability and timeliness of resource availability and use in rice production. The efficiency with which farmers use available resources and improved technologies is important in agricultural production. The future also demands that a sustainable and timely access to relevant factors of production of rice must evolve, if increase

production of rice is to be guaranteed, particularly, in the light of progressively increasing Nigerian population and the more recent border closure that has shot up the price of rice in the market.

This study will therefore assist the Federal Government of Nigeria and indeed the State Government in putting in place the right policy framework to improve the technical efficiency of rice farms in the study area. This study will therefore provide insights that may prove useful to farmers intending to improve upon their current levels of rice production in the study area and possibly elsewhere.

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 THE NIGERIAN RICE PRODUCTION ENVIRONMENT

Rice production started in Nigeria in 1500 BC with the low-yielding indigenous red grain species *Oryza glaberrima* that was widely grown in the Niger Delta Area (Hardcastle, 1959). The high-yielding white grain (*Oryza sativa*) was introduced about 1890 and by 1960 accounted for more than 60% of the rice grown in the country (Hardcastle, 1959).

A significant improvement in rice production in Nigeria was recorded in 1986-1990. During this period the output increased to over 2 million tons while average area cultivated and yield rose to 1,069,200 hectares and 2,096 tons/ha respectively. This significant improvement in production was made possible with the introduction of structural adjustment programme (SAP) in 1986. During this period, there was total ban on importation of rice in Nigeria. This was expected to encourage local production and widen the home market for the nation rice. By year 2000, Kaduna State was the largest producer of rice, accounting for about 22% of the country's rice output. However, during this period great variations also exist in terms of yield. Currently, the average national rice yield during the dry season (3.05 tons/ha) is much higher than that of the wet season (1.85 ton/ha).(Osagie, 2016).

Between the year 2015 and 2017, Nigeria experienced a severe economic recession and one of the effect of the recession was an abnormal rise in the cost of staple food crop like rice. Rice industry report during that period indicated a fluctuation of the commodity production to be between 2,400,000 and 3,600,000 million metric tonnes over a period of five years (FAO, 2017). The import rates also increased to 5,850 tonnes from 4,800 tonnes during the same period of time. Nigeria is currently the largest rice producing country in Africa. This is as the result of conscientious efforts by the current administration to place more emphasis on agrarian production. With the available literature, annual rice production in Nigeria has

increased from 5.5 million tons in 2015 to 5.8 million tons in 2017. From 2015 to date, Nigeria has spent over 117 billion naira on rice importation through the dubious rice import quota scheme. (Federal Ministry of Agriculture and Rural Development (FMARD, 2019)). The consumption rate now is around 7.1 million tonnes and this does not commensurate with the production rate of about 5.8 million tonnes per annum. The increase recorded is largely attributed to such programmes like the Central Bank of Nigeria (CBN)'s Anchor Borrowers Program with a total of 12 million rice producers and four million hectares of FADAMA rice land (Rice Farmers' Association of Nigeria (RIFAN), 2017). It was expected that by 2016 Nigeria should have attained the projected value of up to 10 million metric tonnes of rice production had government enforced its import restriction policy.

Rice is a strategic commodity in the Nigerian economy. The federal government of Nigeria has on a number of occasions intervened to boost its production in many ways. Previous administrations in Nigeria had made deliberate effort to stimulate and encourage rice production with focus on direct investment in programmes and institutions which were meant to increase rice production. Most of the policies however did not adequately address problems associated with production in the areas of resource-use efficiency, costs and returns to rice enterprise (Okuneye, 2011). Corroborating this, Akopokodje *et al.*, (2017) maintained that a comprehensive and up to date picture of rice sector in Nigeria in general and rice production, processing and consumption in particular is lacking. It can be seemingly noticed that, despite its agricultural potentials, Nigeria is yet to harness its vast land resources suitable for agriculture, not only to improve its exportation of rice, but even to cater for its domestic consumption which will invariably serve for sufficient food security.



## 2.2 NIGERIAN EFFORTS TO MEET RICE PRODUCTIONS NEEDS

Active and systematic rice research started in the country in 1953 with the establishment of the Federal Rice station at Badeggi in Niger State, now the headquarters of the National Cereals Research Institute (NCRI). The focus for rice research at the station was the development of varieties with improved grain quality, uniform shape and sizes appropriate for minimal breakage during milling. Between 1953 and 1970, 13 improved rice varieties, comprising two upland, eight shallow swamp and three deep-flooded types of rice, were released to Nigerian farmers. West African Rice Development Agency (WARDA), 1993). From 1971 onwards, research activities on rice focused on developing high – yielding and disease resistant varieties, the efficient use of nutrients and good soil management. Efforts resulted in the release of 16 rice varieties, with the desired traits for pest and disease resistance, nutrition and yield to Nigerian rice farmers between 1971 and 1984. The 16 varieties comprised 1 upland, 12 lowland and three deep – water ecology rice. From 1985 to 2009, an additional 14 high yielding blast resistance varieties, including six upland and three low land varieties were released. From 1990 to date, 11 more rice varieties, comprising eight uplands and three shallow swamp varieties have been released to serve the different ecologies and other specific needs in Nigeria.

A remarkable effort to develop suitable rice varieties for Nigeria farmers was made in 1997 with the release of FARO 51, a variety that is resistant to the African rice gall midge (ARGM) *orseolia oryzivora*. When growing in an ARGM endemic area of Abakaliki, the variety exceeded the yields from farmers' varieties by 26% (FAO, 2001). Recently, WARDA has developed an improved variety mainly for upland farmers. The variety is known as New Rice for Countries of Africa (NERICA) and it is observed the yield could be as high as 3.0 tons per hectare or more with strict compliance with recommendations.

Rice is perhaps the world's most important food crop being the staple food of over 50% of the world population, particularly India, Vietnam, Thailand, Japan, China and a number of other countries in Africa and Asia. Rice is one of the major cereals, which have assumed cash crop status in Nigeria, especially in the producing are, where it provides employment for more than 80% of the population, from cultivation to consumption (Okoruwa and Ogundele, 2006). Due to its increasing contribution to per capita calorie consumption of Nigerians, the demand for rice has been increasing at a much faster rate than domestic production and more than in any other African countries since mid-1970. (Okoruwa and Ogundele, 2006)

Over the years the three tiers of government in Nigeria have been taking steps to control the rampant smuggling that has had a negative impact on local market prices (Research program on rice, Africa, 2017). The recent border control has had a negative effect on the price of rice with the average cost of a 50kg bag 21,000 naira in the domestic market. As at 2015/2016, the market price of rice was 8,500 naira. According to Okoruwa and Ogundele (2006), the Federal Government of Nigeria in its bid to address the demand – supply gap, at various times, came up with policies and programmes. e.g. the Rice Importation Restriction act of the year 2000 and 2016 as well as the re-focusing of operations at the various River Basin Development Authorities in Nigeria to its original mandate of providing necessary irrigation water and other support to rice farmers. These efforts where supported with the development of an improved upland variety of rice known as New Rice for Countries in Africa (NERICA) is also another notable example. However, it has been observed that the various policies driving rice production has not been consistent. These erratic policies of the Federal Government of Nigerian they further noted reflect the dilemma of securing cheap rice for consumers and a fair price for producers (Osagie, 2016). Notwithstanding the various policy measures on rice, production has not increased sufficiently to meet the increased demand. Thus, these inconsistencies in policy and limited capacity of the Nigerian rice sector to match

the domestic demand have led the country to expending huge amount of foreign exchange on the importation of rice into the country.

### **2.3 NIGERIAN RICE ECOSYSTEMS**

In terms of physical environment, especially of sustained water depth and control, Nigerian Rice environment has been classified into five ecosystems as follows [(Glanville, 1993; Hardcastle, 1959; Fagade and Kehinde, 1985)].

#### **a) Upland Rice Ecosystems**

Upland refers to rice areas in which the rice crop is strictly rain fed and where the soil is never saturated with water for significant period of the growing season. Yields are generally low at 0.8 – 2.0t/ha. The upland rice ecosystem constitutes about 55% - 60% of cultivated rice areas and accounts for 30% - 33% of the national rice output. In uplands, more than in other ecosystems, rice is a component of an enterprise. Thus, for the purpose of rice cropping and breeding, four categories of the upland ecosystem have been identified for the West African Sub region as follows, (WARDA, 1993)

- (i) Favourable upland with long growing season
- (ii) Favourable upland with short growing season
- (iii) Unfavourable upland with long growing season
- (iv) Unfavourable upland with short growing season

#### **(b) Irrigated Rice Ecosystems**

This is the most recently developed rice environment in Nigeria, where water is supplied from rivers, reservoirs or tube wells by gravity or pumps to supplement rainfall. Water depth can be controlled throughout the year and yields are generally high, ranging from 4.0 – 8.0t/ha. The irrigated rice ecosystem constitutes about 5% - 10% of cultivated rice areas and accounts for 10% - 12% of the Nation Rice Supply. Irrigated rice is by far the most

productive rice production systems and remains the keystone of National Rice production. Irrigated areas in the West Africa Sub-region have been further sub-divided as follows, (WARDA, 1993):

- (i) Irrigated with favourable temperature
- (ii) Irrigated low temperature Sahel zone

(c) **Rain Fed Lowland Rice Ecosystems**

About one-fourth of the Nigeria's rice areas are estimated to be rain fed lowland. Rain fed lowlands have a great diversity of growing conditions that vary by amount and duration of rainfall, depth of standing water, duration of standing water, flooding frequency and time of flooding, that only one rice crop is generally grown in a year. Estimates put the contribution of this ecology to National Rice output at 43% - 45%. For the purpose of rice cropping and breeding, five categories of the rain fed lowland rice ecosystems have been identified as follows, International rice Research Institutes (IRRI, 1984):

- (i) Rain fed shallow favourable
- (ii) Rain fed shallow drought prone
- (iii) Rain fed shallow drought submergence – prone
- (iv) Rain fed shallow submergence-prone
- (v) Rain fed medium deep waterlogged

(d) **Floating Rice Ecosystems**

Floating rice grows in rain fed lowland fields or under shallow flooding for 1 to 3 months, and then is flooded to depths that exceed 100cm for 1 month or longer. The floating rice ecosystem constitutes about 5% - 12% of cultivated rice areas and accounts for 10% - 14% of national rice output

#### **(e) Tidal (Mangrove) Wetlands Rice Ecosystems**

The Nigerian tidal wetlands rice ecosystems are near seacoast and inland estuaries and they represent very large untapped resources with great future potential for rice production. Tidal wetlands are heterogeneous environments and have been further categorized as follows, (WARDA, 1993):

- (i) Tidal wetlands with perennially fresh water.
- (ii) Tidal wetlands with seasonally or perennially saline water.
- (iii) Tidal wetlands with acid-surface soils.
- (iv) Tidal wetlands with peat red soils.

#### **2.4 The Concept of Sawah Rice Technology**

The term “sawah” is of Malayo-Indonesian origin, and refers to a banded, puddled and levelled rice field with water inlet and outlet to improve water control, especially control of flooding water depth and movement, and thus soil fertility (Wakatsuki *et al.* 2013). Thus sawah ecotechnology can improve irrigation and fertilizer efficiency, and with the technology, the improved varieties can perform well to realize a Green Revolution in Africa (Wakatsuki *et al.* 2011). Sawah rice technology has been said to be one of the best agricultural practices capable of increasing rice yield per hectare. (Wakatsuki *et al.* 2013). Sawah rice technology has a lot of advantages: It enhances effective water control and management, It encourages biodiversity, It encourages nitrogen fixation through the decomposition, there is effective weed control through flooding, It improves soil organic matter accumulation and increases the yield per hectare of rice production (Wakatsuki, 2013.) Essential components of sawah rice technology are: (1) demarcation by bunding based on topography, hydrology and soils, (2) leveling and puddling to control and conserve soil and water, and (3) water inlets to get water through various irrigation facilities and water outlets to drain excess water (4) improved agronomic practices (fertilizer and chemical application)

(5) improved seed varieties. These are the basic characteristics of sawah fields to control water and apply other technologies, National Centre for Agricultural Mechanization (NCAM, 2018).

Sawah ecotechnology is believed to be capable of improving irrigation and fertilizer efficiency, and thus can cope with water shortages and poor nutrient supplies (especially N and P as well as Si and Ca) (Wakatsuki, 2012). It can also neutralize acidity and /or alkalinity, thus improve micronutrient supplies. Through the control of water and puddling weeds can be also controlled. The lowland sawah can also sustain rice yield higher than 4/ha through macro-scale natural geological fertilization and micro-scale mechanisms to enhance the supply of various nutrients. For optimum results, appropriate lowlands must be selected and developed, and soil and water must be managed properly.

Sawah eco-technology has a lot of advantages: (Wakatsuki, 2012)

- i. It enhances effective water control and management.
- ii. It encourages biodiversity
- iii. It encourages nitrogen fixation through the decomposition of micro organism
- iv. It enhances soil organic matter decomposition
- v. There is effective weed control through flooding
- vi. It improve soil organic matter accumulation
- vii. It increases yield per hectare of rice production

According to (Oladele and Wakatsuki, 2008), the technologies involved in sawah are as follows: Levelling, Bounding, Puddling, Canal design, basin formation, transplanting and fertilizer application. It is designed principally to cultivate rice in the low land. It originated from Japan and has been widely used in other African countries (Wakatsuki, 2010).

## **2.5 The Small - Scale Farms and the Agricultural Policy**

Nigeria has not been able to meet the ever increasing food demand of the people, perhaps because of the rural nature of our agriculture that has left the practice of agriculture in the hand of small private farmers or ordinary individuals. The small-scale family farms commonly operated is characteristic of the level of development in Nigeria. The major source of income of the farmers is their personal savings and borrowed capital which can hardly transform the farming into a profitable business. (Olayide and Heady, 1982, Omotesho, 1991). This statement was also corroborated by Madwueke, (2015) when he noticed that the method of agriculture in Nigeria is typically a subsistent one which can hardly feed the entire population system, hence the income of the small-scale farmers can hardly liberate them from poverty.

In addition to doing all the organizing and supervision alone, the bulk of the farm labour is performed by the individual farmer and members of his family. The small-scale farms are operated under many complex systems of cultivation like bush fallowing or shifting cultivation which also varies depending upon the types of crops and the prevailing social-cultural norms in the area (Ayoola, 2001). The systems of farming are characterized by rudimentary farm tools, rain dependency, low input level, low outputs, low income and the farmers are often price takers.

Olubiyo and Adewumi (1997) also submitted that large-scale farms in Kebbi State are more efficient when compared to these small-scale farms. Their study however concluded that efficiency is a relative term and is influenced by various factors such as the type and quantum of resources available, managerial ability, technology and environment factors which farmers are faced with.

It is often suggested that one of the strategies for increasing agric productivity is to increase the level of farm resources as well as make efficient use of the resources already committed to the farm sector. However, agricultural productivity may not be substantially increased by simply increasing all inputs in the traditional state but by a package approach to technology (Babatunde & Omotesho, 2003).

Past policy and programme efforts in Nigeria have been noted to achieve little in meeting the Country's pre-set food target (Madwueke, 2015). Therefore, future prospects will definitely depend on how adequately certain needs are satisfied and some issues attended to by the government if growth is to be achieved the nation's agricultural sector, particularly among the small-scale holders.

## **2.6 THEORETICAL FRAMEWORK**

### **2.6.1 Concept of Adoption of Technology**

Organization for Economic Cooperation and Development (OECD, 1999), defined an innovation as any knowledge (new or existing) introduced into and used in an economically or socially relevant process. The adoption of an innovation within a social system takes place through its adoption by groups or individuals. According to Sahu (2015), adoption may be defined as the integration of an innovation into farmer's normal farming activities over an extended period of time. Adoption, however, is not a permanent behaviour. Nchembi (2017) noted that an individual may decide to discontinue the use of an innovation for a variety of personal, social and institutional reasons one of which might be the availability of another practice that is better in satisfying farmers' needs.

#### **Stages of adoption**

Rogers (1962) outlined the following five stages of adoption and their main functions in the adoption process:



- (i) Awareness stage
- (ii) Interest stage
- (iii) Evaluation stage
- (v) Trial stage and
- (vi) Adoption stage

**(i) Awareness stage**

The individual is exposed to the innovation but lacks complete information about it. The primary function of the awareness stage is to initiate the sequence of later stages that lead to eventual adoption or rejection of the innovation.

In the awareness stage here the farmer merely knows about the existence of an innovation but lacks details about it. This is somewhat like seeing something without attaching meaning or importance to it. Before a farmer can adopt a new idea or practice, the individual must first know about it. It is therefore the major task of the extension staff to bring the new idea, practice or Technology to the knowledge of the farmer (Ogunbameru, 2011).

**(ii) Interest stage**

At the interest stage the individual becomes interested in the new idea and seeks more information about it. The individual favours the innovation in a general way, but he has not yet judged its utility in terms of his own situation. Its main function is to increase the individual's information about the innovation, even as he becomes more psychologically involved in the innovation.

Interest is the stage that farmers seek more factual information about the idea, practice or technology due to the interest the farmer develops in the idea, technology or practice. The

farmer wants to know what the technology is, how it works and also its potential or general merit. He becomes curious about it (Agbamu, 2008).

### **(iii) Evaluation stage**

At the evaluation stage the individual mentally applies the innovation to his present and future situations, and then decides whether or not to try it. If the individual feels that the advantages of the innovation outweigh the disadvantages he will try the innovation.

The farmer at this stage, shows marked interest in the idea, practice or technology as it applies to him. He mentally evaluates the applicability of the innovation in the light of the solution to his problem situation. Farmers evaluate how the information or new practice affects their social, economic and cultural variables (values and conditions). If positive, they go ahead to the next phase. If negative, they stop there.

They ask such question as: Can I do it? How can I do it? Is the new practice or technology better than what I am doing or using now? Will it work in my case? What will I get out of it? All these and other questions flood their minds. They then make mental application of the idea. They obtain more information about the idea and decide whether to try it or not. Trial stage is the where the farmers have weighed the advantages and the risks involved and if idea is visible in small segments, they actually apply the innovation on a small scale under his own circumstances and managerial competence. Such a trial could be done through the assistance of change agents and sales promoters (Agbamu, 2008) who also confirmed that this stage actually raises the questions: how I can do it? The farmer actually uses the innovation on a trial basis: it involves an experimental use of an innovation on a section of the farmer's plot of land. If the farmer is satisfied with the trial, he may decide to continue the use of that innovation. If the trial provides poor result, he may reject the innovation (Ogunbameru, 2011) .

#### **(iv) Trial stage**

At the trial stage the individual uses the innovation on a small portion in order to determine its utility in his situation. Its main function is to demonstrate the new idea in the individual's own situation so as to judge its usefulness for possible complete adoption. The individual may seek specific information about the method of using the innovation at the trial stage.

#### **(v) Adoption stage**

At the adoption stage the individual decides to continue the full use of the innovation. The main functions of the adoption stage are consideration of the trial results and decision to ratify sustained use of the innovation in the future.

At this stage, a farmer has approved of an innovation and decided to continue using it. Adoption involves acceptance and repeated use of an innovation since the new practice brought an improvement on farm productivity or is expected to do so or will help to ease a difficult farm operation (Agbamu, 2008). Adegbeniga (2009) argued that even when people have accepted an innovation, they remain curious until it worked for some time and proved reliable.

Summarily, the adoption of agricultural technologies is a dynamic process and follows hierarchical or pyramidal stages, namely awareness, interest, evaluation, trial and adoption. George and Bohlem as cited by Ovwigho (2013) have explained those five steps in detail in their study.

Awareness simply means the individual's awareness about the existence of the innovation. When the individual wants more information about the new technology to assess if the innovation can help him, then that is interest. The evaluation stage implies the mental examine of the information gathered by the individual, who tries to determine whether it will

really impact his work. In the trial stage, the individual tests the innovation to see if it actually measures up to his expectations. Finally, the individual reaches the adoption stage when he decides he really likes the innovation and wants to adopt the new technology and use it for his work. Though the individual could go through this adoption process steadily, some people are slower to transition between steps (Ovwohwo, 2013).

### **Measurement of Adoption**

There are various ways of measuring adoption of innovations. Wabbi (2002) opined that, the rate of adoption or the extent of adoption can be measured. The rate of adoption is usually measured by length of time required for a certain percentage of a social system to adopt an innovation while the extent of adoption is measured from the number of technologies being adopted and the number of people adopting them. Wabbi (2002) also defined rate of adoption as the percentage of members of a social system who adopt an innovation within a specific period. Agbamu (2006) argued that the level of adoption of an innovation could be measured by obtaining the adoption index through the sigma method, using percentages of adopters, or assigning values to each stage of adoption process using Likert scale and calculating the mean scores Agbamu (2006). He further explained that the sigma method of scoring used to calculate adoption index based on the principle that ordinary frequency numbers and percentages can be standardized by mathematical procedure in order to obtain normalized standard scores. This method was used by Roling and Pretty (1996) and Agbamu (1995). In order to standardize adoption scores, percentage of farmers that adopted a given technology is obtained and a value known as sigma distance is read from the statistical table of normal deviates. Caswell (1999) used percentage to determine adoption levels for three adoption stages (awareness, tried, adopted). Onu and Madwueke (2002) assigned values for each stage of adoption using Likert scale. The values assigned were 0 for non-awareness, 1 for awareness, 2 for interest, 3 for evaluation, 4 for trial and 5 for adoption.

## **Adoption innovativeness process**

In Rogers (1983) postulation, members of a social system can be categorized based on their innovativeness, defined as the degree to which an individual or other unit of adoption is relatively earlier in Adopting new idea than other members of a system. Based on innovativeness, a population of adopters can be partitioned into five adopter categories which include innovators, early majority, late majority and laggards

Rogers (1983) suggested that the dominant attributes of each category are: innovators venturesome (very eager to try new ideas); early adopters-respect (have a great of opinion leadership in most social systems); early majority- deliberate (a deliberate willingness in adopting ideas, but seldom lead); late majority-sceptical (innovations are approached with a skeptical and cautious air and usally do not adopt until others in their social system have done so); and laggards-traditional (decisions are often made with reference to past generations. Laggards typically interact with those who also have traditional values).

As noted by Rogers (1983), past research has identified that relatively earlier adopters in a social system are not different from later adopters in age, but they tend to have more years of formal education, are more likely to be literate, have higher social status and a greater degree of upward social mobility, and have larger-sized units, such as farms or companies. These characterisitcs of adopter categories indicate that earlier adopters generally have higher socioeconomic status than later adopters.

Also noted by Rogers (1983) is the fact that earlier adopters in a system also differ from later adopters in personality variables. Earlier adopters have greater empathy, less dogmatism, a greater ability to deal with abstractions, greater rationality, greater intelligence, a more favourable attitude toward change, a greater ability to cope with uncertainty and risk, a more favourable attitude toward science, less fatalism (fatalism is the degree to which an individual

perceives a lack of ability to control his/her future), greater self-efficacy, higher aspirations for formal education, and have higher-status occupations than later adopters.

Finally, the adopter categories have different communication behavior. Earlier adopters have more social participation, are more highly interconnected in the interpersonal networks of their social system, are more cosmopolite, have more contact with change agents, greater exposure to mass media channels, and greater exposure to interpersonal communication channels, engage of opinion leadership (Rogers, 1983).

Early adopters: this group of farmers comes immediately after the innovators. Some of them are educated but may be conscious and would want to see the new technology tried under local condition. They usually express their interest and willingness but under conviction by result demonstrations. Late adopters (lagggards). This group of farmers is the third that can accept and try a technology. The percentage of late adopters is usually very high because of their conviction from result demonstrations. Although some take a much longer period to adopt.

### **2.6.2 Technical Efficiency Measurements and Agricultural Production**

The measurement of the productive efficiency of a farm relative to other farms has long been of interest to agricultural economists. Theoretically, there has been a cross-cutting exchange of knowledge about the relative importance of the various components of firm efficiency (Lingard *et al*, 1983). From an applied perspective, measuring efficiency is important because this is the first step in a process that might lead to substantial resource savings. Efficiency is a very important factor of productivity growth. In an economy where resources are scarce and opportunities for new technologies are lacking, inefficiency studies will be able to show that it is possible to raise productivity by improving efficiency without the resource base or

developing new technology. It also helps determine the underutilization or over utilization of factor inputs.

Rahji, (2003) also noted that the efficiency with which farmers use available resources and improved technologies is important in Agricultural Production. As the demand for food crops increases (perhaps due to population increases), the possibility of expanding production by bringing more resources, especially land, into use is also becoming more and more limited. It is thus of policy relevance to seek ways of improving the production efficiency of farmers.

The level of technological efficiency of a particular farmer is characterized by the relationship between observed production and some ideal or potential output (Coelli *et al.*, 1980). Hence, the measurement of farms specific technical efficiency is based upon deviations of observed output from the forecast or best production or efficient production frontier. If a farmer's actual production point lies on the frontier, it is perfectly efficient. On the other hand, if it lies below the frontier, then it is technically inefficient. This can be illustrated with the aid of the Figure 1. (Coelli *et al.*, 2002).

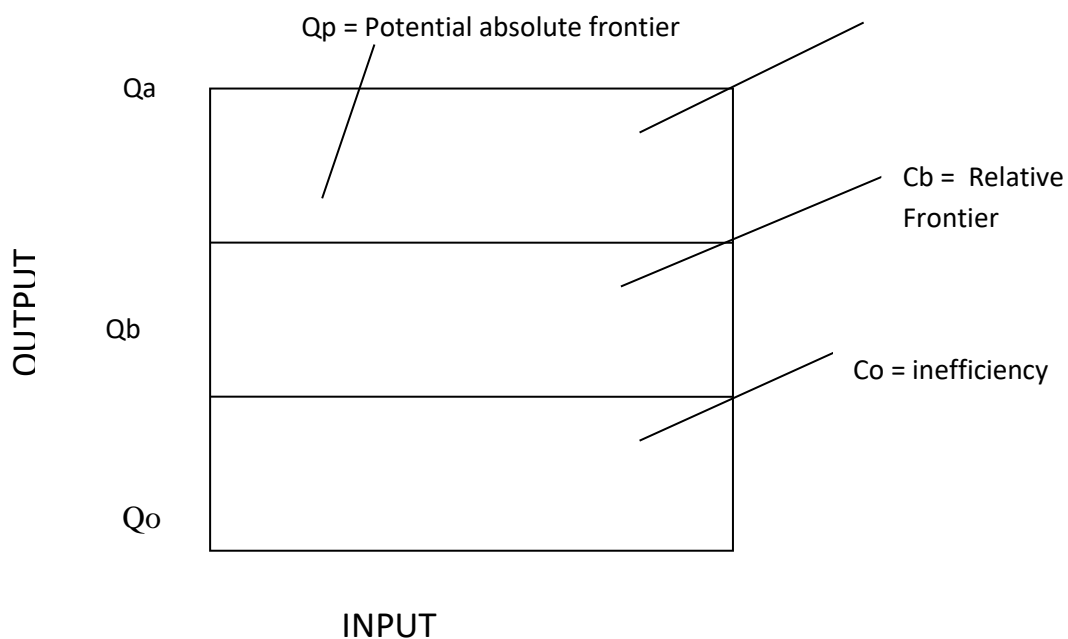


Fig: 1 Best Practice, Potential Absolute Frontier and Measure of Inefficiency.

From the figure 1, we can see the comparison of output  $QO/Qb$  at points  $Co$  and  $Cb$ , each with the same level of input. But, while  $Cb$  lies on the best practices frontier function  $Qb$  (passing through a 100% efficient sample point),  $Co$  lies on  $Qo$  which represents a locus that is a neutral shift of the frontier  $Qb$ . The concept could be measured relative to other frontiers for instance the absolute frontier function  $Qa$  lying above all sample points. In this instance, the ratio will be  $Qo/Qa$  or a comparison of output at points  $Ca$  and  $Co$ .  $Qp$  also represents the potential absolute. This is the maximum output obtained from all conceivable observations embodying the current technology (including over all time periods in which adoption takes place) and it lies above  $Qa$ . Overtime, there would be sequence of absolute frontier functions  $Qa$ 's (associated levels of technical efficiency) moving up to the potential absolute frontier function  $Qp$ . (Okoruwa and Ogundele, 2006).

Of recent there has been the promotion of the Sawah rice technology which is believed as been capable of pushing up the frontiers of rice production from the current low level. Kebbi States are among states currently adopting this technology. It will be of interest to access the performance of rice farms that are currently benefitting from this technology, particularly regarding the technical efficiency of production.

### **2.6.3 Measurement of Efficiency**

The sensitivity of the result of an efficiency study to the-method selected to estimate the efficiency scores is of paramount importance. The two most popular techniques used to measure farm efficiency are the Data Envelopment Analysis (DEA), (Charnes *et al.*, 1978) and the Stochastic Frontier Approach (SFA), (Aigner *et al.*, 1977).

The former used linear programming methods, whereas the latter uses econometric methods. Some qualities that influence the appropriateness of DEA and SFA include the data quality, the relevance of various functional forms and the possibility of making behavioural assumptions. For instance, there are no specific functional forms needed to be selected when



comparing the DEA with the SFA; neither are any behavioural assumption needed as long as allocative efficiency is not considered. However, DEA is a deterministic approach, meaning that it does not account for noise in the data (Charnes *et al.*, 1978) All deviations from the frontier will thus be accounted for as inefficiencies. Therefore, DEA efficiency scores are likely to be sensitive to measurement errors and random errors. The SFA on the other hand, accounts for random errors and has the advantage of making inference possible (Coelli *et al.*, 2002). However, SFA is sensitive to the choice of functional form (Aigner *et al.*, 1977).

#### **2.6.4 The Stochastic Frontier Model with Technical Efficiency Effect**

The Stochastic Frontier model (SFM) in the current literature was originally developed by (Aigner *et al.*, 1977). In this model, Efficiency (TE) is defined as the firm's ability to produce the maximum amount of output given a set of inputs and technology. Stated in a different way, technical inefficiency refers to the gap between the benchmark firms which maximize operating characteristics and thus lies over the efficient frontier and firms that lie below the efficient frontier. SFM can be classified into two basic categories: parametric and non-parametric. The main difference between the two categories is that parametric frontier model relies on a specific functional form, whereas non-parametric frontier models do not (Amar and Muller 2010). For this study, the parametric approach is proposed. The main advantage of SFM over the traditional ordinary least squares is that the latter yields estimation just on the average farm; whereas the estimation of a SFM will be most heavily influenced by the best performing farms and hence reflect the technology they are using. Also, the frontier function represents a best-practice technology against which the efficiency of farms can be measured (Battese & Coelli, 1995). The stochastic frontier production function has two error terms one to account for random effects (e.g., measurement errors in the output variable, weather conditions, diseases and the combined effects of unobserved/uncontrollable inputs on

production) and the other to account for technical inefficiency in production Battese and Coelli (1995).

The stochastic frontier production function can be written as:

$$Y_i = f(X_i; \beta) \exp(V_i - U_i) \quad (1)$$

where  $Y_i$  is the production of the  $i^{\text{th}}$  farm,  $X_i$  is a vector of inputs used by the  $i^{\text{th}}$  farm;  $\beta$  is a vector of unknown parameters,  $V_i$  is a random variable which is assumed to be independently and identically distributed (iid)  $N \sim (0, \sigma_v^2)$  and independent of  $U_i$  and  $U_i$  is a random variable that is assumed to account for technical inefficiency in production.

Following Battese and Coelli (1995),  $U_i$  is assumed to be independently distributed as truncation (at zero) of the normal distribution with mean,  $\mu_i$  and variance,  $\sigma_u^2$  ( $|N(\mu_i, \sigma_u^2)|^1$ ), where

$$\mu_i = Z_i \delta \quad (2)$$

where,  $Z_i$  is a  $1 \times c$  vector of farm-specific variables that may cause inefficiency and  $\delta$  is a  $c \times 1$  vector of parameters to be estimated. The farm-specific stochastic production frontier representing the maximum possible output ( $Y^*$ ) can be expressed as  $Y_i^* = f(X_i; \beta) \exp(V_i)$ . (3)

The original specification of  $u$  to be half normal ( $N(0, \sigma_u^2)$ ) (Aigner *et al.* 1977) has been applied over the past decades (Coelli, 1997). If it will not follow a half normal distribution it will follow either exponential or truncated normal at zero. The study of Parikh and Hjalmarsson, (1995); Greene (2003), all concluded that efficiency levels were essentially the same for half normal, truncated-normal and exponential distribution.

Equation (1) may be rewritten using equation (3) as

$$Y_i = Y_i^* \exp(-U_i). \quad (4)$$

Thus, technical efficiency of the  $i$ th farm, denoted by  $TE_i$ , is given by

$$TE_i = Y_i / Y_i^* \exp(-U_i). \quad (5)$$

This means the difference between  $Y$  and  $Y^*$  is embedded in the  $U_i$ . If  $U_i = 0$ , then  $Y$  is equal to  $Y^*$ . This means production lies on the stochastic frontier and hence technically efficient and the farm obtains its maximum possible output given the level of inputs. If  $U_i > 0$ , production lies below the frontier and the farm/firm is technically inefficient (Dey *et al.*, 2000). Stochastic frontier model will be used for this study because it allows simultaneous estimation of efficiency and in-efficiency.

### 2.6.5 Returns to Scale and Cost Efficiency

In the short run, a farm/firm is handicapped by the fact that some of the inputs are fixed. In the long run, however, the firm has no such problem. It can expand or contract its output according to demand by having more or less of all the factors of production (Akanbi *et al.*, 2012). The Cobb-Douglas production function as specified in this study depicts the long-run situation.

Cost efficiency (C.E) = T.E + A.E

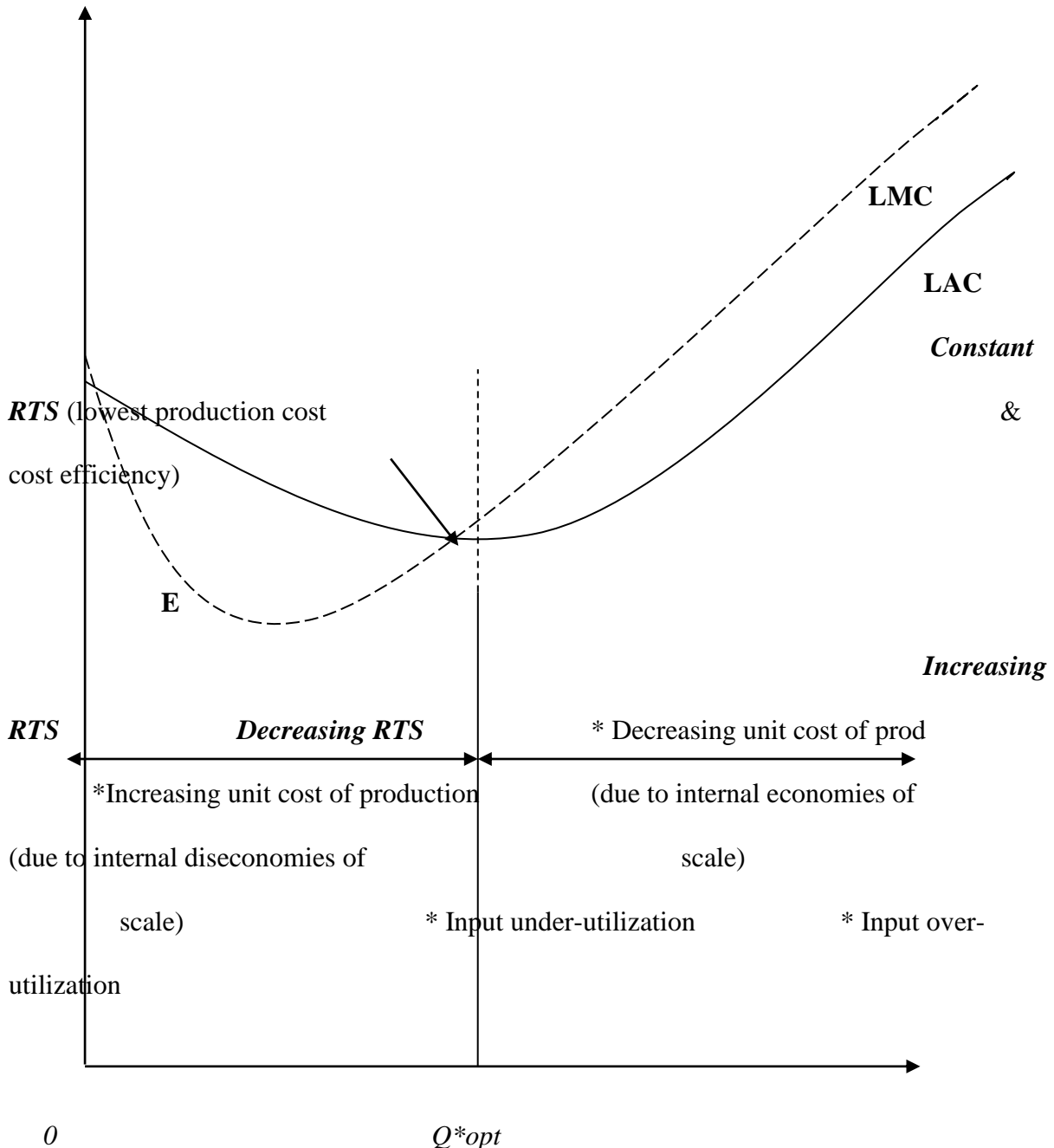
C.E<sub>*i*</sub> can be specified thus  $(\alpha y_i, w_i \beta) \exp(v_i) = \exp(-u_i)$

$$E_i \quad \quad \quad 0 \leq C.E_i \leq 1$$

where = cost efficiency, T.E = Technical Efficiency and A.E = Allocative Efficiency

The Cobb-Douglas production function as specified in this study depicts the long-run situation. All the factors are freely variable. As the firm expands, the nature of output and cost of production is influenced by the law of returns to scale (Sundharam and Vaish, 1979). The average and marginal output in the long-run will rise and reach a maximum point and

then decline. Correspondingly, the average cost and marginal cost of production in the long-run will slope downwards; reach a minimum point and then rise. It is important to note that in the long-run, the distinction between fixed and variable cost does not hold, for all costs are variable. (Akanbi *et al.*,2012).



*N/B: The LMC is flatter than the LAC (i.e. it is more elastic)*

Figure 2: Illustration of the Relationship between LAC and LMC

In figure 2, the LAC curve slopes downwards up to the point E. It indicates diminishing unit cost of production as output is increasing. This is as a result of increasing returns to scale of production between 0 and  $Q^{*opt}$ . This implies that doubling the inputs leads to a more than doubling of the output. This zone does not contain the optimum point of production where cost is efficient, or where cost efficiency could be obtained. At point E, LAC is equal to LMC. This is the optimum point with  $0Q$  as the optimum output. This point is characterized by constant returns to scale. It is the point where the unit cost of production is at a minimum. This indicates the output level at which LAC is the lowest. It signifies the point of cost efficiency, or where cost is efficient in production. Here, doubling the inputs doubles the output. Beyond point E, the LAC is rising. This indicates increasing unit cost of production as a result of diminishing returns to scale (i.e. doubling the inputs leads to less than double output). The U-shape of the LAC curve can be explained by the laws of decreasing and increasing returns to scale. The average cost, at first, decreases as the size of production (output) increases. This is due to internal economies of scale. As the output continues to increase, a point is reached at which the average cost starts increasing. This is due to internal dis-economies of scale. Hence, the decreasing portion of the U-shaped LAC curve corresponds to the phase of increasing returns to scale, while the increasing section of the curve depicts the phase of decreasing returns to scale (Akanbi, 2012).

## **2.7 Analytical Framework**

### **2.7.1 The Stochastic Frontier Production Function**

Aigner, *et al*, (1977); Battese & Coelli, (1977) and Meeusen and Vanden Broeck, (1977) were motivated by the idea that derivation from the production frontier may be entirely under the control of the farmer. The model allows for the estimation of technical inefficiency and the random shock outside the control of the farmers. The main feature of stochastic frontier model is that the disturbance term is composed of two parts, the symmetric component  $V_j$

capture the random of error outside the control of the farmer while the one-sided (non-negative) component  $U_i$  with  $U_i > 0$  capture the random error or technical inefficiency relative to the stochastic frontier. Its distribution is assumed to be half normal or exponential. The  $V_j$  assumed to be independently distributed random variable, independent of  $U_i$  and  $V_j$  assumed to be independently and identically distributed as exponential (Meeusen & Van den Broeck, 1977). An appropriate formulation of stochastic frontier model in terms of a general production function from  $i$ th production unit is

$$Y_i = f(X_{ij}p) + V_i - U_i \quad (6)$$

$Y_i$  = output of  $i^{\text{th}}$  farm

$X_{ij}$  = actual  $j$  input used by  $i^{\text{th}}$  farm

$\beta$  = regression coefficient to be estimated.

$V_i$  = random variability outside the control of the farmer.

$U_i$  = Error term under the control of a farmer.

The direct estimates of the parameters can be obtained by either the maximum likelihood method (MLM) or the corrected ordinary least square method (COLS). In context of stochastic frontier production function the technical inefficiency of the firm is defined as the ratio of the observed output to the corresponding frontier output conditional on the level of inputs used by the farm. Thus, the technical efficiency of the farm is defined as;

$$TE_i = \exp(-u_i) \quad (7)$$

$$TE_i = Y/Y^* = e^{-u_i} \quad (8)$$

where,

TE = technical efficiency of farmer (i)

$Y_i$  = Observed output from  $i^{\text{th}}$  farm

$Y^*$  = frontier output

TE, ranges between 0 and 1 and maximum efficiency has a value of 1

### 2.7.2 The T-Test

The t- test is one of the common tests for comparing two samples to know whether there is a statistical difference in the performance of the two groups. According to Perry *et al.*,(2004), the t-test used in comparing a *control group*, who perform a task in the usual way, with an *experimental group*, who perform the task under the same conditions with an exception, known as "experimental manipulation". If the two groups perform differently, then one can attribute the difference to the effect of the 'manipulation'.

There are a number of assumptions underlying the t test; viz

- i. The samples are randomly and independently chosen from their populations. This is important as the t test uses the samples to estimate details of the populations they come from (such as the population mean and variance, referred to as parameters) and if the samples are selected in a biased way it will affect the accuracy of the estimations.
- ii. The data collected must be interval or ratio, from continuous distributions and normally distributed populations. There is however some debate as to the importance of these assumptions but they do underline the logic of the test. As long as the distributions are approximately normal the result still be meaningful, particularly for large samples (over 30), so that the test can still be carried. (Perry *et al.*, 2004).

The t-statistic would be estimated as follows:

$$t = \frac{\bar{M}_1 - \bar{M}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} \quad (9)$$

### 2.7.3 The Logistic Regression

Logistic regression could in many ways be seen to be similar to ordinary regression. It models the relationship between a dependent and one or more independent variables, and allows us to look at the fit of the model as well as at the significance of the relationships (between dependent and independent variables) that we are modeling (Strathclyde *et al.*,1992).

An important concept in logistic regression is that of odds ratios. Logistic regression, being based on the probability of an event occurring, allows us to calculate these, which are defined the ratio of the odds of an event occurring to it not occurring.

This regression model has a binary response variable and it is a non-linear regression tool. According to Agresti (1996), it is an appropriate tool to use when one wants to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. The coefficients from the regression can be used to estimate odds ratios for each of the independent variables in the model. The logistic regression will serve as an appropriate tool for this study. According to Pampel (2000), the model equation is given as:

$$\text{Logit } (E[Y]) = \text{Logit } (P) - XT\beta \quad (10)$$

Where

Logit ( $E [Y]$ ) - is the binary response/dependent variable

Logit ( $P$ ) = the natural log of the odds of success

$XT$  = the explanatory/independent variables

$\beta$  - is the regression co-efficient

### 2.7.4 Propensity Score Matching

This is a statistical matching technique that attempts to estimate the effect of a treatment, policy, or other intervention by counting for the covariates that predict receiving the treatment. PSM attempts to reduce the bias due to confounding variables that could be found



in an estimate of the treatment effect obtained from simply comparing outcomes among units that received the treatment versus those that did not. The technique was first published by Paul Rosenbaum and Donald Rubin in 1983, and implements the Rubin causal model for observational studies. (Paul R. *et al.*, 1983)

A propensity score is the probability of a unit (e.g., person, classroom) being assigned to a particular treatment given a set of observed covariates. Propensity scores are used to reduce selection bias by equating group based on the covariated value.

In randomly selected Sawah rice farmers in the sample population, it is expected that there would be a user or non-user of the Sawah rice technology. Assuming the potential outcome for using this Technology is represented by  $y_1$  and that for not using as  $y_0$ , then the average treatment effect which represents the expected population impact of usage can be derived as follows:

$$TE_i = y_{i1} - y_{i0} \quad (11)$$

$$ATE = E (y_1 - y_0) \quad (12)$$

Where  $TE_i$  denotes ‘treatment effect’ and represent the effect of usage on farmer  $i$ .

$y_{i1}$  is the potential impact for the Sawah rice Technology variety users.

$y_{i0}$  is the potential impact for the Sawah rice Technology variety non-users.

$y_1 - y_0$  is undefined for farmer  $i$  because in reality, an outcome and its counterfactual cannot be observed.

### **2.7.5 Productivity Concepts**

Productivity measures the physical quantity of output produced by one unit of input. Economic productivity is the value of output obtained with one unit of input. Productivity is

an overall measure of the ability to produce a good or service. More specifically, productivity is the measure of how specified resources are managed to accomplish timely objectives as stated in terms of quantity and quality. Productivity may also be defined as an index that measures output (goods and services) relative to the input (labour, materials, energy, etc., used to produce the output). As such, it can be expressed as: (Coelli *et al*, 1998)

$$\text{Productivity}=\text{Output}/\text{Input} \quad (13)$$

Hence, there are two major ways to increase productivity: either by increasing the numerator (output) or decreasing the denominator (input) in equation (13). Of course, a similar effect would be seen if both input and output increased, but output increased at a higher rate than input; or if input and output decreased, but input decreased at a high rate than output.

Productivity is useful as a relative measure of actual output of production compared to the actual input of resources, measured across time or against common entities. As output increases for a level of input, or as the amount of input decreases for a constant level of output, an increase in productivity occurs. Therefore, a "productivity measure" describes how well the resources of an organization are being used to produce input (Fakayode, 2009).

#### **2.7.6 Gross Margin Analysis**

The Gross margin as an analytical tool under the partial budgeting technique will be used specifically to estimate the costs and returns to rice production systems. This choice is based on the fact that Gross margin is the essential first step in farm budgeting and planning. Its analysis will allow for direct comparison of the relative performances in terms of similar enterprises. This provides a starting point to deciding or altering the farms' overall enterprise mix. The Gross margin can also be used to analyze actual enterprise performance which this study is interested in achieving, and it serves as a useful tool in terms of farm management,

budgeting and estimating the likely returns or losses of particular farm enterprises. The GM is given as Gross Value of Output (GVO) less Total Variable Cost (TVC) incurred in achieving it for a given period of time. GM is best calculated on per hectare basis. This allows for easy projection/estimation of figures based on the actual land size intended for use in rice sold (kilogram, bag, tons, mudus) multiplied by the number produced (Department of Environmental and Primary Industry (DEPI), 2014).

Gross margin is not a measure of farm profit per se because it does not include capital or fixed cost. Nonetheless, it is the most common analysis used to determine profitability in small scale farming. This is because cost incurred in production in any small scale farming majorly constitutes the variable cost so that the fixed cost component is just a negligible portion of total cost (Olukosi & Erhabor, 1998). Nevertheless, the irrigated rice production systems, the rice farmers have certain farm implements such as the water pumping machines, pipes/hose for irrigation and water tanks. As a result, fixed cost components will be factored into the total cost of production and so estimation of profitability will be done based on the net profit. Profitability indices such as the operation ratio and return to capital invested which can be calculated from the gross margin and net profit are therefore appropriate in determining profitability in rice production. Therefore, they will be employed in this study to show how profitable Sawah` rice production systems are.

### **2.7.7 Likert type scale**

The Likert scale was first introduced by Rensis Likert in 1932 (Van Alphen *et al.*,2008). He developed the principle of measuring attitudes by asking people to respond to a series of statements about a topic, in terms of the extent to which they agree with them, and so tapping into the cognitive and affective components of attitudes. A Likert scale is a psychometric scale commonly used in socio-economic researches. It is the most widely used approach to

scaling responses in survey research (Allen & Seaman, 2007). A Likert scale is the sum of responses to several Likert items which when combined provide a measure of a character that can be combined into a single composite score for data analysis. Likert items on the other hand are a statement that the respondent is asked to evaluate. Likert scale uses fixed choice response formats and they are designed to measure attitudes or opinion.

The choice of using a Likert scale for this study is based on the fact that Likert scale is not only useful for telling that the rice farmers are faced with certain challenges in the course of production, it can show the extent of the challenges in the way it scores the challenges along a range so that the degree of severity of each problem can be measured. A typical Likert scale could have a three to ten-ordered response level. Nevertheless, this study will employ a five-ordered level response scale of 'very serious' to 'not a problem at all'. The odd numbered ordered response levels are considered balanced since they have equal number of responses on both sides of a neutral opinion (Jamieson, 2004). This helps to create a less-biased measurement. The traditional way to report on a Likert scale is to sum the values of each selection option and create a score for each respondent. The score is then used to represent a particular trait or opinion. For the score to have a meaning, each item on the scale must be closely related to the same topic of measurement. This is to ensure that the summed score becomes a reliable measurement of the particular trait or opinion the researcher is measuring (Carifo & Rocco, 2007). Likert scales have the advantage that they do not expect a simple yes/no answer from the respondent, but rather allow for range of opinion, and even no opinion at all. Therefore, quantitative data is obtained, which means that the data can be analyzed with relative ease. However, like all surveys, the validity of Likert scale attitude measurement can be compromised due to the social desirability (McLeod, 2008). This means that individuals may lie to put themselves in a positive light.

## 2.8 Empirical Review of Literature on Adoption

### 2.8.1 Theory of Adoption

From the extensive review of the literature on technology adoption in developing countries, by Feder *et al.* (2001), the various factors that influence technology adoption can be grouped into the following three broad categories:

(1) Factors related to the characteristics of producers;

(2) factors related to the characteristics and relative performance of the technology and institutional factors. The factors related to the characteristics of producers include: education level, experience in the activity, age, sex, household size, level of wealth, farm size, labor availability, risk aversion and capacity to bear risk. The institutional factors include the availability of credit, the availability and quality of information on the technologies, accessibility of markets for products and inputs factors, the land tenure system, and the availability of adequate infrastructure (Danded *et al.*, 2012).

Similarly, a study by Meinzen-Dick *et al.* (2004) identified assets, vulnerability, and institutions as the main factors affecting technology adoption. Assets deal with whether farmers have the necessary physical (material) and abstract possessions (e.g. education) essential for technology adoption. Lack of assets will limit technology adoption. Vulnerability factors deal with the impact of technologies on the level of exposure of farmers to economic, biophysical and social risks. Institutional factors deal with the extent or degree to which institutions impact on technology adoption. Institutions include all the services to agricultural development, such as finance, insurance and information dissemination. They also include facilities and mechanisms that enhance farmers access to productive inputs and product markets. Institutions also include the embedded norms, behaviours and practices in society.

Adoption of agricultural technologies is increasingly becoming a major consideration in agriculture. Once invented, a technological innovation must be adopted by producers, and it is here that the demand side of the technology market plays a major role in agricultural productivity. Beginning with Feder and Slade (1984) pioneer research on the role of information and the adoption of new technology, many studies have been devoted to explaining the speed of technology adoption in agriculture. Feder and Slade, (1984) identified factors influencing adoption of agricultural innovations. The most important factors are tenure arrangement, credit constraint, farm size, labour availability, risk exposure and ability to bear the risk, human capital and access to markets for agricultural products. Studies, particularly those done after the year 2000s are replete with expanded lists of factors that influence speed of agricultural technologies adoption. Mangisoni *et al.* (2001) found that experience of farming, land quality and extension contacts were important factors affecting the rate of adoption of soil erosion-control technologies in Malawi. Mensah *et al.* (2012) found that extension contact, the experience of farming, membership to the social organization, access to credit, primary education attendance and land per capita were significant factors in affecting the rate of adoption of land and water management and technology by maize farmers in Ghana.

Studies conducted by Legese *et al.*,(2011), Menale *et al.* (2011), Solomon *et al.* (2012) and Sosina *et al.* (2014) on the impact of various improved crop technologies, in countries such as Ethiopia, Uganda, Tanzania and Malawi, supported the hypothesis that adopter households experience increase in crop income, consumption expenditure and value of asset accumulation through improved household productivity.

### 2.8.2 Technology Adoption

Some of previous studies used various econometrics techniques to identify the determinants of the status and extent of agricultural technology adoption. The application of each model depends on the objective of the research. Shiferaw and Tesfaye (2006), Hailu (2008), Assefa and Gezahegn (2010) and Moti *et al.* (2013) employed Logit or Probit models for estimating the status of technology adoption. Some other authors such as Hassen *et al.* (2012) and Yu and Nin-Pratt (2014) used double hurdle model to analyze the status and intensity of technology adoption sequentially. Moti *et al.* (2013) and Menale *et al.* (2011) used multinomial probit model for estimating the status of more than two interdependent technologies choice options. Hailemariam *et al.* (2013) estimated both multinomial and multivariate probit models for estimating adoption decisions of multiple sustainable agriculture practices in rural Nigeria. Logit or probit is best suited if the objective of the research is to analyze the only status of technology adoption, a multinomial model for analyzing the status of more than two independent technologies adoption options and multivariate probit model for analyzing the status of more than two interdependent technologies adoption options (Hassen *et al.* 2012). Tobit and Double-hurdle models estimate both status and intensity of adoption sequentially, but it overlooks the aspect of selectivity bias (Green, 2003). As a result, studies such as that of Nega and Senders (2006), Jon (2007), Solomon *et al.* (2011) and Moti *et al.* (2013) used Tobit model and assume the two decisions (status and extent of technology adoption) are affected by the same set of factors.

Count data regression models which involve the utilization of either Poisson or the Negative Binomial models have been widely applied in previous studies to identify the determinants of the speed of agricultural technology adoption. For example, Mangisoni *et al.* (2001), Lohr and Park (2002), Isgin *et al.* (2008), Sharma *et al.* (2011) and Mensah *et al.* (2012) employed Tobit model to examine the speed of technology adoption. Lohr and Park rejected the

Poisson model in favour of the Negative Binomial model because of its negative distribution and Isgin *et al.* (2008) employed Poisson and Negative Binomial specifications to identify the factors affecting the speed of multiple independent farming technologies adoptions. Mensah *et al.* (2012) used Negative Binomial regression model to evaluate the rate of technology adoption of land and water management employed by maize farmers in Ghana, while, Sharma *et al.* (2011) employed this model to assess the speed of pest management technology adoption used by farmers. The count data models offer some useful advantages for analyzing the speed of technology adoption studies. First, it relaxed making strong assumptions about relationships between technologies being investigated in the case of multiple technologies as no arbitrary aggregation of techniques is assumed. Second, it provides the special focus on analyzing the speed of technology adoption intensity.

### **2.8.3 Empirical applications of the stochastic frontier model in Efficiency Studies**

The seminal works of Koopman (1951) and Farrell (1957) looked at the theoretical framework of efficiency of farms. The relevance of efficiency in increasing agricultural production has been widely recognized and variously investigated by researchers such as Bravo-Ureta and Evenson, (1993); Ashok *et al.*, (1995); Seyoum *et al.*, (1998); Abay, Miran and Gunden, (2004); Chavas, *et al.*, (2005).

Numerous methods have been developed for the empirical measurement of frontier functions and the potential deviations from such functions. These methods can be categorized according to the specification of the frontier – parametric or non-parametric; the way the frontier is computed, through programming or statistical procedures, and the way deviation from the frontier are interpreted, that is as inefficiency or a mixture of inefficiency and statistical noise.

According to (Forsund and Hjalmarsson,1980) and Amara *et al.*, 1998, a probabilistic production frontier which was put up by Aigner and Chu in 1968, was by used Timmer



(1971) took the problem of outliers into account; this was estimated with mathematical programming technique. A similar frontier production function called deterministic stochastic frontier function was later suggested by Amara *et al.*, (1998) may be estimated using Maximum Likelihood Estimation (MLE) procedures or any other econometric technique. The deterministic approach as argued by Forsund *et al.*, (1980) ignores the fact that farms' performance can be affected by factors such as bad weather, poor performance of machinery or breakdown of input supply which are all beyond the farmer's control (Amara *et al.*, 1998). This indicates that deviations from the efficiency frontier may be of two origins: inefficiency in input-use or random-variations in the frontier across different farms. On the other hand according to Kibaara (2005) and Thiam *et al.*, (2001) the stochastic approach allows for statistical noise. Xu and Jeffrey (1998) said, given the alternative empirical tools available, the choice as to the 'best method' to use is still not clear. This, they said may be because whichever method is adopted gives the same result (Xu and Jeffrey, 1998). Bravo-Ureta and Rieger (1990) compared the results of deterministic (i.e. both programming and econometric analyses) and stochastic parametric efficiency models for a sample of United States (US) dairy farms. The estimates from each approach were different quantitatively. The estimates were ranked for each of the farms using the different models; the results obtained were quite similar. This according to Xu and Jeffrey (1998) suggests that choice between alternative models approach look arbitrary. Accordingly, there has been no consensus among researchers about the best method for estimating efficiency. Xu and Jeffrey, (1998)

Among different major approaches followed to measure and estimate efficiency, the stochastic frontier production function approach involving econometric estimation of parametric function (Aigner *et al.*, 1977; Meeusen and Broeck, 1977) and non-parametric programming, known as Data Envelopment Analysis (DEA) (Charnes *et al.*, 1978), are the most popular. The stochastic frontier approach has been considered more appropriate for

assessing TE in a developing country Agriculture, where data are often heavily influenced by measurement errors and other stochastic factors such as weather conditions, diseases, etc. (Farell *et al.*, 1985; Kirkley *et al.*, 1995; 1998; Jaforullah and Delvin 1996; Coelli *et al.*, 1998; Dey *et al.*, 2005; Singh *et al.*, 2009). The DEA method has a disadvantage in that it does not explicitly accommodate the effects of data noise (Murty *et al.*, 2009).

Since stochastic frontier production models proposed by Mueusen and Van Den Broeck (1977) and Aigner *et al.*, (1977), there has been a vast range of their applications in literature. Battese and Coelli (1995) proposed a stochastic production function, which has firm's effects as a truncated normal random variable, in which the inefficiency effects are directly influenced by a number of variables. Of note is the research work of the duo of Emokaro and Ekunwe, (2009) which gave insights into the measuring efficiency of catfish farms, employing the stochastic production function analysis. Their results showed that the estimated farm level technical efficiency ranged from 47.0 percent to 97.1 percent with a mean of 85.4 percent. About 90 percent of the farmer had technical efficiency exceeding 0.71. Some of the variables of interest such as fingerling, labour and pond size were efficiently allocated as their estimated coefficient value range between zero and one. Gender, household size and education were found to be negatively related to technical efficiency while experience and age were found to be positively related to technical efficiency. Also Singh *et al.*,2009) identified such variables like fingerlings stocked, labour and lime (except for lime in ECM), as having positive significant coefficients which indicate that there is potential of increasing fish production through raising the levels of these inputs.

Adewumi and Adebayo (2004) examined the economic potential of fish farming in Abeokuta zone of Ogun State in the 2003 production season. They examined the costs and return of the business and also determined the resource-use efficiency of fish farming activities in the study area. Their result revealed inefficiency in the use of pond size, lime\* and labour with

over-utilization of fingerlings Stocked. Based on their findings, they suggested that for profit maximization the fish farmers will have to increase the level of their use of fingerlings and fertilizers and decrease the use of lime, labour and pond size. Onumah and Acquah (2010) also came up with findings that may imply that differences in the quality of inputs used, level of advisory services and support from government Aquaculture offices etc. within the respective regions in their study area do not influence technical efficiency of production. The combined effects of operational and farm specific factors, they concluded, influence efficiency. Furthermore, their study revealed that inclusion or interaction between some exogenous factors and input variables in the inefficiency model are significant in explaining the variation in efficiency. Specifically, Onumah and Acquah (2010) posited that Aquaculture farms in the study area suffer from oversize and moreover that extension advice plays a major role in efficiency of production. The overall mean technical efficiency in their study area was estimated to be nearly 80%. However, when locations of farms are categorized by regions, the study did not observe any significant variation in terms of mean technical efficiency. Their findings indicated that it is possible for the farms to improve their performance by using best practice technology.

Dipeolu *et al.*, (2008) also estimated the economic efficiency of fish-farms in Ogun, Nigeria using the stochastic frontiers production approach. They used cross section data of 85 fish farming grouped into concrete and earthen pond type. The research was based on the Cobb Douglas production function involving fish production in kilogram and five inputs, including pond area. Using this method, they analyzed labour, lime, fingerlings, feed and other materials. The technical inefficiency function involved experience such as age and education of the owners as well as household size. The empirical results revealed that the mean technical efficiency of earthen pond and concrete pond type were about 0.88-0.89 with no statistical significant difference between the two pond types.

Kalirajan (1981) estimated a stochastic frontier Cobb-Douglas production function using data from 70 rice farmers for the rabi season in a district in India. The variance of farm effects was found to be a highly significant component in describing the variability of rice yields (the estimate for the  $\gamma$ -parameter was 0.81). Kalirajan (1981) proceeded to investigate the relationship between the difference between the estimated 'maximum yield function' and the observed rice yields and such variables as farmer's experience, educational level, number of visits by extension workers etc. in the second stage analysis. Kalirajan (1981) noted the policy implications of these findings for improving crop yields of farmers.

Okoruwa and Ogundele (2006) examined technical efficiency differentials between farmers farming two varieties of rice: the traditional and improved rice varieties in Nigeria. The study used stochastic frontier production functions in which the technical inefficiency effects are assumed to be functions of educational status of farmers, number of contact with extension personnel, rice farming experience and household size. The results indicate that significant increase recorded in output of rice in the country could be traceable mainly to area expansion. The use of some critical inputs such as fertilizers and herbicides by the farmers were found to be below recommended quantity per hectare. There was also significant difference in the use of such input as labour between the two groups of farmers. The estimated average technical efficiencies for the two groups were correspondingly high ( $>0.90$ ) which implies that there is little opportunity for increased efficiency given the present state of technology. According to Okoruwa and Ogundele (2006) the non-differential in technical efficiency between the two groups therefore puts to question the much expected impact of the decades of rice development programmes in Nigeria.

In another study, Rahji (2003) used the stochastic frontier production function to investigate the production efficiency differentials between two rice farmer groups in Niger state, Nigeria. These farmer groups were categorized as adopters and non-adopters of recommended

improved rice technologies based on an adoption score of 40 per cent. Multiple regression analysis, involving the estimation of stochastic frontier production function was used in analysing the data set for the groups. The results indicated that land, labour and seed were significant variables that influence rice production. The result also showed over-utilization of labour in rice production systems in the study area while the two farmer groups attained 79 and 65 per cent technical efficiency levels respectively. Farm size, education, household size and distance to input source were found to affect the technical efficiency of the farmers. Extension was highly significant for adopters and not for non- adopters.

Kalirajan and Flinn (1983) applied the methodology proposed by Bagi (1982) to data for 79 rice farmers in the Bicol region. They estimated the parameter of their model using the maximum – likelihood method (ML). The Cobb – Douglas model was found to be an inadequate representation of the farm – level data, and so a strong trans-log stochastic frontier production function was estimated to explain variations in rice output in terms of several inputs. The estimated technical efficiencies ranged from 0.38 to 0.91. Kalirajan and Flinn 1983, then undertook the regression of the predicted technical efficiencies on several farm-specific characteristics to determine which factors are associated with estimated efficiency scores. Several variables, including the practice of transplanting rice seedlings, the incidence of fertilization, years of farming and number of extensions, were found to have significant relationships.

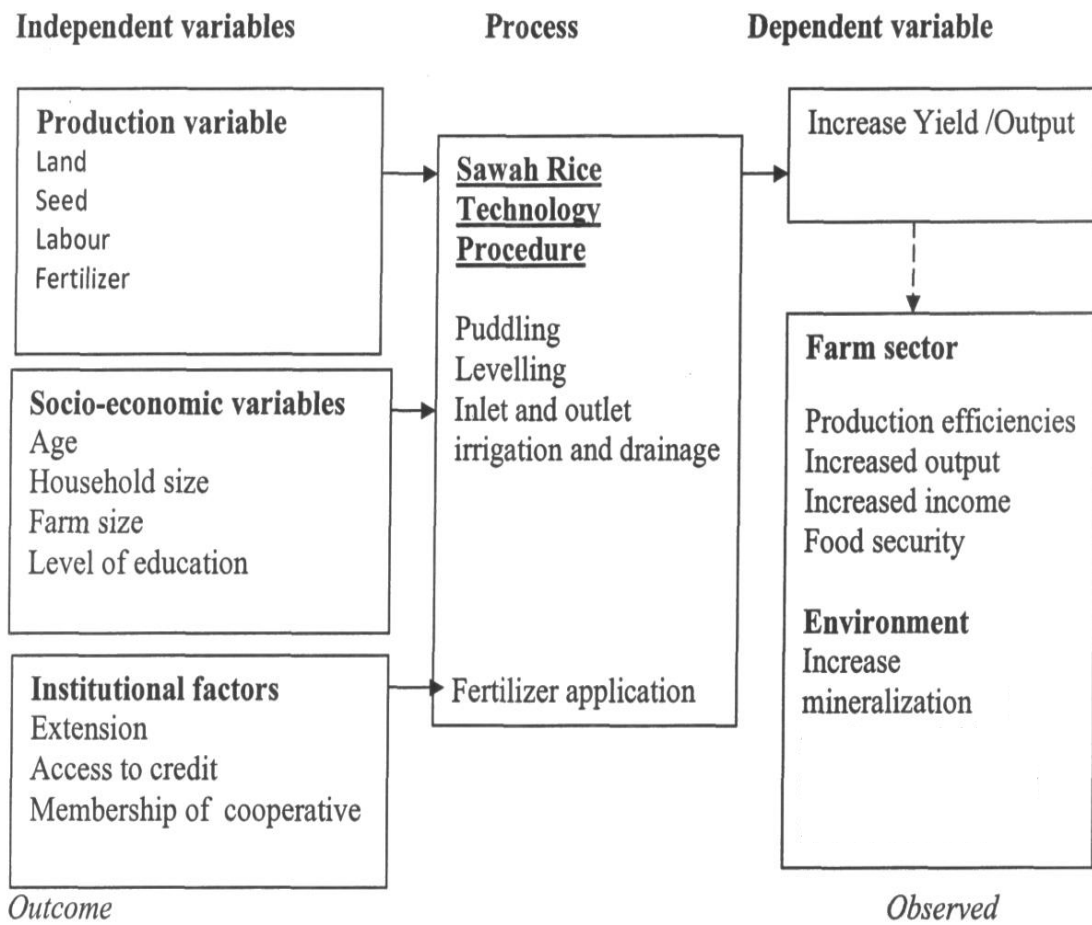
Rola and Quintana – Alejandrino (1993) used a stochastic frontier production to estimate the technical efficiencies of rice farmers in different rice environments in selected regions of the Philippines. The study used a Cobb – Douglas production frontier and estimated the model by the maximum likelihood method. Input variables in the production frontier included farm size, fertilizer (nitrogen), insecticide, herbicide and labour. In addition, variables such as education of the household head, tenurial status and water source were used in the production

function. Input – output data and other demographic information were gathered from farmers in the irrigated, rainfed and upland environments of five rice producing regions in the Philippines. Rola and Quintana (1993) estimated mean technical efficiencies of 0.72, 0.65 and 0.57 for irrigated, rainfed and upland environments respectively. Education, access to capital and tenurial status were some factors that affected the levels of technical efficiencies of farmers in the different environments.

#### **2.8.4 Conceptual Framework for the Study**

Conceptually, this study takes the view that adoption processes take place in contexts beyond the individual (Leewis & van den Ban 2004). Rather than an individual decision making process, social networks (groups, family etc.) in which farmers operate as well as their relationships with agencies such as NCAM shape the degree to which new ideas are taken up and shared according to Mango and Hebinck (2004), sharing ideas and resources is a function of social relations and the respect that people have for each other. The conceptual framework as shown in figure 3 describes the relationship between the independent variables and the dependent variables.

**Fig.3: Conceptual Framework for the Effect of Sawah rice Technology on Rice Production.**



Fertile land, improved seed and adequate fertilizer application is believed to be capable of increasing rice production. Also institutional factors such as extension agents, access to credit and membership of cooperative society will encourage farmers to produce more rice. The elements of Sawah Technology are also believed to be capable of increasing the yield of rice. Increase yield/output will lead to food security, increased income and production efficiency. This study therefore sets out to investigate if these assumptions are true particularly as regards the study area of Kebbi state Nigeria, where Sawah rice technology is being promoted.

## CHAPTER THREE

### MATERIALS AND METHOD

#### 3.1 Description of the Study Area

The study will be carried out in Kebbi State, Nigeria. Kebbi State is located in North Western Nigeria with its capital at Birnin Kebbi. The State was created out of a part of Sokoto State in 1991. Kebbi State is bordered by Sokoto State, Niger State Zamfara State, Dosso Region in the Republic of Niger and the nation of Benin. It has a total area of 36,800 km<sup>2</sup>. The State has features of both Sudan and Sahel savannah. The southern part is generally rocky, with the Niger River traversing it from Benin Republic to Ngaaski LGA of the State.

Kebbi State is mainly populated by Hausa people, with some members of Fulani, Lelna, Bussawa, Dukawa, Dakarkar, Kambari, Gungawa and Kamuku ethnic groups. The people of Kebbi are predominantly Muslims. In Kebbi State, the wet season is hot and mostly cloudy and the dry season is sweltering and partly cloudy. Over the course of the year, the temperature typically varies from 65<sup>0</sup>F varies to 104<sup>0</sup>F and is rarely below 61<sup>0</sup>F or above 108<sup>0</sup>F. The hot season last for 2.1 months, from March 11 to May 16, with an average daily high temperature above 101<sup>0</sup>F. The hottest day of the year is April 10, with an average high of 104<sup>0</sup>F and low of 81<sup>0</sup>F. The cool season lasts for 2.3 months, from July 7 to September 18, with an average daily high temperature below 91<sup>0</sup>F. The coldest day of the year is January 1, with an average low temperature of 65<sup>0</sup>F and high at 89<sup>0</sup>F.

The rainy period of the year lasts for 6.1 months, from April 17 to October 20, with a sliding 31-day rainfall of at least 0.5 inches. The most rain falls during the 31 days centred around August 17, with an average total accumulation of 7.1 inches. The rain-less period of the year lasts for 5.9 months, from October 20 to April 17 (KESADEP, 2018).





Figure 3.1: Map of Nigeria Indicating the Position of Kebbi State

Source: (KESADEP, 2018)

### 3.2 Organization of Farming Enterprise in the State

Agriculture is the main occupation of the people especially in rural areas, Crops produced are mainly grains; animal rearing and fishing are also common. Some of the farmers also practice agroforestry system of farming. Cereals are the major crops grown. Few of the farmers also practice the taungya system of farming. It is a system of farming where tree crops are planted along side with food crops.

Agriculture is the main occupation of the people of Kebbi state and it provides income and employment for more than 75% of the population. Kebbi State Agricultural Development Programme (KESADEP, 2018). Some other persons in the village engage in business in order to cater for their families. The main cash crops are cocoa, coffee, kolanut, cashew and oil palm. Other tree crops popular in the area are: citrus fruits, coconut, mango, sugar-cane and guava. It also has of various species of timber that provide raw materials for wood based industries. Some of the arable crops found in the village are: yam, cocoyam, cassava, maize, plantain/banana, rice beans, pepper, tomatoes and varieties of vegetables (KESADEP, 2018).

### 3.3 Sampling Procedure and Sample Size

The adopters of the Sawah rice technology are to be found mainly in Bagudo, Dandi and Jega area of Kebbi State. From the list of registered rice farmers to be obtained from KESADEP, 270 rice farmers will be purposively selected for this study.

### 3.4 Method of Data Analysis

Descriptive statistical tools to be used for this study will include simple descriptive statistics like mean, standard deviation, percentages and frequencies. They will be applied to describe household and farm characteristics information of the respondents selected for the survey, while inferential statistical methods such as logistic regression analysis stochastic frontier, t-test and propensity score matching and five-point Likert-type scale will be used for this study.

### 3.5 The Logistic Regression Model

The logistic regression model will be used to determine factor influencing the adoption Sawah rice technology among rice farmers in Kebbi State.

The model is given as:

$$\text{Logit} (E[Y]) = \text{Logit} (P) - XT\beta \quad (14)$$

Where

$\text{Logit} (E [Y])$  = is the binary response/dependent variable which represents adoption of Sawah rice Technology.

$\text{Logit} (P)$  = the natural log of the odds

$XT$  = the explanatory/independent variables

The independent variables are:

$\beta$  = is the regression co-efficient

$X_1$  = Farm size (ha)

$X_2$  = Rice seed (kg)

X<sub>3</sub> = Fertilizer (Super Granules) (kg)

X<sub>4</sub> = Herbicides (litres)

X<sub>5</sub> = Family labour (man-day)

X<sub>6</sub> = Hired labour (man-day)

X<sub>7</sub> = Marital status (0,1)

X<sub>8</sub> = Household size (Adult equivalent)

X<sub>9</sub> = Age (Years).

The dependent variable is a dichotomous variable depicting the users of Sawah rice technology. It takes the value of 1 if the rice farmers are willing to adopt and 0 if not. Logit model will be used for this study because the dependent variable is dichotomous in nature indicating 0 for non-adopters of sawah rice technology and 1 for adopters. Also, logit model is the most commonly used among the dichotomous models because the result is easily interpreted than other dichotomous models.

### **3.6 Gross Margin Analysis**

Gross margin analysis will provide a level of profitability of rice enterprise for both users and non users of sawah rice technology.

Gross Margin = Gross Income – Total variable Cost

Net Income = Gross margin – Total fixed cost

### **3.7 The Stochastic Frontier Production Function**

The Cobb-Douglas functional form of the stochastic production frontier will be employed to estimate the technical efficiency of users and non-users of sawah rice technology in the study area.

It is expressed as:

$$Y_i = f(X_i, \mu_i) + (V_i - \mu_i) \quad (15)$$

Where: Y is the output of the ith farm

$X_i$  is a  $k \times 1$  vector of physical input quantities of the  $i$ th farm.

$P$  is a vector of unknown parameters estimated

$V_i$  are random variables which are assumed to be normally distributed  $N(0, \sigma^2)$  and independent of the  $\mu_i$ . It is assumed to account for measurement error and other factors not under the control of the farmer.

$V_i$  are non-negative random variables, called technical inefficiency effects.

The explicit form of the model is expressed as (for adopters of sawah Technology

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V - U_i \quad (16)$$

where:  $Y$  = Rice output (kg)

$X_1$  = Farm size (ha)

$X_2$  = Rice seed (kg)

$X_3$  = Fertilizer (Super Granules) (kg)

$X_4$  = Herbicides (litres)

$X_5$  = Family labour (man-day)

$X_6$  = Hired labour (man-day)

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$  = Parameters to be estimated.

The inefficiency model is represented by  $U_i$  which is defined as follows:

$$U_i = d_0 + d_1 Z_1 + d_2 Z_2 + d_3 Z_3 + d_4 Z_4 + d_5 Z_5 + d_6 Z_6 + d_7 Z_7 \quad (17)$$

$U_i$  — Technical inefficiency

$Z_1$  = Level of education (successful years of formal education)

$Z_2$  — Sex (male = 1, female = 0)

$Z_3$  = Marital status (1 = married, 0 if otherwise)

$Z_4$  = Household size (adult equivalent)

$Z_5$  = Age (years)

$Z_6$  = Household size (adult equivalent)

Z<sub>7</sub> = Membership of farmers' association (1 for being a member, 0 if otherwise)

Z<sub>8</sub> = Credit availability (Naira)

d<sub>0</sub>, d<sub>1</sub>, d<sub>2</sub>, . . . . . d<sub>8</sub> = Parameters to be estimated.

For non adopters of sawah Technology, the model is expressed as follows:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V - U_i \quad (18)$$

where: Y = Rice output (kg)

X<sub>1</sub> = Farm size (ha)

X<sub>2</sub> = Rice seed (kg)

X<sub>3</sub> = Fertilizer (Super Granules) (kg)

X<sub>4</sub> = Herbicides (litres)

X<sub>5</sub> = Family labour (man-day)

X<sub>6</sub> = Hired labour (man-day)

The Cobb-Douglas production function as specified in this study depicts the long-run situation.

Cost efficiency (C.E) = T.E + A.E

$$C.E_i \text{ can be specified thus } \frac{C_i}{(y_i, w_i \beta) \exp(v_i)} = \exp(-u_i) \quad (19)$$

$$E_i \quad \quad \quad 0 \leq C.E_i \leq 1$$

### 3.8 The t-test Analysis

The t-test will be used to analyze if there is any significant difference between the technical efficiency of users and non-users of Sawah Technology

The t-statistic would be estimated as follow:

$$t = \frac{\bar{M}_1 - \bar{M}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} \quad (20)$$

where:

$\overline{M}_1$  Mean of users' variable

$\overline{M}_2$  = Mean of non-users' variable

$S_1^2$  = Variance of MI variable

$S_2^2$  = Variance of MS variable

$N_1$  = Number of users

$N_2$  = Number of non-users

### 3.9 Propensity Score Matching

In randomly selected Sawah rice farmers in the sample population, it is expected that there would be a user or non-user of the Sawah rice technology. Assuming the potential outcome for using this Technology is represented by  $y_1$  and that for not using as  $y_0$ , then the average treatment effect which represents the expected population impact of usage can be derived as follows:

$$TE_i = y_{i1} - y_{i0} \quad 21$$

$$ATE = E (y_i - y_0) \quad 22$$

Where  $TE_i$  denotes 'treatment effect' and represent the effect of usage on farmer  $i$ .

$y_{i1}$  is the potential impact for the Sawah rice Technology variety users.

$y_{i0}$  is the potential impact for the Sawah rice Technology variety non-users.

$y_1 - y_0$  is undefined for farmer  $i$  because in reality, an outcome and its counter-factual cannot be observed. But since using the variety usage is a necessary condition for impact, the  $y_0 = 0$  for a randomly sampled farmer. This implies that the impact on farmer 'i' is  $y_{i1}$  and the average usage impact  $ATE = E (y_1)$ . This however in reality underestimates the true population impact because  $y_1$  is observed only for usage, a situation that could result into selection bias. If  $NA = 1$  denotes users and  $NA = 0$  denotes non-users, then the average

impact on the using sub-population (ATT) will be more relevant for this study. It is derived as:

$$ATT = E (Y_i | NA = 1) \quad (23)$$

Where  $Y_i$  is the outcome variables – technical efficiency, returns per hectare from rice cultivation, gross margin and operating ratio.

### 3.10 BUDGETS FOR THE STUDY

S/N	Activities	Period/ Frequency	Breakdown	Unit cost (₦)	Total cost (₦)
1	Total school fee and Registration		Five-years school fees, acceptance payment and student Union charges		600,000
2	Search and review of literature	23 Months	Internet access	5,000/m onth	115,000
			Library consultations transport (Universities, State, Federal)	5,000/m onth	115,000
			Printing & photocopies		50,000
3	Preliminary consultation to select enumerators		Pre-field visitation		15,000
4	Proposal development		Printing		20,000
5	In-house seminar		Printing and others		10,000
6	Pre-field seminar		Printing and others		30,000
7	Ethnical approval process		Printing and CD burning		3,000
8	Protocol review process		Printing		10,000
9	Data collection	2 Months	Phone call charges		10,000
			Printing of Questionnaires	270 copies	25,000
			Enumerator Training		50,000
			Hotel Accommodation, Transport & Feeding		100,000
			Enumerators payment		80,000
10	Data entry & Analysis		Data collation/processing		70,000
			Analyzing data	Myself	Myself
11	Post-field seminar		Printing, binding etc		35,000
12	Ph.D. Examination		Printing, binding etc		20,000
13	Final printing/Binding				20,000
14	Miscellaneous				20,000
<b>GRAND TOTAL</b>					1,400,000

Source: Researcher's Design, 2018



### **Source of funding**

This project will require a sum of 1,400,000 naira only. The project will be funded with personal savings and grants if obtained. Grants will be sourced from private, local and international organizations to aid the research

### **3.11 TIMELINE FOR THE STUDY**

#### **TASK**

Survey of Literature	2012-2015
Write proposal	2015 – 2017
Develop questionnaire	01/04/2018
In-house seminar	15/08/2018
Pre-field seminar (presentation)	11/10/2018
Input feedback and corrections from seminar	15/12/2018
Pretest questionnaire	20/02/2019
Collect data	30/05/2019
Collate and analyze	10/06/2019
<b>Thesis writing</b>	
Update introduction	25/06/2019
Update literature review	25/06/2019
Update methodology	25/10/2019
Data Gathering	15/11/2019
Data analysis/ discussion of results	16/12/2019
Write conclusions & recommendations	25/12/2019
Update references	10/01/2020
Post-field seminar	17/01/2020
Input feedback and corrections from seminar	30/01/2020

Write acknowledgement, appendices, etc.	01/02/2020
Revise first draft	10/02/2020
Ph.D. Defence	25/02/2020
Make final corrections & submission	03/03/2020

**Source: Researcher's Design, 2019**

### **3.12 CONTRIBUTION TO KNOWLEDGE**

This project will contribute to knowledge in the area of asserting the drivers of Sawah rice technology, the level of compliance to Sawa rice Technology Adoption, the effect of using Sawah rice Technology on the technical efficiency of the farmers. It would also contribute to knowledge by ascertaining the profitability of Sawah rice Technology. Most work on efficiency do not go deep into examining cost efficiency they only focus on technical efficiency. This work will focus on technical, economic as well as cost efficiency of Sawah rice production in Kebbi state.

## REFERENCES

- A Amara, O Lorthioir, A Valenzuela, A Magerus, M Thelen, M Montes, J.L Virelizier, M Delepierre, F Baleux, H Lortat-Jacob, F Arenzana-Seisdedos Stromal (1998) cell-derived factor-1 $\alpha$  associates with heparan sulfates through the first  $\beta$ -strand of the chemokine
- Abay, C. Miran, B, Gunden, C.,(2003)."An Analysis of Input use efficiency in Tobacco production with respect to sustainability: The case study of Turkey". *Journal of sustainable Agriculture* 24(3):123-143
- Adewumi, M.O., & Adebayo, F.A. (2004). Profitability and technical efficiency of Sweet Potato production in Nigeria. *Journal of Rural development*, 31(5), 105-120.
- Agbam J.U (2006). Essentials of agricultural Communication in Nigeria. Malthouse press Limited, Lagos. 47-81
- Agbam J.U. (1995). Effects of socio-economic characteristics in adoption of new varieties of maize and cassava. A case study of Ogun state of Nigeria. *Journal of Agricultural development studies*, 6 (2), 8-16
- Agbam J.U. (2008). Essential of Agricultural Communication in Nigeria. Malthouse press limited, Lagos. 34-56
- Agresti, A. and LANG, J. (1996). A proportional odds models with subject-specific effects for repeated categorical response. *Biometrika*, 80:527-534.
- Aigner, D. J. and S. F. Chu (1968), 'On Estimating the Industry Production Function', *American Economic Review* 58: 826-839.
- Aigner, D., Lovell, C.A.X., and Schmidt, P.(1977), "Formulation and estimation of stochastic frontier production function models". *Journal of Econometrics* 6:21-37.
- Akanbi S.O., Omotesho, .O.A. and Ayinde, O.E (2012): Analysis of Technical efficiency of rice farms in Duku Irrigation Scheme in Kwara State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 7(3):65-72
- Allen, I. E., & Seaman, C.A.(2007)."Likert Scales and Data Analyses" .*Quality Progress*. 30(13),64–65.
- Amor, E.J, Muller. D. 2010 Comparing the determinants of cropland abandonment in Albania and Romania using boosted regression trees. *Agric. Syst.*117,66–71
- Ashok B.T. & Saxena S. 1995 Biodegradation of polycyclic aromatic hydrocarbons a review. *Journal of Scientific and Industrial Research* 54, 443–451.
- Assefa A and Gezahegn A. 2010. Adoption of improved technology in Ethiopia. *Ethiopian. Journal of Economics*, 1(5): 155-178.
- Ayodele, O. S., Obafemi, F. N., & Ebong, F. S. (2016). Challenges facing the achievement of the Nigeria vision. *Global Advanced Research Journal of Social Sciences*, 27, 143-157.

- Ayoola, G.B. (2001), *Essays on The Agricultural Economy 1: A Book of Readings on Agricultural Development Policy and Administration in Nigeria*: Ibadan: TMA Publishers. Food and Agricultural Organisation (FAO), (2004) *The Ethics of Sustainable Agricultural Intensification*.
- Babafada, M. (2003). Integrated rice production and export in Nigeria. Paper presented at a seminar on sustainable rice production in Nigeria, organized by Central Bank of Nigeria at Hamadala Hotel, Kaduna from January 14-15.
- Babatunde, R.O. and Omotesho, O.A. (2003) "Farm Size and Productivity Relationships among Selected Farms in Kwara State of Nigeria" *Centre point Journal*, Science Edition, 11(1): 19-29. Published by the Library and Publication Committee, University of Ilorin.
- Bagi, F.S. (1982), "Relationship Between Farm Size and Technical Efficiency in West Tennessee Agriculture"~ *Southern Journal of Agricultural Economics*, 14, 139-144.
- Battese, G. E. and Coelli T. J.(1995), 'Frontier Production Functions, Technical Efficiency and Panel Data: With Application to Paddy Farmers in India', *Journal of productivity Analysis* 3, 153-169
- Battese, G.E. and Coelli, T.J. (1977), "Prediction of Firm-Level Technical Efficiencies With a Generalised Frontier Production Function and Panel Data", *Journal of Econometrics*, 38, 387-399.
- Bravo-Ureta, B.E. (1990). Technical Efficiency Measures for Dairy farms Based on a Probabilistic Frontier Function Model. *Canadian Journal of Agricultural Economics*, 34,399-415
- Bravo-Ureta, B.E., and R. Evenson. (1993) "Efficiency in Agricultural Production: The Case of Peasant Farmers in Eastern Paraguay." Manuscript Department of Agricultural and Resource Economics, University of Connecticut, Storrs, CT.
- Caswell, M., (1999). Adoption of Agricultural Production Practices, lessons learnt from the U.S Department of Agricultural Area Project. Economics Research Service.
- Charnes, A., W.W. Cooper and E. Rhodes (1978), "Measuring the Efficiency of Decision Making Unit. *European Journal of Operation Research*, (2) 429-444.
- Chavas, J., Petrie, R., Roth, M., (2005). "Farm household production efficiency: Evidence from the Gambia" *American Journal of Agricultural Economics* 87: 160-179.
- Coelli, T. J. (1997), "A Multi-Stage Methodology for the solution of Orientation DEA Models", mimeo, Centre for Efficiency and Productivity Analysis, University of New England, Armidale
- Coelli, T.J, Rahmans, T., C (2002). "Technical, Allocative, Cost and Scale Efficiencies in Bangladesh Rice cultivation : A non-parametric Approach" *Journal of Agricultural and Resource Economics* 48(2): 347-369.
- Coelli, T.J; Rao, D.S.P. & Battese, G.E. (1998). An introduction to efficiency and productivity analysis. Kluwer Academic, Boston.

- CSA. (Community Supported Agriculture) 2014a. Agricultural sample survey 2013/2014 (2006 E.C.): Volume I – Report
- Danded, L., Diagne, A., Biauou, G., Ncho, S. and Midingoyi, K. 2012. Determinants of diffusion and adoption of improved technology for rice parboiling in Benin. *Review of Agricultural and Environmental Studies*, 93(2): 171-191.
- DEPI (2014). Farm gross margin. A publication of the Department of Environment and Primary Industries, State of Victoria Government. Retrieved on 2/12/2014 from [www.depi.vic.gov.au](http://www.depi.vic.gov.au)
- Dey, M.M., P. Kambewa, D. Jamu, M. Prein, D. Pems, F. Paraguas 2000. Development and Dissemination of Integrated Aquaculture-Agriculture
- Dey, M.M., Paraguas, F.J., Srichantuk, N., Xinhua, Y., Bhatta, R. and Dung, Le T.C. (2005) Technical efficiency of fresh water pond polyculture production in selected Asian countries: Estimation and implication. *Aquaculture Economics and Management*, 9: 39-63.
- Dipeolu, A.O. & Akinbode, Sakiru O., 2008. "Technical, Economic and Allocative Efficiencies of Pepper Production in South-West Nigeria: A Stochastic Frontier Approach," *Journal of Rural Economics and Development*, University of Ibadan, Department of Agricultural Economics, (17)1-10.
- Emokaro C.O. and Ekunwe, P.A. (2009). Efficiency of resource-use and elasticity of production among catfish farmers in Kaduna, Nigeria. *Journal of Applied Sciences Research* 5(7): 776-779.
- Fagade, S. O. Kehinde, J. K.1985. Sipi: 692033: A Promising Rainfed Lowland rice variety. *IRRI Newsl.* 14 (2): 22-26
- Fakayode, S. B. (2009): "Technical efficiency and factor productivity in upland and lowland rice production systems.
- FAO, (2001). Food and Agriculture Organization 2001. FAOSTAT <http://faostat.fao.org.default.htm>
- FAO. (2017). Fertilizer Development in Support of the Comprehensive Africa Agriculture Development Programme (CAADP). Paper presented at FAO
- FAO. 2016. Rice Situation Update as of 31 March 2016. *FAO Rice Market Monitor*, Vol. X, Issue No. 1. Food and Agricultural Organization of the United Nations.
- Farrell, M.J. and M. Fieldhouse (1985): "Estimating Efficient Productions Functions under Increasing Returns to Scale." *Journal of the Royal Statistical Society* 125, 252-267.
- Feder, G. and Slade, R. 1984. The acquisition of information and the adoption of new technology. *American Journal of Agricultural Economics*, 66(3): 312-20.
- Feder, G., Richard E. J., and Zilberman D. (2001). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change* 33 (2): 255-98

- Federal Ministry of Agriculture and Rural Development (FAMARD) (2019). State of Nigerian Agriculture: Ministerial press briefing by minister of Agriculture and Rural development, Lagos State.
- Fordsund, F.R. and L. Hjalmarsson, 1980, Technical progress, best-practice production functions and average production functions in the Swedish dairy industry, Paper presented at the Econometric Society European Meetings, Helsinki, 23-27 Aug.
- Glanville, R (1993) "Pask: a slight Primer" in Glanville, R (ed), "Gordon Pask, a Festschrift", Systems Research vol 10, no 3.
- Greene, (2003). *Econometric Analysis*. New Jersey: Prentice Hall.849-850
- Greene, R. D., Z. A. Hassan, and S. R. Johnson. (1980) "Maximum Likelihood Estimation of Linear Expenditure Systems with Serially Correlated Errors," *European Economic Review*, 11: 207-19.
- Hailu, B (2008): Adoption of improved *tef* and wheat production technologies in crop-livestock mixed systems in northern and western Shewa zones of Ethiopia. Doctoral Dissertation. University of Pretoria, Pretoria, South Africa
- Hardcastle, J. E. Y. (1959); The Development of rice Production and research in the Federation of Nigeria. *Trop. Agriculture*, 36.
- Hassen B, Bezabeh E, Belay K and Jema H (2012): Determinants of chemical fertilizer technology adoption in north eastern highlands of Ethiopia: The double hurdle approach. *Journal of Research Economics and International Finance*, 1(2): 39-49.
- Isgin, I. O. & Singh, S. (2008). Ethics and biases in technology adoption: The small farm argument. *Technological Forecasting and Social Change*, 43, 289-300.28(2008):634-650.
- Jaforullah, M., and N.J.Devlin.1996. Technical efficiency in the New Zealand dairy industry: a frontier production function approach. *New Zealand Economic Papers* 30:1-17.
- Jamieson A.O (2004) – conquerany number task by making important statistics simple. Part 1.Types of variables, mean, median, variance and standard deviation.*J. Health Care Qual* 2004;25(4):19–24.
- Kalirajan .K.P 1981. "The Economic Efficiency of Farmers Growing High-Yielding, Irrigated Rice in India," *American Journal of Agricultural Economics*, Agricultural and Applied Economics Association, 63(3), 566-570.
- Kalirajan K. P.& J . C. Flinn, 1983. "The Measurement Of Farm-Specific Technical Efficiency," *Pakistan Journal of Applied Economics*, Applied Economics Research Centre, vol. 2(2), pages 167-180.
- Kebbi State Agricultural Development Programme (KESADEP) (2018). The diary of Kebbi State of Nigeria. Land of equity, Government press Birnin-Kebbi Pp. 1-4.
- Kibaara B.W. (2005). Technical efficiency in Kenyan’s maize production: an application of the stochastic frontier approach, Colorado State University, USA.

- Kirkley, J. E., Squires, D. and Strand, I. E. (1995) Assessing technical efficiency in commercial fisheries: the mid-Atlantic sea scallop fishery, *American Journal of Agricultural Economics*, 77, 686–97.
- Legese, G., A.S. Langyintuo, W. Mwangi, and M. Jaleta. (2011). Determinants of adoption of improved drought tolerant maize varieties and their implication for household food security in drought prone areas. *Ethiopian Journal of Agricultural Economics*, 8(1): 105-132.
- Lohr, L., and T. A. Park, (2002) “Improving Extension Effectiveness for Organic Clients: Current Status and Future Directions.” *J. Agric. Res. Econ.*
- Madwueke M. C. (2015), Practices without Policy. The Nigeria Agricultural Extension Service 30<sup>th</sup> inaugural lecture of the University of Nigeria, Nsukka delivered on April 29, 2015, published by the University of Nigeria Senate Ceremonials Committee. University of Nigeria Press Ltd, Nsukka.
- Mangisoni, J., Easter, W. and Vernon, R. (2001). The speed of adoption of soil erosion-control technologies in Malawi: Application of Negative Binomial Model. *In: Edriss, A. (2003). The Dynamic of Food Production Systems and Adoption of Technologies in a village Economy: Case Studies from Malawi. International Publishers and Press. ISBN 0-9732561-0-9, Canadian Books in Print, Bunda University of Malawi, Malawi.*
- Mango N, & Hebinck P (2004) Cultural repertoires and socio-technological regimes: maize in Luoland. *In: Wiskerke JC, Ploag JD (eds) Seeds of transition: essays on novelty production niches and regimes in Africa. Royal Van Gorcum, Assen, pp 285-319*
- McLeod, J. (2008) Case study Research in Counselling and Psychotherapy. London: Sage.
- Meeusen, W., and J. Van den Broeck: Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* 18, 1977.
- Meinzen-Dick, R., Adato, M., Haddad, L. and Hazell, P. (2004). Science and Poverty: An Interdisciplinary Assessment of the Impact of Agricultural Research. International Food Policy Research Institute, Washington, D.C. USA.
- Mensah, B., Sarpong, A., Bruce, D., Ramatu, A., Brempong, A., Irene, A., John, E. and Osei-Asare, K. (2012). New technology adoption and land and water management practices among maize farmers in Ghana. Department of Agricultural Economics and Agribusiness, College of Agriculture and Consumer Sciences, University of Ghana, Ghana.
- Moti H., Masinde J., Mugenda N., Sindani M. (2013), Effectiveness of credit management system on loan performance: empirical evidence from micro finance sector in Kenya. *International Journal of Business, Humanities and Technology*, 2, 99-108.
- Murty S, Russell RR (2009) On modeling pollution-generating technologies. Mimeo, Department of Economics, University of California Riverside, (<http://www.economics.ucr.edu/people/russell/02-14.pdf>)
- National Bureau of Statistics (2017) LSMS-Integrated Surveys on Agricultural General Household Survey Panel 2016/2017.

- National center for Agricultural mechanization (NCAM). Non-sawah rice farming on Arugungu flood plain in 2018. Demonstration and training of *Sawah Technology by NCAM*.
- Nchembi F.I. (2017). Social capital, Intellectual Capital and the organizational advantage. *Academy of adoption review*, 23(2):242-266
- Nega G and Senders, H. 2006. Farm-level adoption of sorghum technologies in Tigray, Ethiopia. *Journal of Agricultural Systems*, 91(1-2): 122-134.
- Ogunbameru, B.O. (2011). Practical Agricultural Communication. Daily graphics, Ibadan.
- Okoruwa V.O, and Ogundele O.O. (2006). Technical efficiency different differentials in rice production technologies in Nigeria AERC Research Paper 154.
- Olayide, S. O. and E.O. Heady (1982) Introduction to Production Economics. Ibadan University Press Ibadan
- Olayide, S.O. and Heady E.O. (1982). Introduction to Agricultural Production Economics. Ibadan. University Press Ltd.
- Olubiyo S. O. and Adewumi, M.O. (1997) "Comparative Study of Resource Allocation in Small and Large Scale Farm in Kwara State" Centre Point 7(1): 66 – 74 Published by the Library and Publication Committee, University of Ilorin, Ilorin
- Olukosi J.O. Erhaor P.O. (1998), Introduction to Farm Management Economics: Principles and Applications AGITAB Publishers Ltd, Zaria 110-114
- Omotesho, O. A.** (1991) "Impact Agricultural Extension System of Ekiti-Akoko Agricultural Development Project (EAADP), Ondo State. 4(1) 50-52.
- Onu, M.O & Madwueke, M.C (2002). Adoption level and information sources of "brood and sell" poultry operators. *Journal of Tropical Agriculture, Food Environment and Extension*, 3(1): 63-67
- Onumah EE, Acquah HD (2010). Frontier analysis of aquaculture farms in the Southern sector of Ghana. *World Appl. Sci. J.* 9:826-835.
- Organization for Economic Cooperation and development (OECD), (1999). Managing National Innovation Systems. Paris.
- Osagie, C., 2016 rice importation ban: Disregard US report, FG urged. Available from <http://www.thisdaylive.com/articles/2016- rice-importation-ban-Disregard-us- -report-fg-urged/168731/> [Accessed 17/05/16].
- Ovwigho, B.O, (2013). A framework for measuring adoption of innovations: improved cassava varieties in Delta Nigeria, *Extension system Farming journal*, vol, 9, Research Forum, online access: <http:// www.apen.org.au/extension-farming-system-journal>
- Parikh, S.C., and L. Hjalmarsson 1995. "Technical Efficiency and Technical Progress in Swedish Dairy Farms." *The Measurement of Productive Efficiency: Techniques and Applications*. H.O. Fried, C.A. Knox Lovell, and P. Schmidt, eds. Oxford UK: Oxford University Press, 1993.



- Paul Rosenbaum & Donald R.O. (1983). Contributions to the design, analysis, and evaluation of observational studies. In *Research Work of William G. Cochran*, Eds. >S. Rao and J. Sedransk. New York:
- Perry, Brownlow & Cozens (2004). Analysis of statistical methods and errors in the articles published in the Korean journal of pain. *Korean J Pain* 2010; 23: 35-41.
- Rahji, M. A. Y. (2003);” Determinants of Efficiency Differentials in lowland rice production systems in Niger State” *Nig. J. Agric. Res.* 1 (1): 7-17.
- Rice Farmers’ Association of Nigeria (RIFAN 2017) Rice production in Nigeria increases to 5.8m tones. RIFAN Annual Report 2017.
- Rogers, E. M. (1962). Conceptual variable analysis of technological change. Doctoral dissertation, Ames, Iowa State University, Ames, Iowa, US.
- Rogers, E.M. (1983). Diffusion of innovations (3th ed.). New York, USA. Macmillan publishing.
- Roling, N. and J.N. Pretty, 1996. Extension Role in Sustainable Agriculture Development. Improving Agricultural Extension: A Reference Manual, B.E. Swanson *et al.*, Eds., ISBN: 964-6597-11-4, : 471-490.
- Seyoum, E.T., G.E. Battese, and E.M. Fleming (1998). "Technical efficiency and productivity of maize producers in Eastern Ethiopia: a study of farmers within and outside the Sasakawa Global 2000 project", *Agricultural Economics*, 19(3):341-348.
- Sharma, A., Bailey, A. and Fraser, I. (2011). Technology adoption and pest control strategies among UK cereal farmers: Evidence from parametric and non-parametric count data models. *Journal of Agricultural Economics*, 62(1): 73-92.
- Shiferaw F and Tesfaye Z (2006): Adoption of improved maize varieties in southern Ethiopia: Factors and Strategy Options. *Journal of Agricultural Economics*, 31(5): 442-457.
- Singh, A.L., Dey, A.E, Rabbani, R.A Sudhakaran G.E and Thapa H.T 2009. Mineral Stresses and Crop Productivity. In *International Symposium on Natural Resource management in Agriculture*. Dec 19-20 2009, Agricultural Research Station, RAU, Durgapura, Jaipur. pp. 9-23. Invited Lead paper.
- Solomon A, Menale K, Simtowe, F. and Lipper, L (2012): Poverty reduction effects of agricultural technology adoption: A micro-evidence from rural Tanzania. *Journal of Development Studies*, 48(9):1288-1305
- Solomon, S., J. S. Daniel, R. R. Neely, J. P. Vernier, E. G. Dutton, and L. W. Thomason (2011), The persistently variable “background” stratospheric aerosol layer and global climate change, *Science*, 333 (6044), 866–870
- Sosina B, Girma T. K, Bekele S and Ricker-Gilbert, J (2014). Impact of improved maize adoption on welfare of farm households in Malawi: A Panel Data Analysis. *World Development*, 59:120-131.

- Strathclyde, N.D. Costanza M.E., Staddat A.M., Gaw V. and Zapple J.G., 1992, “The Risk Factors of Age and Family History and Relationship To Screening Mammography Utilization”, *Journal of The American Statistical Association*, 40, 776.
- Sundharam, K.P.M. and M.C. Vaish (1979): “Principles of Economics.” 13 Revised and Enlarged Edition. Vikas Publishing House PVT Ltd. Vikas House, 20 / 4 Industrial Area Sahibabad Disu Ghazirabad U.P. India, 76-78.
- Thiam, A., B. E. Bravo-Ureta and T. Rivas (2001). Technical Efficiency in Developing Country Agriculture: a meta-analysis. *Agricultural Economics*. 25: 235-243.
- Timmer, C. Peter, (1971). Using a probabilistic frontier production function to measure technical efficiency, *Journal of Political Economy* 79, 776-794.
- Ureta A.O. and R.A Rieger (1990) “Efficiency of Resource Allocation in Indian Agriculture.” *American Journal of Agricultural Economics* 50 (1968):584-605 Schmidt.
- USDA Foreign Agricultural Service GAIN Report (2019), Grain and Food Annual Report Number: NG-19002
- Van Alphen, A., Halfens, R., Hasman, A., Imbos, T., 2008. Likert or Rasch? Nothing is more applicable than good theory. *Journal of Advanced Nursing* 20, 196–201.
- Wabbi, J. B. (2002). Assessing the factors affecting agricultural technologies: The case of integrated pest Management (IPM) in Kami District, Eastern Ugandan. Unpublished M.Sc Thesis to the Virginia Polytechnic Institute and State University, Blackburg, Virginia.23-27
- Wakatsuki T, Buri MM, Bam R, Ademiluyi SY, and Azogu II (2013). Sawah Ecotechnology: Farmers’ personal irrigated sawah systems to realize the Green Revolution and Africa’s rice potential, <http://www.kinki-econtech.jp/>
- Wakatsuki T, Buri MM, Obalum SE, Bam R, Oladele OI, Ademiluyi SY and Azogu II. 2011. Farmers' personal irrigated sawah systems to realize the green revolution and Africa's rice potential, Paper presented at 151 International Conference on Rice for Food, Market, and Development (rice-Africa), Abuja, Nigeria March 3-5, 2011.
- WARDA, (1993). Training in Rice Production, Instructors Manual (1993) by West Africa Rice Development Association (WARDA). Eds. Sayce Publishing, Exeter, U.K. 290pp.
- Xu, X., and S.R. Jeffrey. 1998. “Efficiency and Technical Progress in Traditional and Modern Agriculture: Evidence from Rice Production in China.” *Agr. Econ.* 18: 157-65.

QUESTIONNAIRE PREPARED FOR TECHNICAL EFFICIENCY AND  
PROFITABILITY OF SAWAH RICE TECHNOLOGY IN EBBI STATE.

**SECTION A:- Personal characteristics**

1. Name of the respondent: .....
2. Sex : (a) Male ( ) (b) Female ( )
3. Marital Status: (a) Single ( ) (b) Married ( ) (c) Widow ( ) (d) Widower ( )  
(d) Separate ( )
4. Age ..... year
5. Years of formal education ..... year
6. Education level: (a) Read and write only ( ) (b) Primary school ( ) (c) Secondary School ( ) (d) Tertiary ( ) (E) Illiterate ( )
7. Religion: (a) Muslim ( ) (b) Christianity ( ) (c) Traditionalist ( )
8. Please specify your household size using the following Table

Household Size Category	Total Family Size
1. Children 10 years age and below	
2. A male children between 10-13 years of age	
3 A female children between 10-13 years of age	
4. A male family member between 14 and 65 years	
5. A female family member between 14 and 65 years	
6. Family member above 65 years of age	

9. Main occupation: (a) Farming ( ) (b) Civil servant ( ) (c) Business/Trading ( )  
(d) Employee in a private company ( ) (e) Other, specify, \_\_\_\_\_
10. Farming experience ..... years

**SECTION B: - Information on rice production for 2017/18 cropping season**

11. Do you grow rice crop? (a) Yes ( ) (b) No ( )

12. Estimates land used for rice cropping

The type of land used	YES	NO	How many hectares for rice production
Land from government			
Purchased Land			
Lease land			
Rented land			

13. What is the rental price of land per hectare? ..... ₦

14. How many plots of land do you have on separate places? \_\_\_\_\_ hectare

15. What is the quantity of rice produced during the last farming seasons? \_\_\_\_ kg

16. What is the amount of rice produced during the last farming seasons? \_\_\_\_ ₦

17. What types of labour used for the production of rice during the last farming season? (a)

Hired labour ( ) (b) Family labour ( ) (c) Both ( )

18. Please give the following details on the family labour employed by you on your farm in last farming season.

Operations	Children	Adult female	Adult male	Cost /day N	Total cost N
1. Planting					
2. Weeding					
3. Herbicide application					
4. Fertilizer application					
5. Harvesting					
6. Transportations					
7. Others					

19. Please give the following details on the hired labour employed by you on your farm in last farming season.

Operations	Children	Adult female	Adult male	Cost /day N	Total cost N
1. Planting					
2. Weeding					
3. Herbicide application					
4. Fertilizer application					
5. Harvesting					
6. Transportations					
7. Others					

20. Which types of rice seed used in the last farming season?

(a) Improved/ hybrid variety ( ) (b) Local/ Traditional variety ( ) (c) Both ( )

21. Which types of rice seed do you prefer to plant?

(a) Improved/ hybrid variety ( ) (b) Local/ Traditional variety ( ) (c) Both ( )

22. Where are the sources of the rice seed used in your last farming season?

(a) Stock from previous harvest ( ) (b) Local market ( ) (c) Extension service

(d) From Government (e) Research Institutes ( ) (f) Private/NGO ( )

(g) Other, specify,.....

23. Have you applied fertilizer for rice production during the last farming season?

(a) Yes ( ) (b) No ( )

24. Fertilizer usage

Type	Qty used (kg, bag)	Sources	Cost/unit N	Transportation N	Total cost N
1. N.P.K					
2. Urea					
3. CAN					
4. SSP					
5. Others					

25. Did you use herbicide to control weeds? (a) Yes ( ) (b) No ( )

26. If yes, complete the following table:

Herbicide Types	Qty use/Ha	Source	Cost/unit N	Transportation N	Total cost N
1. Simazine + paraquat					
2. Diuron + paraquat					
3. Ametryn					
4. Memthabenthiazuron					
5. 2,4 – 5D					
6. Others					

27. What was your source of finance or capital for rice production in last season?

Sources	Amount Obtained (N)	Interest rate (%)	Duration of loan (mths)	Satisfactory Yes /No
(i) Personal savings				
(ii) Family inheritance				
(iii) Thrift and credit societies				
(iv) Friends / relatives				
(v) Cooperative society				
(vi) Agric credit cooperation				
(vii) NACB				
(viii) Commercial bank				
(ix) Money lender				
(x) Others (specify)				

28. How many times did the Extension official visit you on your farm last season?.....
29. Has the visit improved your production? (a) Yes ( ) (b) No ( )
30. Did you receive any other technical assistance from other sources apart from the Extension official? (a) Yes ( ) (b) No ( )
31. If yes, please list the technical assistance and the source

Technical assistances	Source(s)
1.	
2.	
3.	
4	

**SECTION C: - Information on Sawah technology adoption practices**

32. Are you aware of any certified improved/ hybrid rice variety?  
(a) Yes ( ) (b) No ( )
33. If yes, how do you rate the use of certified improved/ hybrid rice variety for productivity enhancement potential?  
(a) Excellent ( ) (b) Very good (c) Good (d) Satisfactory (e) Poor
34. Have you adopted and applied sawah technologies to your rice production in the last cropping season? (a) Yes ( ) (b) No ( )
35. When did you apply the first time? \_\_\_\_\_ years and \_\_\_\_\_ months
36. Please give the following details on Sawah technologies adopted by you

Sawah Technologies	Adopted	fully adopted	Partially adopted	Not at all	Discontinued
1. Bonding					
2. Leveling					
3. Puddling					
4. Canal design					
5. Basin formation					
6. Fertilizer application					
7. Transplanting					
8. Inlet and outlet system					
9. Other specify					

37. What proportion of your farm is devoted to irrigation?

- (a) All ( ) (b) Half ( ) (c) One-third ( ) (d) One-quarter ( )  
 (e) others specify .....

38. What is the source of irrigation water?

- (a) Own well ( ) (b) own borehole ( ) (c) community borehole ( )  
 (d) Small reservoir ( ) (e) canal ( ) (f) river/stream ( ) (g) Other, specify

39. What is the means of water transport from source?

- (a) earthen field channels ( ) (b) lined channels ( ) (c) flexible rubber pipes  
 ( ) (d) canal system (e) Others, specify ( )

40. What is the total production with irrigation technologies ..... (kg)

41. What is the total income from the sale of crop ..... ₦

42. Do you find Sawah rice technology profitable?

- (a) Yes( ) (b) No ( )

43. What are the three most important limiting factors in expanding your area under

- Sawah rice technology? (a) land availability ( ) (b) family labour ( ) (c) The  
 technology is laborious ( ) (d) market for the produce ( ) (e) In adequate extension  
 personnel ( ) (f) other (pls specify).....

**SECTION D: - Information on Rice output, sales and revenue for your last  
 season production.**

44. Please provide the following information on the amount of rice produced on your farm in the last season.

<b>Rice Grades</b>	<b>Qty produced (ton)</b>	<b>Estimated value N</b>	<b>production</b>	<b>Total returns N</b>
Faro 43				
Faro 44				
<b>Others</b>				

45. What portions of your rice output was sold to the following categories of buyers?

<b>Categories</b>	<b>Unit of quantity sold (tonnes)</b>	<b>Price per unit of sale N</b>	<b>Total amount(N)</b>
Farmers			
LBA			
Middle men			
Processing company			
Others			

46. What difficulties did you face in selling your rice output?

- i..... ii.....  
 iii.....iv.....

47. Do you belong to any farmers association? (a)Yes ( ) (b) No ( )

48. If yes, what are the benefits you are deriving from this association?

- i.....ii.....  
 iii.....iv.....