SOCIO-ECONOMIC ANALYSIS OF THEEFFECT OFUREA DEEP PLACEMENT (UDP) TECHNOLOGY ON RICE PRODUCTION IN SELECTED LOCAL GOVERNMENT AREAS OF KANO STATE, NIGERIA.

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY KANO, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (M.Sc.) IN LIVELIHOOD AND NATURAL RESOURCES ECONOMICS

AUGUST, 2019

DECLARATION

I hereby declare that this work is the product of my own research efforts undertaken under the supervision of Dr M. B. Bello and Prof. M.M. Ahmad and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up by

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DEDICATION

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ABSTRACT

The study analyzed theSocio-economic Effect of Urea Deep Placement (UDP) Technology on Rice Production in Selected Local Government Areas of Kano State, Nigeria. Multi-stage sampling techniques were used toselect 300rice farmers for the study, comprising of 189 USAID/MARKETS II programme participants and 111 non-participants. Descriptive Statistics, Binary logit regression model, double hurdle model (DHM), Farm Budgeting Technique and Propensity Score Matching (PSM) methods were used to analyse the data. The resultsshow that,programme participation was primarily influenced by; the age of the farmer, primary occupation, household size, extension contact and cooperativemembership. The adoption of UDP technology was significantly determined by gender, marital status, education, extension contact, experience in rice farming, participation in the USAID/MARKETS II programme, plot size and the reason for rice production. The factors that determine the use intensity of UDP technology were; gender, experience in rice production statistically, cooperativemembership, the reason for rice production, total quantity of labour and total cost of labour.The Return on Investment (ROI) is 1.50 and 1.10 for UDP technology adopters and non-adopters respectively,indicating the adoption of UDP technology makes rice production more profitable. The results of the PSM indicate that the adoption of UDP technology led to adopters having ₦43,961.66 (₦/Ha) more income than non-adopters. Similarly, the adoption of UDP technology increases the farm labour use for rice production by 8.3 (Man-days per Hectare).To sustain the gains ofawareness about UDP technology among farmers, government at all levels and stakeholders in agricultural development should continue to include UDP technology package in ongoing and future agricultural programmes like the Anchor Borrowers Programme and the Agricultural Promotion Policy while researchers should evaluate and share knowledge on the benefits that can be derived from the use of thetechnology.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Rice (*Oryza sativa L.)* is a major food crop and is the staple food of more than half of the world's population. It is a rich source of carbohydrates and a range of nutrients (Saikrishna *et al.,* 2018*).*Rice is rapidly gainingimportance as a staple food and is now one of the largest sources of food energy inSub Saharan Africa(SSA) (FAO, 2016).Domestic demand for rice has been increasing significantly in Nigeria, which is currently the world's third largest rice importer (WASDE, 2019). Nigeria's domestic rice production has also increased significantly at an annual rate of almost 10% since the 1970s mainly due to the expansion of the area under cultivation. However the demand still outstrips the domestic supply of rice; as the crop has become the leading staple food in Nigeria, surpassing cassava in food expenditures (Gyimah-Brempong*et al.,* 2014).

The growing dependence on rice imports has become a mounting concern for the Nigerian government, which has developed numerous programs since the early 1980s to catalyze domestic rice production and become self-sufficient. The agricultural transformation action plan (ATAP) program initiated by the government in 2011 aims to reverse trends in domestic rice production which stagnated or even declined since its peak in the 1980s. These policy initiatives aim at prioritizing the rice sector and decreasing dependence on imports, fostering production, and supplying agricultural inputs. Nigeria rice productivity is among the lowest within the neighbouring countries, with an average yield of 1.51 MT per hectare. Most rice farmers in Nigeria are smallholders (90% of the total), applying a low-input strategy to agriculture, with minimum input requirements and low output (USAID/Nigeria, 2015).

The Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites II (MARKETS II) was a USAID/Nigeria's project under the Feed the Future (FtF) Agricultural Transformation Program (ATP) and is a successor to the previous seven years of the MARKETS and the Bridge to MARKETS 2 (BtM2) projects. For the five years following its creation in April 2012, MARKETS II aimed to sustainably improve the performance, incomes, nutrition, and food security of Nigerian poor rural farmers or smallholders in an environmentally appropriate manner through proven private sector, demand-driven market interventions, focusing specifically on constraints in the agricultural value chain. Key objectives aim to help smallholder farmerswith between 1 to 5 hectares of land under cultivation access better inputs (such as improved seeds and optimal use of fertilizer), adequate finance, better water management, appropriate technology, extension services, and improved nutritional uses of grown or purchased basic foods (USAID/Nigeria, 2015).

MARKETS II facilitated the dissemination of improved, high yielding, and commercially viable rice, and disease resistant varieties of rice to both rainfed and irrigated rice farming techniques (Specifically, varieties FARO 44, 52, and 57 were promoted by MARKETS II). They also introduced farmers to improved rice management practices for both dry season and wet season to increase yields above historical yield levels. This includes efficient use of inputs such as the timely application of fertilizers, herbicides, optimal spacing, land preparation, safe use of herbicides, and ensuring the delivery of required quantities and qualities of paddy rice to buyers. MARKETS II interventions in the rice value chain touched on a number of key areas which include Urea Deep Placement technology (UDP) first introduced by MARKETS in 2010, and gradually is gaining acceptance (USAID/Nigeria, 2012).

Nitrogen is one of the major nutrient elements for crop production that influences the growth and yield of rice. Urea has emerged as an important nitrogen fertilizer for rice cultivation. Statistics indicates that about 80% of urea is used for rice production (Hoque*et al.,* 2013). According to Crasswell and de Datta (1980) broadcast application of urea on the surface soil causes losses of up to 50% but point placement of Urea Super Granule (USG) in 10 cm depth may negligible loss. USG is a fertilizer that can be applied around the root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the rice yield. To minimize nitrogen loss, USG application may be a good technology to increase rice yield as well as reduce of production cost (Hoque*et al.,* 2013).

In lowland rice fields, placement of Nitrogen in the root zone, i.e., urea deep placement (UDP), reduces Nitrogen losses and increases Nitrogen use efficiency(NUE) and crop productivity (Savant and Stangel, 1990; Rochette*et al.,* 2013; Huda *et al.,* 2016). When urea is deep-placed in continuously flooded rice soils, losses of Nitrogen as floodwater ammonium (NH4+-N), NH3 volatilization and nitrous oxide emissions are negligible (Kapoor*et al.,* 2008; Rochette*et al.,*2013; Gaihre et al., 2015; Huda *et al.,* 2016).With the reduction of these losses, UDP increases NUE up to 80% compared to 30-45% with broadcast application. Thus, UDP in rice cultivation reduces Nitrogen fertilizer required by 30–35% and increases grain yields by up to 15–20% compared to broadcast of ordinary or PU (Prilled urea). In addition to increased farm profitability, UDP reduces government subsidy payments in countries where Nitrogen fertilizer subsidies exist (Miah*et al.,* 2016, Islam *et al.,* 2018).

TheUDP technologyunder study consists of five (5) items of the package these include: improved rice varieties, Seed cleaning,nursery, line transplant and UDP Technique. The adoption of

UDP technology has two main benefits; increase yields and lower costs of fertilizer. Both of these are a result of improved nitrogen "uptake" efficiency afforded by the larger Urea particle size and the "point placement" method of application. Farmers appreciate UDP because it saves them money, they only have to fertilize rice once instead of two or three times (the broadcast method) and fewer weeds grow using UDP application. Simply put, farmers use less fertilizer while increasing their yields (Adodo, 2010).

1.2 PROBLEM STATEMENT

Rice represents the basic food for more than 750 million persons in SSA (USDA, 2016). However, the average annual rice consumption in SSA is increasing at a faster rate (4%) than rice production (3.3%) (FAO, 2016). Rice production and consumption levels in SSA are estimated at 14.4 million and 26 million of milled ricerespectively in 2014. The gap between production and consumption suggests that nearly 46% of rice consumed in SSA is imported. This translates into imports of 11.9 Mt of milled rice in 2014, valued at over US $ 5.9 billion (USDA, 2016).Rice consumption in Nigeria is above 7.0 million metric tons annually, domestic production of 4.9 metric tons has never been able to meet the demand, leading to considerable imports which today stand at about 2.2 metric tons (WASDE, 2019). To meet this rising demand for rice, it is estimated that the global rice production needs to increase by116 million tons by 2035. Much of the increase has to come from smallholder rice farmers in developing countries (Yamano*et al.,*2016). Production of rice is input intensive, particularly, the modern varieties (MVs) of rice, which is dependent on the use of inorganic fertilizers and irrigation (Rahman and Barmon, 2015). Nitrogen (N) is the most important and key nutrient for rice production all over the world for its huge requirements and instability in soil (Rahman*et al.,* 2016).

Sustainable intensification has gained prominence as a response to the challenges of increasing global food demand alongside limited supply of land, water, energy and other inputs, (Montpelier, 2013). Due to this interest in increasing food production in a sustainable manner, methods that increase the efficiency of fertilizer use in a manner that minimizes the potentially negative effects of its use on the environment is a top research and policy concern. With current fertilizer use rates considered low, countries like Nigeria are in a position to take advantage of opportunities that can increase fertilizer use in a sustainable manner; particularly when such environmental benefits occur alongside productivity and potential profitability gains(Liverpool-Tasie *et al.,* 2015).

The literature search on the Effects of UDP technology revealed that,several of the existing literatures are focused on the Effect of the UDP technology on Nitrogen use efficiency and grain yield from field and experimental trials. Only a handful of previous studies have examined the Effect of UDP technology adoption on various dimensions of farmers' welfare (e.g.Rahman and Barmon 2015; Liverpool-Tasie *et al.,* 2015; Azumah, *et al.,* 2017).

The present dissertation attempts to fill in those research gaps and contribute to the literature by focusing on examining theSocio-economic Effect of Urea Deep Placement (UDP) Technology on the welfare of the adopter farmers (income and farm labour use) as these aspects have received less attention in the past, particularly in the context ofSub Saharan Africa. Using established econometric procedures that will be addressing the sample selection bias issue accounting for both observable and unobservable factors.

Given this backdrop, the principal aim of this study is to analysetheSocioeconomic Effect of Urea Deep Placement (UDP) Technology on Rice Production in Selected Local Government

Areas of Kano State, Nigeria.In the course of this research, the following research questions were addressed;

1. What are the socioeconomic factors that influenced rice farmers' decision to participate inthe UDP technology project in the study area?
2. What are the socioeconomicfactors influencing theadoption of UDP technology by the rice farmers in the study area?
3. What are the socioeconomic factors influencing the extent of adoption of UDP technology by the rice farmers in the study area?
4. What are the costs and returns associated with rice production among UDP technology adopters and non-adopters in the study area?
5. What is the effect of UDPtechnologyadoptionon the farm labor usefor rice production by the rice farmers in the study area?
6. What is the effect of UDPtechnology adoption on the rice income of the farmers in the study area?

1.3 OBJECTIVES OF THE STUDY

The broad objective of this study is toanalysethe Socioeconomic Effect of Urea Deep Placement (UDP) Technology on Rice Production in Selected Local Government Areas of Kano State, Nigeria.The specific objectives are to:

1. describe the socioeconomic factors that influenced rice farmers' decision to participate in the UDP technology project in the study area;
2. determinethe socioeconomicfactors influencingthe adoption of UDP technology by the rice farmersin the study area;

3. determinethe socioeconomic factors influencingtheextent of use of UDP technology by the rice farmers in the study area;
4. estimate the costs and returns associated with rice production among UDP technology adopters and non-adopters in the study area;
5. evaluate the effect of UDPtechnology adoptionon the farm labor useof therice farmersand;
6. evaluate the effect of UDPtechnology adoptionon theincome of the rice farmers.

1.4 JUSTIFICATION FOR THE STUDY

As many governments and development practitioners pursue sustainable input intensification strategies alongside increased agricultural productivity, UDP technology is one among several current innovations for sustainable input intensification currently being encouraged in rice production in developing countries (including Nigeria) (Adjornonand Liverpool-Tasie, 2014). UDP technology package was activelypromoted across Nigeria by IFDC and Maximizing Agricultural Revenue and Key Enterprises in Targeted Sites (MARKETS II) Nigeria Project funded by USAID since 2012 (Tarfaand Kiger, 2013).

This study will provide some empirical evidences on the potential yield and income effects of UDP technology adoption alongside the socioeconomic factors likely to influence the decision to adopt the technology (UDP) by rice farmers not only in the study area (Nigeria), but can be applied in similar environments or can be contextualised appropriately for environments that might differ in significant ways given Nigeria's complexity and the heterogeneity of its agro-ecology and farming systems.

Lastly, the study will provide information to guide government extension services, farmers and private sector farm service providers about the importance of certain management practices associated with UDP for the successful adoption of this more targeted fertilizer application method for rice production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 AN OVERVIEW OF USAID MARKETS II PROJECT IN NIGERIA

The Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites (MARKETS II) is USAID/Nigeria's flagship project under the Feed the Future (FtF) Agricultural Transformation Program (ATP) and is a successor to the previous seven years of the MARKETS and the Bridge to MARKETS 2 (BtM2) projects. For the five years following its creation in April 2012, MARKETS II aims to sustainably improve the performance, incomes, nutrition, and food security of Nigerian poor rural farmers or smallholders in an environmentally appropriate manner through proven private sector demand-driven market interventions, focusing specifically on constraints in the agricultural value chain. Key objectives aim to help smallholder farmers access better inputs (such as improved seeds and optimal use of fertilizer), adequate finance, better water management, appropriate technology, extension services, and improved nutritional uses of grown or purchased basic foods (USAID/Nigeria, 2015).

MARKETS II invested $60.5 million in activities focused primarily on the large population of smallholder farmers with between 1 to 5 hectares of land under cultivation. MARKETS II also worked along the value chain through producer and processing associations, credit institutions, agribusinesses (suppliers, contractors, transporters and especially agro-processors) and state and federal institutions to identify and alleviate constraints to well-functioning markets. Given the importance of including women and youth in the rural economy, MARKETS II identifies and supports agricultural opportunities along the value chain and incorporates farming services and micro- and small scale processing activities in its assistance approach. The MARKETS II team worked with 696,855 smallholder farms engaging in aquaculture, cassava, cocoa, maize, lowland rice and irrigated rice, sorghum, and soybean production (USAID/Nigeria, 2015).

2.1.1 Objectives ofUSAID MARKETS II project

The objective of the MARKETS II project is to pursue the U.S. Government goalsand the Government of Nigeria(GON) Five Point Plan particularly, with respect to promoting agriculture development through increased private sector participation and investment in the sector, raising income, increasing employment, attaining food security and reducing poverty. The project built on the successes of its predecessor USAID MARKETS project in redressing constraints along the agricultural commodity value chain, working with farmers to increase production and the quality of produce through improved post-harvest handling, linking farmers and agro-processors; providing incentives to adopt improved technology along the value chain, producing value-added products and identifying new markets (USAID/Nigeria, 2012).

2.1.2 USAID MARKETS II intervention in the rice value chain

MARKETS II facilitated the dissemination of improved, high yielding, and commercially viable rice, and disease resistant varieties of rice to both rainfed and irrigated rice farming techniques (Specifically, varieties such as Faro 44, 52, and 57 were promoted by USAID MARKETS II). They also introduced farmers to improved rice management practices for both dry season and wet season to increase yields above historical yield levels. This include efficient use of inputs such as the timely application of fertilizers (UDP and NPK), herbicides, optimal spacing, land preparation, safe use of herbicides, and ensuring the delivery of required quantities and qualities of paddy rice to buyers (USAID/Nigeria, 2015).

MARKETS II interventions in the rice value chain touched on the following key areas:

1. Support to the Government of NigeriaAgricultural Transformation Agendafor rice by making available tested and trusted MARKETS and Bridge to MARKETS II (BtM2) selected methodologies and training materials for newly formed producer group clusters.
2. Access to finance by linking producer groups to financial institutions.
3. Access to inputs through a concerted effort in collaboration with the public and private sector to increase access to high quality seed of the desired varieties and other inputs.
4. Technology dissemination by demonstrating available post-harvest technologies for harvesting, threshing, drying, winnowing and par-boiling. In addition MARKETS IIcontinued the introduction of high yielding varieties with desired end user characteristics.
5. UDP technology was first introduced by MARKETS in 2010 and is gaining rapid acceptance. UDP technology introduction wasexpanding under MARKETS II.
6. Gender by introducing labor saving technologies in women specific tasks such as threshing, winnowing and parboiling.
7. Youth by organizing youth groups in service provision such as spraying, harvesting and threshing.
8. Climate change by introducing flood resistant rice varieties with the desired end user characteristics. (USAID/Nigeria, 2012).

2.1.3 Other interventions in the rice value chain in Nigeria

I. Promoting Pro-Poor Opportunities in Commodity and Service Markets (PropCom): PropCom is an innovative, market-driven program funded by the United Kingdom's Department for International Development (DFID) that aims to reduce poverty in Nigeria. The program works with government, the private sector and businesses to enable rural markets to work better for the poor.

The program uses a ‘making markets work for the poor’ approach in creating systemic changes in agricultural and rural markets in Nigeria. The goal of the program is to increase incomes for the poor. This is to be achieved by improving the pro-poor performance of selected agricultural market systems.

PropCom comprised of three phases of activity. Inception (Phase 1: 2004-2006), Pilot implementation (Phase 2: 2006-2008) and Full scale implementation and impact (Phase 3: 2008-2011). PropCom focus on small number of key markets that have a high profile in the agriculture sector, are significant opportunity to improve food security for poor people, and have good grown potential. The markets were:rice, enterprise training, agricultural mechanization, financial services and fertilizer. PropCom’s interventions cover all these markets and one related theme: agriculture policy. The project focused on the Abeokuta and Kano rice clusters. The interventions are listed below:

- Agricultural Mechanization (Tractors): PropCom developed a private led, coordinated market system through which poor farmers could get access to tractor services through commercial lease finance arrangements to private tractor service providers.
- Agricultural Mechanization (Threshers): PropCom developed a better supply farmers’ demand for threshers, by influencing agricultural machinery producers and importers to market and sell directly to small holder rice farmers.
- Agricultural Policy (State-level and Federal-level interventions): PropCom engaged politicians in order to directly influence the regulatory environment and investment climate surrounding the program’s work in other agricultural sectors, such as rice and fertilizer. PropCom has supported Kano and Ogun states in the development of rice sector policies.

- Fertilizer: PropCom sought to refocus private fertilizer company's sales effort of selling small, affordable packages of fertilizer directly to smallholders in remote areas rather than selling directly to government buyers.
- Mobile banking: PropCom worked with two mobile-payment service providers to increase the access of financial services and savings of the massive un-banked rural population in Nigeria.
- Ricer parboilers: PropCom improved the the ability of women parboilers in Knao and Adamawa states to upgrade the quality of their rice, increase their processing capacity, and improve their business income potential (DFID,2011).

II. Anchor Borrowers' Program (ABP): The Central Bank of Nigeria (CBN) established the Anchor Borrowers' Programme. The Programme was launched on November 17, 2015. The Anchor Borrowers' Program created a linkage between anchor companies involved in the processing and small holder farmers (SHFs) of rice and other key agricultural commodities. The programme thrust of the ABP is provision of farm inputs in kind and cash (for farm labour) to small holder farmers to boost production, stabilize inputs supply to agro processors and address the country's negative balance of payments on food. At harvest, the SHF supplies his/her produce to the Agro-processor (Anchor) who pays the cash equivalent to the farmer's account.

The broad objective of the ABP is to create economic linkage between smallholder farmers and reputable large-scale processors with a view to increasing agricultural output and significantly improving capacity utilization of processors. Other objectives include:

- Increase banks' financing to the agricultural sector
- Reduce agricultural commodity importation and conserve external reserves
- Increase capacity utilization of agricultural firms

- Create new generation of farmers/entrepreneurs and employment
- Deepen the cashless policy and financial inclusion
- Reduce the level of poverty among smallholder farmers
- Assist rural smallholder farmers to grow from subsistence to commercial production levels.

Under the Scheme, Anchor firms serve as Off-takers in recognition of their track record and experience in working with out-growers involved in rice production. The Scheme involves a finance model whereby the anchor firms, The Central Bank of Nigeria(CBN), The Nigeria Incentive-Based Risk-Sharing System for Agricultural Lending(NIRSAL) and State Governments organize the out-growers and ensure that they comply with contractual terms thereby reducing the incidence of side-selling. The financing institutions serve as veritable channels for delivering creditto the out-growers (CBN, 2016).

2.2 CONCEPTS OF INNOVATION, TECHNOLOGY AND ADOPTION IN AGRICULTURE

2.2.1 Agricultural Innovation

Lattimer (2013), defined innovation as a new approach that has not been tried or tested elsewhere, that can generate learning for the stakeholders involved, and that has strong potential to be scaled up to bring positive results for the people. The term innovation is often used to refer to the use of new technology in development. Adekunle*et al.,* (2010) defined an innovation in agriculture as the process of ensuring that a new product or knowledge is converted to use and it leads to social and economic benefit. Fatunbi*et al.,*(2016), further described innovation as a product of application of new knowledge and or a combination of new and existing knowledge for economic gain. Their definition projected innovation as a product of the use of knowledge, technologies or invention in a way that it yields socio- or economic benefit to the different stakeholders. Apparently, the translation of the research products viz., knowledge, technology and inventions to measurable developmental outcomes and impact does not happen in a vacuum. Rather, it happens when the research products are streamed in with complimentary institutional and infrastructural arrangements that enhance the delivery of benefits. Thus, in the agricultural innovation systems parlance, an innovation is more technically knitted to benefits from research product than a mere description of something new (Ajayi*et al.,* 2018).

On innovation, Surbhi (2016) reported 'innovation' as the transformation of an idea into reality. In the purest sense, innovation can be described as a change that adds value to the products or services; that fulfills the needs of the customers. It is when something new and effective is introduced to the market that fulfills the needs of the customers by delivering better products and services. Innovation can be an introduction or development of new product, process, technology, service or improving/redesigning the existing ones that provide solutions to the current market requirements. All the processes that help in the generation of the new idea and translating it into the products demanded by the customers are covered under innovation. This definition further confirms that technology is a vital component of the innovation process.

2.2.2 Agricultural Technology

As regards technology, Lattimer (2013) sees good practice/technology as an intervention or approach that has been tried and tested elsewhere either within a country or in other countries and that can be built upon and/or adapted. FARA (2015) sees technology as the outcomes of the modulation of science that could bring about positive change to agricultural practices and systems in continuous and sustainable ways with resultant increase in productivity. USAID (2011) defines technology broadly to include improved agricultural practices, crop varieties, inputs and associated products such as crop insurance. In technical terms, technology derives its definition from knowledge, where knowledge is defined as a set of concepts, meanings, skills, and routine developed over time by individuals or groups as they process information. Thus, "technology is defined as the sum of knowledge derived from received information, which allows a thing to be done; technology is a flow of new knowledge" (Fatunbi*et al.,* 2016).

Millar and Connell (2010) also classified proven technologies as those ones that have gone through trials with farmers and are found to benefit them. A school of thought also sees technologies as a vital component of the innovation process and feels that it should not be considered as innovation because innovation is considered as knowledge, technologies and inventions that have been used and it has resulted into socio-economic benefits. Technologies need to be accompanied with other institutional environment for it to yield its outputs and benefits. Connell *et al.,* (2004) and Fatunbi*et al.,* (2016) supported the view that improved technologies derived from research require some degree of adaptation to be integrated into local farming systems. Indeed, new production systems are always needed before technologies can affect livelihoods.

Agricultural Technology is considered to be a complex blend of materials, processes, and knowledge. According to USAID (2014), there are two main categories of technology: material technology that takes the form of a physical product (i.e. agricultural tools, improved plant varieties, agrochemicals ....) and knowledge-based technology such as technical knowledge, farm management skills, and other processes that assist farmers' production (i.e. soil and water management practices).

However, according to Christiansen *et al.,* (2011) and UNFCCC (2014), technologies are often classified into three types: hardware, software, and orgware. In considering adaptation, it is important to understand the differences between these technology types, as well as their synergies and complementarities. Hard technologies, or hardware, refer to physical tools; soft technologies, or software, refer to the processes, knowledge and skills required using the technology; and organizational technologies or orgware, refers to the ownership and institutional arrangements pertaining to a technology (Christiansen *et al*., 2011, UNFCCC, 2014). In the agricultural context, hardware is exemplified by different crop varieties, software by farming practices or research on new farming varieties, and orgware, by local institutions that support the use of agricultural adaptation technologies.

2.2.3 Urea Deep Placement (UDP) Technology in rice production

One of the major goals of Nigerian agriculture development programs and policies is transition from low productivity subsistence agriculture to a high productivity agro-industrial economy through improved technology adoption. That is, shift from traditional methods of production to new, science-based methods of production which include new technological components and/or even new farming systems (Hassen, 2014).

Adoption of improved agricultural technologies by smallholders is considered as the main pathway for breaking poverty trap. Applied correctly, adoption should, *ceteris paribus*, increase productivity and provide additional income to farmers. In this way, technology adoption can accelerate economic growth, create marketing opportunities, and help millions of farmers to move out of poverty. However, adoption rates for improved agricultural technologies have been rather disappointing and far from complete and proper identification of the main barriers of adoption remains a challenge (Shiferaw*et al.,* 2008; Solomon *et al.,* 2010; Wossen*et al.,*2015). Adoption of improved agricultural technologies is fundamental to transformation of sustainable farming system, and a driving force for increasing agricultural productivity (Obayelu*et al.,* 2016).

Rice productivity should be increased to meet the food demand of a growing population, taking into account the dwindling amount of land area available for farming. This requires judicious use of agricultural inputs, including quality seeds and fertilizers, and irrigation water management, among other good agricultural practices (Islam *et al.,* 2018).Fertilizer application and water management are the most important practices in rice production. Though Nitrogen (N) fertilizer plays a major role in rice production, all fertilizers should be applied in a balanced way for increasing crop productivity and improving soil fertility (Quamruzzaman, 2006).

Nitrogen is the most important and key nutrient for rice production all over the world for its huge requirements and instability in soil (Rahman*et al.,* 2016). Nitrogen is one of the major nutrient elements for crop production that influences the growth and yield of rice. Unfortunately the nitrogen fertilizer in wetland rice culture is very low. Numerous N use experiments have shown that the efficiency at which N is utilized by wetland rice is only about 30% of the applied fertilizer N and in many cases even less (Prashad and de Datta, 1979).Nitrogen use efficiency for rice crop largely ranges between 25 and 35% and seldom exceeds 50% (Sharma, 1985).

In rice production, the cost of nitrogen fertilizer can be up to one-third of the total production costs. Applying it as granules is inefficient because generally only about one-third of the Nitrogen is used by pants. The remainder is lost. One means to reduce nitrogen losses and improve fertilizer efficiency is to form Urea into “Briquettes” and place them deeply in the soil. This technology developed by IFDC (International Centre for Soil Fertility and Agricultural Development), is now common in parts of Asia and is being introduced into Africa. IFDC’s UDP manufacturing technique concentrates Urea into “Briquettes” that farmers place into rice root zone a few days after transplanting. USG is applied manually just like transplanting of rice seedlings in the field. It is placed at a depth of 8 cm to10 cm under the soil at the center of 4 consecutive hills of 2 adjacent rows. The hand placement of USG is labor intensive and very slow i.e. 0.07 to 0.12 ha/workday (Savant *et al*., 1992). The rice plants absorb the vital nitrogen more directly as the concentrated briquette slowly dissolves. This process significantly lowers the amount of Urea that volatilizes into the atmosphere or disappears into the ground water (Adodo, 2010). Nitrogen loss processes are due to ammonia volatilization, denitrification, runoff, seepage and leaching (Hoque*et al*., 2013).

Deep placement of all essential fertilizers may be more efficient and farmers can be more benefited from this compared to broadcast method. The fertilizer sources of Nitrogen nutrients could be in the form of Ordinary or PU, USG and NPK briquette. Ordinary or PU (Prilled urea) is the most common form of urea available in the market. It contains 46% of N. The mean diameter of PU is 1.5 mm. The USG (Urea super granule) fertilizer is manufactured from a physical modification of ordinary urea fertilizer. The international Fertilizer Development Center (IFDC), Muscle Shoals, Alabama 35660, USA, has developed it. Its nature and properties are similar to that of urea but its granule size is bigger and condensed with some conditions for slow hydrolysis. USG is spherical in shape containing 46% N which is similar to that of PU. Average diameter of the granule is 11.5 mm and weight is 1.8 g (Rahman et al. 2016). The NPK briquette is a mixture of urea, TSP and MOP which helps to reduce the loss of nutrients in flooded condition. So, it is helpful for tidal flooded ecosystem. Weight of each NPK briquette is 2.4 g containing 29% N, 6% P and 8% K (Islam *et al.,* 2011).

Urea has emerged as an important nitrogen fertilizer for rice cultivation. Statistics indicates that about 80% of urea is used for rice production (Hoque*et al.,* 2013). According to Crasswell and de Datta (1980) broadcast application of urea on the surface soil causes losses up to 50% but point placement of USG in 10 cm depth may negligible loss. Urea Super Granule (USG) is a fertilizer that can be applied in the root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen than prilled urea, increase absorption rate, improve soil health and ultimately increase the rice yield. The use of NPK briquette, which is a mixture of urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) may help to reduce the loss of nutrients in tidal flooded ecosystem. To minimize nitrogen loss, USG application may be a good technology to increase rice yield as well as the reduction of production cost (Hoque*et al.,* 2013).

In lowland rice fields, placement of Nitrogen in the root zone, i.e., urea deep placement (UDP), reduces Nitrogen losses and increases NUE and crop productivity (Savant and Stangel, 1990; Rochette*et al.,* 2013; Huda *et al.,* 2016). When urea is deep-placed in continuously flooded rice soils, losses of Nitrogen as floodwater ammonium (NH4+-N), NH3 volatilization and nitrous oxide emissions are negligible (Kapoor*et al.,* 2008; Rochette*et al.,*2013; Gaihre et al., 2015; Huda *et al.,* 2016).With the reduction of these losses, UDP increases Nitrogen use efficiency (NUE) up to 80% compared to 30-45% with broadcast application. Thus, UDP in rice cultivation reduces Nitrogen fertilizer required by 30–35% and increases grain yields by up to 15–20% compared to broadcast PU. In addition to increased farm profitability, UDP reduces government subsidy payments in countries where Nitrogen fertilizer subsidies exist (Miah*et al.,* 2016, Islam *et al.,* 2018).

The adoption of UDP technology has two main benefits; increased yields and lower costs of fertilizer. Both of these are a result of improved nitrogen “uptake” efficiency afforded by the larger Urea particle size and the “point placement” method of application. Farmers like UDP because it saves them money and labour. They only have to fertilize rice once instead of two or three times (the broadcast method) and fewer weeds grow UDP application. Simply put, farmers use less fertilizer while increasing their yields (Adodo, 2010).

2.2.4 Adoption of Agricultural Technology

Adoption is regarded as a decision to make full use of an innovation or technology as the best course of action available. Adoption of an innovation is the decision made by an individual or group to use an innovation (Adekoya and Tologbonse, 2011).Adoption is defined in different ways by various authors. Loevinsohn*et al*.,(2013) defines adoption as the integration of a new technology into existing practice and is usually proceeded by a period of 'trying' and some degree of adaptation. Citing the work of FederJust and Zilberman (1985), Bonabana-Wabbi defines adoption as a mental process an individual passes from first hearing about an innovation to final utilization of it. Adoption is in two categories; rate of adoption and intensity of adoption. The former is the relative speed with which farmers adopt an innovation, has as one of its pillars, the element of 'time'. On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Bonabana-Wabbi 2002).

As indicated by Dasgupta (1989), adoption is not a permanent behaviour. An individual may decide to discontinue the use of an innovation for a variety of personal, institutional or social reasons one of which could be the availability of an idea or practices that is better in satisfying his or her needs.

Each farmer has characteristics that influence how he or she receive information, processes it and either uses or discards it. According to Adekoya and Tologbonse (2011), adoption process has five stages or steps that an individual goes through in adopting an innovation. These include the following; 1) awareness stage, 2) interest stage, 3) evaluation stage, 4) trial stage and 5) adoption stage. These are simply put as an acronym, "AIETA" process. On a practical note, Adekoya and Tologbonse (2011) further stated that a farmer may not alone decide to adopt an innovation as the adoption process model suggested. The decision to adopt is usually taken in situations where farmers are in groups with members influencing one another. This is also in addition to activities of extension agents subtly pushing the innovation. Therefore, the process of adoption model according to Rogers and Shoemaker (1971) can be seen through the following perspective represented by the four basic stages: knowledge, persuasion, decision and confirmation (engagement of positive activities which may lead to eventual acceptance) (Adekoya and Tologbonse, 2011 and Agbamu, 2006).

Adoption of improved technologies can lead to the desired result in agricultural production only if farmers comply with the recommendations and requirements of the technologies, in terms of input use and timing of operations. Any significant deviation from the recommended amount of a particular input can result in lower yields (Ogundele and Okoruwa, 2006). Adesina and Zinnah (1992) noted that the technology package required for enhancing rice production and productivity abounds and many farmers have been exposed to it. Farmers' primary environment such as personnel, socio-economic and biophysical factors, has frequently been associated with determinant of technology characteristics. A farmer may adopt the whole package or a subset of the package. Thus, several adoption and diffusion processes may occur at the same time. The adoption processes may follow specific and predictable sequential pattern.

The factors which influence the adoption of agricultural innovation according to Agbamu (2006) can be classified into:

(a) personal characteristics of farmers (such as age, family size, leadership status, nearness to research station, farm size, gender, economic status, level of education, social participation level, contact with extension workers, cosmopoliteness, mass media exposure, knowledge of recommended practices and year of farming experience);

(b) Characteristics of the innovation (cost of the innovation/triability, complexity and technicality, compatibility with cultural norms and farming system, relative advantage to former methods in economic gain, and observability);

(c) Psychological factors (change proneness of farmer, level of aspiration to socio-economic goal, fear and anxiety, perceived risk and uncertainty/suspicion); and

(d) Situational constraints (insecure land tenure, lack of access to credit and ready markets, inaccessibility to locality and inability to obtain specific input).

Agbamu (2006) further concluded that an important factor that can enhance the rate of adoption is farmers' participation in development. There could be a need gap between researchers and farmers in technology development. Need gap, here, according to him refers to the difference between researchers and technology users in what kind of result they need from a new technology. It is simply differential areas of emphasis.

2.2.5 Concept of Technological Impact evaluation

DFID defines impact assessment as a process of identifying the anticipated or actual impacts of a development intervention on those social, economic and environmental factors which the intervention is designed to affect or may inadvertently affect. Impact assessment in agricultural research is the effort to measure its social, economic, environmental, and other benefits (La Rovere and Dixon, 2007). According to Baker (2000) and Prennushi*et al*., (2000), an impact is the extent to which interventions or programmes cause changes in the well-being of target populations, such as individuals, households, organisations, communities, or other identifiable units to which interventions are directed in social programmes. The changes can be directly or indirectly by the project or Programme. In this context, an impact is conceived as outputs/benefits which are generated from the introduced technologies and which have effects to the beneficiary. The effect may be in the form of economic, social, institutional or environmental nature (Moshi *et al*., 1997; Anandajayasekaram, 2000; Anandajayasekaram*et al.,* 2001; URT, 2001a). An impact refers to the broad, long-term economic, social, and environmental effects resulting from an intervention. Impact assessment can be undertaken before initiating the project (ex-ante) or during the project period (mid-term) or after the completion (ex-post) of the project or activity (Anandajayasekeram and Martella, 1996). Impact assessment examines also differences between outcomes for project participants and non-participants.Anandajayasekeram*et al.,* (1996) stressed that the impact of any technology or project cannot be assessed without information about the number of users (extent) and the degree (intensity) of adoption of improved technologies.

However, it is difficult to evaluate impacts for broad objectives like poverty alleviation or environmental sustainability. Thus FAO (2009) found that it is necessary to use intermediate goals such as increased sustainable agricultural productivity through development of improved technologies. Impact assessment has no one best method; the method chosen depends on the availability of data, the economic environment and the type of results required. The conventional-assessment approaches are focused on tangible impacts such as income, productivity, cost-benefit ratio, the rate of return and failed to capture important benefits accruing to people as a result of the project because they tended to create a certain distance between those assessing impacts and programme beneficiaries (Ashley and Hussein, 2000).

Quantitative or qualitative methods and often integrating quantitative and qualitative methods are used for impact assessment. Four commonly used quantitative methods for measuring impact could be employed: “before and after” comparisons, “with and without” comparisons, “target versus achievement” comparisons and “case study” approach (La Rovere and Dixon, 2007). Any impact evaluation must estimate the counterfactual that is what would have happened had the project never taken place (Baker, 2000). Thus, counterfactual evidence is at the core of impact evaluation analysis techniques. With/without counterfactuals are normally made of participants in innovations versus non-participants, or of adopters (beneficiaries, for instance of a new variety) versus non-adopters (non-beneficiaries). Therefore this is accomplished in this study through the use of "with and without" comparison. Such analysis was conducted easily by comparing the differences in means or percentages of outcome variables between IRM adopters and non-adopters. However, outcome differences may reflect factors other than impact of the technology, especially systematic differences due to the selection of the two groups (DFID, 2002).

2.3 REVIEW OF LITERATURE ON THE IMPACT AND ADOPTION OF AGRICULTURAL TECHNOLOGIES ON MICRO-LEVEL

There is a vast empirical literature of technology adoption on micro-level in developing countries. Over the years, as environmental problems have increased, expanding bodies of work have shifted the focus on the adoption of sustainable agricultural technologies and the adoption of new management practices. Particularly, low-input techniques used by smallholder farmers and natural resource conservation management gained increasing attention (Faltermeier, 2009). Awotide*et al.*(2016) employs Tobit and Heckman two-stage models to assess the determinants of intensity of adoption of Improved Rice Varieties (IRVs) and the effect of market participation on farmers' welfare in Nigeria.The variables that positively and significantly influenced the intensity of IRVs adoption include income from rice production, membership of a farmers' organization, and the distance to the nearest sources of seed, cost of seed, yield and level of training. Gender of household head, access to improved seed, years of formal education, and average rice yield were those variables that are positive and statistically significant in increasing the probability that a farmer would participate in the market. The result further suggests that any increase in the farmers' welfare is conditional on the probability of the farmer participating in the rice output markets. In addition, higher yield, income from rice production, gender of household head, and years of formal education are the variables that are positive and statistically significant in determining households' welfare.

Saiful Islam *et al.,* (2015)employs double hurdle model for determining the factors affecting integrated rice–fish farming system (IRFFS) adoption and intensity of adoption in the first stage and propensity score-matching (PSM) method to analyze the causal impact of IRFFS adoption on welfare of marginalized indigenous farm households in Bangladesh in the second stage. The findings of the first stage study indicate that among the key determinants of adoption are gender of the household head, access to irrigation, education and conflict with villagers. The results also show that farm size and access to credit play a significant role in the extent of use, implying land and credit constraints; hence, it can be difficult for land and credit constraint farmers to extend the adoption of the technology. In the second stage the study shows that IRFFS has a robust positive and significant impact on farm household welfare measured by household annual income, farm income, and quantity and frequency of fish consumption. Likewise, Wossen*et al.,*(2017), examines the impacts of access to extension services and cooperative membership on technology adoption, asset ownership and poverty using household-level data from rural Nigeria employed propensity score matching (PSM), inverse probability weighted adjusted regression (IPWRA) and endogenous switching regression (ESR) approaches to control for endogeneity bias. Findings of the analysis indicated that extension access and cooperative membership have a positive and statistically significant effect on technology adoption and household welfare. Moreover, they find that both extension access and cooperative membership have heterogeneous impacts. In particular, they find evidence of a positive selection as the average treatment effects of extension access and cooperative membership are higher for farmers with the highest propensity to access extension and cooperative services. The impact of extension services on poverty reduction and of cooperatives on technology adoption is significantly stronger for smallholders with access to formal credit than for those without access.

Wiredu, (2014) assessed the impact of NERICA adoption on the incomes of rice-producing households in northern Ghana. To control for endogeneity, the study used the local average treatment effect (LATE) estimation methodology and showed that NERICA adoption significantly increased rice income, agricultural income, per-capita income and total annual income by $196.52, $446.37, $0.44 and $498.44, respectively.

Obayelu*et al.,*(2016) used a Tobit regression model to analyse the determinants and the perceived effects of adoption of selected improved food crop technologies by smallholder farmers along the value chain in Nigeria. The main determinants of adoption were the crop types, farm size and locations. Adoption of herbicide and inorganic fertilizer were influenced by travel cost to nearest place of acquisition, while the age of farmer had a positive and significant influence on the adoption of pesticide, water management and cassava harvester. Interestingly, only male farmers exhibited greater likelihood of adopting land preparation, inorganic and organic fertilizer technologies when compared to their female counterpart.

Abebaw and Haile (2013)investigated the impact of cooperatives on agricultural technology adoption in Ethiopia using cross-sectional data and a propensity score matching technique analysis indicates that cooperative members are more likely to be male-headed households, have better access to agricultural extension services, possess oxen, participate in off-farm work, and have leadership experience. Geographic location and age of household head are strongly associated with cooperative membership. Estimation results show that cooperative membership has a strong positive impact on fertilizer adoption. The impact on adoption of pesticides turns out to be statistically significant when only agricultural cooperatives are considered. Further analysis also suggests that cooperative membership has a heterogeneous impact on fertilizer adoption among its members. The results suggest that cooperatives can play an important role in accelerating the adoption of agricultural technologies by smallholder farmers in Ethiopia.

To ensure the robustness of the results, Cunguara and Darnhofer (2011) used three econometric approaches: the doubly-robust estimator, sub-classification and regression, and matching and regression in assessing the impact of improved agricultural technologies on household income in rural Mozambique. The results show that, overall, using an improved technology did not have a statistically significant impact on household income. This may be associated with a widespread drought that occurred in 2005. Despite drought, distinguishing between households based on propensity score quintiles revealed that using improved technologies, especially improved maize seeds and tractors, significantly increased the income of those households who had better market access. Thus, allowing households to benefit from the use of improved technologies.

2.4 REVIEW OF LITERATURE ON THE EFFECT AND ADOPTION OF UDP TECHNOLOGY IN RICE PRODUCTION

The literature search on the effect of UDP technologyrevealed that,several of the existing literatures are focused on the effect of the UDP technology on Nitrogen use efficiency and grain yield from field and experimental trials. Only a handful of previous studies (Table 1) examined the effect/impact of UDP technology adoption on various dimensions of farmers' welfare for instance Rahman and Barmon 2015; Liverpool-Tasie *et al.,* 2015; Azumah, *et al.,* 2017.

Table 1: The literature search on the effect of UDP technology

S/No.	Title of the Study and Author	Analytical Tool/Estimation metho-dology	Journal title/Volume/Year
1.	Productivity and Efficiency Impacts of Urea Deep Placement(UDP) Technology in Modern Rice Production: An Empirical Analysis from Bangladesh (Rahman and Barmon 2015).	Standard Cost-Benefit Analysis (CBA) and The Stochastic Production Frontier Approach (SFA).	The Journal of Developing Areas Volume 49 No. 3 Summer 2015
2.	Effect of Urea Deep Placement (UDP) Technology on Paddy yield of Rice Farmers in North Central Nigeria (Ajibola*et al.,* 2017)	Ordinary Least Square (OLS) Regression Analysis.	Journal of Wetlands and Waste Management, JWWM, Vol. 1, No. (1-3), 2017.
3.	The Effects of the use of UDP on Rice Yields in Niger State (Liverpool-Tasie *et al.,* 2015).	The Propensity Score Matching (PSM) and Instrumental Variables Methods.	African Journal of Agricultural and Resource Economics Volume 10 Number 1 pages 51-63, March 2015.
4.	The Effect of Urea Deep Placement (UDP) Technology on the Output of Irrigated Rice Farmers in the Northern Region of Ghana (Azumah, *et al.,* 2017)	A Treatment Effect Model.	World Academy of Science, Engineering and Technology International Journal of Agricultural and Biosystems Engineering Vol:11, No:3, 2017

Liverpool-Tasie *et al.,* (2015) investigated the yield effects of urea deep placement (UDP) in Niger State, Nigeria. Using the propensity score matching(PSM) and instrumental variables techniques, consistent evidence was found of the significance of UDP use on rice yields. The most conservative estimates indicate that the use of UDP increases farmers' yields by at least 430 kilograms per hectare, which is a 15% increase in yield.The results indicate that farmers who have access to extra labour are better able to benefit fromUDP use. This likely reflects the higher labour demand of UDP use and necessitates further attention to see how this labour requirement can be met. This also indicates the importance of understanding the labour allocation decisions that are likely to occur in UDP adopting households and their consequent effect on the profitability of UDP use and on household welfare.

2.5 FRAMEWORK OF THE STUDY

2.5.1 Conceptual Framework

This studyadopted the sustainable livelihood framework developedby the U.K. Department for International Development (DFID; 2001) and adjusted by Diagne*et al.,* (2009) to track down how the introduction of improved rice technologies and their adoption would affect the livelihood of rice farmers in the study area.It is based on evolving thinking about the way the poor and vulnerable live their lives and the importance of policies and institutions. It is a useful tool to organize and understand the various factors that constraint or provide opportunities for rice farmers and interaction between them. The sustainable livelihood frameworkrecognises the fact that the rice farmers build their livelihood on widerangeofassets or resources and when a rice farming household surfers' deprivation in some or all of the various type of capita, it resulted into poverty. Capitals such as: Natural capital, Physical capital, Human capital, Institutional resources have been recognised to have causal impact on poverty. These capitals are also conditioned by some exogenous factors such as agro-climatic condition, outside world conditions, policies etc.

The principle of development intervention is to have appropriate technology, policies, institution that creates incentives for people to behave individually and collectively so as to improve household welfare in a sustainable manner (Diagne, 2010).

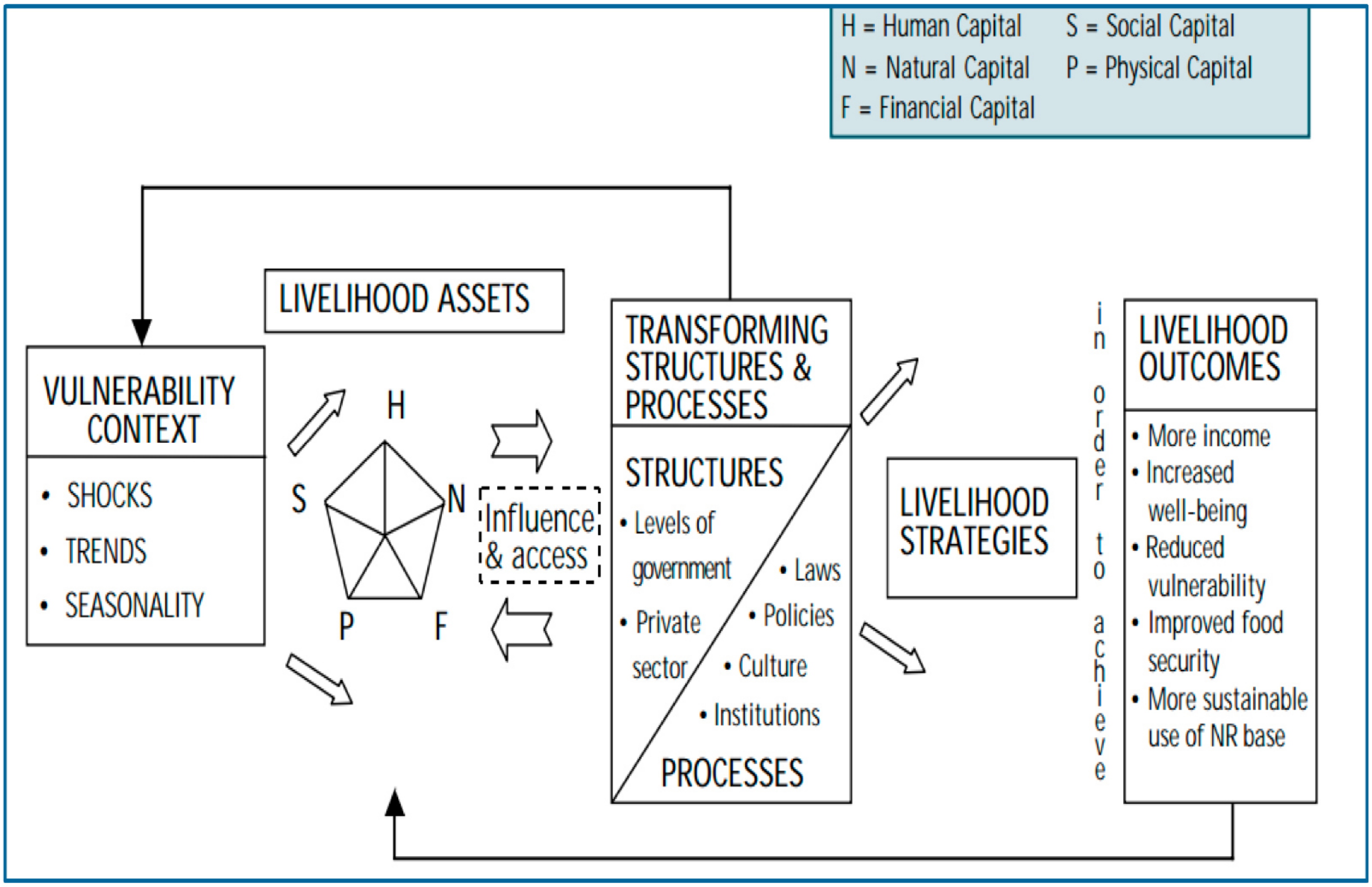

Figure 2.1: Sustainable livelihood framework (DFID; 2001).

2.5.2 Analytical framework

In order to assess the effect of UDP technology adoption on the livelihood of rice farmers in the study area, the choice of the appropriate model to use depends on how the treatment was disseminated and receipt by the intended beneficiaries.In the case of this study,theOverallpopulation ofNigerian rice farmers was not equally exposed to the program (that is the instrument was not randomly distributed). On the other hand, rice farmers that were selected to receive the UDP technology had full control over their decision to receive it or not (the receipt of the instrument is endogenous).Following the impact assessment literatures, the most plausible assumptionin this case is that of selection on unobservable (Imbens, and Wooldridge, 2009; Diagne, *et al.,* 2009).

Most studies have assessed the impact of technology adoption by simply examining the differences in mean outcomes of adopters and non-adopters or by using simple regression procedures that include the adoption status variables among the set of explanatory variables. Critics have pointed out that such simple procedures are flawed because they fail to deal appropriately with the self-selection bias and selection on unobservable attached to observational data collected through household surveys, and hence fail to identify the causal effect of adoption (Imbens, and Wooldridge, 2009; Heckman and Vytlacil, 2005; Lee, 2005; Imbens, 2004; Rosembaum, 2002; Heckman and Robb, 1985; Rosembaum and Rubin, 1983; Rubin, 1974).

However, the package nature of new agricultural technology makes the evaluation of its welfare effects quite difficult. Most of the studies on the impact of agricultural technology on farm incomes and poverty have usually relied on fairly macro approaches, with very few analyses at the micro-level.Some of the few household level studies include Morris (2002), Karanja*et al.,* (2003), Evenson and Gollin (2003), Mendola (2007), Mojo *et al.,* (2007) and Javier and Awudu, (2010). Thus, the literature appears to document overall positive impacts, with far less evidence at the individual household level that specifically show the effects of the adoption of agricultural technologies on farm income and household poverty level. Some of these studies used the propensity score matching (PSM) method to deal with the self-selection bias problem and estimate the average treatment effect (ATE) of adoption of high yielding varieties on income (Mendola, 2007; Mojo *et al.,* 2007 and Javier and Awudu, 2010). Some of them combine both the PSM with the Double Difference (DD) methods (Oni *et. al.,* 2007; Mkonya*et. al.,*2007).

CHAPTER THREE

3.0 METHODOLOGY

3.1 THE STUDY AREA

The study was conducted in Kano state. Kano state lies in the Northern part of Nigeria between Latitudes 10° 33' to 12° 37'N and Longitude 07° 34' to 09° 25'E. The southern part of the state lies in the Northern Guinea Savannah agro-ecological zone while the remaining northern part is covered by the Sudan Savannah. The annual rainfall varies from 600 – 1200 mm in the Guinea Savannah to 300 – 600mm in the Sudan Savannah. The length of the growing periods ranges from 90 – 150 days in the Sudan Savannah and 150 – 200 days in the Guinea Savannah zone. Subsistence and commercial agriculture is mostly practiced in the outlying districts of the state. Some of the food crops cultivated are millet, cowpeas, sorghum, maize and rice for local consumption while groundnuts and cotton are produced for export and industrial purposes.

The population of Kano according to the 2006 population census is estimated at 9.4 millionwith a population growth rate of approximately 3.5% per annum. Kano state population is projected to be 13.7 million people today, women constitute 47.4 percent (6.5 million) of total population and men make up 52.6 percent (7.2 million). There are over 1,754,200 hectares of cultivable land in the State (KSIH, 2013). The dominant tribes are Hausa and Fulani ethnic groups. Also, other ethnic groups are domiciled in the state these include virtually all major and minor tribes in Nigeria. Other foreign nationals from different parts of the world are also found in Kano (KNGS, 2006).

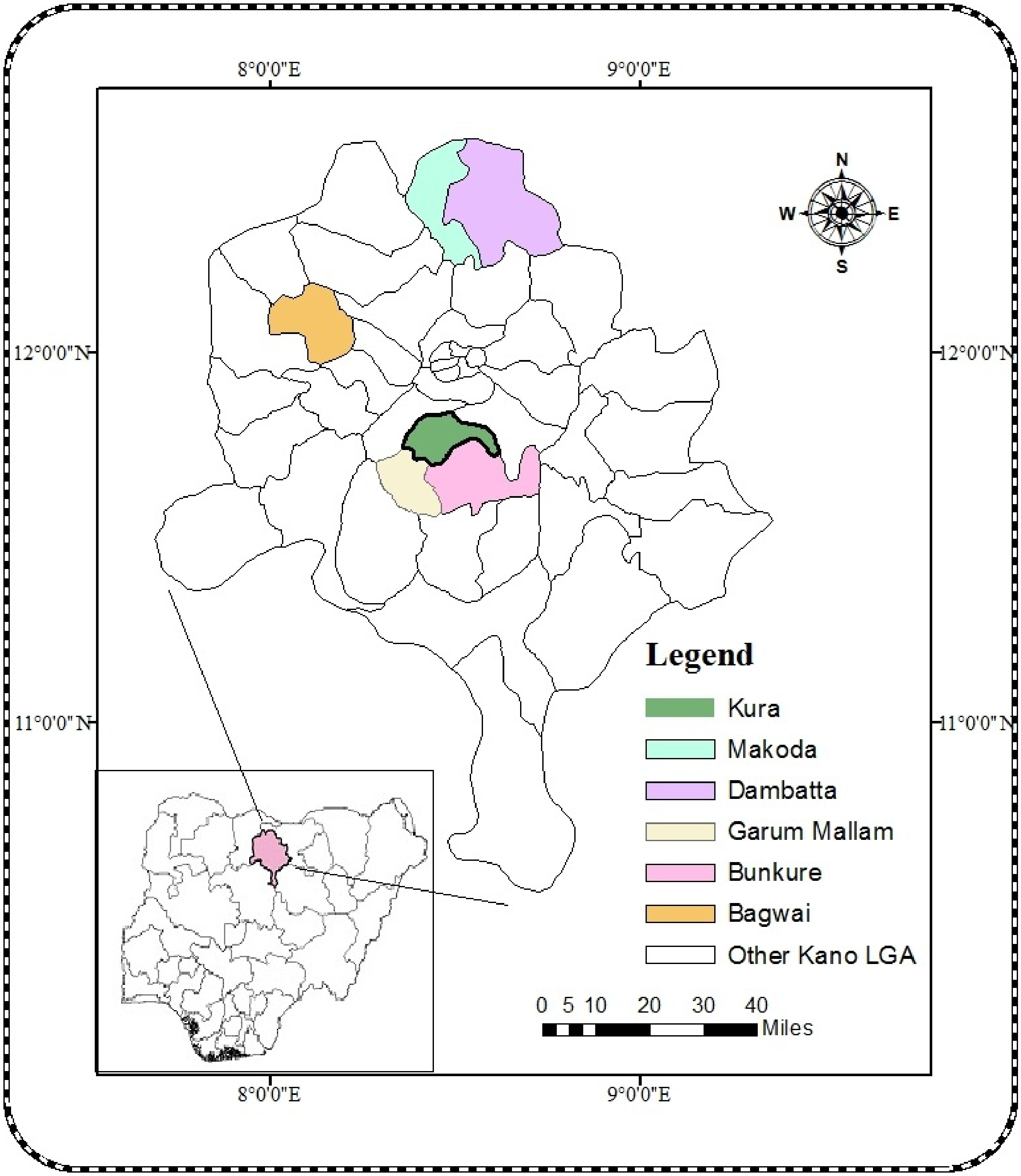

Figure 2.1: A Map showing the Study Area.

Source: Geography Department BUK, 2018.

3.2 SAMPLING PROCEDURE AND SAMPLE SIZE

Multi-stage sampling techniques were used for this research. The first stage involved the purposive selection of six (6) Local Government Areas (LGAs) out of the total of nine (9) participatingLGAsin USAID MARKETS II Programme in Kano state, which were Bunkure, Garun Mallam, Kura, Dambatta, Bagwai and Makoda LGAs.Secondly, two participating communities were purposively selected from each of the purposively selected LGAs making a total of twelve (12) participating communities. Finally, a total of 300 registered smallholder rice farmers were randomly sampled, comprising of 189USAID MARKETS II Participants and 111 Non-participants using Raosoft Sample Size Calculator.

Table 2: The sampling frame of rice farmers

Local Government Area (LGA)	Sample Frame	Community	*Sample Size
Bunkure	981	Zangon Buhari	24
		SabonRuwa	24
Garun Mallam	1204	Kyanfara	30
		Zururu	30
Kura	1621	Butalawa	41
		Imawa	41
Dambatta	780	Balloda	20
		Zakirai	20
Bagwai	768	Bunku	19
		Kiyawa	19
Makoda	662	UnguwarKusa	16
		GawanBature	16
Total	**6016**		**300**

* Sample size is 5% of the Sample Frame.

Source: Rice Farmers Association of Nigeria (RIFAN), 2018.

3.3 DATA COLLECTION

Data for this study were collected from primary and secondary sources. Primary data were collected with the aid of questionnaire and interview schedule which were administered to the randomly selected rice farmers. Data were collected by the researcher with the assistance of trained enumerators. Data was collected on the socio-economic and production information of the rice farmers such as gender, age, level of education, marital status, household size, years of experience, farm size, access to extension service,plot size, quantity of labour used,quantity of fertilizer used, quantity of rice paddy sold etc.

3.4 ANALYTICAL TECHNIQUES

The following analytical tools were employed to achieve the stated objectives of the study.

1. Binary Logit Regression Model
2. Double Hurdle Model (DHM)
3. Farm Budgeting Technique
4. Propensity Score Matching (PSM)

3.4.1 Binary Logit Regression Model:

Binary Logit regression model was used to achieve objective (i). This is one of the binary choice models with a dichotomous dependent variable and this dichotomous variable is related to a set of independent variables that are hypothesized to influence the outcome. Hence, the model allows one to predict outcome from a set of paired variables. In this study, the outcome variable i.e. participation is binary (i.e. participant and non-participant) hence were assigned 1 for participant of the Programme and 0 for non-participant. The binary Logit model for characterizing the influence of socioeconomic and institutional factors is specified as follows:

$$Y= \beta_0+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5+ \beta_6X_6+ \beta_7X_7+ \beta_8X_8+ \beta_9X_9+ \varepsilon_i \text{.............................} (1)$$

Where:

Y=Likelihood of participation in USAID/MARKETS II (Dummy variable 1 If respondent Participated and 0 if respondent did not participate)

β_0 = Constant term

$\beta_1, \beta_2, \beta_3,\ldots,\beta_9$ = the coefficients for the respective variables in the Binary Logit function

X_1 = Age (years)

X_2 =Gender

X_3 = Marital status (0=unmarried, 1=married)

X_4 = Household size (numbers)

X_5 = Educational level (years)

X_6 = Farming experience (years)

X_7 = Extension visit (number of visit/year)

X_8 = Membership of Cooperative

X_9 = Farm size (ha)

X_{10} = Primary Occupation

X_{11}=Access to credit

X_{12} =Quantity of Rice paddy Sold (kg)

ε_i = Error term

3.4.2 Double Hurdle Model (DHM):

The double hurdle model (DHM)was used to achieve objectives (ii) and (iii). The double hurdle model (Cragg, 1971), which assumes that households must pass two hurdles; i) decide whether to adopt or not (probabilityof adoption); and ii) amount of the UDP package (intensity/extent of use)which is conditional on the first decision. It is possible to include different explanatory variables in the two hurdles or even the same explanatory variables in both hurdles may have different effects (Tambo, and Abdoulaye, 2012). Recently, this model is frequently used in technology adoption literatures (see for exampleDimara, and Skuras, 2003; Amare*et al.,* 2012; Gebremedhinand Swinton, 2003). The adoption of UDPtechnology is expected to occur alongside a set of prescribed practices for rice production.

TheUDP technologyunder study consists of five (5) items of package these include: improved rice varieties, Seed cleaning,nursery, line transplant and UDP Technique. Some respondent farmer adopted the whole set of the package while others adopted some items of the package. Therefore, for the purpose of this study and to fit into the binary choice model the dependent variable which is Adoption must be dichotomous hence an adopter of UDP technology (1) is defined as a rice farmer who used theUDP Technique alongside any two (2) items of the package while a non-adopter of UDP technology (0) is a rice farmers who adopts less than three (3) items of the package including theUDP Technique or does not adopt any items of the package at all.

The DHM is expressed as:

Thefirst hurdle, decision to adopt UDP package (A) is expressed as,

$A_i^* = \alpha x_i + \mu_i; \quad \mu_i \sim N(0, 1)$ ……………………………………………………...… (2)

With $A_i = 1$ if $A_i^* > 0$ and $A_i = 0$ if $A_i^* \leq 0$ .... (3)

The second hurdle, intensity of adoption (I) is expressed as,

$I_i^* = \beta z_i + V_i; V_i \sim N(0, \sigma^2)$ ……………………………………………………..………..(4)

With $I_i = I_i^*$ if , $I_i^* > 0$ and $A_i = 1$; $I_i = 0$ otherwise ……………………………………..…….(5)

Where, A_i is a discrete (observed) variable measuring whether or not UDP is adopted, and A_i^* is a latent (unobserved) variable for A_i.

I_i denotes the observed area under UDP (intensity of adoption), and I_i^* is a latent variable for I_i.

X_i and Z_i are vectors of variables illustrating the decision to adopt UDP and the intensity of UDP adoption respectively,which can overlap or can be same.

Aand β are vectors of theparameterstobe estimated μ_i and V_i are the error terms and they are assumed to be independent.

Based on this assumption, the double hurdlemodel is equivalent toa combinationof aprobitmodel and a truncated regression in the two hurdles respectively. Thus, we use maximum likelihood method of probit and truncated regressions to estimate the first and secondhurdles respectively (Gebremedhin and Swinton, 2003).

The empirical model employed to determine the decision to adopt UDP package (A) is specified as follows:

$$Ai = \alpha_0+\alpha_1X_1+\alpha_2X_2+\alpha_3X_3+\alpha_4X_4+ \alpha_5X_5+\alpha_6X_6+\alpha_7X_7+\alpha_8X_8+\alpha_9X_9+\alpha_{10}X_{10}+\mu i \quad \text{............ (6)}$$

Where;

Ai = individual's adoption decision of UDP technology

α_0 = the constant term

$\alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_{10}$ = are the parameters of the respective explanatory variables in the model

X_1= Gender

X_2= Marital Status(0=unmarried, 1=married)

X_3= Education (years)

X_4= Primary Occupation

X_5= Extension Contact

X_6= Experience in Rice production (years)

X_7= Participation in UDP project

X_8= Average plot size(hectares)

X_9= Membership of Cooperative

X_{10}= Reason for rice production

X_{11}= Total quantity of labour (Man-days)

μi=Error term

The empirical model employed to determine the intensity of adoption (I)is specified as follows:

$$Ii = \beta_0+\beta_1Z_1+\beta_2Z_2+\beta_3Z_3+\beta_4Z_4+\beta_5Z_5+\beta_6Z_6+\beta_7Z_7+\beta_8Z_8+\beta_9Z_9+\beta_{10}Z_{10}+V_i \ldots\ldots\ldots\ldots \quad (7)$$

Where;

Ii = the intensity of adoption (measured as the percentage of area under UDP)

β_0 = the constant term

$\beta_1, \beta_2, \beta_3, \ldots, \beta_{10}$ = are the parameters of the respective explanatory variables in the model

Z_1= Gender

Z_2= Marital Status(0=unmarried, 1=married)

Z_3= Education (years)

Z_4= Primary Occupation

Z_5= Extension Contact

Z_6= Experience in Rice production (years)

Z_7= Participation in UDP project

Z_8= Average plot size(hectares)

Z_9= Membership of Cooperative

Z_{10}=Reason for rice production

Z_{11}=Total quantity of labour (Man-days)

V_i = Error terms

3.4.3 Farm Budgeting Technique:

Farm budgetary analysis such as Net Farm Income and some financial ratios such as Gross Ratio (GR), Operating Ratio (OR) and Return on Investment (ROI) were used to achieve objective (iv).

3.4.3.1Net Farm Income:

The Net farm income was used because rice production has sizeable fixed cost elements such as Rent on Land, interest on loan and depreciations on assets (farm tools used). The components of variable cost in rice production: Cost of seed, cost of fertilizer, cost of agrochemicals, Cost of manure, cost of fuel and cost of labour (land preparation, nursery, planting/transplanting, weeding, fertilizer application, spraying, harvesting, threshing,winnowing and transportation)

The General model of the farm budget is as follows:

NFI = GI – TC……………………………………………………………………………….. (8)

Where:

NFI = Net Farm Income (₦/Ha)

GI = Gross Farm Income (₦/Ha) i.e. this is the total paddy output (bags) multiplied by the unit price of the product.

TC = Total Cost (₦/Ha)

TC = Total Variable Cost (TVC) + Total Fixed Cost (TFC)

The fixed inputs are not normally used up in one farming cycle. The fixed inputs were depreciated using the straight line method shown below:

$$D = \frac{P - S}{N} \quad \text{…… (9)}$$

Where;

D = depreciation

P = purchased value (₦)

S = salvage value (₦)

N = life span of asset (Years)

3.4.3.2 Financial Ratios:

The financial ratios used, include:

Gross Ratio:it is the ratio that measures the overall financial success of a business. A less than 1 ratio is desirable for any business, the lower the ratio the higher the profit (Olukosi and Erhabor, 2008). It is stated as

$$GR = \frac{TC}{TR} \quad \ldots\ldots (10)$$

GR = Gross Ratio(₦/Ha)

TC = Total Cost(₦/Ha)

TR = Total Revenue(₦/Ha)

TR = P×Q

Where,

P = Unit price per bag of rice paddy

Q = Total quantity of rice bags sold

Operating Ratio: it measures the solvency of a business. A ratio less than 1 is desirable because it indicates that the business is making profit. A ratio of 1 implies break-even and a ratio greater than 1 implies a loss (Olukosi and Erhabor, 2008). It was given as:

$$OR = \frac{TVC}{TR} \quad \ldots\ldots (11)$$

OR =Operating Ratio

TVC= Total Variable Cost(₦/Ha)

TR = Total Revenue(₦/Ha)

Return on Invested (ROI): The Return on Investment was used to compare the return on investments of the UDP technology adopters and non- adopters. The Return on Naira spent model was specified as:

$$ROI = \frac{\text{Gross Margin}}{\text{Total Cost}} \quad \ldots\ldots(12)$$

Gross Margin (GM) = TR – TVC

Where,

ROI = Return on Investment in Naira

GM=Gross Margin as the difference between Total Revenue (TR) and Total Variable Cost (TVC). All quantities are as defined earlier.

3.4.4Propensity Score Matching (PSM):

Propensity score matching (PSM) method was used to achieve objectives (v) and (vi), it is a commonly used non-experimental approach, to estimate the causal effects of technology adoption on household welfare in a cross-sectional sample without random adoption. It balances the distributions of observed covariates between a treatment group and a control group based on similarity of their predicted probabilities of adopting the UDP (their 'propensity scores'). PSM creates the conditions of a randomized experiment; makes the incomparable comparable and it is insensitive to functional form (Mendola, 2007; Rosenbaum and Rubin, 1983 and Saiful Islam *et al.*, 2015).

A PSM method was used to identify UDP non-adopters who are similar to UDP adopters in their observable characteristics. There are several steps in estimating the PSM model.

The first step is to estimate the predicted probability (p score) which is estimated as follows:

$$P(X_i) = Prob(A_i = 1/X_i)\ (0 < P(X_i) < 1) \ldots\ldots (13)$$

Where, $P(X_i)$ is the propensity score, estimated by a probit model which regresses adoption status (UDP adopters = 1 and non-adopters = 0) on X_i, is a vector of observed control variables. This is also similar to thefirst hurdle in DHM.

The next step is to choose an appropriate matching algorithm for estimating the average treatment effects on the treated (ATT). In this study, several matching estimators (e.g., Nearest-neighbourmatching, Kernel matching and radius matching) wereused to pair UDP adopters to similarnon-adopters using the estimated propensity in thefirst step.

FollowingBecker and Ichino (2002), the ATT (in this case, the effect of UDP adoption on the rice income and farm Labor use of the rice farmers) is estimated as follows:

$$ATT = E\left\{E\{Y_i^1/A_i=1, P(X_i)\} - E\{Y_i^0/A_i=0, P(X_i)\}\ A_i=1\right\} \ldots\ldots (14)$$

Where, Y_i^1 and Y_i^0 are two counterfactual outcomes of UDP adoption and non-adoption

Finally,processes to get reliable resultscheck robustness (sensitivity) of results and to check the matching quality followed. These includes;thebalancing test, the matching quality and lastly, the Rosenbaum bound approach was used to test the sensitivity of the estimated results to hidden bias (Rosenbaum, 2002). Which is one kind of proxy to check main assumption behind PSM i.e. selection on observables (also called CIA-conditional independence assumption).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 SOCIO-ECONOMIC CHARACTERISTICS OF THE RICE FARMERS IN THE STUDY AREA.

In this section, the major socio-economic characteristics of rice farmerscovered in the study areaare described. The Socio-economic variables identified include; Age, Gender, Marital Status, Years in Formal Education, Household Size, Primary Occupation, Farming Experience, Farm Size, Membership of Farmers' Cooperative and Ability to Read and Write in any Language. These Socio-economic Variables are presented in Table 3a and Table 3b.

Table 3a: Socio-economic Characteristics of the farmers

	Non-participants (N=111)		Participants (N= 189)		All Respondents (N= 300)	
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender						
Male	95	85.6	116	61.4	211	70.3
Female	16	14.4	73	38.6	89	29.7
Marital Status						
Married	95	85.6	173	91.5	268	89.3
Single	16	14.4	16	8.5	32	10.7
Primary Occupation						
Farm	88	79.3	175	92.6	263	87.7
Off-Farm	4	3.6	2	1.1	6	2.0
Non-Farm	19	17.1	12	6.3	31	10.3
Membership of Cooperative						
Member	63	56.8	177	93.7	240	80.0
Non-Member	48	43.2	12	6.3	60	20.0
Education						
No Formal Education	35	31.5	75	39.7	110	36.7
Primary Education	29	26.1	62	32.8	91	30.3
Secondary Education	26	23.4	30	15.9	56	18.7
Tertiary Education	21	18.9	22	11.6	43	14.3

Source: Field Survey, 2018.

4.1.1 Gender

The results of the investigation into gender is shown in Table 3a, majority of the respondents (61.4%) were male while(38.6%) were femaleparticipants in theUDP programme. The corresponding values for non-participant rice farmers in the study area are (85.6%) male and (14.4%) female.This means that male rice farmers are more involved in intervention programmes in agriculturein the study area than the female rice farmers. It is significant to note that the relatively higher (38.6%) female among participants than non-participants. Pooled data in the same table indicated that majority (70.3%) of the rice farmers were male while (29.7%) were female.This is consistent with the findings of Dontsop-Nguezet*et al.,*(2011) and Chekene and Chancellor (2015) who found that the majority of ricefarmers inNigeria were males.

4.1.2 Marital Status

It can be seen clearly from Table 2a that,the majority (91.5%) of the rice farmers that participated in the programme were married while only 8.5% were single. Similarly, the majority (85.6%) of the non-participants were married while only 14.4% were single. In the whole population, about 90% of the rice farmers were married while the remaining 10% of them were single.These findings showed that there are more marriedrice farmers in the study area;the likely implicationis that there will be available labour supply in the study area. This result is in conformity with the findings of Ajibola and Onwu (2017) that the majority of the rice farmers are married people.

4.1.3 Primary Occupation

The result in Table 3a revealed that, most of the rice farmers both participants (92.6%) and non-participants (79.3%) had farming as their major occupation. Likewise, pooled entries show that a greater proportion 87.7% of the rice farmers in the study area had farming as their major occupation, while the remaining 2.0% and 10.3% of them had off-farm and non-farm activities as their major sources of income respectively. This finding is in line with Awotide*et al.,* (2015) who reported that about 75 % of the over 160 million people in Nigeria are rural dwellers who rely on agriculture for their livelihoods, particularly the production of staple food crops.

4.1.4 Membership of Farmers' Cooperative

The study reveals in Table 3a,the majority (93.7%) of the rice farmers that participated in the programmeare members of a farmers' cooperative society while only 6.3% of the farmers are not. Similarly, 56.8% of the Non-participants belong to cooperative societies while 43.2% are non-members of any cooperative society. Cumulatively, 80% of the respondents in the study area are members of one cooperative society or another while 20% are not members of any cooperative society.This supports the findings of Liverpool-Tasie (2015), who reported that 78% of rice farmerswere members of at least a cooperative society.Thisimplies that the delivery approach of the UDP programme and other rice value chain development programmes in the study area,to expand outreach and deepen intervention outcomes by supportingfarmers' association development, was a success.

4.1.5 Formal Education

As shown in Table 3a. Majority of the participants(39.7%) and (31.5%) non-participants farmers had no formal education,32.8% of the participants 26.1% of non-participants had primary education, and 15.9% of participants and 23.4% of non-participants had secondary education while about 11.6 % participants and 18.9% non-participants had tertiary education. However, altogether about 36.7% of the rice farmers had no formal education, 30.3% had primary education, and 18.7% had secondary education and 14.3% had tertiary education. Farmers with formal education are likely to have the capacity to understand and adopt process driven technologies than their counterpart with no formal education. The level of education has an implication for adoption of improved agricultural technologies in that education increases the capacity of farmers to comprehend and utilize information received on recommended agricultural practices (Rogers, 1983).This is likely to aid in active participation in the project and adoption of the rice technologies introduced in the area.This supports the findings of Kolawole*et al.,* (2012) who stated that the literacy level of farmers enhances the rate of adoption of improved technology.

Table 3b: Socio-economic Characteristics of the farmers

	Non- Participants (N=111)		Participants (N= 189)		All Respondents (N= 300)	
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Age (years)						
17-26	20	18.0	34	18.0	54	18.0
27-36	29	26.2	44	23.3	73	24.3
37-46	25	22.5	51	27.0	76	25.3
47-56	27	24.3	47	24.8	74	24.7
57-66	10	9.0	13	6.9	23	7.7
Minimum = 17, Maximum = 65, Mean = 39.70, Std. Deviation = 12.110						
Household Size (number of persons)						
1-8	53	47.7	75	39.7	128	42.7
9-16	43	38.7	79	41.8	122	40.7
17-24	13	11.7	27	14.3	40	13.3
25-32	1	0.9	8	4.2	9	3.0
33-40	1	0.9	0	0.0	1	0.3
Minimum = 1, Maximum = 36, Mean = 10.65, Std. Deviation = 6.135						
Farming Experience (years)						
1-10	36	32.4	80	42.3	116	38.6
11-20	47	42.4	58	30.7	105	35.0
21-30	16	14.4	37	19.6	53	17.7
31-40	10	9.0	13	6.9	23	7.7
41-50	2	1.8	1	0.5	3	1.0
Minimum = 1, Maximum = 50, Mean = 16.10, Std. Deviation = 10.517						
Size of rice fields (hectares)						
<1	91	82.0	154	81.5	245	81.7
1.1-2	12	10.8	33	17.5	45	15.0
2.1-3	4	3.6	1	0.5	5	1.7
3.1-4	3	2.7	1	0.5	4	1.3
4.1-5	1	0.9	0	0.0	1	0.3
Minimum = 0.1, Maximum = 5, Mean = 0.78, Std. Deviation = 0.716						

Source: Field Survey, 2018.

4.1.6 Age

As shown in Table 3b, a greater proportion (73%)of the rice farmers that participated in the programme were between 27 to 56 years of age, 9%were within the age range of 57 to 66 years. Similarly, greater proportion(75.1%) of the non-participants were between 27 to 56 years of age, 6.9% were within the age range of 57 to 66 years.The mean age of the rice farmers (pooled) is 39.70 years;this is an indication that rice production in the study area is dominated by farmers in theiractive age. The implication is that rice farmers in this age category may be more likely to handle the risks involved in adopting improved technologies in rice agricultural production.

4.1.7 Household Size

The distribution of household sizes of the farmers in Table 3b revealed that (39.7%) of the participant farmers had household size within the range of 1 to 8 persons and 47.7% for non-participants while those with household size of 9 to16 persons constituted 41.8% for participants and 38.7% for non-participants.The average household size for both participants and non-participants is 10 persons per household. This implies that rice farmers in the area have large family size which infers higher family labour. This is consistent with the findings of DontsopNguezet*et al.,* (2011) who found the average household size of ricefarmers in the three major rice ecologies of Nigeria stands to be 10 persons.

4.1.8 Farming Experience

The result in Table 3b revealed that,42.3% of the participants and 32.4% of non-participants had experience in farming activities within the range of 1 to 10 years in the study area. The rice farmers that had the farming experience of 11 to 20 and 21 to 30 constituted 30.7% and 19.6%for the participants and non-participants were 42.4% and 14.4% respectively.The average for both participants and non-participants was 16 years. This is result is consistent with Ajibola and Fatoki (2017) who found that the average rice farming experience of the rice farmers is 17 years. These findings imply that the rice farmers had very long years of rice farming experience which could serve as an advantage in participation and adoption of improved rice technologies. It is also worthy of note that the age of a farmer may not necessarily correlate with the years ofexperience in farming. While some farmers started farming very early in their lives, some only take to farming after retiring from wage employmentin either public or private service.

4.1.9 Size of rice fields (Hectares)

The study reveals in Table 3b that,the majority 81.5% of the participants and 82.0% of non-participantscultivated less than one hectare of land devoted to rice. Also, 17.5% of participants and 10.8% of non-participants cultivated between 1.1 to 2hectares of rice field. The rice farmers that cultivated 2.1 to 3hectares and 3.1 to 4hectares of rice fields constituted 0.5% and 3.6% for the participants and non-participants respectively. The pooled data showed that the majority of the rice farmers 81.7% cultivated less than one hectare of rice while 15.0% cultivated1.1 to 2hectaresof rice plots. The average size of rice fields cultivated by the rice farmers in the study area was 0.79 hectare.This finding is in line with the findings ofChekene and Chancellor (2015) who found that the majority of ricefarmers in Nigeria are smallholder rice farmers.

4.2 SOCIO-ECONOMIC FACTORS INFLUENCING RICE FARMERS' DECISION TO PARTICIPATE IN USAID/MARKETS II PROGRAMME IN THE STUDY AREA.

The Binary logistic regression model was applied to study the socio-economic factors influencing rice farmers' decision to participate in USAID/MARKETS II intervention in the study area. The result in Table 4presents the statistical results of the analysis.Among several variables investigated, participation in UDP project was significantly determined by age, Household Size, primary occupation, extension contact and membership of cooperative.

Age was significant at 10% ($p<0.10$) in influencing participation in the programme, the estimated coefficient of age was negative in influencing participation in USAID/MARKETS II programme, this implies that participation decreases with age of the farmers.Younger farmers are more dynamic in terms of innovation adoption hence their desire to participate in rice development projects. The result is consistent withMartey*et al*., (2013) who found that age was negatively related to the probability of participation in Rice Development Projects (RDP) among smallholder rice farmers.

The estimated coefficient of household size has a positive and statistically significant influence on participation in USAID/MARKETS II programme and was significant at 10% ($p<0.10$) signifying that the likelihood to participate tends to increase with a rise in household size. This result further affirms the finding of Muhammad *et al.,*(2011) who found that individuals with large household size were likely to participate in the Fadama II project as they appeared to have more family burden to contain with, in terms of social and economic services, and therefore need support to meet their family daily needs.

Primary Occupation also has negative coefficient and was significant at 10% ($p<0.10$)in influencing participation in USAID/MARKETS II programme.This indicates that,participation decreases with having off-farm and non-farm activities as major occupation, there is a high inclination of farmers who are majorly into farming to partake in the programme compared to those that are majorly into off-farm and other non-farm activities.This finding is contrary to the findings ofO-baniyi, *et al.,* (2014) which showed that there is a positive relationship between participation levels of farmers in capacity building programmes of agricultural development programme and secondary occupation. One important explanation that can be profferedfor this is the fact that farmers who are majorly into farming as their major means of livelihood will take participation in UDP projectprogramme with maximal commitment.

The agriculture extension service is a very important institutional factor. Extension contact is used as a proxy for the institutional network (Chandio and Jiang, 2018).In this study, the result also revealed thatlikelihood of participation inUDP project was motivated by Extension contact with Extension agents which has positive coefficient and was significant at 1% (p<0.01). This means that farmers in more contact with extension agents are more likely toparticipation inthe-programme.This finding is in conformity with Umar (2015) who found out that farmers who have frequent contacts with extension agents had a higher probability of participation inintervention programme in Kaduna state Nigeria.

Membership of cooperative society has a positive coefficient and was significant 1% (p<0.01) in influencing participation in USAID/MARKETS II programme. The positive coefficient reveals that the more an individual participates in cooperative associations the more likely he is to participate and benefit from the programme. This result further affirms that individualsthat participated in the programme have been members of cooperative societies. This is in line with the delivery approach USAID/MARKETS II programmeto expand outreach and deepen intervention outcomes by supportingfarmers' association development(USAID/Nigeria, 2012).This result further affirms the finding of Muhammad *et al.*(2011) who stated that membership of cooperative society has positive and significant in influencing beneficiary participation in FADAMA II project.

Table 4: Socio-economic factors influencing rice farmers' decision to participate in USAID/MARKETS II programme.

Variable	Coefficient	Standard Error	P>/z/
Age(years)	-0.027777	0.016042	0.083*
Gender	-0.616633	0.433269	0.155
Marital Status	0.037875	0.517344	0.942
Education (years)	-0.029234	0.029627	0.324
Primary Occupation	-0.390860	0.225912	0.084*
Household Size(number of persons)	0.044977	0.027041	0.096*
Farm Experience (years)	0.023034	0.024775	0.353
Extension Contact	2.663339	0.822958	0.001***
Farm size(hectares)	-0.261684	0.257344	0.309
Membership of Cooperative	1.909610	0.402517	0.000***
Access to credit	-4.15E-07	2.70E-06	0.878
Quantity of Rice paddy Sold (kg)	0.012412	0.008230	0.132
Constant	-2.084568	1.087450	0.055**
LR $\chi^2(12) = 91.24$			
Prob $>\chi^2= 0.0000$			
Pseudo $R^2= 0.2308$			
Log likelihood = -152.0649			
Number of observations = 300			

*** Significant at 1% ($p<0.01$), ** Significant at 5% ($p<0.05$),*Significant at 10% ($p<0.10$).

Source: Field Survey, 2018.

4.3 FACTORS DETERMINING THE ADOPTION AND USE INTENSITY OF UREA DEEP PLACEMENT (UDP) TECHNOLOGY IN THE STUDY AREA.

Table 5 shows the adoption pattern of the UDP technology items of the package by the rice farmers in thestudy area. TheUDP technologyunder study consists of five (5) items of the package these include: improved rice varieties, Seed cleaning,nursery, line transplant and UDP Technique. Some rice farmers adopted the whole set of the package while others adopted some items of the package. Therefore, for the purpose of this study and to fit into the binary choice model the dependent variable which is Adoption must be dichotomous hence an adopter of UDP technology (1) is defined as a rice farmer who used theUDP Technique alongside any two (2) items of the package while a non-adopter of UDP technology (0) is a rice farmer who adopt less than three (3) items of the package including theUDP Technique or does not adopt any items of the package at all. An unexpected outcome was seen where non-adopters of UDP technology took after more nursery practice than adopters, this might be due to differences in rice varieties cultivated, either low land or upland rice varieties.

Table 5: Adoption pattern of the UDP technology items of thepackage by the rice farmers in thestudy area

		Adopters		**Non – adopters**		
S/no.	**Items of the UDP technology package**	**Frequency**	**%**	**Frequency**	**%**	**Total%**
1	Improved rice varieties	290	96.7	10	3.3	100
2	Seed cleaning	169	56.3	131	43.7	100
3	Nursery	136	45.3	164	54.7	100
4	Line transplanting	191	63.7	109	36.3	100
5	UDP Technique	192	64.0	108	36.0	100

Source: Field Survey, 2018.

4.3.1 Factors determining the adoption of Urea Deep Placement (UDP) technology in the study area.

The double hurdle model (DHM) for the factors determining the adoption and use intensity of UDP technology (measured as the percentage of area under UDP) in the study area are presented in Table 6. They were estimated simultaneously using the CraggitStata command.The Wald statistic estimate was 69.42 and was significant at 1% (p<0.01) level of probability. This implies that the modelsignificantly fitted the data. In other words, the independent variables included in the model were jointly important in explaining the variations in the decision to adopt UDP technology and how much to adopt. The sigma estimate representing the estimate of the standard error of the model was 23.993 and was significant at 1% (p<0.01) level of probability. This implies that the estimated double hurdle of the decision toadopt and use intensity of UDP technology are determined by different processes and therefore the use of DHMin place of the standard Tobit model was justified.

The first Hurdle of the double hurdle model (DHM) in Table 6 shows the maximum likelihood estimates of the probit model for factors determining the adoption of UDPtechnology by rice farmers in the study area. The adoption of UDP technologywas significantly determined by gender, marital status, education, extension contact, experience in rice production, participation in USAID/USAIDMKT II,average plot sizeand reason for rice production.

The coefficient of genderwas negatively related to the adoption UDP technology and statisticallysignificant at 1% (p<0.01). This is an indication that male rice farmers in the study area had a higher probability of adopting UDP technology than their female counterparts.This result is contrary to the findings of Liverpool-Tasie (2015), who reported that female rice farmers were more likely to adopt UDP technology for rice production relative to their male counterparts.Ajibolaand

Fatoki (2017) also reported that women rice farmers were more positively disposed to the use of UDP recommended practices.

Table 6: Double hurdle model (DHM)estimates for the factors determining adoption and use intensity of Urea Deep Placement (UDP technology in the study area.

	First Hurdle Adoption		Second Hurdle Intensity of Adoption	
Variable	**Coefficient**	**Std. Err**	**Coefficient**	**Std. Err**
Gender	-0.623***	0.293	-9.427*	5.333
Marital Status	-0.588**	0.422	2.935	6.961
Education (years)	0.052*	0.019	0.267	0.363
Primary Occupation	0.255	0.160	-2.825	3.244
Extension Contact	0.777**	0.383	-13.969	12.003
Experience in Rice production (years)	0.041*	0.014	0.441*	0.251
Participation in UDP project	0.761***	0.202	-1.450	4.473
Average plot size(hectares)	-0.329**	0.127	4.900	3.265
Membership of Cooperative	0.304	0.201	-14.903**	5.789
Reason for rice production	0.997**	0.501	25.966**	12.159
Total quantity of labour (Man-days)	0.005	0.009	-0.399***	0.291
Total cost of labour (naira)	-0.000	0.000	-0.000***	0.000
Constant	-2.104***	0.649	67.222***	18.460
Sigma	23.993***	1.522		

LR $\chi^2(12) = 72.87$
Prob > $\chi^2 = 0.0000$
Log likelihood = -1050.9957
Number of observations = 300

***Significant at 1% (p<0.01), ** Significant at 5% (p<0.05),* Significant at 10% (p<0.10).

Source: Field Survey, 2018

Marital status has a significantly negative effect onthe probability of UDP technology adoption in the study area at 5% ($p<0.05$) level of significance;this result implied that farmers who are married are more likely to adopt UDP technologyrelative to farmers who are single. This is similar to the findings of Liverpool-Tasie (2015) who reported that marital status has an insignificantly negative effect on rice farmers' propensity for adopting UDP technology in Niger state.Thisresult contradicts Marteyet *et al.,* (2014) who reported that marital status is statistically insignificant in influencing the farmers' decision to adopt fertilizer technology. Deep placement requires extra labour and patience in pushing granules into the soil, it can be seen that those with more family labour might adopt better coupled with small plots.

The coefficient of education was positive and significant at 10% ($p<0.10$).This result indicates that more educated farmers are in a better position to understand and appreciate the advantages of adopting UDP technologyamong the rice farmers in the study area. This is becausegenerally, farmers with better education are expected to be better informed about the existence and general performance of different technologies, will make more accurate assessment of differences in farm-level performance and will make more efficient adoption decisions.This agrees with Ajibola and Fatoki (2017) who found that education had a positive and significant influence on the probability of adoption of UDP recommended practices by rice farmers.This finding is also consistent withPaltasingh(2018)who reported apositive and significant effect of education on the adoption of modern rice technologies. Likewise, Abdulai*et al*. (2011)reported that education levels positively determine the adoption of safer irrigation technologies.

Furthermore, the estimated coefficient of extension contact has a positive and significant influence on the adoption ofUDP technology and was significant at 5% ($p<0.05$). This suggests that the adoption of UDP technology increasesas the number of extension visits by extension officers'increase.Extension visits facilitate the necessary information and ultimately leads to the enlargement of the scope of technology adoption, this is because farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. This result is supported by the findings ofAjibola and Onwu (2017) as they discovered that a positive and significant relationship between adoption ofUDP technologies and the number of visits of extension staff. However, Azumah*et al.,*(2017) found that extension contact negatively and significantly affects the probability of rice farmers to adopt UDPtechnology.

The coefficient of experience in rice production was positively related to the adoption of UDP technology and statisticallysignificant at 10% (p<0.10). This implies that more rice farming experience will help the rice farmers in making the decision to adopt the UDP technology. This is because farming experience improves farmers' skills at production, which implies that more experienced farmers may have a low level of uncertainty about improved agricultural innovations, performance and also be able to evaluate the advantages of new agricultural technology. A similar finding was reported by Abubakar *et al.,* (2016), Adedoyin*et al.,* (2016) andChandio and Jiang (2018) who reported that more farming experience significantly helps the farmers in making the decision to adopt agricultural technology.

The estimated coefficient of participation in UDP projecthad a positive and significant influence on adoption ofUDP technology in the study area and was significant at 1% (p<0.01), signifying that the likelihood of adoption of UDP technology tends to increase with participation in the programme.This implies that participation in the programme had some success in improving awareness of rice farmers to adopt UDP technology.This is consistent with the report ofAzumah, *et al.,* *(*2017) that farmers who attend training on the UDP technology by trained staff of international fertilizer development centre(IFDC), through farmer-led demonstrations and learning centreshad a greater probability of adopting the UDP technology than their untrained counterparts.

Additionally,the estimated coefficient of average plot sizewas negatively related to the adoption UDP technology and statisticallysignificant at 5% ($p<0.05$).This result implies that an increase in the average plot size of the rice farmers would lead to decrease inthe likelihood of adoption of UDP technology, significantly. In other words, an increase in average plot size will not result in an increase in the adoption of UDP technology. This may be because of the additional labour requirement and the laborious task of line transplanting and USG application.This finding is consistent with Ajibola and Onwu (2017) that reported an increase in farm size will not result in an increase in the adoptionof UDP technologies.Marteye*et al*., (2014) who reported that mineral fertilizer adoption and use intensity among smallholder farmers was negatively related to the area under cultivation.

Reason for rice production was positively and significantly related to the decision to adopt UDP technology in the study area at 5% ($p<0.05$) level of probability.The"reason for rice production"variablerepresents the optimizing behaviourof the rice farmers. Some farmers treat rice farming as a business venture while others consider it mostly as a means to meet their subsistent requirements.Farmers who produce rice for sale have profit-oriented behaviour; profit-oriented farmers are more attracted to the use of technologies that will increase their utility. Therefore, it can be inferred from this result that profit-oriented behaviour of rice farmers in the study areafavours the adoption of theUDPtechnology.This is similar to the findings of Marianoe*t al.,* (2012) who reported that farmers who treat rice farming as a business enterprise viewedintegrated crop management practices (ICMPs) in rice farming as a profit-maximizing strategy and adopt more of them.

4.3.2 Factors determining the use intensity of Urea Deep Placement (UDP) technology in the study area.

The second hurdle of the Double hurdle model (DHM)in Table 6shows the maximum likelihood estimates of the truncated regression model for the use intensity of UDP technology in the study area. The significant variables thatdetermined theuse intensity of UDP technology by the rice farmers in the study area weregender, experience in rice production, membership of cooperative, quantity of seed used, reason for rice production, total quantity of labour and cost of labour.

The estimated coefficient of gender was negative and significantly related to the intensity of adoption ofUDP technology in the study area at10% ($p<0.10$) probability level. This result indicated that male rice farmers in the study area are more likely to intensify UDP use relative to their female counterparts. This is similar to the finding of Saiful Islam *et al.,* (2015) that reported a negative and insignificant effect coefficient of gender in determining the intensity of adoption. Similarly, Boncinelli*et al.,* (2018) that investigated how structural factors affect both the decision of diversification into on-farm non-agricultural activities and the total labour assigned to them, they discovered a negative and insignificant effect of gender on the probability to allocate more labour i.e. intensify farmdiversification.

The intensity of UDP technology adoption was positively influenced by farmers experience in rice production.The estimated coefficient of experience in rice production was statisticallysignificant at 10% ($p<0.10$) probability level. The result indicated that the likelihood to intensify the use of UDPtechnology by the rice farmers in the study area increases with experience. This is logical as it means that rice farmerswith more experience in rice production are in a better position tounderstand and appreciate the advantages of adopting UDP technology, *ceteris paribus*.Another reason for this could be the active participation of experienced farmers during field days'demonstration of new technologies to increase adoption.This result is similar to the finding of Mariano*et al.,* (2014) who reported a positive and insignificant influence of farming experienceon fertilizer use intensity.

The estimated coefficient of membership of cooperative had a negative and significant influence on the intensity of UDP technologyadoptionand was significant at 10% ($p<0.10$) probability level, indicating that the likelihood to increase use of UDP technology among rice farmers who are not members of any farmer cooperatives was more compared totheircounterparts who have cooperative membership. This result contradicts findings by authors such as Martey*et al.,* (2014),Rahman and Barmon (2015) who reported that cooperative membership have a positive and significant influence on the intensity of UDP technology adoption.This may be attributed to the fact that farmers normally have wide-ranging intentions for joining farmer cooperatives, rather than continuously align themselves to these farmer cooperatives they tend to abandon them after a while and revert back to their old practices of independent non-members or the association may be too weak to exert influence on members.

The estimated coefficient of the reason for rice production was positively and significantly related to the decision to intensify UDP technology adoption in the study area and was significant at 5% ($p<0.05$) level of probability. This variable explains the optimizing behaviour of ricefarmers in the study area.Therefore, it can be inferred from this result that profit-orientation behavior of rice farmers i.e. farmers who treat rice farming as a business venture are more influenced to intensify the adoption of theUDPtechnology in the study area compared to their counterparts who consider rice farming mostly as a means to meet their own food consumption. This is similar to the findings of Mariano*et al.,* (2012) who reported profit-oriented behaviour of farmers favoursthe adoption of technologies.

The use intensity of UDP technologywas negatively influenced by the total quantity of labour. The estimated coefficient of the total quantity of labour was statisticallysignificant at 1% (p<0.01) probability level. This result indicates that the likelihood to intensify the use of UDP-technology by the rice farmers in the study area decreases with an increase in the quantity of labour use. This is because of the additional labour requirement of UDPtechnologywhich includes the laborious task of line transplanting and USG application which are mostly done manually by the farmers in the study area. This result is supported by the findings of Ajibola and Fatoki (2017) who reported that the labour intensive nature of the UDPtechnology from activities such as Line transplanting, USG application (40x40) cm per 4 rice stands and Wet bed rice nursery establishment are some of the major constraints to adoption of UDP recommended practices.

Finally,the estimated coefficient of labour cost had a negative and significant influence on the intensity of adoption of UDP technology and was significant at 1% (p<0.01) probability level, indicating that the likelihood to intensifyUDP technology usetends to decrease with a rise in labour cost. This also indicates the additional labour requirement for UDP technology use as farmers are expected to engage in additional practices (such as wet bed rice nursery establishment, line transplanting and seedling rate (20x20) cm at 1 rice seedling per hill, flooding of fields, USG application (40x40) cm per 4 rice stands). This agrees with Rahman and Barmon (2015), who reported that the utilization of UDP technology is labour intensive.

4.4 THE COSTS AND RETURNS ASSOCIATED WITH RICE PRODUCTION AMONG UDP TECHNOLOGY ADOPTERS AND NON-ADOPTERS IN THE STUDY AREA

The farm budget analysis was used to determine the profitability of the enterprise. The cost and returns analysis of paddy rice production per hectare among UDP technology adopters and non-adopters in the study area is contained in Table 7.

The Net Farm Income Model basically determines the difference between the Gross returns from rice production (Total Revenue) and the total costs of riceproduction. The Total Revenue refers to the gross income accruing to the enterprise as a result of the sales of rice paddy after harvest. This was obtained by multiplying the unit price of a 75 Kg bag of rice paddy by the quantity sold. The Variable costs are those costs that vary with the level of production. In rice production, the relevant variable costs items are Cost of seed,Cost of fertilizer, Agro-chemicals (pre and post emergence), Bagsand labour costs. The Fixed Costs items are rent on land and depreciation on farm tools/equipment. However, for the purpose of arriving at a fixed cost of the rice production enterprise for a given year, the straight-linedepreciation method was used, taken into considera-tion, the expected life span of the different fixed cost items. Using the straight-linemethod, the annual depreciation expenses were calculated on the fixed cost and used to arrive at the net farm income. The various costs incurred on the resources used and the returns from the sale of rice paddy were estimated based on the market price at the period under consideration.

Table 7: Costs and Returns Analysisof rice production (per hectare) in the study area

Items	UDP Adopter				UDP Non-adopter			
	Qty/Ha	Units Price/ Cost (₦)	Value (₦)	% of Total cost	Qty/Ha	Units Price/ Cost (₦)	Value (₦)	% of Total cost
Variable Costs (Inputs):								
Cost of seed (kg)	45kg	360	16,200	8%	50kg	360	18,000	9%
Cost of fertilizer (50kg bag)	6 bags	8,000	48,000	24%	8 bags	8,000	64,000	31%
Agro-chemicals (pre and post emergence)	15 litres	1,300	19,500	10%	15litres	1,300	19,500	9%
Bags for bagging	55 bags	100	5,500	3%	47 bags	100	4,700	2%
Labour Cost:								
Land Preparations (Ploughing, Harrowing and Bunding) (Man-days)	13	1,500	19,500	10%	13	1,500	19,500	9%
Nursery (Man-days)	3	900	2,700	1%	3	900	2,700	1%
Planting/Transplanting (Man-days)	10	1,000	10,000	5%	7	1,000	7,000	3%
Fertilizer application (Man-days)	9	700	6,300	3%	4	700	2,800	1%
Agro-chemicals (pre and post emergence) ap-plication (Man-days)	2	1,000	2,000	1%	2	1,000	2,000	1%
Weeding (Man-days)	15	1,500	22,500	11%	15	1,500	22,500	11%
Harvesting, threshing, winnowing and trans-portation (Man-days)	12	1,700	20,400	10%	12	1,700	20,400	10%
Total Variable Cost (TVC)			**172,600**				**183,100**	
Fixed Cost:								
Rent on Land			15,000	8%			15,000	7%
Depreciation on farm tools/equipment			12,550	6%			12,550	6%
Total Fixed Cost (TFC)			**27,550**				**27,550**	
Total Cost (TC) = TVC+TFC			**200,150**				**210,650**	
Revenue:								
Gross Income (GI):	47bags	9,000	**423,000**		42	9,000	**378,000**	
Gross Margin (GM) = GI-TVC			**250,400**				**194,900**	
Net Farm Income (NFI) = GI-TC			**222,850**				**167,350**	
Gross Ratio (GR)			**0.47**				**0.56**	
Operating Ratio (OR)			**0.41**				**0.48**	
Return on Naira invested (ROI)			**1.50**				**1.10**	

Source: Field Survey, 2018.

Analysis of the costs and returns in Table 7revealed that the Total Variable Cost (TVC), Total Fixed Cost (TFC) and Total Cost (TC) per hectare for UDP technology adopters were ₦172,600.00, ₦27,550.00and₦200,150.00 respectively.The Gross Income (GI)was ₦423,000.00with a Gross Margin (GM) of ₦250,400.00 per hectare. On the other hand, the Total Variable Cost (TVC), Total Fixed Cost (TFC) and Total Cost (TC) per hectare for non-adopters of UDP technology were ₦183,100.00, ₦27,550.00and ₦210,650.00 respectively with Gross Income (GI)of ₦378,000.00and Gross Margin (GM)of ₦194,900.00 per hectare.

Among Variable Costs, the cost of chemical fertilizeraccounted for24% of the Total cost of production for the UDP technology adopters and 31% for non-adopters, implying that UDP technology adopters apply less quantity of chemical fertilizer for rice production compared to the non-adopters, yet get more yield. This is because under UDP technology, Urea is applied once compared to the conventional broadcasting method where urea is applied two or three times during rice production. This result agreed with the findings ofHoque*et al.,*(2013) and Adodo, (2010)who found that UDP technology increases rice yield as well as the reduction of production cost. This is because under UDP technology Urea is applied once in a production cycle unlike the two or three urea applications using broadcasting method. Thecost of labouraccounted for 41% of the Total Cost of rice production for the UDP technology adopters and 36% for non-adopters, meaning that the adoption of UDP technology adds to labour cost because of its additional labour requirements. This finding is consistent with IFDC (2009, 2013b) reports that the adoption of UDP technology also increases labour use while it increases yield per hectare.

The total revenue, Gross Margin (GM) and Net Farm Income (NFI) obtained were ₦423,000**,** ₦250,400 and ₦222,850per hectare for UDP technology adopters while the non-adopters realized₦378,000, ₦194,900and ₦167,350per hectarerespectively.The Return on Investment (ROI) were 1.50 and 1.10 for UDP technology adopters and non-adopters respectively, implying that for every ₦1 invested in rice production in the study area per hectare, the invested ₦1 was re-turned, and a profit of N50kobos and 10kobos respectively, were gained.These shows that rice production using UDP technology is more profitable. This result agreed with the findings of Miah*et al.,* (2016) and Islam *et al.,*(2018) that UDP technology increased farm profitability.

Furthermore, the Gross Ratio (GR) andOperating Ratio (OR)were 0.47 and 0.41per hectare for UDP technology adopters while the non-adopters had Gross Ratio (GR) andOperating Ratio (OR)of 0.56 and 0.48 respectively.This implied that rice production is a profitable business in the study area.

4.5 EFFECT OF THE ADOPTION OF UREA DEEP PLACEMENT (UDP) TECHNOLOGY ON RICE INCOME AND FARM LABOR USE OF RICE FARMERS IN THE STUDY AREA.

The PSM technique was used to determine whether or not the adoption of UDP technologyhad a treatment effect on the two target outcome variables, rice income and Farm Labour use for rice production by the rice farmers in the study area. In estimating the effect of adoption of UDP technology on the rice income and Farm Labour use for rice productionby the rice farmers in the study area using PSM, One of the most commonly used matching algorithms in the literature is Radius Matching (RM). It was used and the results are presented in Table 8.

Table 8: Average treatment effects using propensity score matching

	Radius Matching (RM)		
Outcome variables	**Adopters (Treated)**	**Non-adopters (Untreated)**	**Average Treatment Effect for the Treated(ATT)**
Rice income (Naira per Hectare)	275415.054	231453.398	43961.66(1.81)*
Farm Labour use for rice production (Man-days per Hectare)	60.9139785	52.6666667	8.3(2.47)**

Note:*t*-statistic is in parenthesis and **and*denote significance at 5% and 10%
Source: Field Survey, 2018.

The results show that there is a positive and significant treatment effect of UDP technology adoption on the rice income and Farm Labour use for rice production by the rice farmers in the study area.The results show that the adoption of UDPtechnologyled to adopters having43, 961.66 (Naira per Hectare)more rice income than non-adopters. Similarly, the results indicate that the adoption of UDP technology increases the Farm Labour use for rice production by 8.3 (Man-days per Hectare). This finding is similar to IFDC (2009, 2013b) findings that the adoption of UDP technology also increases employment by 9.5 person-days/ha. The additional labour requirement for UDP used by the adopter farmers are expected to engage in additional practices (such as wet bed rice nursery establishment, line transplanting and seedling rate (20x20) cm at 1 rice seedling per hill, flooding of fields, USG application (40x40) cm per 4 rice stands)

Figures 3 and 4, Table 9 and Table 10 shows the propensity scores of the number of observations that were On-support and Off-support for both adopters (Treated) and non-adopters (Untreated)for the two target outcome variables, rice income and Farm Labour use for rice production by the rice farmers in the study area. Treated On-support indicates the individual rice farmers in the adoption group who find a suitable match with individual rice farmers in the non-adoption group, whereas Treated Off-support indicates the individual rice farmers in the adoption group who did not find a suitable matchwith individual rice farmers in the non-adoption group. However, Untreated indicates non-adopters.

The results fromFigures 3 and 4, Table 9 and Table 10shows that the common support condition was met as most of the Treated and Untreated observations were On-support in other words, there is substantial overlap in the distribution of the propensity scores of both the both adopters (Treated) and non-adopters (Untreated) of the UDPtechnology.

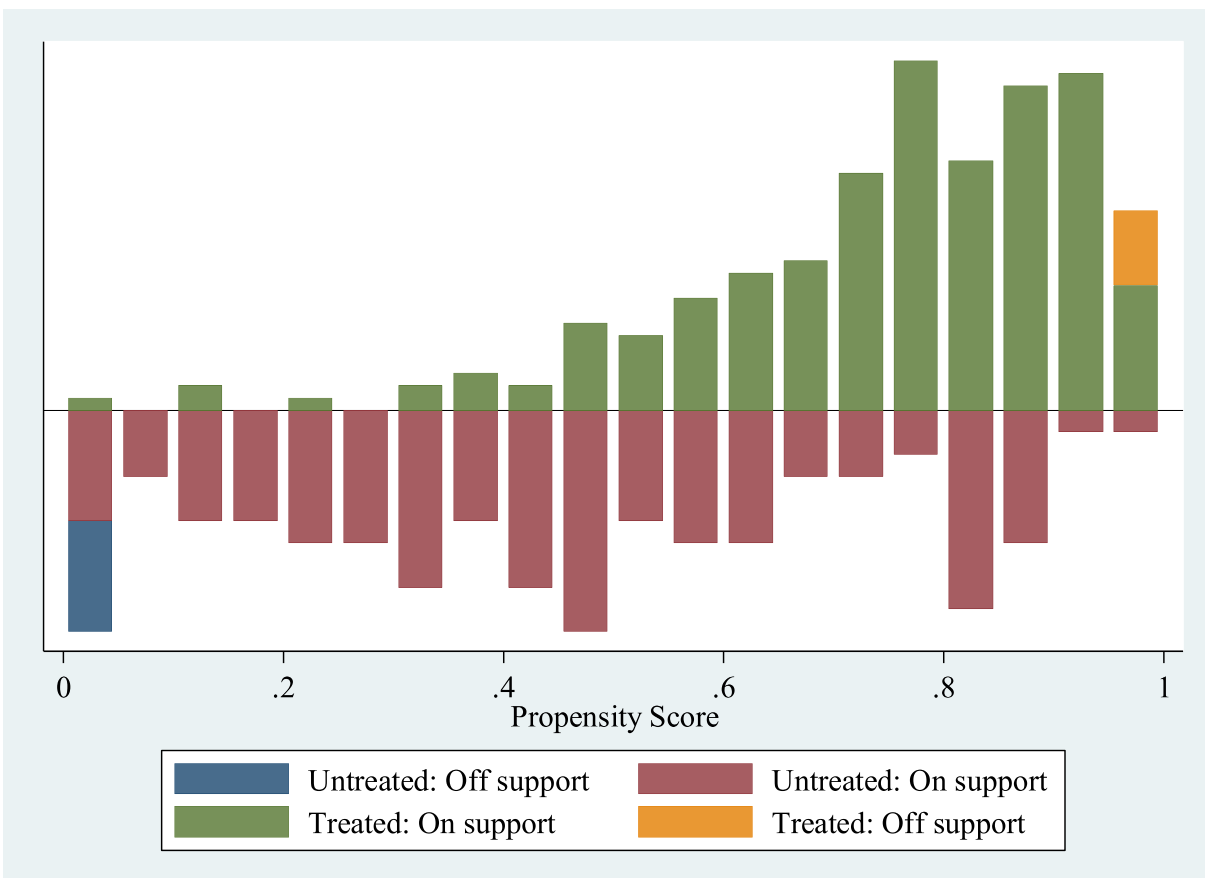

Figure 4.1: Balancing graph for Adopters (Treated) versus Non-adopters (Untreated) by Rice Income

Table 9: Propensity scores of the number of observations that were on support and off support for both adopters (Treated) and non-adopters (Untreated)by rice income

	Common support		
Treatment assignment	**Off-support**	**On-support**	**Total**
Untreated	6	102	108
Treated	6	186	192
Total	12	288	300

Source: Field Survey, 2018.

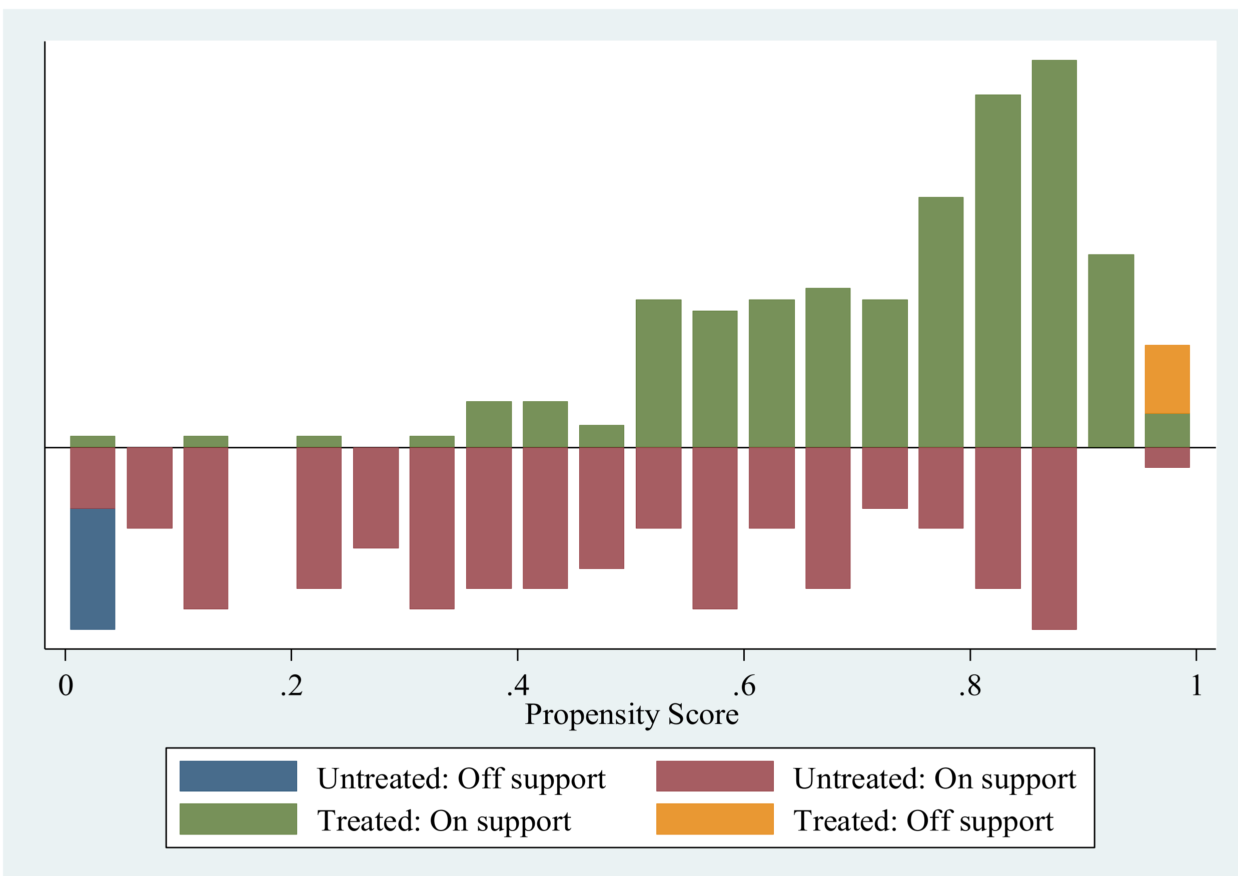

Figure 4.2: Balancing graph for Adopters (Treated) versus Non-adopters (untreated) by Labour Use

Table 10: Propensity scores of the number of observations that were on support and off support for both adopters (Treated) and non-adopters (Untreated)by labour use

	Common support		
Treatment assignment	**Off-support**	**On-support**	**Total**
Untreated	5	103	108
Treated	6	186	192
Total	11	289	300

Source: Field Survey, 2018.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY OF KEY FINDINGS

The study analyzedthe Socio-economic Effect of Urea Deep Placement (UDP) Technology on Rice Production in Selected Local Government Areas of Kano State, Nigeria.Multi-stage sampling techniques were used in the selection of 300 respondents among rice farmers for the study-comprising of one hundred and eighty-nine (189)UDP project participants and one hundred and eleven (111) non-participants, interviewed.

Descriptive Statistics, Binary logit regression model, the Double hurdle model (DHM), Farm Budgeting Technique and the Propensity score matching (PSM)methods were used to study the Socio-economic and Institutional factors that influenced rice farmers' decision to participate in the UDP project, the determinants of the adoption and use intensity of UDP technology, costs and returns analysis of rice production in the study area andthe effect of the adoption of UDP technology on rice income and farm labor use of rice farmers in the study area respectively.

The results of Binary Logit regression analysis shows that participation in the programme in the study area was primarily influenced by age of the farmer which wasstatisticallysignificant at 10% ($p<0.10$), primary occupationstatisticallysignificant at 10% ($p<0.10$), Household sizestatisticallysignificant at 10% ($p<0.10$), extension contactstatisticallysignificant at 1% ($p<0.01$) probability level and membership of cooperativestatisticallysignificant at 1% ($p<0.01$) probability level.

The variables that significantly determine the adoption of UDP technology by rice farmers in the study area from the first hurdle of the DHM were; genderstatisticallysignificant at 10% ($p<0.10$), marital status at 5% ($p<0.05$) level of significance, education statisticallysignificant at 10% ($p<0.10$), extension contact at 5% ($p<0.05$) level of significance, experience in rice farming statisticallysignificant at 10% ($p<0.10$), participation in USAID/MARKETS II programme statisticallysignificant at 1% ($p<0.01$) probability level, average plot size at 5% ($p<0.05$) level of significanceand the reason for rice production at 5% ($p<0.05$) level of significance.

The factors that determine the use intensity of UDP technology by rice farmers in the study area from the second hurdle of the DHM were; gender statisticallysignificant at 10% ($p<0.10$), experience in rice production statisticallysignificant at 10% ($p<0.10$), membership of cooperative at 5% ($p<0.05$) level of significance, reason for rice production at 5% ($p<0.05$) level of significance, total quantity of labour used statisticallysignificant at 1% ($p<0.01$) probability level and total cost of labour used statisticallysignificant at 1% ($p<0.01$) probability level.

The results of the costs and returns analysis of rice production in the study area shows thatthe cost of chemical fertilizeraccounted for24% of the total cost of production for the UDP technology adopters and 31% for non-adopters while the cost of labouraccounted for 41% of the total cost of rice production for the UDP technology adopters and 36% for non-adopters. Other profitability ratios such as the Gross Ratio (GR) andOperating Ratio (OR) were 0.47 and 0.41per hectare for UDP technology adopters while the non-adopters had Gross Ratio (GR) andOperating Ratio (OR)of 0.56 and 0.48 respectively.The Return on Investment (ROI) were 1.50 and 1.10 for UDP technology adopters and non-adopters respectively, implying that for every ₦1 invested in rice production in the study area per hectare, the invested ₦1 was returned, and a profit of N50kobos and 10kobos respectively, were gained.

The results of the PSM indicate that the adoption of UDP technology led to adopters having ₦43,961.66 (₦/Ha)more income than non-adopters. Similarly, the results indicate that the adoption of UDP technology increases the Farm Labour use for rice production by 8.3 (Man-days per Hectare).

5.2 CONCLUSION

Based on the findings of this study, it is concluded that small scale rice farmers' participation in UDP project in Kano state was found to be positively correlated with their; age, primary occupation, household size, extension contact and membership of cooperative.The use of the DHM was justified as different socio-economic factors were found to determine the adoption and use intensity of UDP technology by rice farmers in the study area. Precisely, gender, marital status, education, extension contact, experience in rice farming, participation in USAID/MARKETS II led UDP programme, average plot size and reason for rice production significantly explains the adoption of UDP technology while gender, experience in rice production, membership of cooperative, reason for rice production, total quantity of labour used and total cost of labour significantly determine the use intensity of UDP technology by rice farmers in the study area.

Theadoption of UDP technology had positive and significant effect in improving the wellbeing of the small scale rice farmers in the study area.The Return on Investment (ROI) were 1.50 and 1.10 for UDP technology adopters and non-adopters respectively, implying that for every ₦1 invested in rice production in the study area per hectare, the invested ₦1 was returned, and a profit of N50kobos and 10kobos respectively, were gained. Thus, the adoption of UDP technology makes rice production more profitable. The impact estimation from the propensity score matching suggests thatthe adoption of UDP technology led to adopters having ₦43,961.66 (₦/Ha)more income than their counterparts who do not adopt. Likewise, the impact estimation from the propensity score matching suggests thatthe adoption of UDP technology led adopters to increase their farm labour use for rice production by 8.3 (Man-days per Hectare) compared to the non-adopter rice farmers.

5.3 RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

1. To sustain the gains of awareness about UDP technology among small scale farmers, government at all levels and stakeholders in agricultural development should continue to include UDP technology package in ongoing and future agricultural programmes like the Anchor Borrowers Programme and the Agricultural Promotion Policy while researchers should evaluate and share knowledge on the benefits that can be derived from the use of the technology given its potential of increasing income and alleviating unemployment.
2. To further help to disseminate the use of this UDP technology, Non-governmental agencies and donor agency projects, implementing rice value chain interventions in Nigeria such as Competitive Africa Rice Initiative (CARI), Africa Rice, IFDC and International Fund for Agriculture Development (IFAD) Value Chain Development Project should add UDP tech-

nology package of practices to farmers training modules for stepping up knowledge and capacity of extension agents and farmers.

3. The findings from this study showed that contemporary agricultural cooperatives can facilitate farmers' participation in intervention programmes and adoption of technologies. Thus, the government should step up its efforts to encourage smallholder farmers to join agricultural cooperatives.
4. Given that gender appeared to have a significant influence on farmers' decisions to adopt UDP technology, which implies that women rice farmers were less disposed to the use of UDP technology. Policymakers and researchers should thus explore opportunities for gender sensitization for more adoption during project implementation.
5. Higher labour requirement is a major constraint to the use intensity of UDP technology. Therefore, the use of manuallyoperated USG fertilizer applicator should be encouraged and dissemination alongside the UDP technology to increase its adoptionin Nigeria by Non-governmental agencies and donor projects implementing rice value chain interventions in Nigeria such as Competitive Africa Rice Initiative (CARI), Africa Rice, IFDC, etc.
6. Access to credit that can facilitate access to more land and UDP technology to be explored and more financing agencies be encouraged to be involved in financing rice production.

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APPENDIX

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION
BAYERO UNIVERSITY, KANO

Dear respondent,
I am a postgraduate student of the above named Department. I am currently conducting a research on **"SOCIO-ECONOMIC ANALYSIS OF THE EFFECT OF UREA DEEP PLACEMENT (UDP) TECHNOLOGY ON RICE PRODUCTION IN SELECTED LOCAL GOVERNMENT AREAS OF KANO STATE, NIGERIA".** I wish to elicit some information from you which is strictly for the research purpose and shall be treated with utmost confidentiality.

Please note that participation in this study is voluntary, and at any point you feel uncomfortable answering any question kindly inform us. For further clarification, do not hesitate to contact me at the address above or using the phone number below.

Thank you for your anticipated cooperation.

Yours faithfully,

Muhammad Hussaini
SPS/15/MEX/00032
(07033969793)

RESPONDENT IDENTIFICATION
1. Questionnaire Number ______
2. Enumerator Code/Number ______
3. Date of Interview [/ /] (DD/MM/YY)
4. Local Government area ______
5. Name of village/town ______
6. Name of respondent ______
7. Mobile number of respondent ______

HOUSEHOLD ROSTER
1. What is Sex of respondent? Male 1 Female 0
2. How old are you? _________ (Years)

3. What is the marital status of respondent? Married 1 Single 0
4. Years in formal education _________ (Years)
5. Can you read and write in any language? Yes 1 No 0
6. What is the primary occupation of the Respondent? Farm 1 Off-Farm 2 Non-farm 3
7. What is the secondary occupation of the Respondent? Farm 1 Off-Farm 2 Non-farm 3
8. What is your household size? _________
9. How many are adult male? _________
10. How many are adult female? _________
11. How many are children (below 5 years)? _________

PRODUCTION CHARACTERISITCS

1. What is your Year of Farming Experience? ____________ (Years)
2. Since when have you been cultivating Rice? ____________ (Years)
3. Do you cultivate other crops 1. Yes 2. No
4. When did you start rice production on your own?
5. Reason for cropping Rice? (1) Food (2) Cash (3) Subsidy (4) Other (specify)
6. Do you treat your seeds before planting? Yes 1 No 0
7. Do you have contact with Extension Agent? Yes ( ) No ( )
8. If yes, how often do you have such contact? Daily () Weekly () Fortnightly () Monthly () Quarterly () Yearly ()
9. Intercropping of rice with other crops? Yes 1 No 0
10. Did you participate in USAID-MARKETS II programs? (1=Yes; 0=No)
11. How long did you participate in MARKETS II? ____________ (years)
12. Which of the following rice production technologies/ techniques/ trainings of MARKETS II listed below did you acquired/adopted on rice production?

    Improved rice varieties [ ]
    Seed cleaning [ ]
    Nursery [ ]
    Line transplanting [ ]
    Fertilizer application and timing [ ]
    UDP Technique [ ]
    USG applicator [ ]
    Bird scaring nets [ ]
    Pest identification [ ]
    Water pump/drip irrigation [ ]
    Herbicide application [ ]
    Mini harvesting machine [ ]
    Threshing/winnowing [ ]
    Standard Bagging [ ]
    Storage [ ]
    Marketing/Crop Sales [ ]
    Homestead enterprise training for women [ ]

13. How many times did you or any member of your household attend MARKETS II trainings in the last 12 months? __________
14. Did you or any member of your household pay anything in order to receive any type of advice/information from MARKETS II since the New Year? (1=Yes; 0=No)

15. IF YES, How much in total did your household pay to receive advice/information from MARKETS II since the New Year?
16. Do you think that the extension service provided by MARKETS II is useful? (1=Yes; 0=No)
17. IF YES, on average, how useful was the advice/information received from MARKETS II? Very Useful 1 Somewhat Useful 2 Not Very Useful 3 Not Useful 4
18. How would you describe the quality of the relationship between you and MARKETS II officials? (1)Very good (2) Good; (3) Neutral (4) Bad (5) Very bad
19. How many improved rice varieties listed below were you introduced to you by MARKETS II officials?

FARO 44 (SIPI 692033) [ ]
FARO 52 (WITA 4) [ ]
FARO 57 (TOX 404) [ ]

20. Do you still cultivate local varieties? (1=Yes; 0=No)
21. For how long have you adopted the UDP Technique? [ ] years
22. What did you use for UDP Technique? Hand [ ] Applicator [ ]
23. What proportion of your rice farm did you employ UDP Technique?________ %

HOUSEHOLD ASSET OWNERSHIP

Farm/Transport Assets

1. How many of the following items do you own?

1. Tractor_____ 2. Plough _____ 3. Trailer/Cart _____
4. Ridger _____ 5. Planter _____ 6. Harvester _____
7. Water pumps _____ 8. Sprinkler _____ 9. Sprayer _____
10. Wheelbarrow _____ 11. Cutlass _____ 12. Hoe _____ 13 Vehicle _____
14. Motorcycle_____ 15. Bicycle_____ 16 Others (*grain mill, borehole, private well*) _____

2. If you wanted to sell one of this [ITEM] today, how much would you receive for:

1. Tractor_____ 2. Plough _____ 3. Trailer/Cart _____
4. Ridger _____ 5. Planter _____ 6. Harvester _____
7. Water pumps _____ 8. Sprinkler _____ 9. Sprayer _____
10. Wheelbarrow _____ 11. Cutlass _____ 12. Hoe _____ 13 Vehicle _____
14. Motorcycle_____ 15. Bicycle_____ 16 Others (*grain mill, borehole, private well*) _____

Livestock Assets

1. Since the New Year, have you or any member of your household raised or owned any [ANIMAL]?
2. How many [ANIMALS] are owned by your household now (present at your farm or away)?

1. Camel_____ 2. Cattle_____ 3. Donkey_____ 4. Horse_____
5. Sheep_____ 6. Goat_____ 7.Chicken(*Poultry*)_____ 8. others _____

Communication Assets

2. Do you have access to the following: Radio, TV, mobile phone, personal computer (internet)?
3. How many do you own? Radio ---, TV---, mobile phone---, personal computer (internet) ---
4. During the last 12 months, did you use the ICTs to get information about: Agricultural activities 1 Goods and services 2 Government organizations 3 Health services 4 Entertainment 5 Internet Banking 6 Education/learning activities?

Land Assets/Inventory

1. Number of plots cultivated last season _________

2. Average size of plots _________ (Ha)
3. Total owned/cultivated farmland last season [_____] ha.
4. What is the total size of RICE [PLOT] cultivated last season? [_____] ha.
5. If the [PLOT] were to be sold today, how much could it be sold for? _________ (Naira)
6. What is the overall type of your soil? Clay 1 Loamy 2 Sandy 3 Others 4
7. How will you describe the fertility of main soil type at which rice was planted? 1 Good 2 Medium 3 Poor

SOCIAL CAPITAL

1. Do you belong to farmers' association or cooperative society? Yes 1 No 0
2. How long have you been in this association? ____________ (years)
3. What is your position in the Association?
   A. Any leader (leader, vice-leader)
   B. Very active (other responsibility than leader)
   C. Active (participate in all/most all meetings)
   D. Participate in some meetings
   E. Not active

SAFETY NETS

1. In the last 12 months, did you receive cash, food, or other aid from any [PROGRAMME]? Yes 1 No 0
2. What was the main source of the assistance? Government 1 NGO 0
3. What was the total value of assistance received from the [PROGRAMME] in the last 12 months? 1. Cash Assistance 2. Food Assistance 3. Other/In-Kind
4. How many members of the household received the assistance? _____

CREDIT AND SAVINGS/ FINANCIAL CAPABILITY

1. Do you have a bank account? Yes 1 No 0
2. Do you have any significant deposits in your bank account(s) (more than 50,000 Naira)? 0=No; 1=Yes
3. Have you used any informal groups to save/borrow money? Yes 1 No 0
4. How much was borrowed under [LOAN]? _________ (Naira)
5. Was the amount of [LOAN] sufficient to cover the purpose? Yes 1 No 0
6. Have you used an Institution such as a bank, or micro-finance institution to borrow/save money? Yes 1 No 0
7. What was the main reason for applying for [LOAN]? Purchase land (1) Purchase Agricultural Inputs for Food Crop (2) Purchase Inputs for Cash Crop (3) Business Start-Up capital (4) Non-Farm Business Cost (5) Ceremonies (Marriage, Burial, Other social Functions Etc.) (6) Education (7) Motor Vehicle Purchase (8) Home Purchase or Construction (9) other household Consumption (10)Other (Specify) (11)
8. What is the distance of the Microfinance bank from your household? ________ Km
9. How much is available for day-to-day spending? _________ (Naira)

INPUT COST

Insecticide

1. Did you use insecticide on [PLOT] last season? Yes 1 No 0
2. What was the application frequency (times| year)? _________
3. What was the quantity of insecticide used on [PLOT] last season? _________ (Liters)
4. What was the source of insecticide? Rural market 1 Urban market 2 ADP 3 NGO 4 Private Firm

5. How much was spent on the insecticide you used on your [PLOT] last season? _________ (Naira)

Herbicide

1. Did you use herbicide on [PLOT] last season? Yes 1 No 0
2. What was the application frequency (times| year)? _________
3. What was the quantity of herbicide used on [PLOT] last season? _________ (Liters)
4. What was the source of herbicide? Rural market 1 Urban market 2 ADP 3 NGO 4 Private Firm 5
5. How much was spent in cash on the herbicide you have used on [PLOT] last season? _________ (Naira)

Pesticide Use Behaviors

1. How did you decide the quantity of pesticide use? (1=following packing instructions; 2=suggested by technical persons; 3=following previous experiences; 4=others)
2. What do you care mostly when you purchase pesticide? (1=price; 2=effects; 3=pesticide residue level; 4=environment impact; 5=human and livestock impact; 6=other)
3. Do you use self-protection measure (such as mask) when you spray the chemical pesticides? (1=Never; 2=Sometimes; 3=Always)
4. Compared with pesticide use quantity suggested by technical persons or instruction books, how do you usually decide the amount of pesticide use? (1=higher than the recommended level; 2=the same as the recommended level; 3=Lower than the recommended level)
5. Are you willing to replace chemical pesticide with bio-pesticide in the future? (1=Yes; 0= No)
6. Do you consider the health effect associated with pesticides when you purchase pesticides? (1Yes; 0 No)

Fertilizer

Organic Fertilizer Use

1. Did you apply organic fertilizer last season? (1=Yes; 0=No)
2. If yes, quantity used _________ (unit)
3. What kind of manure do you use last season? 1 Farm yard 2 Compost 3 Green manure
4. Price per (unit) last season _________
5. Application frequency _________ last season (Times/season)
6. The total expenditures of all kinds of chemical fertilizers used last season (naira) _________

Chemical Fertilizer Use

1. Did you apply chemical fertilizer? (1=Yes; 0=No)
2. If you applied compound fertilizer **(NPK):**
Total bags used _________ Price (naira/bag) _________ Application frequency (times/season) _________
3. If you applied **(UREA):**
Total bags used _________ Price (naira/bag) _________ Application frequency (times/season) _________
4. The total expenditures of all kinds of chemical fertilizers used last season (naira) _________
5. What is the distance of the Agro-dealers' shop from your household? ________ Km

FARM LABOR

Family labor

Do you use family labor? (1=Yes; 0=No)

1. During the last production season, how many household members work on this plot for?

Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________

Nursery_________

Planting/Transplanting_________

1st Fertilization _________

2nd Fertilization _________

3rd Fertilization _________

Pre-emergency _________

Post-emergency _________

1st Weeding _________

2nd Weeding _________

Harvesting _________

Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) _________

2. Approximately how many days did they work during the last production season for?

Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________

Nursery_________

Planting/Transplanting_________

1st Fertilization _________

2nd Fertilization _________

3rd Fertilization _________

Pre-emergency _________

Post-emergency _________

1st Weeding _________

2nd Weeding _________

Harvesting _________

Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) _________

3. What was the average daily wage paid per day during the last production season for?

Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________

Nursery_________

Planting/Transplanting_________

1st Fertilization _________

2nd Fertilization _________

3rd Fertilization _________

Pre-emergency _________

Post-emergency _________

1st Weeding _________

2nd Weeding _________

Harvesting _________

Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) _________

Hired labor

Do you use Hired labor? (1=Yes; 0=No)

1. During the last production season, how many paid workers work on this plot for?

Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________
Nursery_________
Planting/Transplanting_________
1st Fertilization _________
2nd Fertilization _________
3rd Fertilization _________
Pre-emergency _________
Post-emergency _________
1st Weeding _________
2nd Weeding _________
Harvesting _________
Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) _________

2. Approximately how many days did they work during the last production season for?
Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________
Nursery_________
Planting/Transplanting_________
1st Fertilization _________
2nd Fertilization _________
3rd Fertilization _________
Pre-emergency _________
Post-emergency _________
1st Weeding _________
2nd Weeding _________
Harvesting _________
Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) _________

3. What was the average daily wage paid per day during the last production season for?
Land Preparation (Ploughing, Tilling, Harrowing,Basin Preparation, Construction bund) _________
Nursery_________
Planting/Transplanting_________
1st Fertilization _________
2nd Fertilization _________
3rd Fertilization _________
Pre-emergency _________
Post-emergency _________
1st Weeding _________
2nd Weeding _________
Harvesting _________
Postharvest (Transportation, Threshing, Winnowing, Bagging, Storage) ________

4. Which activity in rice production is the biggest problem for you referring to labour requirement? ________

MARKETING

1. How much rice did you harvest from your PLOTs during the last farming season _________ (100Kg bag)

2. On average, what quantity of rice did you keep for personal or home use (including "dashed" out) during the last harvest season? ________ (100Kg bag)

3. How much of the harvested rice was sold in total last season?___(100Kg bag)

4. How much was a bag of rice (100Kg bag) sold last season?_________ (Naira)

5. What was the total value of rice sold last season? ______(Naira)

6. How often do you care about rice price information? (1=Seldom; 2=Sometimes; 3=Always)

7. As a whole, how do you evaluate the average sales price of rice during the last production season? (1=Lower; 2=Acceptable; 3=Higher)

8. To whom do you usually sell the rice during the last production season? (1=Local traders; 2=Traders from other province; 3=Processors 4=Exporters)

9. What is the distance of the rural market from your House? ________ Km