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FACTORS INFLUENCING THE,ADOPTION OF FERTILIZER TECHNOLOGY IN OSUN STATE OF NIGERIA

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BY

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CERTIFICATION

This thesis, written by BAMIRE, Simeon Adebayo has been read, approved and adjudged to meet part of the requirements for the award of Ph.D. Degree in Agricultural Economics of the Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

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DEDICATION

This work is dedicated to God Almighty

Who manifests miraculously in all facets

of my life, including the completion of

this work

and

To my wife, Felicia and children:

Oluwatobi, Toluwalope, Temitope and Oluwatimilehin

For their patience, endurance, love and

support during the course of this work.

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ABSTRACT

Sustaining the productive capacity of the land resource base under the changing trend of land use systems and increasing population pressure is imperative for the attainment of Nigeria's food self-sufficiency objective. One major approach to this, is increasing the adoption of agricultural technologies that would enhance farmers' productivity and maintain the land resource potential.

This study examined those factors that affect farmers' adoption decisions and the extent of use of fertilizer technology in Osun State of Nigeria. Primary data were collected using structured questionnaire and focussed group discussions, while the State's Ministry of Agriculture and the Agricultural Development Project provided secondary information. Multi-stage sampling technique was employed in selecting three hundred respondents from two major ecological zones in the State. Data were analysed using descriptive statistics, correlation analysis, Tobit regression technique, and costs and returns analysis.

The socio-economic characteristics of respondents showed that small-scale farmers dominated agriculture with mean farm size of 0.58ha for users and 0.62ha for non-users of fertilizer. Average age of farm operators was 51 years. Pressure on land was found high because farmland was continuously cropped for an average of ten years with a mean fallow period of two years only. Inorganic fertilizer was the most common intensification technology in use. Results from correlation analysis showed that farm size and net farm income positively influenced farmers' adoption and use of fertilizer across the ecological zones.

Tobit regression estimates on all factor categories showed that availability of fertilizer, farm size and net farm income were highly significant in explaining fertilizer adoption decisions in each of the ecological zones and in the survey location. Estimates for each factor category showed that age and gender; farm size and net farm income; availability of fertilizer and land acquisition pattern showed statistically significant effects in the two ecologies. The decomposition of fertilizer adoption elasticities showed that availability of fertilizer and farm size had the greatest impact on the probability of fertilizer adoption and use in the savanna zone, while only the availability of fertilizer recorded a similar impact in the rain forest zone. Partial budget analysis revealed that average net income earned by maize growing respondents who used nitrogenous fertilizers in the rain forest zone was ₦21,507 per annum while non-users recorded ₦15,681. Variations also existed in the mean net income earned by respondents based on their property rights status. Similarly, respondents in the derived savanna zone recorded ₦21,553 and ₦13,865 respectively for the two categories of respondents. There was a significant ecoregional difference on the average net income per annum earned by users of fertilizer. A break-even price of ₦14/kg, or 58% of current market price of fertilizer and ₦18/kg or 75% respectively were estimated for the rain forest and savanna zones. FGDs revealed respondents' preference for use of inorganic fertilizer despite its scarcity and high price because, apart from enhancing their net gains, it also maintains the productivity and provides opportunity for continuous use of scarce land. However, farmers need be trained on the appropriate use of this technology for optimum results and in order to prevent its negative socio-economic and environmental consequences.

These results imply that socio-economic and institutional factors play a critical role in farmers' use of fertilizer technology. Fertilizer pricing policies therefore need be designed to optimize the interest of farmers, while efficient marketing and distribution arrangements are important in enhancing the efficiency of both fertilizer use and supply. A policy that addresses the changing trend of property rights as well as increases the quantity of fertilizer allocated to farmers will also be a more effective instrument for improving expenditure on the technology.

CHAPTER ONE

1.0 INTRODUCTION

The important position of agriculture in any economy cannot be overemphasized. This is due to its critical role in revenue and employment generation, as well as in the provision of raw materials for agro-industrial use. Thus, the main thrust of Nigeria's national agricultural policies is essentially the attainment of food self-sufficiency through enhanced agricultural productivity (Third and Fourth National Development Plans (1975-80, 1980-85) and 1996-97 National Rolling Plan).

According to Olayemi and Ikpi (1995), agricultural development in Nigeria depends on how well policies address problems relating to population pressure (or excessive rate of population growth), over exploitation of natural resources such as land, stagnating agricultural productivity, as well as environmental degradation of the land resource base. This is because agricultural production cannot take place without land and the diverse property rights associated with land ownership and use that have major bearing on the adoption of intensification technologies, economic growth and development (Fabiyi, 1984; Baum and Tolbert, 1985).

One of the principal issues involved in the use of land is property rights. Uchendu (1970), Adegboye (1973), Famoriyo (1979) and Fabiyi (1984) claimed that the land tenure system of any society is often an indication of the level of economic development which exists in that society. For instance, while land ownership is either collective or communal in most developing countries and rural areas, it is frequently based on individual holdings in developed countries and in most urban centres. Additionally, property rights that are non-exclusive, insecure or non-transferable will lead to under-investment in land improvement techniques and depressed mobility of variable factors of production (e.g. labour). This will in turn lead to inefficient agricultural production and over exploitation of natural resources (Swallow, 1994). In the last three decades, the land tenure systems have been confronted with problems of population explosion, rising inflation and unemployment leading to rising rural-urban drift of youths. The result is the need for modifications and deliberate changes in tenure systems with a view to effectively solving the complex and dynamic sets of problems affecting agricultural productivity. The objective of Land Use Policy in the form of Land Use Decree (Act) No. 6 of 1978 in Nigeria was to ensure rational allocation of land among competing uses with the interrelated aspect of productivity and equity of land use. Thus, to achieve self-sufficiency in food production as far as practicable, the pattern of agricultural production needs to be reorganized.

However, with the increasing rate of population growth and the consequent pressures from competing socio-economic demands for land overtime, the already limited cultivable land is being drawn from its traditional agricultural uses with a resultant reduction in man-land ratio such that the average size of farmland is now very small indeed. Tables 1 and 2 show the projected trend in man-land ratio (in hectares per farmer) for Nigeria and the study area respectively.

Traditionally, fallow systems and shifting cultivation practices were used to replenish most of the nutrients removed by crops. However, the length of fallow periods has been reduced in many places. This invariably leads to a depletion of soil fertility through continuous or intensive cropping along with short unfertilized fallow, as the time required for natural regeneration can no longer be entertained (Ruthernberg, 1980; Adesimi, 1988).

TABLE 1

Nigeria: population, area and land-man ratio

Year	Land area (Million hectares) (a)	Estimated population (Million) (b)	Land-man ratio(ha/farmer) (c)
1963*	98.321	55.670	1.766
1991	98.321	88.515	1.111
1992	98.321	90.728	1.084
1993	98.321	92.996	1.057
1994	98.321	95.321	1.031
1995	98.321	97.704	1.006
1996	98.321	100.147	0.982
1997	98.321	102.650	0.958
1998	98.321	105.216	0.934

Source: Projections from the National Population Commission.

CBN Statistical Bulletin. June 1993 (Provisional result)

* F.O.S. Annual Abstract of Statistics 1969, Lagos, Nigeria.

TABLE 2

Osun state*: population, area and land-man ratio

Year	Land area (Million hectares) (a)	Estimated population (Million) (b)	Land-man ratio(ha/farmer) (c)
1991	798,500	2,203,016	0.3625
1992	798,500	2,258,091	0.3536
1993	798,500	2,314,544	0.3450
1994	798,500	2,372,407	0.3366
1995	798,500	2,431,717	0.3284
1996	798,500	2,492,510	0.3204
1997	798,500	2,554,820	0.3125
1998	798,500	2,618,690	0.3049

Source: Projections from the National Population Commission.
CBN Statistical Bulletin. June 1993 (Provisional result)

(a) Land area is assumed constant overtime

(b) Projections from 1991 provisional census figures assume population growth rate at 2.5% per annum.

*Osun State was created in 1991.

1.1 Historical background of Property Rights in Nigeria

Property rights regime currently found in Nigeria have been formed and affected by a variety of historical and socio-political forces that are peculiar to specific regions of the country. Famoriyo (1973) and Fabiyi (1976) reported that the entire part of southern Nigeria (excluding Lagos) was included under the Native Land Acquisitions of 1900. Later, the Lands and Native Rights Ordinance of 1916 established the formal property right system of southern Nigeria, which was in operation until the Land Use Decree of 1978. Oluwasanmi (1966), observed that these early ordinances ensured that agricultural production remained in the hands of Nigerians. The Land Use Decree of 1978 was an attempt by the Federal Military Government to try to correct some of the problems with the existing property right regimes in the country, to provide the country with a uniform land tenure system and to ensure equitable and secure access to land for productive purposes. The Decree vests all land in the each state in the governor (except for land already vested in the Federal Government and its agencies) while acknowledging the role of customary land law. According to Cleaver and Schreiber (1990), this strategy nationalizes the ownership of land, relies on customary law to govern the use of some land while, allocating other lands to private investors and political elite groups.

In Nigeria, the institution of "family property" seems to be established only in the southeastern and southwestern parts of the country and the extended family is usually a corporate body, which may own land. It is a property-owning unit with the family property consisting of land and the structures as well as improvements on the land. Communal land, village, clan, community or tribal land are used interchangeably to mean the same thing, and the head of the community and the paramount chief control and manage everything pertaining to land in their community as if they are "trustees".

Prior to 1978, there were three main sources of Nigerian property law: customary law, English received law and local legislation. Customary law assumes a well-stratified hierarchy of authority and control over land. At the apex is the *Oba* or *Baale* followed by traditional chiefs and then family heads. According to traditional notions of land tenure, no land existed without an owner (Famoriyo, 1973). In western Nigeria, rights to land can be vested in a variety of groups, and as observed by Lloyd (1962), the overriding category is lineage membership. Individuals are entitled to portions of communal land as members of a family or clan (Nwosu, 1991). In most cases, much of the land acquired by a group of people was allotted on a family basis with a portion of land being given to the head of each family. Thus, families could ensure continuous use of the same piece of land overtime. However, neither the head nor a member of the family can alienate his or her own private property from family holdings, even though the sale of family land can be done by the head of the family with the consent of all principal members of the family. The customary tenure system was abused by traditional rulers who built financial empires for themselves out of previous owned communal land. Where customary property law is not applicable, the Common law of property may apply in Nigeria. This English received law; the Common Law of England, the Principles of Equity and the English Status of General Application were brought into Nigerian law on January 1, 1900. Hence, Nigerian laws of mortgages, leases, conveyancing and succession are largely based on English law. Under local legislation, Islamic Law during the Fulani conquest replaced all the existing systems of customary tenure. The 1962 land tenure law repealed the previous laws and created the nationally uniform category of "Native Lands". In the southern states, customary tenure governed land interests before the Land Use Decree in 1978. In view of the variation existing in the north and south, a policy statement was issued by government recommending that ownership of all land in country be vested collectively in all Nigerians, through the allocation of rights of occupancy at the local government and state levels for rural communal tenure and privately owned land. Land tenure systems can therefore be seen as a body of rules and practices that regulate peoples'rights and obligations in relation to land, including any conditions and time limits to the use of land resources. According to Nwosu (1991), customary land tenure systems are breaking down under the impact of cash cropping, population pressure and non-agricultural enterprises and these have enhanced the growing individualization of land tenure.

The use of land varies not only according to ecological or physical factors, which may limit what can be grown, but also according to the tenurial arrangements. Thus, land tenure varies according to rights to make particular use of land to the exclusion of others. Under customary tenure in the southern part of Nigeria, not everyone has the right to grow trees on the land even though the person may have been allocated that land for farming. This is because anyone with a short-term allocation, such as tenants or women, may not be given that piece of land for a long enough period for their trees to reach maturity or to stop producing. Tree tenure is therefore different from land tenure as all trees already growing on the land before another person gains the right to use it remains the property of the person who planted the trees. In addition, the inheritance rules accompanying customary tenure have resulted in fragmentation and dispersion of farm plots. In southwestern Nigeria, it is common for farmers to report that they have about six to eight plots scattered in many locations several kilometers away from each other. The total size of holdings may however, not exceed two or three hectares (Olayide et al., 1980).

In an attempt to improve land quality and integrate crop and livestock more effectively under the changing property right systems, various intensification technologies have been adopted and used by farm operators. These include alley farming, tree planting, organic manure and inorganic fertilizer.

1.2 The need for inorganic fertilizer technology use

Aduayi (1985), Lombin et al.,(1991), Plucknett (1993), Adebayo (1997) and Awe (1997), asserted that under a system of intensive cropping which has now become a characteristic feature of Nigeria's arable agriculture, nutrient availability from organic and natural sources alone becomes inadequate and soil fertility and productivity can only be maintained through efficient and increasing use of land improving and yield-increasing intensification technologies. This involves the use of farm machinery, improved seeds, agro-chemicals, modern agronomic practices (e.g. alley cropping and tree planting), organic and inorganic fertilizers.

The crucial role of inorganic fertilizers in Africa's agricultural production is well recognized (FAO, 1981; Lele et al., 1989). According to FAO (1981), Jibowo and Adepetu (1985), Lele et al., (1989), Matlon (1989), Ogunfowora (1993), Mitchell et al., (1993), FAO (1993) and Rosegrant (1995), fertilizer contributes to increased crop production in several ways. First, by replenishing nutrients, it helps maintain and enhance soil fertility and thereby sustains crop production. Second, fertilizer enables the adoption of high yielding varieties (HYVs), which can increase cereal yields several fold. Without plentiful supply of nutrients through fertilizer and other associated inputs, HYVs cannot produce higher yields. Third, in the nutrient-poor soils of the tropics, fertilizer use can increase both crop yields and biomass (living matter). Thus, today, agricultural growth cannot be separated from fertilizer use, as one of the most effective way of raising agricultural productivity is through the application of fertilizer, especially when combined with adequate water supply, improved seeds and farm management practices. Additionally, future trends in fertilizer use and supply will have important implications for overall socio-economic development and environmental protection at the global, regional and national levels (FAO, 1981; IITA, 1992; Owu, 1995; IFPRI, 1995).

Nwosu (1995) stated that there is increasing awareness among Nigerian farm operators that the use of inorganic fertilizer is important in sustaining soil fertility and increasing crop yields. This is reflected in the high and rising budgetary commitment to fertilizer procurement, distribution and research by government. Nwosu further claimed that among farm operators, the increasing awareness is reflected in terms of the tremendous increase in aggregate fertilizer supply (Table 3), rising from 13 thousand tonnes in 1960, to over 1 million tonnes in 1993, while farmers have also demonstrated their willingness to pay more than the official price for the procurement of fertilizers. However, the evolving population-food imbalances underscore the critical role of yield increasing and intensification technologies, of which inorganic fertilizers constitute a key component. For instance, Okorie (1984) and Ogunfowora (1993) asserted that inorganic fertilizer is agronomically the most important land improvement input for increasing crop yields, and constitutes more than 80% in terms of the quantity of farm input use in Nigeria. Paradoxically, actual performance regarding the diffusion and use of the technology has not met with expectations as the level of fertilizer use per hectare in Nigeria is still among the lowest in the world (Table 4).

Given the current concern all over the world for increased agricultural production in the face of continuous land degradation, Nigeria's agricultural policies need be re-focused to accommodate this problem. It is therefore important to examine how various factors, including property rights, act as obstacles or create opportunities for the adoption of intensification technologies such as inorganic fertilizer. This is necessary because, the development and adoption of technologies appropriate to farmers conditions would considerably increase farmers productivity and income levels, increase aggregate production, as well as help maintain the potentials of the land resource base.

TABLE 3
Fertilizer supply (tonnes) in Nigeria, 1960 - 1997

Year	Imports	Domestic supply	Total supply	Domestic supply as % of total supply
1960	13,177	-	13,177	-
1961	5,651	-	5,651	-
1962	19,855	-	19,855	-
1963	15,636	-	15,636	-
1964	28,406	-	28,406	-
1965	35,467	-	35,467	-
1966	30,505	-	30,505	-
1967	65,843	-	65,843	-
1968	39,188	-	39,188	-
1969	43,206	-	43,206	-
1970	28,106	-	28,106	-
1971	38,173	-	38,173	-
1972	75,675	-	75,675	-
1973	60,960	-	60,960	-
1974	83,789	-	83,789	-
1975	150,963	-	150,963	-
1976	207,857	30,000	237,857	13
1977	305,000	11,000	316,000	4
1978	235,000	28,000	263,000	11
1979	394,000	37,000	431,000	9
1980	532,000	33,000	565,000	6
1981	1,016,000	49,000	1,065,000	5
1982	521,000	45,000	566,000	8
1983	508,000	60,000	568,000	11
1984	745,000	50,000	795,000	6
1985	730,000	55,000	785,000	7
1986	712,500	37,500	750,000	5
1987	829,750	-	829,750	-
1988	384,500	365,500	750,000	49
1989	400,000	500,000	900,000	56
1990	706,000	608,000	1,314,000	46
1991	400,000	600,000	1,000,000	60
1992	610,000	800,000	1,410,000	57
1993	645,000	745,000	1,390,000	54
1994*	208,700	244,719	453,419	54
1995*	277,456	545,500	822,956	66
1996/97*	200,441	604,583	805,024	75

* Provisional

Sources: Ogunfowora (1993); Nigeria, Federal Ministry of Agriculture, Fertilizer Procurementand Distribution Division estimates for 1993; F.O.S, Annual Abstract of Statistics (1997).

TABLE 4

Estimated consumption of fertilizer nutrient per hectare in selected countries, 1992/93.

Country or region	Kilogram of plant nutrient ($N+P_2O_5+K_2O$)
Ghana	2.7
India	57.1
Ivory Coast	8.3
Kenya	51.8
Nigeria	9.4
Pakistan	86.2
Philippines	42.6
Zimbabwe	57.1
Africa	19.3
Latin America	48.2
North America	83.1
Western Europe	231.4

Source: Ogunfowora, 1993

1.3 The Research problem

Developing technologies for improved food production remains an important aspect of research in sub-saharan Africa. This is done with a background understanding of the implications of the changing trend of land use and farm production practices for agricultural production.

In many parts of the developing world, from low-potential regions to some of the best irrigated lands, the demands on resources, including the land resource base arising from population growth, poverty and increased urban competition, have reached the point where it will be difficult to obtain needed increases in agricultural production and rural development without resolving resource management problems. Report from the Environmental Liaison Centre (ELC) in 1992, claimed that accelerating changes occurring in population patterns, tight world food supplies, together with environmental pressures, have led to an increased realization that land resources are relatively scarce and require improved management. The report further claimed that long-run growth in poor agriculture remains a function of technical innovations and investments, moreso, as land values are significantly affected by both potential erosivity and drainage requirements. Thus, a land-use system that entails increasing adoption of intensification technologies in agriculture based on ecological conditions will lead to enhanced food production.

In order to facilitate the needed increases in crop yields in Nigeria and other developing countries therefore, there is an urgent need for accelerated use of appropriate intensification technologies aimed at yield enhancement and stabilization. This is because, as population, poverty and food demands continue to grow, failure to develop and implement appropriate technology in production will lead to more food insecurity and hunger for which the current generation of poor people will pay. Thus, pertinent research questions are: What factors determine the decision to adopt and use intensification technologies in the ecologies of southwest Nigeria? How do these factors affect the extent of use of the technology, and what gains can be attributed to their use? These questions are important because proffering solution to them will assist policy makers in designing and managing technology adoption and acquisition programmes more effectively for improved farm production. It will also reshape the perception of resource degradation problems, as well as the prescriptions recommended to solve such problems while, strategies for resource conservation are ensured and long-term usage made possible.

1.4 Objective of the study

The broad objective of this study is to empirically evaluate the factors influencing the adoption and use of fertilizer technology among farmers in the ecologies of Osun State of Nigeria. This is in order to improve farm yield and income levels. The specific objectives were to:

(i) examine the relationships among factors that affect farmers adoption decisions;

(ii) compare the effects of these factors on fertilizer adoption decisions between ecological zones;

(iii) analyse the extent of use of the technology once adopted; and

(iv) compare the costs and returns to fertilizer use by agroclimatic zone.

(v) derive policy implications of the study.

1.5 Research hypothesis

The hypotheses tested include:

(i) Socio-economic-, ecological-, institutional-, resource-, and property rights- specific factors do not affect farmers fertilizer adoption decisions;

(ii) no significant difference exists in the net benefits derived on fertilizer use in the agroecological zones.

1.6 Definition of terms

Adoption: As a quantitative measure of the extent of adoption, Rogers (1962) defined adoption at the level of the individual farmer as the degree of use of a new technology when the farmer has full information about the technology and its potential. Mansfield (1966), defined adoption as the aggregate level of use of the technology within a given geographical area or a given population.

The definition of adoption used in this study measures the intensity of adoption/use of fertilizer technology in a given time period by the per hectare quantity of the input used per farmer. Analogous measures may apply at the aggregate level for each ecology.

Fertilizer technology: Technology is often identified with the hardware of production-knowledge about machines and processes. According to Olayide et al.,(1980); Meier (1995), technology encompasses managerial and marketing techniques as well as techniques directly involved in production. Technology consists of a series of techniques, while the technology in use is that subset of techniques which has been acquired. Meier further stated that each technique is associated with a set of characteristics which include the nature of the product, the resource use- of machinery, skilled and unskilled manpower, management, materials and energy inputs- the scale of production, the complementary products and services involved. Any or all of these characteristics may be important in determining whether it is possible and/or desirable to adopt a particular technique in a particular country and the implications for so doing.

Suppose all known techniques are expressed as: wT = (Ta, Tb, Tc, Td ... Tn), (where "known" means known to the world) constitutes world technology. For a particular country, the technology available for adoption is that subset of world technology known to the country in question and available. Say, $c\bar{T} = \bar{T}a \ldots \bar{T}n)$ where c denotes the country and the bar indicates that only techniques known to the country and available are included. Thus, $c\bar{T} \subset w\bar{T}$. Each of the techniques $\bar{T}a$, $\bar{T}b \ldots \bar{T}n$ is a vector consisting of a set of characteristics, ai, aii, aiii, bi, bii, biii... Thus, technology can be described in matrix form, with each column representing the characteristics of each technique. Fertilizer technology as applied in this study, is therefore defined in terms of the acquisition and use of fertilizer for the promotion and development of agriculture. Fertilizer is a type of chemical package for agricultural production which saves scarce land by increasing yield per hectare (Smith, 1995).

Intensification: This term connotes how production systems evolve in response to increasing population pressure on a limited land base (Binswanger et al., 1988). Increases in population stimulate increased food production either by extensification or intensification. Extensification means increasing the area under cultivation, while intensification implies increasing the intensity with which the same piece of land is cultivated, and/or increasing the inputs applied to the same piece of land.

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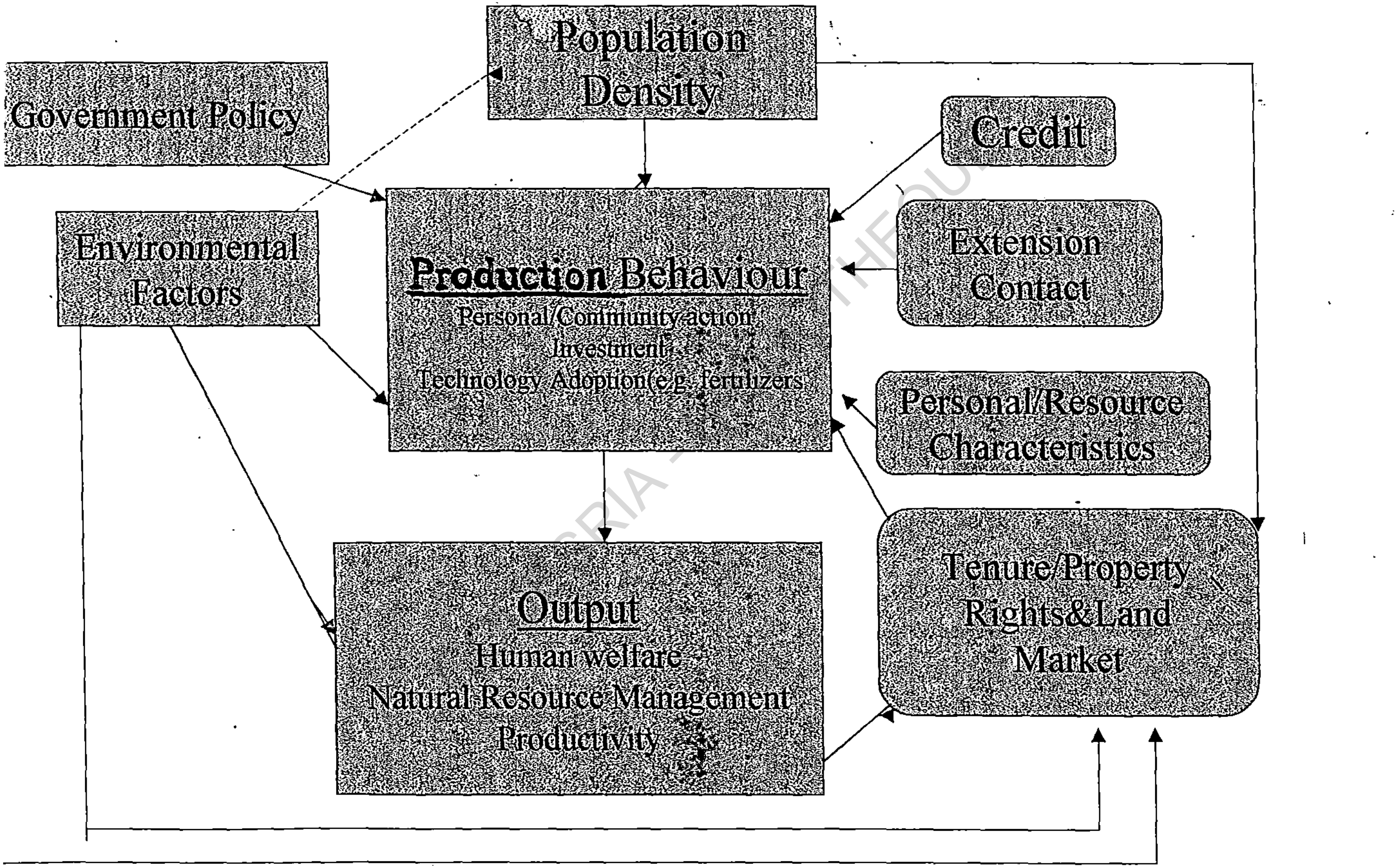
Property rights: This refers to the institutional arrangements (i.e. rights, rules, norms, conventions, and contracts) that govern the way people access, use, and manage the benefit that derives from natural resources. "Property Rights", "Property Institutions", and "Land Tenure" are used by different people to refer to the same phenomena.

1.7 Justification for the study

The widening degradation of cropland and low use of land improvement technologies have created a serious gap in meeting the food self-sufficiency objective of Nigeria's agricultural development programmes (Olayemi and Ikpi, 1985; Nwosu, 1995).

This has aroused the need for farmers to use intensification technologies such as inorganic fertilizers for improved farm production. However, most adoption studies have paid little attention to the extent of use of these technologies under different ecologies, while efforts have been directed on a package of technologies. Though, the package approach has an advantage of its components bearing complementary relationships with each other, farmers have been found to keenly discriminate against technologies contained in a package of recommendations due to various constraints. This results in selective and differential rates of adoption based on the degree of relative importance of the components of the package. Inorganic fertilizer has been found to be a major component of the technological package which contributes to improved farm production by replenishing soil nutrients, increases crop yield and biomass; enables the adoption of high yielding varieties and improve farm income (Feder et al., 1985; Akinola and Young, 1985; FAO, 1997; Awe, 1997). Thus, this study evaluates a representative technology (inorganic fertilizer) which has been found to be a major component of the technological package.

Results from this study are expected to provide valuable information to research, extension or rural development institutions that may wish to assess their progress and take advantage of farmer experience to make future actions more effective. Figure 1 shows the conceptual framework of the study indicating how the major research variables are linked.


Population Density
Government Policy
Credit
Environmental Factors
Production Behaviour
Personal/Community action
Investment
Technology Adoption(e.g. fertilizers
Extension Contact
Personal/Resource Characteristics
Output
Human welfare
Natural Resource Management
Productivity
Tenure/Property Rights&Land Market

CHAPTER TWO

2.0 LITERATURE REVIEW

The use of land improvement techniques for controlling soil degradation, consequent upon increasing population growth rate and over-exploitation of the land resource base, has been the focus of considerable economic research (Falusi, 1974 and 1976; Yapa et al., 1978; Rahm and Huffman, 1984; Feder et al., 1985; Heimlich, 1985; Adesina et al., 1997 and Erenstein et al., 1997). The issues usually addressed include the role of operator, farm and institutional characteristics as well as farm level economic impacts.

Parsons (1970) and Fabiyi (1976, 1984) reported that the property rights upon which land is held defines the use-relations of the land to the farm, as an economic unit, and also defines the price or performance required for the use of the land. Fabiyi (1976), Famoriyo et al., (1977), and Oloruntoba (1984), faulted the Nigerian customary land tenure system with respect to problems of inheritance practices, sustained security of rights, limits on individual holdings, little incentive for improvement, and restricted scale of operations. This in turn greatly influences the incentives to energetic effort, the adoption of modern agricultural techniques, and the care of the soil. In an attempt to correct the ills of the traditional land tenure system, the Federal Military Government introduced the Land Use Act, 1978. The Act has not been thoroughly implemented according to Fabiyi (1984) and Oloruntoba (1984) with the need for a reform in the land-use system that would lead to increasing adoption of land improvement/intensification technologies for enhanced agricultural production. However, the application of the principle of sustained food production suggests that whatever the land use or combination of uses may be, a continuing flow of goods and services can be obtained without impairing the productivity of the land. According to Adesina et al., (1992), the absence of appropriate technical innovation in the past has led to zero growth in agricultural productivity while, many yield-increasing technologies may contribute to environmental degradation that further reduces future production potential when not properly managed and optimally used. For instance, Binswanger and Pingali (1988), argued that yield-increasing technologies do not go well with a land-surplus farming system unless infrastructure and market conditions make it profitable to produce surpluses that can be sold. Aduayi (1985), Lombin et al., (1991) and Adebayo (1997) claimed that intensified agricultural production could best be achieved through the use of fertilizers, organic manure and improved agronomic practices.

In summarizing fertilizer-related experiences of selected countries in Africa, Lele et al., (1989) asserted that "the under-utilization of fertilizer makes fertilizer pricing, subsidy, and distribution policy, together with the alleviation of other technological and institutional constraints one of the most pressing issues in the modernization of African smallholder agriculture". Dayanatha and Behjat (1993) also pointed out that the process of fertilizer diffusion is creating effective demand for fertilizers at the farm level, and depends on the nature of the physical response environment, the status of the fertilizer distribution systems, and conditions of aggregate fertilizer supply at the national level.

2.1 Theoretical models of adoption techniques

This section explores the theoretical studies of the adoption of agricultural technological innovations in order to define adoption variables clearly, set definite relationships for estimation, and suggest hypotheses that can be tested empirically. It also allows for a better understanding of the interdependence among adoption decisions and the conditions under which certain arguments are valid. Considerable attention has been focused on the adoption of yield increasing technologies in agriculture by development economists. This is because majority of the population of less developed countries (LDCs) derive their livelihood from agricultural production for which new technology seem to offer an opportunity to substantial increase in production and income. However, the introduction of many technologies have only been partially successful as measured by observed rates of adoption (Feder et al., 1985; Nwosu, 1995). Falusi (1974, 1976) and Feder et al., (1985), surveyed economic studies of technology adoption and found that farm size, risk and uncertainty, extension contact, human capital, labour availability, credit, property rights and complementary input availability were the major factors affecting the adoption of agricultural technologies. For instance, uncertainty and risk aversion decrease the propensity for individuals to adopt technologies. However, while measuring an individuals' risk perception and risk aversion is difficult, economic theory states that their perceptions are influenced by information and human capital. Thus, human capital (the ability to acquire and process information) variables may be used as proxies for risk. Nelson and Phelp (1966) showed that education and experience are two common measures of human capital which reflects the ability to implement new technology.

Hayami and Ruttan (1981), in their work, examined the patterns of agricultural development in individual countries within which indigenous technological change play a critical role. An important feature of their approach is the use of theory of induced innovation which incorporates a unique dynamic response of each country to its agricultural and relative input prices. Argarwal (1983), posited that the innovation-diffusion model following from the work of Rogers (1962), Gartrell et al., (1977), Jibowo and Adepetu (1985), views that the key factor in determining adoption decisions is having access to information about an innovation. To them, the use of extension, media and local opinion leaders or visits to experimental stations and on-farm trials can make risk-averse non-adopters to become aware of the rationality to adopt. O'Mara (1983) posited that if farmers form their risk perceptions in a rational way, then over time, their perceptions will tend to move from subjective to objective risk assessments based on knowledge of the interactions between technologies and their environment. Effective extension services can accelerate the spread of knowledge about the profitability and risks associated with new technologies, while farmers are also quite efficient in learning from each other and at experimenting on their own farms.

Closely linked to the innovation-diffusion approach is the geographic approach which examines innovation adoption through space using probabilistic and deterministic models. It considers situational factors and communication as the principal explanatory variables in determining spatial diffusion of an innovation (Shaw, 1985). Technologies may be unsuitable beyond the bounds of certain physical, socio-economic, cultural and political environments. Freebairn (1995), Erenstein and Cadana (1997) asserted that agro-climatic conditions have precluded the use of High Yield Varieties (HYVs) in areas with low rainfall (and insufficient irrigation facilities), unfavourable microclimates and poor soils. Likewise, use of ox-plow cultivation or grazing technologies is constrained in areas with very hilly terrain, or in tsetse infested areas. Thus, evaluating the appropriateness of a technology or package of technologies goes well beyond its technical characteristics. The economic-constraint model proposed by Aikens et al., (1975), contends that economic constraints as reflected in the unequal distribution of resources are the major determinants of observed adoption behaviour. Thus, Yapa and Mayfield (1978) claimed that inadequate farm land could significantly constrain adoption decisions, while Havens and Flinn (1976) adduced the economic constraints to large fixed costs and lack of access to capital.

The Adopter-perception model employed by Kivlin and Fliegel (1966); Lynne et al., (1988); and Gould et al., (1989) suggests that the perceived attributes of innovations condition adoption behaviour. Rogers (1962) observed that the adoption of a new technology is positively influenced by the current level of productivity of the farmer, while Ervin and Ervin (1982) and Norris and Batie (1987) in their different studies found that financial characteristics such as debt and income are the most important factors leading to the adoption of yield-improving technologies. Gould et al., (1989) reported that demographic and socio-economic variables such as age, acreage planted, household income, education, family transfer of land and farmers' perception of soil degradation problems are significant determinants of technology adoption. Feder et al., (1985), Dayanatha et al.,(1993) also found that differences in farm sizes, incomes, age, farm types and farming practices influence technology adoption decisions.

Thus, farmers decisions in a given period are assumed to be derived from the maximization of expected utility (or expected profit) subject to land availability, credit and other constraints. This is because profit is seen to be a function of farmer's choices of crops and technology in each time period and therefore depends on his discrete selection of a technology from a mix including the traditional technology and components of the modern technology package. Given this discrete choice, income is a continuous function of land allocation among crop varieties, the production functions of these crops, the variable inputs usage, prices of inputs and outputs, and the costs associated with the discrete technological choice (Tesfatsion, 1980). In other words, the framework for investigating adoption processes at the farm level should include a model of the farmer's decision-making about the adoption of the intensification technology. In view of the foregoing review of literature on farmers adoption behaviour, it is obvious that the adoption of a particular land improvement and yield-increasing technology requires the assessment of the effects of socio-economic, cultural, institutional, property rights and environmental factors on farmers decision behaviour. This study contributes to the existing theoretical literature on adoption by examining the relationship between farm-, farmer-, resource-, environmental-, institutional- and property right- specific factors on farmers' adoption of fertilizer technology.

2.2 Empirical studies of adoption

Deductions from the theoretical models above suggest many hypotheses relating adoption of intensification technologies to key economic and physical parameters. However, these relationships differ in different socio-cultural and environmental conditions and empirical results may seem to conflict if the underlying factors are not considered directly (Feder et al., 1985). It therefore implies that there is a need to specify the terms of technology adoption explicitly for empirical work. Thus, the review of empirical work is based on key explanatory factors affecting the adoption process.

Many empirical studies suggest that size of holding depends on a large number of potentially important factors such as access to credit, capacity to bear risks, access to scarce inputs such as seeds, fertilizers, insecticides, and modern agronomic information. However, these factors vary in different areas and over time with respect to farmers' adoption behaviour. Studies reviewed by Binswanger et al., (1988) revealed a strong positive relationship between farm size and adoption of tractor power in South Asia, while other studies showed that inadequate farm size impedes the efficient utilization and adoption of certain types of irrigation equipments (Gafsi and Roe, 1979). Weil (1970) posited that the negative relationship between technology adoption and farm size may be caused by credit constraints and suggests that capital may be made more available for larger farms to adopt. Parthasarathy et al., (1978) observed a significant positive relationship between farm size and high yield variety (HYV) seed adoption in an Andhra-Pradesh village. Jamison et al.,(1982), in a study of Thai farmers, found a significantly positive relationship between the adoption of fertilizers and farm size, extension advice and level of education. Though seemingly contradictory evidences were cited by Hayami and Ruttan (1981), majority of the evidences show that the incidence of HYVs is positively related to farm size. While studies like Parathasarathy et al., (1978) and Lipton (1978) reveal no significant difference in chemical input use per acre between farms of different sizes, Singh (1979), indicated a positive relationship between the amount of fertilizer applied per hectare of fertilized land and farm size. The relationship between farm size and intensity of use was however, found to depend critically on risk preferences of farms and on the risk effects of the inputs. Though many of the empirical findings on the relationship between farm size and adoption are compatible with the implications of theoretical studies, observations on the effect of agroclimatic variations in technology adoption have been given little attention in the theoretical literature.

The difficulty involved in measuring risk and uncertainty has resulted in its non-treatment in most empirical studies of adoption. The adoption of innovations entails both subjective risks (depicting the uncertainty accompanying an unfamiliar technique), and objective risks brought about by weather variations, susceptibility to pests, and timely availability of inputs. Gerhart (1975) in his study of maize adoption in Kenya, represented high risks by drought-resistant crops. This approach was faulted on the point that the decision to plant drought-resistant crops is an endogenous variable and should not be on the right hand side of the equation. Other studies (Colmenares, 1976; Cutie, 1976) obtained observations from different topographical areas using location-specific dummy variables that are shown to be significant. Binswanger et al., (1988) proxied the risk factor by ascertaining farmers perceptions through direct interviews of a sample of Indian farmers. However, a more common proxy variable is whether the farmer was visited by extension agents or whether he attended demonstrations organized by the extension service (Gerhart, 1975; Colmenares, 1976), since exposure to appropriate information through various communication channels reduces subjective uncertainty. The empirical evidence on the importance of risk in technology choices is not conclusive. Much seems to depend on household livelihood strategies which are subjected to wealth and whether farmers have efficient options for reducing their exposure to risk, and or to coping with losses when they arise (Scherr, 1995; Zeller, 1997). To them, risk reducing options may include income and crop diversification, inter-cropping and plot scattering, while risk-coping strategies may include use of savings or credit and family support networks. Where these options are available, the amount of additional risk associated with alternative crop technologies or production techniques may be too small for risk to play an important role in these decisions.

Lack of credit has also been found to significantly limit adoption of HYV technology even when fixed pecuniary costs are not large (Bhalla, 1979). However, Gerhart (1975) claimed that off-farm income can help to overcome a working capital constraint or may even finance the purchase of a fixed-investment type of innovation. Schultz (1964), attributed the contribution by the human factor to the returns from agricultural production to workers' ability and allocative ability. Though both abilities improve as experience and health improve, formal schooling is hypothesized to play a much more important role in determining allocative ability than workers' ability. Several studies have explicitly verified the link between early adoption and education. Results suggest that farmers with better education are earlier adopters of technologies and apply modern inputs more efficiently throughout the adoption process. For instance, Gerhart (1975) found that the likelihood of adoption of hybrid maize in Kenya was positively related to education. In analysing the adoption of chemical inputs in Thailand, Jamison and Lau (1982) applied a discrete-choice optimization model and a logit estimation technique to show that education affects the probability of input adoption.

Looking at the effects of property rights arrangement and the proportion of farms rented on the adoption of improved yield variety technology, Parthasarathy and Prasad (1978), in their study, concluded that even though inorganic fertilizer use was the same for tenants and owners, tenants had a lower tendency to adopt improved varieties than owners. This is moreso as the landlord is the decision maker regarding the variety of crops to be grown on leased land . Empirical studies of landlord-tenant arrangements on incentives to adopt yield-enhancing technologies claimed that the double role of the landlord as a provider of credit and landowner may hinder the adoption of yield-increasing innovations (Badhuri, 1973). This is because adoption will reduce the tenants' indebtedness to the landlord and the rate at which income from lending decline will outweigh the rate of increase of output from the perspective of the tenant. Scandizzo (1979), corroborated this assertion when he concluded that landlords will be reluctant to adopt land-augmenting innovations if interest earnings and price margins are high owing to the fact that landlords market their tenants' output. Shaban (1987) in his Asian study, revealed that some tenancy and contractual arrangements can significantly lower land investments and input use below levels observed on owned plots.

However, if indigenous African land right systems maintain tenure insecurity, then the risk of not capturing the benefits of long-term land improvements or even the short-term residual effects of some variable inputs could reduce both production efficiency and sustainability. Also, if the transfer of land among households that differ in non-land factor endowments is hindered by indigenous land rights system, then production equity and efficiency could be adversely affected. However, Bell (1972) in his analysis of the choice of lease arrangements, demonstrated that tenurial contract may change as a result of technological change. Hence his model presumes that economic barriers exist to prevent the traditional diffusion model from operating effectively. Vyas (1975), observed that tenants were not only as innovative as landowners but sometimes used more fertilizer per hectare than did owners. The need to draw a distinction between pure tenants who own no land and tenant-owners who own at least some of their land was pointed out by some observers, as the latter can be expected to be more receptive to innovations. In their study, Schutjer and Van der Veen (1977) suggested that any observed effect of tenancy may be indirectly due to the implied relationships between tenure and access to credit, input markets, product markets, and technical information. According to Feder et al., (1985), farmers with more rights have a higher probability of recouping the benefits from land improvements and thus will be more inclined to make medium- or long-term land improvements and to use complementary yield-increasing inputs. Since many factors tend to be related to property rights, there is the possibility of confusing the effects of property rights with that of other related variables. For instance, Adesina, et al. (1997) found that after controlling for other factors such as fuel and fodder scarcity, secure land rights were not a significant factor in adoption of alley farming in Cameroon, though secure tree tenure was. Similarly, Manyong and Houndekon (1997), found that although farmers' plots were not formally registered, divided inheritance, purchase and gift modes of acquisition provided enough long-term security to encourage the adoption of soil-improving technology. Gavian and Ehui (forthcoming) found that in Ethiopia, land with less secure tenure had lower total factor productivity. This was not due to farmers applying less inputs, rather, it was low quality of inputs or low skill in applying them that limited productivity.

Thus, if these relationships differ in different socio-cultural environments, empirical results may seem to conflict if the underlying factors are not considered directly. It therefore implies that there is a need to specify the terms of tenurial arrangements clearly for empirical work. This, according to Feder et al., (1985), is premised on the point that much of the empirical work lacked a theoretical basis on which to specify structural relationships and interdependencies. Thus, the estimated functional forms may not correspond to any rational underlying decision behaviour, while many studies provide only qualitative rather than quantitative information about the adoption process.

Based on the foregoing review on adoption, this study contributes to the existing empirical literature on adoption by analysing the probability of adoption and the extent of use of fertilizer technology under different agroclimatic conditions.

2.3 Review of methodology

2.3.1 The use of Binary Choice models

In the econometric analysis of quantitative variables, the use of standard econometric estimation techniques like the Ordinary Least Squares (OLS) and Two-stage Least Squares (2SLS) regression methods have proved quite useful. Additionally, when one or more of the explanatory variables in a regression model are dichotomous in nature, it can easily be represented as dummy variables. However, the application of linear regression model becomes difficult when the dependent variable is dichotomous in nature. In such instances, binary choice models become appropriate.

Binary choice models assume that individuals are faced with a choice between two alternatives and that the choice made depends on the characteristics of the individuals. Statistical analysis of qualitative response models is complicated in that such behaviour must be described in probabilistic terms. Thus, models concerning choices from a limited number of alternatives attempt to relate the conditional probability of a particular choice being made to various explanatory factors which include the attributes of the alternatives, and the characteristics of the decision makers.

However, in an attempt to employ quantitative methods in adoption studies, many studies have focused on the direct effect of certain explanatory variables rather than their quantitative importance. Rochin and Witt (1975); Parthasarathy and Prasad (1978), have employed the χ^2 contingency tables to perform non-parametric hypothesis tests of the importance of certain explanatory variables. Though, the result may suggest a significant effect in statistical terms, it becomes difficult to establish whether the economic importance of the effect is worth considering. Other studies have employed discriminant analysis as a procedure for classifying observations in one category or another based on several explanatory variables (Yapa and Mayfield, 1978). Rogers (1969), employed correlation analysis to examine the interrelationships of several factors affecting adoption and produced only qualitative information regarding the effect of various explanatory factors. Since the simple correlation between some variables may be greatly influenced by other variables, the resultant spurious correlation effect constitutes a weakness of this approach. Colmenares (1976) employed Ordinary regression methods in his study to explain only the decision of adoption or non-adoption rather than the extent or intensity of adoption. This approach has been faulted on two grounds: (i) that the usual tests of significance for the estimated coefficients do not apply, the summary measure R^2 is no longer meaningful, and the estimated standard errors and t-ratios produced by an OLS regression are not appropriate for investigating hypotheses about the role and importance of various factors in the adoption process; (ii) heteroscedasticity becomes severe and the OLS regression estimates produce predictions other than zero or one for the dependent variable if the decisions are considered as probabilities, so that predictions less than zero or greater than one become untenable (Pindyck and Rubinfeld, 1997).

These have led to the need to find new techniques to estimate such relations. As a way of extending the tools of linear regression to construct models in which the dependent variable is not continuous, appropriate estimation methodology has been developed for investigating the effects of explanatory variables on dichotomous dependent variables.

Application of qualitative choice models in explaining different socio-economic phenomenon is not new (Capps et al., 1985; Akinola, 1987). The forms of probability functions in use are the linear probability model, the logit model, the probit model, and the Tobit model. However, logit and probit models are most commonly used. These models specify a functional relation between the probability of adoption and various explanatory variables.

2.3.2 Model specification

The general form of the univariate dichotomous choice model can be expressed as:

$P_i = P(y_i = 1) = G(X_i^*, \Theta) \quad i = 1,..., n$ ....(1)

With the assumption that the random variables, y_i, are independently distributed, equation (1) states that the probability that the ith farmer will adopt a given technology, such as fertilizer $P_i(y_i=1)$, is a function of the vector of explanatory variables, X_i^*, and the unknown parameter vector, Θ (Amemiya, 1989). However, equation (1) is too general. The problem of model specification is made more manageable if the researcher chooses a certain function $H(X_i^*,\Theta)$, which is linked to the parameter vector Θ, and sets out to find the right function F (a probability function) in the model. According to Amemiya (1989), specifying F is the core of qualitative response modelling:

$$P(y_i = 1) = F[H(X_i^*,\Theta)] \quad \ldots \quad (2)$$

Most researchers choose a linear specification for H, i.e.

$$H(X_i^*,\Theta) = X_i\beta \quad \ldots \quad (3)$$

such that (2) can be rewritten as:

$$P(y_i=1) = F(X_i\beta) \quad \ldots \quad (4)$$

Though equation (4) seems more restrictive than (2), it is more general than it appears since the vector of independent variables X_i^* may be transformations of the original variables X_i. Thus, in choosing the functional form of F, different functional relationships are often specified. They are:

i. Linear Probability Model(LPM)

$$F(W) = W \quad \text{where, } W = X_i\beta \quad \ldots \quad (5)$$

ii. Logit Model(LM) $$F(W) = L(W) \equiv \frac{e^{W}}{1+e^{W}} \quad \ldots \quad (6)$$

iii. Probit Model(PM)

$$F(W_i) = \theta(W_i) \equiv \int_{-\alpha}^{(W_i)} \frac{1}{2\pi} e^{-t_2/2} dt \quad \ldots \quad (7)$$

iv Tobit Model(TM) $$F(W_i) = \begin{cases} 1 & if\ Y_i^* \geq 1 \\ 0 & otherwise \end{cases} \quad \ldots \quad (8)$$

model to obtain homoscedastic disturbances, the efficiency of the weighted (transformed) least-squares estimates depends on the condition that $0 < X_i, \beta < 1$, which may be violated (Goldberger, 1964; Amemiya, 1981). Additionally, the non-normality of the disturbance terms makes the use of traditional tests of significance (the t-test and F-test) inappropriate. Since the LPM involves the interpretation of predicted values of Y as probabilities, the model presents a serious weakness and problem when the predicted value lies outside the (0,1) range. This is because even if the true linear probability model is correct, it is certainly possible that a given sample value of X will lie outside the interval (Pindyck et al., 1997).

In order to overcome the difficulty arising from the LPM, the constrained form of it can be used by involving some notion of probability as the basis of transformation. According to Tobin (1958); Amemiya (1984), this transformation (called monotonic transformation) can be effected with the cumulative probability function: Among alternative cumulative probability functions possible are the logistic (logit model) and the normal (comprising probit and Tobit models). The logistic and probit formulations are quite similar, with the only difference being that the logistic distribution has slightly fatter tails. Pindyck et al., (1997), pointed out that the logistic distribution closely resembles the t-distribution with seven degrees of freedom (the t-distribution approximates the normal as the number of degrees of freedom gets large). According to Liao (1994), if a probit estimate is multiplied by a factor, an approximate value of the corresponding logit estimate is obtained. This factor is normally believed to be 1.814 (Aldrich and Nelson, 1984). The implication of this is that at the usual range of data, the logit gives the same result as the probit (Theil, 1971). Generally, the logit model requires more data than the probit model and its dependent variable must be specified in a ratio form unlike the probit in which it takes values of 1 or zero. However, the probit model involves non-linear estimation, and thus added computational costs. This is because the cumulative normal distribution is non-linear and OLS cannot be applied to estimate the probit model. However, the theoretical justification for employing the probit model is often rather limited vis-a-vis the use of the logit model. The logit model is easier to use for computation and is therefore often used as a substitute for the probit model. The model (logit) has been found useful in determining the variables influencing adoption in a study of high yield variety rice in Bangladesh (Asaduzzaman, 1979). Though the probit model is computationally more difficult, it is more flexible and, unlike the logit model, does not result in any violation of the basic assumptions if some of the alternatives from which a choice is to be made are close substitutes.

Empirical evidence of the application of the probit model can be found in Falusi (1974) in a study of selected factors influencing fertilizer adoption among farmers in Western Nigeria. While employing probit model, Daramola (1987), and Osotimehin (1991) considered technology as a package and assigned standardized weights to each innovation in order to measure the relative contribution of each innovation in their adoption studies. Schutjer and Van der Veen (1977) asserted that the major technology issues relate to the extent and intensity of use at the individual farm level rather than to the initial decision to adopt a new practice. This is because adoption variables in most adoption studies are simply categorized as "adoption" or "non-adoption". However, knowing that a farmer adopts improved yield varieties may not provide much information because he may be using 1% or 100% of his hectarage, or he may be applying a small or large amount of the technology per hectare of land. By the binary method of analysis, both are regarded as adopters. Hence, studies where emphasis is placed on potential adopters decision about whether or not to adopt an innovation and where the adoption variable is specified in binary form (1 if he adopts, 0 otherwise) are also defective. This is because the chosen methodology provides no information on the intensity of use.

Thus, the current trend in adoption studies considers the degree of use of a new technology as a quantitative measure of the extent of adoption. Now, the probit-logit is one possibility when the adoption process is dichotomous, but a strictly dichotomous variable is often not sufficient for examining the extent and intensity of adoption (Amemiya, 1978). An econometric problem that arises in the estimation of these relationship is sample selectivity bias and hence the regression coefficients are likely to be biased (Hagemann, 1981). This is relevant for the intensity of use variable, but it is not observable for the sample as a whole. By excluding individuals who do not use the intensification technology, the dependent variable is censored and the residuals do not satisfy the condition that the sum of residuals must equal zero (Maddala, 1983). This implies that non-adopters have not used the innovation before and will not use it in future. This may not be applicable a priori. The reason being that some farmers may have insufficient income to purchase the technology at the time, others may have used the innovation in previous years and or are planning to use it in the subsequent year. Thus the present number of non-adopters may actually be showing market behaviour by this action and therefore need be included along with adopters in estimating the parameters of potential adopters' decision model. Additionally, excluding non-adopters of the technology seems a waste of data since other information were recorded about them. According to Anden-Lacsina and Barker (1978), there are possibilities for studying econometrically the degree or intensity of adoption as well as the decision of adoption and non-adoption. This will involve representing adoption by continuous but limited variables in which percentage adoption or proportion of adoption variable can be adequately represented such that the dependent variable varies continuously but limited to the interval (0,100) or (0,1) respectively. Examples of such innovations include inorganic fertilizers, improved seeds, and modern agronomic practices. Even innovations which appear to be discrete in choices such as tractors can also be represented as continuous variables by using quantity per hectarage. Hence, for most adoption problems, the necessity for hypothesis testing and of unbiased estimation of parameters of the adoption process requires explicit treatment of the limited nature of the dependent variables connoting adoption intensity. This approach entails obvious specification bias when linearity is used with unreasonable predictions outside the (0,100) interval. The adoption of technologies (e.g. fertilizer) where there is an obvious lower limit of zero on the amount applied but with no clearly defined upper limit, also create problems with limited dependent variables. Here, studies like Cuties (1976) have simply regressed fertilizer use linearly on various explanatory variables without considering the lower boundary where zero responses for fertilizer use are observed. Other studies like David and Barker (1978), avoided the problem of obtaining negative predictions for fertilizer use by using the logarithm of fertilizer use as the dependent variable. Thus, any finite explanatory variable lead to positive predictions for fertilizer use as long as finite coefficient estimates are obtained. Although this approach appears more acceptable, there may be many farms on which fertilizer is not used, and such predictions would not be possible in the logarithms or semi-logarithmic framework, given finiteness of variables and coefficients.

Tobins procedure (sometimes called Tobit analysis) is a logical extension of probit analysis model based on the cumulative normal distribution (Deegan et al., 1976). The cumulative normal distribution is viewed as a desirable transformation in this case since it relates a variable (number of standard deviations from the mean) which has a range from minus infinity to plus infinity to another variable (a probability) which has a range from zero to one. In this way, an unconstrained variable can be "transformed" into a new variable which is bounded. To overcome these problems, studies by Rosett and Nelson (1975), McDonald and Moffit (1980), Rahm and Huffman (1984), Akinola and Young (1985), Shakya and Flinn (1985), Norris and Batie (1987), Gould et al., (1989), Matlon (1989), have employed the Tobit model in one form or the other in their various adoption studies. Wu (1988) employed the Tobit analysis to estimate Japanese peanut imports under quota restrictions while Adesina and Zinnah (1992) used the Tobit model to test the hypothesis that farmer perceptions of technology-specific characteristics significantly condition technology-adoption decisions among mangrove swamp rice farmers in Sierra Leone.

The theoretical framework of the Tobit model can be explained by the threshold concept which proposes that the decision to adopt an innovation may be characterized as a dichotomous choice between two mutually exclusive alternatives. This implies that there is a "cut-off" point or threshold in the dimension of the explanatory variables below which a stimulus elicits no observable response. It is only when the strength of the stimulus exceeds the threshold level that a reaction occurs and the second decision on intensity of use is taken. This model would be most appropriate in that according to Tobin (1958), Amemiya (1978), Akinola et al., (1985), the Tobit model assumes that the dependent variable has a number of its values clustered at a limiting value usually zero and uses all observations, both those at the limit and those above the limit, to estimate a regression line. If no observations are available on the individuals who do not use a particular technology, then the sample is said to be truncated. This is to be preferred, in general, over alternative techniques that estimate a line only with the observations above the limit. For example, while the discrete (Probit) model determines potential adopters' decision about whether or not to adopt a technology, with the dependent variable taking a value of 1 or 0 respectively, the continuous (linear regression) model only explains variations in the quantity of the innovation used after the decision to adopt has been made. Heckman (1979, 1980) offers an alternative procedure to deal with censored samples which would allow for different factors influencing adoption and effort. The two equations procedure involved estimation of a probit model of the adoption decision, calculation of the sample selection bias and incorporation of that bias into a model of effort estimated with OLS. While Heckman's procedure allows for different model specification for adoption and effort, it does not allow for the decomposition of elasticities afforded by the Tobit procedure. The Tobit model is therefore viewed as a hybrid of the discrete and continuous model which will simultaneously analyse the potential adopters decision about whether or not to adopt the innovation and the intensity of use after adoption. Additionally, while the Tobit beta coefficients do not directly measure the correct regression coefficients for observations above the limit, they provide more information than is commonly realized. The technique can be used to determine both changes in the probability of being above the limit and changes in the value of the dependent variable if it is already above the limit. This can be quantified for useful and insightful deductions (McDonald and Moffit, 1980).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

This chapter presents the methodology employed in this study. The chapter is divided into six sections for convenience. Sections one to three describe the survey location, the sampling design and procedure, as well as data collection instruments. Section four discusses data collection problems, while section five examines the analytical techniques employed. These include descriptive statistics, correlation analysis, Tobit regression as well as costs and returns analysis. Section six discusses the description and measurement of study variables as well as the expected signs of independent variables.

3.1 The study area

The study was conducted in ten out of the former twenty-three Local Government Areas (LGAs) of Osun State of Nigeria. The state is bounded by Kwara state to the north, Ogun state to the south, Oyo state to the west and on the East by Ondo state (Figure 2).

The state has an estimated population of 2,618,690 in 1998 (projected) living in an estimated area of 8,882.55 sq. km. Majority of the inhabitants are predominantly small holder farmers who depend on agriculture for their livelihood. The inheritance pattern of tenure rights is predominant in the study area. Two distinct vegetational zones exist in the State: the rain forest and the forest savanna mosaic (or derived savanna). The prevailing vegetation, soil, and weather conditions determine the type of crops grown in different areas of the state. The forest region, with a much higher relative humidity and rainfall favours the cultivation of tree crops like cocoa, kola, citrus, and oil palm along with arable crops such as maize, cassava, rice and yam. Other crops like okro, pepper, tomato and cowpea are also cultivated. On the other hand, the derived savanna zone has mainly arable crops with patches of tree crops grown. The cultivation system is characterized by mixed cropping while

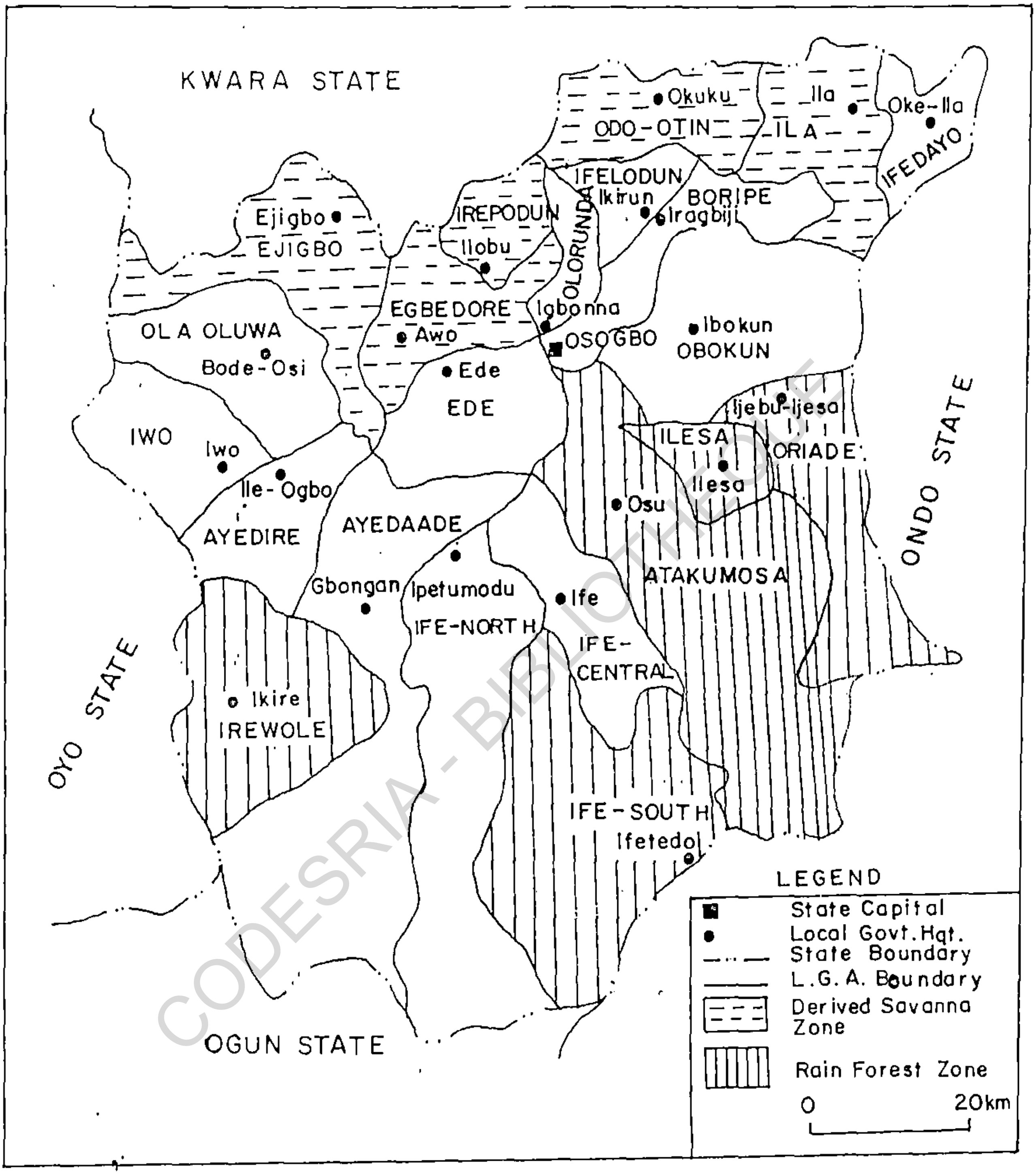


Fig. 2 : Map of Osun State showing the study areas.

separate cropping enterprises are few. Moreover, majority of farmers in the study area had farm sizes below 1.0 hectare.

There has been a relative increase in the proportion of farmers awareness in using nitrogenous fertilizer and other intensification technologies in the state. Estimated hectarage fertilized was 61,791ha and 62,789ha respectively for the 1995 and 1996 farm years, even though the percentage of total cultivated hectarage fertilized remain low (OSSADEP, 1996). In addition, farmers are highly dependent on the state's Agricultural Development Programme (OSSADEP) for the supply of agricultural inputs. Table 5 shows the recommended fertilizer requirement of major crops in the survey location.

The ease of collecting information that aids the quantitative determination of key factors influencing technology adoption prompted the choice of Osun State as the study area.

TABLE 5

Fertilizer requirement according to agroclimatic zones in Osun state, Nigeria

Target crop	Zone	Fertilizer requirement
Maize	Forest	6 Bags (300kg) of 25-10-10/ha
	Forest (with continuous cultivation)	6 Bags (300kg) of 25-10-10 +2 Bags (100kg) of SSP
	Savanna	8 Bags (400kg) of 25-10-10 +2 Bags (100kg) of SSP + 3-5kg $ZnSO_4$/ha OR 10 Bags 20-10-10 + 2kg Sulphur
Cassava	Forest	200kg NPK 15-15-15/ha applied 4-6 weeks after planting 100kg Muriate of Potash/ha; 4-6 months after planting.
	Savanna	200kg 15-15-15/ha. 4-6 weeks after planting 100kg 15-15-15/ha. 2nd dose 4-6 months after planting.
Yam	Forest	400kg of 15-15-15 (60kg N,P_2O_5 and 60kg K_2O\ha).
	Savanna	300kg of 15-15-15 and 100kg of urea per hectare (90kg N, 45kg P_2O_5 and 45kg K_2O \ha); 3-4mths after November planting, and 8 weeks after February planting.
Rice	Forest	200kg of 15-15-15\ha ;100kg of urea\ha at initiation.
	Savanna	100kg of 15-15-15 per hectare and 100kg of urea\ha broadcast at 30 days after transplanting.

Source: Extracts from IAR&T package of recommendations (1991)

3.2 Nature and sources of data

Both primary and secondary data were obtained for this study. Primary data were generated from a cross-sectional data-set of three hundred farm households drawn from two agroecologies (rain forest and forest savanna mosaic) in Osun State of Nigeria. The field survey was carried out with a pretested structured questionnaire of close and open-ended questions based on the study objectives. Information sought included farmers' characteristics such as literacy level, age, gender; tenure factors such as security of tenure, years since last fallow; resource characteristics such as household size and use of land improvement technology. Information on farm inputs and outputs as well as on farmers' maize plots were also obtained. To further gain insight into traditional land tenure rights and other factors which may influence the adoption of fertilizer technology by respondents, two Focus Group Discussion (FGD) sessions were held in two selected villages in each of the ecological zones in the state (Table 6). An interview guide of open-ended questions was used for this purpose. All FGDs were audio-recorded.

Secondary data were extracted from records on supply and distribution of fertilizer in the State Department of Agriculture, Osun State Agricultural Development Project (OSSADEP), and libraries of Universities and International Institute of Tropical Agriculture (IITA).

3.3 Sampling procedure and data collection

A multi-stage sampling technique was employed in selecting respondents for the study, with farmers being the primary sampling unit (figure 3). In the first stage, two main agroclimatic zones in Osun State were distinguished using the geographical map of the area. Ten Local Government Areas (LGAs) were then purposively selected in proportion to the spatial distribution of the two zones, and on information about those LGAs which are relatively mostly affected by soil degradation problems. The third stage involved a random selection of five villages in each of the LGAs. Between three and eleven respondents were then selected in each village in proportion to the size of the village. A total of three hundred and fifty farmers were interviewed altogether for the study. Homogeneous groups of male and female respondents were separately constituted for the focus group discussion (FGD) sessions. Each FGD group comprised seven respondents including opinion leaders who had been living in the village for thirty years and above and have detailed information on knowledge, beliefs, attitudes and practices of people in the study area. Four FGDs were conducted altogether.

Data were collected with the assistance of extension agents who are familiar with farmers in the area. Actual field survey lasted four months from August to November, 1997. Farmers were met on their farms and interview conducted in Yoruba (the native language) which was translated to English for record purposes. After editing the returned copies of questionnaire, only 300 questionnaire were found useful for analysis. Table 6 shows the distribution of respondents in the study area.

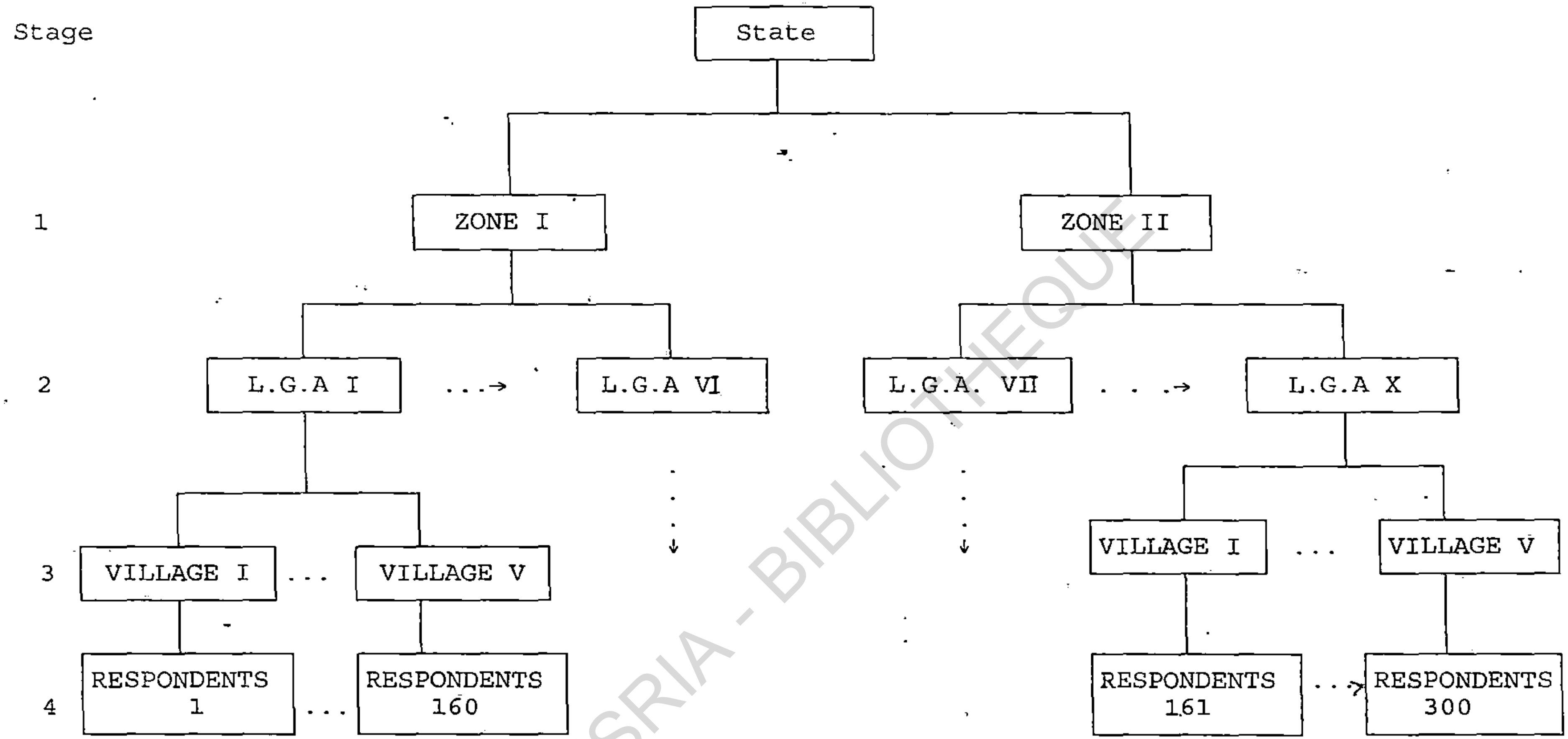


Fig.3: Respondents' sampling Procedure

TABLE 6

Distribution of respondents according to zone and Local Government Area (LGA)

Zone	LGA	Number of respondents (f)	Percentage (%)	Cumulative frequency (cf)
A. Rain forest	1.Irewole: Isokan/Irewole*	40	13.33	40
	2.Ilesa: West/East	41	13.67	81
	3.Atakunmosa: East/West	29	9.67	110
	4.Oriade*	24	8.00	134
	5.Ife South	26	8.67	160
	6.Egbedore	13	4.33	173
B. Derived savanna	7.Irepodun: Orolu/Irepodun*	53	17.67	226
	8.Ila: Ifedayo/Ila	26	8.66	252
	9.Ejigbo	21	7.00	273
	10.Odo-Otin*	27	9.00	300
	Total	300	100.0	_

Source: Field Survey, 1997

* indicates Focus Group Discussion (FGD) areas

3.4 Problems of data collection

Majority of the farmers were reluctant in being interviewed as they claimed that previous interviews granted by them have yielded no results. However, the intervention of the village extension agents and the title of the research study drew respondents attention, as they were very much interested in the fertilizer issue.

Farmers referred to weights/measures in the local way as most of them were illiterate. The extension officers assisted in meaningful interpretation of these concepts. Additionally, absence of good record keeping of farm operations called for respondents reliance on memory recall. Response error was however minimized with the use of records for the previous cropping season.

In view of respondents' cooperation in the data collection exercise, as prompted by the assistance of village extension agents, data collected for this study can be said to be highly reliable.

3.5 Analytical techniques

In processing data collected for the study, different analytical techniques were employed including Descriptive statistics, Correlation analysis, Tobit regression and Costs and Returns analysis. Descriptive statistics involving the use of tables, mean, frequency counts and percentages describe the variables in the study, while correlation technique was employed to examine the relationship among the factors influencing farmers' fertilizer adoption decisions. Other analytical techniques used are:

3.5.1 Costs and returns analysis

A partial budget approach to costs and returns analysis was employed in this study. According to Barlowe, et al. (1979), Horton (1982) and Olusi (1990), such analysis views the farm as a superstructure with basic resources of land, equipment and entrepreneurship, and in which technological inputs such as fertilizer can be used/varied without affecting the costs of the basic resources. It allows us to assess the impact of a change in the production system on a farmer's net income without knowing all his costs of production. Thus, these costs may be omitted from the computations. The partial budget analysis employed attempts to measure the costs and returns to fertilizer use in the study area. For instance, use of fertilizer technology increases production cost by the price and quantity of fertilizer and cost of application. The farmer actually wants to improve soil fertility in order to increase yield but his main concern is income. Thus, in deciding whether or not to adopt the technology, he will want to know the extent to which it will increase net income. It involves the estimation of gross margins or net returns per hectare between users and non-users of fertilizer in each agroclimatic zone. The gross margin was obtained using equation (9), while the rate of return to fertilizer use was estimated with equation (10).

$$G.M. = pq_1 - rx \qquad (9)$$

$$R_f = \frac{(pq_1 - rx) - pq_2}{rx} \qquad (10)$$

where,

G.M = gross margin (₦/ha)

p = average price of target crop (₦/kg)

q_1 = average crop yield (kg/ha) of fertilizer users

q_2 = average crop yield (kg/ha) of non-users of fertilizer

x = average quantity of fertilizer applied per hectare (kg).

r = average cost of fertilizer per hectare (₦)

R_r = rate of returns to fertilizer use (₦/ha) = $\delta NI/\delta VC$.

δNI = change in net income between users and non-users of fertilizer

δVC = change in the unit of expenditure (rx) between users and non-users of fertilizer.

The hypothesis tested is:

$H_0 : \mu_1 - \mu_2 = 0$

(there is no statistical difference in mean net returns earned by users and non-users of fertilizer)

$H_A : \mu_1 - \mu_2 \neq 0$ (does not support H_0) . . . . (11)

$$t = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad \text{. . . . . (12)}$$

where, X_1 = sample mean of fertilizer users

X_2 = sample mean of non-users of fertilizer

S_1^2 = variance of sample of fertilizer users

S_2^2 = variance of sample of non-users of fertilizer

n_1 = sample size of fertilizer users

n_2 = sample size of non-users of fertilizer

t_c = computed value of t-statistic

(The significance will be tested at 5% level of probability).

In order to ascertain the extent to which the size of the mean net return to fertilizer use is sensitive to changes in the value of fertilizer costs or yield levels (key parameters of net returns), a sensitivity analysis was employed for the two zones in the study location. This involved the computation of an Acceptable Minimum Rate of Return (AMRR) to determine the break-even points at which the economic use of a technology like fertilizer becomes established. The AMRR can be obtained by considering an Assumed Rate of Return to Management (ARRM) and the Cost of Capital (CC) for acquiring the technology. This is expressed as :

$$AMRR = CC + ARRM \quad (13)$$

In deciding whether to use a technology or not, a minimum rate of return to management (ARRM) of 1.0 (100%) is assumed to guarantee the adoption of the technology. This implies a rate of return which is at least 100% greater than the change in variable costs (δVC). This is because the ARRM is expected to be higher than those of other investments and high enough to cover the risks associated with the use of the technology. Similarly, farmers need money (capital) to buy the technology and if a farmer uses his fertilizer reserves for example, he forgoes income by not selling it . Thus, the Cost of Capital (CC) depends on (i) the annual rate of interest and (ii) the period over which capital is used (Barlowe, 1979; Horton, 1982). The changing levels of key parameters (cost and yield) are then examined vis-a-vis the AMRR to determine whether the use of the technology is worthwhile.

3.5.2 The Tobit regression model

To determine the effect of various explanatory factors on fertilizer technology adoption as well as the extent of use of the technology on adoption, this study follows from Rahm and Huffman (1984) and Adesina, et al. (1992).

Farmers' adoption decisions on intensification technologies are assumed to be based upon the strength of feeling of the ith farmer to adopt the technology. According to Rahm and Huffman (1984), farmers are assumed to make adoption decisions based upon an objective of utility maximization. If j represents various intensification technologies where $j=1$ for the new technology and $j=2$ for the old technology, then the non-observable and unavailable underlying utility function which ranks the preference of the ith farmer is given by $\mu(R_{ji}, A_{ji})$. Thus, the utility derivable from the various technology depends on R, which is a vector of farm and farmer-specific attributes/variables of the adopter and A, which is a vector of the attributes associated with the technology. Although the utility function is not observable, a linear relationship is postulated between the utility derivable from a jth technology and the vector of observed farm-, farmer-specific characteristics, X_i (e.g. age, gender, cropping system, etc.), the technology/resource-specific characteristics (e.g. farm size), tenure-specific characteristics (e.g. access to farm), institutional characteristics (e.g. extension contact), location-specific factors (e.g. agroecological zones), and a zero mean disturbance term, e_j:

$$\mu_{ji} = \beta_i X_i + e_{ji} \qquad j = 1, 2; \; i = 1, \ldots, n \qquad (14)$$

and $$X_i = F_i(R_i, A_i) \qquad (15)$$

Farm operators are assumed to choose a technology that gives them the largest utility. Thus, equation (15) does not restrict the function F to linear, such that as the utilities μ_{ji} are random, the ith farmer will select the alternative $j = 1$ if $\mu_{1i} > \mu_{2i}$ or if the unobservable (latent) random variable

$$Y^* = \mu_{1i} - \mu_{2i} > 0 \qquad (16)$$

Since the primary aim is to interpret the dependent variable in the model as the probability of making a choice, given information about X_i, there is need to use some notion of probability as the basis of the transformation. This involves translating values of X_i, which may range over the entire real line, into a probability which ranges in value from 0 to 1. A monotonic transformation is also required since it is desirable that the transformation should maintain the property that increases in X_i are associated with increases (or decreases) in the dependent variable for all values of X_i. According to Pindyck and Rubinfeld (1997), the cumulative probability function provides a suitable transformation. This is defined as one having as its value the probability that an observed value of a variable X_i (for every X_i) will be less than or greater than the threshold value. Since all probabilities lie between 0 and 1, the range of the cumulative probability function is the (0,1) interval. Hence, the standard cumulative normal distribution of $X_i\beta$ is expressed as:

$$F(x_i\beta) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{Y_i} e^{\frac{-s^2}{2}} ds$$

where, s. = a random variable which is normally distributed with mean zero and unit variance. Thus, the probability that $Y_i = 1$ (i.e. that the farmer adopts a technology) is a function of the independent variables:

$$P_i = P_r(Y_i=1) = Pr(\mu_{1i} > \mu_{2i})$$

$$= P_r(\beta_1 X_i + e_{1i} > \beta_2 X_i + e_{2i})$$

$$= P_r[e_{1i} - e_{2i} > X_i(\beta_2 - \beta_1)]$$

$$= Pr(\mu_i > X_i\beta)$$

therefore

$$P_i = P_r (Y_i = 1) = F_i(X_i\beta) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (18)$$

where;

P_r = a probability function

μ_i = a random disturbance term

$(e_{1i} - e_{2i})$; $\mu_i \sim N(0,\sigma^2 I)$

X = the n x k matrix of the explanatory variables

ß = a k x 1 vector of parameters to be estimated

$F(X_i\beta)$ = cumulative distribution function for μ_i evaluated at $X_i\beta$.

If Y^*_i is assumed to be normally distributed, then consistent estimates can be obtained by performing a Tobit estimation using an iterative Maximum Likelihood algorithm (White, 1978). The use of maximum likelihood estimation guarantees that the parameter estimates will be asymptotically efficient and the appropriate statistical tests can be performed. This means that all the parameter estimators are asymptotically normal, such that test of significance analogous to the regression t-tests can be performed (Pindyck and Rubinfeld, 1997). The likelihood function is of the form:

$$L = \sum_{t=1}^{S} \log[1 - F(\sigma Y_t - I_t)] + \sum_{t=S+1}^{N} \log f(\sigma Y_t - I_t) \quad \ldots\ldots \quad (21)$$

Where F_i and f are the cumulative normal distribution function of μ_i, and T is the critical (cut-off) value which translates $Y_i^* > T$, as farmer adopts, and $Y_i^* \leq T$, as farmer rejects adoption.

3.5.3 Decomposition of fertilizer adoption elasticities

The single-limit Tobit decomposition framework suggested by McDonald and Moffit (1980) was used to assess strategies aimed at enhancing soil fertility in the study area. This was done by examining the effect of changes in variables of specific factors (i.e farmer specific, resource-, property right-, institutional- and environmental specific) on fertilizer adoption probabilities and use intensities.'

According to Tobin (1958), the expected value of the dependent variable (Y) in the Tobit model is given by:

$$EY = X\beta F(z) + \sigma f(z) \quad \ldots\ldots \quad (22)$$

Where $z = \frac{X\beta}{\sigma}$, normalized index

f(z) = standard unit normal density function

F(z) = cumulative standard normal distribution function.

The expected value of Y for observations above the limit, y^*, is $X\beta$ plus the expected value of the truncated normal error term (Amemiya, 1973):

$$Ey^* = E(Y \backslash Y > 0)$$

$$= E(Y \backslash \mu > -X\beta)$$

$$= X\beta + \sigma f(z)/F(z) \quad \ldots\ldots\ldots\ldots \quad (23)$$

Thus, McDonald and Moffit (1980); Adesina and Zinna (1993) posited that the basic relationship between the expected value of all observations, EY, the expected value conditional upon being above the limit, Ey^*, and the probability of being above the limit F(Z), is:

$$EY = F(z).Ey^* \quad \ldots\ldots\ldots\ldots \quad (24)$$

They employed a useful decomposition of these marginal effects under the single-limit Tobit which can be extended to the two-limit situation. Thus for a given change in the level of specific characteristics in the fertilizer adoption model (equation 20), the effects on farmers adoption behaviour can be disaggregated into two parts; by differentiating equation (24) with respect to specific factor change:

$$\partial EY/\partial X_i = F(z)(\partial Ey^*/\partial X_i) + Ey^*(\partial F(z)/\partial X_i) \quad \ldots\ldots\ldots\ldots \quad (25)$$

Equation (25) can be converted into elasticity forms by multiplying through by

X_i/EY : $(\partial EY/\partial X_i)X_i/EY = F(z)(\partial Ey^*/\partial X_i)X_i/EY + Ey^*(\partial F(z)/\partial X_i)X_i/EY$

Rearranging according to equation (4):

$$(\partial EY/\partial X_i)X_i/EY = (\partial Ey_*/\partial X_i)X_i/Ey^* + (\partial F(z)/\partial X_i)X_i/F(z) \quad \ldots\ldots\ldots \quad (26)$$

Therefore, the effect of a change in an independent variable, X_i, on $E(Y_i/X_i)$ in elasticity form comprises two effects: (1) the change in the elasticity of the probability of being an adopter (i.e effects on the probability of being above zero), (ii) the change in the elasticity of use intensities of fertilizer technology, for those farmers that are already adopters (i.e effects conditional upon being above zero). The relative magnitudes of these two quantities is an important indicator with substantive economic implications (Tobin, 1958).

It should be noted that Tobit beta (β) coefficients do not measure the correct regression coefficients for observations above the limit as the effect of a change in X_i on Y^* is not equal to βi (McDonald and Moffit, 1980). The estimated coefficient vector β is simply the marginal effects of the independent variables on the latent variable y_* (not the observed y). This can be shown following from equation (23):

$$\partial Ey^*/\partial X_i = \beta_i + (\sigma/F(z))\partial f(z)/\partial X_i - (\sigma f(z)/F(z)^2)\partial F(z)/\partial X_i \quad \ldots\ldots\ldots\ldots \quad (27)$$

Thus, the effect of a change in X_i on y_i^* is not equal to βi (equation 27). This is true only when $X = \infty$, in which case $F(z) = 1$ and $f(z) = 0$, which will of course not hold at the mean of the sample or for any individual observation (Judge, et al. 1988).

3.6 Description and measurement of variables

Seventeen variables were proposed and reasons for their inclusion offered. The expected signs of their coefficients were predicted a priori based on past studies, economic theory, and/or logical reasons.

i. The dependent variable (Y_i): This is a continuous and discrete variable for the ith farmer. The continuous part is measured by the quantity of fertilizer in kg/ha used; while the discrete part takes on a value of either zero or one. A farmer is scored one if he adopts the technology, and zero if otherwise. It is hypothesized that this decision is influenced by the independent variables.

ii. The independent variables: These include all those variables that are associated with fertilizer technology adoption along with those whose evidences from previous studies have been inconsistent. They include farmers characteristics, resource/technology characteristics, tenure, institutional and location-specific characteristics.

3.6.1. Expected signs of independent variables

3.6.2 Farmers' characteristics

Farmers age (X_1):

This is the age of the ith farmer measured in years. Evidence from previous studies shows that the age of an individual affects his mental attitude to new ideas and may influence adoption in one of several ways. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk and adopt a technology because of their longer planning horizons (Gould, et al. 1989; (Polson and Spencer, 1991). The older the farmer, the less likely he adopts new ideas as he gains more confidence in his old ways and methods. On the other hand, older farmers may have more experience, resources or authority that may give them more possibilities for trying a new technology. Generally, there is no agreement on the sign of this variable in the adoption literature as the direction of the effect is location or technology specific (Adesina, et al. 1992).

Gender of farmer (X_2):

Women farmers are generally perceived to face more constraints on their farms and this will negatively affect their adoption of new ideas. This variable is expected to have a negative sign on the dependent variable. Male farmers are scored 1, while female farmers score zero.

Level of literacy (X_3):

Education is a measure of the ability to assess new technology. Nelson and Phelp (1966) posited that education and experience are two common measures of human capital (the ability to acquire and process information about a new technology) which may be used as proxies for risk. It is therefore expected to have a positive impact on the decision to use fertilizer. Uncertainty and risk aversion have been shown to decrease the propensity for individual to adopt technologies (Feder et al., 1985). However, while measuring an individual's risk perceptions and risk aversion is difficult, economic theory posits that their perceptions are influenced by information and human capital. Thus, following earlier empirical findings, the maintained hypothesis is that level of literacy is positively related to adoption behaviour. It is measured as number of years spent in school.

3.6.3 Resource/Technology characteristics:

Household size (X_4):

This comprises all the people living under the same roof and who eat from the same pot with the ith farmer. Some previous studies show this variable to be positively related to adoption behaviour as it provides a larger supply of family labour while other studies view that this variable has a negative relationship with adoption since increased household size increases consumption pressure. Thus, it is difficult to predict this variable 'a priori'. The number of persons in the household measures the variable.

Farm size (X_5):

This variable is expected to have a positive relationship with fertilizer adoption decision as shown by various studies (Nelson and Batie, 1987; Akinola, 1987; Polson and Spencer, 1991). This is because, the larger the farm size cultivated, the higher the tendency to adopt. The variable is measured in hectares.

Net farm income (X_6):

This is the net farm income per hectare of the ith farmer. Since this variable can be viewed as a proxy for wealth, the options to acquire and use technologies may be expanded by it (Rogers, 1983). It is included to determine whether the potential adopters' social status and purchasing power have an effect on technology use. This is because wealthy farmers have sufficient resources to absorb the cost and risk of failure of the innovation. The variable is expected to have a positive relationship with adoption, as the farmer tends to experiment with new ideas that tend to increase net farm income. This variable is measured in naira (₦).

3.6.4 Institutional factors:

Membership in association/Cooperative society (X_7):

Cooperatives enhance the interaction and cross-fertilization of ideas among farmers. The influence of credit for instance, on fertilizer use is measured in terms of membership in cooperatives as its use is promoted by cooperatives. If a farmer is a member of a cooperative, credit and fertilizer are provided to him as a package. Thus, membership in a cooperative is very important in the adoption of a technology since it indicates higher socio-economic status. Having access to other sources of credit may not have much effect on fertilizer purchase because a farmer may not know where to buy it. A positive sign is hypothesized for this variable. It is measured as a dichotomous variable with respondents membership attracting one and non-membership, zero.

Extension contact (X_8):

This variable incorporates the information which farmers obtain during the year on the importance and application of new innovations through counselling and demonstrations by extension agents on a regular basis. The impact of this information on adoption decisions vary, however according to its channel, sources, content, motivation and frequency (Ereinstein, 1997). Thus, based on the innovation-diffusion literature, the expected sign for the coefficient of this variable is positive. It is measured as a dichotomous variable with respondents contact during the period recorded as one, and zero otherwise.

Availability of fertilizer (X_9):

The adoption of a technology is promoted by its availability since it is obvious that the technology will not be used unless made available in the right quantity, form and time. This variable will determine whether farmers adoption behaviour of the potential adopter is supply-constrained. It is measured as a dichotomous variable with adequate technology supply attracting one and inadequate supply, zero. The variable is hypothesized to have a positive sign.

Distance of fertilizer source from farm (X_{10}):

Most farmers that adopt new innovations do so because of the proximity of the innovation distribution source. Thus, the response of potential adopters will depend upon the costs associated with acquiring the technology. These costs include transportation and risk costs which increases as the distance travelled by the farmer to purchase the technology increases. The greater the distance between the input buying station and the respondents' farm, the higher the acquisition cost. The variable is therefore expected to have a negative influence on farmers' adoption behaviour. It is measured in kilometers (km).

Cropping practice (X_{11}):

This variable is expected to have a positive relationship with adoption behaviour. This is because the cropping system employed by a farmer may suggest the need for use of some technologies (Feder et al., 1985). For example, sole cropping is considered suitable for easy use of machinery (e.g. tractors) than mixed cropping. This variable is measured as dichotomous with sole cropping scored 1 and mixed cropping, 0.

3.6.5 Property right characteristics:

Mode of land acquisition (X_{12}):

Acquisition of land through primary access (inheritance and purchase) is expected to bear positively on the adoption of fertilizer technology. The variable is measured as dichotomous with primary access awarded 1 and other forms of land acquisition (secondary access), zero.

Security perception of farmland (X_{13}):

If farmer perceives that his farmland is secured, there is tendency to invest in land improvement techniques. This variable is therefore expected to positively influence farmers' adoption decisions. It is measured as a dichotomous variable with positive perception, one and zero if otherwise.

Years of continuous use rights (X_{14}):

The longer the period over which farmland is being used, the greater the farmers confidence in using land improvement technologies. This variable is therefore hypothesized to positively influence farmers adoption decisions. It is measured in years.

Years of fallow. (X_{15}):

Long periods of fallow suggests abundance of cultivable farmlands, while pressure for short fallow periods brings about investment in land improvement to retain soil fertility as well as investment in capital to expedite land preparation and to increase land productivity (Feder, et al. 1987). This variable is therefore expected to influence farmers adoption decisions negatively, such that as years of fallow increases, the tendency to adopt land improvement technologies decreases. It is measured in actual number of years.

3:6.6 Location factors (X_{16}):

An agroclimatic location that is much more prone to soil fertility depletion or soil erosion problems will encourage farmers' use of land quality improvement techniques like fertilizer while zones that are less disturbed by these problems consume little fertilizer. The expected sign on this variable is positive and it is measured as a dichotomous variable with rain forest zone scored, 1 and derived savanna zone, 0.

The expected impacts of the explanatory variables can be summarised as:

$$\frac{dy}{dx_{ki}} > 0 \quad \text{where } ki = 3,5,6,7,8,9,11,12,13,14,16$$

$$\frac{dy}{dx_{ki}} < 0 \quad \text{where } ki = 2,10,15$$

and $$\frac{dy}{dx_{ki}} \gtrless 0 \quad \text{where } ki = 1,4$$

CHAPTER FOUR

4.0 EMPIRICAL RESULTS I: SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

4.1 Age structure

The age distribution of respondents in the survey location is presented in Table 7.

Respondents' ages varied between eighteen and seventy-three years with a mean of fifty-one years for users and non-users of fertilizer in the study area. Fertilizer users in the rain forest and derived savanna zones recorded a mean of about forty-eight and fifty-four years respectively while average ages of fifty-two and fifty-one years were similarly recorded for non-users of fertilizer. The difference between the mean age of user and non-user respondents in each of the two zones was not statistically significant (Table 7). This may suggest that respondents' mean ages for users and non-users of fertilizers are about the same in the study area. The mean age recorded for each category of respondents generally suggests that respondents in the study area were young.

4.2 Gender distribution

Respondents' distribution according to gender and agroclimatic zone is shown in Table 8. Ninety-one percent of the respondents in the study area were male. About ninety-two percent of the total number of respondents were users of fertilizer. On the other hand, from a total of twenty-seven female respondents in the survey location, only about nine percent were fertilizer users (Table 8). This shows that a larger proportion of male respondents use fertilizer in the survey location. A similar trend was observed for each of the agroclimatic zones. Since men generally have easier access to farm resources, this may have some positive implications on farmers adoption decisions in the survey location.

TABLE 7

Age (years) of respondents by zone

Zone	Rain Forest		Derived Savanna		Overall	
	Users	Non-users	Users	Non-users	Users	Non-users
Number of respondents	116	44	97	43	213	87
Mean	47.83	51.83	53.64	50.63	50.49	50.87
Variance	126.21	96.38	122.18	139.33	132.12	116.30
Mode	60.00	55.00	50.00	45.00	50.00	55.00
Median	48.00	53.50	52.00	50.00	50.00	52.00
Minimum	18.00	29.00	30.00	26.00	18.00	26.00
Maximum	72.00	70.00	73.00	72.00	73.00	72.00
t_c	1.81		1.42		0.27	

Source: Field survey, 1998

4.3 Household size

The number of dependents residing with respondents in the study area is as shown in Table 9. Respondents' household size ranged between one and twenty-five in the two zones combined, with a mode of four. The difference between the means of household size of fertilizer users and non-users is not statistically significant at the 5% level in each of the agroclimatic zones and in the study area in general (Table 9).

The high household size in the area suggests increased consumption pressures. It may however, encourage the adoption of yield enhancing technologies to meet the consumption needs of the household.

4.4 Farm size

The distribution of respondents according to farm size (ha) cultivated is presented in Table 10. Respondents' farm size varied between 0.04 and 2.80 hectares in the study area with a mean of 0.58 and 0.62 hectares respectively for fertilizer users and non-users. This may suggest that respondents in the survey location were generally smallholder farmers. The difference between the average farm size cultivated by users and non-users of fertilizer in the study area is not statistically significant. Except for fertilizer users in the rain forest with modal farm size of 0.40 hectares, respondents in other areas recorded a modal farm size of 0.60 hectares. According to Akinola (1987), these small farm sizes may negatively influence farmers adoption decisions. However, when this is viewed with the continuous use of farmland (Table 16) and the reduced fallow period (Table 17), respondents' farm sizes in the area may be found to enhance farmers' adoption of technologies such as fertilizer.

TABLE 8

Distribution of respondents according to gender and ecological zone.

Zone	Male		Female	
	Absolute Frequency	Percentage (%)	Absolute Frequency	Percentage (%)
a. Rain Forest:				
Users	100	86.21	16	13.79
Non-users	37	84.09	07	15.91
b. Derived Savanna:				
Users	95	97.94	02	02.06
Non-users	41	95.35	02	04.65
c. Overall:				
Users	195	91.55	18	08.45
Non-users	78	87.66	09	10.34

Source: Field survey, 1998

TABLE 9

Distribution of respondents according to household size (number of members)

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Mean	6.27	7.32	5.85	4.93	6.08	6.14
Variance	8.23	15.80	9.22	7.31	19.00	12.91
Mode	6.00	7.00	4.00	3.00	4.00	4.00
Median	6.00	7.00	5.00	4.00	6.00	5.00
Minimum	1.00	3.00	1.00	1.00	1.00	1.00
Maximum	19.00	25.00	18.00	16.00	19.00	25.00
t_c	1.60		1.78		0.15	

Source: Field survey, 1998

4.5: Level of schooling

The level of education attained by respondents in the study area is presented in Table 11.

Thirty-eight (17.8%) of the respondents who used fertilizer in both the rain forest and derived savanna zones did not receive any formal education, while 23 (26.4%) of the non-using respondents fall into this group. Seventy-four (34.7%) respondents representing forty-one users and eight non-users in the rain forest zone and thirty-three users and six non-users in the derived savanna zone received secondary education and above. This shows that a relatively larger number of respondents who used fertilizer in the study area were literate. The mean years of schooling was approximately 4.0 and 3.0 years respectively for users and non-users of fertilizer in the rain forest zone. The difference in mean years of schooling between the two groups of respondents is statistically significant at the 5% level (Table 11). In the derived savanna zone however, the difference in mean literacy level between users and non-users was found not to be significant. This shows that mean literacy level of users and non-users of fertilizers in the derived savanna zone and in the two zones combined, was statistically the same.

4.6: Access to farmland

Respondents' pattern of land ownership according to agroclimatic zones is presented in Table 12.

One hundred and three (88.8%) and ninety-three (95.9%) respectively of fertilizer-using respondents in the rain forest and derived savanna zones have primary access to their farmland, while thirteen (11.2%) and four (9.1%) of the fertilizer using respondents similarly acquired their farmland through secondary access. A larger proportion of respondents who use fertilizer acquired their farmland through primary access . Primary access to farmland comprises purchase and inheritance, while secondary access includes gift, borrowing, pledging, leasing and clearing of unallocated land (Table 12).

TABLE 10

Respondents' farm size (Ha)

	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Mean	0.58	0.58	0.59	0.65	0.58	0.62
Variance	0.15	0.08	0.09	0.24	0.12	0.16
Mode	0.40	0.60	0.60	0.60	0.60	0.60
Median	0.48	0.84	0.60	0.60	0.48	0.60
Minimum	0.04	0.20	0.10	0.08	0.04	0.08
Maximum	2.00	1.40	1.60	2.80	2.00	2.80
t_c	0.13		0.74		0.70	

Source: Field survey, 1998.

TABLE 11

Level of education

Level	Years	Rain forest Users (%)	Rain forest Non-users (%)	Derived savanna Users (%)	Derived savanna Non-Users (%)	Overall Users (%)	Overall Non-Use (%)
Never been to school	0	21	14	17	09	38	23
Elementary school	1 - 5	34	18	26	22	60	40
Adult education/modern school	6 - 7	20	04	21	06	41	10
Secondary school	8 - 13	23	05	19	04	42	09
Tertiary institution	> 14	18	03	14	02	32	05
Total (n)		116	44	97	43	213	87
Mean year of schooling (X)		3.83	2.98	3.50	3.58	3.68	3.28
Variance (s)		4.86	2.95	4.04	3.25	4.50	3.16
t_c		2.58*		0.25		1.67	

Source: Field survey, 1998

* significant at 5% level

TABLE 12

Property right regimes and land acquisition pattern

Item	Primary access		Secondary access				
	Purchase	Inheritance	Gift	Borrow	Pledge	Lease	Unauthorised
Rain forest							
Users	12	91	02	06	0	05	-
Non-users	07	05	05	14	1	12	-
Derived savanna							
Users	14	79	01	02	0	01	-
Non-users	02	23	02	10	0	03	3
Overall							
Users	26	170	03	08	0	06	-
Non-users	09	28	07	24	01	15	3

Source: Field survey, 1998

4.7 Distance of farm location

The distance (km) of respondents' farms from dwelling is as shown in Table 13.

The distance of respondents' farm from their dwellings ranged between 1.0 and twenty kilometers (Km) in the study area. Mean distance was 3.53 and 3.34 km for users and non-users of fertilizer respectively in the rain forest zone , while the derived savanna zone recorded a mean of 5.14 and 6.09 km respectively for users and non-users. The difference between the average distance of respondents' dwelling from farm for users and non-users of fertilizer is not significant in each of the zones.

In general, however, for the two zones combined, significant differences were found to exist. This implies that farmers who use fertilizer in the study area have to trek shorter distances to their farms as compared to non-users. Respondents' farms in the survey location were not farther than twenty kilometers from their dwelling. This may possibly encourage farmers to use yield increasing technologies. This view is supported by FGD results that farmers usually find it difficult to carry fertilizer to their farms when the farm distance is far. This, they claim, is because no good roads link their farm sites with their dwellings.

4.8 Distance of fertilizer source

The distance of respondents' farm from fertilizer supply source is shown in Table 14.

The distance of farm from fertilizer supply sources varied between 0.05 and 75 km, with a mean of 11.5 kilometers for the study area. While this distance ranges between 0.05 and seventy-five kilometers with 13.9 mean for the rain forest zone, a range of between two and twenty-four kilometers, with a mean of 8.4 was recorded for the derived savanna. The difference in mean distance for the two zones was found to be highly significant ($t_c = 7.60$). This shows that fertilizer supply points are farther away from respondents farms in the study area, particularly in the rain

TABLE 13

Distance (km) of farm from dwelling

	Rain forest		Derived savanna		Overall	
Distance (Km)	Users	Non-users	Users	Non-users	Users	Non-users
Mean	3.53	3.34	5.14	6.09	4.26	5.21
Variance	6.03	18.37	12.00	12.56	9.36	16.10
Mode	2.00	2.00	2.00	10.00	2.00	2.00
Median	3.00	2.50	5.00	6.00	3.00	4.00
Minimum	1.00	1.00	1.00	1.00	1.00	1.00
Maximum	16.0	20.00	19.00	15.00	19.00	20.00
t_c	1.19			1.47		2.21*

Source: Field survey, 1998

* Significant at 5% level of probability

TABLE 14

Distance (Km) of farm from fertilizer supply source

Zone / Item	Rain forest	Derived savanna	Overall
Mean	13.91	8.40	11.46
Variance	30.06	25.46	27.46
Minimum	0.05	2.00	0.05
Maximum	75.00	24.00	75.00
t_c		7.60*	

Source: Field survey, 1998

* Significant at 1% and 5%

forest zone and this has implications on the total costs incurred on farm inputs (including fertilizer). Focus group discussion findings however revealed that respondents in the study area generally transport their fertilizer bags home first and then move the required quantity to their farms therefrom as when needed. Thus, distant farms are capable of discouraging farmers use of fertilizer.

4.9 Farmland security

Respondents' perception of the security of their farmland is presented in Table 15.

One hundred and sixty-two (54.0%) of the respondents in the study area who perceived the security on their farmland as being adequate used fertilizers on their farms. Respondents however, claimed that except for long term investments, tenure arrangements are not usually considered in their investment decisions. From this total, the rain forest zone accounted for forty-six percent while the derived savanna zone accounted for fifty-four percent. When compared with the proportion of non-users, a larger proportion of fertilizer-using respondents were found to perceive adequate security of their farmland in the two zones. Thus, security perception of respondents' farmland may possibly encourage the use of modern technological inputs in the study area.

4.10 Years of continuous use of farmland

The length of time respondents continuously use their farmland is as shown in Table 16.

The mean periods for the continuous use of farmland by users and non-users of fertilizer were approximately thirteen years. No statistically significant differences were found between the two groups of respondents in each of the agroclimatic zones. This has implications on the need for soil improvement techniques and hence, adoption of yield increasing technologies in order to ensure continuous farm production over time in the survey location.

TABLE 15

Farmland security

Item	Adequate				Inadequate			
Zone	Users		Non-users		Users		Non- users	
	N	(%)	N	(%)	N	(%)	N	(%)
Rain forest	74	46.0	26	41.0	42	82.0	18	75.0
Derived savanna	88	54.0	37	59.0	09	18.0	06	25.0
Overall	162	100.0	63	100.0	51	100.0	24	100.0

N number of respondents

Source: Field survey, 1998

TABLE 16

Years of continuous cropping

	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Mean	12.80	11.82	12.66	13.49	12.74	12.64
Variance	144.91	163.41	112.46	154.92	129.53	158.07
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	54.00	42.00	46.00	46.00	54.00	55.00
t_c	0.44		0.38		0.06	

Source: Field survey, 1998

4.11 Duration of fallow

The most recent length of time for which respondents' farmland were left to fallow is as shown in Table 17.

The mean number of years to which respondents currently put their farmland under fallow is approximately two years in the study area. The difference between the mean duration of fallow for users and non-users of fertilizer was not statistically significant (Table 17). Except for non-users of fertilizer in the derived savanna zone who recorded a modal period of one year for fallow, other respondents recorded a mode of zero years. This implies that some respondents do not put their farmland to fallow at all. It may further show the increasing rate at which land is being used and its consequent negative effect on soil fertility. This view is supported by all FGD results in which respondents claimed that fallow period has been drastically reduced over the years leading to frequent cultivation of the same piece of land for longer periods. Thus, adoption of land intensification techniques becomes imperative.

4.12 Off-farm income

The income earned by respondents from other engagements apart from farm work is shown in Table 18. The average non-farm income earned by users of fertilizers in the study area was₦ 26,789 per annum while non-users earned₦ 19,442. The difference between the average off-farm income earned by fertilizer-using respondents in the derived savanna zone was significant at the 5% level, this was not applicable in the rain forest zone. This implies that fertilizer users earned higher off-farm income than non-users in the derived savanna zone, while almost equal amount was earned by users and non-users in the rain forest zone. This may provide an alternative source of fund for the use of yield improving technologies. It also shows that farmers in the study area do not depend solely on their farm income to earn a living.

TABLE 17

Duration (year) of most recent fallow

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Mean	1.47	2.18	1.50	1.42	1.48	1.81
Variance	3.14	7.97	2.67	2.30	2.91	5.25
Mode	0.00	0.00	0.00	1.00	0.00	0.00
Median	1.00	1.00	2.00	0.00	0.00	1.00
Minimum	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	10.00	10.00	10.00	10.00	5.00	10.00
t_c	0.91		0.27		1.20	

Source: Field survey, 1998

TABLE 18

Off-farm income (₦/annum)

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Mean	24818.69	18961.68	29145.08	19933.88	26788.93	19442.20
Variance	74568	47276	63396	40885	69171	43629
Mode	764	384	665	481	264	384
Median	12313	98600	95150	73625	12313	98600
Minimum	13800	384	665	487	13800	384
Maximum	14600	13259	2234	11304	18020	12560
t_c	1.41		3.39*		2.56*	

* Significant at 5% level

Source: Field Survey, 1998

4.13 Cropping practice

Common cropping practices employed by respondents in the survey location is as in Table 19. A larger proportion of respondents who practiced sole cropping in the study area used fertilizer technology as compared with non-users. Twenty-two and twelve respondents were respectively recorded for the study area (Table 19). Sole cropping may therefore influence respondents' adoption decisions. Generally, however, majority of the respondents in the two agroclimatic zones practiced mixed cropping . This may be a risk aversion approach employed by respondents in the study area. FGDs corroborate this view in that respondents claimed that sole cropping practice was limited to only some plots, particularly maize, since they have to grow other crops to prevent total loss in case of any production hazard.

4.14: Use of fertilizer technology

Respondents' current and previous use of fertilizer technology on their farms is as shown in Table 20. Ninety-three percent of the respondents in the study area have had course to use fertilizers on their farmland, while only seven percent have never used the technology. Out of the total figure of users in the study area, 90.6% and 95.7% respectively of respondents in the rain forest and derived savanna zones have used fertilizer before on their farms, while 72.5% and 69.3% respectively currently use it. The difference in proportion between previous users and current users of the technology in the two zones was not significant at the 5% level ($t_c = 0.55$). This may suggest that almost equal number of respondents who have used fertilizer before currently use the technology.

TABLE 19

Respondents' cropping practice (number of respondents)

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Sole	18	12	04	0	22	12
Mixed	98	32	93	43	191	75
Overall	116	44	97	43	213	87

Source: Field survey, 1998

TABLE 20

Respondents' use of fertilizer technology

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Previous users						
Number of respondents (%)	90.6	9.4	95.7	4.3	93	7
Current users						
Number of respondents (%)	72.5	27.5	69.3	30.7	71	29

Source: Field survey, 1998

FGD findings however, revealed that unavailability of the input may have been responsible for this. Additionally, farmers in the study area were said to be particularly interested in applying fertilizer to their maize plots even though they mainly grew maize either as sole or mixed. Among the respondents who were yet to use the technology in the two zones, some ascribed their non-use to scarcity and high cost of the technology, while others claimed that they could still leave their farmland to fallow for some reasonable number of years.

Generally, however, a larger number of respondents used fertilizer in the study area in spite of the present economic implications on its use. FGDs corroborate this finding as all the participants acknowledged the yield enhancing capability of inorganic fertilizers in the study area. Participants also claimed that use of fertilizer was not specifically aimed at enhancing soil fertility but mainly targeted towards increased farm yield and income levels.

4.15: Use of other technologies

Respondents' involvement in the use of other soil fertility enhancing technologies apart from inorganic fertilizer is shown in Table 21. Organic manure, alley cropping and tree planting are some of the other forms of technologies used in the study area.

Only twenty-one (7.0%) of the respondents in the study area used organic manure. The rain forest zone accounted for fourteen (8.8%) of this total while the derived savanna zone recorded seven (5.0%). The difference in the proportion of manure-using respondents in the two zones was not statistically significant at 5% level (t_c=1.28).

Based on findings from FGDs, the low use of manure by respondents in the study location was attributed to the inconveniences associated with its use, as well as the large quantity requirement per unit land area. Respondents claimed that in spite of the relatively free acquisition of manure from poultry farmers especially, it can only be reasonably used on small-sized and non-distant farm plots . Its use becomes necessary when inorganic fertilizer is not available at all. Respondents however recognize the use of manure as an alternative to fertilizer.

Alley farming practice is embarked upon by fourteen (4.7%) respondents in the study area. Ten (6.3%) of this total was accounted for by respondents in the rain forest zone while only four (2.9%) respondents used the technology in the derived savanna zone. The difference in the proportion of respondents who practiced alley farming in the two zones was not statistically significant at 5 % level (t_c=1.39). Thus, almost equal number of respondents practiced the technique in the two zones. The respondents claimed that this practice was introduced to them as an alternative to inorganic fertilizer used by researchers from IITA and officials of the state's Ministry of Agriculture and Natural Resources (MANR). While seven (70.0%) of the ten respondents who practiced alley cropping in the rain forest zone claimed to have spent one and half years on the practice, the remaining three (30.0%) started nine months ago. The four respondents in the derived savanna zone however, claimed it was introduced to them only about three months ago.

A relatively larger number of respondents have forest trees on their farmland in the study area. From a total of sixty-six respondents, forty-six (69.7%) and twenty (30.3%) respondents respectively have forest trees in the rain forest and derived savanna zones. However, only a few of the respondents use tree leaves purposively to enhance soil fertility while majority use it as boundary markers and for commercial purposes.

Thus, the most common technologies in the study area in descending order of importance are inorganic fertilizers, tree planting, organic manure and alley farming practice. The technologies were also being used together in different combinations (Table 21). Focus group discussions revealed that apart from fertilizer, other technologies were applied on just a small portion of cultivated land in the study area with virtually none of them applied to the maize plots. Participants further claimed that they have been used to inorganic fertilizer in such a way that other technologies become difficult to experiment with, moreso as similar problems of scarcity affecting current fertilizer use may befall these other technologies.

4.16: Location of fertilizer supply

The supply points for fertilizer to respondents according to agroclimatic zones is as shown in Table 22.

The major sources of fertilizer supply to farmers in the study area was through the Osun State Agricultural Development Project (OSSADEP) accounting for one hundred and ninety-seven (92.5%) of the respondents who currently use fertilizer. Thirteen (6.1%), nine (4.2%) and twelve (5.6%) of the respondents obtained their fertilizer supply through Farmers' service centre, Government Task force on fertilizer sales and Market respectively. From the total of one hundred and sixteen users of fertilizer in the rain forest zone, one hundred and ten (94.8%), nine (7.8%), four (3.4%) and nine (7.8%) of the respondents obtained their fertilizer supply through OSSADEP, Farmers service centre (farmers union), Government Task force on fertilizer sales and Markets respectively in the rain forest zone.

TABLE 21

Respondents' use of other soil fertility enhancing technologies

Zone / Technology	Rain Forest Users*	(%)	Derived Savanna Users*	(%)	Overall Users*
Organic manure	14	66.7	07	33.3	21
Alley farming	10	71.4	04	28.6	14
Tree planting	46	69.7	20	30.3	66
Fertilizer/Organic manure	07	58.3	05	41.7	12
Fertilizer/Alley farming	02	100.0	-	-	02
Fertilizer/Tree planting	25	75.8	08	24.2	33
Organic manure/Alley farming	05	62.5	03	37.5	08
Organic manure/Tree planting	12	57.1	09	42.9	21
Alley farming/Tree planting	05	83.3	01	16.7	06
Fertilizer\Organic manure/Alley farming	01	100.0	-	-	01
Organic manure/Alley farming/Tree planting	04	57.1	03	42.9	07
Fertilizer/Organic manure/Alley farming/Tree planting	-	-	-	-	-

Source: Field survey, 1998

* Multiple responses

TABLE 22

Sources of fertilizer supply to the respondents

Zone	OSSADEP		Farmers service centre		Government Task force		Market	
	Frequency	(%)	Frequency	(%)	Frequency	(%)	Frequency	(%)
Rain forest	110	94.8	9	7.8	4	3.4	9	7.8
Derived savanna	87	89.7	4	4.1	5	3.2	3	3.1
Overall	197	92.5	13	6.1	9	4.2	12	5.6

Source: Field survey, 1998

* Multiple responses

4.17 Perception of soil erosion problems

Soil erosion was identified as a constraint to farmers in the study area . Farmers therefore expressed their perception of the problem as shown in Table 23.

About eighty-two percent of the fertilizer-using respondents in the rain forest zone claimed having soil erosion problems on their farmland, while fifty-eight percent made a similar claim in the derived savanna zone. The difference in the proportion of fertilizer users who perceived soil erosion problems in the two zones was highly significant at the 5% level (t_c=4.69). This may imply that a larger proportion of respondents who used the technology in the rain forest zone have their farmland threatened by soil erosion problems than in the derived savanna zone. This higher proportion may however, have implications on the rate of degradation in the rain forest zone, which thereby calls for use of land improvement techniques. This view was supported by FGDs in which respondents, especially in the rain forest zone, claimed to employ techniques such as ridging, tree planting, cross-bars and channelling as soil erosion control measures on their farms.

4.18 Social organizations

Respondents' membership of social organisations is shown in Table 24.

Respondents in the study area belonged to one or more forms of social organisations existing in their locality. The major organisations include: Cooperatives, Farmers union and Esusu in descending order of membership number for the study area. Higher number of respondents who use fertilizers belonged to the various social organisations.

Respondents claimed to have joined these associations in order to obtain credit for their farm operations as well as information on farm input supplies. This may therefore have some positive implications on their fertilizer adoption decisions.

TABLE 23

Respondents' perception of soil erosion problems

	Rain forest		Derived savanna		Overall	
Soil erosion perception	Users (%)	Non-users (%)	Users (%)	Non-users (%)	User (%)	Non-users (%)
Perceived:						
Number of Respondents (%)	82.0	57.0	58.0	63.0	71.0	60.0
Not perceived:						
Number of Respondents (%)	18.0	43.0	42.0	37.0	29.0	40.0
Total number of users	116	44	97	43	213	87

Source: Field survey, 1998

4.19 Extension contact

The number of respondents who have had contacts with extension agents is shown in Table 25. Eighty percent and seventy percent respectively of users and non-users of fertilizers had contact with extension agents in the rain forest zone. The difference in proportion of the two groups of respondents was not significant at the 5% level (t_c=1.32). However, in the derived savanna zone and the study area as a whole, the difference in proportion was statistically significant at 5% (t_c=2.96). This may show that the number of respondents who used fertilizers in these areas had contact with extension agents. This according to Brown (1981) may imply that extension contact is capable of enhancing farmers adoption decisions in the survey location.

4.20: Capital sources

Respondents' sources of capital for farm operations in the study location is shown in Table 26. The main sources of capital to respondents in the study area include institutional (e.g. bank) and non-institutional (e.g. personal savings, friends and relatives and money lenders) sources. Majority of respondents who used fertilizers in the study area mainly depended on personal savings and money lenders for their farm operations. This, according to FGDs, was due to the high rates of interest charged by commercial banks, the inability of friends and relatives to provide needed fund, and banks untimely release of loanable funds. Some respondents claimed to use bank loan (which often arrive late when eventually approved) to off-set money obtained from friends and money lenders, as these are easier and quicker ways of getting fund for their farm operations.

TABLE 24

Membership of cooperative movements

Zone:	Rain forest		Derived savanna		Overall	
Item	Users*	Non-users*	Users*	Non-users*	Users*	Non-users*
None	01	18	03	16	04	34
Cooperative	55	15	56	12	111	27
Esusu	21	07	23	17	44	24
Farmers Union	52	10	28	11	80	21

Source: Field survey, 1998

*Multiple responses

TABLE 25

Respondents' contact with extension agents

Zone	Rain forest		Derived savanna		Overall	
Item	Users (%)	Non-users (%)	Users (%)	Non-users (%)	Users (%)	Non-users (%)
Yes	80.0	70.0	76.0	51.0	78.0	61.0
No	20.0	30.0	24.0	49.0	22.0	39.0
Overall	116	44	97	43	213	87

Source: Field survey, 1998

4.21 Fertilizer application

The quantity of fertilizer used by respondents in the agroclimatic zones of the study area is presented in Table 27.

The quantity of fertilizer applied generally ranged between 8.0 and 650.0 kg/ha with a mean of about 177.2 kg/ha in the two zones combined. The quantity of fertilizer used by location however revealed some variations. The rain forest zone recorded a mean of 172.30 with a range of between 8.00 and 650.0 kg/ha, while the derived savanna zone had a mean of 182.99 and a range of between twenty and five hundred kilogramme per hectare.

The difference between the average rate of fertilizer applied in the two zones was however not significant at the 5% level (t_c=0.66). This implies that fertilizer rates do not vary across agroclimatic zones in the study area. FGDs revealed that the quantity of fertilizer used by respondents in the study area depended on respondents' access to the technology. Table 27 further reveals that about forty-three and fifty-six per cent respectively of total crop area was fertilized. This has further implications on the accessibility of the technology and hence on farmers' adoption decisions.

TABLE 26

Sources of capital

Zone	Rain forest		Derived savanna		Overall	
Item	Users	Non-users	Users	Non-users	Users	Non-users
Personal savings	85	25	34	25	119	50
Friend/relations	09	29	17	28	26	57
Banks	31	16	13	09	44	25
Money lenders	73	02	38	06	111	08

Source: Field survey, 1998

*Multiple responses

TABLE 27

Quantity (kg/ha) of fertilizer used by respondents

Item	Rain forest	Derived savanna	Overall
Number of respondents	116	97	213
Mean	172.30	182.99	177.17
Variance	15122.32	12839.93	14045.92
Mode	150.00	150.00	150.00
Median	150.00	160.00	150.00
Crop area fertilized(%)	42.50	55.60	50.25

Source: Field survey, 1998

CHAPTER FIVE

5.0 EMPIRICAL RESULTS II

5.1 Results of correlation analysis

5.1.1 Relationship among study variables

In order to examine the relationship among factors that bear on farmers adoption decisions, an inter-correlation matrix of these factors was obtained for the study area (Tables 28, 29 and 30). The matrix shows the correlations between the dependent variable (Y) and each independent variable, as well as the correlations between the independent variables.

Farm size (X_5) and net farm income (X_6) showed a fairly strong significant positive relationship with the adoption and use of fertilizer technology (Y) at the 5% level in the rain forest and derived savanna zone. For the two zones combined, age (X_1), farm size (X_5), net farm income (X_6), extension advice (X_8) and mode of land acquisition (X_{12}) showed significant positive relationships with farmers' adoption decisions. Net farm income and farm size recorded a fairly strong correlation, while age, farm acquisition pattern and extension advice showed weak (positive) relationships. When the relationship among independent variables were examined, farm size (X_5) and net farm income (X_6) were found to exhibit a strong significant positive relationship, with each other in the rain forest zone (Table 29). Relationships among study variables in the derived savanna zone revealed that age (X_1), household size (X_4), farm size (X_5), net farm income (X_6), mode of land acquisition (X_{12}) and duration of fallow (X_{15}); as well as farm size, net farm income and duration of fallow have significant positive relationships with each other (Table 29). Age (X_1), level of schooling (X_3) and mode of farm acquisition (X_{12}) however, showed significant negative relationships at the 5% level. This implies that a decrease in any one of these factors will result in a decrease in the associated factor.

Though, all the variables showed one form of linear relationship with the dependent variable and with one another in the rain forest zone and the study area as a whole (since the correlation values obtained were greater than zero), extension advice (X_8) and age (X_1) recorded zero linear correlation in the two zones combined.

In general, the relationship between farm size and net farm income was found to be significant (positive) with farmers' adoption behaviour across the zones and in the study area at the 5% level.

TABLE 28

Intercorrelation matrix of variables in the rain forest zone

Variables	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{12}	X_{11}	X_{13}	X_{14}	X_{15}
Y	1.0000															
X_1	0.0527	1.0000														
X_2	0.1130	0.2195*	1.0000													
X_3	-0.0425	-0.3247*	0.1918	1.0000												
X_4	0.0636	0.3425*	0.1094	-0.2395*	1.0000											
X_5	0.6766*	0.1497	0.1709	-0.0555	0.1651	1.0000										
X_6	0.7406*	0.1081	0.1964	0.0578	0.0832	0.8598*	1.0000									
X_7	0.0765	-0.0600	-0.0325	0.0224	-0.0109	0.0837	0.0792	1.0000								
X_8	0.1786	0.0426	-0.0501	0.0311	0.1720	0.1779	0.2120*	0.1472	1.0000							
X_9	0.0372	0.0019	0.1366	0.1831	-0.0252	0.0684	0.0706	0.0264	-0.0200	1.0000						
X_{10}	0.0262	0.0239	-0.0334	-0.1407	0.2146*	0.2007	0.0909	0.0711	0.0635	0.1903	1.0000					
X_{12}	0.2107*	0.3454*	0.2984*	-0.1604	0.2029	0.3844*	0.3600*	0.1268	0.3620*	0.0232	0.1304	1.0000				
X_{11}	-0.1680	-0.0727	0.1055	0.1536	-0.1028	0.0456	-0.0606	-0.1651	0.1055	-0.0534	0.0287	0.0156	1.0000			
X_{13}	0.1610	0.2154*	0.0848	-0.0447	0.1054	0.3213*	0.2695*	0.1499	0.2580*	0.1260	0.0999	0.5769*	0.0218	1.0000		
X_{14}	0.1067	0.3917*	0.1686	-0.2223*	0.3736*	0.0914	0.0909	0.0686	0.1341	-0.0625	0.0826	-0.3538*	-0.1985	0.2180*	1.0000	
X_{15}	-0.0805	0.0899	-0.0400	-0.1343	0.1555	0.0567	-0.0120	0.0248	0.0272	-0.1139	0.0572	-0.1430	-0.0066	0.1653	0.3073*	1.0000

Source: Field survey, 1998

*Significant at 5% level

TABLE 29

Inter-correlation matrix of variables in the derived savanna zone

Variables	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{12}	X_{11}	X_{13}	X_{14}	X_{15}
Y	1.0000															
X_1	0.2669*	1.0000														
X_2	0.1247	0.0564	1.0000													
X_3	-0.1143	-0.4055*	0.1790	1.0000												
X_4	0.2020	0.4472*	0.0765	-0.2192	1.0000											
X_5	0.3814*	0.2517*	0.0990	-0.0657	0.2066	1.0000										
X_6	0.6485*	0.3177*	0.1601	-0.1150	0.0857	0.7240*	1.0000									
X_7	0.1341	0.0272	0.1055	0.0914	-0.0200	0.0248	0.0686	1.0000								
X_8	0.2028	-0.0062	0.0686	0.0552	0.1609	0.0620	0.1198	0.0264	1.0000							
X_9	0.0049	-0.1417	-0.1980	0.0674	-0.0368	-0.0876	-0.0680	0.0372	0.0474	1.0000						
X_{10}	0.0415	0.0742	0.1074	0.0636	0.0240	0.1329	0.0367	-0.0120	-0.1843	-0.1563	1.0000					
X_{12}	0.1686	0.3993*	0.1616	-0.2385*	0.1959	0.1324	0.2127	0.0909	0.0459	-0.0227	0.0764	1.0000				
X_{11}	-0.0806	-0.1096	0.0294	0.0202	-0.0910	-0.0874	-0.0547	-0.1680	-0.0686	0.4291*	0.1196	-0.0438	1.0000			
X_{13}	0.1217	0.2109*	0.0857	-0.1808	0.1446	0.0986	0.1144	0.0606	0.0308	-0.0642	0.1575	0.5757*	-0.0857	1.0000		
X_{14}	-0.0667	0.0864	-0.0630	-0.1710	0.2550*	-0.0980	-0.0262	0.1067	-0.0163	0.0534	-0.2056	0.1325	-0.0449	0.0681	1.0000	
X_{15}	0.1364	0.2844*	0.1049	-0.2124	0.0836	0.0825	0.2290*	-0.0805	-0.1479	-0.1299	0.0995	0.2395*	-0.0779	0.2489*	0.1321	1.0000

Source: Field survey, 1998

*Significant at 5% level

TABLE 30

Inter-correlation matrix of variables in the study area

Variables	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{12}	X_{11}	X_{13}	X_{14}	X_{15}	X_{16}
Y	1.0000																
X_1	0.1520*	1.0000															
X_2	0.1097	0.1895*	1.0000														
X_3	-0.0741	-0.3583*	0.1730*	1.0000													
X_4	0.1215	0.3506*	0.0613	-0.2252*	1.0000												
X_5	0.5383*	0.2031*	0.1459	-0.0607	0.1744	1.0000											
X_6	0.6999*	0.1900*	0.1736*	-0.0110	0.0864	0.7954*	1.0000										
X_7	0.0568	-0.0329	-0.0182	0.0160	-0.0167	0.0624	0.0613	1.0000									
X_8	0.1883*	0.0000	-0.0316	0.0439	0.1790	0.1148	0.1703*	0.0959	1.0000								
X_9	0.0243	-0.0692	0.0406	0.1433	-0.0082	0.0068	0.0299	0.0159	0.0177	1.0000							
X_{10}	0.0344	0.0909	0.0603	-0.0458	0.0783	0.1712*	0.0581	0.0606	-0.0894	0.0222	1.0000						
X_{12}	0.1917*	0.3819*	0.2788*	-0.1913*	0.1716	0.2792*	0.2988*	0.1078	0.2015*	-0.0097	0.1373	1.0000					
X_{11}	-0.1330	-0.1171	0.0389	0.1139	-0.0509	-0.0027	-0.0497	-0.1618*	0.0729	0.0668	-0.0755	-0.0355	1.0000				
X_{13}	0.1438	0.2326*	0.1131	-0.0959	0.0908	0.2334*	0.2093*	0.1309	0.1414	0.0505	0.1556	0.5858*	-0.0412	1.0000			
X_{14}	0.0309	0.2518*	0.1017	-0.2008*	0.3169	0.0066	0.0438	0.0529	0.0611	-0.0256	-0.0486	0.2658*	-0.1502	0.1625*	1.0000		
X_{15}	0.0036	0.1548*	-0.0155	-0.1617*	0.1341	0.0640	0.0737	0.0175	-0.0403	-0.1107	0.0587	0.1666*	-0.0083	0.1814*	0.2394*	1.0000	
X_{16}	0.0073	0.1757*	0.2008*	-0.0178	-0.1578	0.0420	-0.0215	0.0541	-0.1007	-0.1257	0.2490*	0.1487	-0.2501*	0.1603*	0.0163	-0.0503	1.0000

Source: Field survey, 1998

* Significant at 5% level

5.2 Tobit regression results

5.2.1 The Tobit application: determinants of fertilizer technology adoption

Tobit regression analysis was performed on primary data collected from the study area using the Shazam software package. In the Tobit model, data on the dependent variable can be classified into two groups. One portion of the data, the non-adopters equal to a limit (usually zero) and the other portion the adopters, is above the limit (to be estimated).

According to Tobin (1958), an index, which is a linear function of the explanatory variables, is created as:

$$I_t = X'_t\alpha = X'_t(\beta/\sigma) \qquad (28)$$

Where

I_t = the utility index for the ith farmer. The larger the value of I_i the greater the utility Individual i receives from choosing the option to adopt the technology (y=1).

α = vector of normalized coefficients

β = regression coefficient

σ = standard error of estimate

X_t = explanatory variables, t = 1,2,3,...,16

The coefficient vector, α, (equation 28) is transformed into the regression coefficient vector β by multiplying all elements of α by the calculated standard error of the estimate,σ. For example, estimates of locational factors (X_{16}) in model 1, Table 32 shows that α=0.0456, σ=7.4321 and β= 0.3385.

In the Tobit model, all computations are performed on the normalized α vector, and the estimated standard errors of the coefficients are those of the α vector and not the β. Hypotheses can however be performed on the regression coefficients, β, by working on the α vector (Tobin, 1958). With this, parameters α and σ are estimated to calculate likelihood ratio tests by maximizing the computed values of the log-likelihood function:

$$L = \sum_{t=1}^{S} \log[1 - F(\sigma Y_t - I_t)] + \sum_{t=S+1}^{N} \log f(\sigma Y_t - I_t) \quad \ldots\ldots \quad (29)$$

where f( ) and F( ) represent the Normal density and cumulative Normal density functions respectively. The computed values of f( ) and F( ) at the point I_t are then used

to compute: the predicted probability of Y > limit given Average X(I) = F(I) =0.7582; the observed frequency of Y > Limit = Percent of observations on Y exceeding the limit = 0.7100; and at mean values of all X(I), E(Y) = σ[F(I)I+f(I)] = 6.2672 (Model I, Table 32).

Additionally, for each independent variable, the elasticity of index for the ith variable is estimated as:

$$\beta(\bar{X}_i/\bar{Y}\sigma) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (30)$$

For variable X_1 the elasticity of index = 0.3206. The elasticity of E(Y) for the ith variable is then estimated first by computing the value of the index (I) at the mean values of all variables:

$$\bar{I} = \bar{X}\alpha \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

(estimated values are presented in model I, Table 31)

The conditional expectation of Y at the mean values is then computed as:

$$\beta_i \bar{X}_i F(I)/\sigma E(Y/I) = 0.0601 \quad \ldots\ldots\ldots\ldots\ldots \quad (32)$$

(as estimated for variable X_{16} in Model 1, Table 38).

Table 31

Tobit parameter estimates of fertilizer adoption (Model 1)

Variable	Normalized coefficient (a)	Standard asymptotic error	Regression coefficient (β)	Elasticity of index
X_1	0.0070	0.0070	0.0520	0.3206
X_2	-0.1364	0.2425	-1.0137	-0.1360
X_3	0.0361	0.0354	0.2685	0.1165
X_4	-0.0110	0.0249	-0.0818	-0.0607
X_5	1.0232***	0.2639	7.6045	0.5480
X_6	0.0003***	0.0004	0.0002	0.6765
X_7	0.0645	0.0658	0.4794	0.1309
X_8	-0.0131	0.1625	-0.0974	-0.0149
X_9	1.2265***	0.1205	9.1154	1.6449
X_{10}	-0.0050	0.0211	-0.0371	-0.0205
X_{11}	-0.2026	0.2289	-1.5055	-0.3463
X_{13}	0.2011	0.1955	1.4946	0.2108
X_{16}	0.0456	0.1452	0.3385	0.0605
Constant	-2.6702	0.8029	-19.8450	-

Source: Field survey, 1998.

Predicted probability of Y > Limit given average X(I)	= 0.7582
Observed frequency of Y > Limit is	= 0.7100
At mean values of All X(I), E(Y)	= 6.2672
Standard error estimate (σ)	= 7.4321
Log-likelihood function	= -771.5651
Mean square error	= 34.0976
Mean absolute error	= 0.4025
Squared correlation between observed and expected values	= 0.6887
Number of observations	= 300
Limit observations	= 87
Non-limit observations	= 213

***Significant at 1%

A likelihood ratio of 771.57 leads to the rejection of the null hypothesis that there is no relationship between the dependent variable and the set of explanatory variables. This, together with the R^2 value, supports the adequacy of the model. Nonetheless, low R^2 value for qualitative response models is consistent with results obtained by some studies (Capps et al., 1985; Manyong and Houndekon, 1997).

In order to determine the type of relationship existing between sets of specific factors and farmers adoption behaviour, six variations of the empirical model (equation 20) were examined using the Tobit regression analysis. Model I (as discussed above, Table 31), examined the combined effect of the five variable categories namely: farmers characteristics, resource-, property rights-, institutional- and locational factors on farmers adoption behaviour. Disaggregated regression models were then separately estimated for respondents personal characteristics (Model II), resource specific characteristics (Model III), property right characteristics (Model IV), institutional factors (Model V) and locational factors (Model VI).

Tobit regression estimates from the five categories of variables (Model I) showed that availability of fertilizer (X_9), farm size (X_5) and net farm income (X_6) were highly significant(positive) in explaining fertilizer adoption decisions in the study area (Table 32).

Respondents sex (X_2), household size (X_4), distance of farm from fertilizer source (X_{10}), cropping practice (X_{11}) and extension advice (X_8) negatively influence adoption decisions while location factors (X_{16}), age (X_1), level of education (X_3), security perception of farmland (X_{13}), fertilizer supply (X_9), cooperative society membership (X_7), farm size (X_5) and net farm income (X_6) recorded positive signs. This shows that the signs of most of the estimated coefficients of the independent variables were of the predicted signs except for the coefficients of extension advice

(X_8) and cropping practice (X_{11}). The variable, household size (X_4), whose sign was not predicted came up with a negative sign, while farmers age (X_1) recorded a positive sign.

The negative relationship obtained for extension advice negates the theoretical role extension is supposed to play in innovation adoption. The size of the coefficient (α=-0.0131) is small and not significant at the preset probability level. This may be ascribed to poor extension service to farmers during the study period or that knowledge regarding fertilizer is now widespread due to farmer-farmer contact. Focus group discussion results revealed that the inability of extension agents to assist farmers in obtaining farm resource inputs may have contributed largely to this, as the respondents highly depended on government extension agents for the supply of all agricultural inputs, particularly fertilizer.

The negative coefficient of cropping practice (X_{11}), (α = -0.2026) may be due to the predominantly mixed cropping practice by respondents in the study area. This, according to Agboola (1979), does not enhance technology adoption. However, mixed cropping practice among respondents was mainly to reduce the risk of production loss from a single crop enterprise. Focus group discussion results supported this view in that maize, the dominant crop of the farming system and which mostly attracted fertilizer use, was intercropped with cassava by majority of respondents in the study area. The positive coefficient of respondents, age suggests that younger farmers are more willing to adopt new techniques overtime. This supports the views of studies like Polson and Spencer (1991). Household size (X_4) recorded a negative relationship with adoption behaviour. This may be attributed to the little farm assistance received from respondents wife and children who respectively engaged in trading and attend schools. The higher cost associated with increased household size results in increased risk-aversion and aid the adoption of the technology.

When separately analysed according to agroclimatic zones, availability of fertilizer technology (X_9) farm size (X_5) and net farm income (x_6) were found to be highly significant (positive) in explaining adoption decisions in the rain forest and derived savanna zones respectively (Table 32). This implies that the major factors (among the few considered) which bear on farmers' adoption behaviour may not be strongly linked to agroclimatic variations.

5.2.2 Respondents' personal characteristics (Model II)

Tobit estimates on respondents personal characteristics (Table 33) shows that while respondents' sex (X_2) had a marginally significant (negative) effect in explaining adoption decisions in the rain forest zone, age (X_1) had a strongly significant (positive) effect in the derived savanna zone. This finding suggests that while age is a major determinant of fertilizer adoption decisions in the derived savanna zone, respondents' sex (X_2) was found to constrain adoption decisions in the rain forest zone. Age (X_1) and level of education (X_3) showed weak (positive) influence on respondents' fertilizer adoption decisions in the rain forest and derived savanna zones, a negative sign was obtained for sex (X_2) in the derived savanna zone .

For the two zones combined, age (X_1) and sex (X_2) showed statistically significant effects on fertilizer adoption decisions. Age(X_1) and level of education(X_3) showed weak (positive) relationships with adoption decisions, while weak (negative) relationships were obtained for sex (X_2) and locational factors (X_{16}).

TABLE 32

Parameters estimates for the rain forest and derived savanna zones

Variable	Rain forest		Derived savanna	
	Normalized coefficient	Regression coefficient	Normalized coefficient	Regression coefficient
X_1	0.0098	0.0678	0.0091	0.0586
X_2	-0.2531	-1.7455	-0.2786	-1.8002
X_3	0.0201	0.1384	0.0496	0.3206
X_4	-0.0540	-0.3722	-0.0391	-0.2529
X_5	1.9218***	13.2560	2.1602***	13.9580
X_6	0.0002***	0.0002	0.0002***	0.0001
X_7	0.1048	0.7231	0.0312	0.2018
X_8	-0.0300	-0.2068	-0.2263	-1.4620
X_9	1.0539***	7.2695	1.0922***	7.0577
X_{10}	-0.0200	-0.1380	-0.0252	-0.1630
X_{11}	0.1647	1.1363	0.3018	1.9504
X_{13}	0.3191	2.2010	0.3809	2.4613
Constant	-3.4269	-23.6380	-3.5183	-22.7340

	Rain Forest	Derived Savanna
Predicted probability of Y > Limit given average X(I)	0.7952	0.8070
Observed frequency if Y > Limit	0.7250	0.7214
At mean values of all X(I), E(Y)	6.4811	6.2912
Log likelihood function	-413.69048	-352.33102
Mean - square error	31.149405	27.670447
Mean absolute error	0.35551521	0.31159062
Squared correlation between observed & expected values	0.69490	0.72468
Standard error of estimate	6.8978	6.4616

***Significant at 1% level.
Source: Field survey, 1998.

TABLE 33

Tobit parameter estimates for personal characteristics (Model II)

Overall (Rain forest and Derived savanna)			Rainforest		Derived Savanna	
Variable	Normalized coeff.	Asymptotic t-ratio	Normalized coeff.	Asymptotic t-ratio	Normalized coeff.	Asymptotic t-ratio
X_1	0.0123	2.0498***	0.3263	0.3936	0.0218	2.4687***
X_2	-0.4432	2.0861*	-0.4540	1.9665**	-0.7997	1.3285
X_3	0.0030	0.0927	0.0157	0.3695	0.0062	0.1222
X_{16}	-0.0813	0.6500	-	-	-	-
Constant	0.4007	0.7779	0.8069	1.2914	0.8681	0.9692

*** Significant at 1%; ** Significant at 5%; * Significant at 10%.
Source: Field survey, 1998

5.2.3 Resource-specific characteristics (Model III)

Parameter estimates for resource-specific characteristics (model III) on fertilizer adoption showed that farm size (X_5) and net farm income (X_6) were highly statistically significant at 5% level in each of the two agroecological zones (Table 34). Household size (X_4) is included as being significant in the derived savanna zone. For the two zones combined, only respondents' net farm income (X_6) was found to be statistically significant in explaining fertilizer adoption behaviour. Apart from household size (X_4) and cropping practice (X_{11}) which bear negative relationships to adoption decisions in the study area, farm size (X_5), net farm income (X_6) and locational factors (X_{16}) have positive influences. For each of the two zones, farm size and cropping practice (X_{11}) in derived savanna and household size in the rain forest zone have negative relationships with respondents' fertilizer adoption behaviour.

5.2.4 Institutional-specific characteristics (Model IV)

Tobit estimates on institutional specific characteristics with adoption behaviour (model IV) revealed that availability of fertilizer (X_9) was highly statistically significant at the 5% level for each of the two zones and in the study area as a whole. Thus, availability and accessibility of the technology is an essential component of the adoption process. While only extension advice (X_8) showed a negative influence in each zone and overall, membership of cooperative society (X_7) in addition bear a negative relationship with farmers adoption decisions in the rain forest.

TABLE 34
Tobit parameter estimates for resource characteristics (Model III)

Variable	Overall (Forest and savanna)		Rain forest		Derived savanna	
	Normalized coefficients	Regression coefficient	Normalized Coefficients	Regression Coefficients	Normalized Coeffiecients	Regression coefficients
X_4	-0.0041	0.036784	-0.04041	-0.32784	0.071923**	0.62479
X_5	0.22114	1.9828	1.3457***	10.917	-1.2732**	-11.060
X_6	0.36213***	0.003247	0.24070***	0.001953	0.62119***	0.005396
X_{11}	-0.12206	-1.0944	0.25450	2.0647	-0.80791	-7.0183
X_{16}	0.00097	-0.0086747	-	-	-	-
Constant	-0.04057	-0.36373	-0.71244	-5.7798	1.2093	10.505

Source: Field survey, 1998.
*** Significant at 1%; **Significant at 5%.

	Overall	Rain	Derived savanna
The predicted prob. of Y> Limit given average X(1)	= 0.7642	0.7872	0.7694
The observed frequency of Y> Limit	= 0.7100	0.7250	0.6929
At mean values of all X(1), E(Y)	= 7.6935	7.4438	7.5672
Log likelihood function	= -846.48891	-447.94759	-380.66275
Mean square error	= 49.785782	41.042953	45.879178
Mean absolute error	= 0.34399576	0.39295136	0.29225268
Squared correlation between observed and expected values	= 0.54164	0.60033	0.60368
Limit observations	= 87	44	43
Non-limit observations	= 213	116	97

TABLE 35

Tobit estimates for institutional characteristics (Model IV)

Variable	Overall (Forest and savanna)		Rain forest		Derived savanna	
	Normalized coefficients	Regression Coefficient	Normalized coefficients	Regression coefficient	Normalized coefficient	Regression coefficient
X_7	0.015	0.173	-0.007	-0.084	0.038	0.449
X_8	-0.215	-2.504	-0.250	-2.868	-0.182	-2.16.
X_9	1.066***	12.43	0.948***	10.89	1.994	14.18
X_{10}	0.032	0.375	0.021	0.241	0.040	0.472
X_{16}	0.017	-	-	-	-	-
Constant	-1.168	-13.64	-0.815	-9.359	-1.513	-17.9

*** Significant at 1%; ** Significant at 5% level

Source : Field survey, 1998.

	Overall	Rain forest	Derived savanna
The probability of Y >limit given average X(I)	= 0.6346	0.6495	0.6144
The observed frequency of Y >limit	= 0.7100	0.7250	0.6929
At mean values of All X(I), E(Y)	= 6.9338	7.1216	6.6325
Log-likelihood function	= -863.2077	-470.1205	-392.1964
Mean square error	= 90.4617	88.7819	91.72566
Mean absolute error	= 0.4707	0.49521	0.43574
Squared correlation between observed & expected values	= 0.1675	0.13058	0.20885
Limit observations	= 87	44	43
Non-limit observations	= 213	116	97

TABLE 36

Parameter estimates for tenure-specific characteristics (Model V)

Variable	Overall (forest and savanna)		Rain forest		Derived savanna	
	Normalized coefficient	Regression Coefficient	Normalized Coefficient	Regression Coefficient	Normalized coefficient	Regression coefficient
X_{12}	0.1219**	-1.612	0.8358	-1.0488	-0.1354	-1.6875
X_{13}	0,0840	0.9179	0,2219	2,0101	-0,0583	-0,7265
X_{14}	0.0056	0.0061	0.8929	0.08089	-0.0072	-0.0897
X_{15}	-0,0307	-0,3354	-0,0568	-0,5148	-0,0089	-0,0111
X_{16}	0,0204	0,2223	-	-	-	-
Constant	-0,1902	-2,0769	-0,9545	-8,6469	0,4419	5,5087

Source: Field survey, 1998.

		Overall	Rain forest	Derived savanna
The predicted probability of Y > limit given average X(I)	=	0.7134	0.7578	0.6841
The observed frequency of Y > limit	=	0.7100	0.7250	0.6929
At mean values of All X(I), E(Y)	=	8.1063	7.6300	8.5216
Log-likelihood function	=	-890.5945	-461.2789	-420.1589
Mean square error	=	74.2322	50.8782	93.5087
Mean absolute error	=	0.4301	0.4607	0.3819
Squared correlation between Observed & expected values	=	0.3175	0.5089	0.1909
Limit observation	=	87	44	43
Non-limit observations	=	213	116	97

TABLE 37

Parameter estimates of location factors (Model VI)

ariable	Normalized coefficient	Asymptotic std.error	Asymptotic t-ratio	Regression coefficient
46	0.02654	0.12085	0.21962	0.35795
onstant	0.37659	0.18928	1.9896*	5.0790

Source : Field survey, 1998.

The predicted probability of Y > limit given average X(I)	= 0.6611
Observed frequency of Y > limit	= 0.7100
Mean values of all X(I), E(Y)	= 8.6402
Log-likelihood function	= -931.04365
Mean square error	= 108.02458
Mean absolute error	= 0.439138
Square correlation between observed & expected values	= 0.008765
Limit observations	= 87
Non-limit observations	= 213

5.2.5 Property right-specific factors (Model V)

Tobit parameter estimates for tenure specific factors (model V) showed that while locational factors (X_{16}), security perception of farmland (X_{13}) and years of continuous use rights (X_{14}) positively influence respondents' adoption behaviour in the two zones combined, mode of land acquisition (X_{12}), security perception of farmland (X_{13}) and years of continuous use rights (X_{14}) have positive effects in the rain forest zone. None of the tenure factors positively influence adoption decisions in the derived savanna zone (Table 36). This may be attributed to the impact of population densities and the duration of fallow on the availability of land for agricultural purposes in the rain forest zone. This is not strongly applicable in the derived savanna zone. In all, only mode of land acquisition (X_{12}) showed a signicantly positive relationship in explaining farmers adoption decisions in the study area.

5.2.6 Location-specific characteristics (Model VI)

Table 37 shows that though, environmental factors (X_{16}) exerts no statistically significant effect on respondents adoption and use of fertilizer technology, it however positively influences this decision and need be taken into consideration in fertilizer adoption decisions of farmers in the study area.

5.2.7 Analysis of the extent of fertilizer technology use on adoption

5.2.7.1 Decomposition of fertilizer adoption elasticities

The computed elasticities using model (I) revealed that marginal changes in various characteristics increase the probability of fertilizer adoption than it increases the use intensities in the study area (Table 38). However, apart from the availability of fertilizer (X_9) which showed the greatest impact on the probability of fertilizer adoption and use intensities, elasticity estimates show inelastic responses to changes in every other variable. The total elasticity value is 1.6321 divided into 1.16 for the elasticity of adoption probability and 0.47 for the elasticity of use intensity.

This suggests that a 10% improvement in the supply of fertilizer to respondents in the study area is expected to result in about 16% increase in the adoption and use intensities of fertilizer technology. The probability of adoption will increase by 11.6% while the use intensity increases by 4.7%. Improved net farm income (X_6) to farmers is estimated to increase total elasticity by 0.67, decomposed into 0.48 for the elasticity of adoption probability and 0.20 for the elasticity of expected use intensity. Farm size (X_5) and cropping practice (X_{11}) were estimated to have similar effects on the total adoption elasticities and its components. In each case, the total elasticity of 0.54 and 0.34 respectively consists of 0.38 and 0.24 due to the elasticity of adoption and 0.16 and 0.10 attributable to the elasticities of expected use intensities. However, fertilizer adoption and use efforts aimed at improving extension service in the study area was estimated to have little or no effect on adoption elasticities (e = 0.0148).

TABLE 38

Decomposition of elasticity of the expected value of fertilizer use for the study area

Variable	Elasticity of adoption index	Elasticity of the expected use intensity	Total elasticity
X_1	0.2259	0.0922	0.3181
X_2	0.0958	0.0391	-0.1349
X_3	0.0821	0.0335	0.1156
X_4	0.0427	0.0175	-0.0602
X_5	0.3860	0.1577	0.5437
X_6	0.4766	0.1946	0.6712
X_7	0.0922	0.0377	0.1299
X_8	0.0105	0.0043	-0.0148
X_9	1.1588	0.4733	1.6321
X_{10}	0.0145	0.0059	-0.0204
X_{11}	0.2440	0.0996	-0.3436
X_{13}	0.1485	0.0606	0.2091
X_{16}	0.0427	0.0174	0.0601

Source: Field survey, 1998.

TABLE 39

Decomposition of elasticity of the expected value of fertilizer use in the rain forest and derived savanna zones

	(a) Rain forest zone			(b) Derived savanna zone		
Variable	Elasticity of predicted probability of fertilizer	Elasticity of the expected use intensity	Total elasticity	Elasticity of predicted Probability of fertilizer	Elasticity of the expected use intensity	Total elasticity
X_1	0.2939	0.1115	0.4054	0.2591	0.1000	0.3591
X_2	0.1805	0.0685	-0.2490	0.1975	0.0763	-0.2738
X_3	0.0442	0.0168	0.0610	0.1083	0.0418	0.1501
X_4	0.2167	0.0822	-0.2989	0.1528	0.0590	-0.2118
X_5	0.6801	0.2579	0.9380	0.7514	0.2902	-1.0416
X_6	0.3138	0.1190	0.4328	0.2821	0.1089	0.3910
X_7	0.1488	0.0564	0.2052	0.0449	0.0174	0.0623
X_8	0.0225	0.0086	-0.0311	0.1682	0.0649	-0.2331
X_9	0.8434	0.4542	1.2976	0.9657	0.3729	1.3386
X_{10}	0.0460	0.0175	-0.0635	0.0594	0.0229	-0.0823
X_{11}	0.1832	0.0695	0.2527	0.3223	0.1245	0.4468
X_{13}	0.2386	0.0905	0.3291	0.2749	0.1062	0.3811

Source: Field survey, 1998.

These results may suggest that farmers in the study area currently do not receive much extension contact and as revealed from focus group discussion sessions, extension agents' service have been mistakenly associated with supply of agricultural inputs (especially fertilizer) by farmers in the study area. Thus, when the inputs are not available, extension agents find it difficult to explain their mission to the farmers.

Only the availability of fertilizer supply (X_9) had a total elasticity estimate greater than one (e = 1.3434) in the rain forest zone (Table 39). This value is divided into 0.9740 and 0.3694 respectively for the elasticity of adoption probability and elasticity of expected use intensity. Thus, a 1% increase in the supply of fertilizer in this zone is expected to increase the probability of adoption component by 0.97% while expected use intensity increases by 0.37%. Elasticity estimates show inelastic responses to changes in every other variable. In each zone, however, marginal changes in the variables considered increase the probability of fertilizer adoption than it increases the use intensities.

Thus, almost without exception, farmers adoption response to fertilizer technology (elasticity) is the most important component of total elasticity. Farmers adoption and non-adoption accounted for more of fertilizer technology response than did the quantity factor. Consequently, studies reporting elasticity calculated on the basis of OLS estimates from cross-sectional data sets may significantly underestimate the total fertilizer adoption response to the various factors (Judge et al., 1988).

When the decomposition of elasticity of expected value on fertilizer use was analysed for each zone using model I, availability of fertilizer technology (X_9) and farm size (X_5), in the derived savanna zone and availability of fertilizer (X_9), in the rain forest had the greatest impact on the probability of fertilizer adoption and use intensities with $e \geq 1$.

5.3 Costs and returns to fertilizer technology use

5.3.1 Partial budget analysis (PBA).

Based on the major crop of interest (maize) for using fertilizer technology, partial budget analysis was performed on respondents' maize plots (Table 40.

The average quantity of fertilizer applied per hectare of cultivated maize plot in the derived savanna zone was 182.99 kg/ha while the rain forest recorded 172.30 kg/ha. The mean difference between the two zones was however not significant at 5% level (t_c=0.66). This implies that the difference between the average rate of fertilizer applied by respondents in the two zones is statistically the same. Nonetheless, the rate used in the two zones falls short of the recommended dosage of between 300-400 kg/ha (IAR&T, 1991). This may further call for increased extension advice to farmers in the study area on the need to use adequate quantities of fertilizers in order to obtain better yield and income levels. Since partial budget analysis considers only those costs which change or vary between alternative practices, (Users and Non-users of fertilizer),total variable costs on fertilizer use included : cost of fertilizer material,transport and application costs .The mean cost of fertilizer material in the rain forest and derived savanna zones were respectively₦ 639.23/ha and₦ 673.40/ha. These results are statistically similar as the difference between the average cost of fertilizer in the two zones is not significant at the 5% level (t_c=0.78). It is worth noting that farmers in the survey location obtained fertilizers at government subsidized rate of₦ 160 per 50kg bag during the survey period. FGD results however showed that variations existed in the actual amount spent by individual farmers depending on the source of the fertilizer material.

TABLE 40

Partial budget analysis (PBA) for respondents' use of fertilizer

Item	Rain forest		Derived savanna		(Rainfo Derived
A. Inputs	Users	Non-Users	Users	Non-users	Users
1. Mean rate of fertilizer applied (kg\ha)	172.30	-	182.99	-	177.17
2. Mean price of fertilizer (₦\kg)	3.71	-	3.68	-	3.70
3. Mean cost of fertilizer material (₦\ha)(=1x2)	639.23	-	673.40	-	655.53
4. Mean transport cost(₦\ha)	103.38	-	93.04	-	100.99
5. Mean cost of application (₦\ha)	70.25	-	72.25	-	71.16
6. Total cost of fertilizer (₦\ha)(=3+4+5)	812.86	-	838.69	-	827.68
B. Returns					
7. Mean yield(kg\ha)	1260.31	885.43	1268.62	785.55	1264.32
8. Mean price (₦\kg)	17.71	17.71	17.65	17.65	17.68
9. Gross return(₦\ha)	22320.09	15681	22391.14	13865	22353.1
10. Net return (gross margin) (₦\ha)(=9-6)	21507	15681	21553	13865	21526
11. No. of respondents	116	44	97	43	213

Source: Field data, 1998.
* Interest rate per year based on highest lending rate in the study area =(100%).

Mean yield for users and non-users was 785.55 and 1,268.62 kg\ha in the study area. Fertilizer users in the rain forest zone recorded a mean yield of 1,260.31 kg\ha while in the derived savanna zone, an average yield of 1,268.62 kg\ha was obtained. Non-users of fertilizer in the rain forest and derived savanna zones respectively recorded a mean yield of 885.43 kg\ha and 785.55 kg\ha. The difference in mean yield between the two groups of respondents in each zone was statistically significant at the 5% level (t_c=4.58) for the rain forest zone and (t_c=3.60) for the derived savanna zone. These results show that higher yield levels are obtained with the use of fertilizer in the study area. Though, average yield of fertilizer users in the derived savanna zone was higher than in the rain forest, the difference in mean yield was not statistically significant at 5% level (t_c=0.72). Non-users of fertilizers in the rain forest zone had a mean yield of 885.43kg\ha as compared with the value of 785.55 kg\ha obtained for respondents in the derived savanna zone. When these estimates are compared with the mean yield of between 896 and 1,422 kg\ha, for non-users of fertilizer and between 2,000 and 3,000 kg\ha for users (Adegbola et al., 1978; FOS, 1991), the average yield levels in the study area fall short of expectation. The mean total income earned by respondents in the rain forest was₦ 22,320 and₦ 15,681 respectively for users and non-users of the technology, while₦ 22,391 and₦ 13,865 were respectively recorded for a similar group of respondents in the derived savanna zone. The difference between the average total income earned by users and non-users of fertilizers is statistically significant at 5% level(t_c=2.64) and (t_c=3.25) respectively for the rain forest and derived savanna zones. This implies that fertilizer users in each of the two zones earn higher total income than non-users . Average net income earned by respondents using fertilizer were ₦21,507 and ₦21,553 respectively for the rain forest and derived savanna zones, while ₦15,681 and ₦13,865 were similarly obtained for non-users of fertilizer. The mean difference between the net income earned by users and non-users of fertilizer in the rain forest and derived savanna zones is highly significant at 5% level. The computed t-values were (t_c = 2.28) and (t_c = 3.15) respectively for the rain forest and derived savanna zones. This suggests that users of fertilizer in the two zones earn higher net income in the survey location. Additionally, the difference between the mean net income earned by users of fertilizer in the rain forest and derived savanna zone is statistically significant at 5% level (t_c=2.20) while non-users in the two zones recorded a similar result with (t_c=1.98). This suggests that higher mean net income is recorded by respondents in the savanna zone.

Thus, in spite of the larger number of respondents using fertilizer in the rain forest zone, higher mean total returns and net returns per hectare were recorded in the derived savanna zone. This may be explained by the effect of heavy rainfall which characterizes the rain forest zone, and which tend to wash away applied fertilizer from the soil surface. Heavy rains also do cause fertilizer applied to leach beyond the root zone (Adegbola et al., 1978). This is not applicable in the derived savanna zone.

5.3.2 : Rate of return to fertilizer use

Following from the partial budget analysis (Table 40), changes in net returns and costs to fertilizer-using respondents in the two zones (rain forest and derived savanna) are presented in this section (Table 41).

The Table shows the marginal rate of return (R_f) to fertilizer use in the study area. R_f measures the increase in net income (δNI) due to fertilizer use as generated by each additional unit of expenditure (δVC). Farmers variable costs due to fertilizer use were 812.86, 838.69 and 827.68 naira respectively for the rain forest zone, derived savanna and the two zones combined. Similarly, average total farm returns increased by 5,826, 7,688 and 6,744 naira resulting in a marginal increase in net income of 7.17, 9.17 and 8.15 respectively. This implies that for each additional naira spent on fertilizer use, the additional return generated is 7.17, 9.17 and 8.15 for the rain forest, derived savanna and the study area as a whole. Additionally, respondents' annual net income were categorized according to farm size (Table 42) in order to test for scale effects. Users of fertilizer earned higher net income than non-users in the two zones (rain forest and derived savanna) as farm size increased and for every category of farm size. However, higher marginal increases were recorded between the net income earned by users and non-users of the technology in the derived savanna zone. Hence, use of fertilizer can be considered to have an economic advantage over its non-use. It is capable of enhancing net farm income for the study area and farmers are therefore likely to adopt this technology in spite of its relatively high cost. Focus group discussion findings supported this view in that participants claimed to be more comfortable with the availability of the technology even if the required quantity cannot be purchased at the current cost which, to them, is high. This however, raises a question on the right dosage of the technology needed to enhance farm production without impairing land quality.

TABLE 41

Change in mean net income and costs between users and non-users of fertilizer

Zone Item	Rain forest	Derived savanna	Overall (Rain forest\derived savanna)
A. Net income			
Users	21507	21553	21526
Non-Users	15681	13865	14782
∂NI	5826	7688	6744
B. Costs			
Users[a]	812.86	838.69	827.68
Non-Users	-	-	-
∂TVC	812.86	838.69	827.68
Rate of return to fertilizer use $(R_f)=\partial NI/\partial TVC$	7.17	9.17	8.15

Source: Field data, 1998.

[a] indicates total cost incurred by users of fertilizer. This includes: transport, fertilizer material and application costs.

TABLE 42

Respondents' mean net income per annum according to farm size (₦/ha)

	Net farm income (₦)			
	Rain forest zone		Derived savanna zone	
Farm size (ha)	Users	Non-users	Users	Non-users
0.01-0.50	10,944.00	9,178.00	11,114.00	5,990.00
0.51-1.00	27,955.00	19,379.00	27,490.00	16,352.00
1.01-1.50	41,947.00	33,258.00	51,593.00	27,010.00
1.51-2.00	88,676.00	-	93,330.00	52,288.00
above 2.00	-	-	-	58,675.00

Source: Field survey, 1998.

In an attempt to relate respondents' net income per annum to their tenure status in the agroclimatic zones, respondents' property right status was categorized into four (Table 43). "Divided inheritance" refers to farmers who have inherited the full rights to the land i.e. he has full control, while "Undivided inheritance" refers to land inherited by a farmer but where the extended family still has some control. "Secondary access" refers to renting, leasing, loaning and pledging. Though farmers tenure status is related to several other variables that may affect income earned from a particular field, these estimates are capable of providing insights into the relationship between property right status and farmers' income levels with respect to fertilizer use. Users of fertilizer earned higher mean net income than non-users while, farmers whose tenure position was purchase or divided inheritance earned higher incomes than those with secondary access or undivided inheritance. This may imply that security of tenure affects farm income levels.

Thus, these results show that farmers in the study area could be encouraged to use fertilizer if the current land use pattern persists. However, for this to be practicable, the technology need be made readily available to farmers at economic prices as indicated in section 5.3.3.

TABLE 43

Respondents' mean net income (₦) per annum according to property right regime

Property Right Regime	Agro-Climatic Zone			
	Rain Forest		Derived Savanna	
	Users	Non-users	Users	Non-users
Purchased	16,950.00	9,650.00	18,350.00	12,820.00
Divided Inheritance	14,800.00	6,180.00	15,140.00	10,900.00
Undivided Inheritance	6,370.00	3,520.00	9,262.00	5,770.00
Secondary access	4,260.00	1,255.00	3,130.00	2,575.00
Total respondents	42,380.00	20,605.00	45,880.00	32,065.00

Source: Field survey, 1998

5.3.3 Sensitivity analysis for fertilizer use at different prices according to zone

With an estimated annual interest rate of 100% (as FGDs revealed that majority of farmers in the study area patronized private money lenders who charged double the amount of loan fund) and a maximum cultivation period of six months (1/2 of the year) over which capital is used (taking into consideration those farmers who leave maize crops to dry on their plots), the cost of capital for the cultivation period was 50% of the investment in fertilizer (i.e 1/2 x 100%). Moreover, given an Assumed Rate of Return to Management (ARRM) of 1.0 (100%), an Acceptable Minimum Rate of Return (AMRR) of 1.50 was computed from equation (13). Based on this estimate, the results of sensitivity analysis performed on fertilizer use revealed a break-even price of₦ 14.40 (or 258.76% increase in price),₦ 17.72 (or a price increase of 361.14%) and₦ 16.10 (or 348.11% increase) per kilogramme of fertilizer respectively for the rain forest zone, the derived savanna and the study area in general. At this prices, total income realised equates total cost incurred on fertilizer use. This implies that above these prices (or as R_f decreases), it becomes uneconomical to use inorganic fertilizer technology in the study area. (Tables 44,45 and 46).

TABLE 44

Sensitivity analysis for fertilizer use at different prices in the rain forest zone

Item	Non-users (0 Kg\ha)	Users (172.30 kg\ha)	+100%	+200%	+258.76%	+389.82%	+400%
Price of fertilizer (₦\kg)	-	3.71	7.42	11.13	14.40*	18.25	18.55
Change in fertilizer price (%)	-	-	100	200	258.76	303.23	400
Yield (kg\ha)	885.43	1260.31	1260.31	1260.31	1260.31	1260.31	1260.31
Gross returns (₦\ha)	15681	22320.09	22320.09	22320.09	22320.09	22320.09	22320.09
Variable costs							
Fertilizer material (₦\ha)	-	639.23	1278.47	1917.70	2481.12	3144.48	3196.17
Other variable inputs (₦\ha)**	-	173.63	173.63	173.63	173.63	173.63	173.63
Total variable cost (TVC)	-	812.86	1452.10	2091.33	2654.75	3318.11	3369.80
Net returns (₦\ha)	15681	21507	20868	20229	19665	19002	18950
Change in net returns between users and non-users of fertilizer at different prices	-	5826	5187	4548	3984	3321	3269
Change in total variable costs at different fertilizer prices between users and non-users.	-	812.86	1452.10	2091.33	2654.75	3318.11	3369.80
Rate of returns (R_f)	-	7.17	3.57	2.17	1.50	1.00	0.97

Source: Field data, 1998.

* Indicates the break even price at which the use of fertilizer is as good as its non-use . Above this price it becomes uneconomical to use fertilizer.

** Includes cost of transport and application of fertilizer.

TABLE 45

Sensitivity Analysis for fertilizer use at different prices in derived savanna zone

Item	Non-users (0 kg\ha)	Users (182.99 kg\ha)	+100%	+200%	+300%	+361.14%	+455.50 %	+566.12%
Price of fertilizer (₦\kg)	-	3.68	7.36	11.04	14.72	17.72*	22.35	25.00
Change in fertilizer price (%)	-	-	100	200	300	361.14	455.50	566.12
Yield (kg\ha)	785.55	1268.62	1268.62	1,268.62	1,268.62	1,268.62	1,268.62	1,268.62
Gross returns (₦\ha)	13,865	22,391.14	22,391.14	22,391.14	22,391.14	22,391.14	22,391.14	22,391.14
Variable costs								
Fertilizer material (₦\ha)	-	673.40	1346.81	2020.21	2693.61	3242.58	4089.83	4574.75
Other variable inputs (₦\ha)**	-	165.29	165.29	165.29	165.29	165.29	165.29	165.29
Total variable costs (TVC)	-	838.69	1512.10	2185.50	2858.90	3407.87	4255.12	4740.04
Net returns (₦\ha)	13,865	21,553	20,879	20,206	19,532	18,983	18,136	17,651
Change in net returns between Users and Non-users of fertilizer at different prices	-	7,688	7,014	6,341	5,667	5,118	4,271	3,786
Change in total variable costs at different fertilizer prices between users and non-users	-	838.69	1,512.10	2,185.50	2,858.90	3,407.87	4,255.12	4,740.04
Rate of returns (R_f)	-	9.17	4.64	2.90	1.98	1.50	1.00	0.80

Source: Field data, 1998.

* Break-even price

TABLE 46
Sensitivity analysis for fertilizer use at different prices in the study area

Item	Non-users (0 kg\ha)	Users (177.17 kg\ha)	+100%	+200%	+348.11%	+367.21%	+396.40%
Price of fertilizer (₦\kg)	-	3.70	7.40	11.10	16.10*	20.38	22.00
Change in fertilizer price (%)	-	-	100	200	348.11	367.21	396.40
Yield (kg\ha)	836.06	1,264.32	1,264.32	1,264.32	1,264.32	1,264.32	1,264.32
Gross income (₦\ha)	14,782	22,353.18	22,353.18	22,353.18	22,353.18	22,353.18	22,353.18
Variable costs:							
Fertilizer material (₦\ha)	-	655.53	1,311.06	1,966.59	2,852.44	3,610.72	3,897.74
Other variable inputs (₦\ha)**	-	172.15	172.15	172.15	172.15	172.15	172.15
Total variable costs (TVC)	-	827.68	1483.21	2138.74	3024.59	3782.87	4069.89
Net returns (₦\ha)	14,782	21,526	20,870	20,214	19,329	18,570	18,283
Change in net returns between users and non-users of fertilizer at different prices	-	6744	6088	5432	4547	3788	3501
Change in total variable costs at different fertilizer prices between users and non-users	-	827.68	1483.21	2138.74	3024.59	3782.87	4069.89
Rate of returns(R_f)	-	8.15	4.11	2.54	1.50	1.00	0.86

Source : Field survey, 1998.
* indicates the break-even price

The decreasing trend in the rate of return to fertilizer use as the cost incurred on fertilizer increases is shown in figure 4. When the cost of fertilizer was₦ 3.70\kg in the study area, the rate of return (R_f) to fertilizer use was 8.15. With an increase of 348.11% in cost, R_f reduced to 1.50 while a 396.40% increase in cost further reduced R_f to 0.86.

Similarly, a break-even yield of 1,000, 904 and 953 kg\ha respectively were obtained for the rain forest, derived savanna and the two zones combined (Table 47). This means that for fertilizer use to be considered an economically profitable practice in the study area, the yield obtained from its use should be higher than 1000 kg\ha (or > 79.36 % of the yield obtained for 100 kg/ha) in the rain forest zone; 904 kg\ha (or > 71.29 % of yield obtained for 100 kg\ha) in the derived savanna zone; and 953 kg/ha (or > 75.40 % of yield obtained for 100 kg\ha) in the two zones combined. Figure 5 shows the effect of decreases in yield levels on the rate of return (R_f) to fertilizer use in the study location. At a yield level of 1,268.62 kg\ha, the rate of return to fertilizer use in the study area was 9.17. When the yield level was reduced by 28.71%, R_f was 1.50 while at a further decrease in yield level by 31.26%, R_f reduced to 0.82. Thus, the inability of any farmer to achieve the acceptable minimum rate of return from fertilizer use at the break-even point of 1.50, makes the technology inappropriate for use. Table 47 also shows the percentage of respondents (users and non-users) who attained the break-even yield levels in each zone and the study area. Except for the rain forest zone, the difference between the proportion of users and non-users respondents who attained the break-even yield level was not significant at the 5% level. The computed t-values were 2.34 (in the rain forest zone), 1.47 (derived savanna zone) and 1.66 for the two zones combined. This suggests that use of fertilizer is capable of increasing the proportion of farmers that can attain the estimated break-even yield level especially in the rain forest zone.

TABLE 47

Sensitivity Analysis for fertilizer use at different yield levels

Overall (Rain forest & Derived savanna zones)					Rain Forest Zone				Derived Savanna Zone			
Item	Non-users (0 kg\ha)	Users (177.17 kg\ha)	-24.60% yield	-27% yield	Non-users (0 kg\ha)	Users (172.30 kg\ha)	-20.64% yield	-24.32% yield	Non-users (0 kg\ha)	Users (182.99 kg\ha)	-28.71% yield	-31.26% yield
Mean yield (kg\ha)	836.06	1264.32	953.30	922.95	885.43	1260.31	1000.18*	953.80	785.55	1268.62	904.40	872.05
Decrease in yield(%)	-	-	24.60	27.00	-	-	20.64	24.32	-	-	28.71	31.26
Output price (₦\kg)	17.68	17.68	17.68	17.68	17.71	17.71	17.71	17.71	17.65	17.65	17.65	17.65
Gross returns (₦\ha)	14,782	22,353.18	16,854.34	16,317.76	15,681	22,320.09	17,713.19	16,891.80	13,865	22,391.14	15,962.66	15,391.68
Total variable input costs (₦\ha)	-	827.68	827.68	827.68	-	812.86	812.86	812.86	-	838.69	838.69	838.69
Net returns	14,782	21,526	16,027	15,491	15,681	21,507	16,900	16,079	13,865	21,553	15,124	14,553
Change in net returns between users and non-users of fertilizer at different yield levels	-	6,744	1,245	709	-	5,826	1,219	398	-	7,688	1,259	688
Rate of return (R_f)	-	8.15	1.50	0.86	-	7.17	1.50	0.49	-	9.17	1.50	0.82
Number of respondents at break-even yield level	16	106			11	57			05	49		
Percentage (%)	18.39	49.77			25.00	49.14			11.63	50.52		
t_c		2.34				1.47				1.66		

Source: Field data, 1998

* Indicates the break-even yield at which the use of fertilizer is as good as its non-use. Below this yield level, it becomes uneconomical to use fertilizer technology.

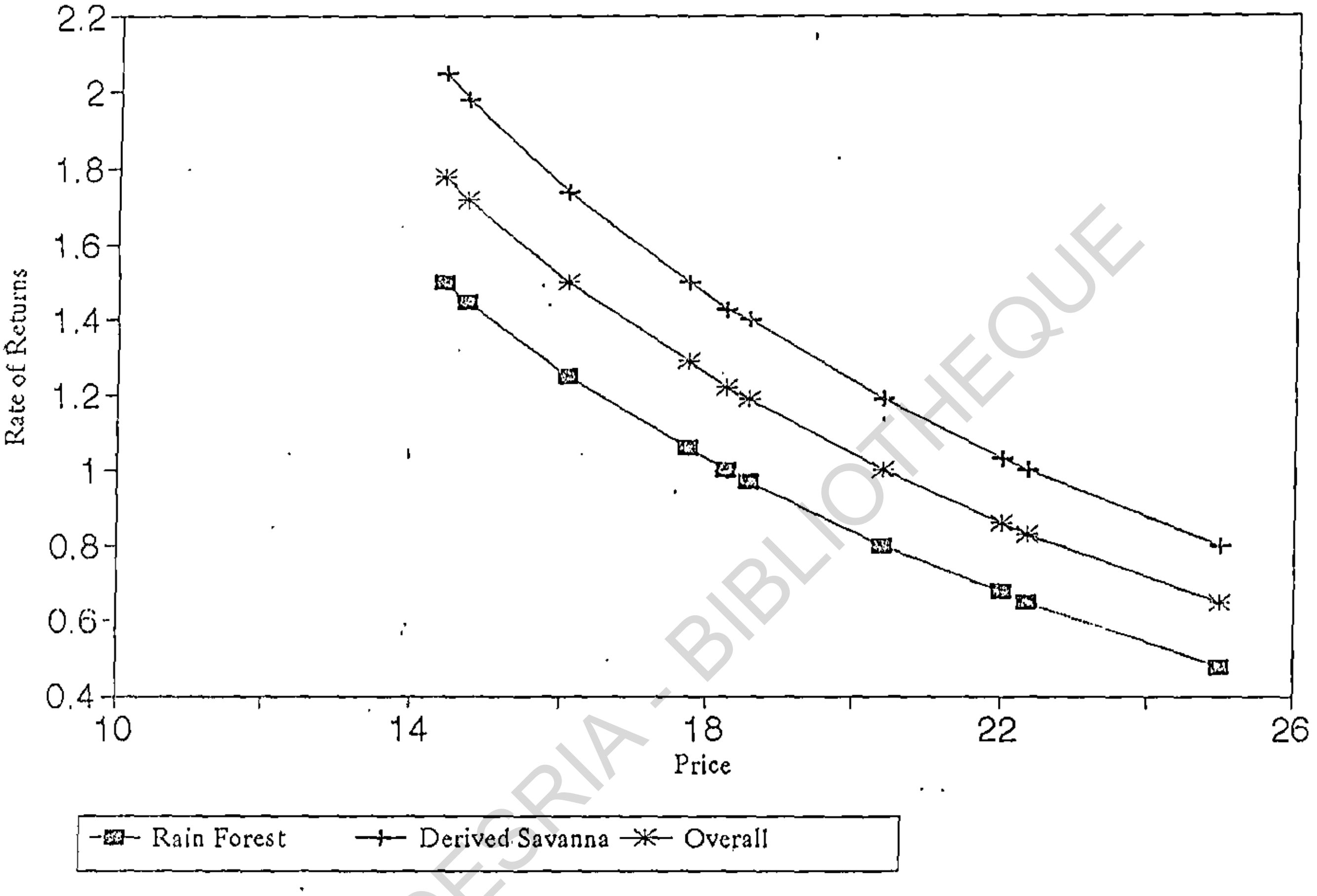


Fig. 4: Effect of increases in cost on the rate of returns to Fertilizer use

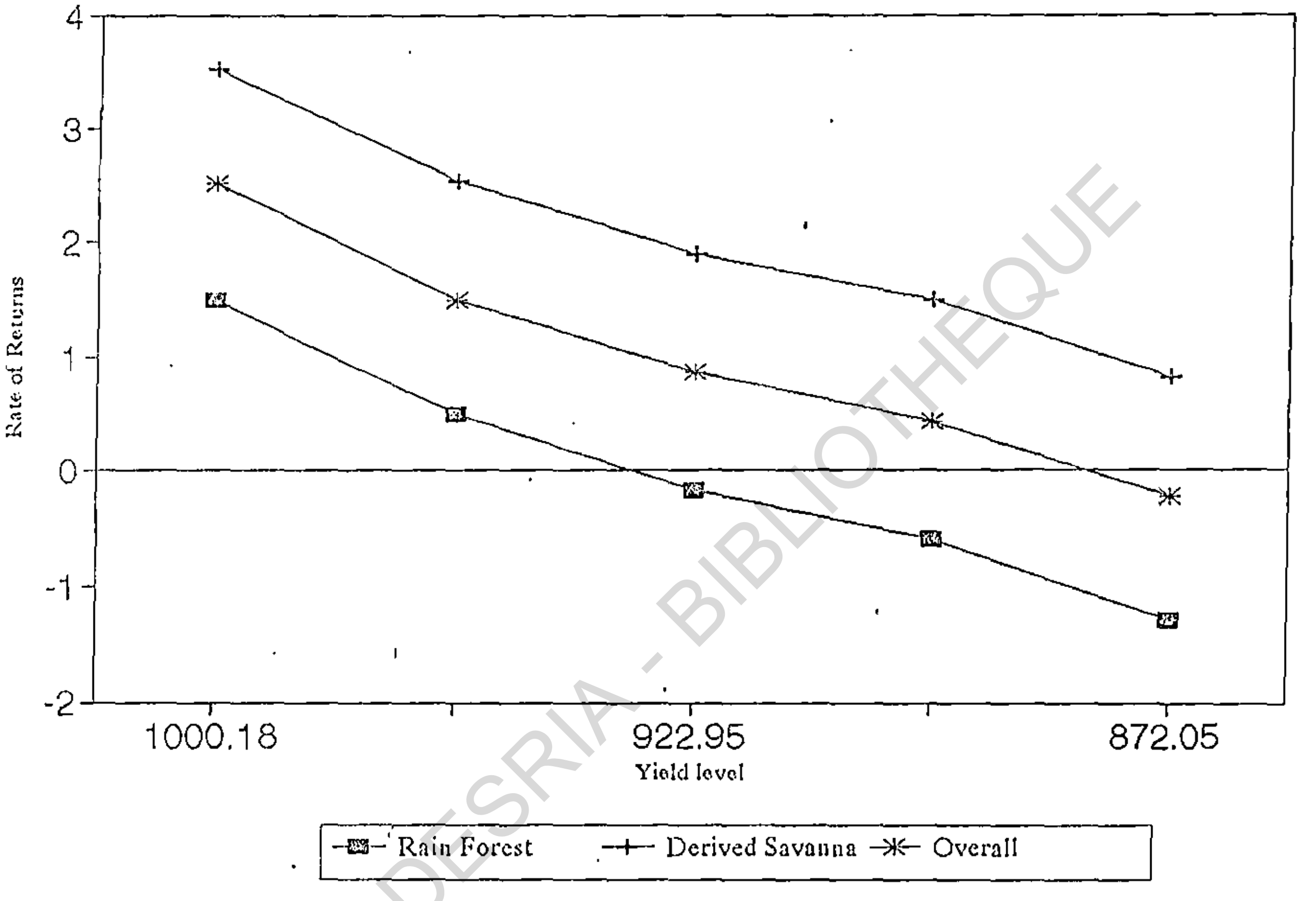


Fig. 5: Effect of decreases in yield level on returns to fertilizer use

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

The attainment of the food self-sufficiency objective of Nigeria's agricultural development programmes implies producing more food under the existing agricultural land-use system. However, interacting factors such as population pressure, urbanization, economic constraints and ecological limitations, among others have caused changes in smallholder access to farm land resulting in a reduction in man-land ratio. This invariably leads to a depletion of soil fertility through continuous or intensive cropping of the land resource. Under this system, nutrient availability from natural sources alone become inadequate and farm productivity can only be maintained through efficient and increasing use of yield-enhancing technologies.

In order to enhance farm productivity and income levels, this study examined those factors viz: farmer-, resource-, institutional-, property rights-,and environmental-specific, which create opportunities or act as obstacles for the adoption of intensification technologies in two agroclimatic zones in Osun state of Nigeria. Specifically, the objectives of the study were to:

(i) examine the relationship among those factors which bear on farmers adoption response to fertilizer technology;

(ii) compare the effects of these factors on farmers adoption decisions between agroclimatic zones;

(iii) analyse the extent of use of the technology once adopted; and

(iv) estimate The costs and returns to fertilizer use in the agroclimatic zones.

Data were collected with the aid of a structured questionnaire administered on three hundred respondents. Four focus group discussion sessions were also held. Data were analysed using descriptive statistics, correlation technique, Tobit regression and partial budget analysis.

Analysis of the socio-economic characteristics of respondents in the study area showed that fertilizer users in the rain forest zone recorded a mean age of about forty-eight years, while a mean age of fifty-four years was estimated for the derived savanna zone. Non-users of the technology also recorded an almost similar age pattern for the two zones. Generally, respondents in the study area are of average age, and this is capable of positively influencing their fertilizer adoption decisions. A mean year of schooling of 3.8 and 3.0 years respectively were recorded for users and non-users of fertilizer in the rain forest zone while approximately 3.6 years was recorded for the two groups of respondents in the derived savanna zone. A fairly large number of the respondents were illiterates while literacy level in the two zones were found to be about the same. Farm size varied between 0.04 and 2.80 hectares among respondents with a mean of 0.58 ha obtained for fertilizer users while non-users cultivated a mean of 0.62ha. The average farm size cultivated by respondents in the two zones was found to be statistically the same. About seventy-eight percent of the respondents acquired their farmland through primary access (purchase and inheritance). Fifty-seven percent of this total were users of fertilizer who acquired their farms through inheritance. Other forms of land acquisition in the area included : borrowing, leasing, gift, clearing of unallocated land and pledging. Farmland was found to be continuously cropped for an average of thirteen years with a mean fallow period of 1.48 and 1.81 years respectively among users and non-users of fertilizer in the survey location. This has implications on the need for farmers to make use of intensification technologies to ensure continuous farm production and sustained yield in the study location. Inorganic fertilizer was found to be the most commonly used intensification technology in the survey location. One hundred and sixteen (54.5%) and ninety-seven (45.55) respectively of the total number of users were found in the rain forest and derived savanna zones. Other yield enhancing technologies used by respondents in the study area include organic manure, alley farming practice and tree planting. A combination of these technologies were also being used.

Results from correlation analysis revealed that farm size and net farm income showed a fairly strong significant positive relationship with the adoption and use of fertilizer technology in the rain forest zone, while mode of land acquisition exhibited a weak significant (positive) relationship. In the derived savanna zone, age, farm size and net farm income recorded significant positive relationships with the probability of fertilizer adoption. In general, farm size and net farm income were found to have significant (positive) relationships with farmers' adoption behaviour across the zones in the study area.

Tobit regression results involving five factor categories (i.e personal-, resource-, institutional-, property rights- and locational- factors) revealed that availability of fertilizer, farm size and net farm income were highly significant in explaining fertilizer adoption decisions in each of the agroclimatic zones as well as in the study area. When only personal characteristics were considered, age and sex were found to have statistically significant effects on fertilizer adoption decisions for the study area. Age showed a positive influence while sex was negative. However, while age recorded a strongly significant positive effect on adoption decisions in the derived savanna zone, respondents' age exhibited negative effects. Resource- specific factors showed that farm size and net farm income have significant effects on fertilizer adoption decisions in each of the zones while only net farm income was significant in the two zones combined. Availability of fertilizer was the only institutional-specific variable which has highly significant estimates for each of the zones and the study area. Locational factors however, exerted no statistically significant effect on respondents' adoption decisions.

The decomposition of fertilizer adoption elasticities revealed that almost without exception, farmers probability of adoption and non-adoption accounted for more of fertilizer technology response than did the quantity factor. In other words, the total population of fertilizer adopters can better be increased by improving the availability of the technology rather than increasing the quantity of fertilizer allocated to farmers in the study area.

The partial budget technique employed to determine costs and returns to fertilizer use in the survey location showed that net returns to users and non-users of the technology was ₦21,507 and ₦15,681 per hectare respectively for the rain forest zone and ₦21,553 and ₦13,865 for the derived savanna zone. Highly significant differences were found to exist between the mean net returns earned by users and non-users of the technology in each of the two zones. Security of tenure was also found to affect the average net income levels of farmers, as farmers who purchased or inherited their fields with full control earned more than others. Thus, fertilizer use is capable of enhancing farmers net income in the survey location. Sensitivity analysis performed on fertilizer use at different price levels showed a break-even price of approximately₦ 14/kg,₦ 18/kg and₦ 16/kg respectively for the rain forest zone, derived savanna and the study area. At these prices, the marginal rate of return to fertilizer use equates the acceptable minimum rate of return of 1.50, such that the use of this technology is as good as its non-use. Above these prices, it becomes uneconomical for respondents to continue with the use of the technology.

6.2 Conclusion

Based on the findings of this study ,the following conclusions were drawn:

(i) Majority of the respondents who use fertilizer in the study area were males of average age who are capable of obtaining information relating to enhancing their farm production efforts. This could thereby positively aid farmers thinking towards using yield-enhancing technologies like fertilizer on their farm plots.

(ii) The average size of respondents farmland in the study area was generally small, while a large proportion of farmland were acquired through the inheritance pattern.

(iii) The average length of time for which respondents farmland is being continuously cropped (13 years), is somewhat high, and this, with the low mean duration of fallow, may have destructive impacts on the soil structure if measures for adequate use of land intensification technologies are not employed.

(iv) A fairly large number of respondents in the survey location are illiterates. This may negate their urge to search for new information and new innovations that can lead to improved farm production.

(v) Apart from inorganic fertilizer use, respondents in the study area are also aware of three other technologies namely: organic manure, alley farming and tree planting that may be used as alternatives to chemical fertilizer. Though these technologies are seldom used when inorganic fertilizer is available, an opportunity is provided for experimenting with each of these technologies or their combination to take care of possible exigencies.

(vi) Variations exist in the type of factors that affect the adoption or non-adoption of fertilizer technology in the study area. This depends on the agroclimatic zone involved and on whether all the factors (i.e personal-, resource-,property rights-, institutional-, and environmental-) are considered singly or in different combinations.

(vii) Decomposition of Tobit regression results showed that farmers probability of adoption and non-adoption accounted for more of fertilizer technology response than did the elasticity of use intensity. Thus, encouraging the use of recommended rates of fertilizer among farmers is capable of enhancing farm yield and income levels above the current levels in the study area. An average maize yield of more than 953.30 kg/ha for maize will further encourage the use of the technology in the study area. Though zonal variations in maize yield and income levels do exist and the effect more pronounced in the derived savanna zone and according to property right status, nonetheless, for this to be achieved, the technology has to be made available at the right time, quantity and at a reasonable price not greater than approximately₦ 16/kg for the study area.

6.3 Recommendations

The changing trend of land use patterns vis-a-vis farm production practices aimed at enhanced food production requires the increasing adoption of appropriate intensification technologies. An assessment of factors which create opportunities or act as obstacles for the adoption of these technologies therefore becomes very crucial for policy consideration. The above conclusions provided the basis on which policy implications of this study were drawn. However, care is taken in drawing general policy inference as the results of this study can only be applicable to areas with similar basic system of farming. In the light of the above, the following policy recommendations are made:

(i) The differential impacts of adoption factors on the probability of adoption and intensity of use of fertilizer technology have important implications as they suggest that agricultural production efforts aimed at enhancing new technologies by policy makers and agricultural planners should generally focus on farm households that are not currently using the technology, while efforts should be concentrated more on educating farmers about fine-tuning their technology use practices to further improve the efficiency of their use. These differential impacts are also important in the light of changes in farmers awareness of the need for fertilizer use due to population pressure, reduced fallow periods and farm sizes as well as increased cropping intensity on the land. As farmland becomes increasingly overused, the traditional fertility maintenance practice of fallowing becomes eroded and use of fertilizer and other intensification technologies must therefore assume greater significance in the future as a way of responding to intensification pressures.

(ii) The use of fertilizer on small farms should be assured through the promotion and expansion of training programmes to young farmers. This could be achieved through the extension unit of the state's Ministry of Agriculture.

(iii) It need be noted that farmers have come to realise the importance of fertilizer technology as they have achieved significant gains in surpluses and income. Thus, increased net farm income can be used to encourage farmers to adopt the use of fertilizer or to move along desired resource allocation paths. It can also induce practicing farmers to expand input use to optimal levels. In this regard, a policy that increases farmers net income is a more powerful means of increasing the total population of adopters, while a policy that increases the quantity of fertilizer available to farmers is likely to be a more effective instrument for increasing their use. However, since not all farmers in the survey location used the technology during the period under study, while those who adopted the innovation may have under-utilized it, policies that will simultaneously increase farmers net income as well as the quantity of fertilizer available to them may be preferred. However, these can not exist in isolation, as it depends on significant government support for agricultural research, marketing\distribution network, infrastructure and remunerative prices for this technology. Additionally, without adequate provision of other services such as improved extension services, credit and input distribution services, most people may not be encouraged to farm, while current farmers become discouraged.

(iv) It can be deduced from this study that the low rate of application of fertilizer stems more from government policies, as well as supply and distribution problems, than from lack of awareness. Given the fact that most farmers are now aware of the benefits of applying fertilizers, emphasis should be placed on ensuring the availability of the right type, quantity, time and place of fertilizer even at the current prices. This is because farmers only want to ensure that fertilizer is applied to their crops and do not know that there are required levels of fertilizer needed per unit of land for specific crops and soils. Since fertilizer use levels are generally low and variations do exist in the net benefits obtained for each agroclimatic zone and property right status, there is considerable potential for increasing fertilizer use in the study area without having adverse consequences.There is also potential for improving fertilizer use efficiency so that more crop output and income can be obtained from the same level of nutrient use. Farmers therefore need be trained on the agronomic requirements and use of these technology in order to prevent negative socio-economic and environmental consequences that may result from its inappropriate application.

(v) Policy makers, agricultural planners, institutions and organisations involved in fertilizer production and distribution need to consider the key variables (net farm income, farm size and availability of fertilizer) identified in this study in order to forecast more accurately, future fertilizer use patterns. Variations in net income and yield levels between the rain forest and derived savanna zones also strengthen the need for targeting scarce fertilizer to areas of high use potential.

6.4 Limitations of study and suggestions for future research

There are various factors that influence farmers adoption decisions of intensification technologies. However, the scope of this study could only examine some of these factors. It is therefore suggested that future research efforts be directed to examining directly, such other factors as risk and uncertainty as well as community factor influences on farmers adoption behaviours.

Additionally, the partial budget analysis employed in this study only examined the costs and returns to fertilizer use. It is therefore suggested that future research efforts could examine the costs and returns to alternative technologies vis-a-vis fertilizer, to establish an adequate combination that would improve soil quality and facilitate improved farm production.

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APPENDIX I
OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE
DEPARTMENT OF AGRICULTURAL ECONOMICS

QUESTIONNAIRE ON FACTORS INFLUENCING THE ADOPTION OF

FERTILIZER TECHNOLOGY IN OSUN STATE OF NIGERIA

Questionnaire No.:

Agroecological Zone

Local Government Area

Village/Town

Interviewer ____________________ Date:

A. **FARMER'S PERSONAL CHARACTERISTICS**

1. Age____________ (Years)

2. Gender: (i) Male_________ (ii) Female

3. Marital status:
(i) Single_________ (iv) Widowed
(ii) Married_________ (v) Separated
(iii) Divorced

4. Household Size:
(i) Male children______ (ii) Female children
(iii) Wife(ves)_________(iv) Relatives

5. How many of your family members are above 60 years of age? (i)Male_________ (No.)
(ii)____________

6. How many years have you lived in this Village/Town____ yrs.

7. Are you a member of a landowning group?
(i) Yes ____ (ii) No

8. Are you head of a lineage? (i) Yes ____ (ii) No

9. Are you a local leader? (i) Yes ____ (ii) No

10. Which position do you hold in this community?

11. Level of Education:

(i) Never been to school
(ii) Did not complete elementary school
(iii) Completed elementary school
(iv) Adult education class/evening school
(v) Modern school
(vi) Secondary school/Teacher's college
(vii) College of Education/Polytechnic/University

12. Nature of farming business:

(i) Full-time ___ (ii) Part-time

13. If Part-time, please, state other types of business

(i) Blacksmitting_____ (ii) Bricklaying

(iii) Carpentary_____ (iv) Tailoring

(v) Trading _____ (vi) Hunting

(vii) Weaving _____ (viii) Others (specify)

14. Farming experience (state specifically) _____ (years)

B. <u>PROPERTY RIGHTS AND LAND-USE FACTORS</u>
<u>PROPERTY RIGHTS</u>:

1. Do you own the land on which you farm?
(i) Yes ___ (ii) No

2. How did you acquire your farmland?

(i) Bought _____ (ii) Inherited

(iii) Gift _____ (iv) Borrowed

(v) Pledged _____ (vi) Leasehold

(vii) Clearing of unallocated land

(viii) Others (specify)

3. Is your farmland located within the domain of your lineage?

(i) Yes ____ (ii) No

4. How many plots of farmland do you have (including those under fallow)? ________ (No.)

5. What is the size, topography, crops grown and the distance of your farm plots from your dwelling place?

Plot	Plot Location on toposequence	Size No. of Heaps or acre	Crop grown	Distance from Home (kms)

6. Can you sell part of your farmland if you wished to now or in future?

(i) Yes ____ (ii) No

7. Can you rent out part of your farmland?

(i) Yes ____ (ii) No

8. Do you receive compensation for unexhausted improvement on your farm?

(i) Yes ____ (ii) No

9. How is the value determined?

(i) Landowner decides ___ (iii) Government decides

(ii)Tenant decides ____ (iv) Others (specify)

10. How do you perceive the security of your rights to use of the farmland?

____

11. If you are a tenant how do you pay rent?

(i) Cash ______ (ii) In kind
(iii) Both _____ (iv) Pay nothing

12. How much do you pay yearly?

Cash Paid (₦)	Value of Crops paid	Total
________	____________	

13. Have you ever considered the type of land tenure arrangement enjoyed by you in your investment decisions?

(i) Yes ___ (ii) No

14. If Yes, how?

15. If No, why?

LAND-USE

1. Can you plant any crop type on your farm?
(i) Yes ___ (ii) No

2. Do you own any Cash/Economic trees?
(i) Yes ___ (ii) No

3. If Yes, which types?
4. What is the cropping form on your farmland?

(i) Individual cropping

(ii) Collective cropping

5. For how long have you been continuously cropping on the land?

Plots	Years
________	

6. Do you have any cultivable land which you are not using at present?

(i) Yes ___ (ii) No

7. If yes, why are you not using it?
(i) Left to fallow ____ (ii) Labour shortage

(iii) Shortage of fund ____ (iv) Others (specify)

8. If left to fallow, what is the year of last fallow?

____ (years).

9. What is the duration of the most recent fallow?

_______ days/years.

10. What is the number of years during which the farmland has been continuously cultivated since last fallow, and what is the area cultivated?

<u>Plots</u> <u>Years</u> <u>Area cultivated (Ha)</u>

____ _____

11. Have you ever heard of the Land Use Decree that all land in Nigeria now belong to the Federal Government?

(i) Yes ____ (ii) No

12. What effect does the Decree have on your farming activities?

C. TECHNOLOGY/RESOURCE CHARACTERISTICS/PRODUCTION

1. What are the major food crops grown by you?
2. What produce did you harvest last cropping season?

Crop	Quantity (Tonnes or Bags)	Price (N)

3. When did your planting operations start?

Crops	Date of Planting	No. of Weeding Before Harvesting

4. Which maize variety do you grow?

(i) Local Yes ___ No

(ii) Hybrid Yes ___ No

(iii) Others (specify)

5. How much did you realise as proceeds from sale of your crops last cropping season? (Please, indicate for each crop)

Crops	Proceeds (₦)

6. How much did you realise from other occupations aside farming?
₦

7. What cropping system do you practice?

(i) Sole Cropping ___ (ii) Mixed cropping

8. How many of your family members normally help you with farm work?

(i) Wives ___ (nos) (iii) Male children ___(Nos)

(ii) Female children ___ (iv) Relatives

9a. Do you use fertilizer on your farm?

(i) Yes ___ (ii) No

9b. On what proportion of your farmland did you apply fertilizer?

10. Which year did you start applying fertilizer to your farmland? 19

11. What level of fertilizer did you apply last cropping season?

Plot No.	Name of fertilizer (type)		Target crop	Quantity applied (kg/ha)	Cost/unit (₦)	Total Cost (₦)
	organic	inorganic				

12. How many times do you apply fertilizer before harvesting?

_______ (times).

13. Do you get the fertilizer on time to start your farm operations?

(i) Yes ___ (ii) No

14. Where do you obtain your fertilizer supplies? (Please, state)

15. What is the distance of your farm to the fertilizer source? __________ (km).

16. How much of the following inputs did you use on your farm last cropping season?

No.	Inputs	Quantity	Unit Cost (₦)	Total (₦)
i	Local Seeds			
ii	Improved Seeds (Hybrid)			
iii	Herbicides			
iv	Pesticides			
v	Tractors			

vi	Manure			
vii	Leafy mulch			
viii	Irrigation water			
ix	Storage facility			
x	Other Inputs (specify) (i) alley cropping (ii)tree planting (iii)cutlass\hoe etc.			

17(a) How much did you spend altogether on your farm operations last cropping season? - (N)

(b) Do you consider the availability/accessibility of the following inputs adequate or inadequate?

No.	AVAILABILITY (adequacy of supply)			ACCESSIBILITY (easy reach)	
	Inputs	Adequate	Inadequate	Adequate	Inadequate
i	Local Seeds				
ii	Improved Seeds				
iii	Herbicides				
iv	Pesticides				
v	Tractors				
vi	Manure				
vii	Leafy mulch				
viii	Irrigation water				
ix	Fertilizer				
x	Storage Facility				

18. If inadequate, please, give reasons

No.	REASONS		
	Inputs	Availability	Accessibility
i	Local Seeds		

ii	Improved Seeds		
iii	Herbicides		
iv	Pesticides		
v	Tractors		
vi	Manure		
vii	Leafy mulch		
viii	Irrigation water		
ix	Fertilizer		
x	Storage Facility		

19. Do you perceive soil erosion problems on any of your farm plots?

(i) Yes ___ (ii) No

20. Which are the plots? ___________________________

21. Do you make use of any control measure?

(i) Yes ___ (ii) No

22. If yes, how do you control it?
23. If No, why? ___________________________

24. What are the physical land improvements carried out by you on your farm

No.	Improvement	Amount Spent (₦)	Useful life
i	Construction of dams, terraces, wells, canals etc.		
ii	Farm buildings, livestock, houses/fencing		
iii	Construction of farm and access roads		
iv	Barn and storage facility construction		
v	Tractors, Ploughs, Harrows, Sprayers, Traction equipment		
vi	Tree planting		

vii	Others (specify)		

D. <u>INFRASTRUCTURE/INSTITUTIONAL CHARACTERISTICS</u>

1. Do you belong to any social organisation?

   (i) Crop society ____ (ii) Esusu

   (iii) Farmers' Union _____ (iv) Others (specify)

2. What is (are) the benefits of this association to you with respect to your farm operations?
3. Who are the sources of fund for your farm business?
   (i) Friends/Relatives
   (ii) Banks
   (iii) Money lenders
   (iv) Others (specify)

4. Have you ever been visited by government extension agents?

   (i) Yes ____ (ii) No

5. If yes, how many times per month? _____ (times)

6. Do you normally follow their advice?

   (i) Yes ____ (ii) No

7. If No, why not?

8. Please, suggest ways by which you could be encouraged to invest more in the use of modern techniques to enhance farm production.

APPENDIX II
OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE
DEPARTMENT OF AGRICULTURAL ECONOMICS

FOCUS GROUP DISCUSSION GUIDE ON FACTORS INFLUENCING THE ADOPTION OF FERTILIZER TECHNOLOGY IN OSUN STATE OF NIGERIA

GUIDELINES BEFORE COMMENCING FGD

* SIZE OF GROUPS: 7 - 10 Participants
* Introduce Facilitator, Recorder and explain purpose of study.
* Explain that a Tape Recorder will be needed, but, that the information will be kept Confidential.
* There are No right or wrong answers; we care about their personal views on the issues to be discussed.
* Encourage all to participate actively, while the conversation should go smoothly and freely. Participants should not interrupt others or dominate the conversation.
* Participants in the FGD should introduce themselves to get more acquainted. As part of introduction start with A.

A. **General**

Participants' sex, age, occupation, level of education, number of dependants.

B. **Personal Attributes**

1. What is the major occupation in this community?
2. How would you describe the level of income from farming in this community?

C. **Property Rights/Land Use Factors**

1. How is farmland generally owned in this area?
2. Is the land enough for everyone in this community to farm?
3. Can farmland be used as collateral security for loan?

4 (a). Please, describe the lineage system in this locality.

(b). What are the property right regimes to which farmers belong in this locality?

5. What are the socio-historical factors which intervene to influence the distribution of land rights among farmers in this area?

6. Under what conditions can land rights of qualified owners be revoked?

7. In your opinion, what are the problems facing <u>landowners</u> and <u>tenants</u> in the use of farmlands in this locality?

8. What is the least number of years that farms are rested (fallow) in this area?

9. What is the longest period that fields are rested?

10. Is the fallow period shorter now than ten years ago, and why?

11. What have been the main effect of shorter fallow periods?

12. What is your view about the Land use decree?

13. What effect does the policy have on farming activities in this locality?

D. **<u>Resource/Technology/Production Factors</u>**

1. What is the average farm size in this locality?
2. On the average, how many of your family members assist you in your farming activities in this area?
3 How much could be realized on the average on a 1 hectare maize farm (sole) in this locality : When fertilizer is applied and when not applied. What about for other major crops?
4. How much could be realized on the average for a 1 hectare maize farm of mixed crops: When fertilizer is applied and otherwise?
5. Do farmers in this area use improved seeds? (Please, list the improved seeds).
6. Please, describe the availability and accessibility of fertilizer technology for farm operations in this locality?

E. **<u>Infrastructural/Institutional Factors</u>**

1. Are there social organisations in this locality? (specify)
2. Which of the organisations do farmers belong?
3. Why do farmers generally join social organisations in this area?