ANALYSIS OF AGROFORESTRY PRACTICES IN KATSINA STATE, NIGERIA

OKONKWO MARIUS CHUKWUJEKWU

B.Sc. (Hons.) Botany (Jos)

M. Sc. Environmental and Resource Planning, (Jos)

PGES/UJ/14150/02

A Thesis in the DEPARTMENT OF GEOGRAPHY AND PLANNING,

Faculty of Environmental Sciences

Submitted to the School of Postgraduate Studies, University of Jos in

Partial Fulfillment of the Requirement for the Award of the DEGREE of

DOCTOR of PHILOSOPHY in Environmental and Resource Planning of the

University of Jos.

NOVEMBER, 2010

DECLARATION

I hereby declare that this work is the product of my own research efforts, undertaken under the supervision of Professor, A. A. Adepetu and Dr. E. A. Olowolafe and has not been presented elsewhere for the award of a degree or certificate. All sources have been duly distinguished and appropriately acknowledged.

_____

Okonkwo, Marius Chukwujekwu
PGES/UJ/14150/02

CERTIFICATION

This is to certify that the research work for this thesis and the subsequent preparation of this thesis by Okonkwo, Marius Chukwujekwu with Matriculation number PGES/UJ/14150/02 was carried out under our supervision.

_____ _____

Prof. A. A. Adepetu Date
(Supervisor)

_____ _____

Dr. E. A. Olowolafe Date
(Co-Supervisor)

_____ _____

Dr. J.Y. Dung Gwon Date
(Head of Department)
Department of Geography and planning

ACKNOWLEDGEMENT

For the successful completion of this research work, I am first and foremost grateful to the Almighty God for giving me the strength and health to accomplish this programme. His divine mercies made it possible for this research work to be a reality. I wish to express my sincere gratitude and indebtedness to my supervisor, Professor A .A. Adepetu and my co-supervisor Dr. E. A. Olowolafe, for supervising this work and for their patience, guidance and encouragement throughout my year of study. Their constructive criticism, suggestions, advice and support have been the hallmark for the productive end of this study. I am grateful to the head of department, Dr. J. Y. Dung Gwom, for his encouragement and support throughout the duration of the programme. I am indebted to my team of advisers especially Professor A. C. Eziashi for his cooperation and moral support. My thanks go to Professor V. C. Ihemegbulem, Professor .E. C. Orji, Professor P. C. Ofojekwu, Dr.F.N. Onumadu, Dr. D.D. Dabi, Dr. C. Y. Oche, Dr. M.O. Osagbemi, and Dr. F. I. Okpiliya, who had contributed in one way or the other to see to the completion of this programme. I appreciate the special love and cooperation I enjoyed from other members of staff (academic and non – academic) of the department.

I wish to express my profound gratitude to the Executive Director Forestry Research Institute of Nigeria Professor S. O. Badejo, the provost Federal College of Forestry, Mr. B.O. Omoayena, my colleges; Mr. O. Owa, , Mr. C. O. Ayeni, Mr. R. Adewoye, I. A Kareem, Dr. S. Adepoju, Mr. A. C. Mgbojikwe, Mr .A. Ampitan and

Mr. A.B. Salaudeen. My sincere gratitude goes to Miss Blessing Ofurum, Mrs. Tina Musa and Mr. Yakubu Musa who made the typing of this project possible.

I remain grateful to Alhaji Idris Abubakar, Yaradua Abubakar, Director and staff of Katsina State Forestry, coordinator of Afforestation projects in Katsina state, who assisted me in no small measure during my field work.

I acknowledge greatly the encouragement I got from my academic mentor late Mr. E.A.U. Umeokafor of blessed memory, may his gentle soul rest in perfect peace with the Lord, Amen.

I am deeply indebted to my Late father Mr. Timothy Okonkwo and my mother Mrs. Elizabeth Okonkwo for the support and care given me to attain to my present status. I say a big thank you to my lovely wife Mrs. Caroline Okonkwo. Her continuous stay by my side at each stage of the research is a source of joy and encouragement. To my children Uche, Chinwe and Emeka Okonkwo I say a big thank you.

DEDICATION

This research work is dedicated to my late beloved father late Mr. Timothy Okonkwo who passed away without reaping what he had sown for several years. May his gently soul and the souls of all the faithful departed rest in perfect peace with the Lord, Amen.

TABLE OF CONTENT

CHAPTER ONE

INTRODUCTION

CHAPTER THREE

MATERIALS AND METHODS

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

The study investigated agroforestry farming among some international organizations, Nigerian Government, Kastina State Government and farmers in Katsina State. The aim of the study was to provide a baseline information on agroforestry practices in Kastina State. The practices undertaken by these bodies include establishment of shelterbelt, windbreak and woodlots, others were reforestation/plantation establishment, trees on farmland, homegarden and street planting. These bodies reforested a total of 11,0832 hectares of land through agroforestry and aforestation practices. The study covered the three agroecological zones of the state, namely Sahel, Sudan and Guinea savanna zones. Farmers were selected from twenty seven villages, nine villages from each of the three agroecological zones, thus giving a sample size of 450 farmers. The data collected were summarized and presented as ratio/frequencies/percentages/propotions/tables and subsequently subjected to chi-square test to verify the observations made. Variables pertaining to the farmers and their farming activities were investigated. The study has revealed that (i) agroforestry is not widely practiced by farmers in Katsina State as only 23 percent of the sampled farmers practiced it. (ii) Farmers who practiced agroforestry were mainly male and largely within 30-39 age cohort. (iii) agrofrorestry farmers cultivated an area of 609 hectares representing a mean of 6.2 hectares. The predominant agroforestry system practiced was maintaining of multipurpose trees on crop land, windbreak and multipurpose woodlot.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Nigeria's forest resources have been declining steadily due to the rapid growth of population and urban expansion, persistence of shifting agriculture and the ever-increasing demand for forest products, especially fuel wood. The Food and Agricultural Organisation (FAO) (1986) noted that if current trend of timber exploitation in Nigeria persisted, the useful timber resources would be exhausted by the year 2000. Indeed, presently most of the useful timber resources have disappeared from our forests. Unless new plantations of these rapidly disappearing species are established in our forest plantations, they would soon become permanently extinct. Land degradation has been identified as the most serious environmental problem in Nigeria. FAO (1989) noted that the pressure of growing populations in developing countries, has forced landless farmers unto soils which cannot sustain crop production and unto slopes which cannot be safely cultivated at least with technologies and resources currently available to the farmers. Also population pressure, compounded by consistent influx of migrants from neighbouring countries, results in over grazing and continuous over-exploitation of marginal lands. This has in turn aggravated the twin problems of drought and desertification. The consequencesof this to the farmers have often been increased wind and soil ersion, silting, and flooding. Some villages and

access roads have been buried under sand dunes in the extreme northern part of the country.

Increasing demand for land has also intensified deforestation. The traditional system of agriculture is largely characterized by clearance of vegetation. The clearance of unwanted woody perennial is not without repercussions, as it has been confirmed to result in lower potential productivity, reduction in leaf area index and ground water recharge, disruption of soil ecology, breakdown of nutrient cycling and increase in soil erosion, siltation of dams and reservoirs, destruction of wildlife habitats and loss of plant and genetic diversity (World Bank, 1991). Furthermore, the pressure on trees and other plant matter due to demand for fuelwood, housing and others have forced some rural poor families to reduce their cooking and eventually their cooked meals. This has also consumed a lot of human labour, as well as significant proportions of family budgets (FAO, 1985). The overall consequence of continuous cultivation and monocropping is thus large scale deforestation which will eventually result to environmental degradation. Attention has therefore shifted to ways through which available land resources could be effectively utilized so that the resources would continue to be available and also be used in such a way as to ensure its cultivation (Kang et al., 1999). The realization of this has thus brought into focus the need for man to work in partnership with the environment. The land should therefore be used in such a way that it would ensure sustainability. One way of doing so is to embark on farming practices that will not only ensure the maintenance of land

fertility, but also enable a balance of the entire ecosystem.. McNamara (1973) advocated for an agricultural system that would address the problem of the rural peasant farmers. Such a system would also help to combat land degradation that has become a glaring characteristic of highly populated farming communities. Tree planting was earlier acknowledged as an approach to combating land degradation and the introduction of trees was considered necessarily a good thing, regardless of the specific components, arrangement or management (Beets, 1990; Nair, 1993; and Kang *et al*., 1999). It is however, now widely acknowledged that the development of more sustainable landuse systems is necessary if the overall improvement of rural productivity and sustainable landuse management is to be achieved (Scheir and Muller, 1991). Forestry, apart from requiring a fairly long time before its benefits can be visible, is also associated with loss of cultivable land. Farmers on the other hand require immediate benefits in terms of increased food productivity (Young, 1989; Ogar, 1992). Thus it has become difficult to convince farmers to invest in and devote their land to forestry production. Although forestry has had some significant success in combating soil erosions, provision of fuelwood and reducing overall land degradation, its adoption has nevertheless been low among farmers and communities in many parts of the world.

The integration of trees with monocultural crops and animal rearing is considered an appropriate strategy that is capable of bringing about a balance in the ecosystem, especially in the already degraded environments and also in areas

already threatened by land degradation as a result of large scale and often uncontrolled anthropogenic activities. The combination of these productions with annual crop cultivation and sometimes with the rearing of animals on the same piece of land could enable an interaction between the combined species, which bring about stability of the soil and equally enhanced increased productivity. This system is known as agroforestry. The system does not only ensure stability of land resources but could also be used as a means of controlling large scale erosion, reclaiming degraded lands, as well as improve food production (Gordon et al., 1997).

1.2 THE STUDY PROBLEM

One of the greatest challenges facing Nigerians in general, and the inhabitants of Sudano-Sahelian regions of Nigeria in particular, is that of deforestation or vegetation loss. Nigerian forests have been undergoing rapid depletion because of human influence. The problem exists at all levels. The disappearance of forests especially in semi-arid zone has attracted global concerns because of the culminating effect on climate and vegetation in particular and environmental quality in general. The ecological destabilization and the consequent displacement of human population as experienced during the 1968-1974 Sahelian drought represent very serious warning signals to governments on the inherent dangers of deforestation (Charly and West, 1997).

Onumadu (2002) has reported that the Federal Government of Nigeria and that of Katsina state, assisted by some international oganizations, namely: European Economic Community/Katsina State Government (EEC/KTSG), Katsina Afforestation Project Unit/World Bank, (KTAPU/WORLD BANK), established agroforestry projects to check the menace of deforestation in the State. Inspite of all these efforts, the problems of deforestation together with the attendant effects seem to continue. The present study was conceived to show how far these agroforestry practices have been able to address these problems. It is on the basis of these that the work attempted to provide answers to the following research questions

(i) How much agroforestry is practised in Katsina State in terms of the number of farmers who practised agroforestry as well as the area of land under agroforestry?

(ii) What types of agroforestry are widely practised in the study area?

(iii) Why do farmer participate in agroforestry in the study area?

(iv) What problems are encountered and what measures are being used to tackle the problems?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to provide baseline information on agroforestry practices in Katsina state. This was as a result of the limited literature on

agroforestry. The specific objectives required to achieve this aim include the following

(i) determine the extent to which agroforestry is practised in Katsina state.

(ii) determine the type of agroforestry practised in the area.

(iii) identify the reasons for farmers' participation in agroforestry practices.

(iv) to identify the constraints to sustainable agroforestry in the area and the measures for tackling the constraints.

1.4 HYPOTHESIS OF THE STUDY

The following hypotheses have been postulated to determine and account for the extent of agroforestry practiced in Kastina State.

i) H_0 – There is not likely to be a significant variation in the respondent participation in agroforestry.

H_1 – There is likely to be a significant variation in respondent participation in agroforestry.

ii) H_0 – Agroforestry practices may vary considerably among the ecological zones.

H_1 – Agroforestry practices may not vary considerably among the ecological zones.

1.5 SIGNIFICANCE OF THE STUDY

In Nigeria, environmental degradation resulting from increased soil erosion, deforestation or vegetation loss and hydrological changes leading to loss of productivity of land is also being tackled through agroforestry projects (Onumadu et al., 2001). Agroforestry is mainly an integration of the forestry programme into rural farm activities of the farmers. The main focus is on the sustainability of the environment with emphasis on the desirable ways in which farmers can utilize the land to prevent it from degrading. Apart from ensuring maximum utilization of land resources for adequate provision of food, shelter and capital, agroforestry also checks environmental hazards like erosion, desertification, global warming, and ozone depletion acid rains among others.

This study is significant as it addresses a key issue, which is increased production and sustainable use of the environment. This study therefore will provide a basis for the design of agroforestry practices that would fit into the farmers' system and experience. The rapidly degradation of land in Katsina State has not only severely hampered agricultural production, but also has serious effect on the ecological balance. Agroforestry, if well programmed, executed and adopted would offer effective solutions to the various problems.

1.6 SCOPE OF THE STUDY

This thesis focused on the analysis of agroforestry practices amongst farmers in Katsina State of Nigeria. Emphasis was on the practice that constitutes

agroforestry and the extent to which agroforestry could be employed to solve the problem of degradation and thereby minimized landuse degradation in the study area. The study covered the entire state which falls within three ecological zones: Guinea, Suden and Sahel savannah zones. The study was restricted to farmer in nine (9) selected villages from each of the three (3) ecological zones. The study also investigates the activities of the small scale formers in agroforestry farming and the extent to which agroforestry has been practiced in Katsina State.

Some international organizations who were involved in agroforestry practices were mobilized in the reforestation of Katsina state. Also the benefits desired from agroforestry by the farmers and their communities were also determined, finally the study highlighted the problems hindering the adoption of agroforestry in Katsina State.

1.7 STUDY AREA

1.7.1 Location

The study area is Katsina State. The State stretches across three ecological zones, namely Sahel savanna to the north, Sudan savanna in the middle and northern Guinea savanna to the south (fig 2). Katsina State was carved out from the former Kaduna State in 1987. The State is bounded to the north by the Niger Republic, east by Jigawa and Kano States, south by Kaduna State and to the west by Zamfara State (fig 1). (Basal, 1998) It lies within latitude 11^{O} 7' and 13^{O} 22' N and longitude 6^{O} 52' and 9^{O} 2' E (Udo, 1978). It has a total land mass area of

23,850km^2 and a population of 5,792,578 (National Population Census, 2006) representing a population density of 140 persons per square kilometer. The estimated livestock population is about 2.5 million. The density of human and livestock population is very high and the intensity of cropping of land is also very high (babsal, 1998). Because of very heavy human and livestock population pressures, most of the forested lands, under State Government and Local Government or community control have been completely deforested over the past two or three decades and there is therefore a very acute scarcity of fuelwood and fodder in the State. All these cumulatively have caused rapid deterioration of farmland and general desertification. The various forest reserves in the State are in a much degraded condition.

1.7.2 Climate

Kastina State lies in the upper sudan and lower sahel region of Nigeria. However cloud cover is very low and insulation is therefore, high. Average daily sunshine hours are about seven months of the year. Solar radiation is 500 – 550 kly per day and between 70 -80kly per annum and net radation is in the region of about 95kly per year. The climate information available in Katsina meteorological station reveal that the climate of the area is humid - tropical climate, characterized by a relatively long dry season and somewhat smaller duration wet season with a cool dry harmattan season in between these two major seasons (Fig 4).

I. Rainfall

Rainfall is experienced in the state when the warm moist tropical maritime air mass and the hot and dry tropical continental air mass in-teract. The two air masses meet along the Inter – Tropical convergence zone (ITCZ) which moves in response to the seasonal disposition of the overhead sun. Rainfall amounts are generally related to the thickness of the Tropical Maritime air mass. The tropical Maritime air mass is wedge shaped and thins Northwards. Consequently, when the ITCZ moves Northwards over the study Area in may, rainfall becomes progressively heavier and more steady, reaching its peak at about August. In September, as the ITCZ moves southwards rainfall becomes lighter and sporadic Rainfall is concentrated in the months of July, August and September with figures generally less than 500mm annually (fig 3).

Mean annual rainfall in the state varies from 1016mm – 1143mm in the south to less than 635mm in the north (fig.4). On the whole the state has a mean annual rainfall of about 840mm. However, rainfall is not uniformly distributed over the months. The number of rain days is between 37-80 days experienced only between June and September each year. Most of the other months often record no rainfall in a year (table 1).

The data collected from five meteorological stations (fig 4) in the state shows that potential evaporation (PE) is uniformly high throughout the year and precipitation is low for most of the months. The State, thus experiences water deficit for most of the year. By October which marks the end of rainy season in

the south the high pressure shifts from the south to the north, causing the rain bearing south- western lies to retreat again and the trade wind from the Sahara desert to take over the whole area. During the rainy season we have the flush and green forest and also intensive cultivation while in the dry season we have very dry situation which gives room for bush burning.

ii. Temperature

The mean monthly dry season temperature is above 30^{O}c but significantly drop in the harmattan periods which strectch from November to February when the dry North East trade winds prevail. During this period, the ambient air mass is very dry and cold, dusty during the day and chilly at night. During this period night temperature can drop as low as between 18 and 21^{o}c resulting in a relatively high diurnal range of temperature. In the rainy season months of July to September, temperature of about 22 -28^{o}c prevails (Table 1).

Fig 1

Table 1: Mean monthly Rainfall, Temperature, Relative Humidity and Wind Gust in Katsina State: (1987 – 2002)

Month/Climatic Variables	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL	MEAN
Rainfall (Mm)	0	0	1.7	3.9	23.9	60.1	113	169.2	74.4	0.2	0.0	0.0	446.4	37.2
No of Rainy Days	0	0	0.3	0.4	3.9	6.1	10.9	13.1	7.1	0.4	0.0	0.0	42.2	35.2
Mean max. Temp (Deg. C)	28.7	32.0	35.7	38.8	38.1	36.0	32.2	30.8	33.2	35.6	33.9	20.0	394.8	32.9
Mean temp. (Deg C)														
Mean min. Temp.	23.7	21.1	28.8	32.0	30.6	29.1	27.5	26.9	28.3	26.4	27.3	33.8	22.4	28.9
(Deg. C)	13.1	15.6	20.1	23.9	25.3	24.2	22.3	21.7	22.6	20.7	16.8	13.5	239.8	20.0
Humidity (% R.H. at 9.00gmt)	18.9	32.0	14.1	22.7	44.6	54.1	59.9	75.6	57.6	35.4	16.0	20.6	451.5	37.6
Highest Wind Gust (Knots)	32.4	30.6	32.1	29.7	41.6	47.7	44.3	43.7	381	25.0	21.1	30.9	417.8	34.8

iii. Relative Humidity

Information on relative humidity shows that the atmosphere is much more humid during the rainy season than the dry season (table 1). Mean relative humidity is lower than 50% in January and February and could be as high as 80% in July-August. Agroforestry crops grow luxuriantly when the relative humidity is high while the period of low relative humidity retards the growth of the crops.

iv. Wind and Wind Patterns

The available fifteen years weather records (1987 to 2002) indicate that strong winds occur from May to September with a peak of 47 Knots in June. The period of strong wind coincides with the beginning of the rainy season when the south-westerly moist tropical maritime air mass slows down passage over the State. Between November and February is the period of low wind while calm wind is recorded in October (table 1). Severe winds force agroforestry crops to loose moisture through evapotranspiration and also the dust-ladden wind kill the young crops and tree seedlings by depositing sand on them.

1.7.3 Historical Background

Katsina state comprises the two ancient kingdoms of Katsina and Daura which form the former Katsina province. During its long pre and post-colonial experience, the State has passed through several distinct stages of development. There was the period of kingdoms formation, growth and development. There was

also the stage of the formation of the Habe dynasty, introduction and spread of Islam, trans-Sahara trade and the Jihad of the 1800's. There was also the period of the British colonial conquests, introduction of Western concept of administration and education.

Babsal (1998) considered the Dawa kingdom as the oldest in the Hausa states. It was founded by Hausa speaking people called Yantsawani around the 9th century AD. The ruling dynasty was based at a place called Tsohon Birni, some few kilometers north of the present Daura city. The same author also noted that Katsina kingdom (one of the Hausa Bakwai) on the other hand was founded by a Hausa speaking giant hunter called "Adawa" in the early part of 9th century AD. Islam was introduced in 1450's and muhammed Koran (reigned in the late 15th century) was the first Katsina Muslim king. During his reign Carmel caravans crossed the Sahara from Ghudamus, Tripoli and Tunnis south ward to Katsina and brought such prosperity to the State. In 1854, Katsina defeated the forces of Songhai and in 1570, those of Kano, its principal rival in the trans-Sahara trade. Katsina entered its greatest period of prosperity in the early 18th century. Besides being the leading Hausa commercial State, it replaced Timbuktu as the Chief West African center of Islamic studies.

Fulani herdsmen settled in Katsina by the 15th century and in 1804, the Fulani Jihad (holy war) leader, Usman Dan Fodio led a revolt against the Hausa overloads. The Fulani leader Usman Dallaji captured Katsina town in 1806 and was named the first Katsina Emir with Katsina as his seat. The emirate was governed

by a representative of the Sultan of Sokoto. Many of the Hausa nobility and people fled to Dankama, Tassawa and Maradi.

In 1903 Katsina Emir pledged allegiance to the British rules of northern Nigeria. When the British and French set the present Niger- Nigeria boundary in 1904, Katsina Emirate was reduced in size, most of the former territory is now in Kano State. In 1903 the Emir accepted British rule, which lasted until Nigeria independence from Britain in 1960.

Fig2.

1.7.4 Geology

The continental sediments of Katsina – Daura plains consist of feldspatic clayey standstones and grits with small basal pebble beds. The sediments have a maximum thickness of about 100 m (Dupra,1994) and regional dip is to the north – west. The sediments thin to the south and in places, only the pebble beds remain on the higher interfluves. The southern boundary is diffuse and outliers are frequent, south of the main body. The sediments have been equated with the Gundumi formation of the Iullemmeden Basin (du preez and Barber, 1965) and therefore mid cretaceous in age (Fig.5). Alluvial deposits are associated with the present valleys. The older alluvium, which is partly colluvial in origin, forms a valley fill and may be contemporaneous with a high terrace found along the rivers. Aeolian deposits overlie the older alluvium. The Aeolian mantle lacks any definite pattern and also shows a marked variation in thickness. The younger alluvium occurs along the rivers within the present floodplain. Recent alluvial deposits are associated with the floodplains of the major rivers in the area.

1.7.5 Hydrology

Katsina State has very few rivers and lakes, many of those present are either intermittent/seasonal or reduced drastically in volume during the prolonged dry season (Babsal, 1998). It however, appears to be a hydrographically active region because of the water resources and most rivers take their sources from the basement complex plains and pediments in the center of the State. For instance, the Gada and Bunsuru rivers take their sources from the plains and flow into

Zamfara State to become tributaries to the Rima River. The Sokoto River also takes its source from this region (Babsal, 1998). The available water bodies in the study area are sources of water used for irrigation of plants in the nurseries where agroforestry crops are raised and nurtured. It is also the source of water for human and livestock consumption.

Fig. 3

1.7.6 Landform

Katsina State lies in the great Hausa plains of northern Nigeria that is composed of basement complex rock that covers over 50% of the Nigerian landmass. Generally, the topography is gently undulating with an elevation of between 305m-610m with isolated inselberge and residual iron stone capped hills that lie between 610m – 905m above mean sea level interspersing the area (Babsal, 1998).

Generally, the following geomorphological regions are observable;

(i) Gently undulating sand and clay plains over quaternary Chad sediments (found around Katsina and Kulam area);

(ii) Gently undulating sand plains over sandstone formation (found around Daura/Bumbum area);

(iii) Gently undulating sandy drift plain with scattered iron stone hills and outcrops overlying basement complex rocks (found around Dutsinma area).

(iv) Gently undulating sandy plain over sandstone formation found in the northern most part of the State and dissected basement complex plains and pediments (found around Funtua); and

(v) Outcrop of hills composed of younger granites (scattered all over the State).

Fig4.

1.7.7. Soil

The soil of Katsina State follows its geology and geomorphology. The soil types found here range from shallow and moderately deep to very deep loamy, loamy-sand and sand-loamy soils.

The following soil types are identifiable over the State.

i. Recent alluvium soils of deep well drained and loamy sand found in the surface drainage channels. This soil type is found in areas like Mallamawa/Ruma and other places with water courses.

ii. Deep well drained loamy sandy surfaces over sandy and clay loam found on the gently undulating plains with scattered outcrops and icebergs. This soil type covers over 70% of the State's entire landmass.

iii. Deep to very deep well drained loamy, sand with few gravelly surfaces found in the undulating plains with scattered outcrops. This soil type is found around Manula area and east of Malumfashi (Babsal,1998).

iv. Shallow and moderately deep, well-drained clay soils on the undulating plains with scattered outcrops found around Kankara, (Babsal, 1998). Well aerated and rich soil promotes the growth and development of agroforestry trees by releasing suitable nutrients to the trees while degraded soils encourages the growth of stunted and scattered trees.

1.7.8 Mineral Resources

The basement complex lacks economic minerals in commercial quantity. It is however important as local sources of economic minerals like tin, columbite, kaolin and gold. The basement complex rock can also provide rich quality stone for building and engineering construction. Younger granites found in some parts of the State are also rich in potentially valuable radioactive minerals such as pyrochlore. The older granites on the other hand, provide workable quantities of cassiterite, columbite, tantalite and asbestors (Babsal, 1998).

The various minerals found in the State and their locations have been summarized as follows;

Kaolin – Kanakara Local Government Area

Gemstone – Faskari/Funtua Local Government Areas

Quartz Sand –Zango Local Government Area

Alluvial Gold – Malumfashi Local Government Area.

1.7.9. Vegetation and Ecological Zones

The climate of most of the arid zone is classified as Sudan Savanna. The area is characterized by a long intensive dry season and a short unreliable rainy season of three months in the southern part to less than one month in the northern part. The arid zone of Nigeria therefore is defined as that area which has less than 800mm of average annual rainfall. Katsina State is in the Sudan grasslands zone of northern Nigeria. The undeveloped flora of this area bears

eloquent testimony to the low rainfall of this area. Periodic droughts have been experienced. The natural vegetation has been modified over most of the area by several years of human activities, including intensive cultivation, bush burning, livestock grazing and browsing.

Generally three different vegetation formation zones are identifiable over Katsina State.

They are- (i) Grassland (ii) Shrubland/grassland, and (iii) Woodlands

The grassland is found around the northern most part of the State over the Gundumi formations. It consists of very short grasses and shrubs with very thick bark. Grasses found in this area include *Androppogan spp., Aristide spp., Pennisetum pendicellatum*, while the shrubs include *Acacia spp, Balanites Aegyptiaca, Boscia senegalensis* among others. The shrubland/grasland zone lies immediately south of the grassland zones. Grasses found in this zone include *Aristida spp., Cenchrus biflora, Cymbopogon schoenanthus, Loudetia togoensis* among others. The woodland zone lies south of the grassland/shrubland zone. The grasses found in this zone include *Andropogon gayanus, Antiseda spp., Echinochlotta spp., Hyperrheria spp., Loudetia togoensis, Penisetum pedicellentum*, the shrubs include *Acacia spp., Anageisus leocarpus, and Boswellia spp. a*mong others.

Fig5.

1.7.10 Katsina State Landuse

Landuse / land cover mapping and detection of change using remote sensing and GIS techniques is of paramount importance to planners, geographies, environmentalists and policy makers, Landuse therefor, is the human modification of the natural environment or wilderness into built environment such as field, pasture, water body, industrialization, settlement and agricultural practices. The major effect of Landuse and land cover has been deforestation especially of temperate region.

In Katsina State, the significance of landuse include urban sprawl, soil erosion, soil and land degradation, salinization and deforestation. In recent years local government area in Katsina State have experienced rapid population growth especially in their headquarters, thus changing population size and commercial needs often necessitates demand for land and change in landuse plan.

The major occupation of the inhabitants of Katsina State is farming. The crops grown include cotton, maize, millets, soya-beans and groundnut. Animal husbandry is also practiced by the inhabitants; the animals kept include cattle, sheep, donkey, horses and goats. Since time immemorial, the State has traditionally been a home of many crafts such as cloth weaving, raffia works, pottery, wood and calabash carvings, iron works and leather works. The art of iron smelting, for instance, was a great scientific technological achievement of the people in the state. For well over a thousand years, the people had acquired the know how in identifying and extracting iron ore from the deposit, crushing and

smelting it to metal which is forged into various tools and implements, as well as weapons. Farm and other house hold material were also made and these immensely improved the living conditions of the people.

Cotton cultivation also gave rise to the growth of indigenous textile industry. The textiles produced did not only satisfy the local demand but also became an important article of trade with neighbouring regions. Similarly pottery, which originated several centuries ago, has assumed an increasing position of importance. Today, pots are used for multifarious purposes, which include cooking, storage, flower and other domestic uses. This industry has been modernized through new technological devices such as klin and potters wheel.

The leather industry is also a major activity producing excellent products for the home and other markets in the West African sub-region.

1.7.11 Population Structure and Distribution

According to the 2006 population census figures, Katsina State has a population of 5,801,586 persons. Out of the figure, about 49 percent are males while 51 percent are females. On the average there are 140 persons living per square mile in terms of density of the population. Seasonal migration takes place especially, of able bodied males in the dry season to the southern part of the State and other states in search of part time jobs and off-farmer labour. This is known as "Cin rani" A great majority of the people are settled cultivators and traders. But there is a considerable number of nomadic cattle Fulanis whose males rear

livestock, while the Female hawk locally prepared fermented milk in towns and villages.

In drought years more people tend to migrate southwards from the northern part of the state on either temporal or permanent basis to avoid the consequence of drought menace. Indeed the southern part of the state receives immigrants from both within and outside the state. A sizeable number of migrants are from southern Nigeria especially the Yourubas and Igbos who usually dwell mostly in towns.

1.7.12 Settlement

Katsina State is a predominantly Hausa Fulani State. The State has no problem of urban primacy. The urban, semi urban location and the model villages, which more or less approximate to the present Headquarters of the thirty four local government areas are evenly spread and are surrounded by other rural settlements. These three types of settlement form close knit economic, cultural, administrative and historical inter-relationship. Furthermore each has a fairly long historical link with Katsina city which has subsequently served as the headquarters of Katsina Emirate of Katsina province and now the capital of Katsina State.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 INTRODUCTION

Agroforestry enhances sustainable resource/utilization by improving the supply of food and being environmentally friendly (FAO, 1987; Spore, 1995) It has been described as a very old system which has been practised by farmers, particularly those characterized by low level of technology and resource inputs and mostly in areas believed to be unsuitable for profitable monocroping systems (Sekhwela, 1990).

Gordon et al. (1997) reported that agroforestry is relatively new and was initially developed for the tropical regions where prevailing climatic conditions are largely harsh and tend not to favour conventional cropping systems (Raintree *et al*., 1994, Gordon *et al*., 1997). Agroforestry can therefore be viewed as a set of old practices with a new name which has however, not been restricted to the tropical region but has been and is still been practised even in the temperate environments.

Gordon *et al*. (1997) also reported that the practiced has been in existence for more than six hundred years in some parts of the world, although it was not considered in that light by the farmers involved. Before the middle ages agroforestry was the general practice in Europe and it continued in Finland up to the 19th century and in Germany up to the 20th Century (King, 1987). In some

parts of temperate Europe and America, the practice has continued up till date (Young, 1987; Gordon *et al*., 1997). The adoption and practice of agroforestry in several areas has often been a remedy to climate and other environmental unclemencies and uncertainties. (Young, 1989; Gordon *et al.,* 1997; Backes,1999).

2.2 DEFINITION AND CONCEPTS OF AGROFORESTRY

Attempt at defining agroforestry began in the mid 1970s and evolved rapidly as studies began on the diversity and scope of agroforestry practices. In the late 1970s and early 1980s the field of agroforestry suffered from a surfeit of definitions and a general lack of common understanding caused by a paucity of hard information. These early efforts to define a broad new area of study have resulted in a conceptual from which to examine complex systems and practices. At least one early understanding definition has summarized the basis for the study of agroforestry.

Nair (1993) noted that agroforestry has been defined in many ways. ICRAF's current definition is a collective name for land use systems and practices in which wood perennials are deliberately integrated with crops and/or animal on the same land management unit (Sanchez, 1995). Bene *et al*. (1977) defined agroforestry as a sustainable management system for land that increases total production, combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of the local population.

Agroforestry has been defined in several ways (Nair, 1991). International Council for Research in agroforestry's (ICRAF) current definition is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit. The integration can be either in a spatial mixture or in temporal sequence. They are normally both ecological and economic interactions between the woody and non woody components in agroforestry. This definition has served well and helped agroforestry to become recognized as a branch of agricultural science that is rapidly becoming a science in its own right (Sanchez, 1995).

King (1987) noted that agroforestry has a rich history of development and has been practised in some parts of the world since over 600 years ago. As a programme, it is directed specifically to peasant farmers to redirect the current trends in land usage and management. Several traditional farming systems have evolved all over the world. They include components of agroforestry but this has never been considered in that light by farmers who utilize them. Enabor *et al*. (1981) viewed agriculture and forestry as traditional competitors for land and accordingly, land allocation for each tends to be mutually exclusive. The relationship between them even becomes greater when it is realized that some crops are trees while some forest trees produce non wood materials for human use.

Raintree *et al.* (1987) described agroforestry as a land use system and technology in which wood, perennials, trees, shrubs, palms and bamboos share

the same farmland with herbaceous crops with or without animals in such an harmonious, ecological and economical interactions among the different components. Agroforestry, therefore, is seen as a means of optimal usage of land to produce for mans needs while at the same time maintain soil fertility status by sheltering the soil from direct sunrays. It also provides animal wastes which enrich the soil. Stocking *et al*. (1989) viewed agroforestry as a land management concept where-in woody perennial species are cropped to protect the land on long term basis. Many species of trees have been identified as having considerable potential for agroforestry and farm woodlots. They provide a wide range of possible products. A particular well-known example is *Leucaena leucocephala* which is frequently grown in lines associated with food crops (alley cropping). It provides fodder and green manure from the leaves and fuel from its branches. It also helps in erosion control in addition to fixing atmospheric nitrogen to the soil.

Agroforestry practices come in many forms but fall into two groups – those that are sequential such as fallows and those that are simultaneous such as alley cropping. Altogether 18 different agroforestry practices have been recognized by Nair (1993); each has a definite number of variations. Thus, at the moment, agroforestry is viewed as a set of stand- alone technologies that together form various landuse systems in which trees are sequentially or simultaneously integrated with crops and/or livestock. In agroforestry, research practices are often applied after diagnosis and design, participatory research or characterization

studies as appropriate, depending on the social, economic and environmental problems in an area.

Agroforestry is generally practiced with the intention of developing a more sustainable form of landuse that can improve farm productivity and the welfare of the rural community. The current view of agroforestry is that many people still see it as a set of distinct prescriptions for landuse. As a result, it falls far short of its ultimate potential as a way to mitigate degradation and land depletion and thus alleviate poverty.

However, among the many attempts at defining the art and science of agroforestry, the following is perhaps the most appropriate. Agroforestry is a land use system that involves deliberate retention, introduction or mixture of trees or other wood perennials in crop/animal production fields to benefit from the resultant ecological and economic interactions (Nair, 1984).

While each of the above definitions has limitations, several basic ideas can be drawn from them.

- Agroforestry is a distinct landuse system which may include combination of agricultural, forestry, horticulture and animal husbandry sub-systems and practices. Simply stated, agroforestry is a means of managing or using land (that is a landuse system) that combines trees or shrubs with agricultural or horticultural or livestock.
- Agroforestry integrates trees with crops and/or animals with the main objectives of reducing risk and increasing total productivity. Farmers have

historically used indigenous mixed cropping practices to minimize the risk of total failure by growing a variety of products on the same piece of land.

- In their ideal forms agroforestry systems are both stable and sustainable. Agroforestry practices have greater diversity than do monoculture practices and can distribute production over a longer period of time to farmers, particularly those who may have different income can provide increased cash flow stability to storing or marketing farm produce.
- Integration of trees into agricultural systems may result in more efficient use of sunlight, moisture and plant nutrients than is generally possible by mono-cropping of either agricultural or forestry crops. In summary, the concepts of agroforestry have been well elucidated in several publications from the International Council for Research in agroforestry (ICRAF) and others (Nair, 1991). Today there is no divergence of opinion that agroforestry:
- Is a collective name for landuse systems involving trees combined with crops and/or animals on the same unit of land;
- Combines production of multiple outputs with protection of the resource base;
- Places emphasis on the use of indigenous, multipurpose trees and shrubs;
- Is particularly suitable for low input conditions and fragile environments;
- Involves the interplay of socio-cultural values more than in most other landuse systems and

- Is structurally and functionally more complex than monoculture.

Be that as it may, ICRAF has continued to redefine agroforestry as new research findings emerge. In their most recent definition of agroforestry, ICRAF (1997) sees agroforestry as a dynamic, ecologically based natural resources management system that through the integration of trees on farms and in the agricultural landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. Thus, agroforestry, often paraphrased as "a new name for an old practice" is no longer a "new term". It is widely accepted as an approach to land use involving a deliberate mixture of trees with crops and/animals.

2.3 HISTORY OF AGROFORESTRY

Historically, cultivating trees and agricultural crops in intimate combination with one another is an ancient practice that farmers have used throughout the world (Nair, 1993). King (1987) stated that in Europe, until the Middle Ages, it was the general custom to clear - fell degraded forest, burn the slash, cultivate food crops for varying periods on the cleared area and plant or sow trees before, along with, or after sowing agricultural crops. This "farming system" was no longer popular in Europe (King, 1987). In Central America, it has been a longtime traditional practice for farmers to plant an average of two dozen species of plants on plots larger than one-tenth of a hectare. For example, a farmer would plant coconut (*Cacus nucifera*) or pawpaw (*Carica papaya*) with a lower layer of

bananas or citrus, a shrub layer of coffee or cocoa, annuals of different structure such as maize, and finally a spreading crown cover such as squash. Such an intimate mixture of various plants, each with a different structure, initiated the layered configuration of mixed tropical forests (Wilken, 1977). In Asia, for example the Philippines, a complex and somewhat sophisticated type of "shifting" cultivation are practised. In clearing the forest for agricultural use, they deliberately spared certain trees which by the end of the rice-growing season provided partial canopy of new foliage to prevent excessive exposure of the soil to the sun. These were indispensable farming systems and were either planted or preserved from the original forest to provide food, medicines, construction wood and cosmetics (Conklin, 1957). These satisfy the socio-economic and environmental benefits of agroforestry practices.

The situation was a little different in Africa. For example in southern Nigeria, Forde (1937) cited by Nair (1993) reported that yams, maize, pumpkins and beans were typically grown together under a cover of scattered trees. He observed that the Yoruba of Western Nigeria have long practised an intensive system of mixing herbaceous, shrub and tree crops, claiming that this system is an inexpensive means of maintaining soil fertility, as well as combating erosion and nutrient leaching (Ojo, 1966). There are innumerable examples of traditional landuse practices involving combined production of trees and agricultural species on the same piece of land in many parts of the world. These are some examples of what is now known as agroforestry (Nair, 1993). However, by the end of the

19th century, Burma established Teak (Tectona grandis) plantation by using a method called "Taungya" which later became the most efficient way of planting Teak (Nair, 1984). It was introduced into South Africa as early as 1857 (Hailey, 1957) and was taken from Burma to India in 1890 (Ragharan, 1960). The ruling philosophy of the taungya system was to establish forest plantations whenever possible using available unemployed or landless labourers. In return for performing forestry tasks, the labourers would be allowed to cultivate the land between the rows of tree seedlings to grow crops. This is a simplification of a system whose details vary, depending on the country and locality (Nair, 1993).

According to Ohu *et al*. (1994) agroforestry concept was developed in tropical regions within the context of developing nations, where initially land shortages brought about by the rapid population growth of indigenous peoples demand that efficient production system to develop for both food and wood resources. As agroforestry systems were developed and refined, it also became obvious that the system has an important role to play in the maintenance of sustainability through its inherent resource, land and soil conservation properties. Indeed, in the tropics, because of the importance of organic matter in the maintenance of soil productivity, research efforts continue to compare agroforestry systems with traditional cropping technologies in an attempt to understand their ameliorative properties, system by system. Several researchers have concluded that agroforestry systems are more conservation effective than

traditional crops on eroded marginal soil and hence suggested for their inclusion in the basket of conservation technologies (Grewal, 1994).

In the Temperate zone, globally, many environmental and social problems have arisen from embracing technological agriculture and the green revolution. This has led to more increased research and practical activity in the development of sustainable farming systems. Among the disciplines and practices advocated as being able to contribute to this, is again agroforestry.

The existence of temperate agroforestry systems has been acknowledged and many have been described for specific regions (Gold and Hanover, 1987, Bandolin and Fislea, 1991). Agroforestry systems are common-sense adaptations of historical knowledge that exists on the benefits of incorporating trees into farming systems (Smith, 1999) though many are new applications of systems that have been successful in other situations (King, 1987) acknowledged the fact that research on temperate agroforestry systems has also mushroomed and research papers on topic of interest to practitioners of temperate agroforestry have become more prevalent in conferences proceedings. In North America, a biennial conference series on temperate agroforestry was initiated in Guelph, Canada, in 1989, with four well-attended conferences held to date. The proceedings of these conferences are still in demand, especially from individuals and groups with an interest in sustainable agriculture, diversified from economics, biodiversity and animal welfare among others. The conferences have helped to define the major temperate agroforestry systems of interest on the North American continent,

namely; alley cropping systems, windbreak systems, silvopastoral systems, integrated reparian management systems and forest farming systems (Ehrenreich, 1996).

Carruthers (1990) reported that there is an increasing appreciation of the fact that the application of agroforestry technologies to the temperate agricultural systems will help when used appropriately to sustain existing food production systems. The key, of course, is to use agroforestry system appropriately in order that not only its usefulness as a landuse system is realized but that its potentials to assess the value and benefits of farming in a particular manner are brought to bear upon the landscape.

Faced with the problems of deforestation and environmental degradation in the tropical regions, individuals and institutions have intensified the search for appropriate landuse approaches (agroforestry systems). These would not only be an additive to the traditional landuse practices but they should be socially acceptable and ensure the sustainability of the production base and meet the need for production of multiple outputs. Nair, (1983) reported that efforts were made to design major programmes which would allow local communities to benefit directly from forest. One the approaches was experimentation in the general field of inter-cropping, and in particular, it was felt that there was a need for a more scientific approach to inter-cropping research. It was suggested that greater efforts were needed with respect to crop physiology, agronomy, yield stability, biological nitrogen fixation and plant protection (Nair, 1979).

Consequently, the International Institute of Tropical Agriculture (IITA) extended its work to include integration of trees and shrubs with crop production (Kang et al. 1991). Other research organizations had also initiated serious work on, for example, the integration of animals with plantation of tree crops such as rubber and the inter-cropping of coconuts (Nair, 1984).

The most significant single initiative that contributed immensely to the development of agroforestry came from the International Development Research Centre (IDRC) of Canada. The IDRC Project Report (1975) recommended the establishment of an internal organization, which would support, plan and coordinate on a worldwide basis research combining the land-management systems of agriculture and forestry. Consequently, the International Council for Research in agroforestry (ICRAF) was established in Kenya in 1977. In 1991, it was renamed the International Centre for Research in agroforestry (ICRAF) and charged to play a leading role in collecting information, conducting research, disseminating research results and pioneering new approaches and systems (Nair, 1993).

Today, agroforestry, instead of being merely the hand-maiden of forestry, is being used more as an agricultural system, particularly by small-scale farmers. The potential of agroforestry for soil improvement and conservation is generally accepted. Indeed, agroforestry is becoming recognized as a land use system which is capable of yielding both wood and food while at the same time conserving and rehabilitating the ecosystem. There is therefore the dire need for

an aggressive agroforestry extension service to convince farmers to adopt this farming system.

2.4 IMPORTANCE OF AGROFORESTRY

Monoculture as practised in developing countries such as Nigeria requires high yielding crop varieties and an intensive use of fertilizers for optimal acceptable performance of the crops (Agromissa, 1989). These inputs are not forth-coming in many situations together with the fact that tropical soils are exhausted more easily than temperate ones. The peasant farmer is then caught between unachievable agricultural technological innovations and the much derided traditional system. An attempt to embrace the more promising modern system usually leaves its mark on the environment. While indicting agriculture for deforestation Okigbo (1983) upholds agroforestry as an integration of compatible components of forestry and agricultural production. This means that agroforestry has the potential to replace the destroyed forest.

Unruh *et al*. (1993) noted that a rehabilitation and management of degraded lands with appropriate agroforestry systems is a significant global opportunity which has not been realized, especially in the effort to reduce accumulation of greenhouse gases in the atmosphere. Agroforestry is therefore a means of correcting the effects of degradation. Hanson et al. (1995); Schulz et al. (1995); Otsyina (1993) and Owusu (1993) agreed that agroforestry can provide new and useful solutions to many of the adverse consequences of human landuse,

including increased diversification of agricultural production system, increased yield of crops and livestock, reduction of non-point source pollution and increased rural development by contributing to an ecosystem-based management system that guarantees sustainability and environmental quality. Agroforestry should therefore be seen as a system that addresses the declining quality of the environment, including the soil, while also increasing the variety of produce by the farmer. This will not only increase the farmers' income but also help ensure food security and balance.

2.5. CLASSIFICATION OF AGROFORESTRY SYSTEM

It is imperative to highlight the factors that are considered in the classification of agroforestry systems. These factors include:

a. Component combination
b. The role of the components in the system.
c. The type of reaction among the components whether spatial or temporal.
d. The way and manner by which woody components are distributed in the agroforestry farm.

Besides the above factors, any sound agroforestry system should have the following features:

a. Presence of at least two leaving plant species, one of which should be woody perennial (the other could be an annual/biennial, crop or livestock).

b. There should be interaction (biological/economic) among the components (agronomic/ annual crop, forest tree/woody perennial, livestock, soil and water).

c. At least, the system should yield two products.

d. The system must have a cycle of more than one year

e. Application of the system to small or medium sized projects involving indigenous initiatives should be easy.

Thus, agroforestry systems according to Nair (1989) could be classified into the following categories:

a. **Agri-Silviculture** (combination of agronoimic and forest tree crops/woody perennial e.g. tanngya system, alley cropping, alternate row planting, random mix or scattered tree farm or parkland system, live fencing and planting.,

b. **Silvo-Pastoralism** (involves trees and livestock).

c. **Agro-silvi-pastoralism** (management of annual crops, woody perennial and livestock.

d. **Api-Silviculture** (bee keeping/honey production and tree/wood production).

e. **Aqua-Silviculture** (fish and production).

f. **Multipurpose Wood lot** (establishment of family and village wood lots (i.e. Community forestry).

In another development, PTPU (1988) grouped agroforestry systems into three categories, Viz:

a. Community forestry (village woodlots, planting of trees along road sides or canals), planting of trees in yards or gardens of village houses).
b. Silvipasture (intergrated wood production and livestock grazing).
c. Agrisilviculture (crop rotation systems (shifting or swidden cultivation and taungya system), intercropping systems (Border tree planting along the border of the farm, alternate strip planting, alley cropping and random mix systems).

2.6. ECOLOGICAL BENEFITS OF AGROFORESTRY

Ecology concerns the relationship between organism, their habits and the environment. It outlines the various inter-relationships existing among the components of the system.

Nature has a way of maintaining and regenerating natural resources as they are utilized. This is done through a series of cycles which connect the various components of the system and their activities in the environment. Agroforestry is a land management practice with consideration for the natural processes of soil nutrient renewal. Charley and West (1977) claimed that the litter falls is the major pathway for the return of nitrogen, phosphorus, calcium and magnesium to the soils. This implies that cultivation of perennial shrubs and trees would allow leaf-fall onto the soil, subsequent decomposition of which would enrich the soil.

It can therefore be asserted that the protection of the soil from direct rays of sunlight also complements nutrient conservation as the rate of oxidation of soil nutrient will reduce. This is in addition to the protection from erosion and fire protection provided by the trees (Hochberg, 1994; Danell, 1986) added that the decomposition of the fine shallow roots enriches the topsoil with nitrogen. The Great Wall of China is only a forest plantation which checks the advancing Gobi desert successfully. The same idea was used in the Tahoma region and Maggia valley of Niger. The WIDE (a programme in Mauritania) assisted the people of Boultilimit in Mauritania to establish forest tress on their farms to reclaim degraded land (Adekoya, 1997). Agroforestry therefore, contributes towards maintenance of the ecological balance which is the basis for environmental sustainability.

Furthermore, climatic changes, global warming or the green-house-effect caused by environmental degradation can be checked with agroforestry practices. Anderson (1990) emphasized that agroforestry plays a major role in reclamation of degraded or abandoned lands and is a workable approach to mimic natural succession and increase biodiversity. Otsyina (1993) gave a detailed account of how deforestation occurred in Shinyanga but soil conservation and afforestation programmes reclaimed the vegetation. The recognition of the potentials of agroforestry has inspired the Portuguese (OECD, 1991) and French Governments to pass legislations that are aimed at protecting forest areas and natural habitats (Richards et al., 1988). The main concept, here is allowing soil stability by

reducing the extent of clearing and tillage and thereby reverting the trend of environmental disequilibrium. It should be noted that there is a tolerance limit to human interference for soil substrates, surface and underground water, the flora, fauna and micro-organisms (Otzen, 1992). The role of the soil in providing a base for the sustenance of life in all forms needs to be appreciated. Hence, the role of agroforestry in ensuring sustainable use of the land, upholding ecological equilibrium and maintaining the environment should be in the right perspective.

2.7 SOCIO ECONOMIC BENEFITS OF AGROFORESTRY

Agroforestry involves some agricultural practices that broaden both the scope of activity of the farmer and the accruing benefits. Its adoption is a social change that requires communal considerations in as much as the environment is a common pool of resources. It bears direct relationship with characteristics of the adopters and their interaction with the environment. The desertification risk in Nigeria has been rated moderately high. Moderate risk for desertification was put at 31.4% while high risk for sand movement scored 5.8% (FAO/UNEP, 1984). All the areas affected were in the semi-arid/arid regions where vegetation removal had caused a lot of environmental problems in the past. Since deforestation is a danger to the environment (Otzen, 1992) very little is needed to encourage participation in agroforestry.

Apart from logs, sawn-wood and plywood, herbs, food, craft and cosmetic materials are got from forests (Adeyoju, 1975; Ipinjolu *et al*., 1988). These

products are of considerable importance to any nation's economy as the industries they support provide means of livelihood to the people, while the products offer means of income and foreign exchange. Other benefits include production of fuelwood, building posts, fodder, forage, fruits, honey, gums and resins.

Dobhal (1994) explained that encouragement of forestry or food products will ensure more progress by reducing the level of poverty whilst raising productivity of the land. Existing research findings support the fact that food derived from forest has the highest potential for energy, carbohydrates, minerals, fiber, medicines and vitamins and least potential for fat. Agroforestry enables the farmer to broaden the sources of income, provides foods of different categories and reduce the devastation of the environment. It brings awareness to the people on the need to manage environmental resources.

Finally, Baumer (1990) summarized the socio-economic and environmental benefits of agroforestry farming systems as follows:

- Make higher contribution to the supply of firewood better than monocropping;
- Woody perennials are less affected than herbaceous plants by temporary water deficit and hence agroforestry farming systems make it possible to increase directly or indirectly the production of food both in quality and quantity, notably by greater product diversity.
- Through product diversification, they also contribute to increase stability in the food supply.

- Their effect on the environment is positive and lasting as they contribute to the maintenance of fertility of soils, reduce wind speeds and create micro-climates favourable to crops.
- Woody perennials in agroforestry farming systems are chosen not only because they give wood; they can also provide tannin, flowers, medicines, dyes, gums, resin etc.
- Agroforestry farming systems contribute to the improvement of economic and social conditions in rural areas, not only by increasing profitability, sustainability and crop security but also by creating jobs.
- Agroforestry farming systems encourage cultural exchanges by combining traditional experiences with advanced technologies and by researching modern solutions that are compatible with the socio-cultural customs of the populations concern.

Young (1989) reported that there are hundreds, possibly thousands of agroforestry systems but only 20 distinct practices. These systems, existing in different places, are so complex and diverse that they need to be grouped and classified into different categories in order to evaluate them and develop some action plans for their improvement. These agroforestry systems were thus classified into system's structure (composition and arrangement of components), functions, socio-economic scale of management and ecological spread. However, there are only three basic sets of components that are managed in all agroforestry systems. These are woody perennials (usually referred to as "trees"), herbaceous

plants or "crops" and animals. A logical step is to classify agroforestry systems based on their component composition (Nair, 1991). Thus there are three basic types of agroforestry systems.

- Agrosilvicultural (crops and trees)
- Silvopastoral (pasture/animals and trees)
- Agrosilvopastoral (crops and pasture/animals and trees).

Other specialized agroforestry systems can also be defined for example apiculture with trees, aquaculture involving trees and shrubs and multipurpose tree lots. Although several agroforestry systems have been recorded all around the world, the distinct agroforestry practices that constitute these systems in various biomes and locations are only few.

The following are some agroforestry practices in vogue in Nigeria at present.

2.8. VARIETY OF AGROFORESTRY PRACTICES (SYSTEM) IN NIGERIA

2.8.1 Taungya Farming

This is an agroforestry system whereby food crops are interpolated with trees in a unit area of land for 2 - 3 years. Food crops cease to exist on the land when the tree crops close canopy. The taungya system was the main agroforestry method practiced in the forest reserves since 1950 to date. Most of the State owned artificial plantations now being exploited were raised through the taungya system (Igugu and Osemebo, 1995). In these plantations, maize, potatoes, yams or beans are inter-cropped between the young plants for the first 1-2 years, to

avoid competition from weeds. The chief problem with this system is the need to plan a planting programme for long-cycle trees with three or four years of crops. The system has proved effective in providing food for forest workers and forage for cutting by cattle rearers (Baümer, 1990).

2.8.2 Integrated Taungya:

Under the integrated system, when tree canopy is closed, raising of agricultural crops is substituted by livestock grazing. The integrated approach aims at invoking the idea of landuse practice whereby the activities on the land are stretched all the year round (Rander, 1988). These include thinning, pruning and other management schedules to the tree crop to reduce the intensity of overstorey shade and thus allow cultivation of crops. The application of fertilizer and other soil management measures are to avoid the deleterious effects commonly associated with the conventional taungya; and the social benefit to farmers is their continued stay on site.

2.8.3 Improved Fallow in Shifting Cultivation:

The main problem in shifting cultivation is soil degradation through erosion and the drop in soil fertility. The system of shifting cultivation worked effectively until quite recently when the rapid increase in human and livestock populations could no longer allow such long fallow-crop cycles (FAO, Sahel, sahelization of the savanna and savannization of the forests (Tolba, 1993).

Due to the shortening of the fallow period many farmers have adopted and intensified landuse systems that require the application of chemical fertilizers to compensate for the loss in soil fertility. Many small-scale farmers in West African countries including Nigeria could not acquire chemical fertilizers because of their unavailability and high cost. Continuous use of chemical fertilizers without addition of organic materials can lead to a degraded soil matrix, invasion of noxious weeds, soil acidification and subsequent decline in crop yield (Tarawali *et al*., 1999).

In an effort to minimize soil degradation associated with agriculture, the use of cover crop such as mucuna has been encouraged. According to Lal and Cummings (1979), the adverse effects of land overuse may be minimized if cover crops are sown on land after clearing. The role of this system is mainly that of soil conservation and improvement. The soil amelioration as a result of the system leads to increase in crop yield during the cropping period.

2.8.4 Alley-Cropping (hedge row intercropping)

This is a relatively new technique developed at the International Institute for Tropical Agriculture (IITA) and ICRAF. In this system arable crops are grown between hedge-rows of planted shrubs and trees, preferably leguminous species which are periodically pruned to prevent shading of the companion crops and the pruning applied as much for the crops. The trees provide nitrogen from atmospheric fixation, recycle nutrients from the depth of soil, suppress weeds and increase organic matter content of the soil (anonymous, 1988). However, recent

studies indicate that alley cropping is most suitable for food production in altisols and other high-base soils in the humid and sub-humid tropic (Ong, 1994). Alley cropping has been accepted in southern Nigeria and the middle-belt on experimental basis in the country. The tree species considered are those with deep rooting, light crown, ability to coppice, nitrogen fixing and good for folder.

2.8.5 Alley- Farming:

This is an agroforestry system focusing on livestock production. In alley farming, trees, shrubs and other perennials are planted with arable crops to supplement the woody plants in the rows. The alleys are designed to suit local environment. Alley farming is designed mainly for sheep and goat grazing. The advantages of alley farming are that crop residues control soil erosion through windbreak. The major disadvantage of the two systems (alley cropping/farming) is the competition of hedgerows with crops for soil water, which is often limiting in semi-arid tropics (Singh *et al.,* 1987).

2.8.6 Shelterbelts:

This is an agroforestry system in which food crops are planted between rows of trees planted as shelter. The shelterbelts are modified to suit the farmers. The trees and shrubs are planted in one or more rows at right angles to the prevailing winds. The practice often increases crop yield because of their beneficial effects on soil and microclimate. The effect on animals is to reduce stress from

heat and wind. Around houses, shade and wind protection are often combined with production of fruit, edible leaves for human and animals and even fuel wood. The main points to consider are placing of the trees in relation to each other and to the houses and crops and ways of managing them in order to have sustained production of the desired benefits. The multi-species shelter-belts protect crop land and at the same time check desertification. Tree cover affects the microclimate of its immediate environment through temperature reduction due to tree cover (Ujah and Adeoye, 1984; Onyewotu, 1989). Disadvantages of the system are that labour involvement is enormous and species used as hedgerow crops are without edible products.

2.6.7 Windbreaks:

In this agroforestry method a double row of trees are planted around the boundary of a food crop farm on the windward side. Each windbreak is 150m long with 100 trees planted at a spacing of 3m x 3m (Grewal, 1994). The advantage is that windbreaks reduce wind erosion and at the same time produce forest alongside food crops. This is most suitable for the semi-arid zone of Katsina State, the area of study.

2.8.8 Home Garden:

This is an agroforestry system, which has a long tradition in many tropical countries. Tropical home gardens consist of an assemblage of plants which may

include trees, shrubs, vines and herbaceous plants growing in or adjacent to a homestead or home compound (Baumer, 1990). Okafor and Fernandes (1989) reported that in this system multipurpose tree and shrubs in multi-stories associated with arable crops are raised with small livestock in homesteads. Home garden is not a formal practice of agroforestry but a traditional farming system with an agroforestry focus. The system has been modified in various ecosystems to suit local conditions. The whole crop-tree-animal unit is managed by family labour. The system affords diversified production, improves the food production level and conserves the soil and indigenous plant species (Igugu and Osemebeobo 1995).

2.8.9 Multipurpose Trees on Crop Land (trees on farmland or farm (Forestry)

This is an agroforestry component applied to the savanna and rain forest ecosystems. It is a practice in which farmers intentionally leave few trees on farms when clearing the land. The trees commonly left are those of economic importance to the farmers. The economic trees are replaced by young ones at maturity. There is also deliberate planting of desirable fruit bearing trees (fruit trees) on farmlands where the density of the natural tree is low (Owusu, 1993).

Other terms with "Forestry" endings are community forestry - a form of social forestry which refers to tree planting activities undertaken by a community on communal lands or the so-called common people's direct

participation in the process, either by growing trees themselves or by processing the tree products locally. It is suited for areas with abundant common lands. Social forestry, on the other hand, is considered to be the practice of using trees and/or tree planting specifically to pursue social objectives, usually betterment of the poor, through delivery of the benefits (of trees and/or tree planting) to the local people. It is sometimes described as "tree growing by the people for the people" (Nair, 1993).

Dove (1992), Laarman and Sedjo (1992) observed that all these labels (Community, Farm and Social Forestry) directly or indirectly refer to growing and using trees to provide food, fuel, medicines, fodder, building materials and cash income. In other words, they all encompass agroforestry concepts and technologies. These terms are often used synonymously sometimes even out of context in landuse parlance.

2.8.10 Trees in Soil Conservation:

Woody perennial plants can greatly assist infiltration and reduce surface water run-off, although a wrong choice of species or poor planting technique can have the opposite effect (Baumer, 1990). In other words, woody plants, whether in hedges or not, can stabilize the soil on terrace edges and other conservation works and contribute leaf and or wood product. However, particular care should be taken in these systems, regarding planting method and long term management.

2.8.11 Aqua forestry

This is an agroforestry system not popular but widely practised by traditional farmers in inland water courses where the farmers have full rights to the land. Aquaforestry is a practice that links trees with aquaculture. Trees are planted around fishponds to provide fodder for herbivorous fish. The fuel-wood from the trees are used for fish processing while decomposed leaves are used as pond fertilizer. The trees also serve as shelter and shade which create a desirable microclimate for the pond. Aquaforestry is widely practised in Malawi and Pearl. River Delta in China where fruits of guava, avocado, papaya and leaves of leucaena are used to feed herbivorous fishes such as *Tilapia, Hilotica, Labeorhita* and *Gatla* (Wouters, 1994).

2.8.12 Apiculture (Api-silviculture)

Carefully chosen woody species grown for their nectar-producing flowers and pollen valued by bees can boost wax and honey production particularly if flowering is staggered, allowing the bees to work as long as there are flowers instead of only working for a few months in the year. This is probably the production with the highest ratio of value of products harvested to plant biomass consumed (Baumer, 1990).

2.8.13 Protein Bank

In production systems that include animals, it is difficult to rely solely on annual plants to supply forage during dry seasons or years of low rainfall. Woody perennial vegetation is judiciously used to help meet this difficulty; not only does it provide green forage when the grass cover has withered but it can also supply more protein than grass. The advantage of woody plants in dry season is therefore, both quantitative and qualitative (Baumer, 1990)

2.9 AGROFORESTRY AND ENVIRONMENTAL SUSTAINABILITY

Forestry refers to the practice of maintaining plantations usually planted with forest trees and managed for periodic exploitation (Costanza, 1991). FAO (1985) classified this as artificial forests. Natural forests abound in areas where population settlement has not extended its deforesting activities. Non-wood materials like medicine, food, craft, cosmetics resin and gum are derived from the forest (Ipinjolu *et al*., 1988). The forest also provides edible plants, wildlife and fresh water fisheries. In addition the forest makes possible diversification to the rural economy by offering employment opportunities and thus consolidating food security (FAO, 1985). Thus the most important contribution of forestry to food supply is in ensuring environmental stability and productivity by mitigating the effects of climatic fluctuations. This is achieved by provision of stable microclimate for animals and plants production and by conserving the soil and water resources.

The forest constitutes one of mankind principal renewable natural resources that are essential for maintaining environmental stability and providing raw materials for wood and non wood based industries. If a forest ecosystem is in a state of balance it is self-perpetuating and is in equilibrium with the environment, thereby ensuring the sustainability of the ecosystem. Goodland et al. (1984) outlined the environmental services rendered by forests as flood control, groundwater recharge, maintenance and restoration of soil fertility, control of landslides and erosion, purification of air and water among others. All these functions help to ensure that the environment provides the necessary nutrients to support life forms.

In addition to enumerating the advantages of forest to the environment, Hochberg *et al*. (1994) gave the various components of forests as trees, shrubs, grasses and epiphytic plants. The authors contended that the combination of these components is important in the protection of forests against natural hazards and hence enhance their being able to render environmental services. With the recognition of the importance of forests within the environment, FAO (1985) recommended that 25 percent of every country's land should be kept under forests. Swaminatham (1988) also contended that the keeping of forests would control the level of carbon dioxide in the atmosphere as well as enhance the albedo effect in relation to heat reflected to the atmosphere.

Agriculture includes all activities of man that involve the cultivation of the soil to produce crop, plants, rearing of animals and raising of fish. It is the oldest

profession of man which, though improved, is handed down from generation to generation. The soil is a natural resource, which like other natural resources, has a way of self-replenishment and maintaining its nutrient composition and balance. Agriculture involves the use of the soil and disturbance of its vegetation cover either directly, as in arable cropping, or indirectly, as grazing animals (OECD 1991). The vegetative cover and its maintenance have significant impact on the soil itself through modifying its physical structure and chemical composition and affecting the fauna it supports. Increasing demands for agricultural products due to the ever increasing human population has led to expansion of cultivated land area, resulting in deforestation and having direct effect on the ecology and habitat of animal species. The applications of modern technology to agricultural production in the form of farm machines, irrigation and use of chemicals have also had devastating effects on the soil quality. These human activities usually have adverse consequences on the ecological equilibrium by inducing radical environmental changes (OECD, 1991).

Champhaka (1986) cited the degrading effect of deforestation on watershed in some Asian countries as a result of bush clearing. In many cases streams are completely silted up and dams disrupted while the soil water is totally depleted. The use of agricultural pesticides has been shown to pollute underground water reservoirs and water supply for human settlements (George, 1990), Available records indicate marked fluctuation in rainfall pattern in areas

subjected to deforestation, although the overall picture does not clearly denote declining rainfall in the regions (Delwaulle, 1976).

The importance of the ecological equilibrium and all the nutrient cycles need to be recognized so as to engender a conservatory approach while attempting to study human wants. Most recent development programmes recognized that the attempt to boost agricultural production must be sustainable over time and that increased production relies on resources that take many years to renew, namely; trees, soil and water (Berkowitz, 1994). In agriculture, sustainable development means safeguarding the national food security and working to improve the quality of life of people who depend on farming for a living while ensuring that the natural resource base, they and their children depend on, is not further depleted or degraded (UNDP, 1994). Rodale (1998) proposed that the resources we use for production should be managed in such a way that they are more or less self generating and ensure continual improvement. He emphasized the need for adoption of sustainable agricultural production system and recommended the use of resource-conserving system, which is environmentally sound and economically viable. Herdt and Steiner (1995), concluded by saying that the issue of sustainability is about whether agricultural productivity gains are occurring at the cost of degradation of the underlying resource base which will eventually result in falling productivity. Therefore, all dimensions relating to production like physical, economical and social concepts

have to be well addressed. It is in the light of this that Kangas and Rivera (1991) recommended intensive preservation of deforested areas.

2.10. PROFITABILITY ISSUES IN AGROFORESTRY

Stocking *et al.* (1989) reported that agriculture is more than a business, it is a way of life, a means of survival and determinant of the well being of future generations. However, it demands the utilization of several inputs which are later measured against the generated output. Profit is declared when the output surpasses the input on the same scale.

Agroforestry is both corrective and conservatory and the profit can best be measured in terms of attainment of the objectives of the programme. Sanchez (1995) explained that agroforestry is about putting money in farmers' pockets in addition to the goals of providing food security, enhancing soil fertility, conserving soil water as well as increasing fodder and fuel-wood production. The profit from agroforestry is therefore in both economic and environment terms, the latter being difficult to measure in monetary terms. In conserving natural resources, agroforestry ensures a stable agricultural production. Although the yield from agroforestry may be slightly lower than when fertilizer is used. Shannon et al. (1990) proved that the yield is stable but the later declined steadily despite additional fertilizer.

While agroforestry system usually entails more labour, the resultant decrease in the use of inputs like fertilizer offsets the extra labour changes

resulting in an attractive net income and marginal rate of return per unit cost (Ngambeki, 1985). In other words profitability of agroforestry is observed more as an opportunity cost in terms of losses that would have been incurred if agroforestry was not employed. The damage done through inappropriate practices are felt only after some years; therefore the effect of agroforestry cannot be immediate. Under real farming conditions, it might take years before the tangible benefits become apparent (AFNETAN, 1990). The farmer may therefore require some encouragement to devote land and energy to agroforestry practices.

2.11 RURAL PARTICIPATORY FOCUS FOR AGROFORESTRY

Agroforestry as a practice can be said to be land-based as well as agriculturally compatible. It is also directed at checking activities leading to deforestation which is rampant in the rural areas. The WCED (1987) and the World Bank (1989) led the argument that the rural poor impoverish their environment carelessly. They plunder the environment continuously because they are not aware of alternative course of action and their activities boomerang on them in a vicious cycle that perpetuates their poverty condition.

However, there is another view which absolves the poor of environmental destruction. For example, the political economy perspective implicates the rich and affluent for most environmental degradation through commercial logging, mining and industrialization. Annis (1992); Cheru (1992) and Thrupp (1990) emphasized that poor people not only realize that they have only their environment to depend

on but that they try their best to maximize utility of their resources and show more concern for what their children would live on.

Effolliot and Thames (1983), maintained that agroforestry is adaptable to the rural set-up and that it develops a complementary association between trees and arable crops. There is therefore the need to focus on user perspective in agroforestry management policies which would incorporate rural land users needs, experiences and contribution into research and development (Rocheleau, 1987). Deforestation should be seen as a community problem which can therefore, only be solved through community action. The focus on the farmer requires the development of agroforestry practices that will fit into the farmers' situation with the least complaint.

Broad (1993) in a study of the Philippines, delineated three conditions that turn poor people into environmental activist

- When environmental degradation is threatening the natural resource base on which the poor live;
- When the poor people have a sense of performance in the area and
- When the civil society is politicized and organized, that is, there is justice, human right consideration and representation of various interests at government level.

Adoption of the practices within a small area in the community would have no effect on the objective of the agroforestry programme. It is necessary to solicit and encourage participation of the people both individually and collectively.

The Forestry Management Evaluation and Co-ordination Unit (FORMECU, 1989) recommended that every body should be involved in identifying the problems, analyzing the causes and assessing the nature, scope and magnitude of interventions needed to ameliorate them. The programme can be successful if the demarcation between agriculture and tree-growing is removed while rural farmers are made to appreciate the value of trees despite the delay in cash income.

2.12 GENDER ISSUES IN AGROFORESTRY

On Citing Idachaba (1992) cited by Olawoye (1993) opined that conventional agricultural development strategies need to be changed to consider different gender roles and responsibilities. For example, division of labour and responsibilities by males and females is a social reality in all societies. The subject of gender is not synonymous with studies of women but rather concentrates attention to the obligations, privileges and duties assigned to men and women in the society and the relationship between them.

The environmental protection idea of agroforestry requires serious consideration of participation of women in the programme and there are many reasons for this; women are more permanently attached to and closer to the environment than men, who easily migrate (Tade and Ademola,1992) even though the environmental problems could have been caused by men while women are left to deal with the consequences. Jacobson (1992) and Timberlake (1989) noted that environmental decline gives women more responsibility but less power

to exercise that responsibility. The problems of deforestation especially water and fuel-wood scarcity is directed at women as home-makers and mothers (FAO, 1985).

George (1990) observed that sustainable practices favour the coming generations and that there is need to inculcate environmentalism into the children who will soon have to uphold the tenets. This is really a task of women who are the children's first teachers and impression makers (Herdt and Steiner, 1995). The design of agroforestry practices cannot but recognize the relationships between members of the community especially as these affect the members' adoption of agroforestry programme. Rural women therefore should have access in securing land, labour, credit, extension services and other inputs as their men counterpart in agricultural production.

2.13 INCENTIVES FOR AGROFORESTRY

As a new practice that is being brought into an existing system, quite expectedly, it would require some adjustment especially with the input demand. It would demand a reallocation of existing resources from the farmer. Kehkhof (1990) explained that this is often a difficult decision especially as the benefits of agroforestry cannot be quantified monetarily nor substantiated in the short term. The main inputs of agroforestry are land, labour and seedlings or animal stocks. When the farmer even decides to release these inputs for agroforestry, there is the problem of immediate reduction in income which often leaves the farmer

dissatisfied with this decision. The resource-poor farmer would therefore require support during the early years (two to three years) due to initial agricultural yield reduction (Koudokpon et al., 1992).

Conway and Babier (1990) observed that small farmer households need incentives to support a decision to invest in conservation. Dupraz (1994) argued against the heuristic approach, which leaves the farmer unassisted and encouraged by way of incentive provision. In support of this, Umeh (1991) and Sheng (1989) suggested incentives in the form of tax exemption, subsidies on inputs, monetary palliatives for land and involvement in choice of agroforestry components. Other incentives are environmental education for farmers, policies to enhance availability of inputs and improved quality of extension services. The farmer's decision to participate in environmental conservation should be seen as a humanitarian and patriotic gesture.

2.14 CONSTRAINTS TO ADOPTION OF AGROFORESTRY PRACTICES

The complexity of agroforestry systems is seen in the production of food crops, fruit, fodder, fuel-wood, poles, and timber, medicine and animal products together with services in the conservation of soil and biodiversity and boundary delineation (Sanchez, 1995). A peasant farmer may either not feel the need for all these goals or get caught up in the confusion of integrating many, probably unusual activities. Dixon (1995) arranged these constraints under three headings.

(i) Social conditions which include land tenure, availability of infrastructure and level of education of the farmers.

(ii) Economic obstacles like inadequate markets for products, capital needs and financial incentives

(iii) Ecological consideration as limited knowledge of impacts and sustainability.

In the United States of America further obstacles are the perception of land owners, lack of government policy and programme support, lack of well developed markets and insufficient/inappropriate research and technical information on agroforestry system (Schultz, 1995). The similarities in the constraints mentioned/outlined above are indications of the peculiarity of agroforestry systems (Olowu, 1994) identified intrinsic and extrinsic constraints of alley farming. While the intrinsic constraints are within the design of the agroforestry practice, the extrinsic constraints represent the externalities like farm mechanization, pest inhibition and low seed germination. An understanding of each of the constraints mentioned above will avail designers of agroforestry practices guidance if well followed, can/may enhance the adoption of agroforestry practices by farmers.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

This chapter describes the data required to achive the objective of the study. It discuses the sources of the data, the method used in collecting the data as well as the techniques employed in presenting and analyzing them.

3.2 DATA REQUIREMENT

The data needed for achieving the objective of the study fall into two main categories.

i) Variables dealing with:

a) The demographic and socio-economic characteristics of the farmers. These include: gender, age, ethnicity, marital status and educational background.

b) Reasons for engaging in agroforestry farming.

c) Respondents land tenure mode.

ii) Variables dealing with the extent of agroforestry farming in the study area and the proportion of the total farming population in terms of the number of farmers who practised agroforestry, the area of land under agroforestry; experience in agroforestry farming and system of agroforestry practised. Basically,

these are variables that describe the type and number of trees in various farms, their year of planting, source and cost of the tree seedlings. Data were also collected on the type of crops planted, reason for planting the trees and also the type and number of livestock kept (reared), climatic data of the study area, International Organizations, Government and some donor agencies participating in agrofoestry practices in the study area; benefits derived from agroforestry and the constraints of the farmers to adoption of agroforestry practices.

3.3 DATA SOURCES

Various kinds of data directly relating to agroforestry practices in Katsina were sought for and obtained from both primary and secondary sources. Secondary sources where data were collected included those obtained from agricultural and forestry literature, reports from institutions, districts/communities where agroforestry is practiced, ministries, International Organisations and some donor agencies participating in agroforestry in the study area. These included the following:

i) Katsina Afforestation and Rural Development Authority (KTARDA). This organization is involved in agroforestry activities like shelterbelt and windbreak establishment, woodlot establishment and fruit trees production. The organization involved the farmers in decision making.

ii) European Economic community and. Katsina State Government (EEC/KTSG) This organization is involved in the afforestation of Katsina State by the

application of agroforestry practices. The aim of this organization is to halt the threatened desertification or desert encroachment in the area. The organization also raised and supplied tree seedlings to farmers free.

iii) Katsina Afforestation Project/World Bank (KTAPU/World Bank) This organization is involved in agroforestry project. The agroforestry models introduced to farmers by this project were woodlot, windbreak and shelterbelt establishment, farm forestry and natural regeneration method of agroforestry.

3.4 DATA COLLECTION METHODS

Two main methods of data collection were employed:-

i) Field observations and measurements

ii) Questionnaire method.

The data from primary sources were obtained partly through field observations and measurements, personal communications with selected small-scale farmers and partly through questionnaire based interviews. Field observation and measurements were employed to obtain information on the number, size and plants grown on agroforestry farms. Other relevant information regarding agroforestry were also observed and recorded. These information helped in designing the questionnaire for the field based interview (suvery).

3.5 DATA COLLECTION PROCEDURE

Prior to data collection exercise a reconnaissance survey of the study area was undertaken from 9th to 11th of March 2001. The aim of this reconnaissance survey is to familiarize the researcher with the study area.

During the survey the researcher attempted to determine the farmers means of communication. It was ascertained that Hausa language is their major means of communication. The researcher also went further to determine the systems of agroforestry practised by the farmers as well as the type of tree crops and arable crops growing on their farms. The constraints include accessibility to the farms, availability of assistants, availability of portable drinking water and accommodation for the researcher and his attendants. Type of tools and materials needed for the collection of data during the real survey were identified. These include poles, measuring tapes cutlass, exercise book and biro.

3.6 SAMPLING PROCEDURE

Nine local government areas were selected out of the thirty four local government areas in Kastina state using a stratified random sampling technique. Three local government areas were selected from each of the three ecological zones of the state to form the first stratum for data collection. In each of the selected Local Government area, three villages were then selected for sampling making it a total of twenty seven villages. These villages include; Birninkuka, Kasanki and Majigiri (Jibia L.G.A), Danmalka, Daunaka and Mai'adua (Kaita

L.G.A.), Bumbum, Dankaba and makera (Daura L.GA), Ruka, Gimi and Safana (Kanke L.G.A.), Safaya Mazaji and Kogami (Rimi L.G.A), Gwarjo, Dangano and Danmusa (Dutsima L.G.A.), Tandama, Kahuta and shema (Funtna L.G.A.), Dandume, Guga, and Jargaba (Malumfashi L.G.A), Danji, Daba and Kokami (Danji L.G.A.). These villages were randomly selected. However, the researcher ensured that the villages selected from the stratified Local Government Areas fall squarely within a particular ecological zone. This selection forms the second stratum for data collection. Due to non existence of accurate data on the actual population of the small scale farmers in each village 150 farmers were selected from nine villages in each of the three agroecological zones of the state, thus giving a sample size of 450 farmers.

Fig6

3.7 QUESTIONNAIRE FORMAT AND ADMINISTRATION

A comprehensive questionnaire designed to seek information particularly on the views of the farmers on key variables on agroforestry was administered to the farmers in the study area. The questionnaire was designed in such a way as to identify the agricultural practices of the agroforestry farmers, the various farm components and the farmers' characteristics that influenced these.

The items included in the questionnaire were:-

i) Socio-demographic characteristics like gender, age, level of education, contact with extension agents, source of farmlands and labour.

ii) Agricultural practices like: Types of crop grown, pattern of cultivation, and experience in agroforestry practices.

iii) Other items included were number of agroforestry farmers, farm size, source of land, socio-economic, environment and benefits of agroforestry as well as problems experienced in the adoption of agroforestry (Appendix I).

The collection of data was carried out between 12th October and 10th November 2005. Trained enumerators were employed as assistants in the exercises while extension agents helped in locating the respondents. Each interview schedule took the form of dialogue. The instruments used in field observation and measurement include; measuring tape, girthing tape, haga altimeter, cutlass, exercise book and biro, measurement taken included the area

and stocking of individual farms. The growing tree crops species and arable crops were also enumerated. The information obtained was promptly recorded in the schedule. Other people involved in this exercise were the Afforestation project co-coordinator, Project co-coordinator European Economic Community/ Katsina State Government (EEC/KTSG), Director of Forestry and some zonal Forestry officers in Katsina State.

3.8 TEST OF RELIABILITY

During the pilot survey, which took place in Daddawa village in Jibiya Local Government between 12th and 19th of July 2004, the instruments were tested to ascertain their reliability for obtaining the intended information. They were considered to be efficient and found reliable in obtaining intended information.

3.9 MODE OF DATA PRESENTATION AND STATISTICAL ANALYSIS.

The data obtained from the study were summarized using either absolute frequencies and/or proportions and then presented in tables. The summaries were analyzed using descriptive statistics namely measures of central tendency and dispersion/spread.

Chi – square (χ^2) was used to test the following hypothesis with reference to Agroforestry practices at 5% level of probability.

1) H_o – Gender influences Agroforestry practices amongst the three ecological zones

H_i – Gender has no influence on Agroforestry practices amongst the three ecological zones.

2) H_o – Agroforestry practices is influenced by age of respondents in the three ecological zones.

H_i – Agroforestry practices is not influenced by age of the respondents in the three ecological zones.

3) H_o – Marital status of respondents influences Agroforestry practices amongst the three ecological zones.

H_i – Marital status of the respondents has no influence on Agroforestry practices amongst the three zones.

4) H_o – Farming experience of the farmers influences Agroforestry practices amongst the three ecological zones.

H_i – Farming experience of the farmers has no influences on Agroforestry amongst the farmers in the three ecological zones.

5) H_o – Area of land under Agroforestry has influence on Agroforerstry practices amongst the three ecological zones.

H_i – Area of land under Agroforestry has no influence on Agroforerstry practices amongst the three ecological zones.

6) H_o – Land tenure pattern has influence on Agroforestry practices amongst the three ecological zones.

H_i – Land tenure pattern has no influence on Agroforestry practices amongst the three ecological zones.

7) H_o – Benefit of Agroforestry farming influences Agroforestry practices amongst the three ecological zones.

H_i – Benefit of Agroforestry farming has no influences on Agroforestry practices amongst the three ecological zones.

3.10 STATISTICAL MODEL

Chi – square (χ^2) model

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \qquad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following quations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad ----------(2)$$

Where - LT is row total

KT is column total

GT is grand total

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 SOCIO-CULTURAL CHARACTERISTICS OF THE RESPONDENTS

Tables 2 – 6 summarize information on the respondents' sex, age, marital status and literacy status.

4.1.1 Distribution of Respondents by Sex

The distribution of respondents by sex is presented on table 2. The table has revealed that agroforestry farmers were male dominated across the three zones as over four-fifths (80 percent) of the agroforestry farmers were male while the females accounted for the rest (20 percent). Similarly the non-agroforestry farmers were predominantly males, three-fifths (60 percent) being males while the rest were females (40 percent). It should be noted that the proportion of women non-agroforestry farmers was higher than the proportion of women agroforestry farmers. This is a clear indication that more women engaged in the conventional or arable farming. Also the proportion of male agroforestry farmers was higher than that of women agroforestry farmers.

Table 2: Distribution of Respondents by Sex

	Agro-forestry Farmers								Non agro-forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Gender	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Male	24	75.0	33	91.7	26	86.7	83	84.7	71	61.7	59	59.0	66	57.9	196	59.6
Female	08	25.0	03	8.3	04	6.3	15	15.3	44	38.3	41	41.0	48	42.1	133	40.4
Total	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

4.1.2 Distribution of Respondents by Age

Information relating to the age of the respondents is presented on table 3. The table revealed that three-fifths of the agroforestry farmers belonged to the 30-49 age cohorts while three out of every 20 respondents were 40 years and above. The rest were under 30 years of age. The age distribution of the non-agroforestry farmers is as follows: Just a little over 45 percent belonged to the 30-49 age cohort, nearly three-eights were over age 40 years and above while the rest were below age 30. It thus appears that the agroforestry farmers were relatively younger than the non-agroforestry farmers.

For the three zones, the age distribution pattern of agroforestry farmers was similar. On the other hand that of the non-agroforestry farmers showed greater variations.

Table 3: Age of Respondents (years).

Variables	Agro-forestry Farmers								Non Agro-forestry Farmers							
	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Age (yrs)	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Under 20	02	6.3	01	2.8	01	3.3	04	4.1	-	-	02	2.0	02	1.9	04	12.0
20 – 29	02	6.3	02	5.6	03	10.0	07	7.2	18	15.7	12	12.0	11	9.6	41	12.5
30 – 39	19	59.2	22	61.1	18	60.0	59	60.2	52	45.2	46	46.0	51	44.7	149	45.3
40 – 49	05	15.6	07	19.4	04	13.3	16	16.3	22	19.1	26	26.0	33	28.9	81	24.6
50 – 59	02	6.3	03	8.3	02	6.7	07	7.1	17	14.8	14	14.0	13	11.4	44	13.4
Above 60	02	6.3	01	2.8	02	6.7	05	5.1	06	5.2	-	-	04	3.5	10	3.0
TOTAL	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

4.1.3 Marital Status of Respondents

Information relating to the marital status of the respondents is presented on table 4. The table shows that more than three-fifths of the agroforestry farmers were married while the rest were either widowed or divorced. However, the distribution pattern varied between zones, three quarters for the Sahel savanna zone, three-fifths for the Sudan savanna zone and just over one half for the northern Guinea savanna zone. The distribution pattern for the non-agroforestry farmers varied from that of the agroforestry farmers. It varied from one quarter through one-seventh to two fifths. For the non agroforestry farmers; just a little over two-fifths were married while a little above one third were single. The rest of the non agroforestry farmers were either widowed or divorced. For the three zones, the table has revealed that the highest percentage of agroforestry farmers was married as against their non-agroforestry counterparts. The corresponding proportion of single farmers was higher among the non-agroforestry farmers than the agroforestry farmers. Also the proportion of widowed/divorced was higher for the agroforestry farmers.

Table 4: Marital Status of Respondents

	Agro-forestry Farmers								Non Agro-forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Marital Status	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Married	24	75.0	22	61.1	16	53.3	62	63.3	58	50.4	50	50.0	36	31.6	144	43.8
Single	05	15.6	09	5.0	08	26.7	22	22.4	33	28.7	35	35.0	58	50.8	126	38.3
Divorced	02	6.2	03	8.3	04	13.3	09	9.2	21	18.3	12	12.0	14	12.3	47	14.3
Widowed	01	3.1	02	5.6	02	6.7	05	5.	03	2.6	03	3.0	06	5.3	13	3.6
Total	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

4.1.4 Respondents Literacy Attainment

The distribution of respondents according to literacy status is presented on table 5. It is significant to note that all the respondents had one form of education or another and that over three fifths of the agroforestry farmers reported that they had Koranic education while the corresponding proportion of the non-agroforestry farmers with Koranic education was over two-fifths. The table also reveals that about one eight of the agroforestry farmers had primary education while about one quarter had post primary education. One third of the non-agroforestry farmers reported that they had primary education as their literacy attainment while over one fifth had post primary education.

Table 5: Respondents' Literacy Attainment

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Varibles	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Type of Education	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Koranic Education	21	65.6	22	61.1	19	63.3	62	63.3	63	54.8	52	52.0	19	16.7	134	40.7
Primary Education	04	12.5	05	13.9	03	10.0	12	12.2	36	31.3	37	37.0	29	25.4	102	31.0
Post primary Education	07	21.9	09	2.5	08	26.7	24	24.5	16	13.9	11	11.0	66	57.9	93	28.3
Total	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

4.1.5 Respondents Land Tenure Mode

Information relating to the mode of tenure of the study population held on their farmland is presented on table 6. The table has revealed that over three-fifths of the agroforestry farmers rented their farmland while about one-fifth owned theirs by inheritance. The table has also revealed that over one sixth of the agroforestry farmers purchased their farmlands.

It is also quite obvious from the table that nearly three-fifths of the corresponding non-agroforestry farmers inherited their farmlands while one quarter purchased theirs. One-sixth of the non agroforestry farmers had been shown to have rented their farmlands.

Table 6: Respondents Land Tenure Mode.

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Land Tenure	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Inherited	08	25.0	04	11.1	05	16.7	17	17.3	62	53.9	59	59.0	72	63.1	193	58.7
Rented	18	56.3	24	60.7	23	76.6	65	66.3	18	15.7	15	15.0	24	21.0	57	17.3
Purchased	06	18.7	07	19.4	02	6.7	15	15.4	35	30.4	26	26.0	18	15.9	79	24.0
Others	-	-	01	2.8	-	-	01	1.0	-	-	-	-	-	-	-	-
Total	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

4.2 ACTIVITIES OF GOVERNMENT/INTENATIONAL ORGANISATIONS ON AGRICULTURAL PRACTICES IN KATSINA STATE

Katsina State was once covered by extensive rich savanna vegetation which was able to support economic activities. However, over the year a greater percentage of this luxurious vegetation has been lost to desertification. Many of the trees/shrubs being cut perform very essential environmental functions of protecting the Land from erosion desiccation, degradation and desertification.

It is against this back drop that the State Govt. assisted by some international organizations initiated agroforestry project to check desertification threat to the state. Some of the project included the follow.

4.2.1 Katsina Agricultural and Rural Development Authority (KTARDA)

This organization participated or sponsored agroforestry. It concentrated on agriculture and fruit tree production. The organization employed 6,668 farmers for all its agroforesty practices. Agroforestry activities carried out by this organization included the establishment of shelterbelts, windbreaks and woodlots and biodiversity conservation using *Acacia nilotica*. This project established a total of 69 shelterbelts in the Sahel and Sudan ecological zones of the study area. The shelterbelts were established in the following locations: Ruma, Riko, Aballawa, Yandaki, Shinkafi, Daddara and Tsagero (Sahel ecological zones). The other

locations included Maru, Zakka, Tsauri, Wurma, Dangei, Gingin, Gwajo, Sayaya, Jino, and Tsami (Sudan ecological zone).

Shelterbelts are long narrow strip of trees planted at right angle to the prevailing dry season wind direction. The trees are normally planted in series of rows 200m apart. A shelterbelt comprises of five rows. Each shelterbelt is 2000m in length and 30m in width representing an area of 6ha. When mature, the shelterbelt would provide considerable protection to surrounding farmlands as well as provide potentially valuable source of forestry products from thinning. Both indigenous and exotic tree species were used by the project for the establishment of the shelterbelts. Indigenous species used included *Parkia biglobosa*, *Adansonia digitata*, *Vitalleria_paradoxa* and *Acacia nilotica*. The exotic species used were *Acacia holosericea*, *Anacardium occidentale*, *Azadirachta indica*, *Cassia siamea* and *Eucalyptus camandulensis*.

The project established a total of 3,470 windbreaks around farmlands and settlements within the study area. These windbreaks were located in the following Local Government Areas in Katsina State; Jibiya, Kaita, Majigiri, Dan Malka, Kasonki, Fago, Ingawa, Babban duhu and Ruma Local Government Areas.

A windbreak consists of double rows of trees planted around the boundary of farm on the windward side. Each windbreak is 150m long and 6m wide and comprises of 100 trees planted at 3m x 3m spacing.

The Shelterbelts were PLATE 1

Windbreaks are primarily designed to reduce wind erosion while small quantities of forest produce will also become available when the trees mature. The windbreak model is most popular with farmers as it takes up very little space and also serves to demarcate their farm boundary. Tree species used for the establishment of windbreak include *Eucalyptus camaldulensis*, *Cassia siamea* and Az*adirachta indica*.

The project established a total of 2,229 units of woodlots throughout the study area. Each unit of woodlot consists of a small plantation of about 0.1ha comprising of 400 trees planted at a spacing of 1.5m x 1.5m. Woodlots are planted at odd corners of farms. They are primarily designed to provide constant source of firewood and poles which may be used for domestic purposes or for sale.

The following tree species were planted in woodlots: *Acacia holosericea*, *Eucalyptus Camaldulensis Tamarindus indica*, and *Azadirachta indica* Forestry activities were stopped due to the political instability in the country from 1991,with the abandonment of the nurseries where seedlings have been raised and supplied to farmers. (see table.7 for summary of achievement).

Fig. 7

PLATE 2

TABLE 7: Summary of planting achievement by KTARDA

ITEM	1987	1988	1989	1990	**Total**
Shelterbelts(Compartment)	13	20	9	27	**69**
Windbreaks(Compartment)	353	768	393	1956	**3470**
Woodlots(Compartment)	1871	556	125	1361	**2229**
No. of farmers	657	1541	564	3,924	**6668**
No. of seedlings distributed	**215300**	**586600**	**609900**	**1243**	**2654810**

Source: KATARDA 1992

4.2.2 European Economic Community/Katsina State Government (EEC/KTSG)

The body was established in 1987. The body designed appropriate models of agroforestry practices in the afforestation of Katsina State. A total of 18,674 contact farmers were recruited by this body in the process of carrying out the various agroforestry exercises. The farmers were involved in three basic models of agroforestry practices; namely windbreaks, woodlotds and scartered trees on farmland.

The body established a total of 9,591 compartments of windbreaks in the Sahel and Sudan Savanna zones of the study area. The windbreaks were located in the following local Government areas: Jibia, Kurfi, Bindawa Mani, Mshi Maiduwa Katsina and Batargawa. The windbreaks establised by this body were similar to those established by the KATARDA organisation. The main difference was that only two tree species *Eucalyptus camandulensis* and *Cassia siamea* were used by this body.

The second model of agroforestry adopted by the body was woodlot establishment. The body established a total of 6,421 compartment of woodlots in the study area. The woodlots were located around the agroforestry farms in Gingiri, Dengana, Sayaya Ruma and Zakka communities. The other agroforestry model practised by this body is "planting or leaving trees on farmland:" These are few individual trees left on farmland during site clearing. The trees left are mainly those of economic importance. This model of agroforestry farming was found in

Kankia, Rimi, Mari, Safana and Ingawa Local Government Areas. Over the whole planting period, windbreaks and woodlots were found to be the models most popular with the farmers. The "trees on farmland" model was least popular. In 1994, the European Economic Union (EEC) withdrew its funding of the project because of the unhealthy political climate in the country. The overall achievement of the project is shown on table 8.

4.2.3 Katsina Afforestration Project Unit/World Bank (KTAPU/WORLD BANK)

This organisation was established in 1985. The agroforestry models, introduced to the farmers by this body were shelterbelt, woodlot, windbreak, and farm forestry, border line planting and natural regeneration. Farmers practising agroforestry where allowed the freedom to determine the models to adopt.

The project was able to establish a total of 21,768 compartments of shelterbelts, 3,664 compartments of woodlots and 5,535 compartments of windbreaks in different parts of the study area.

Another model of agroforestry practised is "trees on farmland" This model is a traditional farming practice where few individual trees are left on farmland after clearing for farming. Trees left are mainly economic trees. Only very few farmers practise this method of farming. This method of farming was observed in Funtua, Danja and Malumfashi Local Government Areas.

PLATE 3

Fig.8

TABLE 8: EEC/KTSG Overall Achievement 1987 – 1991

Planting Model	1987 – 1991	1992	1987 – 1992	TOTAL
Windbreaks	7,227	2,364	9,591	19,182
Woodlots	4,545	1,876	6,421	12,842
Trees on Farmland	2,461	579	3,040	6,080

4.3 FARMERS IN AGROFORESTRY

Table 9 presents information on farmers practising agroforestry/not practising agroforestry. According to the table, over one-fifth of the farmers were agroforestry farmers while the rest are not. The highest percentage of agroforestry farmers was recorded in the Sudan savanna zone while the lowest was recorded in the northern Guinea savanna zone. On the other hand the highest percentage of non-agroforestry farmers was recorded in the Sahel savanna zone followed by the northern Guinea savanna and the Sudan savanna zones respectively.

Table 9: Farmers in Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All zones	
Type of Farmers	Freq	%	Freq	%	Freq	%	Freq	%
Agro-Forestry Farmers	32	21.8	36	26.5	30	20.8	98	23.0
Non-agroforestry Farmers	115	78.2	100	73.5	114	79.2	329	77.0
Total	147	100	136	100	144	100	427	100

4.4 LAND UNDER AGROFORESTRY

The extent of agroforestry farming practices in the study area has been assessed using two criteria, the number of sampled respondents who practised agroforestry and the area of land under agroforestry. The information obtained from the respondents on the extent of land area under agroforestry has been summarized and presented on table 10. The sampled agroforestry farmers were distributed as follows: 32 in the Sahel savanna zone, 36 in the Sudan savanna zone and 30 in the northern Guinea savanna zone. The table has also revealed that the modal farm size was 5.8 hectares for the Sahel savanna zone, 6.9 hectares for the Sudan savanna zone and 5.8 hectares for the northern Guinea savanna zone. The 98 farmers practising agroforestry had a total of 609 hectares of land under agroforestry. This represented a mean of 6.24 hectares per farmer. The mean land size varies from 5.8 hectare to 6.9 hectares for the three zones. Sahel and northern Guinea savanna zones have equal mean size of 5.8 hectares while Sudan savanna zone has mean size of 6.9 hectares.

Table 10: Land Under Agroforestry

Variables	Sahel Savanna			Sudan Savanna			Northern Guinea Savanna		
Farm size(ha)	Freq	%	Total	Freq.	%	Total	Freq.	%	Total
1	02	6.3	02	01	2.8	01	02	6.7	02
2	02	6.3	04	02	5.6	04	03	10.0	06
3	02	6.3	06	01	2.8	03	03	10.0	09
4	02	6.3	08	02	5.6	08	02	6.77	08
5	02	6.3	10	03	8.3	15	02	6.7	10
6	11	34.1	66	04	11.1	24	03	10.0	18
7	03	9.4	21	04	11.1	28	04	13.3	28
8	04	12.5	32	09	25.0	72	07	23.3	56
9	03	9.4	27	06	16.6	54	03	10.0	27
10	01	3.1	10	04	11.1	40	01	3.3	10
Total	32	100	186	36	100	249	30	100	174

4.5 FARMING EXPERIENCE

Table 11 presents the farmers in terms of the number of years they had been farming. The table has revealed that agroforestry farming has just been introduced as a new innovation in the study area. The table has also shown that eleven –twentieths of the farmers had farmed for between 11-20 years, while one-fifth had farmed for between 21 – 30 years. Only one-eights of the agroforestry farmers had above 30 years farming experience. Agroforestry farmers in the Sudan savanna zone had more farming experience, followed by farmers in the Sahel savanna and northern Guinea savanna zones in that order. The table has also revealed that just over two-fifths of the corresponding non-agroforestry farmers had between 21 –30 years of farming experience while about one-third had between 1-20 years farming experience.

Table 11: Farming Experience of Respondents

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Farming Experience (Year)	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
1 – 10	04	12.5	05	13.9	03	10.0	12	12.2	24	20.9	19	19.0	22	19.3	65	19.8
11 – 20	18	56.3	21	58.3	16	53.3	55	56.1	30	26.0	31	31.0	36	31.6	97	29.4
21 – 30	06	18.7	06	16.7	06	20.0	18	18.4	51	44.3	42	42.0	45	39.5	138	41.9
Above 30	04	12.5	04	.1	05	16.7	13	13.3	10	8.8	08	8.0	11	9.6	29	8.9
Total	32	100	36	100	30	100	98	100	115	100	100	100	114	100	329	100

Table 12: Types of Agroforestry Practised by Sampled Farmers

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Agroforestry system	Freq	%	Freq	%	Freq	%	Freq	%
Improved fallow	03	9.4	04	11.1	02	6.7	08	9.2
system2								
Taungya system	-	-	-	-	01	3.3	01	3.3
Home Garden	02	6.2	03	8.3	03	10.0	08	8.2
Alley cropping	01	3.1	-	-	-	-	01	1.0
Multipurpose trees on crop land (trees on farm land)	25	78.1	27	75.0	24	80.0	76	77.6
Plantation crop combination	01	3.1	-	-	01	3.3	02	2.0
Planting of trees in soil conservation	21	65.6	24	66.7	19	63.3	67	68.4
Windbreak system	22	68.7	26	72.2	19	63.3	67	68.4
Woodlot system	19	59.3	22	61.1	18	60.0	59	60.2

4.6 TYPES OF AGROFORESTRY PRACTISED BY SAMPLED FARMERS

Tables 13 - 22 summarize information relating to the respondents awareness and participation in selected types of agroforestry.

4.6.1 Improved Fallow System of Agroforestry

The respondents were asked whether they were aware of and participated in improved fallow system of agroforestry. Their responses are presented on table 13. The table has revealed that over three-fifths of the agroforestry farmers were not aware of any improved fallow system of agroforestry. The highest percentages of these farmers were recorded in the Sudan savanna zone. The table has also shown that about one tenth of the farmers were aware but had never practised it. The rest of the farmers claimed that they had neither participated nor intend to participate. Generally table 11 had revealed that this system of agroforestry farming was not popular in the study area.

Table 13: Improved Fallow System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	Per	Freq	Per	Freq	Per	Freq	Per
Not aware	22	68.7	24	66.7	22	73.3	68	69.4
Aware but had never practiced	04	12.5	05	13.9	02	6.7	11	11.2
Aware and practised but discontinued	03	9.4	03	8.3	04	13.3	10	10.2
Aware and practised but intend to discontinue	03	9.4	04	11.1	02	6.7	09	9.2
Total	32	100	36	100	30	100	98	100

4.6.2 Taungya System of Agroforestry

Table 14 presents information on the agroforestry farmers' awareness of and participation in taungya system of agroforestry. According to the table, over three-fifths of the farmers claimed ignorance of the system while one quarter admitted their awareness but never practised the system. Furthermore, one-tenth of the agroforestry farmers admitted that they had previously participated in the farming system but did not intend to continue. This reason might be due to the high inputs and low productivity of the system in the study area. Also table 11 revealed that just about 3 percent of the sampled farmers practised this system.

Table 14: Taungya System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Not aware	23	71.9	21	58.3	17	56.7	61	62.2
Aware but had never practiced	04	12.5	09	25.0	12	40.0	25	25.6
Aware and practised but discontinued	05	15.6	06	16.7	-	-	11	11.2
Aware and practised and intend to continue	-	-	-		01	3.3	01	1.0
Total	32	100	36	100	30	100	98	100

4.6.3 Home Garden System of Agroforestry

Table 15: has revealed that over two-thirds of the agroforestry farmers were aware of home garden system of agroforestry farming but had never practised it, while one-fifth of the farmers claimed ignorant of the system. Furthermore, about one-tenth of the farmers had participated in the system and still had the intention to continue. According to table 11 just about 8 percent of the sampled farmers practised this system of agroforestry. The system could be regarded as not been popular in the study area.

Table 15: Home Garden System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Aware but had never practiced	22	68.8	27	75.0	18	60.0	67	68.4
Not aware	08	25.0	06	16.7	08	26.7	22	22.4
Aware and practised but discontinued	-	-	-	-	01	3.3	01	1.0
Aware and practised and intend to continue	02	6.2	03	8.3	03	10.0	08	8.2
Total	32	100	36	100	30	100	98	100

Plate 4

4.6.4 Alley Cropping System of Agroforestry

In alley cropping system, arable crops are planted in between the trees. The usual trees planted are the nitrogen fixing species that are capable of fixing nitrogen to the soils. Table 16 has revealed that about four-fifths of the agroforestry farmers were not aware of alley cropping system of agroforestry. The highest percentage of this category was recorded in the northern Guinea savanna zone. One sixth of the farmers claimed to be aware of the system but had never practised it. The rest of the farmers claimed that they had either participated in the system and intended to continue or had participated but did not intend to continue. This system was not widely practised in the study area.

Table 16: Alley Cropping System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Not aware	24	75.0	22	75.0	26	86.7	77	78.6
Aware but had never practiced	05	15.6	07	19.4	04	13.3	16	16.3
Aware and practised but discontinued	02	6.3	02	5.6	-	-	04	4.1
Aware and practised and intend to discontinue	01	3.1	-	-	-	-	01	1.0
Total	32	100	36	100	30	100	98	100

PLATE 5: ALLEY CROPPING OF AGROFORESTRY SYSTEM IN

4.6.5 Maintaining Multipurpose Trees on Crop Land (trees on farmland).

Table 17 has shown that over three quarters of the farmers participated in maintaining multipurpose trees on crop land (trees on farmland) and intended to continue with the practice. The highest percentage of these categories of farmers was recorded in the northern Guinea savanna zone while the least was recorded in the Sudan savanna zone. Over one sixth of the farmers claimed ignorance of the practice while one twelfth claimed that they had participated in the practice but did not intend to continue. As shown on table 11, well over 77 percent of the sampled farmers practised this system of agroforestry.

Table 17: Maintaining Multipurpose Trees on Crop Land (Trees on Farmland).

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Aware and practised and intend to continue	25	78.1	27	75.0	24	80.0	76	77.6
Not aware	05	15.6	06	16.7	04	13.3	15	15.3
Aware but had never practiced	02	6.3	03	8.3	02	6.7	07	7.1
Aware and practised but discontinued	-		-	-	-	-	-	-
Total	32	100	36	100	30	100	98	100

PLATE 6: MULTIPURPOSE TREES ON CROP LAND IN

4.6.6 Plantation Crop Combination System of Agroforestry

Information relating to plantation crop combination system of agroforestry is shown on table 18. The table has revealed that over two thirds of the agroforestry farmers claimed ignorance of plantation crop combination system of agroforestry. The highest percentage of the farmers was recorded in the northern Guinea savanna zone while the least was in the Sahel and Sudan savanna zones. On the other hand over one fifth of the agroforestry farmers claimed that they were aware of the system but had never practised it, while the rest claimed that they had practised it but either intend to continue or discontinue with the system.

Table 18: Plantation Crop Combination System of Agroforestry.

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Not Aware	22	68.7	22	61.1	23	76.7	67	68.4
Aware but had never practiced	07	21.9	10	27.8	05	16.7	22	22.4
Aware and practised but discontinued	02	6.3	04	11.1	01	3.3	07	7.2
Aware and practised and intend to continue.	01	3.3	-	-	01	3.3	02	2.0
Total	32	100	36	100	30	100	98	100

4.6.7 Planting of Trees for Soil Conservation / Reclamation System of Agroforestry.

Information relating to planting of trees in soil conservation \ reclamation measure is presented on table 19. The table has shown that over two-third of the agroforestry farmers were aware and practised this system of agroforestry. The highest percentage of this category was recorded in the Sudan savanna zone. Less than one-third of the agroforestry farmers claimed ignorance of the system. The rest had practised the system but either intends to continue or not to continue. Table 7 had revealed that the system was one of the popular systems practised in the study area.

Table 19: Planting of Trees for Soil Conservation /Reclamation

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Aware & practiced and intend to continue	21	65.6	24	66.7	19	63.7	64	65.3
Not aware	10	31.3	09	25.0	11	36.3	30	30.7
Aware and practiced but discontinued.	01	3.1	-	-	-	-	01	1.0
Aware and practiced but intend to discontinue	-	-	03	8.3	-	-	03	3.0
Total	32	100	36	100	30	100	98	100

PLATE 7: TREES IN SOIL CONSERVATION AND RECLAMATION IN

4.6.8 Windbreak Establishment System of Agroforestry

Information relating to establishment of windbreak system of agroforestry is presented on table 20. The table has shown that over two-thirds of the agroforestry farmers practised it and intend to continue with the system. The highest percentage of the respondents was recorded in the Sudan savanna zone while the least was found in the northern Guinea savanna zone. On the other hand, over one quarter of the agroforestry farmers were aware of the system but had never practised it. The rest were not aware of this system of agroforestry. According to table 7 over 64 percent of the study population practised this system of agroforestry.

Table 20: Windbreak Establishment System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Aware and practised and intend to continue	22	68.7	26	72.3	19	63.3	67	68.4
Aware but have never practiced	08	25.0	07	19.4	10	33.4	25	25.5
Not aware	02	6.3	03	8.3	01	3.3	06	6.1
Aware and practised but discontinued	-	-	-	-	-	-	-	-
Total	32	100	36	100	30	100	98	100

PLATE 8: WINDBREAK ESTABLISHED BY AGROFORESTRY FARMERS INRUMA, BATASARI L.G.A.

PLATE 9: PRIVATE MULTIPURPOSE WOODLOT ESTABLISHED BY AGROFORESTRY

4.6.9 Woodlot Establishment System (fuelwood production) of Agroforestry

Information relating to establishment of woodlot by the sampled population is presented on table 21. The table has shown that over three-fifths of the agroforestry farmers had woodlots, the highest percentage being found in the Sudan savanna zone while the least was found in the northern Guinea savanna zone. One third of the farmers claimed that they were aware of the system but had never practised it. The rest of the agroforestry farmers were not aware of the system.

Table 21: Woodlot Establishment System of Agroforestry

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%
Aware and practised and intend to continue	19	59.3	22	61.1	18	60.0	59	60.2
Aware but have never practiced	11	34.4	12	33.3	09	30.0	32	32.7
Not aware	02	6.3	02	5.6	03	10.0	07	7.1
Aware and practised but discontinued	-	-	-	-	-	-	-	-
Total	32	100	36	100	30	100	98	100

4.6.10 Awareness and Participation in Government Annual Tree Planting Campaign

Table 22 presents information on whether or not the study population was aware of and had participated in the government's annual tree planting campaign. The table had shown that over four-fifths of the agroforestry farmers across the zones were aware and had participated in the government's annual tree planting campaign and had been participating fully while about one-sixth claimed ignorance of the exercise. The highest level of awareness was recorded in the Sudan savanna zone while the least was in the Sahel savanna zone.

The table has also shown that over four-fifths of the corresponding non agroforestry farmers claimed they were ignorant of the government annual tree planting campaign. Only one-eight of the respondents were aware and had participated in the exercise.

Table 22: Awareness and participation in Government Annual Tree Planting Campaign

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Awareness	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Aware	24	80.0	32	88.9	25	84.4	81	82.7	03	9.3	06	16.7	05	16.7	14	14.3
Not aware	08	20.0	04	11.1	05	15.6	17	17.3	29	80.7	30	83.3	25	83.3	84	85.7
Total	32	100	36	100	30	100	98	100	32	100	36	100	30	100	98	100

4.7 CROPS/TREE SPECIES GROWN AND LIVESTOCK REARED

Tables 23 – 26 summarize information on the principal crops, economic trees, fruit trees cultivated and livestock reared by the agroforestry farmers.

4.7.1 Principal Crops Grown

Information on the principal crops grown by the respondents is summarised on table 23. The table has revealed that millet, Guinea corn, groundnut and maize were the predominant crops grown by the agroforestry farmers. About two thirds of the agroforestry farmers grew Guinea corn. The highest percentage of farmers growing Guinea corn was recorded in the Sudan savanna zone while the least was observed in the northern Guinea savanna zone. Exactly one-half of the agroforestry farmers grew millet. The highest percentage of agroforestry farmers growing millet was observed in the Sahel savanna zone while the northern Guinea savanna zone accounted for the least. About one-half of the study population grew maize. The northern Guinea savanna zone recorded the highest percentage of agroforestry farmers growing maize while no agroforestry farmer grew maize in the Sahel savanna zone. Over one-half of the agroforestry farmers grew groundnut. The Sudan savanna zone recorded the highest percentage of agroforestry farmers growing groundnut while the northern Guinea savanna zone recorded the least. Beniseed ranked fifth among the crops grown by agroforestry farmers. Overall, just fewer than 30 percent of the farmers reported that they grew beniseed. The Sahel savanna zone recorded the highest population of

farmers growing this crop with 41 percent. This was followed by the Sudan savanna zone and northern Guinea savanna zone with almost 31 and 17 percent respectively.

The table has also revealed that millet, Guinea corn, groundnut, maize and benniseed were among the crops grown by the corresponding non-agroforestry farmers. Unlike the agroforestry farmers, the principal crop of the non-agroforestry farmers were groundnut and beniseed. The highest percentage of groundnut was recorded in the Sahel savanna zone while the least was recorded in the northern Guinea savanna zone. In the northern Guinea savanna zone, about 28 percent of the farmers reported that they grew benniseed while 20 and 14 percents reported that they grew the crop in Sahel and Sudan savanna zones respectively. It was observed from the table that the non-agroforestry farmers grew groundnut and beniseed principally as cash crop.

Table 23: Principal Crops Grown

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Crops grown	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Millet	28	87.5	13	36.1	08	26.7	49	50.0	14	12.2	20	20.0	08	7.0	42	12.8
Guinea Corn	23	71.9	26	72.2	14	46.7	63	64.3	26	22.6	16	16.0	10	8.0	52	15.8
Ground-nut	20	62.5	23	63.9	18	60.0	61	62.3	28	24.3	24	24.0	17	14.9	69	21.0
Maize	-	-	24	66.7	26	86.7	50	51.0	-	-	08	8.0	45	39.5	53	16.1
Beniseed	13	40.6	11	30.6	05	16.7	29	29.6	23	20.0	14	14.0	25	21.9	62	18.8
Others	06	18.8	03	8.3	02	6.7	11	11.2	24	20.8	18	18.0	09	7.9	51	15.5

4.7.2 Economic Trees Grown

Information presented by the sampled farmers on the economic tree grown by them is summarized on Table 24. The table has revealed that the sampled agroforestry farmers had preference for some tree species than others. The preferred tree species include the following:- *Azadirachta indica* (Neem), *Adansonia digitata* (Kuka), *Parkia biglobosa* (Doruwa), *Tamarindus indica* (Tsamiya), *Acacia senegal* (Bagaruwa) Over one- half of the agroforestry farmers grew both *Azadirachta indica* and *Adansonia digitata* on their farmlands. The highest percentage of farmers growing both *Azadirachta indica* and *Adansonia digitata* was observed in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone. The table has also shown that over three-fifths of the agroforestry farmers grew *Parkia biglobosa*. The highest percentage was recorded in the northern Guinea savanna zone while the least was in the Sahel savanna zone. Over two-fifths of the agroforestry farmers grew *Tamarindus aindica*. The highest percentage of farmers growing this tree species was recorded in the Sudan savanna zone while the least was observed in the northern Guinea savanna zone. *Acacia senegal* ranked fifth among the economic trees grown by the farmers. The overall percentage of the species grown by the farmers is under 36 percent. The highest percentage was recorded in the Sahel savanna zone while the least was recorded in the northern Guinea savanna zone.

Table 24: Economic Trees Grown

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Crops Grown	Freq	%	Freq	%	Freq	%	Freq	%
Parkia beglobosa (Doruwa)	12	37.5	23	63.8	25	83.3	60	61.2
Azadirachta indica (Neem)	24	75.0	22	61.1	12	40.0	58	59.1
Adansania digitata (Kuka	26	81.3	21	58.3	06	20.0	53	54.1
Tamarindus indica (Tsamiya)	15	46.9	19	52.8	09	30.0	43	43.9
Acacia Senegal(Bagaruwa)	18	56.3	12	33.3	05	16.7	35	35.7
Others	04	12.5	03	13.9	05	16.7	12	12.2

4.7.3 Fruit Trees Cultivated

Table 25 presents information on the fruit trees cultivated by the study population. According to the table, over one-half of the agroforestry farmers cultivated *Anacardium occidientale* as their favourite fruit tree. The highest percentage of farmers growing this fruit tree was recorded in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone.

Over two fifths of the agroforestry farmers cultivated both *Mangifer*a *indica* and *Sidium guajava* as their favorite fruit trees. The highest percentage of these fruit trees was observed in the northern Guinea savanna zone while the least was recorded in the Sahel savanna zone. Citrus species ranked fourth among the fruit trees cultivated by the study population. Overall, just fewer than 40 percent of the agroforestry farmers in the study area reported they cultivated citrus species. The northern Guinea savanna zone recorded the highest population of agroforestry farmers cultivating this fruit tree with a proportion of 60 percent. This was followed by Sudan Savanna zone with a little above 36 perce nt.

Table 25: Fruit Trees Cultivated

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Fruit Trees	Freq	%	Freq	%	Freq	%	Freq	%
Anacardium occidentale (Cashew)	21	65.6	18	50.0	11	36.7	50	51.0
Mangifera indica (Mango)	11	34.4	15	41.7	21	70.0	47	48.0
Sidium guajava (Guava)	09	28.1	14	38.9	19	63.3	42	42.9
Citrus spp (orange)	07	21.9	13	36.1	18	60.0	38	38.8
Others	03	9.4	02	5.4	04	13.3	09	9.2

4.7.4 Livestock Reared

Information relating to the distribution of livestock reared by the study population is shown on table 26. The table has shown that majority of the agroforestry farmers reared sheep, goats, birds, cattle and donkeys. According to the table over one-third of the agroforestry farmers reared sheep. The highest percentage of agroforestry farmers rearing sheep was recorded in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone. The table has also revealed that over two fifths of the agroforestry farmers kept goats, the highest percentage was observed in the Sudan savanna zone while the least was recorded in the Sahel savanna zone. Also over one half of the agroforestry farmers kept birds while two fifths kept cattle. The Sudan savanna zone recorded the highest percentage of cattle while the northern Guinea savanna zone recorded the least.

The donkey ranked fifth among the animals kept by the study population. The overall percentage of agroforestry farmers keeping donkey was just under 24 percent. The highest percentage was recorded in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone.

The table also reveals that the non-agroforestry farmers kept the same species of livestock as their agroforestry counterparts. Cattle rearing ranked highest among the animals kept. The highest percentage of respondent rearing cattle was recorded in the Sahel savanna zone while the least was in northern Guinea savanna zone. Over one-fifths of the non-agroforestry farmers kept goats.

The highest percentage was recorded in the Sahel savanna zone, followed by the Sudan and the northern Guinea savanna zones in that order. Sheep rearing was reported by about 18 percent of the non agroforestry farmers while rearing of birds and donkey was reported by over 19 and 12 percent respectively.

Table 26: Livestock Reared

	Agro-Forestry Farmers								Non Agro-Forestry Farmers							
Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones		Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Livestock Reared	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sheep	15	46.9	13	36.1	09	30.0	37	37.6	18	15.7	28	28.0	16	14.0	62	18.8
Goat	12	37.5	18	50.0	14	46.7	44	44.9	29	25.2	21	21.0	19	16.7	69	21.0
Bird	12	37.5	22	61.1	19	63.3	53	54.1	15	13.0	09	.0	41	36.0	65	19.8
Cattle	11	34.4	20	55.6	10	33.3	41	41.8	31	27.0	28	28.0	20	17.5	79	24.0
Donkey	09	28.1	08	22.2	06	20.00	23	23.5	22	19.0	10	10.0	10	8.8	42	12.8
Others	08	25.0	06	16.7	04	13.3	18	18.4	-	-	04	.0	08	.0	12	3.6

4.8 RETURNS/BENEFITS DERIVED FROM SALES OF AGROFORESTRY FARM PRODUCTS

Tables 27 –31 summarize information relating to the income derived from sales of agroforestry products in 2004 by the sampled agroforestry farmers.

4.8.1 Proceeds from Sales of Fruits

Information relating to the cash income realized from the sales of fruits from agroforestry farms in 2004 is presented on table 27. All the sampled agroforestry farmers reported that they earned cash income from the sales of fruits harvested from their agroforestry farms. According to table 26, 4 out of every 5 respondents admitted that they realized over ₦5, 000.00 in 2004.

The modal revenue derived from sales of fruits in 2004 was ₦5001.00-₦7500.00. However, the modal revenue varied considerably between the zones from 33 percent through 47 and 53 percent in the Sudan, Sahel and northern Guinea savanna zones respectively. The table also revealed that 3 percent of the farmers realised below ₦2500.00 while 17 percent realised between ₦2501.00 and ₦5000.00 in 2004 from sales of fruits.

Table 27: Sales of Fruits from Agroforestry Farms

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Proceeds (N)	Freq	%	Freq	%	Freq	%	Freq	%
Under 2500.00	01	3.3	02	5.6	-	-	03	3.06
2501 – 5000.00	05	15.6	09	15.0	03	10.0	17	17.3
5001 – 7500.00	15	46.9	12	33.3	16	53.3	43	43.9
7501 – 10,000.00	07	21.9	10	27.8	06	2.0	23	23.5
Above 10,000.00	04	12.5	03	8.3	05	16.7	12	12.2
TOTAL	32	100	36	100	30	100	98	100

4 8.2 Proceeds from Sales of Fuelwood

Forest products are major source of revenue to the forest communities. The fuelwood is a major source of energy obtained from the forest. It accounts for the highest percentage of energy supply to the forest communities. Table 28 presents information relating to the cash income realised from the sales of fuelwood in 2004 by the sampled agroforestry farmers. According to the table, the modal revenue derived from the sales of fuelwood in 2004 was between ₦5001.00- ₦7, 500.00. However, the modal revenue varied considerably between the zones from 10 percent, through 22 and 28 percent in the northern Guinea savanna zone, Sudan savanna zone and Sahel savanna zone respectively. The table has also shown that one-quarter of the agroforestry farmers realised over ₦10, 000.00 in 2004 from sales of fuelwood.

Table 28 Sales of Fuelwood from Agroforestry Farms

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Proceeds (N)	Freq	%	Freq	%	Freq	%	Freq	%
Under 2500.00	-	-	01	2.8	03	10.0	04	4.1
2501 – 5000.00	07	21.9	06	16.7	04	13.3	17	17.3
5001 – 7500.00	09	28.1	08	22.2	03	10.0	20	20.4
7501 – 10,000.00	06	18.8	13	36.1	14	46.7	33	33.7
Above 10,000.00	10	31.2	08	22.2	06	20.0	24	24.5
Total	32	100	36	100	30	100	98	100

4.8.3 Proceeds from Sales of Poles.

Poles are valued for several uses, namely: for fencing, roofing and for power transmission purposes. Information relating to the sales of poles by the agroforestry farmers is summarized on table 29. The table has shown that all the sampled agroforestry farmers sold poles from their agroforestry farms. One third of the agroforestry farmers realized between ₦7, 501.00 and ₦10, 000.00 in 2004 from the sales of poles. However the proportion of the population who received this amount varied considerably from zone to zone with the highest in the Sudan savanna zone and the lowest in Sahel savanna zone. Over one-fifth of the farmers realized between ₦2501.00 and ₦5000.00 from the sales of poles in 2004. However, less than 10 percent of the agroforestry farmers realized over ₦10, 000.00 in 2004 from the sales of poles while less than 10 percent realized less than ₦5, 000.00.

Table 29 Sales of Poles from Agroforestry Farms

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Proceeds (N)	Freq	%	Freq	%	Freq	%	Freq	%
Under 2500.00	04	12.5	02	5.5	01	3.3	07	7.1
2501.00 – 5000.00	13	40.6	08	22.2	06	20.0	27	27.6
5001.00 – 7500.00	08	25.0	10	27.8	08	26.7	26	26.5
7501.00 – 10,000.00	05	15.6	14	40.0	11	36.7	30	30.6
Above 10,000.00	02	6.3	02	5.5	04	13.3	08	8.2
Total	32	100	36	100	30	100	98	100

4.8.4 Proceeds from Sales of Tree Seedlings

Table 30 presents a summary of the information provided by the sampled agroforestry farmers on raising and sales of tree seedlings in 2004. According to the table, all the sampled agroforestry farmers raised and sold tree seedlings in 2004. The table has also shown that agroforestry farmers generated income through the sales of tree seedlings. Very few farmers in each zone gained financially from the sales of tree seedlings. Over one-third of the farmers realized between ₦7, 500.00 and ₦10, 000.00. The proportion that realized this amount varied considerably from zone to zone. The highest percentage was recorded in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone. Over one quarter of the agroforestry farmers realized between ₦5001.00 and ₦7500.00 while one sixth realized between ₦2501.00 and 5,000.00 in 2004. Over 17 percent of the agroforestry farmers realized over ₦10, 000.00. The highest percentage was recorded in the northern Guinea savanna zone while the least was observed in the Sahel savanna zone.

Table 30: Sales of Tree Seedlings from Agroforestry Nurseries.

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Proceeds (N)	Freq	%	Freq	%	Freq	%	Freq	%
Under 2500.00	-	-	01	2.8	-	-	01	1.1
2501.00 – 5000.00	05	15.6	08	22.2	02	6.7	15	15.3
5001 – 7500.00	09	28.1	10	27.8	07	23.3	26	26.5
7501 – 10,000.00	17	53.1	13	36.1	09	30.0	39	39.8
Above 10,000.00	01	3.1	04	11.1	12	40.0	17	17.3
Total	32	100	36	100	30	100	98	100

4.9 BENEFITS OF AGROFORESTRY FARMING

4.9.1 Introduction

Existing literature has shown that agroforestry enables the farmers to broaden their sources of income, provide foods of different categories and reduce the devastation of the environment (Swaminathan, 1988). The benefits derived from agroforestry farming include the following:- Provision of

- Fuelwood (for domestic and industrial uses)
- Fodder (for livestock)
- Different types of poles
- Medicinal herbs and
- Assorted fruits.

Trees grown by the agroforestry farmers include:

- *Azadirachta indica* (Neem)
- *Cassia siamea* (Egbu)
- *Eucalyptus spp* (Eucalyptus)
- *Tamarindus indica* (Tsamiya)
- *Acacia senegalensis* (Bagarua)
- *Parkia Biglobosa* (Dorowa)
- *Adansonia digitata* (Kuka)

While fruit trees include:-

- *Mangifera indica* (Mango)
- *Anacardium occidentale* (Cashew) and

- *Citrus spp* (Orange).

4.9.2 Benefit Derived from Agroforestry Farming

Information relating to benefits derived by the agroforestry farmers from their farm is presented on table 31. The table has shown that over three quarters of the agroforestry farmers benefited from the collection of fuelwood from their farms. The highest percentage of farmers was recorded in the Sahel savanna zone while the least was observed in the northern Guinea savanna zone. The provision of fodder ranked next to the collection of fuelwood. Over three-fifths of the farmers benefited from the harvesting of fodder from their agroforestry farms. Cutting of poles from the agroforestry farms ranked third amongst the benefits derived by the agroforestry farmers. Over one-third of the farmers benefited from different types of poles collected from their farms. The highest percentage of farmers who benefited from sales of poles was recorded in the Sudan savanna zone while the least was recorded in the northern Guinea savanna zone. Collecting of herbs by farmers ranked next to cutting of poles. One third of the farmers collected medicinal plants from their agroforestry farms while over one quarter collected fruits.

Table 31: Benefits of Agroforestry Farming

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Benefits	Freq	%	Freq	%	Freq	%	Freq	%
Fuel wood	29	90.6	24	66.7	21	70.0	74	75.5
Fodder	24	75.0	21	61.1	18	60.0	63	64.3
Poles	10	31.3	15	41.7	09	30.0	34	34.7
Medicinal herbs	06	18.6	10	27.8	15	50.0	31	31.6
Fruits	09	28.1	10	27.8	07	23.3	26	26.5

4.10 Constraints to Adoption of Agroforestry Practices.

Table 32 presents information on the constraints to adoption of agroforestry practices reported by respondents. The table has shown the various constraints that militate against the respondents' adoption of agroforestry practices. According to the table, majority of the farmers reported that scanty rainfall and lack of incentive from the Government were the major constraint affecting the adoptions of agroforestry farming in the study area. Other constraints include lack of adequate supply of the seedlings, inadequate supply of protective baskets and shortage of extension workers. However these constraints were severe in the Sahel and Sudan savanna zone than in the northern Guinea savanna zone.

Table 32: Constraints to Adoption of Agroforestry Practices.

Variables	Sahel Savanna		Sudan Savanna		Northern Guinea Savanna		All Zones	
Constraints	Freq	%	Freq	%	Freq	%	Freq	%
Lack of adequate seedlings	27	84.4	23	63.9	16	53.3	66	67.3
Lack of protective basket	30	93.7	25	69.4	05	16.7	60	61.2
Inadequate transportation	-	-	03	8.3	01	3.3	04	4.1
Lack of land	05	15.6	03	8.3	07	23.0	15	15.3
Lack of incentive	29	90.6	27	75.0	26	86.7.	82	83.7
Termite attack	24	75.0	18	50	02	6.6	44	44.9
Scanty rainfall	31	96.9	28	77.8	23	76.7	82	83.7
Inadequate extension services	12	37.5	16	44.4	21	70.0	49	50.0
Shortage of labour	06	18.8	08	22.2	11	36.7	25	25.5
None of the above	-	-	-	-	01	3.3	01	1.0

PLATE 10: PROTECTIONS OF YOUNG TREES BY DELDRIN TREATED

4.11 FACTORS INFLUENCING AGROFORESTRY PRACTICES IN THE STUDY AREA

The chi – square (χ^2) result for each of the parameters investigated that influences agroforestry practices in the study area is presented on table 33. The result has shown that Gender, Age Marital status farming experience of agroforestry farmers, area of land under agroforestry, Land tenure pattern and benefit of agroforestry farming had no influence on agroforestry practices amongst the three ecological zones in the study area.

Table 33: FACTORS INFLUENCING AGROFORESTRY PRACTICES

Agroforestry Variables	Probability level	Remarks
Gender	0.29	Not significant
Age	0.99	Not significant
Marital status	0.90	Not significant
Farming experience	0.15	Not significant
Area of land Under Agroforestry	0.98	Not significant
Land tenure pattern	0.06	Not significant
Benefit of Agroforestry	0.44	Not significant

CHAPTER FIVE

DISCUSION

5.1 PARTICIPATORY ORGANISATIONS

Three bodies were mobilized in the reforestation of the study area. These bodies included; Katsina Agricultural and Rural Development Authority (KTARDA), European Economic Community/Katsina State Government (EEC/KTSG), Katsina Afforestation Project Unit/World Bank (KATAPU/WORLD BANK). The organizations used agroforestry and afforestation practices in the reforestation of the degraded sites. The agroforestry practices undertaken by these organizations included establishments of shelterbelt, windbreak and woodlot; others were trees on farmland, homegarden and street planting. These organizations reforested a total of 11, 0832 ha.of land through agroforestry and afforestation.

The ultimate aim of these bodies was to improve the living conditions of the people in the affected area through the provision of certain basic requirements such as fuelwood and poles. The provision of these requirements to the people was designed to reduce the pressure on the remaining natural vegetation and thereby reversing the trend of the environmental degradation affecting the area. Also these organizations aimed at halting the on going desertification in the Arid Zone of Katsina State, at the same time agriculture would be safeguarded and soil condition improved in the endangered areas.

5.2 EXTENT OF AGROFORESTRY FARMING

The principal occupation of the respondents in the study area was farming. However a substantial proportion of the sampled population engaged in other activities such as trading, civil administration and artisanship.

5.2.1 Area of Land under Agroforestry Farming

The extent of agroforestry farming in the study area was determined as a function of two variables, namely the number of sampled respondents who practised agroforestry and the area of land under agroforestry. The size of the farmland is an important determinant of the farming system that is employed by the farmers. According to Dixon (1995) agricultural land availability has been identified as an important factor determining the implementation of any policy aimed at promoting land use changes.

Oloyide (1980) categorized small-scale farms in Nigeria as ranging from 0.2 to 5.9 hectares while medium size farms range from 6.0 to 9.9 hectares holding. The third category which he referred to as large-scale farms are 10 hectares and above. Based on the foregoing categorization, it could be readily claimed that in this study, that nearly 80 percent of the holdings were small scale farms while just over 10 percent and under 10 percent were medium scale and large scale farms respectively (table 9).

5.2.2 Farmers in Agroforestry

The study has revealed that of the 427 sampled, just 98 (under one quarter) practised agroforestry. The agroforestry farmers held a total of 609 hectares of land among them. This represented a mean farm size of 6.2 hectare. Under Oloyide's, (1980) classification the agroforestry farms in Katsina State was medium size.

5.2.3 Land Mode System

The study had revealed that the land under agroforestry was held under varying tenure system. The agroforestry farms were predominantly rented. Over three quarters of the agroforestry farmers rented their farmlands, while one third purchased theirs and one fifth inherited theirs. The inherited farmlands were in fragments which resulted in a farmer's holding consisting of three or more plots scattered in different locations (table 10). According to Arnon, (1981) such fragmented lands are difficult to work economically and may defeat the purpose of land reforms.

5.3 CROP/TREE SPECIES GROWN/LIVESTOCK REARED

5.3.1 Principal Crops/Trees Grown

In Katsina State the sampled agroforestry farmers grew several food crops principally for home consumption but sometimes for cash. Fruit tree growing was found to be an integral part of agroforestry. The fruit trees grown were largely the

improved and early maturing species that start fruiting after one or two years. While the farmers wait for the tree crops to mature, depending on the management objectives (for fuelwood, poles, fodder etc) they fall back on the fruit trees for supply of food and cash income. Majority of the sampled agroforestry farmers in all the ecological zones showed greater preference for cashew and mango trees than for guava and citrus trees (table 15).

5.3.2 Economic Trees Grown

The tree species commonly grown on agroforestry farms included Azadirachta indica (Neem) Adansonia digitata (Kuka). *Parkia*, *biglobosa* (Doruwa), *Tamarindus indica* (Tsamiya) *Acacia senengalensis* (bagaruwa). The dominance of each of the species varied significantly between zones. For example, in the Sahel savanna zone, over 80 percent of the respondents grew *Azadirachta indica* (Neem) This might be due to its ability to resist drought and termite attack, thereby making it to be very effective in checking desert encroachment. However in the northern Guinea savanna zone over 80 percent grew *parkia biglobosa* (Doruwa), this might be traced to the nutritinonal value of the seeds when processed for food. Other tree crops grown by the respondents were for medicine, fodder, shade, poles, soil enrichment, fuelwood, and cash income.

5.3.3 Livestock Reared

One other significant economic activity of the agroforestry farmers in Katsina State was the rearing of animals. The major animals reared by the study population included birds, goats, cattle, sheep and donkey (table 16). This may be due to the abundant availability of grass and shrubs found in the three zones. Cattle are used for transportation. In addition the cattle are used for ploughing and cultivation while the female cattle provide milk and beef. Livestock rearing could be a reflection of their risk aversion by the farmers to provide food in the event of crop failure due to vagaries of weather.

5.4 GOVERNMENT ANNUAL TREE PLANTING CAMPAIGN

The study revealed that the farmers were aware and had participated in Government annual tree planting campaign; for only an insignificant proportion of the respondents claimed that they were ignorant of the campaign. However, greater percentages of farmers from the Sudan savanna zone were aware of the tree planting campaign (table 11).

5.5 TYPES/VARIANTS OF AGROFORESTRY PRACTISED BY THE SAMPLED FARMERS

Awareness, participation and adoption of agroforestry practices varied from zone to zone. Awareness was greatest in the Sudan savanna zone, the system

most common in all the zones being maintaining multipurpose trees on crop land (trees on farmland), (plate 6).

In addition the practice might have aided productivity and contributed to the farmers' cash income or served as important source of food to the farmers' livestock (Verunmbe, 1994). The system has been supplemented with the establishment of woodlots and windbreaks, in addition to soil conservation/reclamation measure.

However, it should be noted that some systems of agroforestry were not common in some of the zones. These systems include the Alley cropping system which is not practised in the northern Guinea savanna zone. Very few agroforestry farmers in the Sahel and Sudan savanna zones claimed they were aware of the system but had stopped practising it.

5.6 BENEFITS DERIVED FROM AGROFORESTRY FARMING.

In Katsina State, farmers adopted agroforestry because of its social, economic and environmental benefits. The social benefits included provision of fuelwood, multipurpose poles, fodders, fruits and medicinal herbs. Majority of the farmers in the Sudan and Sahel savanna zones harvested considerable fuelwood from their farms for domestic use (table 27). The tree species grown for fuelwood included *Azadirachta indica*, *Acacia senegalensis*, *Parkia biglobosa*, *Tamarindus indica*, *Adansonia digitata*. The analysis have revealed that the two zones that were prone tthreats of desertification more than the northern Guinea savanna

could have adopted the woodlot system to check indiscriminate felling of trees from the natural vegetation which had significantly contributed to deforestation and the corresponding environmental degradation.

The benefits derived from agroforestry farming included the revenue accruing from the sales of agroforestry products, namely poles, fuelwood, fodder, fruits seedlings; medicinal herbs among others. Other benefits derived from the system included provision of employment through the raising of these seedlings, transplanting of seedling, and tending of seedlings. Hicks and Johnson (1994) observed that rural labour supply led to grater adoption of labour intensive rice varieties in Taiwan. Improved soil fertility, prevention of floods and land slides, provision of shade and improvement of aesthetic value were also among the benefits derived from agroforestry farming. Majority of the agroforestry farmers regarded the benefits derived from supply of fuelwood and fodder to be far more substantial than for any other purposes.

5.7 CONSTRAINTS TO ADOPTION OF AGROFORESTRY

The constraints to adoption of agroforestry farming and their solutions are summarized as follows:

Most of the forest trees seedlings and arable crops are attacked by termite immediately after germination. The farmers were supplied with aldrin dust and other chemicals by the Katsina State Forestry Department to combat the termite menace.

The State Forestry Service usually procured substantial quantity of treated protective baskets before the farming season. Protective baskets are meant to protect the seedlings from destruction by livestock, (Plate 10).

The problem encountered in seedlings transportation has been reduced by the farmers through establishing personal nurseries close to their farms.

Farmers were constrained by lack of incentives and inadequate extension agents in the Sudan savanna zone.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY

The study has examined agroforestry practices among International organizations, Nigerian Government, Katsina State Government and farmers in Katsina State. Three bodies were mobilized in the afforestation of Katsina State. These bodies carried out the reforestation of the study area through the application of agroforestry programme and plantation establishment. Agroforestry practices introduced by these bodies included establishment of shelterbelts, windbreaks and woodlots, others were afforestation/plantation establishment, trees on farmland, homegardens, and street planting among others. The study covered three ecological zones namely: Sahel savanna zone, Sudan savanna zone and northern Guinea savanna zone.

The study revealed that majority of the sampled respondents were not practising agroforestry. Only 23 percent were agroforestry farmers. The popular agroforestry practices practised, by the farmers were maintaining multipurpose tree on crop land (trees on farmland), establishment of woodlots, shelterbelts and windbreaks. The study also showed that three quarter of the agroforestry farmers belonged to the 30 - 49 age cohort. These age class were active in farming. On the other hand, that of the non agroforestry farmers showed greater variations. Majority of the non agroforestry farmers were 50 years and above. Unlike the non

agroforestry farmers majority of the agroforestry farmers were married. All the agroforestry farmers had one form of education or the other. Majority of the non-agroforestry farmers had Koranic education.

Greater percentage of the agroforestry farmers rented their farmlands while very few owned theirs by inheritance. Principal crops grown by the agroforestry farmers included millet, Guinea corn, groundnut and maize. The non agroforestry farmers preferred beniseed and groundnut.

The sampled agroforestry farmers had preference for some tree species to others. The preferred tree species include: *Azadirachta indica*, *Adansonia digitata*, *Parkia biglobosa*, *Tamarinda indica* and *Acacia senegal*.

Finally, the study reported that the major constraints militating against the respondents' adoptions of agroforestry practices included scanty rainfall and lack of incentives from the Government. Others were inadequate supply of seedlings and shortage of extension workers.

6.2 CONCLUSION

The following conclusions could be drawn from the findings of this research work.

1) Very few farmers in the study area practised agroforestry while majority are non agroforesty farmer.
2) The agroforestry farmers had a total of 609 hectares of land under agroforestry, representing a mean of 6.2 hectares per farmer.

3) Agroforestry practices were initially developed by several international bodies, Government and non-governmental organizations to check desertification menace which has severally affected the economic and social activities of the study population.

These organizations included:

i) The Katsina Agricultural and Rural Development Authority (KTARDA)

ii) The European Economic Community/Katsina State Government (EEC/KTSG).

iii) The Katsina agroforestation Project Unit/World Bank. (KATAPU/WORLD BANK)

4) Farmers have adopted agricultural practices which fit into their socio-economic conditions.

5) Social, economic and environmental factors, gender and sources of farmland has no influence on the adoption of agroforestry practices.

6) The farmers depended on governmental and institutional assistance and encouragement to adopt agroforestry practices.

7) In spite of uniform method of dissemination of information on agroforestry practices, there existed significant differences in adoption and benefits derived from agroforestry practices among the zones. The differences in adoption could be that an innovation which was appropriate for a given zone might not necessarily be accepted in another zone. It might also be

due to soil type and socio-economic reasons. The difference in benefit may not be unconnected with the choice of tree crop combinations.

8) The agroforestry farmers were relatively younger than the non agroforestry farmers.

9) Agroforestry farmers derived substantial financial benefits from the sales of fuelwood

10) Contact with extension agents was a major factor that determined adoption of agroforestry practices.

6.3 RECOMMENDATION

1) The study has shown that a good number of the residents in the study area were peasant farmers, practising traditional rotational bush fallow system of cultivation, the slash and burn system. It is recommended that the rural dwellers should be motivated to practice intensive agriculture. This can be achieved through the adoption of sustainable farming system such as agroforestry.

2) Agroforestry farming naturally requires large area of land. However, most agroforestry farmers do not have access to such lands. Government should therefore look into the possibilities of facilitating access to farm lands.

3) Participation in agroforestry farming is still relatively low in the study area. Effort should be made to encourage more farmers to adopt agroforestry farming by creating government guaranteed credit schemes and bank loans

for such activities. Already awareness has been created since they know that cash income is derivable from the practice, they would be willing to be involved.

4) Farmers' awareness in agroforestry technologies ought to be improved through mass media programmes. These technologies are not as popular as one would expect. Some of the farmers interviewed needed to be educated about agroforestry programmes.

5) Women constitute a very large work force, yet they hardly participate in most agroforestry practices in the study area. This situation ought to be changed as their participation could expand the scope of agroforestry farming and by implication reduce the effect of desertification.

6) More windbreaks and shelterbelts should be established by government, non-governmental organizations, groups and individuals. At the moment windbreak/shelterbelt development is mainly a government activity. There are a few NGOs now taking interest in such plantings. For a strategy, which is so central to the revitalization of the semi-arid zone environment; especially the degraded lands, it ought to be the concern of all rather than that of government alone. This is why government must intensify efforts to get farmers, communities, local government and individuals involved in its planning and planting. Credits could be made available to groups or farming communities and other bodies who show genuine interest in such plantings.

7) Government should motivate agricultural production with more emphasis on agroforestry practices since agroforestry farming combines the production of food, fiber, livestock and protection of the environment. Thus economic and social assistance should be provided to farmers to enhance adoption of agroforestry practices.

8) The development of co-operatives among agroforestry farmers ought to be encouraged and Government may use such co-operatives as the base for the acquisition of soft loans by the farmers. Such co-operatives would keep its members up-to-date on modern techniques on agroforestry practices as well as ensure their continued participation in agroforestry programmes.

9) Investigations have revealed that adoption of agroforestry practices was constrained by lack of farm inputs such as tree seedlings, transportation and insecticides. The government and concerned donor agencies should provide these promptly to farmers as incentives to increase their adoption of agroforestry practices.

6.4 AREA FOR FURTHER RESEARCH

This study has revealed several areas where more research is needed to be carried out. These include:

i) Identifying of tree species that are capable of fixing more nutrients to the soil as some tree species are more capable of fixing nitrogen to the soil than others.

ii) Improvement of some existing agroforestry practices especially those that most of the farmers are not adopting or have adopted but intend to discontinue.

iii) How farmers' participation in agroforestry can be enhanced.

iv) Financing and funding of agroforestry projects in the study area.

v) Analysis of factors constraining the adoption of agroforestry practices and how to minimize or eliminate these factors.

6.5 CONTRIBUTIONS TO KNOWLEDGE

The study has established the following facts. Thus it has been able to determine the extent to which agroforestry is practised in the study area in terms of the number of farmers who practised agroforestry as well as the area of land under agroforestry. It has also established the fact that agroforestry could be successfully employed to solve the problem of deforestation and thereby minimize land degradation.

The study has also established the activities of some international bodies in the afforestation of Katsina State. The study has also established the fact that only very few farmers (23 percent) practised agroforestry in the study area.

REFERENCES

Adekoya, A. E. (1994). An analysis of agroforestry activities in Iseyin L. G. A. of Oyo State, Nigeria an *M.Sc*. *Thesis*. Department of Agricultural Extension Services. University of Ibadan, Ibadan, Nigeria.

Adekoya, A. E. (1997). An analysis of farmers' participation in Agroforestry in Oyo State, Nigeria. A *Ph.D Thesis*. Department of Agricultural Extension Services. University of Ibadan, Ibadan, Nigeria.

Adeola A.O., (2001). Farmer perception of social forestry impact in the semi arid zone of Nigeria. *Unpublished Ph.D thesis*. Department of Forest resources management, University of Ibaban. 275pp.

Adeyoju, S. K. (1975). *Forestry and the Nigerian Economy.* University Press Ibadan. 308 pp. *Columbia*

AFNETAN (1990). Alley Farming Network for Tropical Africa. *(AFNETAN)* 2(3):7

Agromissa (1989). Technical Centers for Agriculture and Small Corporations. *Agromissa*, CTA

Ananthakrishnan, T.N. (1994). "A Report on the Seminar on Biological Control of Social Forestry and Plantation Crop Insects*" Current science.* 67 (2):69.

Anderson*,* A.B*.* (ed) (1990)*. "Alternatives to deforestation": steps toward sustainable use of the Amazon Rain Forest* New York*;* Columbia University Press*,* New York*.* 281pp*.*

Anderson, D. and Fishwick, R. (1988). *Fuel wood consumption and deforestation in African countries*: Washington D.C. the World bank.

Anonymous (1988). *Alley-cropping in West Africa*. 18, 10-11.

Annis, S. (1992). Poverty and National Resources. *Public Policy Central America:* New Brunswick, New Jersey, Transaction Publishers for the Oversees Development Council. 101 pp.

Arnon, I. (1981). *Modernization of Agriculture in Developing Countries*. A Whiley Inter-science Publication, England. 565 pp.

Babsal, A. K. (1998). *Katsina State Environmental Action Plan* (KATSEPA). Federal Republic of Nigeria.

Backes, M. M. (1999). Floristic and Bioculture Landscape Diversity in Autochethonous Agroforestry Systems: A case study from Western Kenya, *Applied Geography and Development.* Vol.54, 11.7 -45

Bambride, D. A. (1997). Agroforestry for the Southwest*. USFS General Technical Report Rocky Mountain Forest Range Experimental Station*, Fort Collins Colorado.

Bandolin,T.H and Fisher R.F.(1991). Agroforestry System in North America Agroforestry System vol. 16:95-118

Barnett, V.; Payne, R. and Steiner, R. (eds) (1995). *Agricultural Sustainability,Economic, Environmental and Statistical Considerations*. John Willy and Sons Limited, Chichester, England. 3 - 13 pp

Baumer, M. (1990). Agroforestry and Desertification, *CTA, The* Netherlands 146-152.

Beets, W. C. (1985)."Agroforestry in the African Farming Systems". *United States Agency for International Development,* Washington, D. C. 9-12

Beets, W. C. (1990). Railing and Sustaining Productivity of Small Holder Farming System in the Tropics Agbe Publishing Holland.

Bene, J. G., Beall, H. W. and Cote, A. (1977). *Trees*, *Food and People*. Ottawa. Canada. IDRC: 89pp.

Berkowitz, P. (1994). *The First Ten Years. of CTA,* CTA *The Netherlands,* 40-75.

Blanford, H. R. (1958). "Highlights of one hundred years of forestry in Burma". *Empire Forestry Review.* 37 (i) 33-42.

Broad, R. (1993). "Plundering paradise"*: The struggle for the Environment in the Philippines:* Berkley*:* University of California Press. 144 p

Brudtland, G. T. (1987). *United Nation Report of the World Commission on Environment and Development*, Oxford University Press. 308pp.

Carruthers, P. (1990). "The Prospects for Agroforestry"*:* An E. C. Perspective*. Outlook on Agriculture.* 147-153

Champhaka, U. (1986). "Watershed Management and Shifting Cultivation. The Asian Approach". *Commonwealth Forestry Review.* 38 (15): 22- 27.

Charley, J. L. and West, N. E. (1977). Micropattern of Nitrogen Mineralization Activity in soils of some shrub – dominated ecosystems of Utah. *Soil Biochemistry Journal*. 9:357-365.

Cheru, F. (1992). "Sustainable Development in Africa*". World Development* 20 (4): 497 – 512

Conklin, H. C. (1957). Hanunoo Agriculture*. F. A. O. Italy*.

Costanza, R., (1991). Ecological Economics: The Science and Management of Sustainability. *Columbia University Press.* New York. 331-345

Conway, G. R. and Barbier, E. B. (1990). After the Green Revolution: Sustainable Agriculture for Development. London Earthsean Publications Limited, 15-59

Danell, K. (1986). "Nitrogen in Shoot lither, root lither, Exudates from Nitrogen-fixing*.* Alnus Incana"*. Plant and soil.* 91: 43-49

Delwaulle, T. C. (1976). "Climate and Soil of the Arid and Semi-arid Savanna of West Africa".*Symposium Paper on afforestation in Africa.* Kaduna, Nigeria. FAO, Rome.

Dixon, R. K. (1995). Agroforestry systems: Sources of sink of green house gases*. Agroforestry systems.* 31(2): 99-116.

Dobhal, R. (1994). "Forestry for food challenges for 2000 AD and Beyond." *Current Science.* 67,271.

Dove, M. R. (1992). "Foresters' beliefs about farmers"*.* A priority for Social science research in social forestry*. Agroforestry systems* 17: 13-41.

Duprax, C. (1994). "Prospects for easing land tenure conflicts with Agroforestry in Mediterranean France"*.* A research approach for inter cropped timbers orchards. *Agroforestry systems*. 25 (3): 181.

Effolliot, P.F. and Thames, J. L. (1983). Environmentally Sound small Scale Forestry Project. Guidelines for Planning New York. Vita Publications, Arlington. Pp 40-42.

Ehrenreich, J. H., Ehrenreich, D. L, and Lee, H. W. (eds) (1996). "Growing a Sustainable feature":*Proceedings of the fourth North America Agroforestry Conference*. University of Idaho, Boise. 21- 28.

Ekong, E.E. (1988). *An Introduction to Rural Sociology*. Ibadan, Ile ife, Lagos: Jumah Publisher limited, 439 pp

Enabor, E. E., Okoye, J. A. and Verimumbe, I. (1981). "Taungya System": Socio-economic prospects and limitation*": In: Macdonal (eds), Proceedings of Workshop on agroforestry in the African Humid Tropic*. Ibadan.

F.A.O (Food & Agricultural Organisation) (1985)." Tropical Forestry". *Action Plan*. FAO .Rome, Italy.119 pp.

FAO (Food and Agricultural Organisation) (1987) Tree growing by Rural people, Forestry Paper No. 64, FAO Rome, Italy. 10-13

F.A.O. (Food and Agricultural Organisation) (1997). "Improving Agricultural Extension"*: A reference manual*. Rome Italy.1-9.

FAO/UNEP, (1984). Map of desertification hazards of Africa: *A Reference Manual.* 2nd edition. Rome, Italy.

FDMP (Federal Ministry of Mines & Power) (1974). Geological map of Nigeria: In Katsina State Environmental Action Plan. (Final Report, 1998). Babsal and Company. Pp 26-31.

Foley, G. and Bernard G. (1984). Farm and Community Forestry*.* Easthscan Productions, London. Pp 61-68.

FORMECU (1989). Strategies for development of Social Forestry in Nigeria. Hedimo Press. Ibadan. 135 pp.

FORMECU (1995). *Annual report* 1995. Federal Department of Forestry, Abuja Nigeria. 120 pp

Forde, D.C. (1937). "Land and Labour in a Cross River Village"*. Geographical Journal.* XC (1)23-29

George, K. P. (1990). Do we have moral obligation to Practice a Sustainable Agriculture? *Journal of Sustainable Agriculture*. 1 (1): 81-96

Gold, M.A. and Hanover, J. (1987). "Agrofor4estry for the Temperate Zone". *Elsevier*, New York.

Goodland, R. J. A., Watson, C. and Ledee, G. (1984). Environmental Management in Tropical Agriculture*.* Boulder Company, West View press. Netherlands

Gordon, A.M., Newman, S.M. and Williams, R.A.(1997). Temperate Agroforestry: An overview, in Gordon, A.M. and Newman S.M. (eds) *Temperate Agroforestry System*, C.A.B. International, 1-8.

Gregersen, H.M. and Lundgreen, A. L., (1989). "Linking Monitoring and Assessment to Sustainable Development". *Workshop paper. Forestry for sustainable development programme*, St Paul, Minnesota, University of Minnesota, College of Natural Resources.

Grewal, (1994). Comparism of two Agroforestry Systems for Soil Water and Nutrient Conservation on Degraded land. *Soil Technology*. 3 :145- 153.

Hailey, L. (1957). An African Survey. Oxford University Press, UK. 10-14.

Hanson, J. C., Kanffman, C. S. and Schaver, A. (1995). Attitudes and Practices of sustainable farmers with Application to designing a Sustainable Agricultural Extension programme". *Journal of Sustainable Agriculture.* 6 (2 &3):147

Harch, E. (1995). "Safeguarding African's Environment by the Grassroots". *African farmers.* 15:2-5.

Herdt, R.W. and Steiner, R.A. (1995). Agricultural Sustainability concepts and Commdrums. Rockefeller Foundations, New York. 29pp.

Hicks, W.H and Johnson, R. (1974). Population growth and the adoption of new Technology in Taiwanese agriculture. *Working Paper in Economics*. No 1974 – EW6. Columbia: Columbia University of Missouri.

Hochberg, M. E., Menat, J. C. and Gignoux, C. (1994). "The Influence of Tree Biology and Fire in Spatial Structure of the West African Savanna." *Journal of Ecology*, 82 (2).

Huxley, P. A. (1983). "Comments on Agroforestry, classification with Special reference to plant Aspects." In: P*lant Research and Agroforestry. ICRAF*. Nairobi, Kenya. 161-172.

Idachaba, F. S. (1992). "The technological transformation of Africa Agriculture: Is there hope"? *Invited 1992 annual guest lecture delivered at the 22 Annual Research Conference of the International center of insect physiology and Biology.* Nairobi, Kenya. 95pp.

Igugu, G. O. and Osemebo, G. J. (1995). "The Impact of forestry in improving small holder land use for agricultural production in Nigeria". Oduwaye (eds). *Proceeding of 24 conference of Forestry Association of Nigeria.*

Forestry and the small scale Farmer Kaduna, Kaduna State, 30 October – 4 November, 1995. Pp135-137.

International Centre for Research in Agroforestry (1997) ICRAF and Agroforestry: A vision and a plan of action. 1 P.

Ipinjolu, J.K., Okoro, S.P.A. and Abdulkadir, A. (1988). "A Survey of non-Wood Forest Products and Their Utilization. A Case Study of Sokoto Central Market". *Proceedings of the 18th Conference of Forestry Association of Nigeria FAN*. Makurdi. Pp116-120.

Jacobson, J. L. (1992). "Gender bias. Road block to Sustainable Development". *World Watch paper* 110, 27-48.

Javis, P. G. (eds) (1991). Agroforestry Principles and Practice. *Elsevier Amsterdam*. The Netherlands. 125-182

Johnston, B. F. and Clerk, W. C. (1982). Redesigning rural Development: A strategic prospective. The Baltimore, M.D. Johns Hopkins University Press. 271 pp

Kangas, P. and Rivera, W. M. (1991). *Militating Tropical Deforestation*. The Role of Extension in Agricultural Extension Worldwide. 164 pp

Kang, B. T. Atto-Krah, A. N. and Renoids, L. (1999). Alley Farming. Macmillian education Ltd.

Kehkhof, P. (1990). Agroforestry in Africa. In*: Foley G. and Bernard G. (eds) A survey of project experience.* Panos Institute. 253 pp.

King, K. F. S. (1987). The History of Agroforestry: In: Steppler, H A. and Nair, P.K. R. (eds) A Decade of Development. *Agroforestry*, *ICRAF* Nairobi, Kenya. 1-11.

Koudokpon, V., Cersterg, M., Adegbola, P. and Budelman, B. (1992). "The Adoption of Hedge Intercropping by Farmers on the Adja Plateau, South Benin Republic*". In alley Farming Research and Development.* ICRF Nairobi, Kenya. 6:3

Laarman, J.G. and Sedjo, R. A. (1992). *Global Forest: Issues for six Billion people*. McGraw Hill, New York, U.S.A.128-153

Lal, R. and Cummings, S. D. J. (1979). Clearing a tropical forest, effects on soil and microclimate. *Field crops research.* 2 (2) : 99-107.

Leakay, R.R. B. (1994) Cinderalla Tree Species, Clock Strikes Eleven, *Agroforestry Today*. 6 (2) 3 – 5.

Lowe, R. G. (1986). Agricultural Revolution in Africa. Macmillan publishers, London. 295 pp.

Lungreen, B. O. (1982). Cited in Editorial: *What is Agroforestry? Agroforestry Systems.* I 7-12.

Lungreen, B. O. and Raintree, J. B. (1982). Sustained agorforestry. In: Nestel (Eds). *AgriculturalResearch for Development Potentials and Challenges in Asia.* 37-49.

Lungreen, B. O. (1987). ICRAF'S First Ten Years*. Agroforestry Systems.* 5: 197-217.

McNamara, R. S. (1977).; "One hundred countries, Two Billion People", Praeges, New York Nair, P. K. R. (1979). *Intensive multiple cropping with coconuts in India.* Verlag Paul Faley, *Berlin,* Germany.204 pp

Nair, P. K. R. (1983). Agroforestry with coconuts and other tropical plantation crop. In*: Huxley, P. A. (eds), plant research and Agroforestry.* Nairobi, Kenya. 79-102.

Nair, P. K. R. (1984). *Fruit trees in Agroforestry, Working paper. Environmental and policyinstitute* Nairobi Kenya: East-West Centre, Honolulu, Hawaii USA.164-182

Nair, P. K. R. (1991). State of the art of Agroforestry systems In: Jarvis, P. G. (ed). Agroforestry principles and practices*.* Elsevier Science publishing company, 5-10. Netherlands.

Nair, P. K. R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers. Netherlands. 499 pp

National Population Census (2006). http://le.n.wi.kspedia.org/w.k1/list of Nigerian States by Population

Ngambeki, D.S. (1985). Economic evaluation of alley cropping, Leucaena with maize – maize and maize cowpea in southern Nigeria*. Agricultural systems.* 17 (4): 243-258.

Ogar, W. N. (1992). "Agroforestry: The key to sustainable Rural Development in Cross River State," Proceedings of the 22nd Annual Conference of the Forestry Association of Nigeria Kano 98 – 105.

Ohu, J. O., Ekwue, E. L. and Folorunso, O. A. (1994). The Effect of Addition of Organic Matter on the Compaction of a Vertisol from Northern Nigeria. *Soil Technology.* 4 :133-162.

Ojo, G.O.A. (1966) Yoruba Culture. University of Ife and London Press London, UK.179 pp

Okafor, J. C. and Fernandes, E. C. M. (1989). Compound farms of Southern. *Agroforestry Systems.* 5: 143-165

Okali, D.U.U. (1997). Environmental and Resource Development: Towards Sustainable Forestry Development in Nigeria. In Oduwaiye E.A., P.C. Obiaga and J.E. Abu (eds). *Proceedings of 25th Annual conference of FAN: Environmental and Resource Development*. Ibandan, Nigeria. Pp 2 – 4.

Okigbo, B. N. (1983). Plants and agroforestry in land use systems of West Africa. *In:* P. A. Huxley, *Plant Research and Agroforestry*. (eds) ICRAF Nairobi, Kenya. 25-42

Olawoye J. E. (1993). "Gender Analysis in Agriculture". *An invited discussion paper presented at the WARDOC workshop institute of African studies*, Ibadan. University of Ibdan, Ibadan.17th -18th February, 5 pp

Olowo, T. A. Tijani-Eniola, H. and Akenova, M. E. (1994). Introducing alley Farming to farmers in the forest and derived savanna of Southwestern Nigeria. *AFNETAN*. 6 (2): 5 pp

Oloyide, S. O. (1980). Characteristics, problems and significances of farmers. In Oloyinde, S.O., Eweka J. A. and Bello V. E. (eds) *Nigerian Small farmers problem and prospects inintegrated rural development.* 2 – 5.

Onumadu, F. N. (1995). An analysis of peoples' participation in Environmental forestry programmes in Oluyole Local Government Area of Oyo State, Nigeria. *M.Sc. Thesis*, Department of Agric Extension services. University of Ibadan, 110 pp

Onumadu, F. N., Popoola, L., Akinsoratan, A. D. (2001). Forestry Extension. The Missing links. In: Popoola L., Abu, J. E. and Oni, P. I. (eds) *Proceedings of the 27 Annual Conference of FAN, Forestry and National Development* Abuja, September 17-21, 2001, 13 pp.

Onumadu, F.N. (2002) Determinants of adoption of agroforestry practices by small-scale farmers in Katsina state, *Nigeria. A Ph.D Thesis*, Department of Forest Resources Management. University of Ibadan, 117-120.

Ong, C. (1994*).* Alley cropping. Ecological pie in the sky*? Agroforestry.* 6(3): 8-10.

Onyewotu, L. O. Z. (1989). The role of tree plantation in the central of environmental degradation in the semi arid areas of Nigeria. *Paper presented at the international symposium on meteorology, hazards and development* Lagos.

Organisation for Economic Co-operation and Development (OECD) (1991). The State of the Environment. OECD*,* Paris. 295 pp

Otegbeye, G. O. and Ogigirigi, M. A. (1991). Research Needs for Economically Important Indigenous Tree Species in Nigerian Savanna. *Proceedings of the 20th Annual Conference of the Forestry Association of Nigeria*. Katsina State. 37 pp

Otsyina, R.M. (1993). World Agroforestry and Afforestation Risk. Tse Tse Fly Re-invasion? *Agroforestry Today*. *ICRAF*. Nairobi, Kenya. 5 (1): 6-8

Otzen, U. (1992). Land is life. Concept Requirements and Measures to Ensure Sustainable Agricultural Development. Intermediate Technology. Publications. 43-58.

Owusu, D.Y. (1993). *Farm Based Agroforestry: Four Years of Experience in Ghana*. *AgroforestryToday. ICRAF*. Nairobi, Kenya. 5 (1): 8-10

Ponk, J. and Haz. M. (1992). *The Hague Report: Sustainable Development from Concept1 Action*. UNDP. 78pp.

PTPU (1988). Agroforestry manual. Nigerian Second Forestry project (Afforestation Prog.) Plateau State Project Unit (PTPU), Jos. Pp 5 – 20.

Rainteee, J.B., Thomson., and Van-Maydell,H. (1984) Agroforestry in West Africa Sahel, National Academy Press, Washington DC.

Raintree, J.B. (1987). D. and D. Users Manual: An Introduction to Agroforestry Diagnosis and Design *ICRAF,* Nairobi, Kenya. 41pp.

Ragharan M. S. (1960). Genesis and History of the Kurmi system of cultivation. *Proceedings of the 9th silviculture conference.* India forest Research Institute.

Rander, H. S. (1988). Agroforestry in Nigeria. *National Workshop on Agroforestry* Ibadan, Nigeria. August, 1988.

Rajagopalon, C. and Singh, J. (1971) Adoption of agricultural innovations. New Delhi National Publishing House. 19-20.

Richard, E. C. Aron, J.R. Savage, G. F. and Williams M.R.W. (1988). Trees as a Farm Crop*.* BSP Professional Books, Oxford, London. 210pp.

Rocheleau, D. F. (1987). The User Perspective and the Agroforestry Research and Action. Agenda. In: Gholz, H. L. (eds) *Agroforestry – Realities, Possibilities and potential*. Netherlands, 59-88.

Rodale, R. (1998). Agricultural Systems: The Importance of Sustainability*: National Forum*, 68 (3): 2-6.

Roges, E.M. (1983). *Diffusion of Innovations*. Third Edition. Macmillan Publishers Company Inc.453 pp.

Sanchez, P. A. (1995). Science Agroforestry. *Agroforestry systems.* Vol. 30, Nos. 1-2, Nairobi Kenya: ICRAF 30(1 & 2): 5-55.

Scheer, S. J. and Muller, E. U. (1991). Technology Impact Evaluation in Agroforestry Project, Agroforestry Systems, 13, 235 – 257.

Schneider S.J. (1989). "The Green House Effect. *Science and Policy" Science. 243:* 771 – 781.

Schultz, R. C. Colletti, J. P. and Faltonson, R. R. (1995). Agroforestr Opportunities for the United State of America. *Agroforestry Systems*. 31(2): 117-132.

Sckhwela, M. (1990).Agroforestry: Technical Aspects and Benefit Analysis in the Contest of land.

Shannon, D. A. Kabaluapa, K. N. and Ngoyi, M. L. (1990) Alley Cropping stabilizes maize yields in Bandajika Zaire. *AFNETAN* 2 (1) : 8-9.

Sheng, T. C. (1989). "*Soil conservation for small farmers in the humid tropics*". *FAO Soil bulletin*, 60 pp

Singh, R. P. Ong, C.K. and Saharan, N. (1987). Microclimate and growth of sorghum and cowpea in alley cropping in semi arid India. *Agroforestry systems.* 31(2): 259-274.

Smith, J. R. (1999*)* Tree Crops: A Permanent Agriculture*. Island Press,* Washington D.C.

Somarriba, E. (1992). Revisiting the past. *An essay on Agroforestry divination. Agroforestry systems.* 19: 234-235.

Spore, (1995). No. 47 Technical Center for Agriculture and Rural Cooperation (CTA). Pp 5 – 7. The Netherlands.

Stocking, M. A., Bojo, J. and Abel, N. (1989). *Financial* and Economic analysis of agroforestry: key Issues. *Commonwealth Science Council*, London 19-34.

Stroup, R. L. and Badan, J. A. (1983). *National Resources: Bureaucratic, Myths and Environmental Management*. Pacific Institute for public policy Research, San Francisco, California 151 pp.

Swaminathan, M. A. (1988). Sustainable development systems for small farmers. Issues and options. *Paper Presented to the International consultation on Environment*, *Sustainable Development and the Role of Small Farmers*. IFAD, Rome.103-167

Tade, A. and Ademola, S. (1992).The challenge of sustainable development in Nigeria*. NEST /Action Team*. 25-80.

Tarawali, G., Manyong, V. M., Cassky, R. J., Vissoh, P. V., Osei-Bonsu, P. and Galiba, M., (1999). Adoption of improved fallow in West Africa. Lessons from Mucuna and Slylo case studies. *Agroforestry systems*. 47.1-3.

Thrupp, L. A. (1990). "Environmental Initiatives in Costa Rica". A political Ecology perspective". *Society and natural Resources*. 3: 243pp.

Timberlake, L. (1989). Land and Food: The Challenge of sustainable agriculture in the tropics. Wageningen, Netherlands. *CTA.*12 – 13.

Tolba, M.K. (1993). The Earth and Africa Development. *Lecture delivered at the 4th distinguished Africa lecture series.* IITA, Ibadan. , Nigeria.37-51

Torres, F. (1983). "Agroforestry Concepts and practices" In Hoekstra, D. A. and Kuguru, F. M. (eds) Agroforestry Systems for small-scale farmers. *Proceedings of the ICRAF/BAT Workshop held in Nairobi in September 1982.* ICRAC Nairobi Kenya PP 22 – 28.

Udo, R.K.(1978). Geographical Region of Nigeria. Ibadan; London: Heinemann.

Uja, J. E. and Adeoye, K. B. (1984). Effect of Shelterbelts in the Sudan Savanna zone of Nigeria on microclimate and yield of millet. *Agric. and Forest meteorology*. 33, 1984.

Umeh, L. I. (1991). Forest strategies. *Paper delivered at the distinguished seminar series of Forestry Research Institute of Nigeria, Ibadan, Nigeria.* 12-15.

UNEP/IFAD (1998). *An evaluation report on the forestry II forestation project in Northern Nigeria*. DEDC/PAC UNEP, Nairobi Kenya. 60 p.

United Nations Development Programme (UNDP) (1994). Sustainability: Human Development and Agriculture. *UNDP. Guide Book Series*. 57p.

Unruh, J. D., Houghton, R. A. and Befebure, P. A. (1993). Carbon storage in Agroforestry: An estimate for sub-Sahara Africa". *Climate Research* 3:39-52.

Verinumber. !., Agumagu, A.O., Adeola, A.O., Amaza, P.S. and Ola, B.A. (1994). Environmental Impact ssessment (Social forestry and protective Afforestation Component) – North FORMEO World bank, Abuja, 106 pp

Ward, D. M. (1971). History of Nigerian Forestry Department. *Bulletin of the Nigerian Forestry Department* Ibadan 31(1)

Wikipedia, (2007). List of Nigerian States by population. Wikipedia the free encyclopedia "http://en.wikipedia.org/wiki/list of Nigerian State by population.

William A. H., Stanfield, S.D. Whiling, G. C. and Senning, L. (1968). Patterns of diffusing in Rural Brazil. *Report of Phase III Diffusion of innovation in rural society*. Michigan State University research, research report. 10:115

Wiersum, K. F. (1981). "Outline of the Agroforestry Concept" In Wiersum, K.F. (ed) View Points on Agroforestry, Department of Forestry, "Hinkeloord". Agricultural University Wageningon. Netherlands. 1-5.

Wilken, G.C. (1977). Integrating forest and small scale farm systems in Middle America. *Agro ecosystems* 3: 291-302.

World Commission of Environment (WCED) (1987). Our common future. New York. Oxford University Press, 308 pp

World Bank (1989). Issue in poverty and Environment. *Environment Bulletin,* 2: 71-72.

World Bank (1991). Forestry Policy paper, The World Bank, Washington D. C. USA.

Wouters, R. (1994). Silvoaquaculture – Fish ponds, trees and forms. *Agroforestry Today.* 6 (1): 3 – 5.

Young, A (1987). The potential of Agroforestry for Soil Conservation Part III, Soil changes under Agroforestry (SCUAF), A predictive model. (CRAF) *Working paper* No. 44. Nairobi.

Young, A. (1989). The Environmental Basis of Agroforestry, in Reifsnyder, W. S. and Darnhofer, T. O. (eds) *Mateorology and Agroforestry*, ICRAF, Nairobi, Kenya 29-48

Yusuf, M.D. (1995). Memo to the Katsina State Government on deforestation and threat to Human life in Katsina State. *CAREFORE Publications* 6pp

APPENDIX 1

INTRODUCTION

I am a postgraduate student of university of Jos, carrying out an investigation on the assessment of farmer's participation in agroforestry practices in Katsina state, Sudan Sahalian Zone of Nigeria.

This research is purely academic. Kindly give correct answers or options to the questions listed. We will have to visit your farm to examine some of the agroforestry innovations you have adopted. Please cooperate. All information given will be treated confidentially.

Thank you.

Okonkwo, M.C.

Date: ……

Village: ……

L.G.A: ……

Clan: ……

Respondent Number (if any): ……

Name of the interviewer: ……

SECTION A: DEMOGRAPHIC/SOCIO ECONOMIC: (Tick X) where applicable.

1. Gender: male( )female ( )
2. Age of respondent: ……
3. Place of birth: ……
4. State of origin: ……
5. How long have you stayed here: ……
6. Marital status: ……

   Married ( )

   Single ( )

   Separated ( )

   Widowed ( )
7. Number of wives: ……
8. Number of children: ……
9. Number of relatives living with you: ……
10. Educational background of respondent:

Primary ( ) Secondary ( )

Koranic ( ) Tertiary ( )

Vocational ( ) Did not attend any school ( )

11. what language do you speak/hear

English ( )

Hausa ( )

Igbo ( )

Yourba ( )

Others (specify): ……..

12. What is your primary occupation?
13. What are your secondary occupations?
14. If a farmer, how many years have you been in farming?

SECTION B: leadership status

15. Kindly tick "X" against any of the following leadership positions you have occupied or currently occupying.

i) Village head ( )

ii) Member of village council ( )

iii) Contact farmer/opinion leader ( )

iv) Head of farmers club/organization ( )

v) Executive member of farmers Club/Organization ( )

vi) A chief ( )

vii) A clan head ( )

viii) Religious leader ( )

ix) Does not belong to any of the above categories ( )

SECTION C: information of farming:

16. Number and size of farm

Plot No.	Size of the plot	How long has the plot been under cropping	Form of acquisition	Primary crops grown	Other crops grown	Types and No. of fruits trees grown	Types and No. of ordinary economic trees grown	Growth status of trees	Types and No. of livestock kept
1									
2									
3									
4									
5									
6									
7									
TOTAL									

17. What is the type of tenure you have on your farm land?

Plot Number	Inherited land	Rented land	Purchased land	Others (specify)
1				
2				
3				
4				
5				
6				
7				
TOTAL				

18. Which tools do you use for land preparation?

    Manual tools (hoe, cutlass) ( )

    Animal traction ( )

    Tractors ( )

    Heavy equipment ( )

19. Are you aware of the annual tree-planting programme of the government?

    Yes ( ) No ( )

20. If yes, how many trees have you planted under the tree-planting programme of the government

21. What ids the source of your tee seedlings? (Tick √)

    a. from ADP
    b. from private nursery
    c. from government nursery
    d. From state forestry nursery.
    e. Others (specify)

22. What are your reason(s) for planting trees?

23. Indicate the benefit(s) you derive from trees (Tick √)

    a. production of fuel wood
    b. promotes soil fertility
    c. improves productivity
    d. reduced wind effects
    e. serve as fodder for livestock

f. for erosion control

g. for production of poles

h. Others (specify)

24. Indicate your source of information about agroforestry practices.

Source of information	Frequency			
	Very often	Often	Rare	Never
Extension agents				
Village chief/Traditional ruler				
Relative/friends				
Mass media (Radio/TV)				
Co-operative farmers				
Visit to some demonstration farmers				
Non-government organization (NGOs)				
Through mobile cinema				
Posters/Pamphlets				

25. Which of the above information sources do you prefer?

26. Evaluation of the effectiveness of extension agents:(Tick √ or X)

i) Have you ever met with the extension agents?

ii) How many times have you been visited or received advice from the extension agent on tree planting?

iii) Types of information and advice received from the extension agents.

iv) How many times in the last one-year were you visited on farm by extension agent?

v) How many group meetings did you hold with them in the last one year?

vi) On which aspect of recommended agroforestry (AF) practices did you seek extension agents advice to your agroforestry practices?

vii) How useful is the advice to you on agroforestry practices

Of no use ( ) extremely useful ( )

viii) Is the advice very difficult to understand?

Yes ( ) No ( )

ix) To what extent are your extension agents interested in the welfare and problems of small and average farmers?

Very interested ( ), Not interested ( )

x) Do you have contact farmers appointed by your extension agents?

Yes ( ) No ( )

xi) Did you increase yield per unit area on the area where you applied the recommended agroforestry practices?

Yes ( ) No ( )

xii) Rate the usefulness of the agroforestry extension programmes to you.

a. extremely useful ( )

b. quite useful ( )

c. useful ( )

d. not useful ( )

e. the recommended practices are wrong ( )

27. Do you use the services rendered by any of the following agroforestry projects?

i) ADP ( )

ii) KATAPU ( )

iii) AZAP ( )

iv) Katsina state/EEC project ( )

v) Others (specify): …….

Section D: Adoption level of farmers

28. For each of the agroforestry practices below, the investigator should determine the last stage in which the farmer is in the process adoption Mark "X".

29.

	TECHNOLOGY	A		B		C		E	
		Know it	Don't know	Like it	Don't like it	Tried it	Not tried it	Using now	Not using now
1	Improved fallow in shifting cultivation								
2	Taungya								
3	Alley cropping								
4	Multi purposed in trees on crops								
5	Home gardens								
6	Tree in soil conservation/reclamation								
7	Shelterbelts and windbreaks								
8	Fuel wood production								
9	Trees on rangeland or pastures								
10	Plantation crops with pastures and animals								
11	Apiculture with trees								
12	Aqua-forestry								
13	Multi purpose woodlots								

30. How long have you been practicing the following agroforestry system? Indicate the appropriate category for each system by marking X in the right column.

	Agroforestry Practices	Innovator	Early adopters	Intermediate adopters	Late adopters	No n adopters
		Number of years				
		16 and above	11 – 15	6 – 10	1 – 5	Not adopted
1	Improved fallow in shifting cultivation					
2	Traungya					
3	Alley cropping					
4	Multi purpose trees on crop land					
5	Home gardens					
6	Tree in soil conservation/reclamation					
7	Shelterbelts and windbreaks					
8	Fuel wood production					
9	Trees on rangeland or pastures					
10	Plantation crops with pastures and animals					
11	Apiculture with trees					
12	Aqua-forestry					
13	Multi purpose woodlots					

30. Indicate your monthly income level (N) by marking (X)

a. 1000 – 2000 ( )

b. 3000 – 4000 ( )

c. 5000 – 6000 ( )

d. 7000 and choose ( )

31. What is the percentage of income level realizable from agroforestry practices/activities?

a. 1 – 20% ( )

b. 21 – 40% ( )

c. 41 – 60% ( )

d. 61 – 80% ( )

e. 81 – 100% ( )

32. Factor which influence adoption of agroforestry. For each of the statement below, please indicate whether you agree (A), disagree (U) or are undecided (U). mark "X"

	Statement	**A**	**D**	**U**
1	I am not aware of any of the agroforestry practices			
2	The technologies are complex and difficult to understand and apply by farmers			
3	None of the recommended techniques to check land degradation is effective			
4	I believe that my indigenous knowledge is effective to check environmental degradation			
5	Agroforestry practice are not additive to existing practices i.e shifting cultivation			
6	Agroforestry produces good household consumption			
7	Agroforestry provides employment and cash income			
8	Agroforestry improves environmental conditions			
9	Agroforestry provides well-developed rural infrastructures			
10	There is shortage of land to adopt the recommended practices			

11	Under agroforestry practices, the soil can continually be cropped to provide fuel wood for farmers			
12	I don't own the land in which I farm so I cannot adopt agroforestry practices			
13	The government must provide farmers with credit to by input if not they cannot afford to adopt the new techniques			
14	Agroforestry practices are not substantive to shifting cultivation system			
COMMUNICATIONS FACTORS				
15	I have no one to enlighten me about agroforestry even though I have heard about its benefits			
16	I use the recommended techniques because of advice of the extension agents			
17	I am too old to learn about new techniques			
18	Other farmers learn from me about agroforestry practices			
19	I understand the values of adoption of agroforestry			

SECTION E: Constraints to Adoption of Agroforestry Practices

33. Indicate some of the problems encountered in agroforestry activities in your village/clan

a. Lack of adequate seedlings ( )

b. Lack of protective baskets/fencing materials ( )

c. Lack of transportation ( )

d. Lack of land ( )

e. Lack of incentive ( )

f. Termite attack ( )

g. Scanty rainfall ( )

h. Late supply of tree seedlings ( )

i. Shortage of labour ( )

j. Inadequate extension agents ( )

k. Others (specify) …….

CHI-SQUARE TEST

Appendix 2: Gender of Respondents

H_0: There is no significant variation in the respondent participation in agroforestry according to gender and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to gender and ecological zones

Table of observed frequencies

	Sahel Savanna	Sudan Savanna	Guinea Savanna	**Total**
Male	28	33	26	87
Female	12	6	7	25
Total	40	39	33	112

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \quad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
Male	31.07	30.29	25.63
Female	8.93	8.71	7.37
Total	40	39	33

Chi – square = 0.304 + 0.242 + 0.005 + 1.057 + 0.841 + 0.18

= 2.466

DF = 2, P – value = 0.291

Since the table value (p-value) 0.291 is lower than the calculated χ^2 - value (2.466), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones

Chi-Square Test

Appendix 3: Age of respondents

H_0: There is no significant variation in the respondent participation in agroforestry according to age and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to age and ecological zones

Table of observed frequencies

	Shahel Savanna	Sudan Savanna	Guinea Savanna	**Total**
Under 20yrs	6	5	5	16
20 – 29yrs	6	6	7	19
30 – 39yrs	25	26	22	73
40 – 49yrs	9	11	8	28
50 – 59yrs	6	10	6	22
Above 60yrs	6	5	7	18
TOTAL	58	63	55	176

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \quad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \quad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Shahel Savanna	Sudan Savanna	Guinea Savanna
Under 20yrs	5.27	5.73	5.00
20 – 29yrs	6.26	6.80	5.94
30 – 29yrs	24.06	26.13	22.81
40 – 49yrs	9.23	10.02	8.75
50 – 59yrs	7.25	7.87	6.87
Above 60yrs	5.93	6.44	5.63
TOTAL	58.00	62.99	55

Chi – square = 0.100 + 0.092 + 0.011 + 0.094 + 0.190 + 0.037 + 0.001 + 0.029 + 0.006 + 0.095 + 0.064 + 0.216 + 0573 + 0.111 + 0.001 + 0.323 + 0.336

= 2.280

DF = 10, p – value = 0.994

Since the table value (p-value) 0.994 is lower than the calculated χ^2 - value (2.280), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones.

Chi-Square Test

Appendix 4: Marital Status of Respondents

H_0: There is no significant variation in the respondent participation in agroforestry according to marital status and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to marital status and ecological zones

Table of observed frequencies

	Sahel Savanna	Sudan Savanna	Guinea Savanna	**Total**
Married	28	26	20	74
Single	9	13	12	34
Divorced	6	7	8	21
Widowed	5	6	6	17
Total	48	52	46	146

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \quad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
Married	24.33	26.36	23.32
Single	11.18	12.11	10.71
Divorced	6.90	7.48	6.62
Widowed	5.59	6.05	5.36
Total	48	52	46.1

Chi – square = 0.554 + 0.005 + 0.424 + 0.015 + 0.155 + 0.118 + 0.031 + 0.289 + 0.062 + 0.000 + 0.077

= 2.253

DF = 6, p – value = 0.895

Since the table value (p-value) 0.895 is lower than the calculated χ^2 - value (2.253), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones

Chi-Square Test

Appendix 5: Farming Experience

H_0: There is no significant variation in the respondent participation in agroforestry according to farming and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to farming and ecological zones

The Expected units are determined using the following equations:

	Sahel Savanna	Sudan Savanna	Guinea Savanna	Total
1 – 10yrs	7	9	7	23
11 – 20yrs	12	25	20	57
21 – 30yrs	20	10	10	40
Above 30yrs	8	8	9	25
Total	47	52	46	145

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \qquad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
1 – 10ysr	7.46	8.25	7.30
11 – 20yrs	18.48	20.44	18.08
21 – 30yrs.	12.97	14.34	12.69
Above 30yrs.	8.10	8.97	7.93
Total	47	52	46

Chi-Square = 0.028 + 0.069 + 0.12 + 2.270 + 1.017 + 0.203 + 3.817 + 1.316 +

0.570 + 0.001 + 0.104 + 0.144

=9.550.

DF = 6, P – Value = 0.145.

Since the table value (p-value) 0.145 is lower than the calculated χ^2 - value (9.550), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones

Chi-Square Test

Appendix 6: Area of Land under agroforestry

H_0: There is no significant variation in the respondent participation in agroforestry according to Area of Land under agroforestry and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to Area of Land under agroforestry and ecological zones

Expected counts are printed below observed counts.

	Sahel Savanna	Sudan Savanna	Guinea Savanna	Total
1 ha	6	5	6	17
2 ha	6	6	7	19
3 ha	6	5	7	18
4 ha	6	6	6	18
5 ha	6	7	6	19
6 ha	15	8	7	30
7 ha	7	8	8	23
8 ha	8	13	11	32
9 ha	7	10	7	24
10 ha	5	8	5	18
Total	72	76	70	218

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \qquad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
1 ha	5.61	5.93	5.46
2 ha	6.28	6.62	6.10
3 ha	5.94	6.28	5.78
4 ha	5.94	6.28	5.78
5 ha	6.28	6.62	6.10
6 ha	9.91	10.46	9.63
7 ha	7.60	8.02	7.39
8 ha	10.57	11.16	10.28
9 ha	7.93	8.37	7.71
10 ha	5.94	6.28	5.78
Total	72	76	70

Chi-Square = 0.026 + 0.145 + 0.054 + 0.012 + 0.059 + 0.132 + 0.001 + 0.259
+ 0.258 + 0.001+ 0.012 + 0.008 + 0.012 + 0. 021 + 0. 002 +
2.617 + 0.578 + 0.720 + 0.047 + 0.000 + 0.051 + 0.624 + 0. 305
+ 0.051 + 0.108 + 0.319 + 0.065 + 0.150 + 0.474 + 0.105
= 7.216

DF = 18, P – Value = 0.988.

Since the table value (p-value) 0.988 is lower than the calculated χ^2 - value (7.216), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones

Chi-Square Test

Appendix 7: Land Tenure Pattern

H_0: There is no significant variation in the respondent participation in agroforestry according to Land Tenure and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to Land Tenure and ecological zones

The Expected units are determined using the following equations:

	Sahel Savanna	Sudan Savanna	Guinea Savanna	**Total**
Inherited	12	8	9	29
Rented	22	28	28	78
Purchased	10	11	6	27
Others	0	5	0	5
Total	44	52	43	139

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \qquad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
Inherited	9.18	10.85	8.97
Rented	24.69	29.18	24.13
Purchased	8.55	10.10	8.35
Others	1.58	1.87	1.55
Total	44	52	43

Chi-Square = 0.866 + 0.748 + 0.000 + 0.293 + 0.048 + 0.621 + 0.247 + 0.080

+ 0.663 + 1.583 + 5.236 + 1.547

= 11.932

DF = 6, P – Value = 0.063.

3 cells with expected counts less than 5.0

Since the table value (p-value) 0.063 is lower than the calculated χ^2 - value (11.932), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones

Chi Square Test

Appendix 8: Benefit of agroforestry farming

H_0: There is no significant variation in the respondent participation in agroforestry according to Benefit of agroforestry farming and ecological zones.

H_1: There is significant variation in respondent participation in agroforestry according to Benefit of agroforestry farming and ecological zones

The Expected units are determined using the following equations:

	Sahel Savanna	Sudan Savanna	Guinea Savanna	Total
Fuelwood	29	24	21	74
Fodder	24	21	18	63
Poles	10	15	9	34
Medicine	6	10	15	31
Fruits	9	10	7	26
Total	78	80	70	228

$$\chi^2 = \sum_{c=1}^{r} \sum_{j=1}^{c} \frac{(nij - Eij)}{Eij} \quad ----(1)$$

Where - nij = observered no of units

Units in cj class

Eij = number of units expected to fall in to cj class

r = number of rows

c = number of columns

The expected units are determined using the following equations:

$$E_I = \frac{(LT)(KT)}{GT} \qquad \text{- - - - - - - - - - (2)}$$

Where - LT is row total

KT is column total

GT is grand total

Table of expected frequency

	Sahel Savanna	Sudan Savanna	Guinea Savanna
Fuelwood	25.32	25.96	22.72
Fodder	21.55	22.11	19.34
Poles.	11.63	11.93	10.44
Medicine.	10.61	10.88	9.52
Fruits	8.89	9.12	7.98
Total 78	80	70	

Chi-Square = 0.536 + 0.149 + 0.130 + 0. 278 + 0. 055 + 0.093 + 0.229 + 0.790 + 0.198 + 2.000 + 0.071 + 3.158 + 0.001 + 0.084 + 0.121 = 7.894

DF = 8, P – Value = 0.444.

Since the table value (p-value) 0.444 is lower than the calculated χ^2 - value (7.894), we must reject H_0. Therefore, there is no significant variation in respondent participation in agroforestry according to gender and ecological zones