AGROFORESTRY PRACTICES AND THEIR POTENTIAL CONTRIBUTIONS TO SOIL FERTILITY AND FOOD PRODUCTION IN KATSINA STATE, NIGERIA

BY

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ABSTRACT

Unsustainable forest land use practices have resulted in land degradation in the northern part of Nigeria leading to low crop yield. Agroforestry is a viable option for reversing dwindling crop yields through proper soil management practices. There is notably no sufficient published information on the contributions of agroforestry to food production in Katsina State. The practices of agroforestry and its potential to slow down the pace of soil degradation and boost food production in Katsina State was therefore investigated.

Multistage stratified sampling was used to select respondents for the study. Three Local Government Areas (LGAs) were randomly selected from each of the agro-ecological zones (Sahel, Sudan and Guinea) of Katsina State. Within each of the selected LGAs, one community was randomly selected and forty respondents were randomly sampled from each community. Using structured questionnaire, information was sought on the socio-economic and demographic characteristics of respondents, Agroforestry Practices (AP), attitude to AP, information sources on AP and AP perceived benefits. Chemical characteristics of soil samples from agroforestry and non-agroforestry plots of respondents in the three zones were also determined using standard methods. Data were analysed using descriptive statistics, Chi-square and ANOVA at p = 0.05.

Most of the respondents (96.3%) were married, 82.5% were male and 50.0% were between 30 and 49 years of age. Their primary occupation was mostly farming (66.1%) while modal annual farm size was 1 – 2 hectares. Means of land acquisition was more by inheritance (50.8%) and 33.1% of the respondents made an annual income of between ₦30,000.00 – 40,000.00. The major farm enterprises were food crop production (74.1%), livestock (5.2%), tree crops (0.6%) and various combinations of these (19.0%). Multipurpose trees on farmland (79.2±11.1%), windbreaks (50.0±13.3%), woodlots (49.7±3.9%), improved fallow in shifting cultivation (32.2±26.3%) and home gardens (24.7±6.9%) were the common AP by the respondents. Benefits of AP to the respondents included preservation of the environment (98.5%), provision of fruits and leaves (98.3%), improvement of soil fertility (97.5%), erosion control (97.5%), improvement of farmers income (95.8%) and provision of fodder (92.7%). Also, 93.9% of the respondents reported increased yield of arable crops from a mixed tree and arable crop farm. Majority of the respondents (70.3%) identified scanty rainfall, land shortage and inadequate labour as problems while 12.8%, 4.7% and 4.4% respectively identified each of the problems as limiting AP. Although significant variation was observed in AP in the zones, sources of information significantly impacted adoption of AP in Sahel and Sudan but not in Guinea savanna zone. Significant variation was observed in soil pH, total nitrogen, Mg^{2+}, K^+ and Na^+ between agro-forestry and non agro-forestry plots with soil nutrient and organic matter content skewing in favour of agroforestry plots.

Agroforestry practices enrich the soil with important nutrients and prevent soil erosion. The adoption of multipurpose trees on farmland in Katsina state will help in preventing environmental degradation, desertification and enhance food crop production.

Keywords: Agroforestry practices, Agro-ecological zones, Farm enterprises, Soil degradation

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CERTIFICATION

I certify that this work was carried out by Mr. J.I. Amonum in the Department of Forest Resources Management, University of Ibadan, Ibadan, Nigeria.

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DEDICATION

To the Glory of God for the provision of knowledge, guidance and protection and to my late brothers Atile Amo and Chief Fateman Amo for their wisdom in ensuring that I went to school.

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CHAPTER ONE

INTRODUCTION

1.1. Background to the study

Nigerian agriculture has come a long way since pre-historic days when like the rest of the emerging civilizations, people shifted from mainly hunting and gathering forms of agricultural production to modern methods. Very early in the development process, the need to sustain the resource base, preserve planting materials and maintain yields was recognized. The traditional practice of improved fallowing or land rotational system exemplifies a strategy adopted to achieve sustainable food production. This practice served agriculture adequately until demographic pressures, the evolution of modern technologies and the limitations of available land started to distort the situation.

At independence, Nigeria was self-sufficient in food and timber production. The export of individual crop, timber and animal products was the major source of foreign exchange earnings. Food production was catered for by the traditional systems, and managed by individual small holders. However, Nigeria's need for improved agricultural production is increasingly becoming more crucial in the face of a steadily rising population and a global uncertainty about the future of oil that has been the nation's foreign exchange earner. This of course has created a lot of concern and led succeeding governments to initiate various agricultural policies to enhance self-sufficiency in food production.

It is in the light of this that the use of agroforestry practices as an alternative option for improving soil fertility and boosting food production is being advocated.

Agroforestry is an age-old land - use that has been practiced by farmers the world over. In recent years, it has been developed as a science that promises to help farmers increase their productivity, as well as sustain the nutrient status on their land. Scientific efforts to understand classify and improve agrosforestry systems are on the increase.

1.2. Statement of the problem

Despite Nigeria's dependence on petroleum resources, agriculture continues to play a prominent role in the country's economy. It accounts for about 38 % of the Gross Domestic Products, and employs about 70% of the population (Adeyoju 1975). However, the agricultural sector, particularly the food production subsector, has been plagued with a number of problems due principally to successive regimes which have tended to favour the urban sector to the detriment of rural areas where small holder farmers predominates.

The result is continuous stress on the natural resources base with the conversion of forested areas into croplands, the cropping of marginal lands and the use of adverse agricultural methods including inappropriate and excessive application of agro-chemicals.

Environmental degradation has intensified during the worldwide population boom, just within about a quarter of a century the population has doubled (Repetto, 1987). The concomitant demands for living space, and higher food and energy production have resulted in some lands being converted to intrinsically unsuitable ones. Slash-and-burn farm plots cut out of rain forests, which at best will support only a few years of crops, are one example of land use practices, that were nearly harmless in an area of low population densities and resource demand, but are fast becoming unsuitable. It has been reported by various authors that shifting cultivation can no longer support the needs of the farmers in Nigeria because of the increasing population pressure and attendant short fallow periods resulting in soil deterioration and ecological inbalance (Kang *et al* 1984; Adeola and Ola Adams, 1985; Kang and Wilson 1987).

Generally, it has been stressed that once there is a population of about 100 people per square kilometer, shifting cultivation will not be able to sustain them. Fallow period gets shorter and the restoration of soil fertility gets lower. This will lead to land degradation (Okali, 2005).

The need for more food has led to increased deforestation, shortened fallow periods in shifting cultivation cycles, and set in motion a degradation spiral, leading to reduced productive capacity of the land and decreased crop yields. In addition, indiscriminate fire wood gathering, timber harvesting and grazing have aggravated land degradation in many parts of the tropics (Bene *et al*, 1977, Poulsen, 1978 and Gorse, 1985).

Of all the environmental concerns facing developing nations in the humid tropics, large-scale deforestation is certainly the cause, which has most attracted world attention. It is one of the most serious environmental problems facing Nigeria today. In a developing country like Nigeria the importance of forests in sustaining the lives of the poor, in providing them with food, fuel, shelter and a means of livelihood, cannot be over-estimated.

Umeh (1989) reported that lives of several millions of Nigerians, primarily the rural and urban poor, are disrupted by environmental deterioration due to wood scarcity, flooding, soil erosion, sand storms, water degradation and reduced agricultural productivity. Commenting on deforestation, Eboh (1995) observed that deforestation refers to the loss of forestlands to arable agriculture and/or decline in the quality of forest vegetation cover through unguarded exploitation.

Nigeria's natural forest resources are fast diminishing and forecasts are that they may be exhausted by the end of 21st century as many species in our flora and fauna are threatened with extermination (Okojie, 1997). Forest destruction in the country is put at an average of 400,000 hectares per year, while reforestation has been only 32,000 hectares annually (FAO, 2007).

Worldwide, it is estimated that half of the tropical forests have been cleared already. Destruction continues at 25 to 30 million hectares per year and the majority of plant species are vanishing before they have been recorded or investigated.

The steadily increasing rate of deforestation is due to rapid growth of population and urban expansion, other agricultural development programmes and the pressure of increasing demand for forest products especially firewood. As soon as the vegetative cover of the soil is removed, the protective influence of the forest is reduced to the barest minimum.

Soil conservation and soil improvement values of the forest are immediately lost and erosion sets in. This may later lead to serious land degradation problem. Okojie (1991) reported that it is estimated that about 0.5% of the country's land surface has been ravaged by gully erosion. NEST (1995) also opined that gully erosion is the most observable, best-documented and most frightful type of erosion in the country. It occurs in areas of soft rock such as Anambra and Imo States where they develop very rapidly. The damage amounts to about 30 million tonnes of soil lost annually through this process.

Besides land degradation, deforestation also has implications for the regional and global climate. On a global basis, it contributes about 20% of the annual carbondioxide added to the atmosphere (Anon, 1990). This development is disturbing because the rising level of atmospheric carbon dioxide will bring about a global warming through the so-called "green house effect". Carbon dioxide taps the sun's energy, thus causing the temperature to rise. The accompanying increase in global temperature could directly affect agricultural production (Swaminathan, 1987). Rainfall patterns are also disturbed by large-scale deforestation, and this leads to unpredictable weather, which in turn affects crop yields.

Anon (1988) reported that a mixture of tree and annual crops of different heights (an agroforestry practice) provide a more complete ground cover which again helps protect the soil from erosion and makes maximum use of available sunlight. Gatherson (1982) opined that agroforestry seeks to develop sustainable land-use systems that supply people's needs for food and other basic necessities while maintaining critical environmental stability. The problem of insufficiency of food production to which successive governments in Nigeria have attempted to look for a probable solution, suggests adoption of agroforestry options. For this study, the following research questions are stated.

1. What type(s) of agroforestry practices are being used by farmers along with their food crop production in Katsina state?
2. What are the impacts of agroforestry practices on food crop production in Katsina state?
3. What types of food crops are planted along side with trees in the agroforestry practices?
4. By what means do farmers obtain information on the use of agroforestry practices in Katsina State?
5. What are farmers perceived benefits of agroforestry practices?

1.3. Objectives of the study

The general objective of the study is to evaluate farmers' use of agroforestry practices in Katsina State with a view to ascertaining the beneficial effects on food crop production.

The specific objectives include the:

1. Identification of the various agroforestry practices adopted by farmers in parts of Katsina State.

2. Determination of the benefits derived from planting trees along with food crops.

3. Comparison of the use of agroforestry practices in the three ecological zones of Katsina State.

4. Determination of the farmers' attitudes towards the adoption of agroforestry practices, and

5. Assessment of the variation in soil chemical properties among the zones and between agroforestry and non agroforestry plots.

1.4. Hypotheses tested

The following hypotheses were tested for variations in the level of farmers' use of agroforestry practices and to determine the relationship between the dependent variable and some independent variables.

1. There is no significant relationship between the demographic characteristics and the use of agroforestry practices by farmers in Katsina state.

2. There is no significant relationship between farmers' source of information and use of agroforestry practices.

3. There is no significant relationship between the benefits that can be derived and use of agroforestry practices.

4. There is no significant difference in the use of agroforestry practices in the three agro ecological zones in Katsina state.

5. There is no significant relationship between farmers' attitudes and the perceived benefits derived in the use of agroforestry practices, and

6. Soil chemical properties are not significantly affected by ecological zone and land use.

1.5. Justification of the study

The issue of self-sufficiency in food production has been of serious concern to successive Governments in Nigeria. A good number of policies and programmes have been put in place without meaningful result (e.g. National Accelerated Food Production Programme (NAFPP), Operation Feed the Nation (OFN), Green Revolution, River Basin Development Authority, Directorate of Foods, Roads and Rural Infrastructure (DFRRI) and so on. Despite these, there constant land degradation arising from deforestation in an attempt to open up more land for increased food production to feed the teeming population. Agroforestry will therefore contribute in no small measure in relieving the problems of environmental degradation, desertification and increase in food production.

United Nations Development Programme (UNDP) (1998) observed that Nigeria was facing structural food shortages and about 40% of the people were reported to be suffering from food insecurity on an annual basis, while about 43% suffer from malnutrition. The increasing population is exerting severe pressure on the natural environment resulting in accelerated level of deforestation and consequently soil degradation.

The United Nations Environmental Programme (UNEP, 1985) assessment of desertification shows that over 80% of Africa's arid zone is at least moderately affected by desertification. Also affected are some 80% of its rain-fed croplands and over 30% of its irrigated lands. In the humid areas south of the Sudano-sahelian belt, UNEP reports that half of the population depending on rain-fed crops are affected by land degradation. African forests are estimated to disappear at the rate of about 5% every 10 years (Okojie, 1997). Population pressure today therefore precludes practices that would enable the environment to recover from extensive cropping systems. It is expected that this study will assist agricultural planners and policy makers to properly address the issue of food sufficiency and environmental degradation.

1.6. Scope of study

The study site covers Katsina State of Nigeria which is located in the Northern part of the country. The state lies on latitude 12^0N and longitude 8^0E, and it has 34 Local Government Areas. Twenty five (25%) % sampling intensity was adopted in the study. Thus three LGAs were randomly selected from each of the three agroecological zones into which the state is divided. The three ecological zones of the state are: Sahel savanna, which lies to the extreme north, the Sudan savanna which lies immediately after the Sahel savanna and the Guinea savanna which lies down south.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Introduction

Agroforestry is often called a new name for a set of old practices; is recognized as a promising land use technology and an interface between agriculture and forestry especially in developing countries of the tropics and subtropics (ICRAF, 1997). Increased concerns, at the highest international policy levels, about the sustainability of agricultural development, in the light of the apparent rapid depletion of the natural resources base has brought agroforestry even further into the limelight (FAO, 2004). In a loose sense agroforestry began when man first turned from a hunting and gathering lifestyle and took up planting culture. Though may not be purposefully integrated, trees and arable crops have always occurred together in systems where subsistence was the primary farming objective (Winrock, 1995).

Human society has always had a range of strategies for sustainable survival (Canway and Barbier, 1990). Agroforestry can be viewed as one of such societal response, primarily borne out of a need to fulfil immediate basic human needs of food, fuel, fodder, shelter, protection and so on. (Dove, 1992). The term agroforestry for social scientists, represents a combination and interrelationships between people, domestic animals, crops and trees, designed to rehabilitate land or to sustain and increase production of certain desired social benefits. Thus, agroforestry concerns the structure and functioning of human ecosystem and not merely biophysical system (Khot, 1999).

2.2. Concept of agroforestry

Efforts to define agroforestry began in the late 70s and evolved rapidly as studies on the diversity and scope of agroforestry practices defy a universal definition. Agroforestry has been defined in various ways by different researchers and scholars. Thus there is apparent lack of precision surrounding what could be conveniently classified as an agroforestry practice or technology. Conceptually, there are two main characteristics common to all agroforestgry systems – namely: the deliberate growing of woody perennials on the same unit of land as agricultural crops and/or animals, either in some form of spatial mixture or sequence and the second characteristic is that there must be a significant interaction (positive or negative) between the two or more constituent plant species (FORMECU, 1990).

King (1987) defined agroforestry as a sustainable land management system which constitute the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population. Nair (1993) described agroforestry as a form of land use that successfully satisfies the needs of the crop farmer, forester and livestock farmer.

Steppler and Nair (1987) defined agroforestry as a deliberate integration in space or time, of woody perennials with herbaceous crops and/or animals on the same land management unit. This can be simplified to mean the practice of growing trees with agricultural crops and/or livestock on the same piece of land as later defined by Nair (1991).

Young (1989) opined that agroforestry can best be defined as "a land management system that integrates forestry and agricultural crops in relation to land use system in which trees are grown on the same land as agricultural crops and/or animals either in spatial arrangement or in a time sequence and in which there are both ecological and economic interactions between the tree and non-tree components."

Lundgren (1987) defined agroforestry as "a collective term for systems and technologies of land use where perennial woody plants (trees, shrubs, scrub and by assimilation, palms and bamboos) are deliberately cultivated on the ground otherwise used for crops and/or livestock rearing in a spatial or temporal arrangement, and where there are interactions of ecological and economic between the woody plants and the other components of the system." These interactions can take several forms, positive or negative, and do not necessarily remain stable in time.

Evans (1982) defines agroforestry as simply the mixing or blending tree growing and food growing. Quashie-Sam (1994) defined agroforestry as a land use system in which trees or shrubs are grown in association with crops (agricultural and pastures) in a spatial arrangement or rotation in which there are both ecological and economic interactions between the tree and other components of the system.

Beets (1989) also defined agroforestry as a land use system in which trees are grown on the same land as agricultural crops and/or animals either in spatial arrangement or in time sequence and in which there are both ecological and economic interactions between the tree and non-tree components. This definition encompasses many well known land use systems long practiced in the tropics. For example, the concept includes the "traditional shifting cultivation" and "improved fallow" systems which are all forms of *Taungya* and the homegardens in which crops are under planted with other crops or pastures. The deliberate use of fodder trees and shrubs in the dry tropics, traditional agriculture with tree systems, agriculture and fisheries under mangroves are included.

Huxley (1983) defined agroforestry as a dynamic ecologically based natural resource management system that through the integration of trees in farm and rangeland with diversified products and sustain small holder production to increase social and economic benefits.

Okali (2001) regards agroforestry as a sequential or simultaneous production of forestry plants, agricultural crops and/or animals on the same unit of land. He maintains that it is a collective name for land use systems and practices where woody perennials (trees, shrubs etc.) are deliberately integrated with crops and animals on the same land management unit. The integration can either be in spatial mixture or in temporal sequence.

ICRAF (1997) defines agroforestry as a dynamic, ecologically based natural resources management system that through the integration of trees on farms and in agricultural landscape diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels.

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

Each of the above definitions has limitations, several basic ideas can be drawn from them:

- Agroforestry is a distinct land-use system which may include combination of agricultural, forestry, and animal husbandry subsystems or practices. Simply stated, agroforestry is a means of managing or using land (i.e. a multiple land-use system) that combines trees or shrubs with agricultural crops an/or livestock.

- Agroforestry integrates trees with crops and/or animals with the main objective of reducing risk and increasing total productivity. Farmers have historically used indigenous mixed cropping practices to minimize the risk of total crop failure by growing a variety of products on the same piece of land.

- In their ideal forms, agroforesty systems are both stable and sustainable. Agroforestry practices have greater diversity than do monoculture practices and can distribute production over a longer period. This provides income that is more regular with increased cash flow stability.

- To farmers, particularly those who may have difficulty storing or marketing farm produce, agroforestry helps to reduce the risk of complete crop failure in terms of fall in price.

- Integration of trees into agricultural systems may result in more efficient use of sunlight, moisture and plant nutrients than is generally possible by monocropping of either agricultural or forestry crops.

However, the concepts of Agroforestry have been well elucidated in several publications. Today, there is no divergence of opinion that Agroforestry:

- Is a collective name for multiple land-use 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 condition and fragile environments;
- Involves the interplay of socio-cultural values more than in most other land-use systems; and
- Is structurally and functionally more complex than monoculture.

2.2. Types of agroforestry systems in Nigeria

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, namely: 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 viz:

* Agrisilviculture (Crops + Trees)
* Silvopastoral (Pasture/animal + Trees)
* Agrosilvopastoral (Crops + Pasture + Trees)

Other specified agroforestry can also be defined e.g. apiculture (Bees with trees), aquaculture (Fishes with trees and shrubs), and multipurpose tree lots. Although several agroforestry systems have been recorded from around the world, the distinct agroforestry practices that constitute these systems in various biomes and locations are only few. Of course, same or similar agroforestry practices can be found in agroforestry systems in different places.

The varieties and descriptions of agroforestry systems practiced in Nigeria are presented in Table 1.

Table 1: Varieties and description of agroforestry practices in Nigeria

S/N	Agroforestry practices	Description	Remark
1.	*Taungya* Farming	Food crops are interplant 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 system has proved effective in providing food for forestry workers and forage for cutting by cattle rearers.	Main Agroforestry model 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 Osemeobo, 1995). The main problem with this system is the need to plan a planting programme for long-cycle trees with three or four years of crops.
2.	Integrated *Taungya*	Similar to *Taungya* farming, but here, when the tree canopy is closed, livestock grazing substitute rising of agricultural crops.	The integrated approach aims at invoking the idea of land use practice whereby the activities on the land is stretched all the year round (Rander, 1988).
3.	Improved Fallow in Shifting Cultivation	This is introduction suitable woody species on the farmland during the fallow period, which might have potential to restore soil fertility more rapidly and at the same time provide one or more useful products.	The role of this system is mainly that of soil conservation and improvement
4.	Alley-cropping (hedgerow inter-cropping)	In this system, arable crops are grown between hedgerows of planted shrubs and trees, preferably *leguminous* species that are periodically pruned to prevent shading of the companion crops and the pruning applied as mulch for the crops.	This is a relatively new technique developed at IITA and ICRAF. The tree provides nitrogen from atmospheric fixation, recycle of nutrients from the depth of soil, suppresses weeds and increases organic matter content of the soil.
5.	Alley farming	This is similar to alley-cropping except that the remnants are also introduced into the system to help restore soil fertility.	Alley farming was designed mainly for sheep and goat grazing. The advantages are that the land provides crop residues and controls soil erosion through windbreak. Major disadvantage is the competition of hedgerows with crops for soil water, which often limit crop productivity (Singh *et al.*, 1989).
6.	Shelterbelts	Agroforestry system in which food crops are planted between rows of tree belts planted as shelter. The trees and shrubs are planted in two or more rows at right angle to prevailing winds.	The practise 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. Disadvantages of the system are that labour involvement is enormous and species used as hedgerow crops are without edible by products.
7.	Windbreaks	Here, double rows of trees are planted around the boundary	The advantage is that windbreaks reduce wind erosion and at the

		of a food crop farm on the windward side. Each windbreak is 150m long with 100 trees planted at escapement of 3m x 3m.	same time produce forest alongside food crops.
8.	Homegarden	Tropical homegardens 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.	Okafor and Fernandes (1989) reported that in this system, multipurpose trees and shrubs in a multi-stories association with agricultural crops are raised with small livestock in homesteads. Homegarden is not a formal practice of agroforestry but a traditional farming system with an Agro-forestry focus.
`9.	Multipupose trees on cropland (Trees on farmland or farm forestry)	Farmers intentionally leave few trees on farms when clearing the land in the practice. The trees commonly left are those of economic importance to the farmers.	There is also deliberate planting of desirable fruit bearing trees (fruit trees) on farmlands where the density of the natural tree is low. 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.
10.	Trees in Soil Conservation	Woody plants, whether in hedges or not, planted to stabilize the soil on terrace edges and other areas in need of soil conservation	Woody perennials 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.
11.	Aquaforestry	Is a practice that links trees with aquaculture. Trees are planted around fishponds to provide fodder for herbivorous fish.	The trees serve as shelter and shade which create a desirable microclimate for the pond, widely practised by traditional farmers in inland watercourses where the farmers have full rights to the land.
12.	Apiculture (apisilviculture)	Carefully chosen woody species grown for their nectar-producing flowers and pollen valued by bees. Can boost wax and honey production.	If flowering is staggered, bees will work as long as there are flowers instead of only working for a few months in a year.
13.	Protein Bank	Leguminous woody perennial vegetation judiciously used to supply forage during dry seasons or years of low rainfall.	Not only does this provide green forage when the grass cover has withered but it can also supply more protein than grasses. The advantage of woody plants in dry season is therefore both quantitative and qualitative.

Adapted from Baumer (1990).

2.2.1. Integrated *Taungya*

In the southern savanna and humid/subhumid zones where plantation forestry is predominantly practised, but farmland shortage results in under-development, the *Taungya* system has been accepted as a means of forest plantation establishment. Under the system, food crops are interplanted during the first few years of establishment of commercial forestry plantations, with the aim of food production on forest land, combined with cost effective planting operations.

When the tree canopy is closed, agricultural operations are abandoned and substituted by livestock grazing. An improvement over the existing *Taungya* system, the integrated approach aims to invoke the idea of land-use practice wherein the activities will be stretched the year round, community wide, largely self contained and ritually sanctioned way of life.

2.2.2. Alley-cropping (hedgerow intercropping)

Hedgerow intercropping or alley cropping may be defined as a zonal or spatial approach to agroforestry wherein agricultural crops are planted in alleys between multiple hedgerows of nutrient recycling trees or shrubs (ICRAF 1990). The woody shrubs are kept pruned throughout the cropping season to control shade and above-ground competition, at the same time producing fodder, green manure or mulch material for the benefit of livestock, associated crops or soil fertility. Fodder and fuelwood might be considered as a by-product of the system. Alley cropping agroforestry practice has been propagated by IITA, Ibadan as a possible alternative to shifting cultivation (Kang *et al* 1986), wherein woody perennial integrated with agricultural crops may be managed spatially or temporally to produce biomass for restoration of soil fertility on a continuous basis, besides control of weeds during fallow period (Popoola (1990). Main wood species recommended are *Leucaena leucocephala, Gliricidia sepium, Calliandra calothyrsus, Sesbania grandiflora, Alhornea cordifolia,* most of them being leguminous capable of fixing atmospheric nitrogen so vital for soil fertility restoration.

2.2.3. Improved fallow in shifting cultivation

Shifting cultivation widely practised in humid/subhumid tropical lands over the ages was a stable agricultural production system when the population was within limits i.e. 25 - 30 persons per km^2 (Rander, 1988). With increased human and livestock pressure during the recent past, the system came under strain and started disintegrating resulting in reduced yields, however soil fertility, ecological disturbance due to excessive overfelling of vegetation, and poor socio-economic condition of the inhabitants. The system can be improved through supplementation of the natural growth with suitable woody species during the fallow period, which might have the potential to restore soil fertility more rapidly and at the same time provide one or more useful products. This practice of supplementing the natural growth with suitable woody species during the fallow period of the shifting cultivation is termed improved or enriched fallow in shifting cultivation. It could be simply called improved shifting cultivation. 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.

2.2.4 Multipurpose-trees on cropland (scattered trees on farmland/parkland agroforestry)

This is the practice where trees are retained on farmers' cropland while the crops are grown in the under storey. Usually the trees are out in the field in a widely dispersed manner. They could also be scattered at random based on farmers' desire. Typical examples of this form of arrangement can be found in many parts of the arid and semi-arid areas of Nigeria where trees dispersed naturally in farmlands form an integral part of the cropping system. Different species are found in such dispersed park-like stands, depending on site conditions. Examples are *Faidherbia albida, Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata* and *Borassus aethiopum* (Ekwebelam, 1988).

Traditionally, the trees are homogeneously distributed across farms in random patterns due to their ability to regenerate naturally. The tree do not take up as much space, thus a large part of the productive land is left for crop production. The trees provide wood, fodder and other forest products to the farmers. Some of the trees like *Parkia biglobosa* provide a lot of income for the farmer through their fruits. Parkia seeds are used for the preparation of condiment called dadawa sold to the natives at a very economic price. It is also known for its ability to resuscitate the soil with mychorrhiza association and nitrogen fixation which helps to improve soil fertility (Ikpa *et al* 2006).

2.2.5 Homegardens

The homegardens involve a large number of herbaceous and woody plants including food, vegetable, fodder, fruit species with or without livestock i.e. ruminant, poultry and piggery. The species propagated are grown mixed, spatially or sequentially but the vegetation forms multi-storeyed canopy, favourably placed to exploit both above and below the ground environmental conditions i.e. sun, space, nutrients and water at different layers of atmosphere and soil. Output from such compound gardens is reported 5 – 10 times more than from the out-fields. Financial returns to labour input are also higher as the operatioins are labour intensive. Main species being multipurpose, are oil palm, mango, coconut, cola nut, citrus, banana, custard apple, pineapple, guava, with under storey formed by vegetables, yams, cassava, plantains, groundnut, beans, maize, flowering plants and recently introduced *Leucaena*. Most of the produce is consumed locally but surplus, if any, is marketed too.

2.2.6 Fringe/boundary/border planting

This is the planting of trees on boundaries of agricultural crops. In this practice, trees, shrubs and grasses are established to delineate individual farmlands. They are property markers even though they provide wood and other forest products for various purposes. It is one of the simplest methods of incorporating woody perennials into an agricultural production system. Baumer (1990) regards it as also a way of reducing the problem of competition between trees and crops, provided there is no other field on the adjacent side of the tree stand. Species used for this technology include *Moringa oleifera, Acacia* *sp; Tamarindus indica, Eucalyptus sp, Dalbergia sisso,* and so on. These species are useful either as vegetables or in water treatment in the northern parts of Nigeria (Verinumbe *et al* 1994).

2.2.7 Shelterbelts/Windbreaks

Mainly confined to northern savanna region and except shelterbelts to Mambilla plateau, this agroforestry practice has been developed to protect the agricultural crops and soils from the desiccating winds and soil erosion. Woody species are planted in spatial arrangement in linear strips of multiple rows in case of shelterbelts and 1 – 3 rows in case of windbreaks. The alignment, orientation may be planned to meet the specific requirements of the individual farms or groups of farms depending upon the wind direction and topography; etc. The commonest tree species planted in this practice include *Azadirachta indica* Eucalyptus sp, Casuarina equisetifolia and so on.

2.2.8 Woody Perennial for soil conservation

Physical and chemical constraints to plant growth severely limit the productivity of some vast areas of land in Nigeria. Waterlogging, acidity, aridity, salinity and alkalinity, and the presence of excessive amounts of clay alkalinity, sand or gravel are some of the major constraints. To solve some of these problems, agroforestry techniques involving planting of woody trees that are tolerant of these adverse soil conditions are planted with management options for reclamation of such areas. For example, some success has been accomplished in soil amelioration by planting *Eucalyptus* trees in some flooded areas of sudan savanna (Field survey, 2006). Therefore, trees are planted in these areas with erosion problems and desert encroachment.

2.2.9 Woodlots

In Katsina state, private multipurpose woodlots are established by farmers with assistance of European Union (EU) and Katsina state government (KTSG) to meet farmers' wood and fodder need. The tree crops such as *Azadirachta India,* Casia spp, and *Parkia biglobosa* are usually planted behind the food crops (maize, sorghum, millet, etc).

2.2.10 Fuelwood production

This involves inter-planting firewood on/or around agricultural lands. It is adaptable in almost all ecological regions. Agroforestry for fuelwood is also used to promote rearing of animals during adverse conditions. In the initial stage, the crop residues are used as forage and protein banks. Also severely affected by over-exploitation, excessive denudation and experiencing ecological degradation resulting in fuelwood shortage, are ideally suited for fuelwood production agroforestry system. Suitable woody species with potential of maximum biomass production can be combined with agricultural crops in different forms. Thus fuelwood production may come from woodlots, contour single line, multiple rows, field boundary tree rows, windbreaks, shelterbelts, multipurpose woodlots and even farm trees. Woody perennials may be planted as part of agroforestry practice on farmlands, community lands managed for livestock purposes and the practice is widespread in all the ecological zones.

2.2.11 Crop combinations with plantation crops

Mixture of tree crops mainly comprising of coconut, oil palm, cocoa, rubber, forming the upper or middle canopy intimately grow with other agricultural crops namely banana, cocoyam, yam, cassava and beans, etc. in the southern parts of Nigeria. Usually the plantation crops occupy either systematic lines or haphazardly scattered. The production of plantation crop are mainly for cash, while food, vegetables are for home consumption or soil sustainability purposes. Generally, it is commonly practised in humid lowlands or tropical humid or subhumid highlands (depending on the adaptability or the plantation crops concerned, usually in small holder).

2.2.12 Trees on rangeland or pastures

Areas in tropical high forests and plantation lands primarily managed for pasture or grazing purposes do grow fodder trees in combination with grasses/legumes. Similarly in low land humid/subhumid region, the natural woodlands, occupying sizeable lands being utilized as grazing grounds or range lands do grow scattered fodder trees in combination with other woody species and herbaceous growth. Various species of *Ficus, Terminalia, Bauhinla, Annona* and *Ricinodendron* spp. are exploited for leaf fodder production and fuelwood purposes too. The composition of woody species in the vegetation may vary from scattered trees spread all over to localized groups depending on soil characteristics, past management and hydrological conditions.

2.2.13 Protein bank/fodder bank

In production systems that include animals, it is difficult to rely solely on annual plants to supply forage during the dry seasons or years of low rainfall. Woody perennial vegetation, judiciously used, helps to meet this difficulty. These woody perennials could be planted in a protein. A protein or fodder bank is a small, well-protected and intensively managed plot of trees that is continuously cut for feeding livestock (Bohringer, 2001). The trees used are mostly leguminous; and therefore capable of supplying more protein than grasses. This also takes off the pressure from the grassland ecosystem; and therefore offers a sort of protection to the ecosystem. The advantage of woody plants in dry season is therefore both quantitative and qualitative (Baumer, 1990).

2.2.14 Apiculture (api-silviculture)

This is the science of bees and beekeeping with agroforestry. 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 (Baumer, 1990). Trees and bees represent truly harmonious symbiosis, while at the same time helping to safeguard natural habitats by encouraging it. Beekeeping is one way of exploiting forests without destroying them. Therefore, beekeeping is capable of conserving the forest.

2.2.15 Aquaforestry

This is an agroforestry practice that links trees with aquaculture. The trees are planted around fish ponds to provide fodder for herbivorous fish. The fuelwood 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, and leaves of *Leucaena* are used to feed herbivorous fishes such as Tilapia, Hilotica, Labeorhita etc. (Wouters, 1994).

2.2.16 Live Fences

These are fences composed of living trees. In the arid zones, the trees are preferably termite-resistant. They are either sufficiently closely planted to form a barrier, or barbed wire is stretched between them. They can be cut above barrier height for wood or green branches (Baumer, 1990). Baumer *loc. cit.* reported that in the arid zones, existing trees are often used to form the fence, even though the alignment is not perfect. These formations arranged spatially serve the multipurpose of protection of crops and property from outside damage, production of fuelwood, fodder and fruit processed to cattle feed. Examples abound in the tropics. Main species planted are *Gliricidia sepium, Erithrina spp Sesbania spp, Leucaena spp.* The woody perennials are spatially arranged.

2.2.17 Agroforestry Development in Nigeria as a way to Sustainable Land use System.

The development of agroforestry began in Nigeria as a way of bringing forestry and farming into co-existence and thus tackling our increasing food and wood shortages from limited land resources. Osemeobo (1993), while recommending agroforestry, recounted the poor productivity of our soils. Rapid loss of soil fertility and structure is said to occur while organic matter is not added in sufficient quantities. Thus Oyer and Touchton (1990) concluded that the most appropriate methods of development in the tropics are those, which aim at protecting the soil against direct rain impact and conserving the organic matter in the soil.

An ecological analysis of the spread of various agroforestry practices has shown that the existence/adoption of an agroforestry system in a given area is determined largely by the ecological potential of the area (Nair 1993). Hence various types of systems have been adopted in different parts of the country to meet specific needs. Lowe (1986) described how *Taungya* farms were established in Omo and Oluwa Forest Reserves for the planting of *Gmelina* by the former Regional Government of Western Nigeria, while Umaru (1992) emphasized the increasing dependence on *Faidherbia albida* for dry season fodder and fuel wood by farmers in the northern part of the country. Alley-cropping food production was developed at International Institute of Tropical Agriculture (IITA) Ibadan to enhance continuous crop cultivation instead of shifting cultivation (Kang and Chuman, 1991).

Beets (1989) defined agroforestry as a "land use system in which trees are grown on the same land as agricultural crops and/or animals either in spatial arrangement or in time sequence and in which there are both ecological and economic interactions between the tree and non tree component". This definition encompasses many well-known land use system long practised in the tropics. For example, the concept includes the traditional "shifting cultivation" and "improved fallow" systems, all forms of *Taungya* afforestation systems and the homegardens in which crops are under planted with other crops or pastures; the deliberate use of fodder trees and shrubs in dry tropics, traditional agriculture with trees systems, aquaculture and fisheries under mangroves are included.

2.2.18 Characteristics of useful agroforestry trees

The selection of trees for agro-forestry is based on the general criteria of climate and soil (Nair, 1989). Even though different situations will dictate specific needs, the desirable characteristics of agroforestry trees is summarized by Huxley (1983) as follows:

(a) Multiplicity of uses for leaves, flowers, fruits and woody parts of the trees so that they can help satisfy the various needs of the farmers.

(b) Rapid rates of growth to reduce the waiting period for the products by the farmers.

(c) Nitrogen fixers, so that they can contribute much to rehabilitation/ improvement of the soil.

(d) Deep-rooted species, so that they can effectively stabilize slopes, their roots do not compete for nutrients, moisture with the shallow roots of the annual agricultural crops and be able to reach the lower water table to survive droughts.

(e) Light crowned, so that they do not totally shade the food crops.

(f) Not an aggressive colonizer, to avoid dominating the area.

(g) Coppicer, so that they can re-grow from stumps after periodic cutting.

Most of the leguminous tree crops have the ability to fix nitrogen into the soil by their mutual beneficial partnership with soil bacteria of the Genus *Rhizobium* through nodulation. Yamoah *et al* (1986) observed that *Sesbania* species are adapted to hydromorphic nodulation. Thus for average growth, the nitrogen fixing tree species usually require no fertilizer and therefore can survive in some nitrogen poor soil, which in turn enrich the soil with nitrogen to sustain the shallow food crops.

Mulching studies carried out by Angels and Prager (1989) showed that leaves from nitrogen fixing trees can significantly increase maize yields. The potentials of nitrogen fixing as a source of materials for agricultural crops is exploited by the Alley-cropping practice, developed at the International Institute of Tropical Agriculture, Ibadan. The trees or shrubs in this agroforestry practices; apart from pruning that enrich and protect the soil also produce browse, staking materials and firewood (Kang, 1991).

2.2.19 Land, Trees and the Environment

The life of the rural farmer in Africa is directly linked with the land changing seasons. In the past, when the population was low. people's needs were in balance with the resources of land (Adeola, 1996). The present 3% rate growth in Africa Office of Technological Assessment (OTA), 1988) is an indication that most African countries may not be able to meet their needs from land resources by the year 2015 AD (FAO, 1984). Today, most African countries are highly impoverished considering their purchasing power parity per capita (PPP). For Africa as a whole the figure is US$ 1961, which is the lowest for all regions of the world (FAO, 1997).

Land as a factor of production is very important to the rural farmer in Africa who resides outside the urban centres and are predominantly employed in agricultural activities (FAO, 1997). They are poor because of low output from their agricultural enterprises. They lack basic amenities while resource allocation for rural and forest resources are usually vary negligible. Khot (1999) noted that forest resources are basic to socio-economic development of the rural people in any nation as forests provide food to many nations especially developing ones.

In the savanna and semi arid areas, forestry is linked with agricultural activities as rural people depend on the forest for food, folder, livestock and fuelwood for domestic energy (Khot, 1999). The forests are the dominant sources of building materials such as poles, branches, and leaves of *Raphia* palms and thatching leaves for roofs. They are the primary sources of animal protein (bush meat), snails, reptile, and birds (FAO, 1991). The trees, which make up the forests, help in environmental protection and contribute to food production in the rural set up.

Trees and forests influence both their immediate surroundings and the larger environment. The environment includes all things external to the organism, which influence its life in the place where it lives. It includes living and non-living things present within the surrounding of the organism and which influence its life. It is the physical and biological surrounding of the human species and constitutes the fabrics of his life (Anon, 1981). According to Okojie (1997) all the life supporting systems of the human race constitute environment. Trees and forests are known to influence this larger environment in many ways. Their destruction causes deterioration of farming and rangeland in all instances to an impoverishment of the rural community (Bada 1997). The many ways in which trees influence the environment include microclimate, global warming, land degradation, loss of biodiversity, and food securities.

2.22. Effects of Trees on Microclimate

Trees have influence on a range of climatic parameters – temperature, humidity, precipitation and light conditions of the environment. Trees moderate air and soil temperatures and increase relative humidity of the immediate environment. Their influence depends on their number and the species used. The moderating effect on humidity and temperature is more pronounced as the canopy structure of the aggregate trees closes. The more the system resembles a closed forest in its canopy structure and tree spacing, the greater the beneficial effects on humidity and temperature. Oguntala (1996), Onyewuotu (1985), Adebagbo (1975) in their various studies in the high forest and semi-arid regions observed that the greater the number of trees, the more beneficial their effects on climatic parameters. The presence of trees has been known to reduce the effect of turbulent windstorms. Trees obstruct, guide, deflect and filter winds. They serve as wind breaks in their resistance to winds (Okojie, 1997).

Trees also have effect on shade. This is especially important for animals growing in very hot climate. In this wise, every single tree is highly valued in the arid and semi-arid areas. Trees also affect the availability of soil moisture in their immediate environment. The tree canopy influences the amount of precipitation reaching the soil in a forest during rains. In light showers, very little or nothing reaches the ground. In heavy rains, the canopy is wet and most of the precipitation reaches the ground.

Climate is related to many human activities. This is because human activities such as trading patterns between countries in various commodities are actively linked with climate. Climatic changes and variability pose a serious challenge to life on earth since present patterns of economic activities have grown over the past thousand years in a period of relatively stable climate (Okojie, 1997).

2.23. Trees and Global Warming

Global warming refers to an increase in the average temperature of the earth's surface due to emissions of carbon dioxide (CO_2) and other green house gases into the atmosphere as a result of the activities of man activities especially the removal of trees and other green vegetation. There have been increased levels of some gases (notably CO_2) which prevent the escape of some of the energy received from the sun hence making the surface of the earth warmer by 1.5-4.5% than it would otherwise be (Okojie, 1991). Forest and the oceans serve as CO_2 sinks and may reduce the rate of CO_2 concentration in the atmosphere. Continued indiscriminate removal of trees/forest without appropriate replacement reduces the effect of trees to act as sinks for CO_2. (Amonum, 2008). Trees help to keep carbon in the terrestrial ecosystem and out of the atmosphere.

Biodiversity conservation also helps to keep over 96 billion tonnes of carbon in the remaining humid tropical forest biomass *in-situ;* thus preventing its release through burning (Sanchez 1995). In recent years, there have been large-scale forest removal, which may result in increased levels of CO_2 (Chambers 1992). Such global warming caused by increased CO_2 may result in major climatic changes causing thermal expansion of oceans, melting of glacier in cold regions and increased ocean levels. This may lead to floods, changes in food chains and disruption in agricultural production systems. Many coastal wetlands and mangrove areas would also be destroyed with serious consequences for the world's fishery resources (FAO, 1995).

2.25. Contribution of agroforestry to rehabilitation of degraded land

Monoculture as practised in developing countries such as Nigeria requires high yielding crop varieties and an intensive use of fertilisers for optimal or acceptable performance of the crops. 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. 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 forests.

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 realised, especially in the effort to reduce accumulation of greenhouse gases in the atmosphere. Agroforestry is therefore a means of correcting the effects of degradation. Owusu (1993) Hanson *et al* (1995), Shultz *et al* (1995), agreed that agroforestry can provide new and useful solutions to many of the consequences of human land use. These include increased desertification 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 nutrition.

2.25. Ecological Benefits of Agroforestry

Ecology concerns the relationship between organisms, their habitat 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 utilised. 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 process of soil nutrient renewal. Charley and West (1977) claimed that litterfall 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, and their subsequent decomposition would enrich the soil.

It can therefore be asserted that protection of 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 provided by the trees (Hochberg *et al, 1994*). Danell (1986) added that the decomposition of fine shallow roots enrich the top soil with nitrogen. The Great Wall of China is only a forest plantation which checked 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 Boutilimit in Mauritania to establish forest trees 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 greenhouse effect caused by environmental degradation can be checked with agroforestry practices (Amonum *et* al 2009). Anderson (1990) emphasised that agroforestry plays a major role in reclamation of degraded or abandoned lands and is a workable approach to mimic natural succession and increased 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 potentialities of agroforestry have inspired the Portuguese and French governments to pass legislations that are aimed at protecting forest areas and natural habitats Organization for Economic Cooperation and Development (OECD, 1991). The main concept here is allowing soil stability by reducing the extent of clearing and tillage 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 microorganism (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 land, upholding ecological equilibrium and maintaining the environment should be put in the right perspective.

2.26. Importance of nutrient elements in trees

The optional availability of forest soil nutrients is essential for the healthy growth of the forest floral component (Ader and Melillo, 1980); which is an important cover for the fauna including the wildlife resources that range freely within the forest. If the floral component of the forest is fully luxuriant, the food and energy requirements of the fauna can be fully realized. Moreover, wildlife can obtain better shelter in the forest for their protection against their predators if the forest were fully grown (Noss 1991, Scott *et al.* 1991). Soil nutrients play a vital role in enhancing the growth of forest because plants require essential soil nutrients such as nitrogen, calcium, phosphorus, and potassium which are assimilated from the soil to complete their vegetative and reproductive life cycles (Melillo *et al.* 1989). Other essential elements such as carbon, hydrogen, and oxygen are more readily available to plants because they are freely obtained from carbon dioxide and water and converted to carbohydrates during photosynthesis (Kaspar *et al* 2006). Thus, the critical elements that might limit the growth of forest plants are the nutrient elements that are assimilated by the plants from the soil.

Table 2. Major Functions of Nutrient Elements in Trees

Elements	Roles in Plants
Nitrogen (N)	Constituent of all proteins, chlorophyll, in coenzymes and nucleic acids.
Phosphorus (P)	Constituent of all proteins, chlorophyll, in coenzymes and nucleic acids.
Potassium (K)	Enzyme activation, osmoregulation energy relativions, translocation of assimilates, N uptake and protein and starch synthesis.
Calcium (Ca)	Meristematic cell elongation and division, structure and permeability of cell membranes.
Magnesium (Mg)	Meristematic cell elongation and division, structure and permeability of cell membranes.
Sulphur (S)	Development of meristematic cells, carbohydrate, N, and P.
Boron (B)	Translocation synthesis of amino acids and proteins. And phytohormone activity.
Iron (Fe)	Component of molecules involved in redox reactions, and in enzyme systems.
Manganese (Mn)	Electron transfer in photo system II in chloroplast membrances structure, enzymes.
Copper (Cu)	Electron transfer in photo system II in chloroplast membrances structure, enzymes.
Zince (Zn)	Auxin metabolism in enzymes systems, stability of ribosomes (and DNA and RNA levels).
Molybdenum (Mo)	Constituent of nitrate reductase (No 3 reduction), and of nitrogenase (in N fixation) enzymes.
Chlorine (Ci)	Osmoregulation, o_2 evolution in photosynthesis.
Cobalt (Co)	N_2 Fixation in legumes and non-legumes and by free-living organisms.
Sodium (Na)	In C4 and CAM in halophyte plants. K substitute, involved in nitrate reductase.
Silicon (Si)	Cell wall structure of some plants e.g., rice, grasses, sugarcane and barley.

Source: Nwoboshi, 2000

2.26.1 Nitrogen

Nitrogen is one of the nutrient elements assimilated from the soil (Voigt, 1985). It was apparently the first nutrient element to be specifically recognized as necessary for plant growth (Russel, 1983). It is now generally accepted that all life processes depend on nitrogen. Nitrogen is a constituent of purine, pyrimidine, porphyrin and coenzyme which are fundamental units in proteins, nucleic acids, the chlorophyll and metabolic enzymes. These together constitute 40 – 50 % of the dry matter in protoplasm. Its function as a vital constituent of chlorophyll and the enzymes thus underlines its central importance in all the metabolic processes in plants (Melillo *et al* 1989). It is thus needed in abundant supply for reproduction, growth and respiration. Trees need it mainly for wood production and protein synthesis in cells and seeds. Leguminous plants which possess Rhizobium bacteria in their nodules fix and use molecular nitrogen. Non-leguminous plants obtain their nitrogen supply mainly in the form of nitrates and ammonium ions from the soil.

Deficiency of nitrogen causes a considerable decrease in tree growth. It blocks chlorophyll synthesis, causes some reduction in size and premature senescence of leaves. The deficiency may also impede respiration through lack of substrate caused by depressed photosynthesis.

2.26.2 Phosphorus

Phosphorus derived from calcium phosphate in the soil is essential in the transfer of energy processes, and the growth of plants (Olson and Sommers, 1982, Turnera and Newman, 2005). It therefore plays a central role in tree growth. It forms an important constituent of every living cell. Nucleic acids are present in every plant cell, in all tissues and organs. Their content in leaves and leaf stalks reaches up to 1 % of dry matter, being higher in young leaves and meristematic regions than in older leaves and stalks. The greatest amount of nucleic acids are found in root tips, pollen and seed germs.

Trees, therefore require adequate supplies of phosphorus for the formation of reproductive organs, for cell division and cell structure, for seed germination and seedlings metabolism, and for root development. Phosphorus is thus a constituent of many organs and compounds of biological importance, without which plants cannot live or reproduce.

Deficiency or excess supply of phosphorus thus affects tree growth through its influence on stem elongation. Phosphorus deficiency lowers the rate of photosynthesis primarily by disturbing the phosphate bond energy transfer of ATP – ADP system which among other things disturbs the reductive carboxylation process in the chloroplasts (Vishmaiceand Ocha 1952).

2.26.3 Potassium

Potassium acts as an internal buffer of physiological processes in plants (Leigh, 1989). It is therefore very essential for healthy growth of plants. Potassium is associated with chlorophyll and amide formation, activation of certain peptide bonds in the course of protein biosynthesis. Potassium influences gaseous exchange by controlling the opening and closing of the stomata. Potassium apparently participate in phosphorus utilization by activating reactions and enzymes associated with ATP synthesis and breakdown. It increases osmotic pressure, favours the absorption of water and opposes wilting. Consequently, its deficiency increases transpirational losses.

Potassium sufficiency encourages development of strong root system and proper water regulation in plants (Nwoboshi, 2000). It increases resistance to pest, diseases and drought but delays seed maturing (Nwoboshi, 2000). Potassium deficiency results in rolling of leaves in teak, chlorosis and weakening of leaves and stunted growth. Generally, potassium deficiency slows down virtually all the biochemical processes associated with every aspect of plant metabolism. Plants grown in potassium deficient conditions are more prone to attack by various disease organisms.

2.26.4 Calcium

Calcium is essential for the maintenance of the structural and functional integrity of plant cell membranes. As calcium pectate, it combines with magnesium pectate to bind cellulose chain together as middle lamella in cell wall formation. Calcium is thus involved in cell wall stabilization. It is also intimately concerned in meristematic activities and especially in root development as it participates in cell division, cell elongation and the detoxification of oxalic acids0 (Nwoboshi, 2000). Calcium, thus promotes root growth through greater cell extension. Contrary to potassum, it retards the absorption of water, the permeability of the cytoplasmic membranes, viscosity, and elasticity of the protoplasm and therefore the water supply to the biocoiloids. These predispose the plant to increase transpiration and lower drought, heat and salt resistance.

Calcium is absorbed from the soil as calcium nitrate or calcium sulphate. Absence or acute deficiency of calcium causes structural disorganization of such important organoids of the cell as the cell membrane, nucleus and mitochondria, especially in the meristematic tissues (Nwoboshi, 2000). Death of the meristematic regions is usually the outward manifestation of calcium deficiency. Purnell (1958) cited in (Nwoboshi, 2000), Hacskaylo *et al* (1969), Nwoboshi (1973, 1978) found that calcium deficiency led to the disintegration of the terminal buds and their associated tissues. Nwoboshi (1973) found that calcium deficiency drastically reduced the size and complexity of the root systems, heights and dry matter production by the shoot.

2.26.5 Magnesium

Magnesium fulfils many important and essential functions in the vital processes of plants. Magnesium is involved in the formation of chlorophyll as a central constituent, and as magnesium pectate, it combines with calcium pectate to bind the cellulose chains together in the formation of cell walls. These make magnesium a pre-requisite for satisfactory course of photosynthesis and growth.

Magnesium is also indispensable as a constituent and activator of various enzymes involved in the phosphoric acid economy of plants, in the formation of carbohydrates, proteins, fats and vitamins. It is also involved in the transformation of sugars in respiration, oxidation of falty acids and the respiration breakdown of amino acids. Aikawa (1963) cited in (Nwoboshi, 2000), maintains that in protein synthesis, magnesium is necessary for the synthesis of DNA and RNA, and in the activation of all enzymes that catalyze the transfer of phosphate from ATP to a phosphate receptor or from a phosphorylated compound to ADP. Magnesium is thus involved in enzyme activation and energy transfer. It is also active in the formation of the phospholipids fraction of mitochondria (Mazelis and Stumpf 1956) cited in (Nwoboshi, 2000). Deficiency of magnesium often leads to functional and structural changes in the mitochondria, which in turn weakens or disraps the coupling of the oxidative phosphorylation processes and intensifies leaf respiration (Zaitseva 1965). Magnesium is thus, required by tree crops for photosynthesis, the cell division phase of growth and in the general metabolism since it activates more enzymes than any other element.

2.26.6 Sulphur

Sulphur is an essential constituent of three sulphur – bearing amino acids – cystein, methionine and cystine which are necessary for protein synthesis of sulphur – containing vitamins like biotin and thiamine and many proteins. Tree crops, therefore require sulphur for the synthesis of new protoplasm for the maintenance and repair of their tissues. Root nodule bacteria need sulphur for continued biological fixation of atmospheric nitrogen. Fruit and seed maturity is usually delayed in sulphur deficient plants.

Sulphur deficiency affects plant metabolism particularly protein synthesis. Amino acids and other soluble nitrogenous compounds tend to accumulate in the deficient tissues owing to some lag in protein synthesis. Lack of sulphur also prevents the fixation of atmospheric nitrogen by root nodule bacteria.

Consequently, members of the Leguminosale and Cruciferae are recognized as being especially dependent on sulphur (Baule and Fricker, 1970)

2.27. Perceived advantages of agroforestry systems

Multi-storied cropping system absorbs sunlight at all levels. Therefore, increased utilization of the above and below ground environment should result in an increase in total biomass production potential. The planting of crops that differ in light requirements, root development and height allows for more and efficient use of solar radiation, soil moisture and nutrients. Deep tree root take up soil nutrients and moisture that are out of reach of the roots of annual crops. Enhanced interception of solar radiation by the extension of leaves through a larger area results in higher levels of photosynthetic production.

Agroforestry practices contribute to the maintenance of soil fertility through enhanced nutrient cycling or nutrient pumping in agroforestry practices that use deep-rooted tree species (Pickergill, 1983, Glover and Beer, 1986). The concept of nutrient pumping in agroforestry is that tree roots extend into portions of the soil profile that may not be accessible to annual crop root systems, and that tree crops extract nutrients to above ground plant parts (i.e. leaves, branches, stem etc) and to a much larger root mass in the surface horizons (A and B horizons), Litter fall complete the nutrient translocation from lower soil horizon to the surface.

The main effects of trees on soil properties are a consequence of:

1. above –ground organic matter inputs through litter fall or pruning and
2. root system inputs to the soil. Nutrients released through the decomposition of tree litter and roots are a major perceived benefit of agroforestry systems, particularly when nitrogen-fixing trees are included in the mixture.

Other perceived advantages of agroforestry include:

- Contribute to the supply of firewood better than mono-cropping.

- Woody perennial 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 increased stability in food supply.

- Their effect on the environment is positive and lasting, reduce wind speed, create micro- climate favourable to crop and to animal/man.

- Woody perennials in agroforestry farming system are chosen not only because they give wood, they also provide many tannin, flowers, medicines, dyes 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 exchange by combining traditional experiences with advanced technologies, and by researching modern solutions that are compatible with the socio-cultural customs of the populations concerned.

2.28. Disadvantages of agroforestry

Inspite of the numerous benefits of agroforestry systems, there are some adverse effects or drawbacks of the systems. These negative effects equally deserve adequate attention.

Trees compete with annual crops for nutrients, space, sunlight and water or moisture and may significantly reduce the yields of the favoured food crops. Tree crowns often block out a large part of sunlight and the shallow roots of trees compete with food crops and pasture for water and nutrients. This drawbacks may, however, be minimized by the choice of deep rooted tree crops. Likewise, tree species with narrow crowns are likely to be less competitive in suppressing neighbouring vegetation and may also be more effective in light interception due to the large vertical crown depth (Karki, 1985). Some trees produce certain toxic substances in their roots or foliage and this could inhibit the establishment or growth of herbaceous vegetation. This phenomenon is known as allelopathy.

Trees could serve as habitats or hosts for pests or other organisms such as snakes, insects and fungi that could be very harmful to crops (Brils, *et al*, 1994). When in proximity to other crops, trees can provide a habitat for pests of all kinds. This is particularly true for trees and cereal combinations, where the cereals are attractive food for rodents, birds and insects. The presence of additional bird habitats in crop fields can result in increased bird damage to intended grain crops.

Likewise, homegarden as an agroforestry practice can provide an improved habitat for rodents, snakes, mosquitoes, tsetseflies and other insects and disease pests. Some pests of trees can also affect crops and vice versa. The micro-climate created by trees is usually humid. This climatic condition stimulates the growth of bacteria and fungi which may have a negative effect on the crop, the herbaceous vegetation and/ or the tree species.

There are also increased chances of mechanical damage by trees growing on a farmland. Tree branches, fruit or foliage may fall through wind, lightening, heavy rainfall or death. Such falls could cause serious damage to herbaceous vegetation. This situation is better appreciated on farms where crops such as cassava, yams and cocoyams are interplanted with trees. Mechanical damage to the tree species is potentially great during the early stages of the tree fuelwood production and is potentially more damaging to other associated crops as the trees grow larger and thinning or harvesting operations are required. Mechanization or tillage operations is also more difficult because of irregular spacing of tree and crop components.

There is also damage to tree and crop components from livestock. An agrosilvopastoral system, which integrates livestock, crops and trees have a potential for negative interactions among these components. Grazing animals often damage trees in silvopastoral plantations (Lewis *et al* 1984, Tsutsumi, 1986). This may be a serious problem when species with palatable foliage such as *Dalbergia sisso, Leucaena leucocephala*, or *Shorea robusta* are used.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1. The study area

Katsina State was selected as the study area for two main reasons. Firstly, it is one of the states in the north that have been threatened with the problem of desert encroachment; and secondly it is also one of the few states in the north that have embraced and actively participated in the use of agroforestry practices as one of the options in combating environmental degradation. The thrust of this research is to evaluate the use of agroforestry practices in the state with a view to ascertaining variation in adoption among the ecological zones and perceived benefits.

Katsina State lies on latitude 12^0N and longitude 8^0E. It is bounded in the north by Niger Republic, south by Kaduna State, east by Kano and west by Zamfara State (Figure 2).

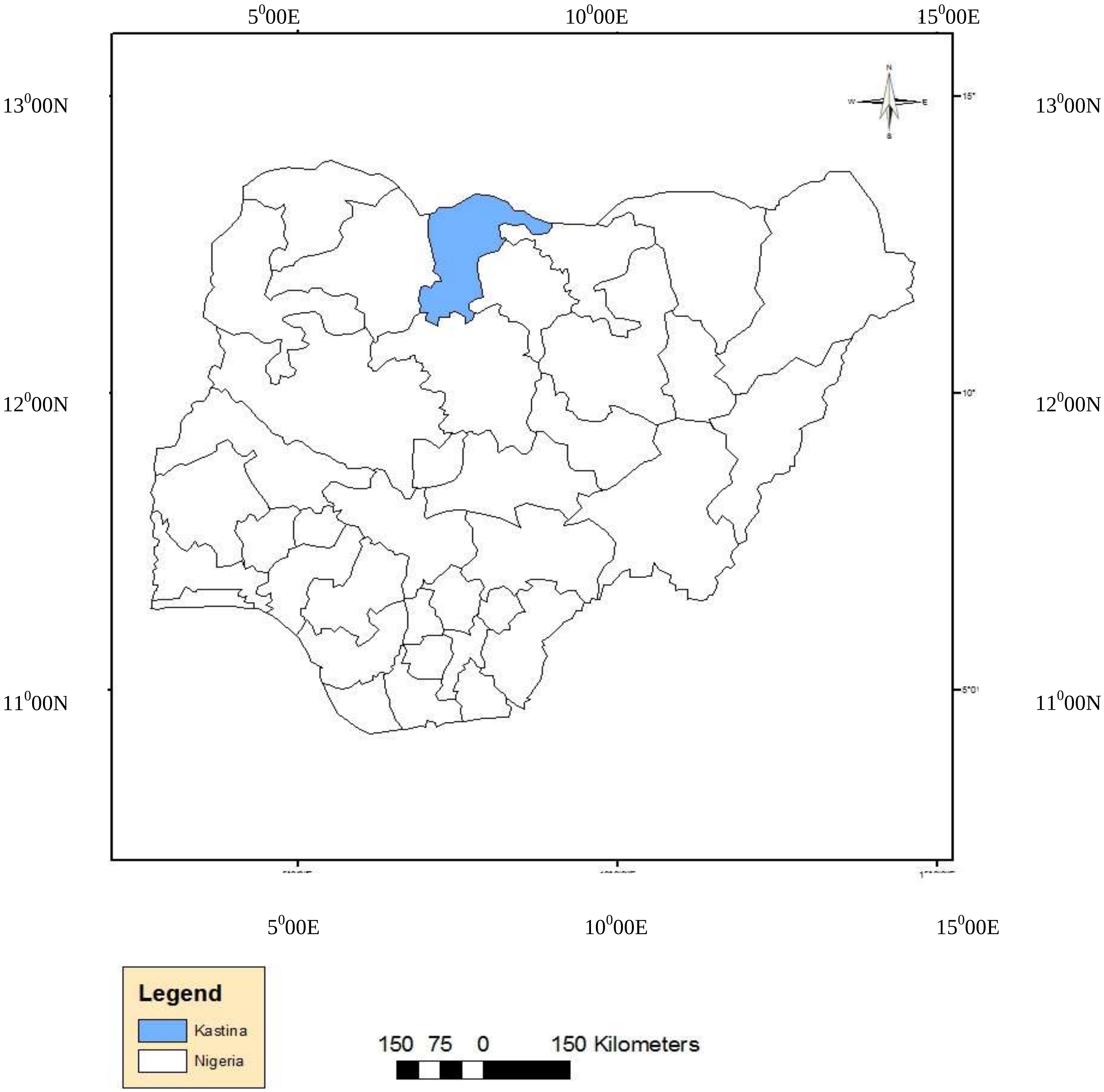

Figure 1. Map of Nigeria showing Katsina State.

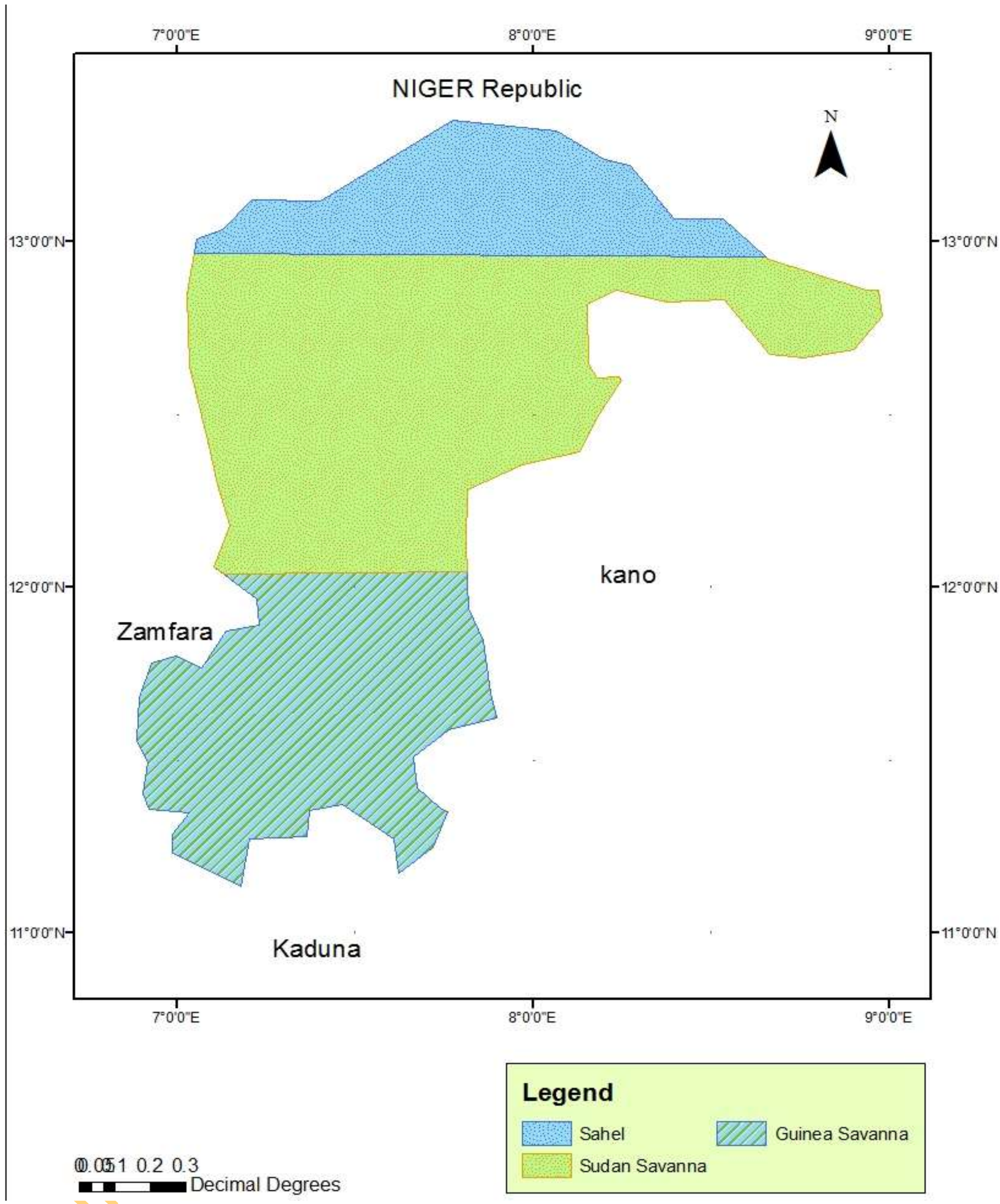

Figure 2. Map of Katsina state showing the three main Agroecological zones

3.2. Climatic and geomorphological description of the study area

Katsina State lay in the upper Sudan and lower sahel regions of Nigeria. Hence; it is removed from the moderating effect of the cool, humid Atlantic air mass. However, it is highly affected by the North Easterly Trade Winds (NETW) from the Sahara. The hot, dry and dust laden North East Trade wind predominates in this area for as long as 7 months of the year.

Rainfall is experienced in the state when the Inter-Tropical Front (ITF) moves northward in June following the onset of the rainy season in the south and upward movement of the overhead sun in March. The high pressure over the west and other southern parts forces the trade winds from the northern border of the country and thus, Katsina State and other states in the northern part of Nigeria receive rainfall.

Mean annual rainfall in the state varies from 1016 mm to 1143mm in the south and less than 635 mm in the North. The state on the whole has a mean annual rainfall of about 840mm. However, the rainfall is not uniformly distributed over the months. Overall, total rainy days are between 60 and 80 days experienced only between June and September each year. Most of the other months often record no rainfall.

Mean relative humidity is lower than 50 % in January and February and could be as high as 80 % in June – July. Temperature range is often from $38^0 – 41^0$C.

The entire landmass of Katsina State is composed of basement complex of pre-Cambrian era, which consists of meta-sediments that have been transformed into anatectic migmatites and granites.

3.3 Sampling procedure and sample size

3.3.1 Questionnaire surveys

Twenty-five % sampling intensity was adopted in the study. Thus, nine LGAs (three per agro-ecological zone) were randomly selected out of the 34 LGAs making up the state using stratified random sampling.

Accurate data on the actual population of the rural farmers in Kastina state were not readily available, therefore equal number of farmers (120 farmers) were randomly sampled from each of the agro-ecological zones through the use of random numbers. This gave a sample size of 360.

3.3.2 Soil sampling and collection technique

In Sahel Savanna, one agroforestry plot measuring 40 by 40m was selected in each of the 3 sampled Local Government Areas. In each sampled plot, thirty auger points were drilled at random to a depth of 30cm, using soil auger. The soil samples from the thirty auger points in each plot were pooled together and mixed thoroughly in a polythene bag. An appreciable quantity was transferred to another polythene bag, labelled and taken to the laboratory. Similar exercise was also carried out in the non-agro forestry plots, adjacent to each of these selected agro forestry plots. Soil samples were similarly collected from the other two agro-ecological zones. The soil samples were air dried at 30^0C and later ground to pass through a 2mm sieve and then put in well labelled polythene bags for laboratory analyses.

3.4 Analytical procedures for soil in the laboratory

This was carried out as explained below

3.4.1 Sample Preparation

Soil samples for total elemental analysis and total carbon were ground to pass through a 100R mesh. The samples were stored in a labelled screw-capped bottle and analyzed for elements.

Chemical determinations were made for the following:

1. Soil pH using glass electrode
2. Exchangeable cations and effective exchange capacity
3. Available phosphorus by $Bray_1$ method.
4. Total nitrogen by Micro kjeldahl method
5. Potassium by flame photometry
6. %age organic carbon by wet oxidation (Black and Walkley, 1934).

3.4.2 Soil pH

The soil pH was determined by mixing 20g of dried soil with 20ml of deionised water and allowed to settle at room temperature. The 1:1 soil-water mixture was titrated with 0.022 Ca $(0H)_2$ and stirred occasionally with a glass rod pH electrode used to determine the pH value of the soil (Min Liu *et al,* 2004).

3.4.3 Determination of exchangeable cations and effective cation exchange capacity (ECEC)

Soil exchangeable cations: Ca^{2+}, Mg^{2+}, K^+ and Na^+ were estimated by initial displacement of exchangeable cations with Barium acetate solution, followed by replacement of Barium with a known quantity of each exchangeable element with the excess solution of the added element measured (Rible and Quick 1960). ECEC (mol/kg) was calculated from the difference in the quantity of the added element and the amount formed in the resulting solution.

3.4.4 Available phosphorus

Solid phosphorus content in parts per million (ppm) was determined by $Bray_1$ method. A mixture of 5g soil and 15ml of extracting solution was centrifuged at 2000 revolution/minute for 15 minutes. 5ml of the supernatant was titrated with equal volume of ammonium molybdate solution. The %age transmittance of the resulting solution was measured at 660mμ wavelength, and the content of extractable soil phosphorus in (ppm) obtained by plotting and extrapolation of the Optical Density (OD) measurement against a standard solution with a range of 0-1 ppm (Betino *et al* 1991).

3.4.5 Total nitrogen

%age nitrogen content was determined by the Kjeldahl method. Briefly, 5 g of fried soil, 20 ml distilled water, a mercury catalyst , and 30 ml concentrated H_2S0_4 were heated in Macrokjeldahl flask. The content was distilled and an aliquot of the distillate titrated with 0.01N hydrochloric acid from which the %age nitrogen in the soil was estimated (Jones, 1991).

3.4.6 Potassium

Potassium in solution was determined by flame photometry using the Blackman flame photometer as was recommended by Jackson (1958) that intensity of radiation emitted when an element is introduced into a flame is

correlated with the concentration of that element.

The sample in solution was put in a small cup of atomizer to which was added a mixture of air and petrol (acetylene could also be used). The solution was then vapourised and at high temperature of the flame the salts vapourized. The vapour of the metal atoms were then excited by thermal energy to give the emission radiation which was measured photo-electrically after passing through a suitable filter.

3.4.7 Carbon and Organic Matter

Organic carbon was determined from the soil by the wet oxidation method of Black and Walkley (1934) Procedure: 1 gram of soil was weighed into a 500ml conical flask and 10ml of potassium dichloromate solution added to it. The flask was then swirled gently to effect the mixture of the reagents with the soil. $20cm^3$ of concentrated sulphuric acid was added rapidly while the swirling of the flask continued. The flask was left to stand for 30 minutes after which 100ml of water was added and the solution then allowed to cool. 0.5ml of barium diphenylamine sulphonate solution was added and the excess dichromate was titrated with ferrous ammonium sulphate solution.

Near the end point the colour became deep violet blue and at the end point, the colour changed to green sharply. A blank determination was made exactly as stated above but without the soil sample which served to standardize the iron (11) sulphate solution.

Calculation

$$\% \text{ oxidizable organic carbon (un-corrected)} = \frac{\text{blank titre - actual titre x 0.3m}}{\text{weight of oven dry soil sample in grams}}$$

Where m is the concentration of ammonium (II) sulphate solution.

The uncorrected result is expressed as %age organic carbon. Black-and Walkley, 1934) while it can also be expressed as total organic matter by multiplying the uncorrected result by a constant 1.729

3.5. Instrument for data collection (questionnaire survey)

A standardized interview schedule consisting of open and close ended questions was used to collect information on the study objectives. The instruments were used to identify the various agroforestry practices adopted by the rural farmers in Katsina State. The instrument was sub-divided into the following units.

i. Demographic characteristics such as age, ethnicity, marital status, gender, educational level, occupation , religion, among others.

ii. Non-demographic information comprised source of farm land, labour, farm location and size.

iii. Other agricultural activities such as production, types of crops and trees planted, estimated farm yield, estimated agricultural income, types of agroforestry practices, source of information and the perceived benefits of agroforestry practices.

iv. Soil analysis was conducted in the sampled plots.

v. Information was also obtained from agroforestry project coordinators, Director of Forestry, extension agents and zonal forestry officers in the state, through interactions with them and they provided other information on afforestation programmes in the state.

3.5.1 Validation of instrument

The instruments were presented to agroforesters, extension personnel, and other experts in farming systems who went through the items carefully so as to ascertain the appropriateness of the instrument by correcting/reconstructing or deleting where necessary in order to remove any ambiguity.

3.5.2 Test of reliability

A test-retest reliability study was carried out. This was conducted at a Local Government Area which was not part of the sample. The validated instrument was administered on sixty (60) randomly selected farmers in this local government twice within three weeks. The two sets of data were collected and correlated to obtain the reliability coefficient of 70% which was considered high enough to be accepted as reliable.

3.6. On-farm observation

In this study, some data were collected through on-farm visual assessment during guided visits to farms of some key informants. Information was obtained through personal observation and participation in some activities during visits to some of the farmers. The information obtained by personal observations and participation are generally more reliable and accurate. This is another means of confirming and validating information obtained through other methods/ techniques. The farms of nine randomly selected key informants were visited during the study (three farms per zone).

3.7. Collection of data

Trained enumerators were used in the administration of the instruments with the support of the extension agents in the selected zones. The interview normally took place after the farmers might have finished their day's work on the farm and were relaxed in their houses. A total of 360 questionnaires were administered. All these were collected after the respondents had satisfactorily given information which were correctly recorded.

3.8. Measurement of variables

The independent variables of the study such as marital status, gender, occupation, religion and source of farmland were categorized and measured at the nominal level. The educational levels are ordered hierarchically for the respondent to indicate his/her attainment. Age, farm size and farm income were measured at the interval level i.e. the years, hectares and naira. The estimate for the farm income was calculated by multiplying the actual quantity of the farm produce with the prevailing market price.

Attitudes of the farmers to the use of agroforestry practices were measured by adding together the scores of reaction of positive and negative statements on a three point Likert scale. A total of eight attitudinal statements were contained in the instrument resulting in 24 and 8 points as the maximum and minimum possible scores respectively. Farmers' use of agroforestry practices was determined by summing up the number of such practices used by the farmers in an array of practices listed in the instrument used. A list of benefits that could be derived from the use of agroforestry practices is presented for the farmers to select the ones applicable to them, this was categorized into: Yes, No and Undecided.

Soil chemical analysis was also carried out in the laboratory using standard methods as earlier described.

3.9. Statistical analyses and data presentation

The data obtained from the study were collated and analysed. Descriptive statistics like frequencies and %ages were used to describe the variables and their occurrence among the respondents. Means was also employed as a measure of central tendency for variables measured at interval levels. Tables and graphs were equally used.

3.10. Statistical models for the study

The data were subjected to statistical analysis to facilitate drawing up of some conclusions. Thus, some statistical techniques were employed for analyses. The techniques used included

(i) **Pearson Product Moment Correlation (PPMC)**

Correlation analysis measures the strength or the degree of linear association between two continuous variables. The real concern is the correlation coefficient (r) which is computed thus:

$$r = \frac{\Sigma(X - \overline{X})(Y - \overline{Y})}{\sqrt{\Sigma\left(X - \overline{X}\right)^2 \Sigma\left(Y - \overline{Y}\right)^2}}$$

Where:

r = is the correlation coefficient

Σ = Summation sign

X & Y = are the variables of interest and

$\overline{X}$ & $\overline{Y}$ are their respective means.

(ii) **Chi-square**

Analysis was also used to test relationship when the demographic characteristic is measured at nominal level, i.e. to test the respondents demographic characteristics and the use of agro forestry practices. The Chi-square statistics (χ^2)is given as:

$$\chi^2 = \sum \frac{(F_o - F_e)}{F_e}$$

Where χ^2 = Chi – square

Σ = Summation

F_o= Observed frequencies of demographic characteristics and

F_e = Expected frequencies of the demographic characteristics.

(iii) **Partial Correlation Analysis**

This measures the relationship between any two variables when all other variables connected with the two are kept constant. This technique is used to control for the effect of zonal variation on the result derived from the use of PPMC.

It is computed thus:

$$rXY_Z = \frac{rxy - (rxz)(ryz)}{\sqrt{(1 - r^2xz)(1 - r^2yz)}}$$

Where x and y are the deviations of variables of interest from their respective means while z is the variable held constant (zone).

(iv) **Analysis of variance (ANOVA)**

Analysis of variance is a technique used to compare two or more groups in terms of their mean scores on a continuous dependent variable. ANOVA assumes that values of a variable are made up of two components.

- The 'true' value of the measurement also called Explained sum of Squares (ESS).

- The 'error' component, also called the Residual Sum of Squares (RSS). ANOVA calculates separately the variance estimate of both the 'true' and error components by the formula:

$$\text{Variance Estimate} = \frac{\sum x^2 - \frac{(\sum X)^2}{N}}{N-1}$$

Where: X = variable of interest

Σ = Summation sign

N = Sample size

Further, the F-ratio is then computed:

$$F = \frac{\text{Variance estimate (true)}}{\text{Variance estimate (error}}$$

$$= \frac{ESS/df}{RSS/df}$$

Where df = degree of freedom.

3.11. Testing of hypotheses

The dependent variable is the perceived benefits of agroforestry practices while other variables like age, gender, marital status, education, and so on are considered independent in the study. The hypotheses were tested at 0.05 level of significance.

CHAPTER FOUR

4.0. RESULTS

4.1. Respondents gender

The demographic and socio-economic characteristics of the respondents are believed to affect their role in agroforestry practice in the state. Results of gender distribution among respondents in the study area revealed that the males are more involved in agroforestry practices than their female counterparts (Figure 3).

4.2. Age of respondents

Most of the respondents In the Sahel and Sudan Savanna, were between 30 and 49years (Figure 4). While in the Guinea savanna, majority of the respondents was 60 years or more. The age distribution is an important factor in farming activities because it affects the work force and decision-making in farming activities. The dominant age bracket among rural dwellers (30 – 49 years) in Sahel and Sudan and $\geq$ 60 years in Guinea savanna was indication that this was the age bracket that was actively involved in agroforestry practices.

4.3. Marital status of respondents

Majority of the respondents in the three agro-ecological zones was married men and women. Most marriages were polygamous and had an average of more than five children that provided labour force for farming. Figure 5 shows that 93.3 % of the respondents were married, 4.2 % were single, 0.8 % divorced and 1.7 % widowed.

4.4. Number of wives of the respondents

Figure 6 shows that majority of the respondents (96.3) across the zones had between 1 to 3 wives, 26.3% of the respondents had between 4 and 6 wives and 10.0% had between 7 and 9 wives while those who had between 4 to 6 wives were on the average 5.8 % across the zones.

4.5. Number of children of the respondents

Figure 7 indicates that respondents that had between one to six children were more in the Guinea savanna (70.5%) than in the sahel (70.0%) and Sudan (60.5%). Respondents with between 7 to 12 children were more in Sudan (40.0%) followed by Guinea (30.5%). Respondents with more than 19 children had the least percentage across the zones.

4.6. Religious affiliation of the respondents

Figure 8 reveals that about 92 % of the respondents were Muslims, 4.6% were mixture of Islam and Traditional religion, 2.6 % and 0.9 % Christians and traditional worshippers respectively.

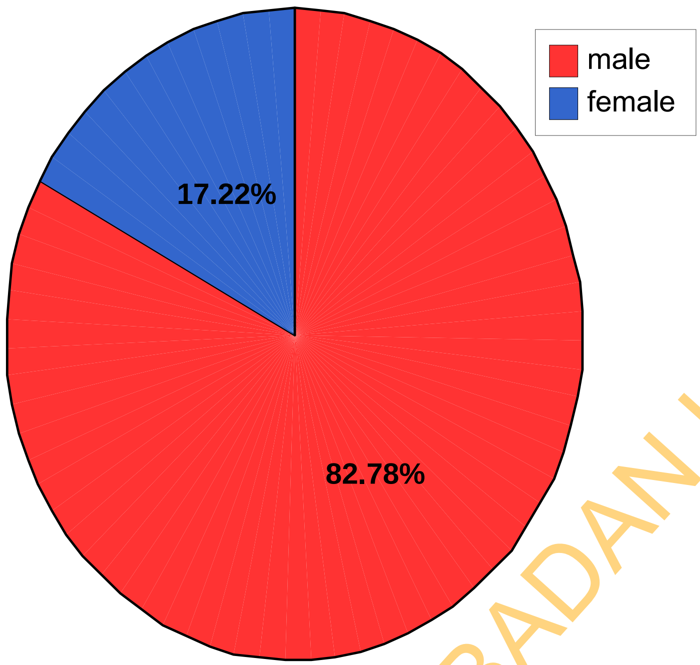

Fig 3: Distribution of respondents by Gender

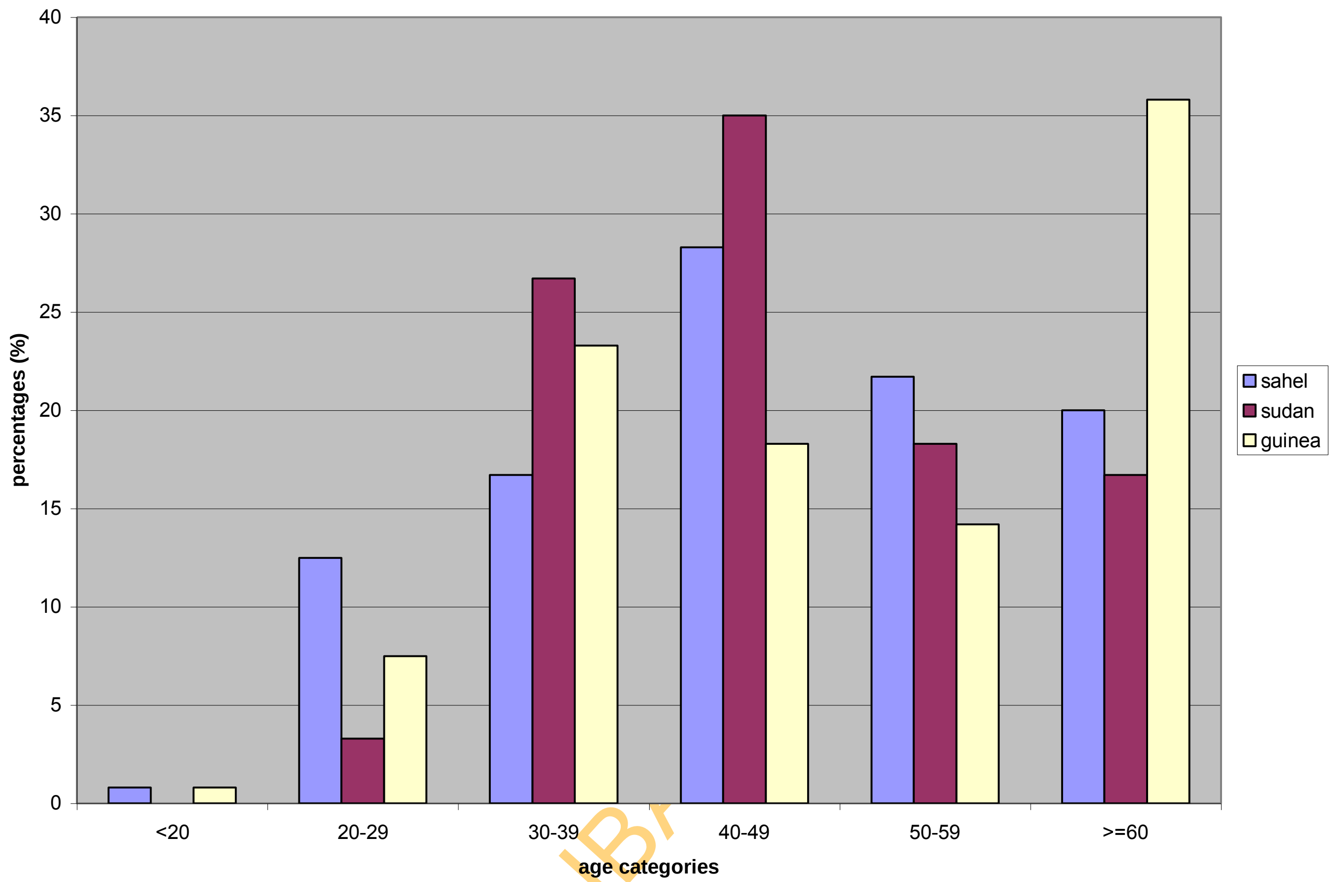

Fig 4: Distribution of Respondents by Age

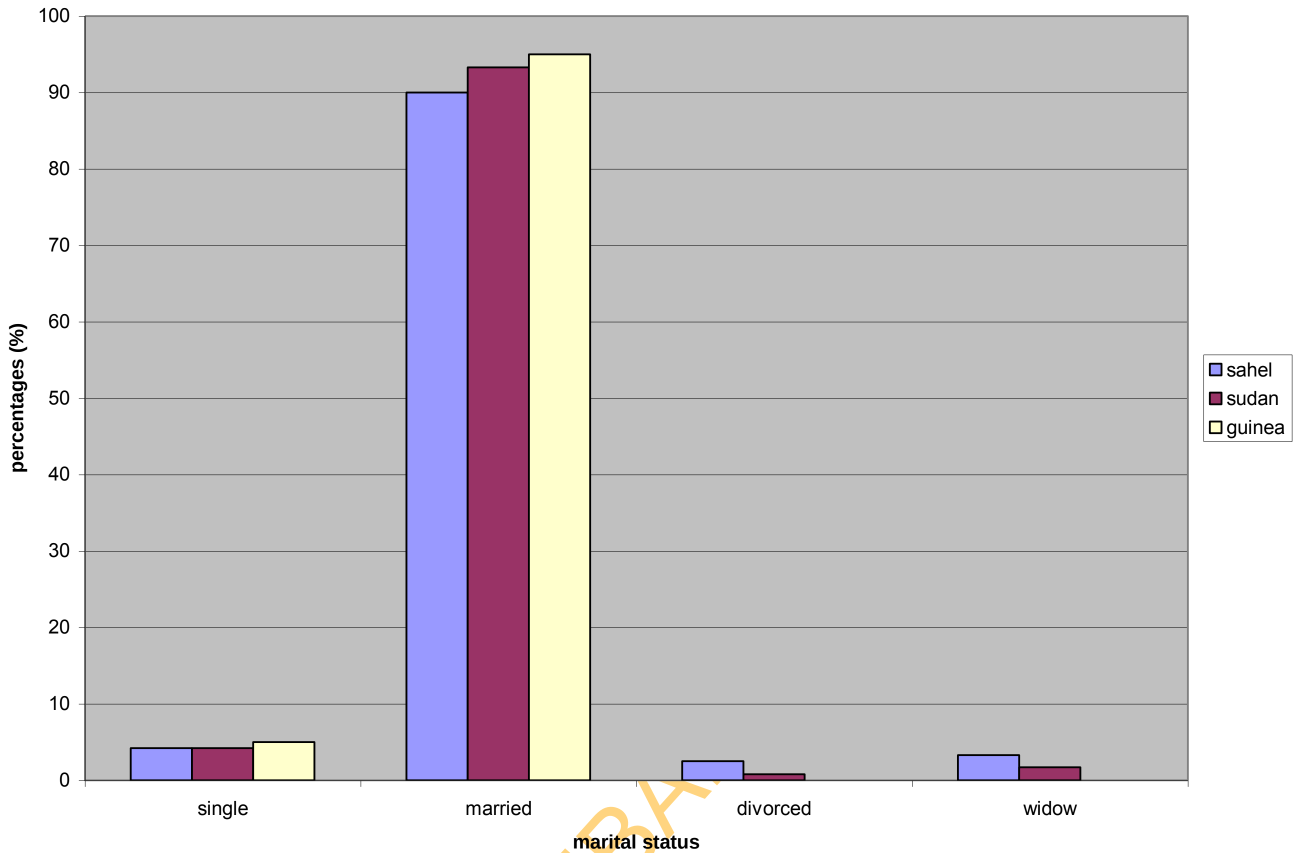

Fig 5: Distribution of Respondents by Marital Status

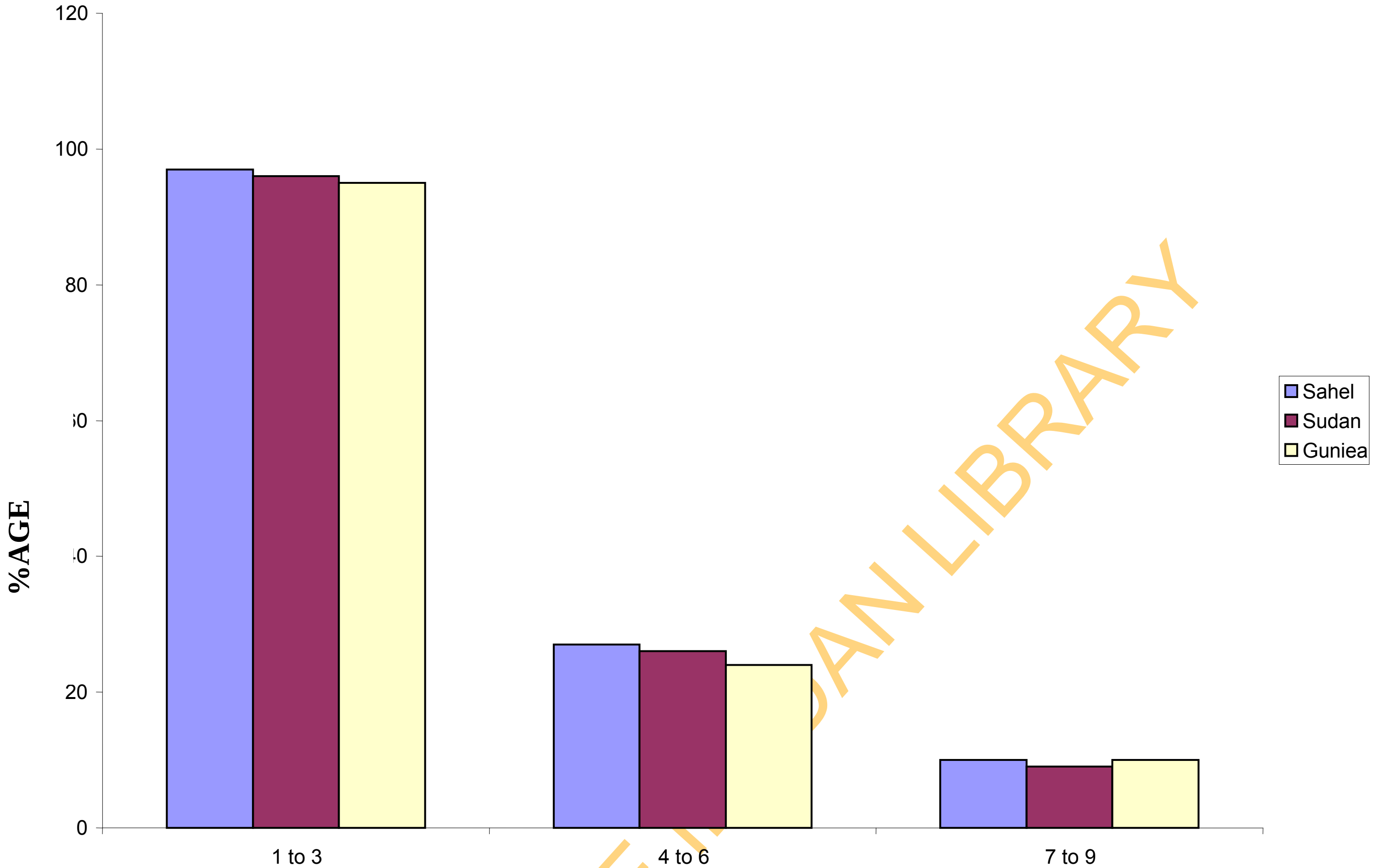

Fig 6: Number of wives

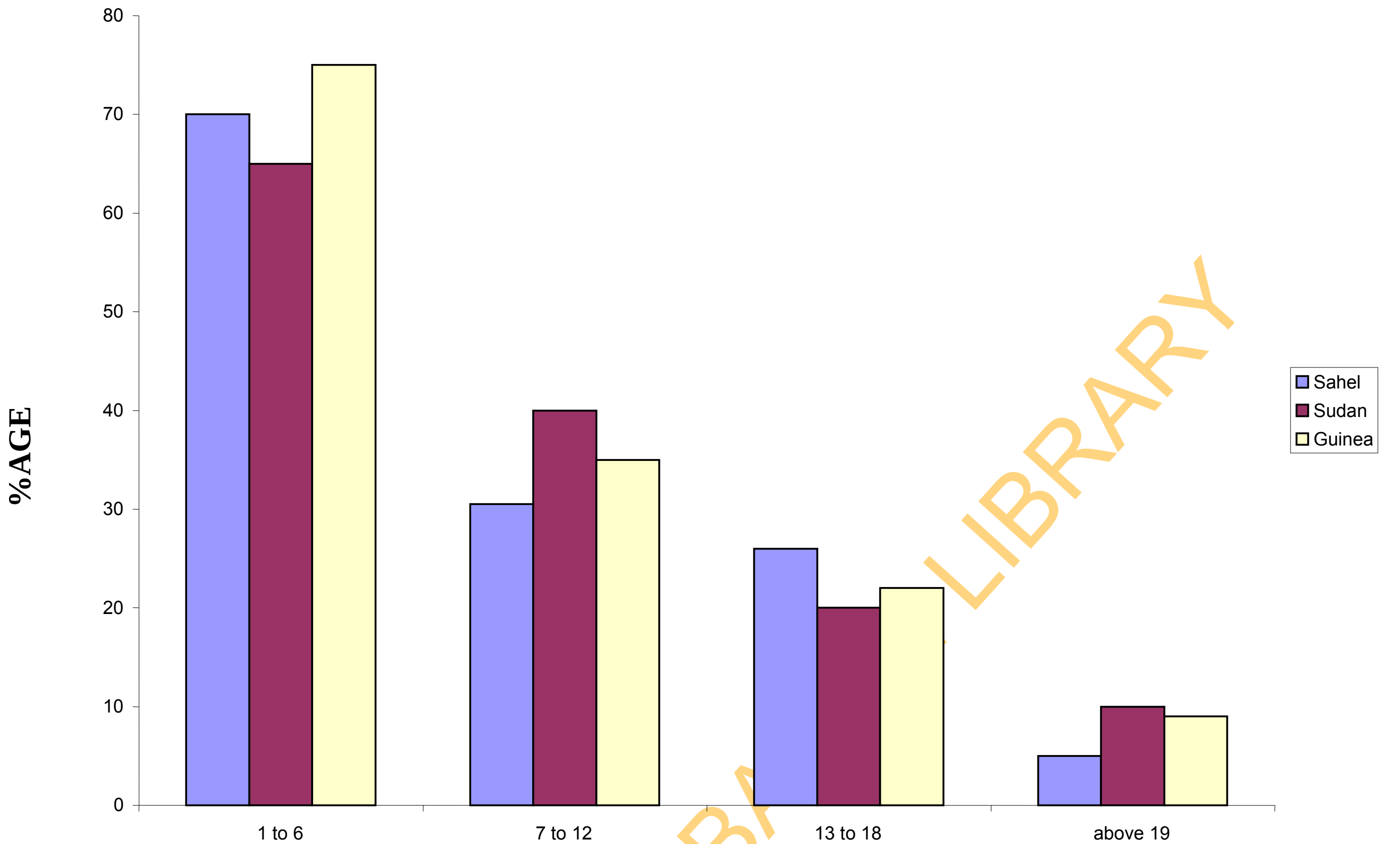

Fig 7: Number of Children

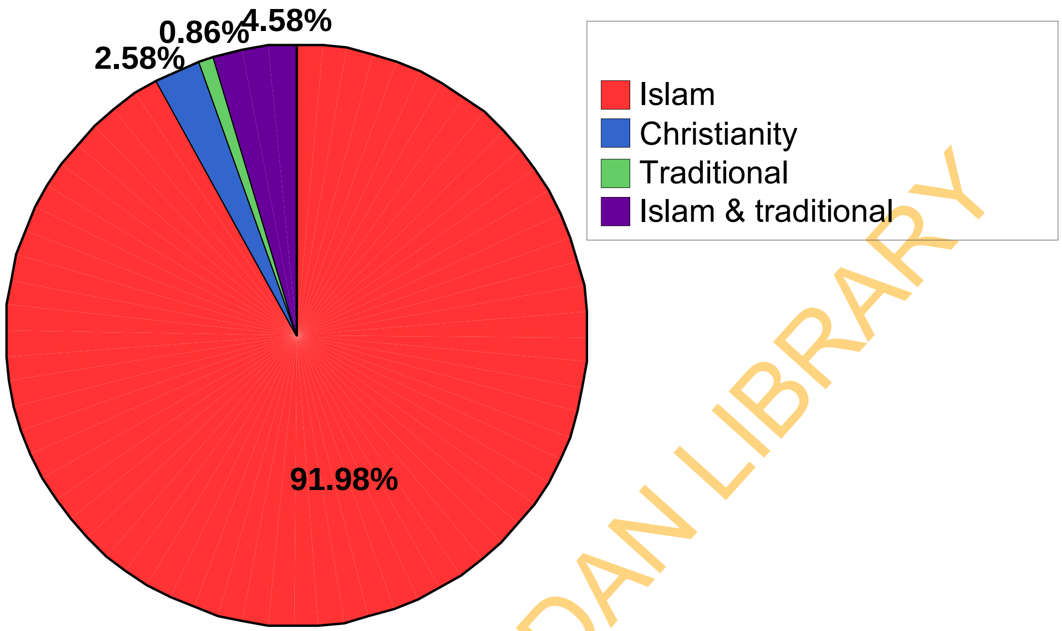

Fig 8: Respondents Distribution according to Religion

Educational status of the respondents

As shown in figure 9 majority of the respondents acquired Islamic education as their highest educational attainment. On average, it represented 41.0 % across the three zones. This was followed by primary education with 17.9 %.

4.7. Major occupation of respondents

Frequency analysis of the respondents (Figure 10) revealed that farming was the major occupation in the three agro-ecological zones of the study area. The study revealed that an average of 66.1 % of the respondents as farmers. Other occupation in the study area included trading, civil service, fishing and cattle rearing among others.

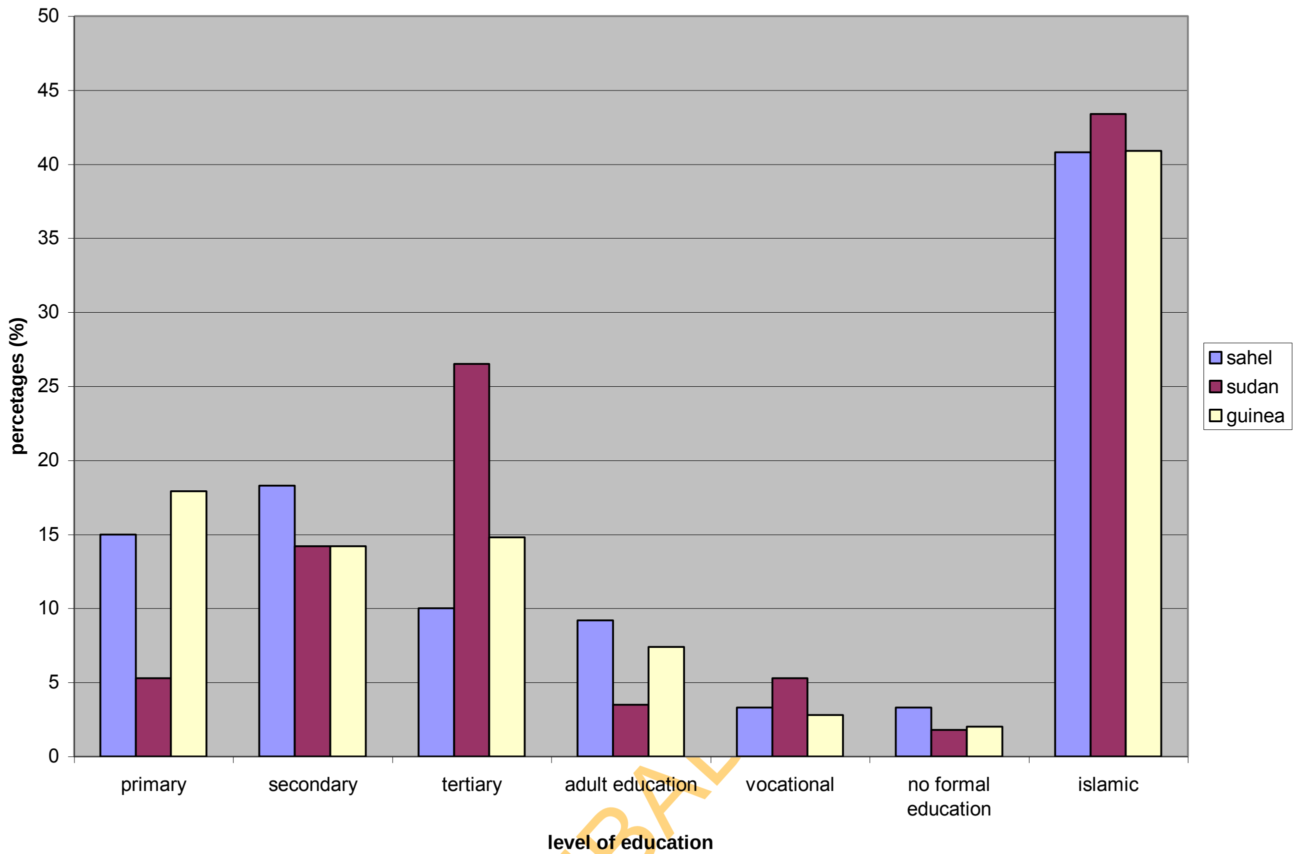

Fig 9: Distribution of Level of Education of Respondents

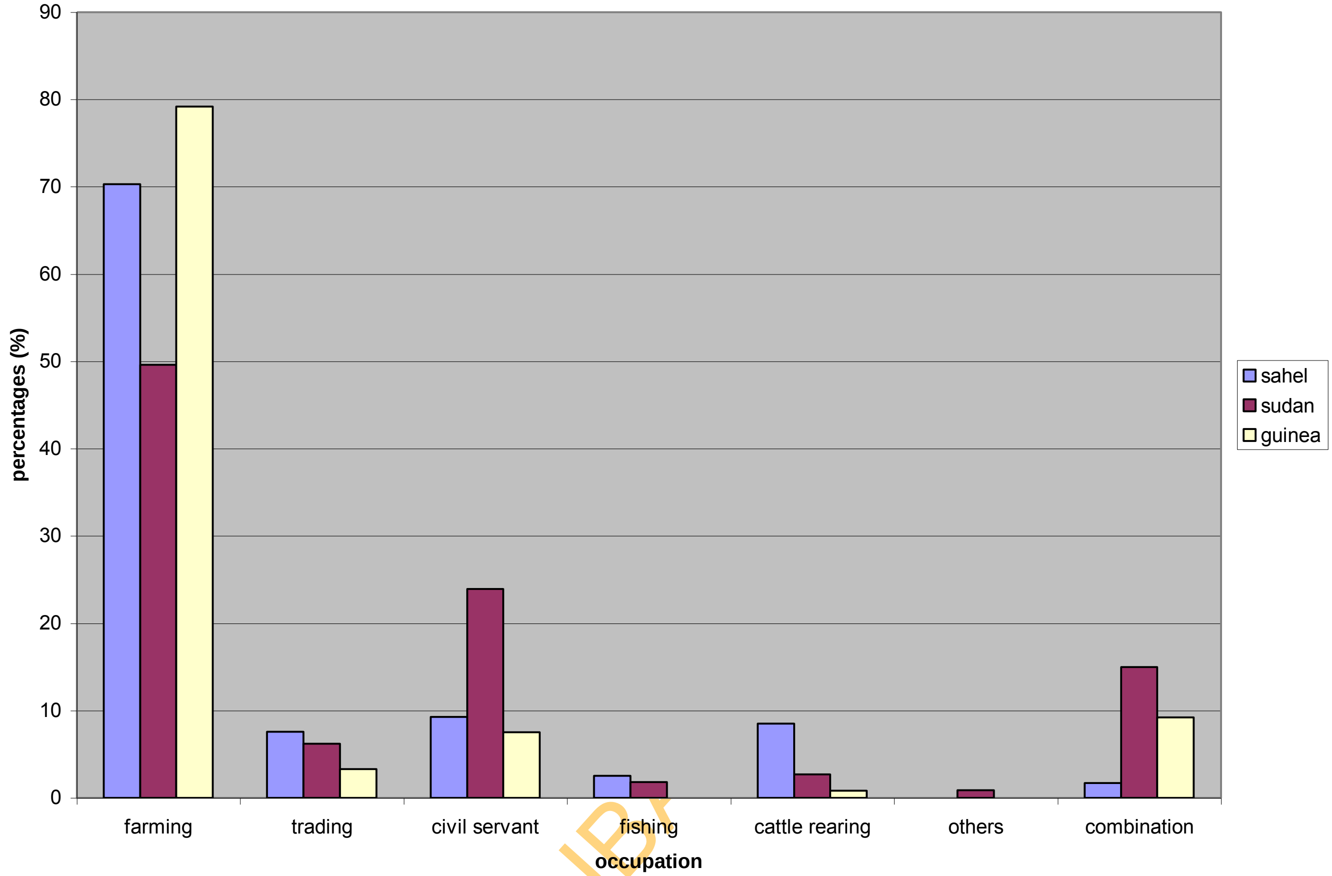

Fig 10: Distribution of Respondents according to Occupation

4.8. Respondents' annual farm size

On the average, more than half of the respondents (59.7%) had farm sizes of 1 – 4 hectares (Table 3). This confers a low income status on farmers who farm mainly for household consumption and so earn very little income, and thereby continue to live in abject poverty.

Table 3: Respondents' annual farm size

Annual Farm Size (ha)	**Sahel**		**Sudan**		**Guinea**		**Mean**
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**%**
1 -2	61	(50.8)	19	(15.8)	34	(28.3)	(31.6)
3 – 4	27	(22.5)	29	(24.2)	45	(37.5)	(28.1)
5 – 6	11	(9.2)	23	(19.2)	25	(20.8)	(16.4)
> 6	21	(17.5)	49	(40.8)	16	(13.3)	(23.9)
Total	120	(100)	120	(1000)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.9. Respondents' tenural pattern

The study revealed that on the average more than half of the respondents (51.1%) acquired their farmlands through inheritance. (Table 4). Others 12.5; 3.6 and 2.2% of the respondents acquired land through purchase, rental or government respectively. In addition 28.9% of the respondents acquired their land through a combination of two or more of these.

Table 4: Respondents' tenural pattern

Land Tenure Types	Sahel		Sudan		Guinea		Mean	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Inheritance	71	(59.1)	43	(35.8)	70	(58.3)	61	(51.1)
Purchase	27	(22.5)	9	(7.5)	9	(7.5)	15	(12.5)
Rent/Lease	7	(5.8)	5	(4.2)	1	(0.8)	4	(3.6)
Gift	2	(1.7)	1	(0.8)	3	(2.5)	2	(1.7)
Government	8	(6.7)	-	-	-	-	3	(2.5)
Combination	5	(4.2)	62	(51.7)	37	(30.8)	35	(28.9)
Total	120	(100)	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.10. Respondents' annual income from agriculture

Figure 11 shows that on the average 31.4 % of the respondents earned an annual income of less than N10,000.00; while 33.1% earned between N30,000.00 and N40,000.00. The study revealed that farmers generated little income from agriculture because they farmed primarily for household consumption with very little for sale.

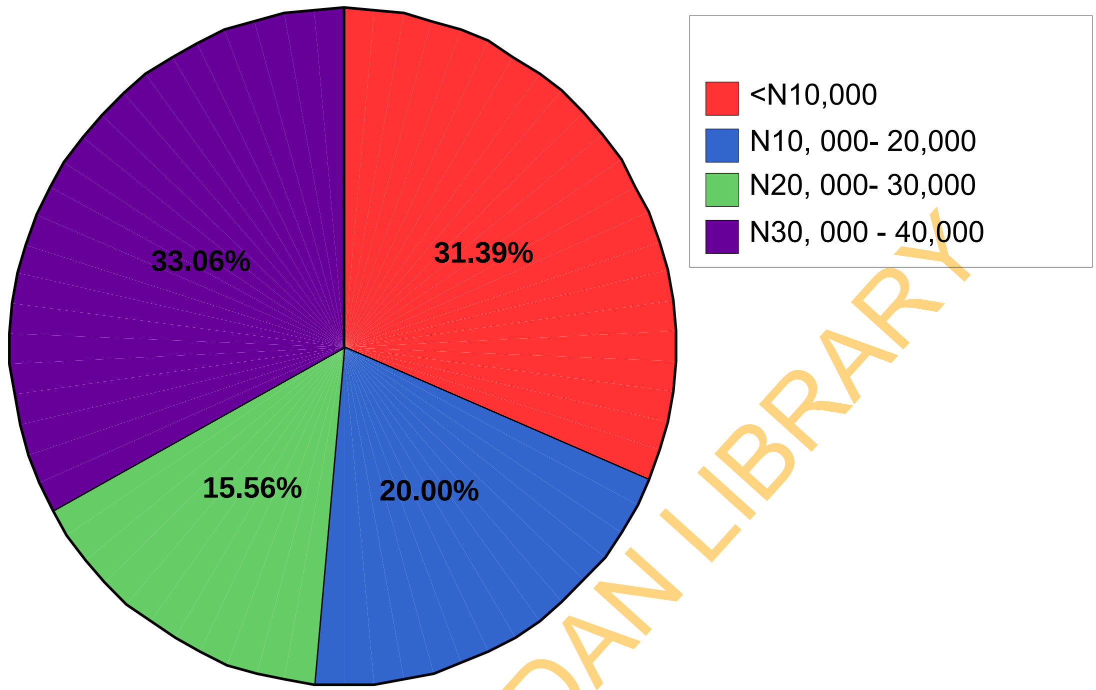

Fig 11: Distribution of Respondents Annual Farm Income

4.11. Respondents' number of farm locations

Figure 12 shows that 67.5 % of the respondents had their farms in 1-4 locations/places, 20.0% had theirs in 5 – 8 places while 12.5 % had theirs located in 9 – 12 places.

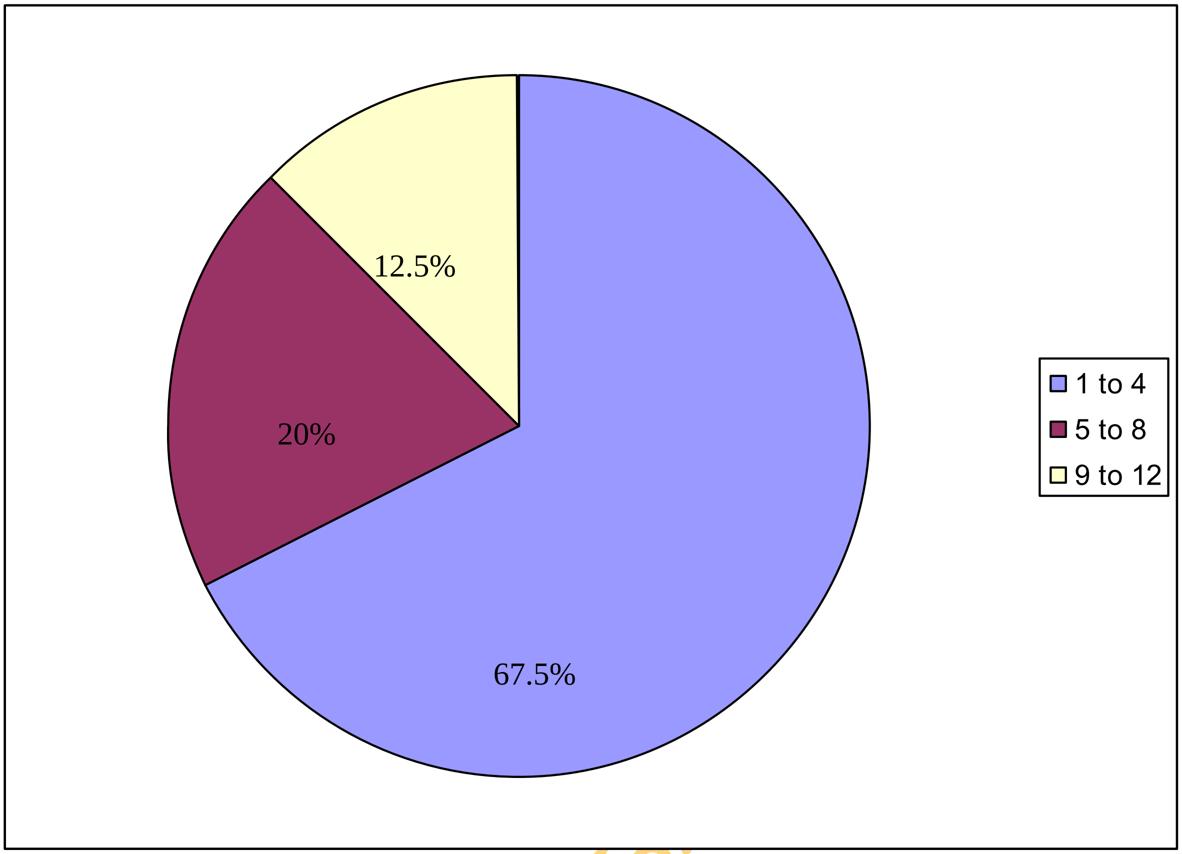

Fig 12: Distribution of Respondents according to number of Farm Locations

4.13. Major farm produce

Table 5 shows that majority (71.9%) of the respondents were involved in food crop production. On average, 9.1% reared animals, while 2.2% planted tree crops such as *Azadirachta indica, Parkia biglobosa, Adansonia digitata* and a combination of two or more of these.

Table 5: Major farm produce by the respondents

Major Farm Produce	Sahel Freq.	Sahel %	Sudan Freq.	Sudan %	Guinea Freq.	Guinea %	Mean %
Food Crops	91	(75.8)	64	(53.3)	104	(86.7)	(71.9)
Livestock	14	(11.6)	9	(7.5)	10	(8.3)	(9.1)
Tree Crops	5	(4.2)	2	(1.7)	1	(0.8	(2.2)
Timber Crops	2	(1.7)	-	-	-	-	0.6
Combination	8	(6.7)	45	(37.5)	5	(4.2)	(16.1)
Total	120	(100)	120	(100)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.14. Food crops grown by respondents

Table 6 shows the food crops grown by the respondents. They included maize, rice, cowpea, sorghum and millet. These crops were mostly grown as mixed cropping. Among the crops grown, millet was the most favoured by farmers across the three agro-ecological zones of the state. This was followed by maize and sorghum respectively.

Table 6: Food crops grown by respondents

Important Food Crops	**Sahel**		**Sudan**		**Guinea**		**Mean**
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**%**
Maize	16	(13.3)	10	(8.3)	1	(0.8)	(7.5)
Rice	12	(10.0)	-	-	-	-	(3.3)
Cowpea	5	(4.2)	2	(1.7)	2	(1.7)	(2.5)
Sorghum	7	(5.8)	7	(5.8)	2	(1.7)	(4.4)
Millet	69	(57.5)	25	(20.8)	47	(39.1)	(39.2)
Others	-	-	1	(0.8)	2	(1.7)	(0.8)
Combination	11	(9.2)	75	(62.5)	66	(55.0)	(42.2)
Total	120	(100)	120	(100)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.15. Livestock reared by respondents

Table 7 shows that goats were the most favoured livestock reared by the respondents across the three agro-ecological zones of the study area. On the average, goat production accounted for 26.1% while sheep and cattle had 12.5% and 11.9% respectively. Poultry and pig production was very low in the study area, particularly pig production that almost had zero %.

Table 7: Livestock reared by respondents

Important Livestock	**Sahel**		**Sudan**		**Guinea**		**Mean**
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**%**
Poultry	6	(5.0)	5	(4.2)	1	(0.8)	(3.3)
Cattle	26	(21.7)	12	(10.0)	5	(4.2)	(11.9)
Sheep	28	(23.3)	11	(9.2)	6	(5.0)	(12.5)
Goat	51	(42.5)	12	(10.0)	31	(25.8)	(26.1)
Pig	1	(0.8)	-	-	-	-	(0.3)
Combination	8	(6.7)	80	(66.6)	77	(64.2)	(45.9)
Total	120	(100)	120	(100)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.16. Scale/level of farming

Figure 13 shows that most of the respondents were engaged in subsistence farming which was mainly for household consumption and very little for sale. majority (77.5%) of the respondents were involved in subsistence farming, while only 22.5 % were large scale farmers.

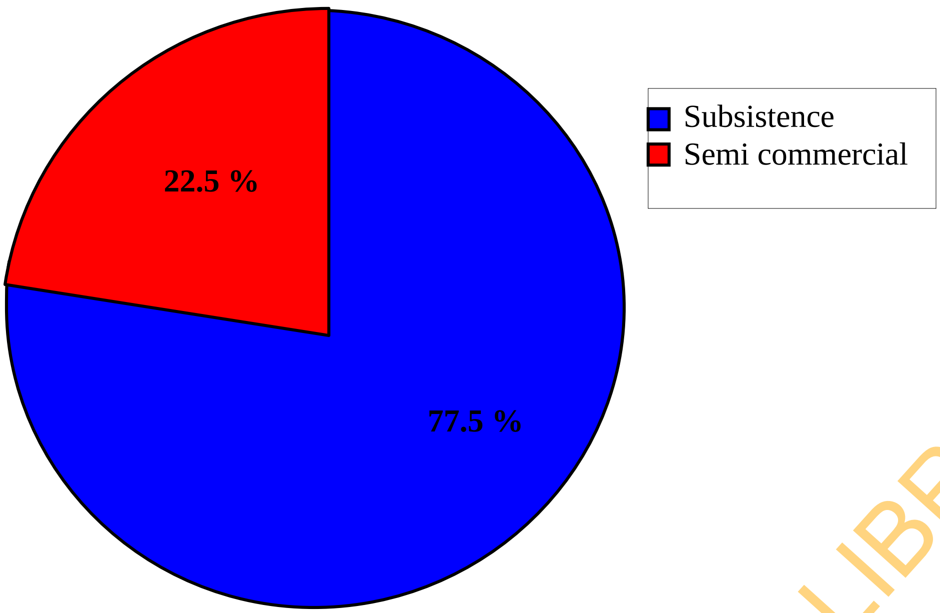

Fig 13: Distribution of Respondents according to Scale of Farming

4.17. Involvement of respondents in the use of agro-forestry practices

Based on the list of agro-forestry practices identified by ICRAF, Nair, (1990), some agro-forestry practices that were adopted in the study area were selected and the respondents were made to react to the practices, that is, their involvement in the use of any of the practices. The responses were classified into five: do not practise, practised but stopped, practise occasionally, practised but do not intend to continue, and practise regularly. Plate 1 shows a typical farm land with multipurpose trees.

Table 8: Respondents Adoption of Multipurpose Trees on Farmland

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	4	(3.3)	15	(12.5)	7	(5.8)
Practised but Stopped	0	(0)	10	(8.3)	3	(2.5)
Practise Occasionally	6	(5.0)	8	(6.7)	5	(4.2)
Practised but do not Intend to Continue	0	(0)	12	(10)	5	(4.2)
Practise Regularly	110	(91.7)	75	(62.5)	100	(83.3)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

Plate 1: A Typical Multipurpose Trees on Farmland in Katsina State. Here *Azadirachta indica*, *Eucalyptus* sp and *Parkia biglobosa* are randomly mixed with Sorghum.

4.18. Adoption of multipurpose trees on farm-land by respondents.

Table 8 indicates that majority of the respondents had adopted this system across the zones. The highest was Sahel savanna with 91.7 %, followed by Guinea savanna (83.3%) and Sudan (62.5%). Farmers who had never practised at all, practised but stopped, practised occasionally or practised but did not intend to continue were negligible.

4.19. Adoption of homegardens

Table 9 shows that majority of the respondents in Sahel and Guinea savanna had never practised home gardens, with 54.2% each. Those farmers had adopted the system were relatively few, (Sahel 35.0%, Sudan savanna 20.8%, Guinea savanna 18.3%), while those who had practised but stopped, practiced occasionally or practised but did not intend to continue recorded very low scores. Plate 2 shows a typical homegarden in the Sudan savanna area of Katsina state.

Table 9: Respondents' Adoption of Home gardens

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	65	(54.2)	48	(40)	65	(54.2)
Practised but Stopped	0	(0)	32	(26.7)	0	(0)
Practise Occasionally	13	(10.8)	10	(8.3)	33	(27.5)
Practised but do not Intend to Continue	0	(0)	5	(4.2)	0	(0)
Practise Regularly	42	(35.0)	25	(20.8)	22	(18.3)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

Plate 2: A Typical Homegarden in the Sudan Savanna Area of Katsina State.(crops grown here include: *Citrus spp, Mangifera indica, Psidium guajava,* palms, *Eucalyptus* spp and some ornamentals.

4.20. Adoption of improved fallow in shifting cultivation

Table 10 shows that in Sahel savanna, majority (71.7%) of the respondents had never adopted improved fallow as an agro-forestry practice. Whereas in the Sudan and Guinea savanna zones, the respondents that had never adopted the practice were few (Sudan savanna 8.3, Guinea savanna 16.7%). Conversely, those that had adopted the practice in Sudan and Guinea savanna zones recorded very high scores (Sudan savanna 87.5 % and Guinea savanna 80.8%). Nevertheless, the respondents in Sahel savanna recorded low scores in adoption with 25 %. Across the zones, there were no respondents who either practised but stopped, or practised but did not intend to continue.

Table 10: Adoption of improved fallow in shifting cultivation

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	86	(71.7)	10	(8.3)	20	(16.7)
Practised but Stopped	0	(0)	0	(0)	0	(0)
Practise Occasionally	4	(3.3)	5	(4.2)	3	(2.5)
Practised but do not Intend to Continue	0	(0)	0	(0)	0	(0)
Practice Regularly	30	(25)	105	(87.5)	97	(80.8)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.21. Adoption of *Taungya* System

Table 11 indicates that majority of the respondents across the zones had not adopted *Taungya* system of agro-forestry (Sahel savanna 91.7%, Sudan savanna 87.5% and Guinea savanna 81.7%). Only very few of the respondents had adopted the *Taungya* system of agro-forestry. (Sahel 5.0, Sudan savanna 8.3 and Guinea Savanna 15.0%). No farmer had adopted the system but stopped practising it across the zones.

Table 11: Respondents' adoption of *Taungya* system

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	110	(91.7)	105	(87.5)	98	(81.7)
Practised but Stopped	0	(0)	0	(0)	0	(0)
Practise Occasionally	4	(3.3)	0	(0)	0	(0)
Practised but do not Intend to Continue	0	(0)	5	(4.2)	4	(3.3)
Practise Regularly	6	(5.0)	10	(8.3)	18	(15.0)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.22. Adoption of Woodlots

Table 12 shows that about 55.0 % of the respondents in Sahel savanna had adopted woodlot system which was the highest across the zones, thus was followed by Sudan savanna with 50.0%, and Guinea savanna with 44.2%. Those that had never adopted the system were 37.5 % in Guinea savanna, 35.0 % in Sahel savanna, and 26.7% in Sudan savanna. Plate 3 shows woodlots established by farmers in Sahel savanna zone of Katsina state.

Table 12: Respondents' adoption of woodlots.

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practice	42	(35)	32	(26.7)	45	(37.5)
Practised but Stopped	0	(0)	18	(15.0)	7	(5.8)
Practise Occasionally	0	(0)	10	(8.3)	15	(12.5)
Practised but do not Intend to Continue	12	(10.0)	0	(0)	0	(0)
Practise Regularly	66	(55.0)	60	(50)	53	(44.2)
	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

Plate 3: Woodlots established by farmers with the assistance of EU/KTSG to meet farmers' wood and fodder need. The tree-crops such as *Azadirachta indica* and *Parkia spp* were planted behind the food crops (maize and sorghum)

4.23. Adoption of border planting

A distribution of the respondents according to adoption of border planting as shown in Table 13 indicates that majority of the respondents had never adopted the system across the zones (Sahel savanna 81.7, Sudan savanna 74.2 and Guinea savanna 91.7%). No respondent adopted the system but stopped practising it. Sudan savanna recorded the highest number of adopters with 18.3 %, followed by Sahel savanna (10.0%), while Guinea savanna recorded only one adopter (0.8%). Plate 4 shows a typical border planting where farmers planted trees along the boundaries of land they have inherited or bought and intend to build a house on.

Table 13: Respondents' adoption of border planting.

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	98	(81.7)	89	(74.2)	110	(91.7)
Practised but Stopped	0	(0)	0	(0)	0	(0)
Practise Occasionally	0	(0)	5.0	(4.2)	9	(7.5)
Practised but do not Intend to Continue	10	(8.3)	4	(3.3)	0	(0.0)
Practise Regularly	12	(10.0)	22	(18.3)	1	(0.8)
	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

Plate 4: Border Planting: Here farmers plant trees along the boundaries of land they have inherited or bought on which they intend to build a house. Such planted trees are used as markers and for firewood. Tree crops here include; *Accasia spp, Eucalyptus spp, Dalbergia sisso* and *Cassia alata.*

Table 14: Adoption of windbreaks or shelterbelt by respondents.

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practise	39	(32.5)	24	(20)	63	(52.5)
Practised but Stopped	0	(0)	10	(8.3)	8	(6.7)
Practise Occasionally	3	(2.5)	6	(5.0)	3	(2.5)
Practised but do not Intend to Continue	0	(0)	14	(11.7)	10	(8.3)
Practise Regularly	78	(65.0)	66	(55.0)	36	(30.0)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.24. Adoption of windbreaks/shelterbelt

Table 14 shows that majority of the respondents across the Sahel and Sudan savanna zones had adopted the windbreaks system of agro-forestry. The respondents from the Sahel savanna, however, recorded the highest number of adopters with 65.0 %, followed by Sudan savanna with 55.0 %, while Guinea savanna recorded only 30.0 %. Conversely, for the respondents that had never adopted the system, Guinea savanna recorded the highest number with 52.5%. Plate 5 shows shelterbelt established with the assistance of EU/KTSG in order to protect cultivated farmland from the destructive effect of wind.

Plate 5: Shelterbelt established to protect the cultivated farmland from the destructive effect of wind.

4.25. Adoption of Alley Cropping System

Table 15 indicates that majority of the respondents across the entire zones had never adopted the alley cropping system (Sahel savanna 95.0, Sudan savanna 80.0 and Guinea savanna 97.5%). Very few of the respondents had adopted the system (Sahel savanna 3.3 Sudan savanna 7.5 and Guinea savanna 1.7%). No farmer from Sahel and Guinea savanna had adopted the system and stopped, but in the Sudan savanna 6.7 % had. Similarly, for those that practised the system occasionally, the Sahel and Guinea savanna also recorded zero %, while Sudan had 2.5 %.

Table 15: Adoption of alley cropping system.

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practice	114	(95)	96	(80.0)	117	(97.5)
Practised but Stopped	0	(0)	8	(6.7)	0	(0)
Practise Occasionally	0	(0)	3	(2.5)	0	(0)
Practised but do not Intend to Continue	2	(1.7)	4	(3.3)	1	(0.8)
Practise Regularly	4	(3.3)	9	(7.5)	2	(1.7)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.26. Adoption of Woody Perennial for Soil Conservation

Table 16 shows that respondents that had not adopted the system were highest in Guinea savanna with 87.5 %. This was followed by Sahel savanna with 81.7, while Sudan savanna recorded only 31.7%. On the other hand, the Sudan savanna recorded the highest number of adopters for this system, with 53.3 %; while Sahel and Guinea savanna had very low scores. No respondents had adopted the system but stopped practising it or did not intend to continue to do so across the zones. Plate 6 shows woody perennial for soil conservation in Sudan savanna area of Katsina state.

Table 16: Adoption of woody perennial for soil conservation.

Variables	Sahel		Sudan		Guinea	
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**
Do not Practice	98	(81.7)	38	(31.7)	105	(87.5)
Practiced but Stopped	0	(0)	0	(0)	0	(0)
Practice Occasionally	9	(7.5)	18	(15.0)	5	(4.2)
Practiced but do not Intend to Continue	0	(0)	0	(0)	0	(0)
Practice Regularly	13	(10.8)	64	(53.3)	10	(8.3)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

Plate 6: Woody perennials for soil conservation. This is practised by farmers in Sudan savanna area of Katsina state to check erosion / conserve the soil.(Here *Eucalyptus* species are mostly planted).

4.27. Distribution of respondents according to sources of information about agro forestry practices.

Respondents' means of awareness was determined by listing some land use practices against the sources of information and subjecting the respondents to choose the most applicable from the array of options provided. The results, showed that extension agents, radio media and a combination of two or more of these sources were the commonest means of awareness of the various sustainable land use practices listed.

Extension agents were the major means of knowing about all the land use practices in the study area. Also, radio media recorded high scores, an indication that the respondents also obtained a lot of information on agroforestry practices through radio/TV/print media. Mass media therefore play an important role in the dissemination of information on agricultural activities as they enable the cattle rearers who roam about in the bush to have access to information on agricultural activities through their radio. This was also supported by Onumadu (2002), who observed that mass media was one of the most important sources of information on agroforestry practices. Other sources such as traditional and a combination of two or more of these sources also recorded relatively high scores, whereas sources such as "relatives" and "neighbours" recorded very low scores; while some of the respondents claimed that they had no information at all.

About 37.5 % of the respondents from Guinea savanna zone indicated that their source of information on *Taungya* was through extension agents, 15.0 % from Sudan savanna had their information from traditional media, while only 28.3 % of them from the Sahel savanna zone claimed that they obtained their information through radio.

On improved fallow system, 33.3 % of the respondents from the Guinea savanna indicated that their source of information was through extension agents, 10.0 % from the Sudan savanna and 9.2 % from the Sahel savanna obtained their information on improved fallow system through tradition media.

More than (45.8) and 13.3 % of the respondents from the Guinea and Sahel savanna zones obtained their information on the use/practice of alley cropping through extension agents respectively, while 7.5 % from Sudan savanna indicated that their source of information was through radio. On fuelwood production, 50.0 % of the respondents in the Sudan savanna zone obtained their information through radio, while 59.2 and 38.3 % of the respondents from the Guinea and Sahel savanna zones respectively obtained their information on crop production through extension agents. On tree planting, 29.2 % of the respondents from the Sahel savanna zone obtained information on tree planting through radio, while 10.8 and 60.8 % of the respondents from the Sudan and Guinea savanna respectively obtained their information on tree planting through extension agents.

Distribution of respondents according to sources of information about agroforestry practices

Table 19 shows that about 56.6 % of the respondents from the Sudan savanna zone obtained information on homegarden through radio, while 65.8% and 45.0% from the Guinea and Sahel savanna zones respectively obtained theirs through extension agents.

For the windbreaks, to protect other crops such as millet, sorghum and maize from being blown off by the wind, 28.3 % of the respondents obtained information through radio in the Sudan savanna zone and 72.5 and 25.0 % through extension agents, in the Guinea and Sahel savanna zones respectively.

On woody perennials for soil conservation, 9.2% of the respondents had their information through traditional media in Sahel savanna zone, 8.3 % through radio in the Sudan savanna and 39.2 % obtained information through extension agents in the Guinea savanna. Some 26.7 % of the respondents indicated that they obtained their information on rearing of bees through radio in the Sahel savanna, 15.8 and 43.3 % respectively through extension agent in the Sudan and Guinea savanna. Information on border planting was obtained through extension agents by 66.7 % in Guinea savanna, while 19.2 and 17.5 %

from Sudan and Sahel respectively obtained theirs from the same source. Some 24.1 % from Guinea savanna obtained their information on border planting through radio.

Furthermore, 65.0 and 16.7 % respectively of the respondents from the Guinea and Sudan savanna obtained information on woodlot from extension agent, while 11.7 % from the Sahel savanna got theirs from radio. While 59.2, 25.8 and 22.5 % respectively of respondents from the Guinea; Sudan and Sahel savanna zones obtained information on multipurpose tree on farmland through extension agents.

Table 17: Distribution of respondents according to sources of information about agroforestry practices.

Variables	Sahel		Sudan		Guinea	
	Freq.	%	Freq.	%	Freq.	%
Taungya						
Traditional	28	(23.3)	18	(15.0)	18	(15.0)
Radio	34	(28.3)	40	(33.3)	38	(31.7)
Extension Agent	28	(23.3)	38	(31.7)	45	(37.5)
Neighbour	-	-	-	-	-	-
Combination	30	(25.0)	24	(20.0)	19	(15.8)
Total	120	(100)	120	(100)	120	(100)
Improved Fallow						
Traditional	11	(9.2)	12	(10.0)	23	(19.2)
Radio	18	(15.0)	17	(14.2)	29	(24.2)
Extension Agent	13	(10.8)	15	(12.5)	40	(33.3)
Neighbour	-	-	-	-	2	(1.6)
Combination	78	(65.0)	76	(63.3)	26	(21.7)
Total	120	(100)	120	(100)	120	(100)
Alley Cropping						
Traditional	5	(4.2)	14	(11.7)	8	(6.7)
Radio	23	(19.2)	9	(7.5)	35	(29.2)
Extension Agent	16	(13.3)	20	(16.7)	55	(45.8)
Neighbour	-	-	1	(0.8)	1	(0.8)
Combination	76	(63.3)	76	(63.3)	21	(17.5)
Total	120	(100)	120	(100)	120	(100)
Fuelwood production						
Traditional	14	(4.2)	14	(11.6)	6	(5.0)
Radio	31	(19.2)	60	(50.0)	37	(30.8)
Extension Agent	46	(13.3)	42	(35.0)	71	(59.2)
Neighbour	-	-	2	(1.7)	3	(2.5)
Combination	29	(24.2)	2	(1.7)	3	(2.5)

Total	120	(100)	120	(100)	120	(100)
Tree Planting						
Traditional	9	(7.5)	10	(8.3)	4	(3.3)
Radio	35	(29.2)	31	(25.8)	27	(22.5)
Extension Agent	36	(30.0)	13	(10.8)	73	(60.8)
Neighbour	1	(0.8)	1	(0.8)	2	(1.7)
Combination	39	(32.5)	65	(54.1)	14	(11.7)
Total	120	(100)	120	(100)	120	(100)
Home Garden						
Traditional	8	(6.7)	5	(4.2)	1	(0.8)
Radio	37	(30.8)	68	(56.6)	23	(19.2)
Extension Agent	54	(45.0)	41	(34.2)	79	(65.8)
Neighbour	2	(1.7)	1	(0.8)	2	(1.7)
Combination	19	(15.8)	5	(4.2)	15	(12.5)
Total	120	(100)	120	(100)	120	(100)
Windbreaks						
Traditional	5	(4.2)	2	(1.7)	9	(7.5)
Radio	65	(54.2)	34	(28.3)	10	(8.3)
Extension Agent	30	(25.0)	27	(22.5)	87	(72.5)
Neighbour	-	-	1	(0.8)	-	-
Relatives	-	-	-	-	1	(0.8)
Combination	20	(16.6)	56	(46.7)	13	(10.8)
Total	120	(100)	120	(100)	120	(100)
Woody perennial for soil conservation						
Traditional	11	(9.2)	7	(5.8)	1	(0.8)
Radio	42	(35.0)	10	(8.3)	20	(16.7)
Extension Agent	35	(39.2)	42	(35.0)	47	(39.2)
Neighbour	-	-	1	(0.8)	10	(8.3)
Combination	32	(26.6)	60	(50.0)	42	(35.0)
Total	120	(100)	120	(100)	120	(100)
Rearing Bees						
Traditional	4	(3.3)	6	(5.0)	4	(3.3)
Radio	32	(26.7)	22	(18.3)	14	(11.7)
Extension Agent	25	(20.8)	19	(15.8)	52	(43.3)
Neighbour	3	(2.5)	2	(1.7)	-	-

Combination	56	(46.7)	71	(59.2)	50	(41.7)
Total	120	(100)	120	(100)	120	(100)
Border Planting						
Traditional	9	(7.5)	5	(4.1)	-	-
Radio	17	(14.2)	29	(24.2)	29	(24.1)
Extension Agent	21	(17.5)	23	(19.2)	80	(66.7)
Neighbour	1	(0.8)	2	(1.7)	2	(1.7)
Combination	72	(60.0)	61	(50.8)	9	(7.5)
Total	120	(100)	120	(100)	120	(100)
Woodlots						
Traditional	4	(3.3)	3	(2.5)	-	-
Radio	14	(11.7)	14	(11.7)	30	(25.0)
Extension Agent	22	(18.3)	20	(16.7)	78	(65.0)
Neighbour	-	-	1	(0.8)	2	(1.7)
Combination	80	(66.7)	82	(68.3)	10	(8.3)
Total	120	(100)	120	(100)	120	(100)
Multipurpose Tree on farmland						
Traditional	1	(0.8)	3	(2.5)	7	(5.8)
Radio	11	(9.2)	11	(9.2)	23	(19.2)
Extension Agent	27	(22.5)	31	(25.8)	71	(59.2)
Neighbour	-	-	1	(0.8)	3	(2.5)
Combination	81	(67.5)	74	(61.7)	16	(13.3)
Total	120	(100)	120	(100)	120	(100)

Source: Field Survey, 2006/2007

4.28. Perception of respondents about some indices of sustainable land use

As shown in appendix 12, 50.8 % of the respondents agreed that planting trees with foodcrops could reduce crop yield, while 39.2 did not agree with this view only 10.0 % were undecided. Majority (79 %) of the respondents were of the view that trees required very long time to mature, 16.7 % did not agree, while 4.1 % were undecided. Nearly 53% of the respondents were of the view that government did not provide good seedlings to farmers to plant, 37.2 % were on the opposing side, while 9.9% did not take any side at all.

Many of the respondents (67.5%) were of the opinion that planting trees and food crops together make farming cumbersome, while 22.5 % disagreed. Only 10.0 % were undecided. About 94 % of the total respondents agreed that tree planting prevented soil erosion. 0.8 % did not agree, while 5.0 % were uncommitted. More than (64.2 %) were of the view that tree and food crop planting required a large area of land, 30.3 % did not agree with this, while 5.0 % were undecided. On whether tree and food crop combination could sustain farm resources, 81.0 % of the respondents agreed, 12.4 % did not, while 6.6 % did not take side. Some 88 % of the respondents were of the view that livestock products improved farmers' nutritional status, 9.2 % did not agree, while 2.5 % were undecided.

Appendix 12 shows that about 90.0 % of the total respondents agreed that planting of trees together with food crops ensures continuous land utilization, 0.8 % of them disagreed with the statement while 9.2 % of the respondents did not take any side. On whether agroforestry helps to improve farmers income, furthermore, 95.8 % of the respondents agreed, while 0.8 % of them were on the opposing side, 3.3 % of the respondents were undecided. 95.8 % of the respondents agreed that planting of trees together with food crops contributes to the preservation of the environment, 1.7 % disagreed with the statement, while the remaining 2.5 % of them were undecided. Furthermore, 95.0 % of the respondents were of the view that planting of trees together with food crops could reduce the risk of complete crop failure, 1.7 % of the respondents did not agree with the statement, while 3.3 % were undecided. 97.5 % of the respondents agreed that growing of trees together with food crops could enhance production of fuel wood, while 2.5 % of the respondents were undecided. On whether it is good to plant trees to prevent wind erosion, 98.3 % of the total respondents agreed, 0.8 % of them disagreed with the statement, while another 0.8 % of the respondents were undecided. On whether agroforestry trees could be of benefit to some food crops in providing shade, 97.5 % of the respondents agreed with this statement, 0.8 % of the respondents disagreed, while the remaining 1.7 % of the respondents were undecided.

Majority 98.3 % of the respondents were of the view that planting trees and food crops together contributes to the provision of fruits/leaves, and 0.8 % of the respondents disagreed, while another 0.8 % of the respondents did not take any side. Furthermore, 97.5 % of the respondents agreed that planting of trees in combination with food crops could be beneficial in providing medicinal herbs, 0.8 % disagreed with the statement, while 1.7 % of them were undecided. On whether agroforestry practices could improve land tenure system, 87.5 % of the respondents agreed, 9.2 % of them disagreed with the statement, while the remaining 3.3 % were Undecided.

On the improvement in soil fertility, 97.5 % of the respondents agreed that agroforestry practices help to increase soil fertility, 0.8 % disagreed, while 1.7 % of them did not take any side. Majority of the respondents (97.2 %) agreed that planting of trees in combination with food crops helps in providing fodder for the livestock; 1.4 % of the respondents disagreed with the statement, while another 1.4 % were undecided. On whether trees could reduce leaching, 97.5 % of the respondents agreed, 0.8 % of the respondents disagreed with the statement, while 1.7 % of the respondents were undecided. Furthermore, 95.8 % of the respondents agreed that planting of trees is also beneficial in providing timber/building materials, 1.7 % disagreed, while 2.5 % of the respondents were undecided. More than (95%) of the respondents agreed that growing of trees helps in boundary/land demarcation, 1.7 % of the respondents disagreed with the statement, while 2.5 % were undecided.

Appendix 12 reveals that 92.5 % of respondents were involved in growing agricultural crops together with forest trees; while only about 7.5 % of the respondents were not involved. On whether they deliberately leave forest tree species on farm during clearing about 96.4 % of the respondents agreed, while 3.6 % of the respondents disagreed with the question. Majority of the respondents (96.7 %) agreed that combining forest tree species with agricultural crops contribute to conservation; while only 3.3 % of the respondents disagreed. On whether the respondents care for and protect forest tree species from agent of destruction, 96.7 % agreed, while 3.3 % of the respondents responded negatively. On whether the farmers observe a significant yield from a mixed tree farm and a pure crop farm, about 94 % of the respondents agreed, while about 5.8 % gave a negative response. Majority of the farmers (97.5 %) use fertilizer on their farms and only 2.5 % of them do not use.

4.29. Crop productivity under agroforestry and non-agroforestry plots

The yield of five crops grown under agroforestry and non-agroforestry plots by sampled farmers was obtained for all the nine LGAs. Crops covered by the survey include: millet, maize, sorghum, rice and cowpea. The yields compiled for agroforestry plots were compared with yields the farmers realized when the same crops are grown outside agroforestry plots. All the crops had means that significantly differed ($P \leq 0.0$) with higher yields observed from agroforestry plots than for non-agroforestry plots (Table 18).

Table 18: T-test of mean crop yield/ha for agroforestry and non-agroforestry plots

Parameter	Mean yield per/ha (kg)	T. Value	Df	P
Millet				
Agro-forestry	1083.33	6.14*	4	0.0001
Non Agro-forestry	756.67			
Maize				
Agro-forestry	1133.33	13.40*	4	0.0000
Non Agro-forestry	710.00			
Sorghum				
Agro-forestry	725.00	5.73*	4	0.0001
Non Agro-forestry	516.67			
Rice (unmilled)				
Agro-forestry	1155.00	7.05*	4	0.0000
Non Agro-forestry	833.33			
Cowpea				0.0358
Agro-forestry	458.33	2.42*	4	
Non Agro-forestry	408.33			

** Significant N.S Not significant.*

4.30. Tree species combined with agricultural crops among the respondents

Table 19 reveals some of the commonest trees used in combination with agricultural crops among the respondents in the study area. In the Sahel savanna zone, those tree species with high scores include: *Azadirachta indica* with 25.8 % *Parkia biglobosa* with 14.2 % and *Adansonia digitata* having 13.3 %. In Guinea savanna, those species recorded in decreasing number include: *Adansonia digitata*, with 9.2 %, *Parkia biglobosa*, with 6.7 % and *Azadirachta indica* having 5.8 %. Across the three zones, the highest score is recorded by *Azadirachta indica,* having 13.3 %, while *Adansonia digitata* and *Parkia biglobosa* recording 9.7 % respectively. Other tree species recorded include: *Borassus aethiopum, Anacardium occidentale* and *Tamarindus indica.*

Table 19: Identified Tree Species Combined with Agricultural Crops Among the Respondents.

Tree Species	Sahel		Sudan		Guinea		Mean
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**%**
Adansonia digitata	16	(13.3)	8	(6.7)	11	(9.2)	9.7
Azadirachta indica	31	(25.8)	10	(8.3)	7	(5.8)	13.3
Anacardium occidentale	2	(1.7)	-	-	3	(2.5)	1.4
Borassus aethiopum	2	(1.7)	-	-	01	(0.8)	0.8
Parkia biglobosa	17	(14.2)	6	(5.0)	8	(6.7)	8.6
Tamarindus indica	-	-	-	-	6	(5.0)	1.7
Combination/others	52	(43.3)	96	(80)	84	(70)	64.4
Total	120	(100)	120	(100)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.31. Constraints to adoption of agro-forestry practices in the study area

Table 20 reveals some of the problems militating against the adoption of agroforestry practices in the study area. The most serious problem preventing adoption of agroforestry practices in Sahel savanna zone was scanty rainfall, which accounted for (30.8 %) of the problems. This was followed by lack of land (6.7 %) and inadequate labour (5.0 %). In the Guinea savanna zone, the most serious problem was high labour demand (8.3 %), followed by lack of land (6.7 %). Lack of required seedlings and scanty rainfall had 5.0 % respectively. The problems, in decreasing order of severity across the three zones were: scanty rainfall, lack of land, high labour demand, inadequate extension personnel and lack of transportation recording the same percentage, lack of required seedlings and lack of incentives recorded the same percentage.

Table 20: Identified constraints to adoption of agro-forestry practices in the study area

Identified Problems	Sahel		Sudan		Guinea		Mean
	Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**%**
High Labour Demand	6	(5.0)	-	-	10	(8.3)	4.4
Lack of Required Tree Seedlings	3	(2.5)	-	-	1	(0.3)	1.1
Inadequate Extension Personnel	2	(1.7)	-	-	4	(3.3)	2.5
Lack of Land	8	(6.7)	1	(0.8)	8	(6.7)	4.73
Scanty Rainfall	37	(30.8)	3	(2.5)	6	(5.0)	12.8
Lack of Transportation	4	(3.3)	1	(0.8)	4	(3.3)	2.5
Lack of Incentive	2	(1.7)	-	-	2	(1.7)	1.1
Combination	58	(48.3)	115	(95.8)	80	(66.7)	70.3
Total	120	(100)	120	(100)	120	(100)	(100)

Source: Field Survey, 2006/2007

4.32. Testing of Hypotheses

This section highlighted the relationship between dependent variable and some of the independent variables. The dependent variable of the study was the perceived benefits, while the independent variables that were considered include; age, gender, marital status, educational attainment, occupation, religion, attitude toward use of agroforestry practices, sources of information etc. The significance of the relationships were determined at 0.05 (5 %) level of significance.

Hypothesis 1: There is no significant relationship between the demographic characteristics and the use of agroforestry practices by farmers in Katsina state.

Appendix 2-6 shows the relationship between some of the demographic characteristics of the farmers and use of agroforestry practices. With the exception of education, all the other characteristics in the study showed no significant relationships. For the impact of age on use of agroforestry practices, appendix 2 reveals that there was a significant relationship between planting trees for wind breaks and age in Sahel savanna (χ^2 = 11.48, P = 0.04). Improved fallow/shifting cultivation in Guinea savanna (χ^2 = 14.19, P < 0.05) and in raising of forest trees with agricultural crops in Sudan savanna (χ^2 = 12.50, P < 0.05).

For the impact of gender on agroforestry practices, appendix 3 shows that use of livestock manure is dependent on gender in Guinea savanna (χ^2 = 4.45, P < 0.05) while planting of food crops between trees and shrubs is dependent on age in Sahel savanna (X^2 = 4.35, P < 0.05) and in Sudan savanna, (χ^2 = 9.14, P < 0.05). There was also a significant relationship between rearing of bees for honey and age in Guinea savanna (χ^2 = 5.56, P < 0.05).

On the influence of marital status on some identified agroforestry practices, appendix 4 showed that there was no significant relationship between marital status and use of agroforestry practices in the study area. Therefore the identified agroforestry parameters are not dependent on marital status. This is because χ^2 calculated was less than X^2 tabulated in each case across the three zones.

Apart from planting of trees for wind breaks in Sudan savanna (χ^2 = 36.69, P < 0.05) all other agroforestry practices were not significantly related with religion (appendix 5). This may be that either Muslim or Christian can effectively utilize the agroforestry practices. The null hypothesis is thus accepted.

Appendix 6 showed a significant relationship between farmers' use of agro-forestry practices and educational background of the respondents. For instance, planting of trees on the farm in Sudan savanna (χ^2 = 29.58, P < 0.05), use of livestock manure in Sahel savanna (χ^2 = 12.76, P < 0.05), planting of food crops between trees and shrubs in Sudan savanna (χ^2 = 19.63, P < 0.05) and Guinea savanna (χ^2 = 41.49, P < 0.05). Planting of trees for wind breaks in Sudan savanna (χ^2 =20.27, P<0.05) and Guinea Savanna (χ^2 =22.17, P<0.05). Improved fallow/shifting cultivation in Sudan savanna (χ^2 = 31.25, P < 0.05), and Guinea savanna (χ^2 =25.64, P<0.05) Raising of forest trees with agricultural crops in Sudan savanna (χ^2 = 30.59, P < 0.05) and Guinea savanna (χ^2 = 46.49, P < 0.05) and rearing of bees for honey in Sudan savanna (χ^2 = 24.84, P < 0.05). Appendix 7 showed that there was no significant relationship between occupation and farmers' use of agroforestry practices. With the exception planting of trees on the farm in Sudan savanna (χ^2 = 23.96, P < 0.05), planting of trees for wind beaks in Guinea savanna (χ^2 = 15.96, P < 0.05) and improved fallow/shifting cultivation in Guinea savanna (χ^2 = 12.86, P < 0.05), all other agro-forestry practices in the study showed no significant relationship with occupation. The null hypothesis which sates that there is no significant relationship between the demographic characteristics and the use of agroforestry practices by farmers in Katsina state is thus accepted.

In Table 21 the impacts of education on farmers use of agroforestry practices was examined using analysis of variance (ANOVA). There was a significant relationship between use of agro-forestry practices and educational background as confirmed by ($F = 2.661$, $P < 0.05$). The hypothesis is therefore rejected. Although no special education is required for the use of any farming practice, a certain level of educational attainment could serve as impetus for the use or adoption of an agroforestry practice.

Table 21: Analysis of Variance showing the Relationship between Impact of Education on Agroforestry Practices.

Tests of Between-Subjects Effects

Dependent Variable: use of agroforestry practices

		Type III Sum of Squares	df	Mean Squar	F	Sig.
Source	Model	*9340.24*	*9*	*1037.80*	*463.64*	*.000*
	ZONE	*278.08*	*2*	*139.04*	*62.119*	*.000*
	LEVDUCAT	*35.733*	*6*	*5.955*	*2.661*	*.015*
	Error	*767.752*	*343*	*2.238*		
	Total	*10108.00*	*352*			

R Squared = .924 (Adjusted R Squared = 0.922)

Hypothesis 2: There is no significant relationship between farmers' source of information and use of agroforestry practices.

Table 22 shows the relationship between sources of information and use of agroforestry practices. It is observed that, among the three agro-ecological zones, it is only in Guinea savanna that sources of information was not significantly related to use of agroforestry practices by the farmers ($\chi^2 = 0.32$, $P > 0.05$). The null hypothesis which states that there is no significant relationship between source of information and use of agroforestry practices was thus accepted.

Conversely, in Sahel and Sudan savanna zones, source of information was significantly related. In Sahel savanna zone, $\chi^2 = 0.01$, $P < 0.05$ and in Sudan savanna, $\chi^2 = 0.03$, $P < 0.05$. The null hypothesis was therefore rejected. Thus use of agroforestry practices by farmers is dependent on choice of source of information, that is there is a significant relationship between the source of information and use of agroforestry practices in these study sites.

This implies that farmers in these zones had several options of other sources of information that could enhance or stimulate their use of agroforestry practices.

Although, radio/mass media and extension agents were the principal means of the awareness, these two sources of information could as well be responsible for the significance of the agroforestry practices.

Hypothesis 3: There is no significant relationship between the benefits that can be derived and use of agroforestry practices.

Table 22: Chi-square analysis of sources of information and use of agroforestry practices in the three agro-ecological zones of Katsina state.

Variable	χ^2 Value	Df	P	Decision
Sources of Information in Sahel	4.60	2	0.01	S
Sources of Information in Sudan Savanna	4.51	1	0.03	S
Sources of Information in Guinea savanna	5.21	1	0.32	NS

S = Significant at $P < 0.05$

NS = Not Significant

N = 360

Table 23 shows the relationship between use and benefits of agroforestry practices across the three agroecological zones of Katsina state. The table shows a significant positive relationship between the use and benefits of agroforestry practices, with a Pearson correlation (r) of 0.160, ($P < 0.05$). This implies that farmers derived immense benefits from the use of agroforestry practices; and that farmers who use agroforestry practices more, also benefit more. This result is still maintained even in the partial correlation analysis which controls for the effect of zone (see appendix 8b).

Hypothesis 4: There is no significant difference in the use of agroforestry practices in the three agro-ecological zones in Katsina state.

Table 23: Correlation Analysis Showing the Relationship between use and Benefits of Agro-forestry Practices.

Variable	Mean	Standard deviation	Pearson	Partial	Decision
Use	5.07	1.76	0.160	0.143	Sig.
			(0.0022)	(0.007)	(S)
Benefits	14.58	1.10			

Note: Probability in Parenthesis

S = Significant at P < 0.05

NS = Not Significant

N = 360

In Table 24 the difference of agroforestry practices among the three zones (Sahel, Sudan and Guinea savanna) was examined using analysis of variance (ANOVA). The test shows that there was a significant difference in the use of agroforestry practices among the three zones as confirmed by ($F = 63.29$, $P < 0.05$). The null hypothesis (Ho) which states that there is no significant difference in the use of agroforestry practices in the three agro-ecological zones in Katsina state is therefore rejected. The differences in adoption might be due to differences in soil types, rainfall patterns, socio-economic reasons and readiness or otherwise of the people to accept innovations.

Similarly, the Duncan multiple range (DMR) test was used to ascertain the differences in the use among the zones. The result shows that the use of agroforestry practices is:

i. not significantly different between the Sahel and Sudan ($P > 0.05$), but significantly different between the Sahel and Guinea ($P < 0.05$).

ii. not significantly different between Sudan and Sahel ($P > 0.05$) but significantly different between Sudan and Guinea ($P < 0.05$).

iii. significantly different between Guinea and Sudan and between Guinea and Sahel ($P < 0.05$).

Table 24: Analysis of variance for the use of agroforestry practices among the three zones of Katsina state.

Zone		F	P	Decision
Sahel	5.53 ± 1.12^{b}			
Sudan	5.88 ± 0.14^{b}	63.29	0.000	Sig.
Guinea	3.82 ± 0.15^{a}			

S = Significant at P < 0.05

NS = Not Significant

N = 360

Note: mean $\pm$ S.E with different superscripts are significantly different, with a<b.

Table 31 also shows that the use of agroforestry practices is least in Guinea savanna ($\bar{X}$ = 3.82) and highest in Sahel ($\bar{X}$ = 5.53) and Sudan ($\bar{X}$ = 5.88).

Hypothesis 5: There is no significant relationship between farmers' attitudes towards adoption and the perceived benefits derived in the use of agroforestry practices.

Table 25: Correlation Analysis showing the Relationship between Farmers' Attitudes and benefits of Agroforestry Practices.

Variable	Mean	Standard deviation	Pearson	Partial	Decision
Benefits	14.58	1.10			
			0.017	0.006	
Attitudes	5.89	1.70	(0.748)	(0.917)	N.S

Note: probability in parenthesis

S = Significant at P < 0.05

NS = Not Significant

N = 360

Both the zero order correlation (0.017) and the partial correlation (0.006) coefficients in Table 25 showed that there was no significant relationship between the farmers' attitudes and the benefits derived from agroforestry practices in the study area. This implied that even though, farmers derived immense benefits from agroforestry practices, they were not favourably disposed towards the use of agroforestry practices ($P > 0.05$). The hypothesis was therefore accepted.

Hypothesis 6: Soil chemical properties are not significantly affected by zone and land use.

Table 26 shows that in Sahel savanna zone, there was a significant difference in the following soil parameters: pH, ($P < 0.01$), Ca^{2+} ($P < 0.001$), Mg ($P < 0.01$), $K,^{+}$ ($P < 0.05$), Na^{+} ($P < 0.001$) and CEC, ($P < 0.001$). There was also significant difference in total nitrogen ($P < 0.01$), Mg^{2+} ($P < 0.05$), K^{+} ($P < 0.001$), and Na^{+} ($P < 0.001$) between agroforestry and non-agroforestry plots.

Table 26: Mean squares from analysis of variance for CRD for soil parameters in Sahel Savanna

Source of variation	Df	pH	OC	OM	TN	AP	Ca	Mg	K	Na	HAL	CEC
Location	2	0.173**	0.054ns	0.092	0.001ns	226.96 ns	4.207 ***	0.238**	0.0014 *	0.002***	0.023ns	5.62 ***
Landuse	1	0.030ns	0.003ns	0.005ns	0.004**	9.22 ns	0.496 ns	0.104*	0.0096 ***	0.005***	0.013ns	0.03 ns

N S = not significant

*,**,*** = significant level at P<0.05, 0.01 & 0.001

Table 27 showed that in Sudan savanna zone, there was a significant difference in the concentration of total Nitrogen ($P < 0.01$) and Na^{+} ($P < 0.001$) within the zone, and there was also a significant difference in total nitrogen between agroforestry and non-agroforestry plots, with ($P < 0.01$).

Table 27: Mean squares from analysis of variance for CRD for soil parameters in Sudan Savanna

Source of variation	Df	pH	OC	OM	TN	AP	Ca	Mg	K	Na	HAL	CEC
Location	2	0.36 3 ns	0.02 8ns	0.04 8ns	0.00 7**	23.20 1 ns	0.315 ns	0.02 2ns	0.00 1 ns	0.02 1***	0.025 ns	0.428 ns
Landuse	1	0.03 0ns	0.00 8ns	0.00 7ns	0.00 4**	12.52 5ns	0.034 ns	0.01 6ns	0.00 5 ns	0.00 1ns	0.012 ns	0.002 ns

NS = not significant

*, **, *** = significant level at P<0.05, 0.01 & 0.001

Analysis of variance (ANOVA) result showed that in Guinea savanna, there was a significant difference in the following Soil parameters: pH, ($P < 0.001$), organic carbon ($P < 0.001$), organic matter, ($P < 0.001$), calcium ($P < 0.05$), K^+ ($P < 0.05$) and Na^+ ($P < 0.001$) within the zone. There was also a significant difference in: pH ($P < 0.001$), organic carbon ($P < 0.001$), organic matter ($P < 0.001$), available phosphorus ($P < 0.01$) and in Na^+ ($P < 0.001$) in land use types.

Table 28: Mean squares from analysis of variance for CRD for soil parameters in Guinea Savanna

Source of variation	Df	pH	OC	OM	TN	AP	Ca	Mg	K	Na	HAL	CEC
Location	2	0.63**	0.20***	0.34***	0.001ns	239.11 ns	2.96*	0.351ns	0.036*	0.001***	0.053ns	4.89***
Landuse	1	1.20***	0.142***	0.24***	0.001ns	918.29**	0.178 ns	0.008ns	0.17 ns	0.002***	0.013ns	0.65 ns

NS = not significant

*,**,*** = significant level at P<0.05, 0.01 &0.001

Table 29: Mean squares from analysis of variance across 3 zones for soil parameters

Source of variation	Df	pH	OC	OM	TN	AP
Zone	3	0.04 ns	0.46 ***	0.79 ***	0.002 *	161.59 ns
Landuse	1	0.401 ns	0.039 ns	0.067 ns	0.0004 ns	453.36 ns
Zone X landuse	2	0.431 ns	0.057 ns	0.098 ns	0.0001 ns	243.33 ns

Ns = not significant

*,**,*** = significant level at $P<0.05$, 0.01 &0.001

Analysis of variance result showed that there was a significant difference in organic carbon ($P < 0.001$), organic matter ($P < 0.001$) and in total nitrogen ($P < 0.05$) among the three agro-ecological zones in the state. The result however showed that there was no significant ($P > 0.05$) difference in any of the soil parameters between agroforestry and non-agroforestry plots.

For exchangeable cations and the effective cation exchange capacity (ECEC), Table 30 shows that there was a significant difference only in Na^+ ($P < 0.05$) among the three zones, whereas there was no significant difference in any of the soil variables in land use type.

Table 30: Mean squares from analysis of variance (ANOVA) across 3 zones for exchangeable cations and ECEC

Source of variation	df	Ca	Mg	K	Na	HAL	CEC
Zone	3	0.287 ns	0.521 ns	0.001 ns	0.006 *	0.000 1 ns	1.43 4 ns
Landuse	1	0.296 ns	0.027 ns	0.000 5 ns	0.004 ns	0.04 ns	0.35 2 ns
Zone X landuse	2	0.206 ns	0.50 ns	0.016 ns	0.002 ns	0.166 ns	0.16 6 ns

Ns = not significant

*,**,*** = significant level at P<0.05, 0.01 &0.001

However, the Duncan Multiple Range (DMR) test was employed to ascertain the difference among the zones. The result shows that:

i. For organic carbon, Guinea savanna with the highest mean value was significantly different from those of and Sahel ($P < 0.05$) which had means that were not significantly different from each other ($P > 0.05$).

ii. For total nitrogen, Guinea savanna with the highest mean value was significantly different from the values of Sudan and Sahel savanna ($P < 0.05$), which were also not significantly different from each other ($P > 0.05$).

iii. For Na^+, Sudan with the highest mean value was significantly different from both Guinea and Sahel savanna ($P < 0.05$), having means that were not significantly different from each other ($P > 0.05$). Hence, the null hypothesis which states that soil chemical properties are not significantly affected by zone and land use is accepted for pH, Ca, Mg, K, HAL, available phosphorus and ECEC, while it is rejected for Organic carbon total nitrogen and Na+ for zone.

Table 31: Duncan Multiple Range Test

Zone	Organic Carbon	Total Nitrogen	Sodium (Na^+)
Guinea	0.557[a]	0.07[a]	0.504[b]
Sudan	0.223[b]	0.049[b]	0.539[a]
Sahel	0.209[b]	0.043[b]	0.499[b]

CHAPTER FIVE

5.0. DISCUSSION

Respondents' gender showed that there were more male than female farmers across the zones. This implies that the male gender are more involved in agroforestry practices as compared to their female counterparts. Farming generally, is almost an exclusive business for the male in the study area. This may be as a result of the strenuous nature of most farming activities in general and agroforestry practices in particular. These activities are not attractive to women who often engage in household activities. The paucity of women in agroforestry practices might also be attributed to culture and religion which made access to women by male extension agents difficult since there were very few women extension agents.

In Sahel and Sudan savanna zones, majority of the respondents fell between 30 and 49 years. Except in Guinea savanna, where majority of the respondents fell from ≤ 60 years.

This dominant age bracket among the rural dwellers implied that this is the age bracket that is actively involved in agroforestry practices. This also meant that, the farming population is mainly made up of both the old and the middle-aged people. The young ones might have migrated to urban areas in search of white collar jobs while others might have been in school or too young to have farms. This has an adverse effect on the economy of the rural people because at old age, farmers can not have optimum productivity.

Also, majority of the respondents across the three zones were married men and women. Most marriages were polygamous and have an average of more than five children that provided labour force for farming. This is because agroforestry practices are not only capital intensive but also labour intensive.

On religious affiliation, most of the respondents were Muslims while other religious included Christians and traditional worshipers.

As revealed in the study, educational level of the rural dwellers was low. However, on average, Islamic education recorded the highest %age, which was followed by primary education. The study also revealed that inspite of the low level of western education, they had indigenous/traditional knowledge and high level of awareness about farming systems, tree species, shrubs, herbs and other agroforestry practices. This indigenous knowledge affects their perception and willingness to participate in agroforestry practices. However, they still needed more enlightenment and training on modern agroforestry techniques as a means of sustainable land management.

Frequency analysis of the respondents' occupation revealed that farming is the major occupation in the three agro-ecological zones of the study area. The study reveals on average, a high % of the respondents as farmers. Other occupation in the study area includes: trading, civil servants, fishing and cattle rearing among others.

On the average, more than half of the respondents had farm sizes of between 1 and 4 hectares. This confers the low income status on the farmers who farm mainly for household consumption and so earn very little income, and thereby continue to live in abject poverty.

The study reveals that on the average, more than half of the respondents acquired land on which they were farming through inheritance. This finding is in agreement with Adegboye (1979) and Adekoya (1997) who observed that ownership of rights in the forests are generally acquired through group inheritance. In descending order, other respondents acquired their land through purchase, rental and government respectively. Land tenure system therefore plays an important role as to whether a particular land can be conserved or put into forestry/agricultural use. This is because; there is no land in the country that is not owned either by individual, community or government. Under the traditional land tenure system, occupant of rented land cannot dispose of it or put into use for permanent tree crop cultivation. Apart from inheritance, acquisition of land through government and purchase remain more permanent for farmers using agroforestry practices.

Agroforestry entails combination of agricultural crops with tree crops together with pastures or animals on the same piece of land either in sequence or at the same time. This means that agroforestry facilitates multiple land use. The study shows that majority of the respondents were involved in food crop-production, while others were involve in rearing of animals, and planting of tree crops such as *Azadirachta indica, Parkia biglobosa, Adansonia digitata* among others.

The study also revealed that the respondents were also involved in food crop production. Crops grown by the farmers include maize, rice, cowpea, sorghum and millet. These crops were mostly grown as mixed cropping. Among the crops grown, millet was the most favoured crop grown by the farmers across the three agro-ecological zones in the state. This was followed by maize and sorghum respectively.

The reveals that goats were the most favoured livestock reared across the three zones of the study area. Poultry and pig production were very low in the study area; particularly pig producing that almost had zero %. This may be due to religious affiliation since consumption of pork is forbidden in a Muslim community. The high production of goats in relation to sheep production may be due to the preference of the farmers for goat consumption, although some of the farmers maintained that the sheep was more prolific than the goats.

The study also indicates that most of the respondents engaged in subsistence farming which was mainly for household consumption and very little for sale. This explains why most of the peasant farmers cannot make enough profit from their produce and therefore remain permanently poor lacking purchasing power enough to maintain a minimum standard of living. The study revealed that a very high %age of respondents were involved in subsistence farming, while very few were involved in semi-commercial farming.

Respondents' involvement in agroforestry practices varied from zone to zone. 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 socio-economic reasons, complexity and incompatibility of the innovation with the existing practices. Thus majority of respondents across the zones could not adopt *Taungya*, border planting and alley cropping. Very few respondents across the zones adopted these systems of agro-forestry. Conversely, multipurpose trees on farmland, improved fallow in shifting cultivation, homegarden, woodlots and windbreaks or shelterbelt were much more adopted by farmers.

Majority of the respondents adopted multipurpose trees on farmland across the zones. The findings therefore reveal that this agroforestry system was popular among the farmers across the zones hence the massive adoption. This might be due to the blend of the system with indigenous or traditional farming practice across the zones.

The study also revealed that majority of the respondents in sahel and guinea savanna had not practiced homegardens, as the two zones recorded high scores each. Those farmers that had adopted the system were relatively few. While those that had practiced but stopped, practice occasionally or practiced but do not intend to continue recorded very low scores.

The study revealed that in Sahel savanna, the respondents that had never adopted improved fallow system as one of the agroforestry practices recorded very high scores. Whereas in Sudan and Guinea savanna, the respondents that had never adopted the system were very few. Conversely, those that had adopted the system in Sudan and Guinea savanna recorded very high scores. Nevertheless, the respondents in Sahel savanna recorded low scores in adoption.

The study shows that majority of the respondents across the zones had not adopted *Taungya* system of agroforestry. There were very few of the respondents that had adopted the *Taungya* system of agroforestry. The reason for low adoption of *Taungya* system of agroforestry might be that food crop might compete with tree crop.there were no respondent that had adopted the system but stopped practicing it across the zones. Sahel and Sudan zones adopted woodlots practices more than Guinea savanna.

The reason for their adoption might be to stem the environmental degradation in the Sahel and Sudan savanna zones. Farmers could only take fuelwood from these plantations and no other place. Indiscriminate felling of trees for timber, fuelwood and other domestic uses and clearing of land for agricultural purposes and industrial development help to remove the forest cover, thereby exposing the soil to wind erosion (Repetto, 1988). Adeola (2001) observed that the system is used for various purposes such as provision of wood, fodder, electric-poles, fencing poles, roofing poles, soil protection, soil reclamation etc.

The result revealed that most of the respondents had not adopted border planting across the zones. There were also no respondents that had adopted the system but stopped practicing across the zones. Sudan savanna recorded the highest number of adopters, followed by sahel savanna and then Guinea savanna.

Adoption of windbreaks was highest in Sahel savanna across the zones. The highest %age in Sahel implied that the zone was mostly threatened by desertification than other zones because of its location. Again, farmers in the Sahel zone had to adopt the system in order to protect their environment from wind erosion, lesson evapotranspiration, control air temperature, provide aesthetic value which the system offers.

Conversely, for the respondents that had never adopted the system, Guinea savanna recorded the highest number. The reason might be that there were more woody trees found in Guinea Savanna than other zones and therefore less exposed to agents of degradation.

The study shows that majority of the respondents across the entire zones had never adopted the alley cropping system. Very few of the respondents had adopted the system. There no respondent that had adopted the system but stopped in Sahel and Guinea savanna.

Similarly, for those that practice occasionally, Sahel and Guinea Savanna also recorded low scores. Sudan Savanna had the highest adoption of woody perennials for soil conservation across the zones . The farmers' interest and adoption of the system could be to check the menace of annual flooding of this zone which leads to soil and gully erosion. Plants help to stabilize the soil and other conservation works thereby fulfilling one of the environmental functions of agroforestry (Baumer, 1990).

On whether planting trees with food crops could reduce crop yield, majority of the respondents agreed, while very few were undecided. Most of the respondents were of the view that trees require very long time to mature, were very few did not agree with it. About half of the respondents were of the view that government does not provide good seedlings to farmers to plant, while very few of the respondents did not take any side at all.

On whether planting trees and food crops together makes farming cumbersome, majority of the respondents agreed to this statement, while few of the respondents disagreed. Also majority of the respondents agreed that tree planting prevents soil erosion. While very few did not agree. More than half of the respondents were of the view that tree and food crop planting requires a large area of land, while very few respondents were undecided. On whether tree and food crop combination could sustain farm resources, majority of the respondents agreed to it, while very few disagree with the statement. Also a very high %age of the respondents were of the view that livestock products improve farmers nutritional status, while very little % of the respondents did not agree.

On sources of information/awareness on some sustainable land use practices, the study revealed that extension agents recorded high scores for all the land use practices in the study area. This may be due to the availability of the agricultural development programme in the area. This study therefore agreed with the findings of Onumadu (2002) who observed that agricultural agents were the most important source of agricultural information to farmers. This view was also supported by other studies by Azeez (2002), Hurst (1977) and Obibuakwu.

Majority of the respondent were of the view that they obtained information on sustainable land use practices/agro-forestry practices through radio. Mass media therefore plays an important role in the dissemination of information on agricultural activities as it enables even the cattle rearers that roam about in the bush to have access to the information on agricultural activities through their radio. This was also supported by Onumadu (2002), who observed that mass media was one of the most important sources of seeking information on agro-forestry practices. Other sources such as traditional and a combination of one or more of these sources also recorded relatively high scores, whereas sources such as relatives and neighbour recorded very low scores; while some of the respondents reported that they had no information at all. This may be due to lack of adequate publicity or enlightenment. This calls for an increase in agricultural extension agents who should take up the responsibility of educating, training and monitoring of farmers in the areas of food crop production.

Farmers in Katsina state adopted agroforestry practices because of the various benefits they derive from it. These benefits range from social, economic and environmental benefits. The social benefits in the study area include provision of fruits and leaves, provision of shade, provision of fuelwood, provision of fodder and medicinal herbs.

Majority of the farmers across the zones with the exception of Guinea savanna harvested much fuelwood from their farms for domestic use (Appendix 13). The findings revealed that the two zones that were most threatened by desertification than Guinea savanna could have adopted woodlot and windbreaks system of agroforetry to check indiscriminate felling of trees from the natural vegetation which contribute to deforestation and the corresponding environmental degradation (Table 12). Animal rearing is one of the major pre-occupation of the people of Katsina state and it is concentrated in the Sahel zone with abundant grassland. The adoption of agroforestry woodlot system in the zone might be to produce demarcation/fencing materials which could be used to protect food crops, tree seedlings in farms and the natural vegetation being destroyed by livestock. Okali (1997) observed that increased livestock population depend on natural vegetation for grazing and livestock feeding practices which cut trees for browse and burn vegetation to obtain fresh bite is one of the causes of environmental degradation in Nigeria.

Economic benefits derived from the adoption of agroforestry practices in this study included sale of fuelwood, sale of fruits and leaves, sale of seedlings, sale of fencing poles/demarcation materials and improvement of farmers' income generally (Appendix 13). The study revealed that because most of the farmers in the study area were operating on a subsistence level, and without any assistance from the government in terms of loans and other inputs, their income generations was very small. This could not adequately take care of their basic needs such as labour wages and other household requirements. In Nigeria more than 70% of the population use fuelwood for cooking and women alone gather 60 – 80% of domestic fuelwood in each household (Anderson and Fishwick, 1988). The damage done on the environment by this act could best be imagined. The only way to protect the environment from daily deforestation is by the adoption of agroforestry practices. People can establish fuelwood farms for their domestic use and for sale too instead of engaging in indiscriminate felling of trees. Agroforestry practices therefore contributes 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 (Baumer, 1990)

Environmental benefits derived by farmers in adoption of agroforestry practices in this study included improved soil fertility, preservation of the environment, erosion control, provision of shade for some crops, continuous land utilization and so on. Majority of the respondents across the three zones agreed that agroforestry improved soil fertility (Appendix 13). The clearing of vegetation cover leads to ecological degradation, resulting in increased soil erosion and subsequent decreasing soil fertility. This study has revealed that the farmers could have experienced increase in their crops yield, livestock numbers since they adopted agrofoestry Kang *et al* (1984) observed that agroforestry has the potential to restore soil fertility more rapidly and at the same time provide one or more useful products. He concluded that cultivation of perennial shrubs and trees would allow leaf-fall onto the soil and subsequent decomposition of which would enrich the soil.

Majority of the respondents acrrose the zones asserted that agroforestry prevented soil erosion (Appendix 13). Soil erosion can result to gully and sheet erosion which according to Yusuf (1995) result from the removal and destruction of protective vegetation cover and the subsequent desertification threat of Katsina state. The planting of *Eucalyptus* species especially in the flood areas of Sudan savanna by farmers could be to check the destructive annual flooding and gully erosion in this zone (Plate 6).

The findings also revealed that majority of the respondents agreed that agroforestry provided much shade for crops and animals including man. This region has nine months of dry season and three months of rainy season. This harsh climate with a long intense dry season is coupled with periodic disastrous droughts (FORMECU, 1989). The planting of trees around homestead by farmers might be to provide shade and create micro-climate for the farmers, their crops and livestock during the scorching heat of the sun and to check desertification.

The yields of five crops grown by the sampled farmers within the agroforestry and non- agroforestry plots were computed for all the three agro-ecological zones (Table 23). The yields of crops and t-test showed that the yield of agricultural crops were higher for agroforestry plots compared to non-agroforestry plots. Bada (1992) observed that agroforestry systems aim to maintain or increase production as well as productivity of the soil. The higher yields of crops obtained from agroforestry plots could have emanated from positive contribution of the agroforestry practices to soil organic matter, nutrient cycling, soil fertility, soil fauna, weed and pest control (Fagbemi, 1991). The adequate supply of nutrients is essential to a sustainable system of agroforestry; it is important to evaluate the effect of management on nutrient stocks and losses (Nwoboshi 2000). For nutrient-poor tropical soils, crop productivity may be increased by use of inorganic fertilizers. The soil fertility of agroforestry plots were generally higher compared to non- agroforestry plots (which may have been impoverished as a result of continuous cropping). The fertility of agroforestry plots could have been an incentive to farmers' adoption of agroforestry systems.

Farmers were asked to list the constraints which militated against their adoption of agroforestry practices (Table 25). In Sahel savvana, the respondents mentioned scanty rainfall, shortage of land, high labour demand, and lack of transportation. In Sudan savanna, the main constraint was also scanty rainfall. This suggests the high demand for adequate rainfall for crops production. The long period of drought and very few months of rainfall does not auger well for both arable and trees crops to do well in these zones. Generally speaking the identified constraints across the zones no matter the fewness of the respondents could be related to social conditions and economic situations.

CHAPTER SIX

6.0. SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of findings of the study

The study analysed the farmers' use of agroforestry practices. This involved land management principles that the farmers apply to enhance agricultural productivity, as well as maintain and prevent environmental degradation.

The demographic analysis indicated that 82.5 % of the respondents were males while 17.5 % were females. About half of the farmers (184) across the zones were 30 – 49 years of age. A large proportion of the farmers (93.3%) were married while 96.3 % of the respondents had 1 – 3 wives. 92.0 % of the respondents were Muslims, 2.6 % Christians, 0.9 % were traditional worshippers, 4.5 were combination of Islam and traditional religion. On the average, Islamic education recorded 41.0 % which was the highest across the zones; followed by primary education with 17.9 %, while secondary and tertiary education recorded 14.5 % each.

The primary occupation of the respondents was farming (66.1 %), 5.9 % were traders 13.6 % were civil servants, while 1.7 and 4.2 % were fishermen and cattle rearers respectively. Annual farm size of 1 – 2 hectares recorded the highest number of respondents with 31.4 %, followed by annual farm size 3 – 4 ha with 28.8 %.

The main source of land acquisition of the respondents was through inheritance (50.8 %), other sources include rental, purchase and government.

Most of the respondents had their farms located in 1 – 4 places (67.5 %) while only 12.5 % had theirs located in 9 – 12 places. 33.0 % of the respondents had an average annual income of N30,000.00 – 40,000.00.

The respondents were involved in diversified agricultural activities including livestock, tree crops and even fruit tree cultivation. Among the food crops produced by the respondents were maize, rice, cowpea, sorghum, millet and a combination of two or more of these crops. The livestock raised by the respondents included poultry, cattle, sheep, goat and pig.

Respondents involvement in agroforestry practices varied from zone to zone. Thus majority of the respondents across the zones could not adopt *Taungya*, border planting and alley cropping. Very few farmers adopted these systems of agroforestry in the study area. Conversely, multipurpose trees on farmland, improved fallow, homegardens, woodlots and windbreaks were much more adopted by farmers.

Majority of the farmers had a good knowledge of most of the agroforestry practices as the study revealed high scores when the sources of information were matched with the listed practices. In all, extension agents and radio/TV/print media and a combination of two or more of these sources of information recorded very high scores. The problems encountered by farmers in adoption of agroforestry practices were scanty rainfall, lack of fund, lack of land, high labour demand, lack of improved seedlings, inadequate extension personnel, lack of transportation and lack of incentives.

The study showed very significant relationships between the respondents' demographic characteristics and the agroforestry practices e.g planting of trees for wind breaks and age in Sahel savanna (x^2=11.48 P <0.05), education (x^2=29.58 P <0.05). religion, gender, marital status, occupation, were not significantly related to the agroforestry practices.

Chi-square analysis also showed a significant relationship between sources of information and use of agroforestry practices in Sahel savanna. (x^2=4.60 P<0.05) and in Sudan savanna (x^2=4.51, P <0.05).

Correlation analysis also showed a significant relationship between use and benefits of agroforestry practices. (r = 0.160 P< 0.05). Analysis of Variance (ANOVA) also showed a significant difference in the use of agroforestry practices among the three zones of Katsina state (F = 63.29, P <0.05).

ANOVA also showed a significant difference in the following soil parameters in Sahel Savanna. p^H ($P < 0.01$)$^{2+}$ Ca^{2+} ($P<0.001$), K^+ ($P<0.05$) Na^+ ($P<0.001$) and CEC ($P < 0.001$).

There was also significant difference in total nitrogen ($P <0.01$), Mg^{2+} Na^+ ($p <0.001$) between agroforestry and non-agroforestry plots.

6.2. Conclusion

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

1. The various agroforestry practices that were common in the study area include scattered trees on farmland, windbreaks, woodlots, improved fallow in shifting cultivation and homegardens.

2. The benefits derived from agroforestry practices among the three ecological zones were preservation of the environment, provision of fruits and leaves, improvement of soil fertility, erosion control, improvement of farmers' income, and provision of fodder.

3. There were differences in adoption of agroforestry practices among the three agro-ecological zones. The differences in adoption could be that an innovation in which was appropriate for a given zone might not necessarily be accepted in another zone. This could also be due to soil and climate type and socio-economic reasons.

4. Socio-economic, gender, level of education, sources of information to agroforestry practices including perceived benefits derived from agroforestry practices highly influenced adoption of the system in the study area.

5. There was a significant variation in soil p^H, total nitrogen, Mg^{2t}, K^t and Na^t between agroforestry and non-agroforestry plots with soil nutrient and organic matter content skewing in favour of agroforestry plots.

6.3. Recommendations

In order to sustain and even increase our agricultural productivity and to reduce, to the barest minimum, the effects of desertification and environmental degradation, the following recommendations are made.

i. Government should encourage the adoption of agroforestry as a system of multiple land use to increase wood and food production thereby ensuring the optimum use of land.

ii. Encourage individuals and communities to embark on planting of trees and establishment of nurseries in degraded areas of the state.

iii. Public enlightenment/awareness and education campaign should be made by Government on the benefits of forests and the consequences of fast disappearance of these forests in the lives of the local communities.

iv. Provide soft loan and other incentives such as seedlings, transportation, inorganic fertilizers and tractors to farmers so as to encourage them to participate actively in agroforestry activities.

vi. Training and re-training of more extension agents should be carried out from time to time to make them perform their duties effectively, since they are the link between the farmers and the researchers.

vii. Federal and state government should encourage more research into agroforestry practices, so that farmers can benefit from it.

viii. The use of more indigenous tree species that can improve soil fertility and at the same time more adaptable to the environment should be promoted (eg. *Parkia biglobosa*)

ix. Female farmers should be encouraged to be involved in the agroforestry practice to reduce male dominance. This will help to boost agroforestry practises in the study area. This could be done by providing them with more incentives and introduction of species which are attractive to women.

x. Application of organic fertilizers and planting of leguminous trees will help to resuscitate the soil for high productivity.

6.4 Areas for Further Research

i. A study to re-examine the factors limiting the adoption of some agroforestry practices that have low adoption in the study area such as alley cropping and *Taungya*.

ii. Reappraisal of the role of extension agents in the adoption of agroforestry practices in Katsina state.

iii. Research into indigenous trees that can be used as potent agroforestry trees.

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APPENDIX I

DEPARTMENT OF FOREST RESOURCES MANAGEMENT

UNIVERSITY OF IBADAN

Evaluation of Agro-forestry practices in Katsina state, Nigeria

INTRODUCTION

I am a post graduate student carrying out an investigation on Evaluation of Agro-forestry practices in Katsina state, Nigeria.

The purpose of this research is purely academic and your cooperation will be appreciated if you would kindly provide the correct answers.

Thank you.

J. I. Amonum

A. DEMOGRAPHIC CHARACTERISTICS

1. Age of respondent ………………………………. years

2. Local Government Area of Origin ……………………..

3. Gender (a) male ( ) (b) Female ( )

4. Religion (a) Islamic ( ) (b) Christianity ( )
(c) Traditional ( ) (d) others ………. (Specify)

5. Marital status (a) Single ( ) (b) Married ( )
(c) Divorced ( ) (d) widowed ( )

6. If married, number of wives (a) 1 – 3 (b) 4 – 6 (c) 7 – 9

7. Number of children (a) 1 – 6 (b) 7 – 12 (c) 13 – 18
(d) above 19

8. Occupation (a) farming ( ) (b) Trading ( ) (c) Civil servant ( ) (d) Fishing ( ) (e) Cattle rearing ( ) (f) others............specify

NON – DEMOGRAPHIC CHARACTERISTICS

B: Agricultural Activities

9. When did you start practising farming? .... years ( )

10. How many farm locations do you have? (a) 1- 2 (b) 3 – 4 (c) 5 – 6 (d) 7 – 8 (e) 9 – 10 (f) >10

11. How did you acquire your land? (a) By inheritance ( ) (b) By Purchase ( ) (c) Rent/Lease ( ) (d) Gift ( ) (e) From Government ( )

12. What is your main farm produce? (a) Food crops ( ) (b) Livestock ( ) (c) Tree crops ( ) (d) Timber trees ( ).

13. State the most important food crop cultivated in your locality (a) Maize ( ) (b) Rice ( ) (c) Cowpea ( ) (d) Sorghum ( ) (e) Millet ( )(f) Other specify ( ).

14. What is your annual farm size? (a) 1 – 2 ha ( ) (b) 3 – 4 ha ( ) (c) 5 – 6 ha ( ) (d) Above 6 ha ( ).

15. State the most important livestock kept in your locality (a) Poultry ( ) (b) Cattle ( ) (c) Sheep ( ) (d) Goat ( ) (e) Pig ( )

16. Indicate your present level of farming (a) Mainly subsistence ( ) (b) Semi – commercial ( )

17. From the above activities, please indicate your estimated agricultural income category. (a) Less than N10,000 ( ) (b) N 10,000 – N20,000 ( ) (c) N21,000 – N30,000 ( ) (d) 31,000 – 40,000 ( )

AGROFORESTRY PRACTICES

18. Have you heard about agroforestry systems? (a) Yes ( ) (b) No ( )

Indicate which of the following agroforestry practices you are engaged in by ticking either Yes or No as the case may be:

19. Planting of trees on the farm (a) Yes ( ) (b) No ( ) Give reasons

20. Improved fallowing land rotation (a) Yes ( ) (b) No ( ) give reasons.

21. Use of livestock manure (a) Yes ( ) (b) No ( ) give reasons.

22. Raising of forest tree with agricultural crops (*Taungya* system) (a) Yes (b) No ( ) give reasons.

23. Planting of food crops between trees or shrubs (Alley cropping) (a) Yes ( ) (b) No ( ) give reasons.

24. Rearing of bees for honey (Apiculture) (a) Yes ( ) (b) No ( ) give reasons

25. Planting of trees for wind break (a) Yes ( ) (b) No ( ) give reasons

ATTITUDES TO AGROFORESTRY PRACTICES

Please respond through the following statements by ticking yes, no or undecided.

1. Planting of trees together with food crops reduce crop yield (a) Yes ( ) (b) No ( ) (c) Undecided
2. Trees require very long time to mature (a) Yes ( ) (b) No ( ) (c) Undecided ( )
3. The government does not provided good seedlings to farmers to plant trees (a) Yes ( ) (b) No ( ) (c) undecided ( )

4. Farming operations becomes cumbersome when tree crops are planted together with food crops (a) Yes ( ) (b) No ( ) (c) Undecided ( )

5. It is good to plant trees to prevent erosion (a) Yes ( ) (b) No ( ) (c) undecided ( )

6. To plant trees and food crops together requires large hectares of land. (a) Yes ( ) (b) No ( ) (c) undecided ( )

7. Farm resources are sustained when food crops are planted with trees (a) Yes ( ) (b) No ( ) (c) Undecided ( )

8. The livestock products improve the farmers' nutritional status

   (a) Yes ( ) (b) No ( ) (c) Undecided ( ).

SOURCES OF INFORMATION

26. Are you aware of agroforestry practices? (a) Yes ( ) (b) No ( )

27. If yes, indicate your source of information on the following practices. If more than one source, rank as 1, 2, 3, ...12 in order of importance.

		Traditional	Radio/ TV/ Print media	Extension Agents	Neighbours	Relatives	others
1	*Taungya*						
2	Improved fallow						
3	Alley cropping						
4	Fuelwood production						
5	Tree planting						
6	Home gardens						
7	Wind breaks						
8	Woody perennial for soil conservation						
9	Rearing of bees						
10	Border planting						
11	Wood lots						
12	Multipurpose tree on crop land						

28. PERCEIVED BENEFITS OF AGROFORESTRY PRACTICES

From the following list of benefits, indicate those you derive and the degree of each benefit

	BENEFITS	YES	NO	UNDECIDED
1	Continuous land utilization			
2	Yield income			
3	Preservation of the environment			
4	Reduced risk of complete crop failure			
5	Provide fuel wood			
6	Erosion is controlled			
7	Positive use of shade for some			
8	Provide fruits/leaves			
9	Provide medicinal herbs			
10	Land tenure is improved			
11	Improvement in soil fertility			
12	Provide fodder			
13	Reduction in leaching			
14	Provide timber/building materials			
15	Boundary/land demarcation			

29. Do you combine forest tree species with agricultural crops on your farm? (a) Yes ( ) (b) No ( )

30. Do you deliberately leave forest tree species on your farm land during site clearing? (a) Yes ( ) (b) No ( )

31. Do you believe a combination of forest trees species with agricultural crops contributes to the conservation of the forest? (a) Yes ( ) (b) No ( )

32. What forest tree species do you leave on the farm? (please list them)

………………………………………………………………………………………………
………………………………………………………………………………………………
…………………………………………………

33. Do you care for the forest trees and protect them from destruction by fire and other agencies? (a) Yes ( ) (b) No ( )

34. Do you destroy forest tree species whose existence is likely to have adverse effect on the growth of agricultural crops? (a) Yes ( ) (b) No ( )

35. Has the destruction of forest tree species any adverse effect on agricultural crops on your farm? (a) Yes ( ) (b) No ( )

36. What type of farming do you practice?

a. Shifting cultivation

b. Fuelwood production

c. Home garden

d. Tree Planting (wood lot development)

e. Animal rearing

f. Others (specify)

37. Is there usually a significant difference in crop yield between farms with forest tree species which are intercropped with agricultural crops and those without forest tree species? (a) Yes ( ) (b) No ( )

38. Do you use fertilizer on your farm? (a) Yes ( ) (b) No ( )

39. Do you burn your proposed farm land before cropping (a) Yes ( ) (b) No ( )

40. If yes, why?

....

....

41. Does the combination of agricultural crops with forest tree species reduce crop yield? (a) Yes ( ) (b) No ( )

42. Do you allow improved fallow periods to increase soil fertility? (a) Yes ( ) (b) No ( )

43. What is the length of your fallow period? .... Years

44. Is the soil fertility and structure maintained better when forest tree species are cut down? (a) Yes ( ) (b) No ( )

S/No	Agricultural Crop	Yield on A/F Plots (Kg)	Yield on non-A/F Plots (Kg)
1			
2			
3			
4			
5			
6			
7			
8			
9			

45. Which of the following forest tree species do you combine with agricultural crops on your farm?

a. Kuta (Adansonia digitata)

b. Dogon yaro (Azadirachta indica

c. Anacardium occidentale (yazawa)

d. Borassus aethipum – (Giginya)

e. Parkia Sp (Dorowa)

f. Mangifera indica – Mango.

g. Vitex doniana

h. Others ……….. (specify)

46. What are the major problems you encounter in the adoption of agroforestry practices?

a. High labour demands ( )

b. Lack of capital/funds ( )

c. Lack of required tree seedlings ( )

d. Inadequate extension agents ( )

e. Lack of land ( )

f. Scanty rainfall ( )

g. Lack of transportation ( )

h. Lack of incentive ( )

i. Others (specify)………………………….

47. What assistance/inputs will you like to get from the government or other agencies?

(a)……………………………………………………….

(b)……………………………………………………….

(c)……………………………………………………….

(d)……………………………………………………….

APPENDIX 2

IMPACT OF RESPONDENTS DEMOGRAPHIC CHARACTERISTICS ON THEIR USE OF SOME IDENTIFIED AGROFORESTRY PRACTICES

Table 38: Summary of Chi-Square Analyses on Impacts of Respondents Age on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	9.84	5	0.08
Zone 2		0.89	4	0.93
Zone 3		2.85	5	0.72
Use of livestock on farmland	Zone 1	6.22	5	0.29
Zone 2		3.74	4	0.44
Zone 3		6.97	5	0.22
Planting of food crops between	Zone 1	4.25	5	0.51
trees and Shrubs	Zone 2	8.09	4	0.09
Zone 3		7.20	5	0.21
Planting of trees for wind breaks	* Zone 1	11.48	5	0.04
Zone 2		6.61	4	0.16
Zone 3		10.72	5	0.06
Improved fallow land rotation	Zone 1	6.19	5	0.29
Zone 2		2.85	4	0.58
Zone 3		14.19	5	0.01
Raising of forest trees with	Zone 1	3.26	5	0.66
agricultural crops	* Zone 2	12.50	4	0.01
Rearing of bees for honey	Zone 1	6.81	5	0.24
Zone 2		6.26	4	0.18
Zone 3		6.48	5	0.26

* Test is significant at 0.05 confidence limit – parameters are dependent on age of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 3

Summary of Chi-Square Analyses on Impacts of Respondents Gender on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	0.01	1	0.91
Zone 2		0.52	1	0.47
Zone 3		0.34	1	0.34
Use of livestock on farmland	Zone 1	0.51	1	0.48
Zone 2		0.38	1	0.54
*Zone 3		4.45	1	0.04
Planting of food crops between	*Zone 1	4.35	1	0.04
trees and Shrubs	*Zone 2	9.14	1	0.01
Zone 3		0.01	1	0.94
Planting of trees for wind breaks	Zone 1	0.14	1	0.71
Zone 2		0.48	1	0.49
Zone 3		1.07	1	0.30
Improved fallow land rotation	Zone 1	3.02	1	0.08
Zone 2		0.39	1	0.53
Zone 3		0.52	1	0.47
Raising of forest trees with	Zone 1	1.65	1	0.19
agricultural crops	Zone 2	3.69	1	0.05
Zone 3		0.01	1	0.92
Rearing of bees for honey	Zone 1	0.04	1	0.84
Zone 2		2.78	1	0.09
*Zone 3		5.56	1	0.02

* Test is significant at 0.05 confidence limit – parameters are dependent on gender of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 4

Summary of Chi-Square Analyses on Impacts of Respondents Marital Status on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	0.47	3	0.93
Zone 2		0.70	3	0.87
Zone 3		0.72	1	0.39
Use of livestock on farmland	Zone 1	1.00	3	0.80
Zone 2		4.84	3	0.18
Zone 3		0.34	1	0.56
Planting of food crops between	Zone 1	3.53	3	0.32
trees and Shrubs	Zone 2	3.92	3	0.27
Zone 3		0.12	1	0.73
Planting of trees for wind breaks	Zone 1	0.72	3	0.87
Zone 2		4.47	3	0.22
Zone 3		0.00	1	0.96
Improved fallow land rotation	Zone 1	3.81	3	0.28
Zone 2		0.80	3	0.85
Zone 3		0.25	1	0.62
Raising of forest trees with	Zone 1	2.07	3	0.56
agricultural crops	Zone 2	5.60	3	0.13
Zone 3		1.14	1	0.29
Rearing of bees for honey	Zone 1	2.01	3	0.57
Zone 2		1.03	3	0.79
Zone 3		2.79	1	0.09

* Test is significant at 0.05 confidence limit – parameters are dependent on marital status of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 5

Summary of Chi-Square Analyses on Impacts of Respondents Religion on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	0.72	3	0.87
Zone 2		4.47	3	0.22
Zone 3		0.00	1	0.96
Use of livestock on farmland	Zone 1	6.31	4	0.18
Zone 2		0.84	4	0.93
Zone 3		-	-	-
Planting of food crops between	Zone 1	2.49	4	0.65
trees and Shrubs	Zone 2	4.09	4	0.39
Zone 3		-	-	-
Planting of trees for wind breaks	Zone 1	2.33	4	0.68
*Zone 2		36.69	4	0.01
Zone 3		-	-	-
Improved fallow land rotation	Zone 1	1.74	4	0.78
Zone 2		2.75	4	0.60
Zone 3		-	-	-
Raising of forest trees with	Zone 1	4.95	4	0.29
agricultural crops	Zone 2	5.01	4	0.29
Zone 3		-	-	-
Rearing of bees for honey	Zone 1	3.35	4	0.50
Zone 2		6.03	4	0.19
Zone 3		-	-	-

* Test is significant at 0.05 confidence limit – parameters are dependent on religion of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 6

Summary of Chi-Square Analyses on Impacts of Respondents Educational Background on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	7.83	6	0.25
*Zone 2		29.58	9	0.01
Zone 3		7.45	5	0.19
Use of livestock on farmland	*Zone 1	12.76	6	0.04
Zone 2		10.88	9	0.28
Zone 3		2.77	5	0.74
Planting of food crops between	Zone 1	3.89	6	0.69
trees and Shrubs	*Zone 2	19.63	9	0.02
*Zone 3		41.49	5	0.01
Planting of trees for wind breaks	Zone 1	5.09	6	0.53
*Zone 2		20.27	9	0.02
*Zone 3		22.17	5	0.01
Improved fallow land rotation	Zone 1	4.03	6	0.67
*Zone 2		31.25	9	0.01
*Zone 3		25.64	5	0.01
Raising of forest trees with	Zone 1	8.74	6	0.19
agricultural crops	*Zone 2	30.59	9	0.01
	*Zone 3	46.49	5	0.01
Rearing of bees for honey	Zone 1	9.47	6	0.15
*Zone 2		24.84	9	0.01
Zone 3		2.77	5	0.74

* Test is significant at 0.05 confidence limit – parameters are dependent on education background of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 7

Summary of Chi-Square Analyses on Impacts of Respondents Occupation on their Perception of some Identified Agroforestry Practices

Perception parameters		Pearson's x^2 Value	Degree of Freedom	Pr
Planting of trees on farm	Zone 1	2.21	6	0.89
*Zone 2		23.96	14	0.04
Zone 3		9.69	5	0.08
Use of livestock on farmland	Zone 1	1.98	6	0.92
Zone 2		6.77	14	0.94
Zone 3		6.06	5	0.30
Planting of food crops between	Zone 1	14.71	6	0.02
trees and Shrubs	Zone 2	13.54	14	0.49
Zone 3		1.76	5	0.88
Planting of trees for wind breaks	Zone 1	2.00	6	0.92
Zone 2		21.56	14	0.09
*Zone 3		15.96	5	0.01
Improved fallow land rotation	Zone 1	3.44	6	0.75
Zone 2		11.87	14	0.62
*Zone 3		12.86	5	0.03
Raising of forest trees with	Zone 1	3.96	6	0.68
agricultural crops	Zone 2	16.45	14	0.29
Zone 3		1.62	5	0.89
Rearing of bees for honey	Zone 1	5.36	6	0.49
Zone 2		13.77	14	0.47
Zone 3		2.66	5	0.75

* Test is significant at 0.05 confidence limit – parameters are dependent on occupation of respondents.

Zone 1 = Sahel savanna

Zone 2 = Sudan savanna

Zone 3 = Guinea savanna

APPENDIX 8a

Variable	Mean	Standard Dev	Cases
BENEFITS	14.5750	1.0969	360
ATTITUDE	5.8931	1.6985	360

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- - -

Zero Order Partials

	BENEFITS	ATTITUDE
BENEFITS	1.0000	.0170
	(0)	(358)
	P= .	P= .748
ATTITUDE	.0170	1.0000
	(358)	(0)
	P= .748	P= .

(Coefficient / (D.F.) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S
- - -

Controlling for.. ZONE

BENEFITS ATTITUDE

BENEFITS	1.0000	.0055
	(0)	(357)
	P= .	P= .917
ATTITUDE	.0055	1.0000
	(357)	(0)
	P= .917	P= .

(Coefficient / (D.F.) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

APPENDIX 8b

Variable	Mean	Standard Dev	Cases
USE	5.0722	1.7601	360
BENEFITS	14.5750	1.0969	360

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S - - -

Zero Order Partials

	USE	BENEFITS
USE	1.0000	.1602
	(0)	(358)
	P= .	P= .002
BENEFITS	.1602	1.0000
	(358)	(0)
	P= .002	P= .

(Coefficient / (D.F.) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

_

- - - P A R T I A L   C O R R E L A T I O N   C O E F F I C I E N T S - - -

Controlling for..   ZONE

	USE	BENEFITS
USE	1.0000	.1427
	(0)	(357)
	P= .	P= .007
BENEFITS	.1427	1.0000
	(357)	(0)
	P= .007	P= .

(Coefficient / (D.F.) / 2-tailed Significance)

" . " is printed if a coefficient cannot be computed

APPENDIX 9

Correlation coefficients for soil variables in Guinea savanna.

Soil variable	p^H	OC	TN	AP	Ca	Mg	K	Na	HAL	CEC
p^H	1	0.672 ns	-0.057 ns	-0.107 Ns	0.305 ns	0.153 ns	0.084 ns	-0.037 ns	-0.862 ***	0.169 ns
OC		1	0.427 ns	0.120 Ns	0.573 ns	0.558 ns	0.519 ns	0.057 ns	-0.473 ns	0.497 ns
TN			1	0.214 Ns	0.819 ***	0.973 ***	0.788 ***	0.378 ns	0.117 ns	0.895 ***
AP				1	-0.275 ns	0.112 ns	-0.360 ns	-0.747 ***	0.541 ns	-0.187 ns
Ca					1	0.905 ***	0.945 ***	0.711 ***	-0.368 ns	0.985 ***
Mg						1	0.837 ***	0.421 ns	-0.105 ns	0.948 ***
K							1	0.784 ***	-0.217 ns	0.943 ***
Na								1	-0.247 ns	0.680 **
HAL									1	-0.228 ns
CEC										1

*,**, *** = Significant level at $P < 0.01$ & 0.001 respectively

APPENDIX 10

Correlation coefficients for soil variables in Sudan savanna.

	p^H	OC	TN	AP	Ca	Mg	K	Na	HAL	CEC
p^H	1	-0.548 ns	0.072 ns	-0.219 Ns	-0.127 ns	-0.316 ns	0.292 ns	-0.236 ns	-0.816 ***	-0.358 ns
OC		1	0.186 ns	0.412 Ns	0.448 ns	0.449 ns	-0.218 ns	-0.553 ns	0.491 ns	0.436 ns
TN			1	0.780 ***	0.585 *	0.325 ns	0.377 ns	-0.050 ns	-0.349 ns	0.427 ns
AP				1	0.939 ***	0.827 ***	0.633 *	0.059 ns	0.066 ns	0.887 ***
Ca					1	0.929 ***	0.727 ***	-0.050 ns	0.106 ns	0.941 ***
Mg						1	0.622 *	0.149 ns	0.422 ns	0.989 ***
K							1	0.162 ns	-0.337 ns	0.626 *
Na								1	0.317 ns	0.199 ns
HAL									1	0.398 ns
CEC										1

*,**, *** = Significant level at $P< 0.01$ & 0. respectively

APPENDIX 11

Correlation coefficients for soil variables in Sahel savanna.

	p^H	OC	TN	AP	Ca	Mg	K	Na	HAL	CEC
p^H	1	-0.330 ns	0.072 ns	0.601 *	-0.591 *	-0.246 Ns	0.127 ns	0.771 ***	0.160 ns	-0.537 ns
OC		1	0.211 ns	-0.306 Ns	0.046 ns	0.713 ***	0.514 ns	-0.183 ns	-0.700 **	0.066 ns
TN			1	-0.502 Ns	-0.522 ns	0.136 ns	0.357 ns	0.652 *	0.091 ns	-0.339 ns
AP				1	-0.002 ns	-0.147 ns	0.201 ns	0.253 ns	-0.343 ns	-0.105 ns
Ca					1	0.487 ns	0.122 ns	-0.723 **	-0.138 ns	0.966 ***
Mg						1	0.793 ***	-0.140 ns	-0.512 ns	0.603 *
K							1	0.360 ns	-0.626 *	0.250 ns
Na								1	0.091 ns	-0.591 *
HAL									1	-0.056 ns
CEC										1

*,**, *** = Significant level at *P*< 0.01 & 0.001 respectively

Appendix 12

Distribution of respondents on some indices of sustainable land use

Planting Trees with Food Crops Reduce Crop Yield	Frequency	%
Yes	184	50.8
No	141	39.2
Undecided	35	10.0
Total	**360**	**100.00**
Trees Require Long Time to Mature		
Yes	285	79.2
No	60	16.7
Undecided	15	4.1
Total	**360**	**100.00**
Government does not Provide Good Seedlings to Farmers		
Yes	134	37.2
No	191	52.9
Undecided	35	9.9
Total	**360**	**100**
Trees and Food Crops together make Farming Cumbersome		
Yes	244	67.5
No	81	22.5
Undecided	35	10.0
Total	**360**	**100.00**
Tree Planting Prevents Erosion		
Yes	335	93.1
No	04	1.1
Undecided	21	5.8
Total	**360**	**100.00**
Tree and Food Crop Planting require Large Area		
Yes	232	64.4
No	109	30.3
Undecided	19	5.3
Total	**360**	**100.00**
Tree and Food Crop Mix Sustain Farm Resources		
Yes	293	81.0
No	44	12.4
Undecided	23	6.6
Total	**360**	**100.00**
Livestock Products Improve Farmers Nutritional Status		
Yes	317	88.3
No	33	9.2
Undecided	10	2.5
Total	**360**	**100.00**
Continuous Land Utilization		
Yes	325	90.0
No	3	0.8
Undecided	32	9.2
Total	**360**	**100**
Improves Farmers' Income		
Yes	346	96.1
No	02	0.6
Undecided	12	3.3
Total	**360**	**100**

Preservation of Environment		
Yes	345	95.8
No	05	1.4
Undecided	10	2.8
Total	**360**	**100**
Reduce Risk of Complete Crop Failure		
Yes	343	95.0
No	06	1.7
Undecided	11	3.3
Total	**360**	**100**
Produce Fuel Wood		
Yes	351	97.5
No	-	-
Undecided	09	2.5
Total	**360**	**100**
Erosion is Controlled		
Yes	353	98.1
No	04	1.1
Undecided	03	0.8
Total	**360**	**100**
Positive use of Shade for some Crops		
Yes	352	97.5
No	03	0.8
Undecided	05	1.7
Total	**360**	**100**
Provide Fruit/Leaves		
Yes	354	98.3
No	02	0.6
Undecided	04	1.1
Total	**360**	**100**
Provide Medicinal Herbs		
Yes	351	97.5
No	04	0.8
Undecided	05	1.7
Total	**360**	**100**
Improve Land Tenure		
Yes	316	87.5
No	33	9.2
Undecided	11	3.3
Total	**360**	**100**
Improve Soil Fertility		
Yes	352	97.5
No	03	0.8
Undecided	05	1.7
Total	**360**	**100**
Provide Fodder		
Yes	350	97.2
No	05	1.4
Undecided	05	1.4
Total	**360**	**100**
Reduce Leaching		
Yes	351	97.5
No	02	0.8
Undecided	07	1.7

Total	**360**	**100**
Provide Timber/Building Materials		
Yes	344	95.8
No	07	1.7
Undecided	09	2.5
Total	**360**	**100**
Assist Boundary/Land Demarcation		
Yes	346	95.8
No	05	1.7
Undecided	09	2.5
Total	**360**	**100**
Do you Combine Forest Tree with Agricultural Crops?		
Yes	111	92.5
No	9	7.5
Do you deliberately leave Forest Tree Species on Farm during Clearing?		
Yes	116	96.4
No	4.0	3.6
Do you believe that Combining Forest tree Specie with Agricultural Crops Contribute to Conservation?		
Yes	116	96.7
No	4	3.3
Care for and Protect Forest Tree Species from Agent to Destruction?		
Yes	116	96.7
No	4	3.3
Destroy Forest Tree Species Endangering Agricultural Crop Growth?		
Yes	94	78.3
No	26	21.7
Has Destruction of Forest Tree Species Adversely Affected Agricultural Crops on your Farm?		
Yes	100	83.3
No	20	16.7
Observe Significant Yield from a Mixed Tree Farm and a Pure Arable Crop Farm?		
Yes	113	94.2
No	07	5.8
Do you use Fertilizer?		
Yes	117	97.5
No	03	2.5

Source:Field Survey 2006/2007