THE ROLE OF AGROFORESTRY PRACTICES IN SUSTAINABLE LAND MANAGEMENT IN RURAL AREAS OF KADUNA STATE, NIGERIA

BY

James Olufemi ADEDAPO

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DECLARATION

I hereby declare that this dissertation titled **The Role of Agroforestry Practices in Sustainable Land Management in Rural Areas of Kaduna State, Nigeria** had been prepared by me and it is record of my own work under the supervision of Dr I. J. Musa and Dr S.S. Obeka. The information derived from the various literatures has been duly acknowledged in the list of references and has not been previously submitted in any Higher Institution of learning.

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Adedapo James Olufemi **Date**

CERTIFICATION

This thesis title **The Role of Agroforestry Practices in Sustainable Land Management in Rural Areas of Kaduna State, Nigeria** meets the regulations governing the award of the degree of **M. Sc. Environmental Management** of Ahmadu Bello University, Zaria, Nigeria, and is approved for its contribution to knowledge and literary presentation.

……………………………………….. ……………………… Chairman,
Supervisory Committee Date Dr. Ibrahim Jaro
Musa

……………………………………….. ……………………… Member,
Supervisory Committee Date Dr. Samuel
Sunday Obeka (Very Rev.)

……………………………………….. ……………………… Head of
Department Date Dr. Ibrahim Jaro
Musa

……………………………………….. ……………………… Dean,
School of Postgraduate Studies Date Prof Kabir Bala

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ABSTRACT

The concern of humanity is the need to tackle the increasing challenges of severe land degradation and desertification of the ecosystem. The study examined the critical role of agroforestry practices in sustainable land management in rural areas of Kaduna State, Nigeria. Purposive sampling technique was employed in collecting data from three hundred and fifty-seven (357) rural farmers with structured questionnaire administered in threeLocal Government Areas of Kaduna State, namely Chikun, Zaria and Kubau.The data were analyzed using statistics such as simple Percentage, Tables, graphs, charts and Chi square to test for the hypothesis. The study result showed the socio- economic characteristics of farmers in the rural areas such as age, gender, marital status, educational level, farm size, farming experience and farm ownership.From the study, different land management practices were examined, and result showed that30% farmers adopt irrigation and fertilizer each, 21% of them practiced application of organic manure, 10% and 4% adopted mulching and cover crops respectively. Bush fallow and crop rotation are practiced by 4% and 1% respectively. Also from the study, it was discovered that 73% of farmers believed that the presence of the trees in their various farms helped them to control erosion, while only 17% and 4% applied Mulching and cover crops respectively. The rest of the 3% applied organic manure and other methods to control erosion.It was discovered from the survey that about 87% practiced agroforestry, while only 13% of the total sampled did not practice agroforestry. Also discovered that 83% respondents considered agroforestry as a land management practice, while only 16% did not consider it as means of land management practices and only 1% were indifferent.The types of agroforestry practiced by the respondents in the study area are as follows, most of the farmers 62% practiced parkland, followed by windbreak/shelterbelt with 15%, the next one is living fence or boundary system with 10%, followed by forest farming with 6%, alley cropping, riparian buffer system are practiced by 4% each, only 1% practiced silvopasture, the rest representing 11% did not practice any of these systems.The trees and shrubs species most favoured by majority of the farmers are *Mangifera indica, Parkia clappertoniana, Butyrospermum paradoxum,Psidium guajava,Azadirachta indica,Adansonia digitata, Anacardium occidantale, Moringa oleifera, Anogeissus leiocapus, Musa sappientum.*The pattern of crop production showed that Maize, Tomatoes, Sorghum, Rice and Pepper are the principal crops in the study area since more than one-quarter of the total sampled cultivate them every year. Other crops common in the area but are produced at insignificant measure by few farmers are Ground nut, Onion, Millet, Green Beans, Carrot, Cabbage and Sweet Potatoes. On the basis of the findings, the study recommends that, education and research should be promoted, local involvement should be encouraged, financial support should be provided and policy should be reformed. It was therefore concluded that, there is need for an aggressive agroforestry extension to convince farmers to adopt a sustainable land management farming system like agroforestry, which is fast disappearing from the earlier practices. Hence, the role of agroforestry practices in ensuring sustainable use of land, upholding ecological equilibrium and maintaining the environment should be put in the right perspective.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

In recent times, it has become obvious that to achieve much success on sustainable land management, Farming System, Research and Extension have to be intensified. This involves improving and modifying where necessary the farmers methods of land management, soil improvement.

Sustainability means making things last, making them permanent and durable. What is being sustained can be an object of choice such as economy, industry, ecosystem or set of ecosystem, (Pearce, 1988). The need and means for ensuring sustainable development should transcend all generations and be international in scope, if long lasting records are to be obtained (Mamman and Ogbonna, 1993). Thus, the ecology debate of the past twenty-five years has been characterized by increasing concern for problems of the whole; Man, biota, the globe and the biosphere (Pearce and Atkinson, 1993). Growing population pressure and unabating droughts in recent years together with excessive deforestation, overgrazing and yearly bush burning have all combined to bring about rapid rate of desertification in the northern fringes of Nigeria, particularly Kaduna State which is the study area. Desertification is a term used to describe the spread of desert-like conditions in arid or semi-arid environment such as steppe and Savanna (UNCOD, 1977).

The feasible approach to stem the environmental problems should be interdisciplinary and take into account, concurrent production of food, wood and animal products for the overall well-being of the rural and urban populace. A collection of Agroforestry systems which have the potentials to providing food, fodder, fuel wood, crops and livestock products is the obvious answer.

Sustainable land managementis the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (FAO, 2009). Sustainable land managementis the key entry point for improving land resource resilience and productivity within the context of the potentially devastating effects of climate change in Africa, bridging the needs of agriculture and environment.

Land refers to cropland, range, pasture, forest and woodlands. Land is defined by the UN Convention to Combat Desertification as the terrestrial biologically productive system that comprises soil, vegetation, other biota and the ecological and hydrological processes that operate within the system.

Within the sphere of agriculture, Sustainable land management includes the maintenance over time of soil productivity. This requires the combination of soil fertility treatment (perhaps including application of mineral and organic fertilizers) with soil and water conservation measures (implementation of agronomic, soil management and physical measures, such as contour ridging, terracing, tied ridges or providing ground cover through mulching, use of plants and leaving crop residues).

Recent evidence demonstrates returns on Sustainable land managementinvestments (forestry, soil and water conservation, irrigation) ranging from 12 to 40 percent in East and West Africa (Reij and Steeds, 2003). However, the incentive mechanisms for change are often poorly understood. It is a vital prerequisite for successful adaptation and mitigation that land users have enhanced knowledge and understanding of climate change and how Sustainable land managementcan assist them in coping with its impacts. Ultimately, land users in Africa will make their own choices, based on expected net returns. This will always be in the context of the land users‟ understanding of the likely impacts of climate change and existing agriculture and environmental policies.

Agroforestry can be defined as an approach to land use based on the deliberate integration of trees and shrubs in crop and livestock production systems. The practice can help to ensure sustained productivity of crops and animals by protecting and enhancing the natural resources base. Agroforestry is the intentional mixing of trees and shrubs into crop and animal production systems to create environmental, economic, and social benefits (USDA, 2011).

The foundation of agroforestry is putting trees to work in conservation and production systems for farms, forests, ranches, and communities. Agroforestry begins with placing the right plant, in the right place, for the right purpose (USDA, 2011). Trees play a crucial role in almost all terrestrial ecosystems. They provide a wide range of products and services to rural and urban people. As natural vegetation is cleared for agriculture, trees are integrated into productive landscapes – the practice known as agroforestry.

Agroforestry is practiced by millions of farmers, and has been a feature of agriculture for millennia. It encompasses a wide range of working trees that are grown on farms and in rural landscapes, and includes the generation of science-based tree enterprise opportunities that can be important in the future. Among these are: fertilizer trees for land regeneration, soil health and food security; fruit trees for nutrition and income; fodder trees that improve smallholder livestock production; timber and fuel wood trees for shelter and energy; medicinal trees to combat disease, particularly where there is no pharmacy; and trees that produce gums, resins or latex products (Garrity, 2004). Many of these trees have multiple uses, each providing a range of benefits. An estimated 1.2 billion rural people currently practice agroforestry on their farms and in their communities, and depend upon its products (World Bank, 2004). Their tree-based enterprises help ensure food and nutritional security, increase their income and assets, and help solve their land management problems. Trees play a particularly pivotal role wherever people depend on fragile ecosystems for survival and sustenance.

Agroforestry is a unique land management approach that provides opportunities to integrate productivity and profitability with environmental stewardship, resulting in healthy and sustainable agricultural systems that can be passed on to future generations (USDA, 2011). Agroforestry practices are *intentional* combinations of trees with crops and/or livestock which involve *intensive* management of the *interactions* between the components as an *integrated* agro ecosystem. These four key characteristics - intentional, intensive, interactive and integrated - are the essence of agroforestry and are what distinguish it from other farming or forestry practices (Garrett, 2009).

There are five common agroforestry practices: alley cropping, silvopasture, windbreaks, forested riparian buffers and forest farming (Gold *et al*., 2000). In alley cropping, trees are planted in single or multiple rows with agricultural or horticultural crops cultivated in the alleyways between rows. Silvopasture combines trees, forage and livestock into one integrated practice. Windbreaks are trees or shrubs planted as barriers that reduce wind speed and protect crops and livestock, or provide wildlife with a habitat. Riparian buffers are strips of permanent vegetation—trees, shrubs and grasses—planted between agricultural land and water resources to reduce run-off and non-point source pollution, stabilizing stream banks and protecting water quality. Forest farming consists of high-value, shade-tolerant crops cultivated under a forest overstory, modified to provide appropriate micro conditions. Many of these practices have multiple benefits, in terms of long-run income, stream, environmental, and/or scenic beauty (Gold *et al*., 2000).

The annual deforestation rate is about 11.3 million ha (Mastrantonio and Francis, 2004). People depend on forest and trees in the developing countries in many different ways (Dubois, 2003). Shifting cultivation is believed to have originated around 7000 BC, and this system is still common in some part of Asia, Latin America and Africa. It was predominantly sustainable in the past due to a low population pressure and the availability of large forest areas. Today, shifting cultivation contributes to excessive soil erosion and to land degradation (Steppler and Nair, 1987). It is estimated that 500 million farmers in developing countries still use shifting cultivation systems (Scherr, 1999). Most of them cultivate their land in marginal areas with poor soil quality, or on steep slopes. Shortening fallow periods and widespread burning to control weeds and pests further contribute to land degradation. Large areas have already been abandoned due to nutrient and organic matter depletion or invasive weeds (Scherr, 1999). Soil on steep slopes have commonly completely lost their productivity due to soil erosion. This causes serious local food shortages (Sah, 1996).

The most common reason for declining productivity is water erosion. Other reasons are wind erosion, chemical soil degradation (loss of nutrients, salinization, pollution, and acidification) and physical soil degradation -loss of organic matter, water logging, and compaction saeling or crusting; (Scherr, 1999). The extent and effect of water erosion depend on the soil erosivity, which is the power of the rain to cause erosion; and erodibility, which is the ability of the soil to resist the rain (Hellin, 2006). Water erosion is problematic in the tropics because of heavier rain showers, as compared to other regions. Erosion is caused in the tropics due to uncovered soil, absence of windbreaks, lack of organic matter in the soil, and monocultures in farming (Glover, 2005).

Agricultural soils in the tropics, as also in the northern Guinea Savannah Zone, maintain their fertility due to tight cycling of nutrients between vegetation and soil; if this cycle is broken through forest destruction, nutrients are likely to be rapidly lost, which results in an impoverished soil (Hamilton and Bensted-Smith, 1989). Soil degradation is a major contributor to nutrient losses, because most of the scarce soil nutrients in the tropics are in the top 5-10 cm of the soil (Nkonya, Pender, Jagger, Kaizzi, and Ssali, 2004). The soils have a low water holding capacity due to low content of small soil particles. High temperatures favour rapid decomposition of organic residues; thus organic inputs are needed to avoid erosion. Steep lands are more sensitive to rapid soil degradation through runoff (Hellin, 2006).

Therefore, carefully selected and managed trees can increase soil fertility and control erosion. Inappropriate agricultural and forestry production systems and population growth (animal and human) outstripping production lead to land degradation. This problem is severe in Kaduna State where the pressure of population is high, ecosystems are fragile and exploitation of forest cover is ruthless. The consequence is that wood and food supplies are dwindling. It is against this background that strengthening agroforestry practices using appropriate trees and shrubs would encourage rural dwellers in tackling environmental problems.

1.2 STATEMENT OF THE RESEARCH PROBLEM

One of the areas in need of sustainable land management is that which will help to stabilize the physical environment and increase agricultural production through better use of local, natural and human resources. Land management plans must optimize the production of crops, fodder, tree and livestock species and maximize their returns without detriment to the environment.

Soil fertility depletion on smallholder farms in Africa is already considered as a biophysical limiting factor affecting food production (Sanchez, Burersh and Leakey, 1997). This soil degradation affects more of the rural poor, because they are more dependent on annual agricultural crops that also cause more degradation than the other crops. They also rely more on common-property lands, which often are most seriously degraded. Land degradation has thus become a social, economic, political and technical problem (Hellin, 2006).

During the past 30 years, agroforestry has progressed from being a traditional practice with great potential to the point where development experts agree that it provides an important science-based pathway for achieving important objectives in natural resource management and poverty alleviation. Despite its ubiquitous use by smallholder farm families, there is inadequate awareness about the potential of agroforestry to benefit millions of households trapped in poverty. We need a global 'agroforestry transformation' to mobilize science and resources to remove the socio-economic, ecological and political constraints to widespread application of agroforestry innovations, and thereby help attain the MDGs. (World Agroforestry Centre, 2005).

Although, several studies have been carried out on the role of agroforestry practices in sustaining land management in different parts of the world and Nigeria in particular. For instance, Bugayong (2003) in a study, socioeconomic and environmental benefits of Agroforestry Practices in a community-based forest management site in the Philippines, observed that agroforestry practices play an important role as a strategy to uplift the socioeconomic conditions of the farmers while rehabilitating the degraded upland has made inroads in the project site.

Edmund (2005) in a study of agroforestry systems of West Africa in Nigeria, noted that Nigeria had experienced considerable depletion of their forested areas over years and this was attributed to a host of factors associated with anthropocentric activities in the use of land in the country. This problem is evident considering the growing incidence of land degradation emanating from sectors of the economy such as agriculture and the overdependence on oil revenues. Another important point that was noted by Edmund, (2005) is that the rural nature of the country and their dependence on subsistence farming and the ecological ramifications is quickening the gradual spread of agroforestry among communities in other to arrest the problems. In light of these findings, it is evident that analysis of agroforestry practices of West Africa with a focus on Nigeria stands as a valuable tool for decision makers and resource managers in gauging the problems posed by the developmental activities prompting loss of forest cover, rural poverty and environmental degradation in the country's ecological zones.

Similarly, Amonum, Babalola and Agera (2009) in a study carried out on the concepts and practices of agroforestry systems in the southern part of Nigeria, showed that agroforestry had become recognized as a land use system which is capable of yielding both wood and food, while at the same time conserving and rehabilitating ecosystems.

Ekpo and Asuquo (2012) in another study of adaptation tools of agroforestry practices to Climate Change Hazards in Itu LGA, Akwa Ibom State, Nigeria, revealed the following as potential role of Agroforestry to the farmers, reducing poverty through increased production of agroforestry products for home consumption and sale; contributing to food security by restoring farm soil fertility for food crops and production of fruits, nuts and edible oils; reducing deforestation and pressure on woodlands by providing fuel wood grown on farms; increasing diversity of on-farm tree crops and tree cover to buffer farmers against the effects of global climate change and improving nutrition to lessen the impacts of hunger and chronic illness associated with climate change.

Alao and Shuaibu (2013) in their recent study on agroforestry practices and concepts in sustainable land use systems in Lafia Local Government Area, Nasarawa State, Nigeria, identified the inherent role of Agroforestry practices accruable to farmers which include: additional income, human nutrition, medicinal herbs, fuel, stakes and timber, shades for human and livestock, reduce weeding, wind break and soil improvement.

It is noted that the attempts being made under agroforestry practices are to optimize the use of land for agricultural production on a sustainable basis at the same time meeting other needs from forestry

(Fagbemi, 2002). Various authors (Sanchez *et al.*, 1997; Bugayong, 2003; Edmund, 2005, Hellin, 2006; Ekpo and Asuquo, 2012; Alao and Shuaibu, 2013) were of the view that successful agroforestry practices play crucial role to sustain land management in the following ways: Consistent restoration of the fertility status of the soil through the recycled litter deposition and nitrogen fixing mechanism of trees; A variety of products, firewood, poles, woodcraft, fodder, medicinal herbs and food for livestock and man respectively; Prevention of wind and water erosion by trees acting as wind break and intercepting the raindrop impact on the soil respectively; Improving the micro-climate effect of the immediate and adjourning environment; Restoration of water table to an absorbable level for crops use; increased income opportunities; increased economic stability; reduced cost for establishing plantation and increased ability to manage for sustained yield.

Agricultural soils in the tropics, as also in the Northern Guinea savannah zone which Kaduna State is one of them, maintain their fertility due to tight cycling of nutrients between vegetation and soil; if this cycle is broken through forest destruction, nutrients are likely to be rapidly lost, which results in an impoverished soil (Hamilton and Bensted-Smith, 1989). Soil degradation is a major contributor to nutrient losses, because most of the scarce soil nutrients in the tropics are in the top 5-10 cm of the soil (Nkonya, Pender, Jagger, Kaizzi, and Ssali, 2004). The soils have a low water holding capacity due to a low content of small soil particles. High temperatures favour rapid decomposition of organic residues; thus organic inputs are needed to avoid erosion. Steep lands are more sensitive to rapid soil degradation through runoff (Hellin, 2006).

In all the previous researches reviewed, none has been carried out in Kaduna State which is the study area as well as failed to obtain the farmers' productivities to determine the sustainability of land management. Secondly, their findings were focused on only one Local Government Areas, while this study tries to investigate the variability of agroforestry practices across villages in three different Local Government areas in Kaduna State.

Therefore, the variability exiting among vegetation zones, peculiar environmental problems, farming systems, land use patterns and tenurial rights call for a different Agroforestry system that would be adaptable and adoptable in each community. It is based on the forgoing that the present research intends to investigate and establish the peculiar roles of Agroforestry practices in sustaining land management in the rural areas of Kaduna State, Nigeria.

In order to fill the existing gap in knowledge, the study intends to address the following research questions:

i. What are the socio-economic characteristics of farmers practicing agroforestry in the study area?

ii. What are the methods of land management practices in the study area?

iii. What are the various types of agroforestry practice in the study area?

iv. What is the justification for the roles of agroforestry practices with land management through farm productivity in the study area?

v. What are the possible ways to improve agroforestry practices in the study area?

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to assess the role of agroforestry practices in sustainable land management in some rural areas of Kaduna state. However, the specific objectives of the study are to:

i. examine socio-economic characteristics of farmers that practice agroforestry in the study area;

ii. assess methods of land management practices in the study area;

iii. characterize various types of agroforestry commonly practiced by the farmers in the study area; and

iv. examine the roles of agroforestry practices with land management through farm productivity in the study area;

1.4 HYPOTHESIS

The following Null hypothesis guided the research work:

There is no significant relationship between farmland size and total number of trees for sustainable land management in the farmland of respondents in the study area.

1.5 SCOPE OF THE STUDY

The study focuses on the role of agroforestry practices in sustainable land management. Due to financial cost and time, this study will cover few villages in the selected three local governments namely Kubua, Zaria and Chikun LGAs in Kaduna State. In these local government areas, Kubua- Pambegwa, Anchua, Dutsen-wai, Gubuchi and Angwa Kwala, Zaria- Angwa Jebba, Shika Dam, Tsahoni, Nagoyi and Maleruwa, Chikun- Kujama, Sabon Gida Damishi and Buruku villages were used. These three local government areas represent the most populous registered farmers among the Twenty Three Local Government Areas in the state. Though, there are different land management methods commonly practiced by the rural farmers which include fallowing, crop rotation, application of organic manure, irrigation, mulching or cover crop, minimum tillage and agroforestry, the study intends to evaluate on the crucial role played by agroforestry, because it is the most effective and widely practiced one. The study also focuses on socioeconomic characteristics of the farmers in the study area, different types of agroforestry practices that aids sustainable land management, various land management practices, farm productivities of farmers for the last five years, from, 2009 to 2013.

1.6 SIGNIFICANCE OF THE STUDY

As one of the studies which try to provide solution to the global issues of desertification, deforestation and land degradation, it intends to evaluate on the role of agroforestry practices as a management/development of resources to make for sustainable land management, it would be of interest to drawing out the role of farming practices that are capable of sustaining the farming land in the rural areas of Kaduna state. In this part of Nigeria, rainfall is very erratic and scarce and exploitation of natural resources is very high as a result of agricultural activities. If we are really concerned about the future generations, we must engage ourselves in deep thinking on how to manage our land and develop our resources for the good of all without degrading the land in particular and environment as a whole.

The transformation of the study area into the effective and aggressive practices of agroforestry will go a long way in combatting the problems of desertified land, deforestation, erosion, pollution, wind damage, flood, land degradation and other environmental disasters.

To understand and develop a sustainable model for environmental amelioration in the rural areas of Kaduna state, there is a need for rural farmers to understand the benefits derived from any farming operations practiced on the land which provides for their basic needs holistically.

The knowledge gained from this study would also be useful to rural development planners and administrators in the future planning for sustainable land management and productive environment.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 CONCEPTUAL FRAMEWORK

2.1.1 Concept of Agroforestry

Effort to define Agroforestry began in the mid-1970s and evolved rapidly as studies began on the diversity and scope of Agroforestry practices. In the late 1970s and early 1980s, the fate of Agroforestry suffered from a surfeit of definitions and a general lack of common understanding caused by a paucity of information. These earlier struggles to define a broad new area of study have resulted in a conceptual understanding from which to examine complex systems and practices. At least, one other early definition summarizes the basis for the study of Agroforestry.

Agroforestry is thus defined as a sustainable management system for land that increases total production, combines agricultural crops, and forest plants and/or animals simultaneously or sequentially and applies management practices that are compatible with the cultural pattern of the local population (Amonum *et al*, 2009).

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

2.1.2 Concept of Sustainability

Sustainable development may mean different things to different people, but the idea itself is simple. We must work out models for a relatively steady state society, with population in broad balance with resources and the environment." (Tickell, 1993).

The concept of sustainability includes notions of limits to resource availability, environmental impact, economic viability, biodiversity and social justice (Dumanski *et al*., 1991; Harmsen and Kelly, 1992).

The concept of sustainability is dynamic in that what is sustainable in one area, may not be in another, and what was sustainable at one time may no longer be sustainable. Although sustainability cannot be measured directly, assessments of sustainability can be made on the performance and direction of the processes that control the functions of a given system at a specific location (Dumanski and Smyth, 1993).

The concept of sustainability is pertinent only against a background of limits to resource availability and use. If no such limits exist, or they are not perceived to exist, then it is common that resources are overexploited; under restraints, however, the concept of sustainability becomes increasingly important, rising as the scarcity of the resource increases. Our perception of scarcity and our knowledge of alternate resource possibilities for the same applications, determine the important factors to be considered in the supply-demand equation of sustainability and sustainable land management.

2.2 LITERATURE REVIEW

2.2.1 Origin of Agroforestry Practice

Historically, cultivating trees and agricultural crops in intimate combination with one another is an ancient practice that farmers have used throughout the world (Amonum *et al*, 2009). King (1987) stated that in Europe until the middle ages, it was the general custom to clear-fell degraded forest, burn the slash, cultivate food crops for varying periods on the cleared area and plant or sow trees before, along with, after sowing agricultural crops.

This “farming system” is no longer popular in Europe (King, 1987). In Central America, it has been a long time traditional practice for farmers to plant an average of two dozen species of plants on plots larger than one-tenth of an hectare. For example, a farmer would plant coconut (*Cocus nucifera*) or Pawpaw (*Carica papaya*) with a lower layer of bananas or Citrus, a shrub layer of coffee or cacao, annuals of different stature such as maize and finally a spreading grown cover such as squash. Such an intimate mixture of various plants, each with a different structure, imitated the layered configuration of mixed tropical forests (Amonum *et al*, 2009). In Asia, for example the Philippines, a complex and somewhat sophisticated type of "shifting cultivation" were practiced. In clearing the forest for agricultural use, they deliberately spared certain trees which by the end of the rice growing season provided partial canopy of new foliage to prevent excessive exposure of the soil to the sun. These were an indispensable farming system here and were either planted or preserved from the original forest to provide food, medicines, construction wood and cosmetics (Amonum *et al*, 2009). These satisfy the socio-economic and environmental benefits of Agroforestry practices. The situation was a little different in Africa. For example in Southern Nigeria, Nair (1993) reported that yams, maize, pumpkin and beans were typically grown together under a cover of scattered trees. He observed that the Yoruba of Western Nigeria have long practiced an intensive system of mixing herbaceous plants, shrubs and trees crops, claiming that the system is a means of conserving human energy by making full use of the limited space won from the dense forest. The Yoruba also claim that this system is an inexpensive means of maintaining soil fertility as well as combating erosion and nutrient leaching (Amonum *et al*, 2009).

There are innumerable examples of traditional land-use practices involving combined production of trees and agricultural species on the same piece of land in many parts of the world. These are some examples of what is now known as Agroforestry (Nair, 1993). However, by the end of 19th century Myanmar established Teak (T*ectona grandis*) plantation by using a method called

"Taungya" which later became the most efficient way of planting Teak. It was introduced into South Africa as early as 1857 and was taken from Burma to India in 1890 (Hailey, 1957). The ruling philosophy of the Taungya system was to establish forest plantations whenever possible using available unemployed or landless labourers. In return for performing forestry tasks, the labourers would be allowed to cultivate the land between the rows of tree seedlings to grow agricultural produce. This is a simplification of a system whose detail varied depending on the country and locality (Nair, 1993).

2.2.2 Modern Agroforestry

Faced with the problems of deforestation and environmental degradation in the tropical regions, individuals and institutions intensified their search for appropriate land use approaches. These would not only be an additive to traditional land-use practices but also socially acceptable, ensure the sustainability of the production based and meet the need for production of multiple outputs. Efforts to design major programmes which would allow local communities to benefit directly from forests, paved the way for new forestry concepts such as social forestry in many countries (Nair, 1993). One of the approaches was experimentation in the general field of intercropping and in particular, it was felt that there was a need for a more scientific approach to intercropping research. It was suggested that greater effort were needed with respect to crop physiology, agronomy, yield stability, biological nitrogen fixation and plant protection (Nair, 1979). Consequently, the International Institute of Tropical Agriculture (IITA) extended its work to include integration of trees and shrubs with crop production. Other research organizations had also initiated serious work on, for example, the integration of animals with plantation of tree crops such as rubber and the intercropping of coconuts with legumes (Nair, 1979).

The most significant single initiative that contributed to the development of Agroforestry came from International Development Research Centre (IDRC) of Canada. The IDRC Project Report recommended the establishment of an internal organization which would support, plan andcoordinate on a world-wide basis, research combing the land-management systems of agriculture and forestry. Consequently, the International Council for Research in Agroforestry (ICRF) was established in 1977.

In 1991, it was renamed the International Centre for Research in Agroforestry (ICRAF) and charged to play a leading role in collecting information, conducting research, disseminating research result and pioneering new approaches and systems (Nair, 1993).

2.2.3 Types of Agroforestry Practices 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 perennial (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:

1. Agrisilviculture (Crop + Trees) 2. Silvopastoral (Pasture/animal + Trees)

3. 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 2.1

Table 2.1: Varieties and description of Agroforestry practices (systems) in Nigeria

Agroforestry system	**Description**	**Remarks**
Taungya Farming	Food crops are inter planted with trees in a unit area of land for 2-3 years. Food crops cease to exist on the land when the tree crops closecanopy. The system has proved effective in providing food for forestry workers and forage for cutting by cattle rearers.	Main Agroforestry model practice 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 chief problem with this system is the need to plan a planting programme for long cycle trees with three or four years of crops.
Integrated Taungya	Similar to Taungya farming, but here, when the tree canopy is closed, livestock grazing substitute raising of agricultural crops	The integrated approach aims atinvoking the idea of land use practicewhereby the activities on the land isstretched all the y ear round (Rander,1988).
Improved Fallow in Shifting Cultivation	Introduction of cover crops on the farmland in an effort to minimize soil degradation associated with agriculture	The role of this system is mainly thatof soil conservation and improvement.The soil amelioration because of thesystem leads to increase in crop yieldduring then cropping period.
Alley-cropping (hedge row intercropping)	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 techniquedeveloped at IITA and ICRAF. Thetree provides nitrogen from atmospheric fixation, recycle nutrients from the depth of soil, suppress weeds and increase organic matter content of the soil.
Alley farming	Trees, shrubs and other perennials are planted with agricultural crops to supplement the woody plants in the rows.	It is focused on livestock production.Alley farming was designed mainlyfor sheep and goat grazing. Theadvantages are that the land providescrop residues and controls soil erosion through windbreak. Major disadvantage is the competition of hedgerows with crops for soil water, which is often limiting crop productivity (Singh *et al*, 1989).
Shelterbelts	Agroforestry system in which food crops are planted between rows of trees belts planted as shelter. The trees and shrubs are planted in one or more rows at right angle to prevailing winds	The practice often increases crop yieldbecause of their beneficial effects onsoil and microclimate. The effect onanimals is to reduce stress from heatand wind. Disadvantages of the system are that labour involvement is enormous and species used as hedgerow crops are without edible by products.
Windbreaks	Here, double rows of trees areplanted around the boundary of a food crop farm on the windward side. Each windbreak is 150m long with 100 trees planted atescapement of 3m x 3m.	The advantage is that windbreaksreduce wind erosion and at the same time produce forest alongside food crops.
Home Garden	Tropical home gardens consist of an	

	assemblage of plants which may include trees, shrubs, vines and herbaceous plants growing inor adjacent to a homestead or home compound	Okafor and Fernandes (1989) reportedthat in this system, multipurpose treesand shrubs in a multi –storeyassociation with agricultural crops areraised with small livestock inhomesteads. Home garden is not aformal practice of Agroforestry but atraditional farming system with anAgroforestry focus.
Multipurpose 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 plantingdesirable 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 –calledcommon peoples direct participationin the process, either by growing treesthemselves or by processing the treeproducts locally.
Trees in Social conservation	Woody plants, whether in hedges or not, planted to stabilize the soil on terrace edges and other conservation	Woody perennials can greatly assistinfiltration and reduce surface waterrun-off, although a wrong choice ofspecies or poor planting technique canhave the opposite effect
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 shadewhich create a desirable microclimate for the pond. Widely practiced bytraditional farmers in inland watercourses where the farmers havefull rights to the land.
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, allowing thebees to work as long as there are flowers instead of only working for a few months in a year.
Protein Bank	Woody perennial vegetationjudiciously used helps to supply forage during dry seasons or years of low rainfall.	Not only does it provide green forage when the grass cover has withered but it can also supply more protein than grass. The advantage of woody plants in dry season is therefore both quantitative and qualitative.

Sources: (Adapted from Baumer, 1990)

2.2.4 Contribution of Agroforestry in Rehabilitation of Degraded Land

Monoculture as practiced in developing counties such as Nigeria requires high yielding crop varieties and an intensive use of fertilizers 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. Anattempt to embrace the more promising modern system usually leaves its mark on the environment. While indicting agriculture for deforestation, Alao and Shuaibu (2013) 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 realized, especially in the effort to reduce accumulation of green house gases in the atmosphere. Agroforestry is therefore a means of correcting the effects of degradation. Hanson *et al* (1995), Shultz *et al* (1995), and Onwusu (1993) agreed that Agroforestry can provide new and useful solutions to many of the consequences of human land use, including 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.

2.2.5 Ecological Benefits of Agroforestry

Ecology concerns the relationship between organisms, their habitat and the environment. It outlines the various inter-relationship existing among the components of the system. Nature has a way of maintaining and regenerating natural resources as they are utilized. This is done through a series of cycles which connect the various components of the system and their activities in the environment. Agroforestry is a land management practice with consideration for the natural process of soil nutrient renewal. Alao and Shuaibu (2013) claimed that the litter fall 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, subsequently decomposition of which would enrich the soil.

It can therefore be asserted that the protection of the soil from direct rays of sunlight also complement nutrient conservation, as the rate of oxidation of soil nutrient will reduce. This is in addition to the protection from erosion and fire protection provided by the trees (Hochbeg *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. Anderson (1990) emphasized that Agroforestry plays a major role in reclamation of degraded or abandoned lands and is a workable approach to mimic natural succession and increased biodiversity.

Ostyina (1993) gave a detailed account of how deforestation occurred in Shinyanga but soil conservation and afforestation programmes reclaim 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 (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 the land, upholding ecological equilibrium and maintaining the environment should be put in the right perspective.

2.2.6 Sustainable Land Management (SLM)

Sustainable land management, as defined by the TerrAfrica partnership (2005), is the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (FAO, 2009).

SLM is the key entry point for improving land resource resilience and productivity within the context of the potentially devastating effects of climate change in Sub-Saharan Africa, bridging the needs of agriculture and environment, with the twin objectives of:

- Maintaining long term productivity and ecosystem functions (land, water, biodiversity); and
- Increasing productivity (quality, quantity and diversity) of goods and services (including safe and healthy food).

Land refers to cropland, range, pasture, forest and woodlands. Land is defined by the UN Convention to Combat Desertification as the terrestrial biologically productive system that comprises soil, vegetation, other biota and the ecological and hydrological processes that operate within the system.

Within the sphere of agriculture, SLM includes the maintenance over time of soil productivity. This requires the combination of soil fertility treatment (perhaps including application of mineral and organic fertilizers) with soil and water conservation measures (implementation of agronomic, soil management and physical measures, such as contour ridging, terracing, tied ridges or providing ground cover through mulching, use of plants and leaving crop residues).

SLM will prioritise different elements of this combination depending on the terrain, ecosystem, climate and land use that determine the potential forms of degradation. It will always encompass all elements of farming – small and large livestock, commercial and subsistence crops and agroforestry – which impact on the ecosystem.

Within the sphere of natural resources management, SLM is the maintenance over time of the productivity and ecological integrity of rural landscapes, including forest, water and wildlife resources. SLM practices aim to deliver a range of public goods, which include the rehabilitation of degraded production landscapes, protection of watershed functions, expansion of carbon pools, prevention of forest degradation and depletion, systematic replanting of felled trees and biodiversity conservation in production landscapes. Measures to ensure SLM of forests could include the creation of forest reserves with managed access, prevention of bush fires, woodlots, logging and harvesting permits accompanied by replanting as well as forest management regulations and legislation.

2.2.7 Issues of Sustainable Land Management

Perceived wisdom in the approach to evaluation, use and management of land resources is changing rapidly and dramatically. Past emphasis on land 'development', focused on maximizing production and return from land use investment and planned against a background belief that suitable lands for expansion could always be found somewhere, is forced to give way to a more cautious approach-one that recognizes the finite extent of fertile land and the seemingly insatiable demands of a growing human population.

Globally, and in many individual countries, there is clear evidence of impending land shortage. Areas in which the combination of land and freshwater resources is moderately or well suited to agriculture are, for the most part, already in use. Efficient use of these lands is becoming a matter of life or death for increasing millions of mankind. Future generations in still larger numbers are more seriously at risk-their livelihood endangered by present production choices that degrade the very resources on which future agriculture depends. Global production must increase dramatically to meet foreseen demand but the levels and means of production targeted locally must be those that can be maintained on a sustained basis. Global, and even local agriculture must be sustainable.

"We need a value system which enshrines the principle of sustainability over generations.

The first of these factors is the fixed supply of land suitable for agriculture and food production. The World's total ice-free land area is approximately 13.4 thousand million hectares, but of this only 24 percent or 3.2 thousand million hectares are potentially arable, i.e. land that can be cultivated and/or maintained in productive pasture. Of this, about 40 percent (1.3 thousand million hectares) is highly to moderately productive and 60 percent is of low productivity. Currently the best of these lands, about 1.5 thousand million hectares, are used for cropland, and the remainder are in permanent pasture, forest and woodland (Buringh and Dudal, 1987).

The second factor is the impact of competition between increasing numbers of people for the same land area. Each year global populations increase by about 90 million people. Since the best lands are almost all in use, necessary further expansion of agriculture will come increasingly at the expense of pasture lands and forests; lands usually of marginal quality where the risks of crop production are higher and the returns lower. Over the last three hundred years, human-induced land use change has resulted in a net gain of approximately 12 m km^2 of cropland but net losses of 6 m km^2 of forests and 1.6 m km^2 of wetlands. Even over the past two decades the global extent of cropland has increased by 9.1 percent, whereas pasture and forest lands have decreased considerably. Currently, the rate of tropical deforestation, primarily for agricultural purposes, is estimated at 17 million hectares (0.9 per cent) per year, sharply increased from the rate of 11.3 million hectares (0.6 percent) per year estimated in the early 1980s (WRI, 1992). Temperate and boreal forests suffered in the past, but they are no longer subject to acute deforestation; in fact, forest in these areas may have increased by about 5 percent since the early 1980s.

Since the middle of this century human-induced land use change has become so drastic, so rapid and so global that its impacts are affecting processes that sustain the interacting systems of the geosphere-biosphere (IGBP, 1992). The direct effects of these changes on global systems remains poorly understood but there is general agreement on the potential impacts. For example, expansion of agro-ecosystems over the last 150 years has resulted in a net flux of CO_2 equal to that released by burning fossil fuel during the same period; current release of CO_2 from land conversions is between 10 and 30 percent of that from fossil fuel combustion; land conversion is also the largest human-induced source of N_2O, which contributes to greenhouse gas accumulation and ozone depletion.

With or without climate change, the conversion of natural habitats for agriculture and other uses is recognized as a major cause of loss of genetic stock and of genetic diversity. At current rates of conversion, it is estimated that 25 percent of the World's plant species will disappear in the next 50 years (IDRC, 1992). Modern agriculture, with its trends towards monoculture is particularly vulnerable; already only 20 crops provide 90 percent of the World's food; and wheat, rice, maize and potato contribute more than all other crops combined (IDRC, 1992). Only four varieties produce 75 percent of all wheat grown on the Canadian prairies whilst, in India, where as many as 30 000 varieties of rice were planted 50 years ago, it is estimated that by the turn of the century three quarters of the rice fields will be planted to only 10 varieties.

The pending onset of climate change, the narrowing genetic stock and the disturbance of global biogeochemical cycles all add considerable uncertainty to the evaluation of sustainability.

The third major factor in the sustainability equation is the depletion of biological production potential by the insidious processes of soil and land degradation, often accelerated by human activities. Although the extent of global soil degradation is not known with certainty, current best estimates are that approximately 1.2 thousand million hectares of agricultural, forestry and range lands have been affected by moderate to extreme soil degradation (75 percent of this is moderate degradation and 25 percent is severe to extreme). A further 750 million hectares have been affected by slight degradation. This degradation is caused by human related activities, namely: overgrazing (35 percent of degraded land); improper agricultural practices (28 percent); deforestation and overexploitation for fuel wood (37 percent); and industrial pollution (about 2 percent). A secondary effect of land degradation, often at least as serious in its local consequence as the loss of soil material, is the pollution of surface and groundwater. Transposed and dissolved materials may cause salinization, alkalinization, and other forms of toxification and eutrophication. The impact of these effects may be felt far from the site of initial degradation. Within this century the impact of land degradation on production has been masked by greatly increased fertilizer use and other inputs, but it is obvious that productivity increases would have been much higher in the absence of degradation.

2.2.8 Nature of Sustainable Land Management (SLM)

Many definitions have been proposed to describe aspects of 'sustainable development'. Their variety reflects the complexity of relationships involved. Environmental characteristics, market forces, social ambitions, development objectives and conservation aims are but examples of the forces and factors that interact to determine sustainability. Definitions of sustainable management differ because observers place differing importance on these various factors.

"Sustainable land management combines technologies, policies and activities aimed at integrating socio-economic principles with environmental concerns so as to simultaneously:

- maintain or enhance production/services (Productivity)

- reduce the level of production risk (Security)

- protect the potential of natural resources and prevent degradation of soil and water quality (Protection)

- be economically viable (Viability)

- and socially acceptable (Acceptability).

These five objectives of Productivity; Security; Protection; Viability and Acceptability are seen to be the basic 'pillars' on which the SLM edifice must be constructed and against which its findings must be tested and monitored. Each objective is complex, and requires further brief examination:

Productivity: the return from SLM may extend beyond material yields from agricultural and non-agricultural uses to include benefits from protective and aesthetic aims of land use.

Security: management methods that promote balance between a land use and prevailing environmental conditions, reduce the risks of production; conversely, methods that destabilize local relationships increase that risk.

Protection: the quantity and quality of soil and water resources must be safeguarded, in equity for future generations. Locally, there may be additional conservation priorities such as the need to maintain genetic diversity or preserve individual plant or animal species.

Viability: if the land uses being considered are locally not viable, the use will not survive.

Acceptability: land use methods can be expected to fail, in time, if their social impact is unacceptable. The populations most directly affected by social and economic impact are not necessarily the same.

Sustainable Land Management has been defined as: ‘the adoption of land use systems that, through appropriate management practices, enables land users to maximise the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources’.

SLM includes management of soil, water, vegetation and animal resources.

SLM also includes ecological, economic and socio-cultural dimensions (Hurni, 1997). These three are not separate: in reality they are interconnected. They are also referred to as the '3 Es' of sustainable development - Equality, Economy, and Ecology (UNESCO, 2006).

Ecologically, SLM technologies – in all their diversity – effectively combat land degradation. But a majority of agricultural land is still not sufficiently protected, and SLM needs to spread further.

Socially, SLM helps secure sustainable livelihoods by maintaining or increasing soil productivity, thus improving food security and reducing poverty, both at household and national levels.

Economically, SLM pays back investments made by land users, communities or governments. Agricultural production is safeguarded and enhanced for small-scale subsistence and large-scale commercial farmers alike, as well as for livestock keepers. Furthermore, the considerable off-site benefits from SLM can often be an economic justification in themselves.

Best practices are basically the 'best' known to us at present: in the view of TerrAfrica 'best' implies those practices that increase production and are profitable, cost-efficient with primarily rapid, but also long-term payback, are easy to learn, socially and culturally accepted, effectively adopted and taken up, environmentally friendly and are appropriate for all stakeholders including socially marginalised groups (FAO, 2008).

SLM best practices and their up scaling in Africa is essential for a variety of reasons – but the most basic is to sustain and improve livelihoods while protecting the land's resources and ecosystem functions. SLM thus seeks to increase production including traditional and innovative systems and to improve resilience to food insecurity, land degradation, loss of biodiversity, drought and climate change.

2.2.9 Land degradation

Land degradation is both a source and a result of climate change as well as a constraint to adapting production to climate variability. A UNCCD definition refers to *land degradation* as the reduction or loss of the biological or economic productivity and complexity of land, resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns. These include long-term loss of natural vegetation, soil erosion caused by wind and/or water as well as the deterioration of the physical, chemical, biological or economic properties of soil.

The GLASOD project (FAO, 2007c; Oldeman, 1994) was the first comprehensive effort to map land degradation globally using standardized criteria and expert judgment. The effort revealed that by 1990 some 20 percent of Sub-Saharan Africa was affected by slight to extreme land degradation. The Land Degradation Assessment in the Dry lands (LADA) program of GEF/UNEP/FAO is currently preparing a map that demonstrates degradation based on net primary productivity and rain use efficiency, which will provide more objective and monitored data related to land degradation. Preliminary results indicate land degradation affects across 15 percent of Sub-Saharan countries over the last 25 years, though the LADA "hot spots" differ from those identified in the GLASOD approach. The UNCCD (2009) states that worldwide, 38 percent of cropland and 73 percent of rangelands are degraded. A further statistic that clearly demonstrates the current unsustainable condition of the land is the average annual rate of soil formation in Africa, South America and Asia - just 1 t/ha yr-1.. This contrasts sharply with the average rate of soil loss through erosion - 30-40 t/ha yr-1 . (UNCCD, 2009).

Land degradation is clearly a cause for concern. It puts the productive potential and general well-being of communities at risk because it results in a significant reduction in economic, social and ecological benefits of land for crop, livestock and tree production purposes. Land degradation also has important implications for climate change mitigation and adaptation, given that the loss of biomass and soil organic matter releases carbon into the atmosphere. The consequences of continuing land degradation are severe, with repercussions not only for the welfare of individual rural households, but also at the community, district, national, sub-regional, regional and global levels.

2.2.10 Focus on Sustainable Land Management

Land degradation is simply defined, as a decline in ecosystem goods and services from the land. Land degradation negatively affects the state and the management of the natural resources – water, soil, plants and animals - and hence reduces agricultural production. Assessments in African countries show the severity of land degradation and the urgency of improving natural resource use through sustainable land management (SLM). Land degradation occurs in different forms on various land use types:

On cropland: soil erosion by water and wind; chemical degradation - mainly fertility decline - due to nutrient mining and salinisation; physical soil degradation due to compaction, sealing and crusting; biological degradation due to insufficient vegetation cover, decline of local crop varieties and mixed cropping systems; and water degradation mainly caused by increased surface runoff (polluting surface water) and changing water availability as well as high evaporation leading to aridification.

On grazing land: biological degradation with loss of vegetation cover and valuable species; the increase of alien and 'undesirable' species. The consequences in terms of soil physical degradation, water runoff, erosion are widespread and severe. Low productivity and ecosystem services from degraded grazing lands are widespread and a major challenge to SLM.

On forest land: biological degradation with deforestation; removal of valuable species through logging; replacement of natural forests with monocrop plantations or other land uses (which do not protect the land) and consequences for biodiversity, and soil and water degradation.

2.3 LAND MANAGEMENT PRACTICES

2.3.1 Mulching and Crop Residues

Plant residues provide a renewable resource for incorporation into Soil Organic Carbon SOC. In a natural ecosystem at steady-state or equilibrium, the production of plant residues will be balanced by the return of dead plant material to the soil. In agricultural systems, however, as plants are harvested, only about 20 percent of production will be accumulated into the soil as organic matter. In cool climates, below-ground carbon inputs from roots alone can generally maintain SOC levels. In warmer or semi-arid regions, where residues decompose more swiftly and especially when continuous cropping is practiced in such areas, failure to return above-ground plant residue will inevitably lead to a reduction in SOC.

Evidence of Role in Land Management

Both the quality and quantity of plant residues are important factors that determine the amount of carbon eventually stored in a soil (for mitigation and adaptation). The quantity is highly dependent on environmental conditions and agricultural practices, but the differences between crops can be great. Cereals are better than legumes at sequestering carbon (a cereal crop adds 2-3 times more carbon annually). Subsequently, the chemical composition of the plant residues affects their rate of decomposition. (A high concentration of lignin and other structural carbohydrates together with a high carbon to nitrogen ratio mean cereals have a lower rate of decomposition than legumes, which have low carbon to nitrogen ratios). This means that the choice of crop – in terms of species and variety – can have a major influence on how much SOC an agricultural system can sequester.

Use of mulch and other crop residues contributes to adaptationin situations where precipitation is erratic and of higher intensity– as “the plant biomass absorbs the energy of falling raindrops allowing rainwater to gently flow to the soil surface where it infiltrates into soil that is porous and undisturbed” (Derpsch, 1991). In areas of erratic and low rain fall coupled with increasing temperatures, crop residues will protect the soil, reducing the soil temperature and, hence, water loss due to evaporation, both important factors for optimum plant growth.

Retaining crop residues will reduce the amount and speed of rainwater running off croplands (from between plants during the growing season, also after harvest) reducing soil erosion and contributing to an improved hydrological regime. Soils with high organic carbon retain more plant nutrients, increasing crop yields and, thus, food security.

Implementing Conditions

The thicker the mulch applied and more residues left on a field, the higher the rate of SOC accumulation. However, only a small fraction of the residue is in contact with the soil surface, which means that when mulch is very thick, decomposition will be slowed as oxygen availability is limited within this layer. This would possibly reduce crop growth and yields. Care must also be taken in timing the application of residues, as large losses of carbon can occur under wet conditions. Residues should be stored and applied shortly before the onset of the rainy season.

Remarks

Use of mulch does not yield uniform benefits. Rather, the extent of beneficial effects is dependent on the soil type, agro-climatic factors, timing of application, nature of the residue (e.g. maize, millet, pigeon pea, cowpea) and the depth of the residue layer. Such techniques may not be possible in dryland areas, where residues are in limited supply and are required for other purposes (e.g. forage, fodder and thatch), which will limit its effectiveness as a mitigation and adaptation strategy in these areas. These areas however are where soils could most benefit from mulching, due to the low productivity and alternative uses (fodder, forage, thatch).

2.3.2Crop Rotations

Farmers traditionally recognize that diverse crop rotations are effective in maintaining soil fertility and health in arable systems. Economic and demographic pressures have reduced the practice of crop rotations in land management, as farmers have developed management systems that obtain and sustain higher yields by continuous cultivation, often of a single crop. This is at high financial and environmental cost, requiring frequent tillage (with high labour or tractor and fossil fuel costs) and the application of large quantities of agrochemicals (fertilizer, pesticides and herbicides) which are expensive to produce in terms of cost, energy and GHG emissions.

Evidence of Role in Land Management

Restoration of the practice of crop rotation can increase the rate of accumulation of SOC at various depths in the soil profile, as different crop species have different rooting forms and depths, which in turn promote the distribution of organic matter throughout the soil profile (contributing to mitigation). A study conducted to quantify potential SOC sequestration rates for different crops found that enhancing rotation complexity can sequester an average 20 ± 12 g C/m2/yr and SOC accumulation will continue over many years, reaching a new equilibrium in approximately 40 to 60 years (West and Post, 2002).

Numerous long-term field experiments have directly compared continuous maize cultivation with a legume-based rotation (Gregorich *et al*, 2001). The difference between monoculture maize and the rotation was 20 tons C/ha after 35 years. In addition, the SOC present below the ploughed layer in the legume-based rotation appeared to be more biologically resistant, demonstrating that these deep-rooting plants are especially useful for increasing carbon storage at depth, where it is most secure, contributing to climate change mitigation. Legumes also benefit in rotations as they biologically fix nitrogen, thus saving farmers the cost of buying fertilisers.

The use of rotations is also beneficial as it reduces the build-up of pests and diseases in farming systems given that most pests and diseases are crop specific. Change of crop breaks the lifecycle of the pest and disease organisms. This reduces the need for “carbon costly” pesticides and herbicides, contributing further to climate change mitigation.

Increasing rotation complexity also reduces the risk of the harvest being insufficient in subsistence farming systems, as failure of one crop-type, for example due to a pest, is less likely to ruin the entire harvest, contributing to adaptation. Increasing rotation complexity in most situations will increase crop yields and in turn food security.

Remarks

The amount of carbon that accumulates in a system depends on the crop in the rotation. Some rotations may lead to loss of carbon (e.g., rotation of pasture and annual crop compared with continuous pasture production). It is vital to consider each rotation system, ensuring that smallholders are discouraged from practices that decrease soil nutrients.

2.3.3Fallows

Fallows refer to when arable land is left for a period of time without being planted with a crop that is to be harvested. It is done principally to restore fertility. In many densely populated areas of Africa, fallow periods have become shorter and in many cases have been abandoned altogether due to pressure caused by shortages of arable land.

Planted, bush and bare fallows should be distinguished. The former refer to a period when land is planted (sometimes referred to as green manures) and the vegetation is incorporated into the soil after a short growing period (adding SOC and replenishing nutrients). Bush fallows are when land is left for several years without cultivation and cropping, during which time natural succession begins and the local natural vegetation will start to invade, with multiple benefits to agro-ecosystems. Bare fallows are shorter periods when land is left unplanted.

Evidence of Role in Land Management

Bare fallows are increasingly recognised in most Sub-Saharan African agro-ecosystems as harmful, because bare ground is exposed to intense heat from the sun, intense rainfall, erosion by wind and potential invasion by weeds – all contributory factors in land degradation. The exception is in certain dryland situations, where a period of bare fallow can increase soil moisture storage (“fallow storage”), increasing total yields of a subsequent crop and reducing their variability (contributing to adaptation). Some preliminary estimates show that the average yield of rain-fed cereals in drylands could be increased by 30–60 percent by making available an additional 25–35 mm of water to crops during critical growth periods through such a water conservation measure. This approach has clear adaptation benefits where climate change predicts declining precipitation (Washington, 2008).

Planted fallows or “green manures” – usually legumes (e.g. *Crotalaria, Mucuna, Macroptilium, Sesbania and Tephrosia)* – bring multiple benefits. Unlike synthetic fertilizers, green manures represent sources of biologically fixed nitrogen that also add large amounts of organic matter to cropping systems. Biological nitrogen fixation can contribute as much as 300 kg N/ha in a season. The slow release of nitrogen from decomposing green manure residues also appears to be better synchronized with plant uptake than sources of inorganic nitrogen, possibly increasing nitrogen-uptake efficiency and crop yield while reducing nitrogen pollution downstream.

Using appropriate fallow periods in drylands to accumulate soil water content is less costly – in financial and carbon terms – than irrigation. It also has greater water use efficiency.

Remarks

Where land scarcity is not a constraint, leaving land fallow allows for short and medium-term regeneration of soils‟ physical, chemical and biological properties, including restoration of fertility. Where land can be devoted to bush fallows, this provides fuel and non-woody forest products offering additional income sources for rural households. Even in areas of land scarcity fallows should be encouraged through promotion of off-farm activities (Nkonya *et al*, 2008).

2.3.4 Crop Diversification/Inter-Cropping

Diversified cropping systems and inter-cropping systems were elements of many traditional Sub-Saharan Africa farming systems, but have been less practiced in the latter part of the 20th century due to commercial pressures.

Evidence of Role in Land Management

The Chagga home gardens on the southern and eastern slopes of Kilimanjaro in Tanzania represent an indigenous integrated SLM system that has been used for over 100 years in one of the most densely populated parts of rural Africa. The system includes: (i) a diverse mixture of annual and perennial cash and subsistence food crops; (ii) the planting and retention of a wide range of woody species for fruit, fodder, fuel, soil fertility and medicines; (iii) poultry and stall-fed livestock, utilising feeds produced on-farm (crop residues, fodder plants) and providing manure for fertilising crops; (iv) a diverse pattern of vertical and horizontal zoning of different tree and crop components to exploit different micro-niche environments; (v) sequential cropping patterns to maximize continuity of production (reducing the risk of crop failure); and (vi) bees to provide honey and improve crop pollination (FAO, 2007).

Higher crop and livestock diversity is also highly beneficial in drier areas, although in the latter decades of the 20th century mono-crops seem to have been encouraged, with deleterious effects on food security and soils. Examples include smallholders growing millet, sorghum and maize – or different varieties of on crops, such as sorghum – to reduce the risk of crop failure.

Diversified cropping systems will improve the function of hydrological systems. Crop failure due to drought, flood, pests or disease in a monoculture is disastrous. With diversification, if one crop fails, there is still a chance that one or more of the other crops in the system will yield, thus, ensuring greater food security.

Remarks

Chagga home gardens provide an example of a highly diversified cropping system that has survived economic and other pressures and can act as a model of a highly resilient system. This is valuable for replication to adapt to the impacts of climate change.

In general, diversification is across farms, with different crops being planted on different plots. However, in the most vulnerable areas and/or where land is scarce, farmers should be advised to plant a number of crop varieties and species on individual plots of land (inter-cropping) (FAO, 2007). In addition to diversification at the farm level, diversification is also important at the national level, for example, where a single export crop is grown (e.g. cocoa).

2.3.5 Conservation Tillage and Conservation Agriculture

Soil tillage aerates the soil, speeding microbial decomposition of organic matter and, therefore, leading to a reduction in SOC and a release of carbon into the atmosphere. Machinery, human and livestock traffic also lead to soil structural damage due to compaction, which particularly leads to poor drainage and also increased surface erosion (Bellarby, 2008).

"Conservation tillage" is any tillage and planting system in which at least 30 percent of the crop residue remains on the soil surface after planting, thus, reducing mechanical cultivation (e.g. zero/no-till, minimum tillage, ridge-till, mulch-till, zone-till, non-inversion tillage and strip-till systems). These systems are often adopted as steps towards the more strictly defined "conservation agriculture," which aims to restore, sustain and enhance agricultural production through the integrated management of soil, water, and biological resources, combined as required with cost-effective use of external inputs (FAO, 2007). It is a holistic approach to agricultural production, based on enhancing natural soil biological regeneration processes involving improved soil organic matter management for the efficient use of precipitation, soil moisture and plant nutrients. Also it promotes the maintenance of soil physical properties through keeping mechanical tillage to the absolute minimum required for direct planting/seeding.

Evidence of Role in Land Management

In the absence of tillage in most soil types, the structure of the soil is maintained. Soil fauna particularly benefit, maintaining a healthier soil ecosystem, with earthworms and termites performing biological tillage. The root channels in the soil are not destroyed by ploughing and, thus, serve as drainage channels for excess water and airways for gas exchange. The surface mulch that develops protects the soil surface from the impact of heavy raindrops, reducing the erosive power of the water (Derpsch, 1991) and wind whilst protecting the surface from excessive heat. All of these measures can help land users in adaptingto climate change.

It is difficult to make definitive quantitative statements on the effects of reducing tillage on SOC, because the effects are highly dependent on the individual site (*inter alia* soil type, climate, crops grown, previous intensity of tillage, new regime). In general, SOC will increase and soil properties (physical, chemical and biological) will improve. Coarse-textured soils are damaged more by tillage (loosing SOC) than are fine ones, therefore will show greater increase in SOC following adoption of reduced tillage.

A change from conventional tillage to no-till can sequester 0.57 ± 0.14 t C/ha yr-1 (West and Post, 2002) and the accumulation of SOC will continue (provided the soil is not tilled). Levels can be expected to peak after five to 10 years, with SOC reaching a new equilibrium in 15 to 20 years. Overall, rates of SOC are lower in hotter climates. Nevertheless, a field monitoring site in western Nigeria recorded that no-tillage combined with mulch application increased SOC from 15 to 32.3 t/ha in four years (Ringius, 2002). The IPCC (2000) estimated that conservation tillage can sequester between 0.1 and 1.3 t C/ha yr-1 globally and could feasibly be adopted on up to 60 percent of arable lands on stabilizing (Pacala and Socolow, 2004).

When low tillage is used within an irrigation system, the improved water-use efficiency means that less water is required and the energy (thus carbon) cost of irrigation is reduced.

Communities and the wider environment benefit from lower tillage and conservation agriculture systems through the improved functioning of the hydrological cycle at the watershed level.

No-tillage systems favour multi-cropping. Harvesting can be followed immediately by planting, allowing for continuous or near continuous plant growth. This maximizes the land's capacity to produce plant biomass and consequently the potential to provide the greatest volume of organic matter for incorporation into the soil. Baker(1996) concluded that "no technique yet devised by mankind has been anywhere near as effective in halting soil erosion and making food production truly sustainable as no-tillage."

Implementing Conditions

A radical change is required of farmers, technicians, extensionists and researchers to move away from soil degrading tillage operations to sustainable low/no tillage and conservation agriculture systems, as they are completely different from conventional tillage. Appropriate training is vital.

The biggest change that farmers must face in moving from conventional to any of these reduced tillage systems is weed control. Ideally, weeding should be manual and chemical free, but this may not be feasible depending on labour availability, costs and other resources. Thus, they may need to use herbicides. Farmers must be educated in the correct use of these herbicides, to avoid the harmful effects to the environment through improper use.

The only agro-ecosystems where conservation agriculture has not been successfully adapted are arid areas with extreme water shortage and low production of organic matter, where humans and animals compete with the soil for crop residues. Certain very heavy soil types are also unsuitable for conservation agriculture, although reduced tillage is appropriate on most of these. In soils with a hardpan this can be broken by mechanical means ("ripping") before conservation agriculture is implemented.

Remarks

At the farm level, introduction of conservation agriculture has been demonstrated to produce yield increases within a single year and reduce inter-year variation in yields (FAO, 2008).

Globally conservation agriculture could potentially sequester carbon equal the annual CO2 production due to human activities, thus widespread long-term adoption of conservation agriculture could make a major contribution to climate change mitigation. water and airways for gas exchange. The surface mulch that develops protects the soil surface from the impact of heavy raindrops, reducing the erosive power of the water (Derpsch, 1991) and wind whilst protecting the surface from excessive heat. All of these measures can help land users in **adapting** to climate change.

2.3.6 Organic Agriculture

Organic agriculture is a holistic production system that avoids the use of synthetic fertilizers, pesticides and genetically modified organisms in order to minimise pollution of air, soil and water, while optimizing the health and productivity of interdependent communities of plants, animals and people. The term "organic agriculture" here is used in its broadest sense, including both certified and non-certified systems.

Evidence of Role in Land Management

A life cycle analysis of the global warming potential of some certified food products in England and Wales (Williams, 2006) found clear GHGs benefits for some products. Organic milk, eggs and poultry showed no benefits in terms of GHGs, but organic wheat bread, oil seed rape and potatoes showed benefits (lower global warming potential) than conventional ones. No comparable studies could be found for Sub-Saharan Africa, where organic agriculture has not been as widely adopted by intent (although it is widespread by *de facto)*, but similar patterns can be expected.

Organic field crops and animal products can contribute to mitigatingclimate change as they consume less primary energy than non-organic counterparts, owing particularly to the use of legumes to fix nitrogen rather than fuel to make synthetic nitrogen fertilizers (Williams, 2006). Emissions related to crop production are lower in organic farms than in conventional farms when measured per hectare, but this advantage is less clear in units of crop yield, since yields are lower for some crops in organic farms.

Other studies in Europe showed that organic farming would lead to lower yield but to higher energy efficiency (Mader, 2002). Long-term experiments have shown that cereal yield under organic farming achieves only 60 to 70 percent of the yield under conventional methods, but the energy used to produce a dry matter unit was 20 to 56 percent lower. This energy use efficiency obviously reduces GHG emissions and contributes to mitigation**.**

Organic systems usually have well-linked crops and livestock production systems, where animal manure is used to augment crop residues to maintain soil nutrients. Organic agriculture specifically forbids the use of agrochemicals, thus, eliminating the risk of water course pollution. The SOC increase under organic farming will further improve the function of hydrological systems. Due to the premium paid in many markets for certified organic produce, these systems should theoretically be more profitable, but transaction costs must be considered. Achieving certified organic status can be extremely difficult for individual or groups of farmers in Sub-Saharan Africa, thus, benefits can take time to be realised (FAO, 2008).

Remarks

Organic systems clearly bring benefits in terms of mitigation and adaptation. However, the lower yields per hectare compared to other systems mean that they are only appropriate in specific situations (i.e. where there are no food shortages). Due to the current global economic climate, sales of organic produce have declined in many developed countries, making this a risky option for Sub-Saharan farmers.

2.3.7 Integrated Plant Nutrient Management

Small-scale farmers have removed large quantities of nutrients from their soils, without using sufficient volumes of organic (manure and/or compost) or inorganic fertilizer to replenish fertility. This is largely because mineral fertilizers cost between two and six times as much in Africa as elsewhere in the world. There is accordingly great pressure today to increase the availability and affordability of fertilizers for small-scale subsistence farmers in Sub-Saharan Africa.

It should, however, be noted that while it is vital that soil fertility is improved across the continent to raise food production towards that needed to meet the Millennium Development Goals (MDGs), indiscriminate use of fertilizers is not the solution. Indeed, it can be very costly and harmful to the environment

Evidence of Role in Land Management

The widespread overuse of synthetic nitrogen-based fertilizers (at present mainly outside Sub-Saharan Africa) is a major direct source of nitrous oxide from agricultural soils. This issue is not currently widespread in smallholder farmland, due to the limited use of synthetic nitrogen-based fertilizers. However, action must be taken to avoid it, as current efforts to increase fertilizer availability and commercial pressures may encourage farmers who have no knowledge of the potential harm in using large quantities of synthetic fertilizer. Applying balanced fertilizer (including nitrogen, phosphorus and potassium) increases the efficiency of use of all the nutrients. Experiments conducted in China, India and the US have shown a nitrogen recovery rate of 54 percent when N, P, and K were applied in balanced amounts (Fixen, 2005). The corresponding recovery rate when nitrogen was applied alone was only 21 percent.

Farmers in Sub-Saharan Africa should focus on Nutrient Use Efficiency (NUE). Practices that improve NUE and that should be promoted and mitigateclimate change include:

- Adjusting application rates based on assessments of actual crop needs (possibly including split application);
- Using controlled-release forms of fertilizer or nitrification inhibitors (which slow the microbial processes leading to N2O formation);
- Applying nitrogen when least susceptible to loss (i.e. just prior to plant uptake); and
- Placing the nitrogen more precisely into the soil to make it more accessible to crops" roots (micro-dosing).

Over large parts of Africa, the addition of fertilizer will have a beneficial effect by increasing crop yields. It will also encourage the accumulation of SOC in many currently extremely nutrient deficient regions (Sanchez, 2002). This usage would contribute to climate change mitigation and also adaptation, as a consequence of increased food security. Although this is very much dependent on increased fertilizer availability and reduced cost.

Fertilizer in its own right is a carbon sequestering practice (mitigating and contributing to adaptation). Fertilizer use reduces or eliminates soil nutrient depletion, deforestation and cultivation of marginal and fragile land. Borlaug (2000) estimated that if 1950s cereal yields had remained unchanged in 2000 (i.e. not increased), a total of 1.8 billion hectares of land would have been converted to cropland to meet cereal demand. Borlaug and Dowsell (2004) also estimate that 80 percent of the production needed to meet the predicted increase in cereal demand can be met by intensification and only 20 percent need be from area expansion.

A study modelling the impact of a combination including the use of fertilizer (also a ridge tillage system which increased rainwater infiltration and residue management) on dryland soils in Mali calculated that this would sequester 54kg C/ha yr-1 (i.e. accumulating 1.35 t C/ha over 25 years) compared to the traditional system (conventional tillage, minimal fertilizer and no residue management), which loses 1.1 to 1.7 t C/ha over 25 years (Doraiswamy, 2007).

Implementing Conditions

Soil testing is an important step in planning, as it helps to determine the type of nutrients required to supplement natural soil fertility. However, soil testing services in developing countries are poor and blanket fertilizer recommendations are common (Roberts, 2008). Better provision of simple soil testing through extension services could help address this problem.

Judicious application of fertilizers will increase yields, particularly when applied to crops that have a strong response to fertilizer application (unimproved crop varieties generally have a poor response to fertilizer). This, in turn, will contribute to greater food security. Where smallholders cannot afford to purchase fertilizers or they are not available, the use of legumes (crops which biologically fix nitrogen) should be introduced or improved in cropping systems.

Remarks

Fertilizers are not always considered in Sustainable Land Management issue. However, in the context of climate change mitigation and adaptation they have a profound and complex role, making them critically important. There are benefits and trade-offs relating to local soil types as well as wider environmental and economic factors to be considered before any decision should be taken regarding fertilizer, including whether to use, when to use and how much to use.

The more environmentally-friendly option is to obviate any reliance on synthetic fertilizers by adopting cropping systems that maintain high yields, have high mitigation potential and are more appropriate for smallholder systems in Sub-Saharan Africa. The main challenge for applying balanced nutrients is the high price of phosphorus and potassium and the lack of emphasis on their importance by extension service providers.

2.3.8 Integrated Plant and Pest Management

Integrated plant and pest management (IPPM) combines solutions to various production related problems and includes a variety of focus areas ranging from integrated pest management (IPM) to integrated plant nutrient management (IPNM) (FAO, 2007c).

Evidence of Role in Land Management

IPPM provides farmers with the skills required to grow healthy crops, which are vital as they contribute to adaptation(healthier crops are more likely to withstand the adverse effects of increased temperatures, droughts and unreliable or more intense precipitation). A further major benefit of IPPM is that it reduces the need for agrochemicals, reducing input costs hence avoiding their energy intensive production which has globally important mitigationbenefits.

In a review of the need to develop technologies and practices that do not have adverse effects on environmental goods and services while leading to improvements in food productivity, Pretty (2005) studied 286 recent interventions in 57 poor countries covering 37 million hectares (3 percent of the cultivated area in developing countries). This showed an overall increase in productivity on 12.6 million farms while improving the supply of critical environmental services. The average crop yield increase was 79 percent (geometric mean 64 percent). Of projects with pesticide data, 77 percent showed a decline in pesticide use through IPPM (by 71 percent) while yields grew by 42 percent. Implementation of IPPM strategies reduces the risk of pesticide pollution of soil and waters. Successful adoption of IPPM strategies will lead to increased crop yields thereby increasing food security. IPPM also reduces farmers‟ input costs (on pesticides) and potential health problems from pesticide use.

Remarks

IPPM is a necessary component of farmers‟ ecological literacy which will be required as part of the so called "new green revolution" (World Bank, 2007a). IPPM is being encouraged through development projects throughout the continent.

2.3.9 Manure Management

Manure is the residue from an animal's digestive process and, thus, a waste product. However, it contains important amounts of valuable soil nutrients such as nitrogen, phosphates and potassium. Poor manure management can result in increased losses of pollutants to the environment. Nitrogen in manures can be lost as nitrates, nitrous oxide (a GHG) or ammonia (a constituent of acid rain and a cause of terrestrial eutrophication). Phosphorus-rich manure particles can raise phosphorus in soil to levels where leaching of phosphorus begins. Also, if manure is managed as a liquid substance, it decays and forms the GHG methane.

Evidence of Role in Land Management

In the wild, animal manure is spread over a wide area and decomposes aerobically in the presence of oxygen in the natural environment. However, intensive livestock rearing methods mean high concentrations of manure build up in relatively small areas. Such conditions lead to a predominance of anaerobic (oxygen-free) decomposition of the manure, which exacerbates the production of methane. The balance of feed that an animal consumes influences the properties of its gaseous emissions and manure. Manure with high nitrogen content will emit greater levels of methane than manure with lower nitrogen contents, thus increasing the C: N ratio in grazing materials/feeds will reduce nitrogen emissions from cattle in all types of management systems which has a mitigationbenefit. Handling manures in solid form (e.g. composting), which is more common in small zero grazing systems in Sub-Saharan Africa, rather than liquid form can suppress CH4 emissions. Preliminary evidence suggests that covering manure heaps can reduce N2O emissions, but the effect of this practice on CH4 emissions is variable (Steinfeld, 2006) and should be assessed locally.

Rapid incorporation of manure into cropland and shallow injection methods reduce loss of nitrogen to the atmosphere (thus maximize benefit to the soils) by at least 50 percent and deep injection into the soil essentially eliminates this loss. Biogas is produced by controlled anaerobic digestion – the bacterial fermentation of organic material under controlled conditions in a closed vessel. This capture and subsequent use of methane released from animal wastes is becoming an increasingly common method of energy generation alongside intensive animal rearing units and is also the basis for a number of carbon reduction and trading projects in other parts of the world. Improved manure management will restore soil fertility, increasing crop yields and food security.

2.3.10 Fire Reduction in Forest Management

Cyclical deforestation and reforestation are natural processes catalysed by natural fires ignited by lightening. Natural fires maintain forest health by clearing away dense brush, dead wood and pests and allowing new growth to emerge. They are essential in the lifecycles of some tree species. The natural burning of trees and other organic matter in forests releases carbon dioxide into the atmosphere and the decay of dead plants produces methane. However, the emission of GHGs by burning and decay of plant matter is normally compensated by the process of photosynthesis in living plants, especially the new vegetation that springs up on cleared land.

In recent decades, a still largely uncontrolled process of deforestation by burning as a result of human activity has been altering the natural balance of GHGs (FAO, 2007b). These fires range in scale from small plot clearance for smallholder agriculture to large-scale slash burning after forest harvesting, which is common in the large scale plantations of southern Africa (FAO, 2007g). Climate change itself is further increasing the area burned, as prolonged unseasonable periods of drought are increasing the likelihood of fires igniting and widening their spread.

Evidence of Role in Land Management

Forest fires release a wide range of gases, including the important GHGs: CO2, CH4 and N2O. The amount released depends on the specific type of forest concerned, other properties of the fire (amount of smouldering and the duration and temperature of the fire) and the total area burnt.

Any reduction in the area burnt and/or the frequency of burning will reduce emissions of all these GHGs, with major benefits for climate change mitigation, while also assisting forest dwellers in adaptingto climate change, through supplying NWFPs. Fire ravaged forests are prone to high levels of degradation, particularly erosion of soil, which subsequently pollutes rivers and causes sediment build up in lakes, reservoirs and along coastlines. Any success in reducing the area and frequency of human-lit forest fires will improve the functioning of hydrological systems and protect wild biodiversity. Reduction in the frequency and extent of forest fires will increase the amount of locally available wood for fuel and timber (from sustainable sources) and non-woody forest products (*inter alia* medicinal plants, wild fruit, nuts, fodder, etc).

Remarks

Limitations on forest burning have enormous potential to protect sequestered carbon and reduce GHGs emissions, mitigating climate change.

2.3.11 Irrigation Systems

The inter-annual storage of excess precipitation and the use of resource efficient irrigation are critical to maintaining cropping intensities in many parts of Sub-Saharan Africa.

Evidence of Role in Land Management

Small-scale irrigation systems – involving the combination of new and indigenous technologies (e.g. buried porous ceramic pots, pipe drip irrigation and sunken streambed structures) – are already increasingly being promoted, as reliance on irregular and unreliable rainfall for agricultural production is a major constraint on crop productivity. Such systems are a mitigationmeasure in the face of climate change. These practices are also particularly important as many new higher-yielding crop varieties are unable to achieve their full production potential under increasingly unreliable rain-fed conditions, thus, contributing to adaptation.

Remarks

A transition toward more precision irrigated agriculture in water stressed areas needs to be planned for, as reliable water supplies are a vital prerequisite to sustainable livelihoods.

2.4.1 Agroforestry Practices and Sustainable Land Management

Agroforestry is the set of land-use practices involving the deliberate combination of trees, agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence (FAO, 2005c). Cultivating trees in combination with crops and livestock is an ancient practice. However, several factors have contributed to a rising interest in agroforestry since the 1970s, including: (i) the deteriorating economic situation in many parts of the developing world; (ii) increased tropical deforestation; (iii) degradation and scarcity of land because of population pressures; and (iv) growing interest in farming systems, intercropping and the environment.

Main agroforestry practices include improved fallows, taungya (growing annual agricultural crops during the establishment of a forestry plantation), home gardens, alley cropping, growing multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, orchards or tree gardens, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and apiculture with trees (FAO, 2005c).

In southern Nigeria, yams, maize, pumpkins and beans were typically grown together under a cover of scattered trees. In Zambia, in addition to the main crop in the homestead, there were traditionally numerous subsidiary crops grown in mixture with tree species. Indeed, the Yoruba of western Nigeria, who have long practiced an intensive system of mixed herbaceous, shrub and tree cropping, explain that the system is a means of conserving human energy by making full use of the limited space laboriously won from the dense forest. They compare the method to a multi-storied building in a congested area in which expansion must perforce be vertical rather than horizontal. They also claim that it is an inexpensive means of combating erosion and leaching and of maintaining soil fertility.

Evidence of Role in Land Management

The evidence presented demonstrates that agricultural lands are significant potential carbon sinks which could absorb large quantities of carbon above ground vegetation, roots and SOC). Trees and shrubs in farming systems can play a significant role in land management as they have a higher biomass per unit area than, for example, annual crops or grasslands. The magnitude of carbon sequestration above and below ground in agroforestry systems depends on the species, soil type, management system, climate and duration of practice of the system.

In a review of a paper analyzing data from tropical agroforestry systems, a wide range of results were shown. The carbon sequestration potential in plant biomass and in long-lasting wood products of agroforestry systems was found to range between 12 and 228 Mg ha^{-1} with a median value of 95 Mg ha−1 (Albrecht and Kandji, 2003) [Note 1Mg = 1 Megagram = 1 ton = 1,000kg]. The results clearly show the importance of agroforestry systems as carbon sinks in mitigatingclimate change and given the acknowledged link between SOC and soil nutrient holding capacity (CEC), AF systems also contribute to increasing soil fertility. The extent of this, however, depends on the initial land condition/use and the management methodology (Bellarby, 2008). The greatest benefits will be obtained by reclaiming degraded soils.

Leguminous tree species further improve soil physical properties through tree root activities (microbial activity in root nodules characteristic to legumes, which improve soil aggregation) in addition to the biomass incorporated into the soil and nitrogen fixed (Ajayi, 2007).

"Fertilizer tree systems" are one type of agroforestry system that has been identified as a promising pathway for smallholders to use that will increase on-farm food production (Garrity, 2004). After years of experimentation with a wide range of soil fertility replenishment practices, three types of simple, practical fertilizer tree systems have been developed that are now being scaled-up but have not yet achieved widespread adoption in Sub-Saharan Africa. These are:

- Improved fallows using trees and shrubs such as sesbania *(Sesbania sesban)* or tephrosia (*Tephrosia vogelii);*
- Mixed intercropping with gliricidia (*Gliricida sepium*) or *Faidherbia albida*13; and
- Biomass transfer with species such as wild sunflower (*Tithonia diversifolia*) or gliricidia.

"Fertilizer tree systems" provide between 50 and 200 kg N/ha to the associated cereal crops, which has been reported to result in yield increases of two to three times those obtained under farmers‟ previous practices. The Malawi Agroforestry Extension Project is using participatory planning approaches to encourage some 20,000 farmers on 4,200 hectares to adopt various agroforestry practices in their fields

(FAO, 2007c). A report of the results describes the range of practices as: (i) under sowing maize with *Tephrosia vogelii*, pigeon pea and/or *Sesbania sesban* to improve soil fertility; (ii) widely dispersed inter-planting of trees (e.g. *Faidherbia, Acacia polycantha. A. galpinii*); and (iii) adoption of other soil and water conservation practices, especially vetiver contour hedgerows. The results showed that maize yields improved on average from 700 kg/ha to 1500-2000 kg/ha, farmers became less dependent on fertilizers and more households became both food and wood fuel secure.

In addition to benefits such as the provision of wood and NWFPs, restoration of soil fertility and the conservation of biological diversity, trees and forests improve the microclimate by buffering winds, acting as a barrier against extreme weather events (wind, heavy rain / hail), regulating the water table and providing shade to crops and animals. They are, therefore, part of sustainable agricultural production systems contributing to sustainable land management.

Agroforestry practice bring hydrological benefits from the field to watershed level. Introduction of trees into arable farming systems requires careful management to maximise synergies and minimise trade-offs. For example, if densely planted, the excessive shade will reduce under-storey crop yields. Increased yields of food crops, including tree crops, will increase food security. Other non-woody forest products (medicinal plants, fruits, fodder, wood for fuel and timber) will have wider household benefits and may generate additional income, stimulating rural economies.

The central role of agroforestry was highlighted on July 24, 2009, when the World Agroforestry Centre (ICRAF) and the UNEP called for the widespread uptake of such “green” agricultural practices that will deliver multiple benefits to the world’s rapidly growing populations, from combating climate change and eradicating poverty to boosting food production and providing sustainable sources of timber.

Remarks

There are a number of particular issues which need to be considered when Agroforestry systems are being planned/advocated by advisers. This is because decisions on tree planting require having longer time horizons than is the case for traditional arable crops. The uncertainties particularly relate to future shifts in global climate, land-use and land cover, the likely poor performance of trees on degraded soils and in dry environments; and existing and potential future pests and diseases.

2.4.2 Challenges of Agroforestry Practices

Trees can have directly adverse effects on soil properties, whilst other consequences arise when they are grown in association with herbaceous plants. Leaving aside shading, a major problem at the tree/crop interface but unconnected with soils, the main soil-related problems that can arise are explained below:

Loss of organic matter and nutrients in tree harvest. Of concern in forestry is the depletion of soil resources by fast-growing trees, with consequences for subsequent forest rotations. Trees assemble considerable quantities of nutrients in their biomass, part of which is necessarily removed in harvest. The problem is greatest where there is whole-tree harvesting, most commonly the gathering up of fine timber and litter by local people after timber harvest. From a soil-management point of view, it is desirable to allow all branches and litter to decay *in situ* and even to return bark, but this frequently conflicts with social necessity—to the local population it appears totally unreasonable. In agroforestry, the soil-improving potential of trees is greatly reduced if both foliage and wood are harvested, for fodder and fuel wood.

Nutrient competition between trees and crops. In general, trees are less demanding of nutrients than crops. The problem is most likely to be serious when trees or shrubs have an established root system which can dominate that of newly planted annual crops. It is desirable that trees in agroforestry should have rooting systems which penetrate deeply but have limited lateral spread. Whereas lateral spread of the canopy can be controlled by pruning, root pruning is generally too expensive to be practicable.

Moisture competition between trees and crops. In the semi-arid and dry savanna zones, moisture competition is possibly the most serious problem in agroforestry research and design. Discussion of soil-moisture competition lies beyond the scope of the present review.

Production of substances which inhibit growth or germination. Some *Eucalyptus* species produce toxins which can inhibit the germination or growth of some annual herbs (Power and Fries, 1985). The production of allelopathic substances by tree roots has been suggested as a possible problem in agroforestry, although there is little evidence.

Acidification by trees which produce mor-type humus. This is a known problem in conifer plantations of the temperate zone. Wherever a decrease in crop or pasture growth close to, or beneath, trees or shrubs is observed, it is important to establish the degree to which this is due to shading, nutrient competition, moisture competition, growth inhibition, or light suppression by leaf litter.

CHAPTER THREE

THE STUDY AREA AND METHODOLOGY

3.1 STUDY AREA

3.1.1 Location

The study was carried out in Kaduna state which lies within the Latitude 8^o 55'N - 11^o27'N of Equator and Longitude 5^o55'E - 9^o45'E of Greenwich Meridian (Figure 1). The population of the state has been estimated to be 6,066,562 (NPC, 2006). It has a total area of about 45,789Km^2. It shares common borders with Abuja in the south-East and six other states, and Niger state in the North-West. Kaduna was once the regional Capital of the North and played significant roles in agricultural production with Guinea Savannah vegetation. There are twenty-three (23) LGAs in Kaduna State (Figure 3.1).

3.1.2 Climate

The state falls under the Tropical Continental climate which is characterized by seasonal variations with alternation of moist maritime air mass and dry continental air mass resulting in two distinct seasons. The area experiences the on-set of the rainy season in April which ceases in October while the dry season (hamattan) lasts from November to March (Bello, 1993). The length of rainfall varies from 150 days to 190 days with an annual rainfall ranging between 1500mm and 2000mm. The temperature is high throughout the year with the peak in March and April (37^oc), while the mean annual temperature varies between 24^oC and 28^oC. Humidity is constantly high (above 60%) at mid-day and close to 100% at night during the rainy season, relative humidity is low ranging between 20% and 40% in January and rising to between 60% and 80% in July (Ati, 1998).

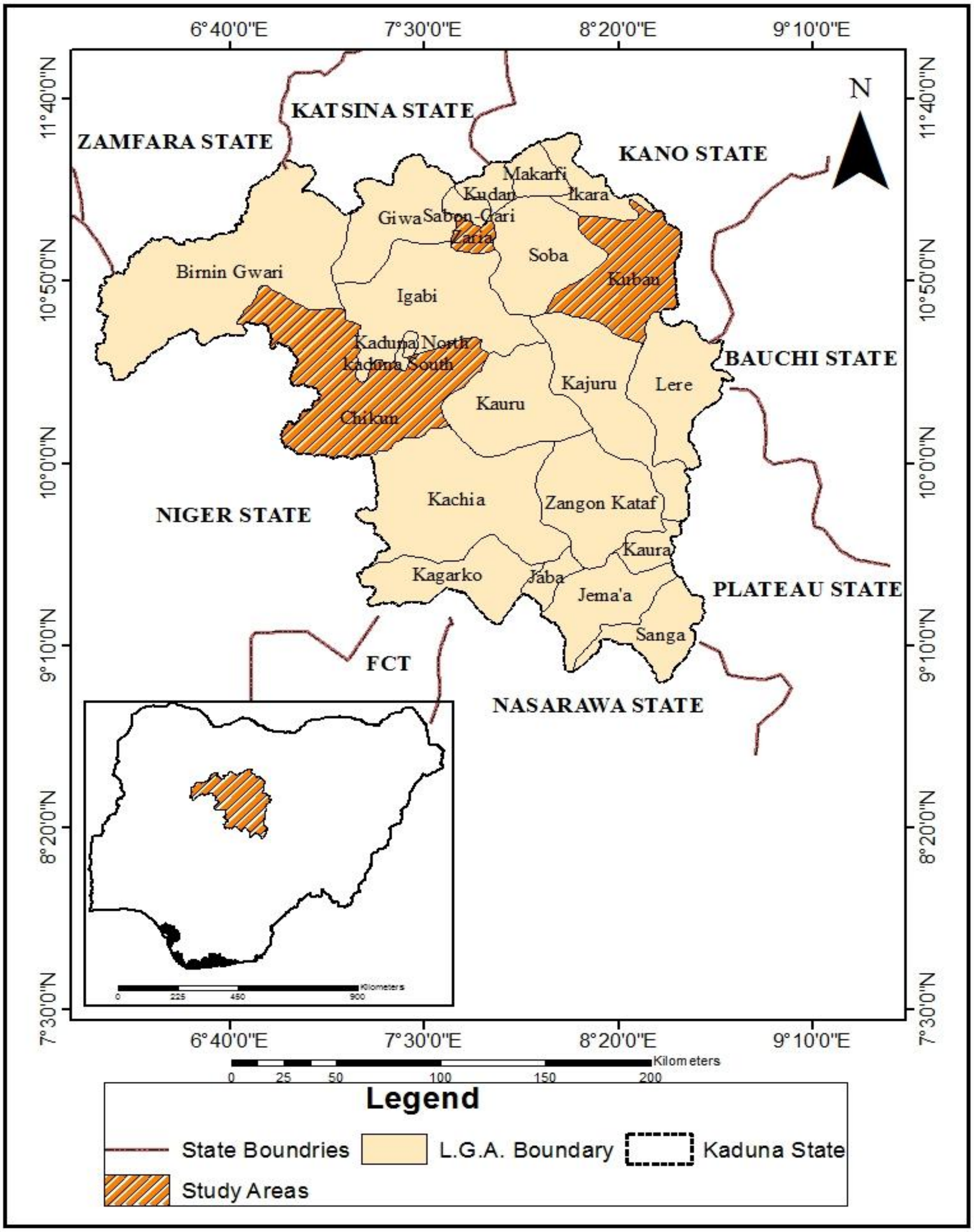

Figure 3.1: Showing Map of Kaduna State and the Selected Study Areas.

Source: (Ministry of Land and Survey, Kaduna State)

3.1.3 Soil

The study area falls within the basement complex of central Nigeria and the soil type are derived from the weathering of the rocks. The area consists mainly of lateritic rocks, the soil of the area can be classified as ferruginous tropical soil (Nwadelor, 2001).The soils are typically red-brown to red-yellow tropical ferruginous soils. Those within the 'fadama' areas are richer in kaolinitic clay and organic matter, very heavy and poorly drained which are characteristics of vertisols (Bello, 1993).

3.1.4 Vegetation

Kaduna State lies under the Northern Guinea savanna vegetation belt. The vegetation cover classes consist of indigenous species like *Isoberlinia doka, Monotes kerstingii, Uapaca togoensis, Parinarie curatellifolia, Hyparrhenia notolosia, Loudetia simplex, Andropogon gayanus, Annona sengalensis, Raphia sudanica,* and *Oxytenanthera abyssinica*. Some ofthe exotic species include; *Eucalyptus rudis*, *Albizzai lebbek, Cassia siamea, Eucalyptus cerebra, E. citriodora, E. tereticonis, E. saligna, E. cloeziana, E. maculata, E. micrantha, E. tetradonta, E. racemosa, E. pilularis, E. marginata, E. fastigata, Mangifera indica, and Pinus oocarpa* (Nwadialor, 2001). Some trees are deciduous, and shed their leaves during the dry season in order to cope with the long dry season (Bello, 1993).

3.1.5 People and Occupation

The ethnic group in Kaduna State comprises of Gbagyi predominantly, Hausa, Kataf, Igbo, Fulani, Yoruba and so on. The main occupations are farming, civil servant, traders etc. The major economic activities of the people in the rural areas are processing and marketing of agricultural products. The major crops processing and marketing are rice, guinea corn, millet, maize, groundnut, millet, soya beans and pepper.

3.2 RESEARCH METHODOLOGY

3.2.1 Reconnaissance Survey

Reconnaissance Survey (direct observation) was carried out at the initial stage of the research, in order to get acquainted with the study area with respect to agroforestry practices for sustainable land management in some rural areas of the selected Local Government Areas of Kaduna State

3.2.2 Types of Data

In order to achieve the set objectives of this study, information was collected from farmers residing in the sampled rural areas. The questionnaire was designed to provide information on the following:

i. socio-economic characteristics of the respondents such as gender, age, marital status, level of education, farm size, year of farming practice,

ii. different of land management practices among the rural farmers,

iii. various types of agroforestry in the study areas such as parkland, shade system, alley cropping, shelterbelt or windbreak , boundary/living Fence, and forest farming

iv. farm productivities of the farmers for the last five (5) consecutive years;

v. possible ways to improve on the agroforestry practices in the study area.

3.2.2 Sources of Data

3.2.2.1 *Primary Source of Data*

Firsthand information was collected through the application of questionnaire. This was administered to farmers to obtain information for the research. It contained relevant and well-structured questions aimed at getting information that address the set objectives for the study. The questionnaire was designed to contain open and closed ended format to obtain adequate information.A total of 357 farmers were interviewed in sampled villages of the three Local Government Areas selected (See Table3. 2).

3.2.2.2 Secondary Source of Data

This source was also employed to collect more relevant information. It includes the information collected from the Federal Ministry of Agriculture Kaduna State on the registered farmers in each local government under the Agriculture Transformation Scheme 2012. Also as part of secondary source is the maps of Kaduna State that were adopted and modified from the Administrative Map of Kaduna State to show and locate the selected study areas. Other relevant publications like books, research journals, magazines, newspapers and internet materials were being consulted for conceptual framework and literature review.

3.3.3 Sample Size and Sampling Technique

Table 3.1: Number of Registered Farmers in Each LGA of Kaduna State

S/N	Local Government Areas	No. of Reg. Farmers
1.	B/Gwari	10
2.	Chikun	476
3.	Giwa	162
4.	Igabi	249
5.	Ikara	406
6.	Jaba	2
7.	Jema'a	62
8.	Kachia	262
9.	Kaduna North	104
10.	Kaduna south	92
11.	Kagarko	17
12.	Kajuru	145
13.	Kaura	136
14.	Kauru	48
15.	Kubau	1936
16.	Kudan	164
17.	Lere	67
18.	Makarfi	217
19.	S/Gari	147
20.	Sanga	57
21.	Soba	396
22	Zagon Kataf	173
23	Zaria	892
	Total	**6024**

Source: **(**Federal Min. of Agric. Kaduna State - Agric. Transformation Scheme, 2012)

Kaduna State is made up of Twenty-Three Local Government Areas. The population is based on the entire registered farmer in each local government under the Agricultural Transformation Scheme of 2012, from Federal Ministry of Agriculture, Kaduna State (Table 3.1).From the Table, the total number of registered farmers in the State is Six Thousand and Twenty-Four (6024), and it is from this that Three Local Government Areas were purposively selected for the study and they are Kubau, Zaria and Chikun LGAs.

3.3.3.1 *Sample of the Study*

Table3. 2: Distribution of Sample Size by Local Government Areas

S/N	**Local Government Areas**	**Population**	**Sample Size**
1	Kubau	1936	209
2	Zaria	892	96
3	Chikun	476	52
Total	**3304**	**357**	

Source: (Author's Field Survey, 2014).

Multi-stage sampling technique was used in the study. The first stage was purposive sampling which was used to select most populous number of registered farmers in three local government areas, these are Kubau, Zaria and Chikun which their total number of registered farmers are, Three Thousand, Three Hundred and Four (3304). It is from this that Three hundred and Fifty- Seven (357) respondents were selected for the administration of questionnaire out of sampled population of 3304. This was obtained through the application of Yamane (1967) sample size selection formula. The formula is thus:

$$S = \frac{N}{1 + N(e)^2}$$

Where S = Sample Size

N = Finite population of the study area

e = Error margin or level of significance (0.05)

1 = constant

$$S = \frac{3304}{1 + 3304\,(0.05)^2} = \frac{3304}{9.26}$$

$$S = 357$$

The second formula below was used to determine the proportion of respondents in each of the selected local government areas (see Table 3. 2)

$$s = \frac{n \times 357}{N}$$

Where s = Sample from each local government area selected

n = Population of local government area selected

N = Total number of Three local government selected

Sample from Kubau LGA (s) = $\frac{1936 \times 357}{3304} = 209$

Sample from Zaria LGA (s) = $\frac{892 \times 357}{3304} = 96$

Sample from Chikun LGA (s) = $\frac{476 \times 357}{3304} = 52$

While random sampling technique was adopted in the administration of questionnaire to 357 respondents sampled of the three selected Local Government Areas (Table 3.2).

3.3.4 Methods of Data Analysis

The information obtained from the questionnaire was statistically analysed by the use of Tables, percentages, means, mean deviation, charts and graph.

To achieve the stated objectives in this study, different methods were used to analyze all the relevant data that were generated for this study. These were done as follows:

Objective one: to examine socio- economic characteristics of farmers practicing agroforestry in the study area, Tables and percentage were used to summarize and present the data such as sex, age, marital status, level of education, years of farming, farm size, that were collected from questionnaire administration.

Objective two: to assess other land management practices among the farmers in the study area, some segments of the questionnaire requested the farmer to name other methods adopted in land management practice, the table with percentage and chat were used to determine the most widely adopted method in each of the local government in Kaduna State.

Objective three: to characterize various types agroforestry practice, different agroforestry practices were itemized in a segment of the questionnaire and each respondent was asked to pick the one(s) been practiced for the purpose of land management in the farm. Having gotten that, table and chart were used to present the most common practiced agroforestry use to manage land in the study area.

Objective four: a non-parametric statistics by way of Chi-Square ($\chi 2$) statistical technique was used to test whether there is significant difference between farmland size and average number of trees per farmland. This involved comparing the differences which exists between the observed and expected or theoretical frequencies to determine the calculated ($\chi 2$). Under the appropriate degree of freedom and 0.05 level of significance. The critical ($\chi 2$) was determine and appropriate conclusion was made. Also, this Chi-Square was used to test for the hypotheses.

It is through the analysis and presentation of these set objectives and hypotheses set that the role of agroforestry practices on the sustainable land management in rural area of Kaduna was justified.

The calculation of Chi-Square was obtained through the use of SPSS.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1 Socio-Economic Characteristics of Respondents

The data collected during the field survey involved socio-economic characteristics of the respondents mainly farmers. The data are presented here in form of tables and are quantitatively and qualitatively discussed in this chapter.

4.1.1 Gender of the Respondents

There were 357 farmers sampled for the interview. The sampled farmers comprised of 350 (98%) male and 7 (2%) females. (See Table 4.1) The low number of females reflects the predominance of Islamic culture which allows the practice of Puddah (women are restricted inside houses). Thus accessibility to interview them in large number was not possible. The few interviewed were either widow or came from other region to reside in the study area. Generally, the cultural practice in the study area does not allow women to engage in the work like farming.

4.1.2 Age of Respondents

The ages of the respondents ranged between 20 and 60 years. The distribution of the ages is shown in the table 4.1. The bulk of the sampled population showed that majority of the respondents fall within the ages of 31- 50 with the same total number of 100 (28%) each. This group forms the active percentage of farming population. People bellow 30 years of age are expected to be in school that is the reason why only 71 (20%) of them were able to be interviewed and those above 60 years of age mostly have retired from farming activity, except few individuals of 11 (3%) who may not have children that can cater for them.

4.1.3 Marital status of the Respondents

Most of the farmers sampled for the interview were married. The marital status showed that 336 (94%) are married, 18 (5%) are single, 3 (1%) are divorced and no widow was interviewed. (SeeTable 4.1)

4.1.4 Educational Level of the respondents.

The educational level shows the predominance of those with Koranic school and primary leaving school as their highest educational level with 157 (44%) and 107 (30%) respectively. The other groups comprised secondary education with 57 (16%), only 14 (4%) had tertiary education, while 21 (6%) did not have any education (See Table 4.1). The low level of education among the farmers in the study area has important implications for the practice of agroforestry for land management because it is known to have a positive correlation with many variables.

4.1.5 Years of Farming Experience

This is one of major factor that contribute to the effective land management in this type of occupation. Most of the farmers interviewed have been in farming practice for more than 15 years that is 207 (58%). While 75 (21%) have between 6 – 10 years farming knowledge, and 46 (13%) had between 11 – 15 years of farming experience. Only 29 (8%) have just spent less than 5 years on the farm (See Table 4.1). This shows reasonable numbers of respondents actually understand the research topic in the sense that their perception on the role performed by the trees on the farm would have been deduced over the years.

4.1.6 Farm Size of Respondents

The farm sizes of the respondents are fairly large. This corresponds with the nature of the terrain which is devoid of vegetation cover. Soil is also easy to work, as a result, wide expanse of land is put under cultivation. Table 4.1 shows the farm size of the respondents.Majority of the respondents have farm sizes ranging between 2 and 7 hectares per farmer. A total of 175 (49%) respondents have their farmlands ranging between 2 and 4 hectares, while 98 (25%) people have theirs between 5 and 7 hectares. 18 (5%) have total farm land between 8 and 10 hectares , 7 (2%) have above 10 hectares and 68 (19%) farmers have below 2 hectares of land. This factor is also necessary because the farm size determines the types of land management practiced.

4.1.7 System of Farm Ownership

Land is the most important and vital resource for the productivity of the rural populace. Access to it is fundamental in rural system for the satisfaction of most of the basic needs. Figure 5 shows the type of land ownership system among the respondents.About 296 (83%) farmers interviewed personally owned the land while 54 (15%) hired the land, and only 3 (1%) of the farmers either rent the land or borrowed from the community head. This group of people are those whose farm lands are not quite productive or those with large number of families, whose lands are not large enough to support their food requirement. (See Table 4.1).

As mentioned previously, the form of tenure on a plot can affect land management and productivity for several reasons. If there is insecurity of tenure, the farmers operating the land may have less incentive to invest in land improvement (Feder *et al.* 1988).This is not necessarily the case, however, if the farmers can increase tenure security by investing in the land (Besley 1995; Otsuka and Place 2001).

4.1.8 Sources of Farm Labour

Sources of labour used by the respondents were also investigated during the field survey. Most farmers depend on family and hired labour force with 203 (57%). Table 4.1 shows the sources of labour used by respondents. The use of hired labour is necessitated by two factors. Firstly, the land under cultivation has to be fairly large before adequate food to feed the family is ensured. Also, married women do not normally participate in farming activity and therefore more hands must be employed.However, 104 (29%) people depend solely on family labour. This group complained of having no money to hire labour for farm work, and only 50 (14%) can afford to hire labour for their farming activities, and this also has to do with the types of crop planted and farm size.

Table 4.1: Socio-Economic Characteristics of Respondents

		Chikun		Zaria		Kubau		Total	
	Variable	F	%	F	%	F	%	F	%
Age in Years	21-30 Years	4	6.7	18	18.5	50	24.1	71	20
	31-40 Years	7	13.3	21	22.2	71	34.5	100	28
	41--50 Years	29	53.3	14	14.8	57	27.6	100	28
	51-60 Years	7	13.3	39	40.7	29	13.8	75	21
	Above 60 Years	7	13.3	4	3.7	0	0	11	3
	Total	54	100.0	96	100.0	207	100.0	357	100
Gender	Male	50	93.3	96	100.0	203	98.3	350	98
	Female	4	6.7	0	0	3	1.7	7	2
	Total	54	100.0	96	100.0	207	100.0	357	100
Marital Status	Married	50	93.3	92	96.3	192	93.1	336	94
	Single	4	6.7	4	3.7	11	5.2	18	5
	Divorced	0	0	0	0.0	3	1.7	3	1
	Total	54	100.0	96	100.0	207	100.0	357	100
Educational Leve	Primary Education	29	53.3	32	33.3	46	22.4	107	30
	Secondary Education	14	26.7	4	3.7	39	19.0	57	16
	Tertiary Education	4	6.7	0	0	11	5.2	14	4
	Quranic School	7	13.3	53	55.6	96	46.6	157	44
	No Formal Education	0	0	7	7.4	15	6.9	21	6
	Total	54	100.0	96	100.0	207	100.0	357	100
Farming Experi	Less than 5 Years	0	0	4	3.7	25	12.1	29	8
	6-10 Years	7	13.3	14	14.8	61	29.3	75	21
	11- 15 Years	11	20.0	14	14.8	25	12.1	46	13
	16- 20 Years	0	0	36	37.0	71	34.5	118	33
	Above 20 Years	36	66.7	28	29.6	25	12.1	89	25
	Total	54	100.0	96	100.0	207	100.0	357	100
Farm Size	Less than 2 Hec	4	6.7	4	3.7	61	29.3	68	19
	2-4 Hec	35	66.7	46	48.1	92	44.8	175	49
	5-7 Hec	11	20.0	32	33.3	46	22.4	89	25
	8-10 Hec	4	6.7	11	11.1	4	1.7	18	5
	Above 10 Hec	0	0.0	4	3.7	4	1.7	7	2
	Total	54	100.0	96	100.0	207	100.0	357	100
Ownership	Owned	36	66.7	75	77.8	185	89.7	296	83
	Communual	0	0	12	18.5	4	1.7	16	4.6
	Hired	18	33.3	4	3.7	18	8.6	40	11
	Rent	0	0.0	5	4.8	0	0.0	5	1.4
	Total	54	100.0	96	100.0	207	100.0	357	100
Labour	Family Only	14	26.7	21	22.2	68	32.8	104	29
	Hired Only	11	20.0	7	7.4	32	15.5	50	14
	Both	29	53.3	68	70.4	107	51.7	203	57
	Total	54	100.0	96	100.0	207	100.0	357	100

Source: (Author's Field Survey, 2014).

4.2 Land Management Practices in the Study Area

The adoption of land use management that enhance the ecological support functions of land with appropriate management practices, and thus enable land users to derive economic and social benefits from the land while maintaining those of future generations. This is usually done by integrating socio-economic principles with environmental concerns so as to: maintain or enhance production, reduce the level of production risk, protect the natural resource potential, prevent soil and water degradation, be economically viable, and be socially acceptable.

4.2.1 Land management Practices by the Respondents

The most common land management practices used by farmers in the study villages are as follow- Mulching, Cover Crops, Crop Rotation, Irrigation, application of Organic Manure, application of Fertilizer, bush fallow and others (See Table 4.2). From the table, it was revealed that 107 (30%) farmers adopt irrigation and fertilizer each, 75 (21%) of them practiced application of organic manure, 36 (10%) and 14 (4%) adopted mulching and cover crops respectively. Bush fallow and crop rotation are practiced by 14 (4%) and 3 (1%) respectively.

4.2.2 Land management Practices Alternative to Agroforestry

The study tried to determine other land management practiced by farmers aside agroforestry and the followings were revealed, 189 (53%) adopted organic manure as alternate to agroforestry, 64 (18%) and 39 (11%) practiced application of fertilizer and irrigation respectively. Mulching, cover crops and crop rotation were adopted by 26 (7%), 22 (6%) and 14 (4%) respectively. Only 3 (1%) were the sampled farmers adopting bush fallow (See Table 4.2).

Table 4.2: Land Management Practice by The Respondents

Variable		Chikun		Zaria		Kubau		Total	
		F	%	F	%	F	%	F	%
Land Mgt	Mulching	18	33.3	14	14.8	4	1.7	36	10
	Cover Crop	4	6.7	4	3.7	7	3.4	14	4
	Crop Rotation	0	0.0	0	0.0	4	1.7	3	1
	Irrigation	7	13.3	43	44.4	57	27.6	107	30
	Organic Manure	22	40.0	32	33.3	21	10.3	75	21
	Fertilizer	4	6.7	4	3.7	100	48.3	107	30
	Bush Fallow	0	0.0	0	0.0	14	6.9	14	4
	Others	0	0.0	0	0.0	0	0.0	0	0
	Total	**54**	**100.0**	**96**	**100**	**207**	**100.0**	**357**	**100**
Not Agroforestry	Mulching	7	13.3	18	18.5	0	0.0	26	7
	Cover Crop	4	6.7	14	14.8	4	1.7	22	6
	Crop Rotation	4	6.7	4	3.7	7	3.4	14	4
	Irrigation	0	0.0	25	25.9	14	6.9	39	11
	Organic Manure	25	46.7	28	29.6	136	65.5	189	53
	Fertilizer	14	26.7	7	7.4	43	20.7	64	18
	Bush Fallow	0	0.0	0	0.0	3	1.7	3	1
	Others	0	0.0	0	0.0	0	0.0	0	0

Source: (Author's Field Survey, 2014).

4.2.3 Determinant Factors for Land Management Practices

The study tried to investigate determinant factors by the respondents in adopting different land management practice. The determinant factors are grouped under different categories of problems associated with land and agricultural activities. Farmers' land management practices depend on many factors, including erosion, strong wind, drought and flood, bush fire, crop pests, natural hazards, climate change, sustain land, financial cost, adoptability and farm productivity. (See table 4.3). From the table, it was discovered that 261 (73%) of farmers believed that the presence of the trees in their various farms helped them to control erosion, while only 61 (17%) and 14 (4%) applied Mulching and cover crops respectively. The rest of them 11 (3%) applied organic manure and other methods to control erosion.

Another environmental problem is strong wind which is peculiar problem to the farmers of the study area, about 343 (96%) believed trees reduced the effects of strong wind on their farms, while 11 (3%) adopt cover crop to solve the problem, the remaining number 3 (1%) made use of other methods to checkmate the problem.

Also, it was revealed that about 218 (61%) of the farmers applied irrigation to solve the problem of drought and flood, while 93 (26%) believed the trees can also be used to reduce the effect of drought and flood in the area. Taking bush fire, most of the farmers 268 (61%) applied irrigation to fight bush fire, while very few of them used other methods like weeding, clearing, agroforestry.

Moreover, reasonable number of farmers knew the presence of trees on their farm helped in preventing other natural hazards and climate change with about 236 (66%) practiced agroforestry for these purposes, the rest of them were either using irrigation or organic manure.Among the other factors that determined the choice of land management practice is sustainability and cost of practice 164 (46%) adopted organic manure while agroforestry is also adopted by a reasonable number of respondents. For adoptability socially and culturally in the rural areas, 182 (51%) applied organic manure and only 25% applied agroforestry, on the area of the land management practice that increase their farm productivity, half of the respondents 179 (50%) applied fertilizer while the rest of them make used of other methods suitable to them.

Generally, from the sample it can be concluded that 1495 (38%) of the farmers in the rural areas of Kaduna state applied agroforestry, followed by irrigation and organic manure as a land management practice if encountered with these aforementioned determinant factors, the few of them below 7% are practicing mulching, fertilizer and crop rotation.

Table 4.3: Determinant Factors for Land Management Practices

Determinant	Agroforestry	Mulching	C/Crops	C/Rotation	Irrigation	Manure	Fertilizer	B/Fallow	Others
Erosion	261 (73%)	61 (17%)	14 (4%)	0	0	10 (3%)	0	0	11 (3%)
Strong Wind	343 (96%)	0	11 (3%)	0	0	0	0	0	3 (1%)
Dro & Flood	93 (26%)	26 (7%)	3 (1%)	0	217 (61%)	11 (3%)	0	0	7 (2%)
Bush Fire	22 (6%)	11 (3%)	3 (1%)	3 (1%)	268 (75%)	7 (2%)	0	0	43 (12%)
Crop Pests	22 (6%)	0	7 (2%)	189 (53%)	7 (2%)	0	0	0	132 (37%)
N/Hazards	228 (64%)	3 (1%)	2 (0.7%)	3 (1%)	86 (24%)	32 (9%)	0	0	3 (1%)
Climate Change	236 (66%)	0	0	3 (1%)	79 (22%)	29 (8%)	7 (2%)	3 (1%)	0
Sustain Land	100 (28%)	26 (7%)	0	3 (1%)	39 (11%)	164 (46%)	22 (6%)	3 (1%)	0
Less Expensive	82 (23%)	96 (27%)	7 (2%)	3 (1%)	0	164 (46%)	3 (1%)	2 (0.7%)	0
Adoptability	89 (25%)	32 (9%)	4 (1.4%)	3 (1%)	43 (12%)	182 (51%)	3 (1%)	0	1 (0.4%)
Increase Prod	19 (5%)	3 (1%)	3 (1%)	3 (1%)	71 (20%)	79 (22%)	179 (50%)	0	0
Total	**1495 (38%)**	**258 (7%)**	**54 (1%)**	**210 (5%)**	**810 (21%)**	**678 (17%)**	**214 (5%)**	**8 (0.2%)**	**200 (5%)**

Sources: (Author's Field Survey, 2014).

4.3 Agroforestry Practice in the Study Area

Agroforestry has been defined as a dynamic ecologically based natural resources management system that through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. Agroforestry practices offer practical ways of applying various specialized knowledge and skills to the development of sustainable rural production systems.Agro-forestry is recognized as a land use option in which trees provide both products and environmental services. In agroforestry practice, the trees grown on different farmlands in the same locality when aggregated can bring about improved wooded situation thereby enhancing environmental protection (Otegbeye, 2002).

It was discovered from the survey that about 311 (87%) practiced agroforestry, while only 46 (13%) of the total sampled did not practice agroforestry at all. Also when asked if considered agroforestry as a land management practice, 297 (83%) agreed, while only 57 (16%) did not considered it as means of land management practice and only 3 (1%) were indifferent. Another important issue germane is to know the number of respondents that planted trees on the farm land, little about half of total number sampled that is 186 (52%) planted trees or shrubs on their farm land while just a little bellow half, 171 (48%) did not plant trees on the farm but retained the existing trees on their farmlands. it was from this that the next question was generated to know the sources of tree seedlings planted, 247 (69%) of the total respondents personally raised the seedling, 14 (4%) raised it from private sources, 3 (1%) are supply by the government agencies, 57 (16%) of the total respondents naturally find the trees on the farm land, and 36 (10%) did not have trees at all on the farm (See Table 4.4).

Table 4.4: Level of Agroforestry Practice by the Respondents

Variable		Chikun		Zaria		Kubau		Total	
		F	%	F	%	F	%	F	%
Practice	Yes	54	100	78	81.5	178	86.2	311	87
	No	0	0	18	18.5	29	13.8	46	13
	Total	54	100	96	100	207	100.0	357	100
Consider for Land Mgt	Yes	54	100	96	100	150	72.4	300	84
	No	0	0	0	0	57	27.6	57	16
	Total	54	100	96	100	207	100.0	357	100
Plant Tree	Yes	47	86.7	78	81.5	54	25.9	186	52
	No	7	13.3	18	18.5	153	74.1	171	48
	Total	54	100	96	100	207	100.0	357	100
Average No. of Trees	Less than 10	11	20	18	18.5	64	31.0	93	26
	11 - 20	22	40	43	44.4	75	36.2	138	39
	21 - 30	11	20	4	3.7	43	20.7	57	16
	31 - 40	7	13.3	14	14.8	4	1.7	26	7
	40 and Above	4	6.7	7	7.4	0	0.0	11	3
	No Trees	0	0	11	11.1	21	10.3	32	9
	Total	54	100	96	100	207	100.0	357	100
Source of Trees	Govt Agencies	0	0	0	0	3	1.7	3	1
	Privately Raised	4	6.7	0	0	10	5.2	14	4
	Personally Raised	43	80	82	85.2	121	58.6	247	69
	Naturally Raised	7	13.3	0	0	50	24.1	57	16
	None	0	0	14	14.8	21	10.3	36	10
	Total	54	100	96	100	207	100.0	357	100

Source: (Author's Field Survey, 2014).

Investigating the average number of trees or shrubs had by the respondents on their farms, 93 (26%) have below ten trees on the farm, 138 (39%) have between 11 and 20 trees on average, 57 (16%) have from 21 to 30 number of trees, 26 (7%) are on 31 to 40 trees on average, while only 11 (3%) have above 40 number of trees on the farm irrespective of the farm size. Only 32 (9%) did not have any trees or shrubs on the farm, because they did not consider it as a means of land management methods. (See Table 4.4).

The types of agroforestry practiced by the respondents in the study area are as follows, most of the farmers about 221 (62%) practiced parkland, followed by windbreak/shelterbelt with 54 (15%), the next one is living fence or boundary system with 36 (10%), followed by forest farming with 21 (6%), alley cropping, riparian buffer system are practiced by 14 (4%) each, only 4 (1%) practiced silvopasture, the rest representing 39 (11%) did not practice any of these systems (See Table 4.5).

Table 4.5: Types of Agroforestry Practice by the Respondents

	Chikun		Zaria		Kubau		Total	
Types	F	%	F	%	F	%	F	%
Alley Cropping	3	5.2	4	3.6	7	3.0	14	4
Silvopasture	0	0	4	3.6	0	0.0	4	1
Windbreak/Shelterbelt	8	13.8	32	28.8	14	6.0	54	15
Riparian Buffer	0	0.0	4	3.6	10	4.3	14	4
Forest Farming	10	17.2	11	9.9	0	0.0	21	6
Parkland	30	51.7	30	27.1	161	68.8	221	62
Living Fence/Boundary	7	12.1	8	7.2	21	9.0	36	10
None	0	0.0	18	16.2	21	9.0	39	11

Source: (Author's Field Survey, 2014).

It is apparent that numerous species of perennial woody and shrubs plants are planted and retained in the farmlands of indigenous people for the purpose of land management.The trees and shrubs species most favoured by majority of the farmers are *Mangifera indica, Parkia clappertoniana, Butyrospermum paradoxum,Psidium guajava,,Azadirachta indica,Adansonia digitata, Anacardium occidantale, ,Moringa oleifera, Anogeissus leiocapus, Musa sappientum.*

These species are retained or planted by 56%, 44%, 31%, 27%, 21%, 11%, and 10% respectively of the study population (See table 4.6).

Other significant species of less than 8% population response are Gugiya (*Borassus acthiopum*), Binidazugu (*Jatropha curcas*), Tapashiya (*Naudea diderrichii*), Dinyo (*Vitex doniana*), Leemu (*Citrus aurantifolia*), Samiya (*Tamarindus indica*), Kanya (*Diospyros mespiliformis*) and Ganji (*Ficus ovata*).

Table 4.6: Major types of trees or shrubs planted or retained by the Respondents

		Chikun		Zaria		Kubau		Total	
Scientific Name	**Local Name (Hausa)**	F	%	F	%	F	%	F	%
Mangifera indica	Mangoro	39	32.2	75	27.9	86	18.7	200	23.5
Parkia clappertoniana	Dooruwa	29	24	43	16	121	26.3	193	22.7
Butyrospermum paradoxum	Kadayan	7	5.6	36	13.4	68	14.8	111	13
Psidium guajava	Gwaabaa	21	17.4	43	16	32	7	96	11.3
Azadirachta indica	Mainna/ Delbegia	7	5.6	21	7.8	46	10	75	8.8
Anacardium occidantale	Kanjuu	11	9.1	25	9.3	7	1.5	43	5.1
Adansonia digitata	Kuka	3	2.5	4	1.5	32	7	39	4.6
Moringa oleifera	Zogalia	4	3.3	11	4.1	21	4.6	36	4.2
Anogeissus leiocapus	Marke	0	0	0	0	29	6.3	29	3.4
Musa sappientum	Ayaba	0	0	11	4.1	18	3.9	29	3.4
Total		121	100	269	100	460	100	851	100

Source: (Author's Field Survey, 2014).

There are numerous tree species which did not significantly show up on aggregate on farmlands, but do occur in the agroforestry practices for the purpose of land management in farming system of the people. These species are indicative of numerous forest resources integrated into the farming systems of the study guinea savannah of Kaduna State some of these species are Gawo (*Acacia albida*), Madachi (*Khaya segalensis*), Shirinya (*Ficus iteophylia*), Rimi (*Salix ledormaunii*), Leile (*Lawsonia inermis*), Dabino (*Phoenix dactylifera*).

Farmers in the study area know the importance of retaining or raising trees on their farmlands. Those who raised or planted trees gave the benefits they enjoyed from such a practice. Table 4.8 summarizes their responses.

Table 4.7: Roles of Agroforestry to the Respondents

	Chikun		Zaria		Kubau		Total	
Roles	F	%	F	%	F	%	F	%
Controlof wind	29	14.8	36	12.7	64	15.5	129	14.4
Provision of food	21	10.7	29	10.2	50	12.1	100	11.2
Provision of fodder	3	1.5	4	1.4	7	1.7	14	1.6
As a shelterbelt	11	5.6	29	10.2	14	3.4	54	6
Control of Erosion	43	21.9	61	21.5	89	21.5	193	21.6
Replenishment of Nutrients	32	16.3	50	17.6	61	14.7	143	16
Regulate Soil Temperature	14	7.1	25	8.8	11	2.7	50	5.6
Serve as Shade	39	19.9	29	10.2	96	23.2	164	18.3
Others Functions	4	2.0	7	2.5	0	0.0	11	1.2
None	0	0.0	14	4.9	22	5.3	36	4
Total	196	100.0	284	100.0	414	100.0	894	100

Source: (Author’s Field Survey, 2014).

Trees are concomitant to the survival of rural areas of the farmers in the study areas. All respondents recognized the potentials of trees on their farmlands for land management. Only 36 (10%) of the respondents displayed ignorance on the roles of agroforestry in solving both environmental and human problems.

4.4: Justification of the role of Agroforestry with farm products

4.4.1 Types of Crops Produced by the respondents

The types of crops produced by the farmers in the area are cereals, legumes, fruits and vegetable that are well adapted to the environment, the table below summarised the farm productivities of the farmers in the study areas for a period of five years (See table 4.8). They are presented in order of importance. The survey covered five years to determine the consistency in their farm productivities as a measure for land management sustainability.

Table 4.8: Summary of Crop Production by Year in the Area

Crops	Output by Year (100kg)						
	2009	2010	2011	2012	2013	Total	%
Maize	10566	10082.5	9772.5	9312.5	8764.5	48498	24.29
Sorghum	5527.5	5327.5	5201	4629.5	4758	25443.5	12.74
Rice	4876.5	3976.5	3798.5	3434	3856.5	19942	9.99
Pepper	3827	3574.5	3897	3181	3181	17660.5	8.84
Soya Beans	2724.5	2364.5	2391	2291	1915	11686	5.85
Tomatoes	8027	7245.5	7135.5	6555.5	6377.5	35341	17.7
Beans	1029.5	1076	1006	878	889.5	4879	2.44
Other Crops	7549.5	7170.5	6866	7466	7190.5	36242.5	18.15
Total	44127.5	40817.5	40067.5	37747.5	36932.5	199693	
Percentage (%)	22.1	20.44	20.06	18.9	18.49	100	

Source: (Author's Field Survey, 2014).

The pattern of crop production shows that Maize, Tomatoes, Sorghum, Rice and Pepper are the principal crops in the study area since more than one-quarter of the total sampled cultivate them every year. Other crops common in the area but are produced at insignificant measure by few farmers are Ground nut, Onion, Millet, Green Beans, Carrot, Cabbage and Sweet Potatoes.

4.5 Hypothesis Testing

H_o:There is no significant difference between farmland size and the number of trees for sustainable land management on the farmland.

H_1: There is significant difference between farmland size and the number of trees for sustainable land management on the farmland.

Table 4.9: Chi Square Table From SPSS

Farm Size * Average Tree Cross-tabulation

Count

		Average Tree						Total
		Less than 10	11 - 20	21 - 30	31 - 40	40 and Above	No Tree	
Farm Size	Less than 2 Hec	25	18	11	0	0	14	68
	2-4 Hec	39	75	32	7	11	11	175
	5-7 Hec	21	36	14	14	0	4	89
	8-10 Hec	7	11	0	0	0	3	18
	Above 10 Hec	0	0	0	4	0	1	7
Total		93	139	57	25	11	32	357

Source: (SPSS)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	27.619[a]	20	.119
Likelihood Ratio	26.897	20	.138
Linear-by-Linear Association	.558	1	.455
N of Valid Cases	357		

a. 24 cells (80.0%) have expected count less than 5. The minimum expected count is .06.

Table 4.9is a chi square test result on the difference between farm land size and the average number of trees for sustainable land management. The table convey that the chi square value of 27.619, with corresponding degree of freedom of 20 and with a P-value of 0.119 which is higher than the convenient level of significance of 0.05, thus revealed the absence of statistically significant difference between farm land size and the average number of trees for sustainable land management.

This result reveals that there is statistically significant difference between the data with respect to the total number of trees and farmland sizes for sustainable land management in the study area.

Therefore, the study concluded that as farm size increases there is no corresponding increase of the total number of tree species retained in the farmlands for sustainable land management. If this trend of trees or shrubs retention in the farmlands continues, it will enable sustainable land management in the study area.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

It should be noted that the attempts being made under agroforestry practices are to optimize the use of land for agricultural production on a sustainable basis at the same time meeting other needs from forestry (Fagbemi, 2002).

The presentation, analysis and interpretation of the results obtained from the data generated have led to the following findings from the study:

The socio-economic characteristics of the respondents in the study area showed that their perceptions on the research study are adequate to form the basis for the study, for instance, the sampled farmers comprised 98% male and just 2% female, the bulk of sampled population showed that the majority of the farmers fall within the active age of 31- 50 years old with 54%. On the educational level, only 26% of the total population did not have any form of formal education, which indicated that the farmers are enlightened about the roles of agroforestry for sustainable land management. More importantly, is the farmers years of experience on the farm, about 55% of the respondents have more than 15 years of farming experience.

The common land management practices in the study area are irrigation, fertilizer, organic manure, mulching, cover crop, crop rotation and bush fallow in order of percentage of respondents practicing them on their farmland.

It also discovered that the dominant types of agroforestry practiced by majority of farmers are, Parkland, windbreak, boundary system, forest farming, while alley cropping and riparian buffer were practiced by very few farmers.

It was also noticed from the findings that about 90% of total sampled recognized the role played by the trees in land management, if properly and carefully maintained and practiced, very few displayed ignorant of the fact.

Finally, the followings are the major role that different agroforestry practiced mentioned above performed for sustainable land management, these are listed in order of respondents perception: Control of erosion, control of strong wind, replenishment of nutrients, serve as shade to human, animal and plants, serve as food for human and animals, regulate soil temperature.

5.2 CONCLUSIONS

The role of Agroforestry in sustainable land management cannot be over emphasized. Agroforestry practices offer practical ways of applying various specialized knowledge and skills for sustaining land management to the development of rural production systems. It evolves a synergy between agricultural production and forestry that is beneficial for increased food production, sustainable wood production and improvement of the quality of the soil. The roles of Agroforestry practices are quite quantum. Agroforestry, among other benefits strive to optimize the use of land for agricultural production on a sustainable basis and at the same time meeting other needs from forestry.

This study has explored agroforestry practices of Kaduna State with a major focus on the experiences and perceptions of farmers in three selected local government areas. The study deep down to the origin, concepts, issues and role of agroforestry practices for sustainable land management, anthropocentric activities such as farming practices and land use in fueling the growing incidence of environmental degradation in the area. Considering the rate at which Kaduna state has been losing her forested land areas, agroforestry has gradually emerged as a viable tool to minimize the trend. To gather the data for these issues, the research carried out a field survey in accordance with the set objectives.

The results indicate that prior to the emergence of agroforestry, some of the ecological zones inNigeria experienced considerable depletion of their forested areas over the years and this may beattributed to a host of factors associated with anthropocentric activities in the use of land in thecountry.The analysis of community-based efforts in agroforestry reveals the growing adoption ofagroforestry among some of the communities in Kaduna state to sustain land management,environmental and economic benefits. To build upon the successes stories in the communities inorder to minimize the problems of poverty, food scarcity and land degradation, the study offered four recommendations based upon education and research, local involvement, funding, and policy reform. Having gone this far, it is evident that that this study offers resource managers and the decision makers the appropriate tools and an essential road map for the design of a viable index for tracking community efforts in environmental protection. This is necessary in dealing with the problems of poverty and lack of economic opportunities at the margin in rural areas in Nigeria.

There is therefore the need for an aggressive Agroforestry extension to convince farmers to adopt this farming system, most of which is fast disappearing at the former places it was earlier practiced.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 practices in ensuring sustainable use of the land, upholding ecological equilibrium and maintaining the environment should be put in the right perspective.

5.3 RECOMMENDATIONS

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

1. Promote Education and Research Efforts

Forested land areas in Nigeria's different ecozones have experienced enormous degradation dueto human activities for decades. This threat can be minimized by building upon the success stories of these communities by providing training and assistance in managing the lands forsustainable uses (NERC 2002). This can be attained through education and research programs toacquaint farmers with the right practices to boost food security and techniques suitable for theirrespective ecozone in addressing the problems. The authorities and institutions can also workclosely with these communities to develop action plans anchored on local needs in the areas ofsoil management and host of other priorities (Franzel *et al*.2001).

2. Encourage Local Involvement

Nigeria's population is predominantly rural in close proximity to forested areas and the mostfertile soil. The extent and nature of forest decline and number of agricultural programs thatfailed to revitalize the food sector of the economy in the past are clear indications of the negationof rural communities who are much closer to the problems. The authorities should involve localcommunities in agroforestry programs in the areas of harvesting and processing of forest products by offering assistance that can help develop village tree plantations in wood poor areasdependent on wood fuels for cooking and on poles and timber to meet local fencing and buildingneeds. This will be quite viable in communities that are yet to embrace the techniques of agroforestry (Haggar, 2001).

3. Provide Financial Support and the Right Climate for Income Generation

The successful implementation of agroforestry programs as suggested by few people in this research requires availability of seedlings. The provision of adequate funding to secure a prompt supply of seedlings is highly indispensable in that it enables communities procure seedlings for tree planting initiatives. This effort can be supplemented by instituting programs that help farmers and agroforestry teams gain knowledge and the skills to market their products in order to Sustain land management for forests and farming activities. This will enhance income-earning potentials from small holder production and sale of products (Bohringer, 2001).

4. Policy Reforms

The history of program design and implementation with regards to agriculture and forestry in Nigeria show that they are adhoc and reactionary in nature. Urgent matters such as deforestation, land degradation, natural hazards, climate change, food scarcity and rural poverty are only accorded topmost priority on the policy agenda when these problems have reached a calamitous proportion.. The right instruments such as incentives for rural farmers in agroforestry programs as well as a command and control mechanism to regulate land use activities should be incorporated in existing policies as part of the reforms (Mande 2003; Aturamu 2005).

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APPENDIX 1

Questionnaire

The Role of Agroforestry Practices in Sustainable Land Management in Selected Rural Areas of Kaduna State, Nigeria

SECTION A: Socio-Economic Characteristics of the Respondent

1. Location …………………………………………………………………..

2. Age in Years: a. 21 – 30 [ ] b. 31 – 40 [ ] c. 41 – 50 [ ] d. 51 – 60 [ ] e. Above 60

3. Gender: a. Male [ ] b. Female [ ]

4. Marital Status: a. Married [ ] b. Single [ ] c. Widowed [ ] d. Divorced [ ]

5. Educational Level: a. primary [ ] b. Secondary [ ] c. Tertiary [ ]
   d. Quranic School [ ] e. No Formal Education [ ]

6. Years of Farming Experience: a. < 5 [ ] b. 6 – 10 [ ] c.11 – 15 [ ]
   d.16 – 20 [ ] e. > 20

7. Size of your farmland in hectare: a. < 2 [ ] b. 2-4 [ ] c. 5-7 [ ] d. 8-10 [ ] e. > 10 [ ]

SECTION B: Agroforestry Practices

8. What do you consider as agroforestry? ____

9. Do you practice agroforestry in your farmland? a. Yes [ ] b. No [ ]

10. If yes, which system of agroforestry do you practice? a. Alley Cropping [ ] b. Silvopasture [ ] c. Windbreaks/Sheterbelts [ ] d. Riparian Buffer [ ] e. Forest Farming f. Others Specify______________________________________

11. Why do you think agroforestry is necessary in your farmland?
    a. Control of wind [ ] b. Provision of food [ ] c. Provision of fodder [ ] d. As shelter belts [ ] e. Control of Erosion [ ] f. Replenishment of Nutrient [ ] g. Regulate soil temperature [ ] h. To serve as Shade [ ] i. Others (Specify) ______________________

12. What is average number of trees and shrubs in your farmland per hectare? a. < 10 [ ] b. 11-20 [ ] c. 21-30 [ ] d. 31-40 [ ] e. > 40 [ ]

13. Do you consider agroforestry as commonly practice for land management? a. Yes b. No

14. Do you plant trees on your farmland? a. Yes [ ] b. No [ ]

15. If yes, what species do you normally plant? (Give Hausa name if necessary)

a. ___________________________________ b. _______________________________

c. ___________________________________ d. _______________________________

e. ____________________________________ f. _______________________________

16. From where do you get your seedling to plant? a. Government agencies [ ] b. Privately raised [ ] c. Personal raised [ ] d. Others (specify) _____________________________

17. What do you think can be done to improve the practices of agroforestry in your area? a. Educate the farmers [ ] b. Supply the seedlings by government [ ] c. Encourage the farmers to plant trees [ ] d. Enforce the Laws to plant trees regularly [ ] e. Seek for permission before cutting down of trees [ ] f. Others Specify ______________________

SECTION C: Land Management Practice

18. What other land management practices do you know as a farmer apart from agroforestry? a. Mulching [ ] b. Cover crops [ ] c. Crop Rotation [ ] d. Irrigation [ ] e. Organic Manure [ ] f. Fertilizer [ ] g. Bush Fallow [ ] h. Others Specify___________________

19. Which one of these do you practice, if not agroforestry? a. Mulching [ ] b. Cover crops [ ] c. Crop Rotation [ ] d. Irrigation [ ] e. Organic Manure [ ] f. Fertilizer [ ] g. Bush Fallow [ ] h. Others Specify___________________

20. Which one of these land management practices do you think can minimize the rate of Erosion in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify___________________

21. Which one of these land management practices do you think can minimize the rate of Strong Wind in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify___________________

22. Which one of these land management practices do you think can minimize the rate of Drought and Flood in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify___________________

23. Which one of these land management practices do you think can minimize the rate of Bush Fire in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify___________________

24. Which one of these land management practices do you think can minimize the rate of Crop Pests in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify___________________

25. Which one of these land management practices do you think can minimize the rate of other natural hazards in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

26. Which one of these land management practices do you think can minimize the problem of climate change in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

27. Which one of these land management practices do you think can sustain land for a very long time in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

28. Which one of these land management practices do you think can be less expensive in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

29. Which one of these land management practices do you think can be culturally and socially adoptable in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

30. Which one of these land management practices do you think can increase your farm productivity for many years in your area? a. Agroforestry [ ] b. Mulching [ ] c. Cover crops [ ] d. Crop Rotation [ ] e. Irrigation [ ] f. Organic Manure [ ] g. Fertilizer [ ] h. Bush Fallow [ ] i. Others Specify____________________

SECTION D: Farm Products

31. What is nature of your farm ownership? a. Owned [ ] b. Communal [ ] c. Hired [ ] d. Rent [ ] e. Others (specify) ____

32. Do you operate collective (family) farm holding (gandu) and/or individual plots (gayauna)? a. Family [ ] b. Individual [ ] c. Both [ ]

33. How do you provide labour for your farms? a. Family labour only [ ] b. Hired labour only [ ] c. Family and hired labour [ ] d. Others (specify) _________________________

34. What crops do you grow on your farm? (List them in order of importance)

a. ____________________________________ b. _________________________________

c. ___________________________________ d. ________________________________

e. ___________________________________ f. ________________________________

g. ___________________________________ h. ________________________________

35. Kindly provide information by completing the table below based on your harvest in the last five years.

Year	No.	Crop	Yield (100kg/bag)/ ha
2009	1.		
	2.		
	3.		
	4.		
	5.		
2010	1.		
	2.		
	3.		
	4.		
	5.		
2011	1.		
	2.		
	3.		
	4.		
	5.		
2012	1.		
	2.		
	3.		
	4.		
	5.		
2013	1.		
	2.		
	3.		
	4.		
	5.		

APPENDIX 2

Table 1: Maize production by the Respondents

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	61	61	75	82	89
10 – 19	61	71	71	64	68
20 – 29	50	43	43	32	26
30 – 39	36	39	22	50	36
40 – 49	26	22	32	22	29
50 – 59	36	18	11	4	14
60 – 69	0	11	11	18	7
70 – 79	3	11	7	8	7
80 – 89	3	7	4	3	7
90 – 99	0	0	3	0	0
> 100	32	22	26	22	18
None	0	3	3	3	7
Total	**308**	**308**	**308**	**308**	**308**

Sources: Field Survey, 2014.

Table 2: Sorghum Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	96	107	114	111	113
10 – 19	57	50	39	39	29
20 – 29	18	14	29	32	21
30 – 39	15	18	14	18	22
40 – 49	18	22	18	14	18
50 – 59	11	0	7	3	7
60 – 69	3	3	0	0	0
70 – 79	0	7	0	3	3
80 – 89	3	0	0	0	0
90 – 99	0	0	3	0	0
> 100	14	14	14	11	11
None	3	3	0	7	14
Total	**238**	**238**	**238**	**238**	**238**

Sources: Field Survey, 2014.

Table 3: Rice Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	39	61	64	39	54
10 – 19	36	26	22	22	46
20 – 29	14	22	18	29	14
30 – 39	29	7	11	14	11
40 – 49	7	18	11	11	14
50 – 59	7	3	7	7	3
60 – 69	0	3	11	3	1
70 – 79	11	11	3	0	3
80 – 89	7	3	3	1	0
90 – 99	0	0	0	3	0
> 100	7	3	3	3	11
None	7	7	11	32	7
Total	**164**	**164**	**164**	**164**	**164**

Sources: Field Survey, 2014.

Table 4: Pepper Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	36	43	46	57	46
10 – 19	39	26	26	22	26
20 – 29	18	14	11	3	11
30 – 39	2	11	14	3	14
40 – 49	4	3	3	2	0
50 – 59	3	3	0	4	7
60 – 69	1	0	0	11	0
70 – 79	0	7	0	8	0
80 – 89	7	0	11	1	0
90 – 99	8	0	7	0	0
> 100	8	14	8	7	14
None	6	11	6	14	14
Total	**132**	**132**	**132**	**132**	**132**

Sources: Field Survey, 2014.

Table 5: Soya Beans Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	57	61	57	61	61
10 – 19	22	18	22	18	18
20 – 29	14	14	14	11	14
30 – 39	0	11	7	14	11
40 – 49	7	0	4	0	3
50 – 59	14	11	7	7	3
60 – 69	0	3	0	0	1
70 – 79	0	0	1	3	0
80 – 89	0	0	0	1	0
90 – 99	0	0	3	0	0
> 100	7	3	3	3	3
None	0	0	3	3	7
Total	**121**	**121**	**121**	**121**	**121**

Sources: Field Survey, 2014.

Table 6: Tomatoes Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	11	7	14	11	3
10 – 19	7	7	3	3	14
20 – 29	0	7	0	11	0
30 – 39	3	0	18	7	7
40 – 49	0	14	0	7	18
50 – 59	22	3	0	7	0
60 – 69	3	3	7	7	7
70 – 79	3	3	0	0	3
80 – 89	0	0	0	0	1
90 – 99	0	1	0	0	3
> 100	50	54	57	46	39
None	3	3	3	3	7
Total	**102**	**102**	**102**	**102**	**102**

Sources: Field Survey, 2014.

Table 7: Beans Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	43	39	36	39	43
10 – 19	11	7	14	11	11
20 – 29	0	7	7	0	11
30 – 39	14	11	7	11	3
40 – 49	0	0	0	0	0
50 – 59	0	1	3	3	3
60 – 69	3	3	1	0	0
70 – 79	0	0	0	0	0
80 – 89	0	0	0	0	0
90 – 99	0	0	0	0	0
> 100	0	0	0	0	0
None	0	3	3	7	0
Total	**71**	**71**	**71**	**71**	**71**

Sources: Field Survey, 2014.

Table 8: Other Crops Production

100kg/Bag	No. of Respondents by Years				
	2009	**2010**	**2011**	**2012**	**2013**
< 10	71	86	93	82	85
10 – 19	46	56	54	43	57
20 – 29	26	14	11	29	22
30 – 39	46	14	29	22	7
40 – 49	14	22	11	18	13
50 – 59	13	17	11	0	29
60 – 69	11	18	14	36	18
70 – 79	0	0	7	0	0
80 – 89	0	11	0	0	0
90 – 99	0	0	0	0	0
> 100	22	11	18	18	18
None	0	0	1	1	0
Total	**249**	**249**	**249**	**249**	**249**

Sources: Field Survey, 2014.