AGRO-FORESTRY TECHNOLOGY ADOPTION AND ITS EFFECT ON FARMERS' CROP PRODUCTIVITY IN THE UPPER EAST REGION OF GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL AGRIBUSINESS DEGREE.

COLLEGE OF BASIC AND APPLIED SCIENCES

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

UNIVERSITY OF GHANA, LEGON

JULY, 2017

DECLARATION

I, Abdallah Akurubila Mohammed do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled "Agroforestry Technology Adoption and Its Effect on Farmers' Crop Productivity in the Upper Region of Ghana" is the product of my own research work in the Department of Agricultural Economics and Agribusiness, University of Ghana.

I also declare that this thesis has not been presented either in part or in whole for another degree in this University or elsewhere.

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This thesis has been submitted for examination with our approval as supervisors

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DEDICATION

To the almighty Allah the creator in whose love I delight. My parents Alhaji Mohammed Azelgo Akurubila and Madam Mamata Abugubilla, who unconditionally instilled in me values that continues to inspire me to this day. Finally to my friend Mr. Iddrisu Sulemana whose love, inspiration, support and company have continued to give my life good reason to aspire for big achievements.

ACKNOWLEDGEMENTS

My deepest appreciation is to the almighty Allah, for HIS sufficient and unfailing guidance throughout my life and stay in school especially during the period of writing this thesis.

I register my honest appreciation to my main supervisor, Mr. Ditchfield P. K. Amegashie, for working insistently to give shape to this work through his mentoring, guidance, necessary and timely comments and suggestions.

I am equally very grateful to my co- supervisor, Dr. (Mrs.) Irene S. Egyir for her personal commitment and suggestions which were amazing and has contributed immensely to the success of this Research. Many thanks for the hours you both spent guiding me to come out with this research. I wish to express my sincere gratitude to the Strategic Analysis and Knowledge Support System (SAKSS) through the Ministry of Food and Agriculture research grant support which financially contributed greatly towards making this research a success.

I am also indebted to all lecturers of the Department of Agricultural Economics and Agribusiness, University of Ghana for the support and advice given me towards this work.

My deepest appreciation goes to my own brother Mr. George Akuriba Agana for his kind guidance in the analyses of the data which produced this results.

Many thanks to my colleagues at the department. It has wonderful being with you, especially Jawula Abdulai, Baba Hassan Taahir Naama, Hamida Shiraj, Daniel Antwi, David Antwi, Eric Nilson Donkoh, Richard Kofi Kofituo, Benjamin Sarfo, Ramla Keelson, Salma Suhuyini and Richard Asiamah.

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ABSTRACT

This study was conducted to investigate the agroforestry technology adoption and its effect on farmers' crop productivity in the Bawku West, Talensi and Nabdam Districts of the Upper East Region of Ghana. Three hundred farmers from six communities within the study area were interviewed using semi-structured questionnaires. The study employed descriptive statistics in identifying the types of agroforestry technologies adopted by farmers. A five point likert scale was employed to assess the perceptions of farmers on the benefits of adopting agroforestry technologies. The binary logit model was used to determine the factors that influenced the adoption of agroforestry technologies. Finally, the Log linear production model was employed to determine the effects of adopting agroforestry technologies on farmers' crop productivity in the study area. The study identified the major types of agroforestry technologies adopted by farmers as alley-farming, intercropping, shifting cultivation, homegarden, fodder banks, taungya system, woodlot establishment and hedgegrow. The study revealed that the farmers in the study area have a positive perception about benefits of agroforestry such as its economic advantage, soil erosion reducing and soil nutrient increasing properties. The socio-economic factors influencing farmers' decision to adopt agroforestry technologies were age, marital status, agroforestry education awareness, landownership, land size, nature of land and access to credit and these were identified as significant positive variables. Finally, variables such as land size, labour, fertilizer and agroforestry technology adoption had significant effect on farmers' crop productivity in the study area. Small holder farmers and farming households are encouraged to adopt more advanced agroforestry technologies to increase their crop productivity. Farmers had positive perceptions about the benefits of agroforestry technology adoption. It is recommended that Government, Non-governmental Organizations and other relevant stakeholders should further support in the provision of improved tree seedlings and extension services to improve on farmers' adoption of agroforestry technologies and their economic wellbeing.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Agroforestry is defined briefly as the integration of trees and crops on the same land management unit. Its purpose is to produce food, wood, fibre and at the same time ensures the conservation of land resource. By so doing agroforestry is anticipated to moderate the effect of climate change variations which may negatively affect agricultural production.

According to Rao et al., (2007); Verchot et al., (2001); and Kiptot and Franzel, (2011), the agricultural adaptation strategies employed by farmers and farming households include agroforestry practices which the farming communities employ to cope with climate change; agroforestry adjustments made in response to climate change; and, agroforestry processes to reduce harm or risk of harm resulting from the changing climate. Hence, making it crucial to deliberate on the implications of planting and nurturing trees on farm lands towards avoidance and reduction of harm or risk of harm which may result from climate change.

Stige, et al., (2006); FAO, (2009) pointed out that because of the success of agriculture especially rain-fed agriculture which depends on climatic conditions farmers and farming household practices and attention towards it is very crucial. According to Sivakumar et al., (2005), climate in Africa is directly associated with variable rainfall, accompanied by high temperatures with relatively low agricultural productivity as a resultant effect. Agricultural production in developing countries will not farewell under climate change, and the severity of the impact would be experienced by smallholder farmers (McCabe, 2013). Hence, urgent attention must be given to agroforestry technologies practices which is capable of reducing temperatures and enhancing the growing of crops on farms Sanchez (2000).

Agricultural production could be increased by adapting to an agroforestry technologies practices which has the potential to enhancing farmers' livelihoods. This will minimize the climate change elements such as drought, extreme temperatures and rainfall variability (Syampungani et al., 2010). Agroforestry technology practices is important for crop production and serves as climate change mitigating measure towards increased agricultural production. Van Noordwijk et al., (2011), reports that emanation of greenhouse gases from agriculture, changes in land-use and forestry have intensified climate change. Deforestation and burning of fossil fuels are mentioned as additional anthropogenic causes of climate change (Robledo, 2006).

In Africa, the impacts of climate change are not hard to find, Nair, (2009) pointed out that agroforestry is an effective strategy for greenhouse mitigation and carbon sequestration and has received international attention. Agroforestry as a forest-based system plays an important role in conserving existing carbons, thus, limiting carbon emissions and also absorbing carbons that are released into the atmosphere (Schlamadinger et al., 2007 cited in Syanpungani et al., 2010). Farmers and farming household's adoption to agroforestry technology can increase their resilience and strategically position them to adjust to the adverse effects of climate (Charles et al., 2013).

Agroforestry has been noted to have multi-functional purposes, making it a most promising tool in climate change mitigation strategy for farmers. In agriculture, the use of shrubs and trees serves as a remedy to solving the numerous challenges of alleviating and reducing the vulnerability, securing food security and increasing the adaptability of agricultural systems to climate change (FAO, 2010: 9). Agroforestry is very important as it creates considerable benefits in agricultural crop and livestock production in several mutual interdependent ways such as trees on agricultural fields improve soil fertility and controls erosion, increase soil organic matter and improve nitrogen content as well as providing forage for livestock production and development, (IPCC, 2001 cited in Rao et al., (2007).

Agroforestry in recent times has been addressed internationally as an effective sustainable agricultural land use approach because of its production and environmental benefits, (Nair et al., 2009). With agroforestry technology adoption practices, degraded lands are transformed into viable and more productive lands and develops the productive capacity of soils Rao et al., (2007).

In Ghana, farmers' adoption to agroforestry technologies will augment other climate change adaptation strategies towards an increased agricultural production. According to (Agyemang and Antwi, 2013), to achieve the sustainable Millennium Development Goals, Ghana remain positive that effective agroforestry technology adoption will contribute towards its achievement.

Agroforestry development in Ghana is not new. The significance of agroforestry technologies was first realized in the 1980s which informed the formulation of national agroforestry policy in 1986, this policy provided guidelines and directions and facilitated the development of agroforestry in the country (Asare, 2004). MOFA/AFU, 1986 cited in Asare, 2004, noted that the main purpose of the policy was to whip farmers' interest to adopt agroforestry practices which has the potential to minimize cost of chemical fertilizer for sustainable land use.

Regrettably, success stories of agroforestry adoption in Ghana is not widespread and are found in few isolated areas showing a cross-section of farmers who adopt the practices. This is clear that not always the case that policies are implemented as they were intended and so the need to assess farmers' perspective on agroforestry adoption and implementation especially when climate change has become a serious constraint to agricultural development.

Though agroforestry is hailed at the international and national levels as an effective adaptation approach with a positive effect on climate risk and global warning, its practices among farmers and farming households in Northern Ghana is not promising.

However, it is crucial to examine the benefits of agroforestry technology adoption practices that makes it one of the most effective climate change adaptation strategy to agricultural production and how it is practiced in the study area.

1.2 Problem Statement

According to Laube et al.,(2011) “variation in farming systems and practices as well as land degradation result in decreasing yields and crop failure in Northern Ghana and has further caused further production decline of Ghana’s poorest region”. The sixth round of the Ghana Living Standards Survey ranks the Upper East Region (UER) in terms of poverty as 2nd in Ghana with 70.4% (GSS, 2014a). Agroforestry undoubtedly has a great potential to increasing farmers’ agricultural production in the study area. Some challenges have been observed to be affecting the adoption of agroforestry technologies and these challenges include; soil nutrient erosion, inadequate education on agroforestry technologies, unavailability of tree species seedlings, bush fires, inadequate awareness on agroforestry and unsuitable nature of land to practice the technologies, (Gyamfi, 2011).

The region according to (USAID, 2011) is prone to desertification and severe soil degradation due to unsuitable agricultural practices and high poverty rate. Significant decline in rainfall accompanied by increasing unfavorable temperatures in recent times were recorded in the UER, (Laube et al., 2011). The aggregate effects of poverty and land degradation have made most farmers not knowing what type of land to use to practice a specific type of agroforestry technology and therefore complain of unsuitable land. This may be as a result of low level of sensitization and education on agroforestry technology adoption. The intermitted drought, floods, over grazing and often wind storms has contributed heavily to loss of soil fertility leading to a decline in agricultural production in the study districts. Continuous cropping on the same agricultural fields affects the soil's ability to recover its lost nutrients.

According to Garrity (2004:7), "Farmland in the developing world generally suffers from the continuous depletion of nutrients as farmers harvest without fertilizing adequately or fallowing the land. Smallholder farmers removed large quantities of nutrients from their soils without using sufficient amounts of manure or fertilizer to replenish fertility".

Agroforestry technology adoption reestablishes and enhances nutrient preservation in the soil and reduces fertilizer application by 50% (Carsan et al., 2014). McCabe (2013:4) stated that "agroforestry merits special attention because of the diverse benefits it provides for smallholder farmers across the developing world".

Notwithstanding the massive ecological land use and environmental benefits; studies conducted did not explore agroforestry technology adoption and its effect on farmers' crop productivity in the study area.

The questions that arise from the foregoing are:

1. What are the various types of agroforestry technologies adopted by small holder farmers in the Upper East Region?
2. What are the perceptions of farmers on the benefits or otherwise of adopting agroforestry technologies?
3. What factors influence agroforestry technology adoption?
4. What is the effect of adopting agroforestry technology on farmers' crop productivity?

1.3 Objectives of the Study

The main objective of the study is to assess agroforestry technology adoption and its effect on farmers' crop productivity in the Upper East Region.

The specific objectives are;

1. To identify the various types of agroforestry technologies adopted by small holder farmers
2. To assess the perceptions of farmers on the benefits or otherwise of adopting agroforestry technology
3. To determine the factors influencing agroforestry technology adoption.
4. To assess the effect of adopting agroforestry technology on farmers' crop productivity

1.4 Relevance of the Study

Previous studies, research and development organizations have contributed significantly to the efforts in encouraging and propagating agroforestry technologies to increase and maintain farm productivity, and improve environmental conservation (Raussen et al., 2001; Franzel and Scherr, 2002). However, agroforestry technology adoption levels of the small holder farmer and farming households are less than satisfactory.

According to Pattanayak *et al*., 2003; Franzel *et al*., 2004 Researchers in several different ways and context have examined the determinants and constraints to the adoption of agroforestry technologies. Majority of these factors studied have concentrated on farm size, extension service, age, education and land tenure.

As a result, the study is conducted to assess the agroforestry technologies adopted by small holder farmers and its effect on their crop productivity in the study area.

It is of this view that when realized, farmers will obtain practical knowledge to help address issues relating to their land use problems as the benefits from agroforestry technology adoption is enormous and will significantly lead to increase and sustained agricultural productivity.

1.5 Organization of the Study

The study is organized into five chapters. With chapter one which covers background to the study, problem statement, research objectives, relevance of the study and organization of the study. Chapter two reviews relevant literature on agroforestry technology adoption, chapter three presents the methodology employed in the study, conceptual and theoretical framework, methods of data analysis and the study area. Chapter four presents the results and discussion of the study. Finally, Chapter five presents the summary, conclusion, recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviewed relevant literature on the concept of agroforestry technologies, the types of agroforestry technologies adopted by the small holder farmers, the perceptions on the benefits and otherwise of adopting agroforestry technologies, the factors that influence agroforestry technology adoption and the effect of adopting agroforestry technology on farmer's crop productivity.

In addition, literature on agroforestry practices, the benefits of agroforestry, challenges of agroforestry technologies and practices, agroforestry policies and Ghana national climate change policy were reviewed.

2.2 Definition of Agroforestry and Terminologies

MacDicken and Vergara, 1990 cited in Darkoh, (2003), defined agroforestry as a resilient land use practice where farmers make deliberate efforts to retain trees and plant other woody perennials in association with crops as well as livestock in agricultural fields to benefit from the resultant ecological and economic interactions.

Also, Charles et al., (2013), defined agroforestry as farmers planting of tree species incorporated with crops or animals on the same land management unit whilst deliberately allows trees naturally occurring on croplands for mutual benefits.

This means that small holder farmers and farm families may deliberately maintain some of the tree species naturally existing on the their farm lands during the first time of land preparation and clearing and also introduce some new improved tree species which when integrated with crop farming may lead to an improved land management system and crop productivity. If the resultant economic, biological and ecological interactions will be mutually beneficial, then tree and other combinations must be compatible, therefore it is important for small holder farmers and farm families to know the suitable combinations that will derive optimum benefits from agroforestry technologies. The definition above shows all the important components that qualifies for an agroforestry as it includes different crops, animals and tree species combinations in their most economic proportions, hence, this study has adopted this definition of agroforestry which comprises of different tree species characteristics as well as crops which are significant to the study.

2.2.1 Classification of Agroforestry Systems

Agroforestry systems (AFs) have been classified mainly under the following, agrosilviculture which comprises of (trees and crops), Silvipastoral (trees with pastures and livestock) and Agrosilvopasture (crops with trees, pasture and/or animals) (Nair, Young 1989).

Taungya, shifting cultivation, hedgegrow intercropping comprising of alley cropping and barrier hedges, improved tree fallows, homegardens, windbreaks as well as boundary planting are all components of agrosilviculture.

Silvipastoral comprising of pastures, trees on rangeland, live fences, plantation crops with pastures, woodlots establishments, forestry reclamation, and fodder banks all constitute tree component predominance category. Herbaceous plants (agricultural crops), animals manage by farmers and farm families and other land users and woody perennials are the three main components of agroforestry systems. (Nair, 1993).

2.2.2 Agroforestry Practices

According to Long and Nair (1999), farmers practice different forms of agroforestry depending on their geographical areas and characteristics. In tropical countries farmers and farm families are engaged in the following agroforestry practices: improved fallows, homegardens, alley cropping, hedgegrows, fodder production and intercropped trees for shade. Farmer's decision to adopt any of these practices is mainly influenced by the existing opportunities for adaption and local needs.

Badege et at., (2013) revealed that fodder banks, live fences, boundary planting, improved fallows, alley farming, rotational woodlot establishment, silvopasture, riparian forest buffers as well as forest farming are appropriate for climate change adaptation in Ethiopia and Kenya.

Home Garden

According to Badege et al., (2013), homegardens technology practices may have come about due to global increase in population, making it challenging to access large parcels of lands so therefore farmers and farm families have resorted to this form of practice as an adaptation measure. Crops and animals as well as wood perennials are well integrated in this system to derive maximum benefit among them. However, homegardens exist with or without animals (Nair, 1993)

Homegardens as an agroforestry technology practice is important for women participation involving the cultivation of vegetables, medicinal trees, shrubs, fodder and retention of some naturally occurring trees on a relatively small piece of land that are close to people's houses. Benefits derived from this form of practice is enormous and farmers engage in this on the same piece of land for an extended period of time (Oluka-Akileng, et al., 2000)

Homegardens are considered providing supplementary food to the farming households and farm families as it provides vegetables and fruits all year round. It is also an important source of income to farmers especially during the dry season.

Taungya System

According to FAO, (1984), Taungya is an agroforestry technology practices involving tree specie planting with crops production. Majority of the farmers' cultivate crops as staple foods and hence, serves farmer's and land users quest for arable land and use of agroforestry technologies towards an increase crop productivity. With these practices and arrangements farmers are expected to tend the tree species to mature and are expected after some years to move to other lands, mostly in degraded managed forest reserves. Trees and crops under this system are considered to achieve complementary rather than competitive effects (Vieira *et al.,* 2009).

Imo (2009), argues that, the integration of trees and crops is influenced by factors related to planting densities, climatic and edaphic factors, species combinations and the level of competition for growth.

Woodlot Establishment

Woodlots is system whereby a preferred trees species and planted on large tracks of lands, farmers and land users can plant one or multiple of different tree species on the same piece of land. It is noted that woodlot is a form a fallow since woodlot establishments are usually located in marginal lands (Oluka-Akileng et al., 2000)

The most preferred species used in the establishment of woodlot plantations are Kalitunsi (*Eucalyptus species*) and *Nsambya (Markhamia lutea)* this is because of a significant demand for their products such as fuel wood and timber.

Alley Cropping

Alley cropping is an agroforestry technology practice in which farmers and farm families cultivate food crops between trees preferably leguminous species and hedgerows of planted shrubs within the same land management unit. The hedges are periodically pruned during the crop's growth to provide biomass which improves soil nutrient status and to prevent shielding of growing crops (Kang *et al.*, 1990). Alley cropping is an agroforestry technology that places trees within agricultural crops on same land management unit land. It is especially attractive to small holder farmers interested in growing multiple crops on the same piece of land to improve whole-farm yield. Growing a variety of crops in close proximity to each other can create significant benefits to farmers to help them increase their productivity and manage agricultural risk and uncertainty.

Alley cropping systems change over time as trees and shrubs grow, they influence the water, light, and nutrient managements in the field. These interactions are what sets alley cropping apart from more common mono cropping technologies. Farmers adopt alley cropping technique to provide additional functions that support and enhance other aspects of their farm operations. For example, a livestock farmer may grow crops that supply fodder, bedding, or mast crops for their livestock. Organic producers may choose tree species that fix nitrogen. Like all agroforestry technologies, alley cropping is considered as part of the whole farm operation.

High nutrient composition and fast decomposition organic materials properties such as trees and shrubs with fairly pruning have been recommended as soil amendments and in combination with other fertilizers such as chemical fertilizers (Nziguheba *et al.*, 2000; Quinkenstein *et al.*, 2009), These pruning of shrubs and trees through alley cropping contributes significantly to the development of sustainable land use management as result proving effective cost mechanism for enhancing agricultural productivity Young (1997).

The regular pruning and return of residues from shrubs or hedgegrow trees through alley cropping contribute to improvements in soil temperature, erosion control, high soil nutrient status, maintenance of microbial activity and recycling of plant nutrients (Isaac et al., 2003 and Wang et al., 2010).

Cropping and Plantation

It is an integrated multistory combination of tree crops mainly, coffee, rubber, coconut, shade trees, cacao, herbaceous crops and other tree crops (Long and Nair, 1999).

Trees Generated on Farm Land

Alao and Shuaibu, (2013), reported that trees on farm land is an agroforestry technology practice where farmers deliberately allow some natural generated trees on their farm lands while planting some new improve tree species so as to increase the tree population in order to maximize agroforestry benefits as the farmer has access to food, fruits and additional income from these tree products and enjoys shade as well. It also helps reduce unfavorable climatic and environmental conditions within its geographical area. Undoubtedly in the long run, it enhances soil nutrients which contributes to an increased agricultural production.

2.3 Role of Agroforestry

Franzel and Scherr, (2002) in sub-Sahara African case studies, have demonstrated the potential of agroforestry technologies practices to increasing farm incomes of farmers and help solve difficult environmental challenges towards an overall increase in farm output.

Pattanayak et al., (2003), stated that previous studies of agroforestry technology adoption had concentrated mainly on how farmers, crop lands and other socio-economic and demographic characteristics are connected with previous agroforestry technology adoption decision.

2.3.1 Environmental Benefits

Agroforestry contributes to improving the quality of water in agricultural landscape, conserves variety of life forms, enriches soil nutrients, and reduces poverty levels of farmers and farming families as well as removing carbons from the atmosphere. These enormous benefits are not only enjoyed by the farmer alone but also the larger society due its positive externalities (Nair, P.K. 2009).

Trees on agricultural lands provides suitable environment for farmers, farming families and other land users thus, providing a convenient human habitation, improves soil nutrient, serves as wind break, enhances the climatic condition of the area as well as providing shade for living organism (Verheij, 2004 cited in Kwaku and Wiafe 2014). Similarly, trees on agricultural fields play several important roles such as improving environmental health and for the wellbeing of mankind. Place et al. (2012) stated that agroforestry creates some environmental benefits such as sustainability of biodiversity, watershed protection and carbon sequestration.

2.3.2 Socio-economic Benefits

The integration of different tree species with herbaceous crops on agricultural fields comes with great socioeconomic benefits to farmers and farming families. The products of agroforestry such as timber, fuel wood, fruits, herbs and honey serves as an additional income generating potential which helps farmers earn more revenue through its sales which may be ploughed back to increase agricultural production (Gebrehiwot, 2004; thorlakson and Neufeldt, 2012). Combination of trees and shrubs is an effective cost reduction strategy which replenishes soil fertility for women farmers who find it difficult to acquire fertilizer and also a sustainable source of firewood for households (kiptot and Franzel, 2011)

Other benefits includes, ensures food security, capacity to control poverty, improve production capacity of soil, medicinal trees provides herbs or medicine to farmers, reduce deforestation and pressure of forest and empower female farmers and other under privilege rural dwellers (Tewari, 2008 cited in Kwakwu and Wiafe, 2014).

2.3.3 Biological Benefits

According to Darkoh, (2003), agroforestry systems enhances crop lands in diverse ways by significantly contributing to soil organic renewal, maintenance of soil nutrients, soil erosion control, minimize soil nutrient leaching as well as improve the soil recycling potentials for increase agricultural productivity. This will improve the biodiversity in semiarid lands in Africa he added.

Agroforestry practices has multiversity of agro ecological benefits which has the potential of sustaining agricultural growth in Africa without compromising yields (Carsan et al., 2014)

Leguminous trees on agricultural landscapes play an important role in nitrogen fixing so as to improve soil nutrients, as it also aids the natural decomposition of biomass to fertilize the soil (Badege et al., 2013). Kiptot and Franzel (2011) stated that the practice significantly contributes in generating and replenishing soil nutrients and improving its fertility for agricultural production and thus can be used as measure to mitigate soil degradation.

2.4 Agroforestry as a Climate Change Adaptation Strategy

Agroforestry is an active measure that can empower farmers and farming families towards absorbing the climate change shocks which may occur from unfavorable temperature and rainfall variability.

Scholars have proven that the availability of trees on farm lands and agricultural fields has a great potential of protecting crops from extreme climatic conditions and in the long run support farmers to maintain production (Pramova et al., 2012)

Researchers in recent times have argued that farmers and farming families especially in the rural communities are turning to agroforestry as a means of a climate change adaption towards its negative consequences which has the potential of affecting agricultural output. Agroforestry helps to minimize the effects of extreme weather conditions on crop cultivation to enhance agricultural production among smallholder poor famers, it also helps regulate soil water and altering of microclimate within a particular geographical location (Pramova et al., 2012; Ozor et al., 2012).

Agroforestry systems are mainly helpful in crop production as the deep roots trees can draw underground water to enhance soil moisture during agricultural drought period, roots play crucial role in improving soil porosity and helps significantly in checking soil erosion (Verchot et al., 2007).

Tree planting on agricultural fields is considered to be a good land-use practice that influences farmers' access to improved livelihoods. This practice makes it possible for farmers and land users to cultivate food crops, fodder and incorporate trees on crop lands continuously for adaptation purposes which help farmers to meet timber, fodder, fruit needs and poles (Darkoh, 2003).

In Africa, nitrogen fixing trees boost agricultural production even in drought years as trees play diverse roles in improving moisture and nutrient content of the soil (Garrity et al., 2010 cited in Pramova et al., 2012). Hence, it can concluded that agroforestry systems are more resistant to drought than non-agroforestry farming systems. Therefore, one of the agroforestry adaptation potentials has to do with its ability to improve food crop production. Syampungani et al., (2010) studied the probable use of agroforestry as a win-win solution to climate change and established that agroforestry can help farmers who have suffered from drought, floods and rainfall variability to sustain their agricultural production and have an improved livelihoods. Similarly, Verchot et al., (2007) noted that agroforestry technologies are dynamic as they can increase agricultural production in both wetter and drier seasons since trees planted on agricultural fields have the ability to pump excess water from the soil and reduce runoff during wetter seasons and deep roots trees are able to discover large volume for water and nutrients in the soil in times of drought for increase agricultural production.

Consequently, agroforestry systems are more resilient to severe weather conditions than any of the other farming practices, making it a viable climate change adaptation strategy for rural farmers. Agroforestry as a climate change adaptation strategy have been widely embraced by some farmers in Ghana. Danquah et al., (2013) noted that some farmers in the Brong Ahafo Region have gained some level of understanding about environmental and climate change management practices in recent times as result of the activities of environmental NGOs, as such farmers are more willing to plant or retain trees on their farms to be able to manage the challenges posed by climate change.

2.5 Perception of Farmers on Agroforestry Technology Adoption

Falconer, (1990), pointed out that many studies have stressed on the importance of improved tree planting and management to rural and farming households around the world. Leakey et al., (2003) emphasized that indigenous tree planting promotion could play a very good strategic role in poverty alleviation for the humid forest zone in Africa. Garrity (2004) highlights the prospective contribution of agroforestry practices of indigenous fruit trees in eradicating hunger and extreme poverty a top priority of achieving the Millennium Development Goals.

According to Arnold and Dewees, (1995) a number of factors influence the decision of farming households and other land users to retain and plant new tree species. Edwards and Schreckenberg, (1997), stated that these factors can broadly be divided into internal factors such as farm size, access to capital and labour, land tenure, and ethnic background of household decision makers and external factors to the household such as market access, land-use system, off-farm resources as well as policy and legislative regimes.

According to Arnold and Dewees, (1998), approaches put in place to positively influence tree species establishment on agricultural field should be based on the perspective of farmers and farming households' livelihood strategies, stating that little is known about farmers' perceptions on the benefits of these trees and the challenges of its establishment.

Research from Wiersum, (1984) disclose that rural people are often familiar with tree growing but have different attitudes towards trees and these attitudes can affect tree growing on farms. Several studies in developing countries have pointed scarcity of fuel wood as one of the key factors to influence tree planting among farming households (Dewees, 1992). FAO, (1985) reported that as long as fuel wood could be collected without paying for it, farmers and farming households had little or no incentive to plant fuel wood producing trees. Godoy, (1992), however, raised the question on the assumptions that increased fuel wood demand stimulates tree production in developing countries, suggesting that this is the only case of tree planting in the times of fuel wood crisis or high demand.

Hence, the high cost of purchasing fuel wood may stimulate farmers and farming households to plant more trees. FAO, (1985) reports that planting of trees at the initial stage requires intensive labour and these activities coincide with crop harvesting operations.

2.6 Factors Affecting the Adoption of Agroforestry Technologies

Keil et al., (2005) pointed out factors such as socio-economic, environmental, cultural factors that affect farmers' decision to adopt different types of agroforestry technologies. The findings noted significant knowledge and understanding of farmers which influence their adoption to agroforestry technologies. Available literature by Place and Dewees (1999) and Pannel (2003), noted factors such as land tenure, inadequate extension services, risk and uncertainty, household resource endowments, policy constraints, household preferences and market constraints most likely to affect farmers adoption decision of agroforestry practices.

2.6.1 Land Size

The high rate of increase in population in the Upper East Region has led to fragmentation of land (Aboud, 1992). The parcel of land available to framers in the study area are small and shared by too many people, so that after planting cash and food crops, there is limited space for planting of trees (Bradley, 1991). Many Agroforestry technologies require reasonable farm size (Ragland and Lal, 1993). A study in Bangladesh found out that tree planting increased with smallholding parcel of land and farming households whose major source of generating income was off farm agricultural activities were more likely to influence their decision to adopt tree planting (Salam *et al,* 2000). The size of land will most of the time determine the type of land use practices to be put on it and in the study area, the farmer's increase in crop yields is key to other land uses.

2.6.2 Land Tenure Arrangement

According to Mercer (2004) and Pattanayak *et al.*, (2003), land is the most critical factor in determining a long-term development and maintenance of agroforestry technology adoption by small holder farmers. Land tenure system that do not promise continued title and control of land are not likely to be conductive to a long-term agroforestry technology adoption practices (Bruce and Fortmann, 1988).

Ehrlich *et al.,* (1987) added that secure land rights have proven fundamental in determining whether the benefits of agroforestry reach the intended beneficiaries. Mercer (2004) reviews research from several topics on agroforestry adoption and found out the significant factor positively linked with agroforestry technology adoption to be a secured land use arrangement. Pattannaya *et al.,* (2003) pointed out that for an effective adoption of agroforestry technologies, owners of land are well positioned to adopt agroforestry technologies than tenants.

Fraser (2004) researched on conservational agricultural practices and revealed that landownerswere linked with long-term agricultural crop investments whiles land occupants or users had crops with short-term returns. According to Pattanayak et al., (2003) several empirical studies on adoption of agroforestry technologies revealed more secure land tenure system and arrangement to always have a significant positive effect on farmer adoption. Few cases of land tenure was showed to have an insignificant predictor of adoption (Adesina et al., 2000). Land tenure is the most significant institutional arrangement affecting agroforestry technology adoption at the farm level.

Long-term investment in tree planting and management influences farmers’ decision and expectation towards agroforestry technology adoption (Meinzen-Dick, 2006).

Studies conducted in developing countries such as Mali, Zambia, Kenya, Cameroon, Uganda and Ghana revealed that farmers and farming households with short-term land use are shortchanged as a result of the land insecurity in their decision to invest and harvest from trees (Place, 1994).

2.6.3 Inadequate Extension Services

Appropriate extension service delivery to farmers and farming households on good agricultural agronomic practices and agroforestry technologies adoption are of great importance towards increasing agricultural production. According Scherr and Franzel, (2002), deficiency in national extension lead services in developing countries serves as a major challenge to increasing agroforestry technology adoption. There are several other related factors affecting agroforestry adoption such as weak and limited available resources of governments towards extension systems, lack of appropriate training for agroforestry change lead agents, lack of locally organized extension content or message to farmers is unclear as there is no clear distinction of the various roles and responsibilities played by the agricultural institutions and forestry extension service personnel.

2.6.4 Risk and Uncertainty

In agroforestry technology adoption, risk and uncertainty coupled with agroforestry practices are said to be important factors influencing the decision of smallholder farmers to adopt or otherwise of a particular agroforestry technology (Pannell, 2003). Though there is limited studies on the effect of risk and uncertainly on agroforestry adoption, available literature suggests that farmers will tend to adopt an agroforestry technology when the risk involved in adopting that particular technology is less and also when the agroforestry practices is less stressful (Pannell, 2003). Planting perennial trees as agroforestry technology is sometimes risky for farmers especially when they have little knowledge about the outcome of such technology. According to Shively (1997), the role of relative consumption risk and farm assets of farmers and farming households has influence on the nature of land and practices at the farm level.

Literature so far on the effect of risk and uncertainty with regards to agroforestry adoption is scanty and that there is limited available evidence to accurately predict the exact effect of farmers' perceived risk and uncertainty of a particular agroforestry technology on its adoption as reported by Pannell, (2003) and Marra *et al.*, (2003). Also, Pannell (2003) reveals that farmers will tend not to adopt highly risky agroforestry technologies.

2.6.5 Household Resources Endowment

Availability of household resources is an important factor influencing smallholder farmers' adoption decision of agroforestry technologies. Labour, land, livestock, credit or savings are significant to agroforestry adoption (Hyde *et al*., 2000). Farmers who adopt agroforestry technology early enough tend to be well resourced compared to the laggards (Hyde *et al*., 2000).

Households may have the necessary risk capital, labour, land or income to assist deal with these uncertain technology adoption (Scherr, 1995). Scherr and Franzel (2002) found that, supply of tree species seedling is inadequate and considered a challenge to the adoption of agroforestry technologies. Demand and availability for tree species seedlings by farmers and farming households far exceed the supply of them towards enhancing agroforestry technology adoption, therefore, the need for available and reliable tree species seedlings to farmers and farming households to meet the increasing demands for modern adoption of agroforestry technologies towards a long-term sustained increase in agricultural productivity.

Formal and informal seed producers need to nurse and develop improved tree seedlings to meet the increasing demands by farmers to further enhance adoption and help cube the adverse climate change effect.

According to Kindt *et al*., (2006), seed vendors, independent nursery owners and individual farm households made up of the informal sector, whiles, public and private entities with specialized roles in seed distribution comprised the formal sector.

2.6.6 Agroforestry Policy in Ghana

Policies play significant role in interventions by governments and other development organizations. Usually, the intentions of government on development are spelt out in policy which will be translated into action to attain the needed development. Place et al. (2012) concluded that policies are crucial in the determination of agroforestry technology adoption and practices among countries.

In countries where there are favorable polices, the rate of agroforestry technology adoption and practice of are higher than those where policies are lacking or not implemented. Findings indicate that implementation of agroforestry projects have been hindered by the absence of appropriate policies, hence, the importance of policy issues in agroforestry development cannot be overemphasized (Nair, 1993).

Place et al. (2012) defined three policy areas that are important for agroforestry practices to thrive; these include land tenure system that allows private individuals to own land and for that matter trees on the land; the development of an effective agroforestry information dissemination strategy; and, also the recognition of agroforestry as a viable venture by agricultural institutions and national agricultural programmes. The study pointed out that agroforestry creates some benefits that are enjoyed by the small holder farmers and farming households as well as the general populace.

From the reviewed literature, Ghana has National Agroforestry Policy that was developed about three decades ago with the main objective of promoting the agroforestry technology adoption and practices among farmers in the country. The policy was mainstreamed into National Agricultural Policies to facilitate implementation (Asare, 2004). Government of Ghana in recent years has observed a physical deterioration of arable lands as one of the serious environmental challenges facing the country; which lead to policy development of rehabilitation, promote, and restoration of degraded lands.

2.6.7 Agroforestry Policy Constraints

In Africa, policy based limitations hinder the expansion of agroforestry technology adoption (Place and Prudencio, 2006). Researchers pointed out that a clear enabling policy environments that favors the development and adoption of agroforestry technologies is significant for the continuous success of agroforestry. Lack of policy and institutional support for agroforestry to strive in African is the main hindrance and related agroforestry policy issues have not been adequately researched into towards the development and maintenance of agroforestry. Specific policy directions and factors essential for scaling up agroforestry development and adoption is greatly supported by public policy. At the national level raising agroforestry technology awareness was carried out by the Food and Agriculture Organization (FAO), where they stated the important agroforestry technology adoption to small holder farmers and farming households to have a great potential for increased agricultural output (Sadio, 2006).

2.6.8 Household Preferences on Agroforestry Technologies

Mercer and Pattanayak, (2003) state that, adoption patterns to agroforestry technologies are determine by the farmers' preferences, attitudes, conservation priorities and risk tolerance. Preferences differs from farmer to farmer and are very challenging and not suitable measure to ascertain the adoption of agroforestry technologies hence, different factors are used to determine adoption unilaterally.

Factors such as education, gender and age, are some demographic characteristics that determines the potential of a farmer to adopt agroforestry technology practices (Traore *et al*., 1998). Several studies points out age to have negative relationship with agroforestry technology adoption as farmers ages their productivity and adoption decision to modern agroforestry technologies declines (Feder and Umali, 1993). However, educational level of farmers and farming households in several researches have a significant positive effect of adoption of agroforestry practices (Adesina *et al*., 2000).

2.6.9 Agroforestry Products and Marketing Constraints

Terray (1974) pointed out good available agroforestry products markets is a motivation for farmers adoption to agroforestry technologies as it's provides a window for income generation.

According to Hellin and Higman (2002) farmers' adoption to agroforestry technologies has the potential to increase agricultural output and reduce poverty whilst providing opportunities for large markets. Gabre-Madhim, (2002) working on smallholders‟ access to markets, noted that post-reform markets in Africa continued to be characterized by high transaction costs, limited market information, lack of coordination, missing markets for storage and finance, lack of smallholder market power and increased risk.

Research conducted by Hoskins, (1987) revealed that, improved market infrastructure can increase the availability of agroforestry products on markets. Supporting policies for appropriate market set-up and desired skills with respect to local and improve agroforestry technologies appear to suggest prospects for effective continued community and households' development (Gabre-Madhim, 2002).

Scherr and Franzel, (2002) have mentioned that marketplace restrictions has a significant role in hampering the improvement of agroforestry technology adoption. Research and extension on agroforestry technologies tend to stress on growing production stages of trees and crops but these determinations have been undertaken with little regard for demand or price. Current research has shown that marketplace settings play a critical role in farmer adoption of agroforestry technologies.

It was establish that when the value of maize in Zambia reduced, farmers were more likely to use enhanced harrows to lessen the capacity under maize cultivation allowing them to scale up production of higher value cash crops on other fields (Scherr and Franzel, 2002). Agroforestry is adopted on a measure that has significant economic, social and environmental bearings, it is essential that markets for agroforestry tree products are expanded. For this to occur there must be robust relations between tree domestication and product commercialization (Leakey *et al*., 2006).

2.6.10 Effect of Fertilizer on Agroforestry Technology Adoption on Farmers' Crop Output

Literature on the effect of agroforestry technology adoption on farmers' crop productivity is scanty, however, Norton, (2004) and ISSER, (2008) revealed that agricultural sector in Ghana has received considerable attention and implementation of several government interventions aimed at improving farmers' crop yield, reduce poverty, increase income and improving food security. Some of these government interventions include the provision of technical support and distribution of improved varieties of crops and other advanced farming technologies to small holder farmers and farming households (Jatoe, 2002; Alhassan *et al.*, 2004; Langyintuo and Dogbe, 2005).

Recent interventions from government through MoFA employing numerous programmes aimed at ensuring improved farmers' crop yields. Some of the interventions include agricultural policies to increase the production of the major stables (rice, maize, cowpea, cassava, and yam) through the provision of chemical fertilizer input subsidy which enables the smallholder farmers' access to fertilizer at subsidized prices (MoFa, 2007) and also ensure the distribution of livestock and poultry to carefully chosen smallholder farmers to help as out-growers to other farmers. However, according to Akudugu *et al.*, (2009), the fertilizer subsidy did not benefit the intended poor or small holder farmers, farming households and women who cannot afford and have limited access to productive resources. Smuggling of the fertilizer to neighboring countries to sell for profit by individuals thereby depriving farmers of the benefit of the government intervention is a major challenge facing the fertilizer subsidy progamme.

2.6.11 Summary of Literature Review

Adoption is the decision to make use of an idea, practice or a new technology and is an important requirement in sustained increase in agricultural and farmers' crop productivity, income and fuel wood availability. Theories in research in agroforestry systems, technologies, and practices, role of agroforestry, agroforestry as a climate change adaptation strategy, perception of agroforestry technology adoption, factors affecting adoption, agroforestry policy and policy constraints among others have been reviewed in this study. In as much as adoption is important in Agroforestry based production systems, utilization of agroforestry technologies is still low. To ensure sustained and increase in farmers' crop productivity, it is important that small holder farmers adopt these agroforestry technologies. However, a number of socio-economic and demographic factors influencing the adoption of these technologies and its effect on farmers' crop productivity differ in different communities and regions. Therefore this research aims to establish how agroforestry technology adoption has an effect on farmers' crop productivity in the study area.

CHAPTER THREE

METHODOLOGY

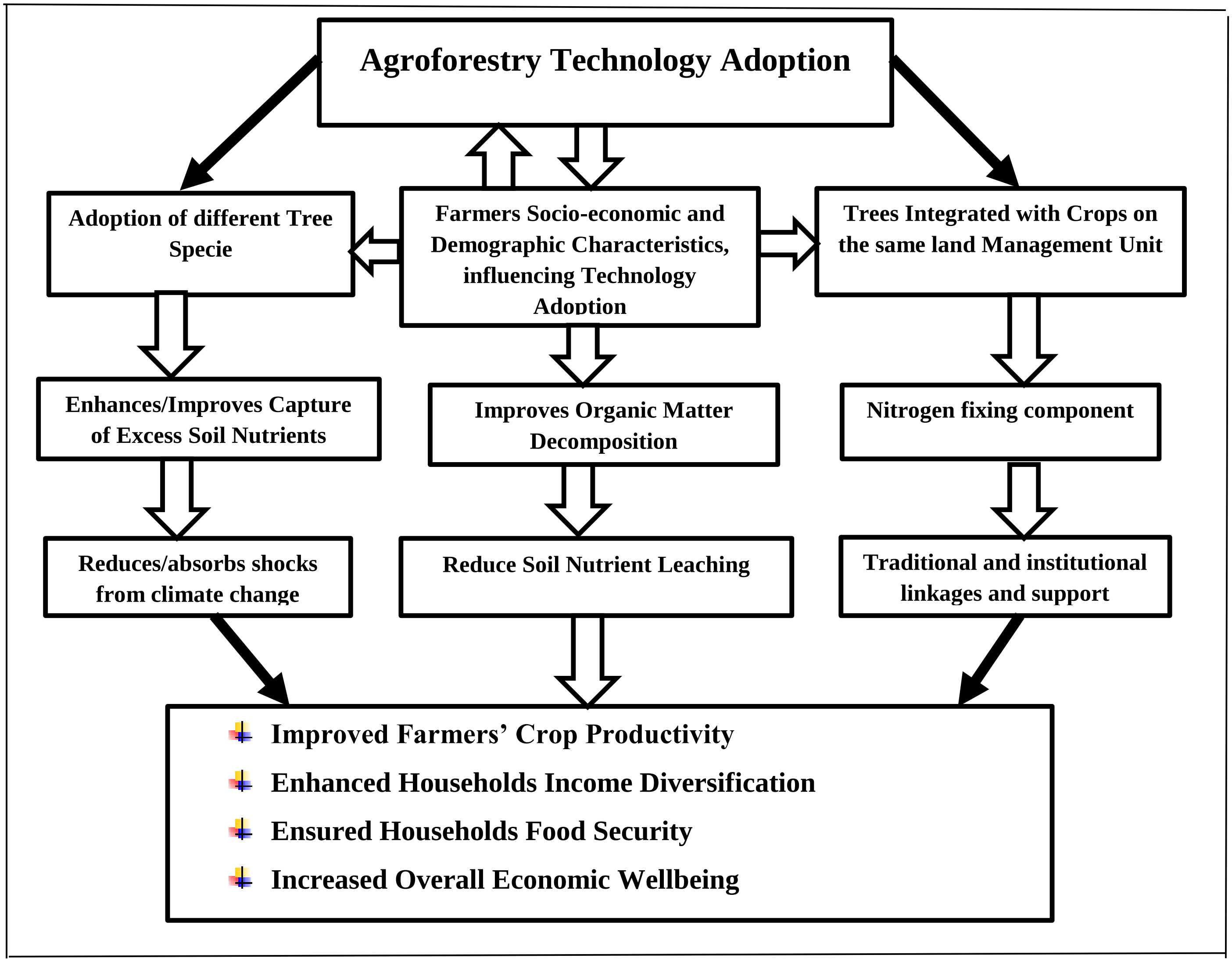
This chapter focuses on the research methodology employed in the study. It describes and justifies the methods and strategies that were used to collect and analyse the data to achieve the research objectives. The chapter is organized into the following sections: conceptual framework, theoretical framework, methods of analysis, data collection instruments, and description of the study area.

3.1 Conceptual Framework for the Study

The framework of factors that determines the decision of farmers to embrace agroforestry technology adoption is presented as a flow chart in Figure 3.1.

The conceptual framework illustrates how farmers adopt to different types of agroforestry technologies and practices as a resilient, efficient and effective method of improving their crop productivity, ensuring overall economic wellbeing under an environmentally friendly manner. Generally, the main sources of these tree species as seedlings available to the smallholder farmers are from development partners, NGOs, and the government with some training on planting technology methods and farm demonstration clinics to further enhance and sustain farmers' adoption to this technologies. Some socio-economic and demographic characteristics of farmers such as gender, age, farm size, farming experience, marital status, household size, household labour size, farm age, landownership, membership of an FBO, access to credit among others are the factors influencing farmers' decision to adopt one or more of the agroforestry technologies.

Figure 3.1 Conceptual Framework: Agroforestry and Crop Productivity



Source: Author's, 2017

Based on the background above, with factors influencing agroforestry technology adoption given the different options of tree species available with their enormous economic benefits and the resultant expectation is to see smallholder farmers integrate tree species with crop production on the same land management unit which will improve organic matter decomposition, improve capture of soil nutrients, fix nitrogen content, absorb shock from adverse climatic and environmental conditions, reduce soil nutrient leaching and improve traditional and institutional support and linkages towards an enhanced and improved farmers' crop productivity, preserved biodiversity, household income diversification and food security as well as improve the economic wellbeing.

3.2 Theoretical Framework

The theory that underlies the study is the production function. It comprises the extent to which inputs are transformed into output for a given level of available technology. The theory of production of a firm therefore, provides the theoretical framework for this study. The theory deals with the general principles for resource allocation such land, labour, capital and management inputs which have limited amounts and alternative uses so as to achieve a predefined objective, mainly output maximization in this case (Sankhayan, 1988).

However, several characteristics of inputs use are measured in agricultural production, the factor shares (total, average and marginal products) and the returns to scale were the main aspects of production considered by this study. The factor shares reflect the relative combination of different factors of production to total output (Q).

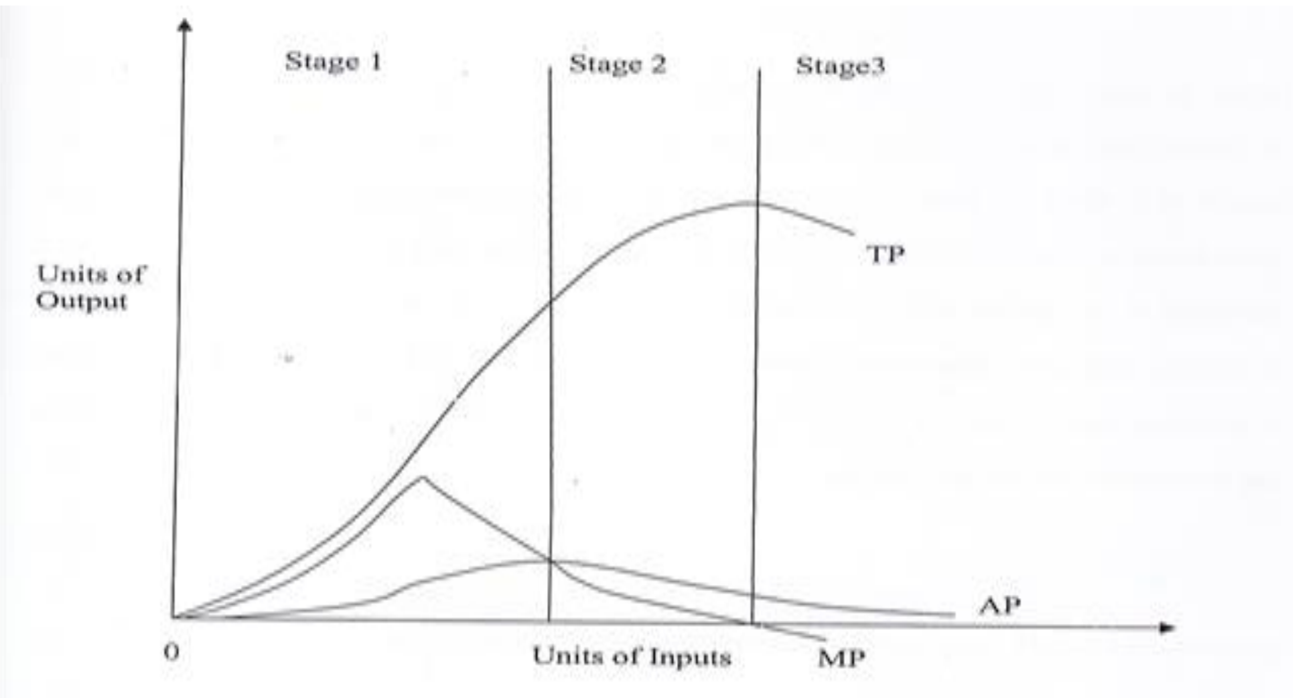
The contribution of these different factors are in terms of total product (TP), explained by the level of output associated with any quantity of variable resources; average (AP), which is output per unit of variable input, keeping other inputs constant at some specifies levels; the marginal product (MP), which is the change in total output due to a unit change in the input, keeping all other inputs constant at some prescribed levels; and the elasticity of production (EP), explained by the percentage change in the quantity of output (Q) due to a percent change in the quantity of a given input while keeping all the other inputs constant as some prescribed levels.

The allocations of variable inputs in a way that will stimulate the realization of the objective of output maximization by a farmer require the operation at the efficient part of the production function.

This effective part is the estimated by considering the behavior of the marginal product (MP) in the production function. In principle the marginal product (MP) of a factor may assume any value, positive, zero or negative. However, basic production theory focuses only on the productivity part of the production function, that is, on the range of output over which the marginal products (MP) of the factors are positive (Koutsoyiannis, 2003). The rational for this principle is illustrated on Figure 3.2.

This is illustrated on Figure 3.2

Figure 3.2 Production Function and Stages of Production



Source: Adegeye and Dittoh (1985) *Essentials of Agricultural Economics;* Bishop and Taussaint (1958) *Introduction to Agricultural Economic Analysis;* and Chisholm and McCarty (1981) *Principles of Economics.*

Figure 3.2 illustrates the three stages of production (i.e. stage 1, 2 and 3). Stage 1 is characterized by increasing marginal product (MP). At this stage, total product (TP) increases at an increasing rate as a result of the increasing marginal product (MP) and hence average product (AP) also increases. Stage 2 begins where the average product (AP) and marginal product (MP) intersect. Stage 2 is characterized by decreasing marginal product (MP) and total product (TP) increases at a decreasing rate.

These makes the average product (AP) to be falling at this stage. Stage 3 begins where marginal product (MP) moves below zero and total product (TP) starts to fall. In stage 3 an increase in the variable factor concerned would result in a decrease in the total output of the farmer. Hence it is unproductive for the farmer to continue to increase input use beyond this level.

Furthermore, the basic theory of production typically concentrates on the rages of output over which the marginal product (MP) of factors, although positive, decrease (i.e. over the range of diminishing productivity of the factors of production as specified on stage 2 in (Figure 3.2).

Any point in stage 1 also suggests that the plant is underutilized and as such more variable inputs be added to move it into stage 2. Hence, there would be a continual increase in inputs use until a point of efficient maximum possible output is achieved. Whereas the factor shares are short run analysis, the returns to scale analysis is a long run problem and deals with what happens when all the factors of production are increased simultaneously (Sankhayan, 1988).

In general, the production function is specified as follows:

$$Y = f(X_1, X_2, X_3 \ldots\ldots\ldots X_n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3.1)}$$

Where:

Y = quantity of output and $X_1, X_2, X_3, \ldots, X_n$ are the quantities of inputs variables such as fertilizer, , agroforestry technology adoption, land size, agrochemicals and labour. However, this form does not encompass joint production, which is a production process that has multiple co-products and hence the linear form of the Cobb-Douglas production function is relevant. It is specified as follows:

$$Y(A, K, L) = AK^{\alpha}L^{\beta} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3.2)}$$

Linearizing the Cobb-Douglas production function expressed as follows:

$InY = InA + \alpha InK + \beta InL$…………………………………………………………..… (3.3)

An expanded form is expressed as follows:

$InY = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + B_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + \varepsilon$ …………………...…… (3.4)

Where:

In = Log transformed variable

β_0 = Constant factor

β_i = Parameters to be estimated

$X_1 - X_5$ = factor inputs for capital and labour

ε = Error term

3.3 Methods of Data Analysis

3.3.1 Identifying the Types of Agroforestry Technologies Adopted by Farmers

The types of agroforestry technologies listed in the literature include: were home garden, taungya system, woodlot establishment, alley cropping, fodder banks, hedgegrow, shifting cultivation and intercropping. A list of these agroforestry technologies were provided in the questionnaire and the respondents were asked to choose from the options of technologies presented in their certain. Simple descriptive statistics, relative frequencies (%), were calculated to weight and rank the types as most important to least important types of agroforestry technologies practiced. Quantitative and qualitative data were integrated by merging them in the discussion. Graphs were constructed using Microsoft Excel.

3.3.2 Assessing the Perception of Farmers on the Adoption of Agroforestry Technology

A five point likert scale with perception indices from averages of coded responses comprising; strongly disagree, disagree, neutral, agree, and strongly agree was designed and presented to the respondent to choose from, based on the extent to which each statement captures their idea of the attribute.

The likert scale is multi-item scaling method which enables one to create the set of prospective measure that can be graded on a scale 1-5, 1-7 or 1-10 response scale (Trochim, 2006).

The five point likert scale has been said to be a perfect measure, previous research showed that individual respondents are not able to place their point of view on a scale greater than seven (Babbie, 2005). Therefore, a five point closed ended scale was used in achieving this objective on the benefits or otherwise of adopting agroforestry technologies. The statements are shown in the questionnaire included in Appendix 3.1. A perception index was computed to assess the level of perception of respondents.

First, the index of a particular statement is computed as follows:

$$n_i = (\frac{\sum i}{n}) \qquad (3.5)$$

Where:

n_i = index computed for a particular statement under a main heading

i = figure assigned to a particular scale (e.g.1 = strongly disagree)

n = number of respondents

The computed index for a particular statement is first estimated for further computation of the index for a particular statement. The index for a set of statements (statements presented to respondents to read using the five point likert scale) is estimated as follows:

$$M_i = (\frac{\sum(n_1+n_2+\cdots\ldots\ldots+n_i)}{c}) \qquad (3.6)$$

Where:

M_i = The index computed for a particular statement

C = The number of the respondents

$(n_1 + n_2 + \cdots \ldots \ldots . . + n_i)$ is the summation of the indices computed for the individual statement. Equation 3.2, is then generated from equation 3.1. The M_i (index for a set of statements) so as to compute for the overall perception index. The overall perception index is therefore computed from equation 3.2. It is expressed as follows:

$$Q = \left(\frac{\sum M_1 + M_2 + \cdots \ldots . + M_i}{k}\right) \tag{3.7}$$

Where:

Q = The overall perception index

K = The number of statements

$(M_1 + M_2 + \cdots \ldots . + M_i)$ = the summation of the overall statements

Since the likert scale was measured on the scale 1-5 (1=strongly disagree, 5=strongly agree, with 3 been neutral), the implication is that an overall perception index below 3 implies a negative perception whilst an overall perception above 3 implies a positive perception. Therefore, the individual and overall farmers' statements' on perception index were computed to determine whether the farmers' had positive perception towards agroforestry technology adoption or otherwise.

3.3.3 Determining the Factors Enhancing Agroforestry Technology Adoption

The binary logistic regression was employed in determining factors influencing the agroforestry adoption decision of a given technology. The application of the model is based on the understanding that the farmers are rational.

The general model is the binary choice model involving estimation of the probability of adoption of a given agroforestry technology (Y) as a function of a vector of explanatory variables (X)

$$\text{Probability } (Y=1) = F(\beta' X) \tag{3.8}$$

$$\text{Probability}(Y=0) = 1 - F(\beta' X) \tag{3.9}$$

Where:

Yi is the observed response for the ***i***th observation of the response variable Y.

Yi = 1 for a farmer adopting an agroforestry technology, and the description of variables relating to the factors enhancing adoption is presented in Table 3.1.

Specification of empirical model:

$$\mathbf{Y} = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 MS + \beta_4 EDU + \beta_5 HHS + \beta_6 FS + \beta_7 HHLS + \beta_8 LO + \beta_9 FA + \beta_{10} FBO + \beta_{11} AC + \beta_{12} AES + \beta_{13} FE + \beta_{14} CEA + \varepsilon \tag{3.10}$$

Where:

Age = Age of Respondent (years)

Gender = Gender of Respondent (1 = male, 0 = female)

MS = Marital Status (1 = Married, 0 = Not married)

EDU = Educational Status (0=no education, 1=primary, 2=JHS, 3=SHS, 4=Tertiary)

HHS = Household Size (Number)

FS = Farm Size (Hectares/Acres)

HHLS = Household Labour Size (Number)

LO = Land Ownership (Dummy: 1= Ownership, 0 = Otherwise)

FA = Farm Age (Years)

FBO = Famer Based Organization Membership (Dummy: 1= member, 0 = Otherwise)

AC = Access to Credit (Ghana cedis)

AES = Access to Extension Service (Numbers)

FE = Farming Experience (Years)

CEA = Cost of Establishment of Agroforestry (Ghana cedis)

$\varepsilon =$ Error term

Table 3.1 Description of Variables, Measurement and a Priori Expectations

Variable	Description of Variable	Measurement	A priori expectation
Adoption	Farmers of agroforestry technologies	1 adopt, 2 otherwise	
Age	Age of respondent	Years	+
Age 2	Age squared	Years	-
Gender	Gender of respondent	1 if male, 0 female	-/+
Marital status	Marital status	1 if married, 0 not married	-/+
Education	Educational status of respondent	0 = no education, 1=Primary, 2= JHS, 3 =SHS, 4= Tertiary	+
Household Size	Household size	Number	+
Farm Size	Farm size	Hectares/Acres	+
Labour Size	household Labour size	Number	+
Land ownership	Land Ownership	1 if farmer owns the farmland, 0 otherwise	+
Farm age	Farm age	Years	+
Farm age2	Farm age squared	Years	-
FBO	FBO membership	1= member, 0 = otherwise	+
Credit	Access to credit	Ghana Cedis	+
Extension service	Access to Extension service	Numbers	+
Farming experience	Farming experience	Years	+
Agroforestry establishment	Cost of establishment of agroforestry	Ghana Cedis	+

3.2.4 Determining the Effect of Adopting Agroforestry Technology on Crop Productivity

The log-linear production function was used to analyze the effect of agroforestry adoption on crop productivity among maize farmers in the study area (Y). It was assumed that farmers adopt agroforestry technologies in order to enhance crop productivity. Farmers combine several inputs (X_i) to produce output (Y). Yilmaz and Ozcan (2004) expressed this technical relationship between output and inputs as:

$$Y = f(X_i) \tag{3.11}$$

Where:

X_i = vector of inputs (land, labour, fertilizer and agrochemical)

For a log-linear function:

$Y = f(Xi)$ Taking a log-log transformation of the equation and expressing the variable: (3.12)

$$\ln Y = \ln f(X_i) \tag{3.13}$$

The empirical model is specified as:

$$\ln Y = \beta_0 + \beta_1 \text{InLand} + \beta_2 \text{InLabour} + \beta_3 \text{Fertilizer} + \beta_4 \text{Agrochemical} + \beta_5 \ln \text{Agro} + \varepsilon \tag{3.14}$$

Where:

In = Log transformed variable

Y = total productivity (output/area)

β_0 = constant factor

β_i = Parameters to be estimated

Land = Total cultivated land area (acres)

Labour = Labour used (man-days/man hours)

Fertilizer = Fertilizer use (Dummy, 1=use, 0=otherwise)

Agrochemicals = Agrochemicals use (Dummy, 1=use, 0=otherwise)

Agro = Adoption of agroforestry technology (Number)

ε = error term

Table 3.2 Description of Variables, Measurement and a Priori Expectations

Variable	Description of Variable	Measurement	A priori expectation
Output	Output per hectare	Kilograms	
Land Size	Land size cultivated	Hectares/acres	+
Adoption	Farmers adoption to agroforestry technologies	1 adopt, 2 otherwise	+
Fertilizer	Fertilizer used by respondents	Kilograms	+
Agrochemicals	Agrochemicals used by respondents	Litres	+/-
Labour	Labour used by respondents	Man-days	+/-

Yilmaz and Ozkan (2004) added dummy variables to a log-linear production function to analyze structural operations. In this study, fertilizer and agrochemicals were added as a dummy variable to analyze effect on farmers' crop productivity using a log-log function.

3.4 Method of Data Collection

This section of the study presents the types and source of data, techniques for data collection, sample size and sampling technique, survey instruments used and the study area.

3.4.1 Types and Sources of Data

Primary and secondary data were collected for this study. Survey of individual farmers using personal interviews with the aid of semi-structured questionnaires, key informant interviews and focus group discussions were used in collecting primary data. Primary data obtained from the field survey.

Survey

The data obtained comprised, socio-economic and demographic characteristics of the farmers' on agroforestry technologies and agricultural activities: Gender, access to credit, household size, age of the household head/respondent, marital status, major occupation, educational status of household head, total income of household, off-farm activity, membership of farmer based organization/community based organization were obtained from the study to aid in the analysis. In order to improve the quality of discussions, clarification as well as to supplement the primary data, secondary data was also used in addition to the primary data.

Key Informant Interview

Relevant qualitative data was also collected through key informant interviews from stakeholders and opinion leaders in the study area, such as chiefs of the area, assembly members' district MoFA agricultural officers' and extension agents as well as lead farmers.

Focus Group Discussion (FGD)

Focus group discussion was conducted among farmers who adopted agroforestry technologies in each of the six communities.

Focus group discussions were employed to collect information from the farmers and farming households. Krueger (1994), defines a focus group as a group of people who possess certain characteristics and provide information of a qualitative nature in a focused discussion. Focus group discussion is of great significance in research work in that the participants can use the thoughts and comments of others to support stimulate and express their own thoughts. In addition, participants' reactions and comments can often provide valuable understandings into methods for revising questions and questionnaires (Royston *et al*., 1986). In the selected six communities visited focus group discussions were organized to obtain detailed information on farmers' adoption to agroforestry technologies. In each community, the focus group discussion was made up nine participants which made up of the lead farmer, agricultural extension agent, the chief or his representative for the area and farmers, each discussion lasting for 1:30 minutes.

Field observations were also made to observe agroforestry farming practices employed by farmers and farm families. Visits to farmers' farms was done randomly. Field observation helped to get the overview of how farmers manage agroforestry technologies in the study area. The observation included some indigenous trees that could be incorporated into agroforestry activities.

The secondary data was collected from both published and unpublished sources including journals, articles, books and internet sources. Secondary data from the district assembly and Ministry of Food Agriculture (MoFA) operating in the area and other relevant publications and records were also accessed for this study.

3.4.2 Sample Size and Sampling Technique

Sampling in data collection is very important as it is meant to contribute to an improve understanding of the research and hence, the method of selecting and obtaining the data and from whom the data will be collected should be considered (Bernard, 2002).

A multi-stage sampling technique was used in the sampling process. In the first stage, three districts were randomly selected in the Upper East Region made up of Bawku West, Talensi and Nabdam districts out of the 13 districts. The second stage involved the selection of the communities. A total of 6 communities were selected from the 3 districts made up of 2 communities each from each district. The selected communities were: Binnaba and Tilli in Bawku West, Balungu and Datuko in Talensi and Zua and Kongo in Nabdam districts' of the Upper East Region.

The final stage involved the selection of smallholder farmers where a total of 50 smallholder farmers were selected from each community using the simple random sampling technique. A grant total of 300 smallholder farmers were therefore used for the study. Albertin and Nair (2004), revealed that random sampling technique can be combined to produce a good sampling method (Table 3.3).

Table 3.3 Sample Size and Sampling Technique

Variable	**District**	**Communities**	**No. of Respondents**	**Total**
Sampling Technique	Simple Random	Simple Random	Simple Random	
Upper East Region	Bawku West	Binnaba	50	100
		Tilli	50	
	Talensi	Balungu	50	100
		Datuko	50	
	Nabdam	Zua	50	100
		Kongo	50	
Total			**300**	**300**

Source: Authors Computation, 2017

3.4.3 Survey Instruments

Open-ended and close-ended questionnaire are permissible data collection technique under this type of research and study (Kusi, 2012). In this study therefore, closed and open-ended semi-structured questionnaire was the main instrument used for collecting the data in this study. This instrument covered data on respondents' demographic and socio-economic characteristics, types of agroforestry, indigenous trees on their farms, crop production, factors influencing agroforestry technology adoption, access to credit and other relevant data available to aid in the analysis.

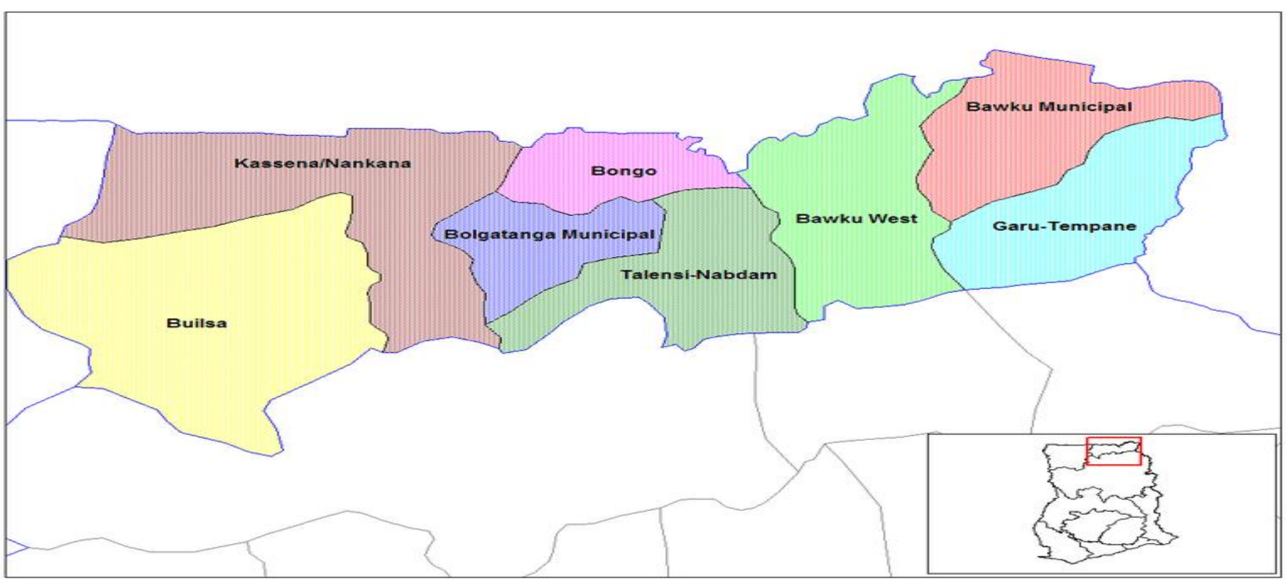
3.5 The Study Area

The Upper East Region is located in the northern part of Ghana and is the second smallest of 10 managerial regions in Ghana, occupying a total land surface of 8,842 square kilometers or 2.7 percent of the total land area of Ghana. The Upper East regional capital is Bolgatanga, sometimes referred to as Bolga. Other major towns in the region include Navrongo, Paga, Bawku and Zebilla.

The Upper East region is located in the north-eastern corner of Ghana, precisely located in the Kingdom of Dagbon, and bordered by Burkina Faso to the north and Togo to the east. It lies between longitude 0° and 1° west, and latitudes 10° 30′N and 11°N. The region shares boundaries with Burkina Faso to the north, Togo to the east, Upper West Region to the west, and the Northern Region to the south. The Upper East region is divided into 13 districts, each headed by a district chief executive. Crop farming and livestock raising are the two main agricultural activities in the district. Livestock rearing was one of the second commonest agricultural activity. Fish farming and tree growing are uncommon activity in agricultural households.

The region's soil has an "upland soil" primarily established from granite rocks. It is shallow and low in soil fertility, weak with low organic matter content, and predominantly coarse textured. Erosion is a problem. Valley areas have soils ranging from sandy candy loams to salty clays. They have higher natural fertility but are more difficult to till and are prone to seasonal waterlogging and floods. The most common economic trees are the shea nut, dawadawa, boabab and acacia. The climate is characterized by one rainy season from May/June to September/October. The mean annual rainfall during this period is between 800 mm and 1.100 mm. The rainfall is erratic spatially and in duration. There is a long spell of dry season from November to mid-February, characterized by cold, dry and dusty harmattan winds. Temperatures during this period can be as low as 14 degrees centigrade at night, but can go to more than 35 degrees centigrade during the daytime. Humidity is, however, very low making the daytime high temperature less uncomfortable. Figure 3.2 represents the map of the Upper East of Ghana and specifically showing the various districts and communities of the study within the Region.

Figure 3.3 District Map of the Study Area



Source: (Upper East Regional Coordinating Council).

CHAPER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and the analysis of the data obtained from the field. Data collected from respondents includes; demographic and socio-economic characteristics, gender, marital status, educational status, FBO membership, access to credit as well as access to extension services.

Data was obtained on farmers' perception on the benefits or otherwise of adopting agroforestry technology, factors influencing agroforestry technology adoption and the effect of adopting agroforestry technology adoption on farmers' crop productivity. The data was analyzed using Statistical Package for Social Sciences (SPSS), version 21 and STATA 14 and the results presented on graphs, charts and tables.

4.2 Demographic and Socio-Economic Characteristics of Respondents

Based on current literature, social, demographic and economic features of respondents, it is important to look at factors such as gender, marital status, educational status, FBO membership, access to credit and access to extension service delivery by respondents so as to ascertain findings relating with the background of respondents in the Bawku West, Talensi and Nabdam districts of the Upper East Region of Ghana.

Gender of Household Respondents

In the study communities, farming activities are undertaken by farming households comprising males and females. From Table 4.1, the study shown (83.3%) of agroforestry technology male farmers, (16.7%) of agroforestry technology female farmers constituting the 300 respondents interviewed in the study area making agroforestry technology adoption a male dominated activity.

Males constituted a greater proportion of the sampled respondents because they are the custodians of the land per the land tenure arrangements of the study areas, and would decide the size of farm land to allocate for use by the women in the communities which is directly linked with agroforestry technology practices, and hence affects their willingness and decision to adopt agroforestry technologies. Scherr (1995), confirmed this in a study of economic factors in farmer adoption of agroforestry that females are not allowed to make decisions to adopt agroforestry technologies without consulting the men.

Incorporation of women in agroforestry technology adoption and its practices cannot be underestimated as Gladwin and McMillan (1989) reported that, inventive methods such as agroforestry technologies to replenish Africa's soil fertility is largely dependent on the shoulders of the African rural women, who by practice produce the food crops in various African farming communities.

Table 4.1: Gender of Households Respondents

Gender	Frequency of Respondents	Percentage of Respondents
Female	50	16.7
Male	250	83.3
Total	**300**	**100**

Source: Field Survey, 2017

Findings from the results showed (P>0.05) indicating chi-square test for gender which was not significant, hence gender does not influence agroforestry technology adoption practices. It was also clear from the field that females have been subordinated and relegated my men which affects their decision to adopt agroforestry technologies as the men from the research areas would say "we own you and everything you have". Gender was not significant to agroforestry technology adoption in Southwest

Nigeria because women face challenges in adopting alley farming technology as a result of gender based discrimination to plant, own and manage trees (Fabiyi et. al., 1991).

Marital Status of Households Respondents

Table 4.2: Marital Status of Households Respondents

Variable	**Frequency of Respondents**	**Percentage of Respondents**
Not Married	4	1.3
Married	296	98.7
Total	**300**	**100**

Source: Field Survey, 2017

Majority of the population constituting (98.7%) were married and (1.3%) represented respondents not married out of the total sampled respondents in the study area (Table 4.2). This is because most of the respondents interviewed constituted heads of households and adult population and because of the selected communities of study which places high priority in early marriages and building big family size to increase households' family labour.

Educational Status of Households Respondents

Table 4.3 presents the educational status of farmers in the study area, generally formal education was low, this was because majority of the respondents who had formal education constituted (31.3%) and respondents with no formal education were (68.6%). This shows that a greater proportion of the sample population interviewed had no formal education from the study area.

Table 4.3: Educational Status of Households Respondents

Variable	Frequency of Respondents	Percentage of Respondents
Formal Education	94	31.3
No Formal Education	206	68.6
Total	**300**	**100**

Source: Field Survey, 2017

Agroforestry technology requires considerable educational level of farmers and farming households towards its adoption and practices because it is knowledge intensive (Mekoya et al., 2008). Prospective new agroforestry technology adopters are more likely to be farmers with formal education as compared to farmers who have no formal education (Adesina et al., 2000). Therefore, with the low level of formal education among respondents with the study communities, agroforestry technologies adoption could be affected. With a Chi-square test of (P>0.05) showed the level of formal education of respondents not significant. Also, Sheikh et al., (2003), and Lapar and Ehuni (2004), emphasized in several studies that education significantly influences adoption of improved soil conservation technologies.

Meanwhile, formal education in the study area did not have any positive significant influence on adoption of agroforestry technologies as the adoption rate was close to 100%. This low level of education as Stoll-Kleemann and O'riordan (2002), confirmed that low level of education was not significant to agroforestry technologies adoption.

FBO Membership of Respondents

In the study communities, farmer based organization membership for agroforestry technology adoption stood at 13.3% of the total number of respondents interviewed and 86.7% representing farmers and farm families who do not belong to any farmer based organization. Membership of farmer based organization have some influence on adoption of agroforestry technology and as farmers and farm families come together they may share some experience on good agronomic and new agricultural practices as well as share some knowledge and experience in tree specie planting and management to further enhance on their adoption process.

Table 4.4: FBO Membership of Household Respondents

Variable	Frequency of Respondents	Percentage of Respondents
FBO Membership	40	13.3
No FBO Membership	260	86.7
Total	**300**	**100**

Source: Field Survey, 2017

Respondents Access to Credit

Availability, access and utilization of farm credit is an important factor towards the adoption of agroforestry technologies, the study revealed (82.3%) constituting majority of the respondents with no access to credit, and a small cross-section of the respondents (17.7%) with access to agricultural credit. Credit access contributes significantly to agroforestry technologies adoption since its initial cost of establishment is huge (Table 4.5).

Table 4.5: Access to Credit by Household Respondents

Variable	Frequency of Respondents	Percentage of Respondents
Access to Credit	53	17.7
No Access to Credit	247	82.3
Total	**300**	**100**

Source: Field Survey, 2017

Respondents' Access to Extension Services

Respondents with access to extension services formed majority (86%) of the smallholder farmers and farming households, whereas (14%) of the smallholder farmers and farming households with no access to extension services in the study communities. Extension services significantly influence adoption of agroforestry technologies and with the information gathered from the study, agricultural extension agents visit farmers on their farm lands at least three times within a cropping season to sensitize and educate them on new and improved methods and technologies associated with agricultural production best practices and agroforestry technology practices.

Table 4.6: Access to Extension Service of Household Respondent

Variable	**Frequency of Respondents**	**Percentage of Respondents**
Access to Extension	258	86
No Access to Extension	42	14
Total	**300**	**100**

Source: Field Survey, 2017

Table 4.7: Other Demographic Characteristics of Respondents

Variable	Minimum	Maximum	Mean	Std. Deviation
Age	20	78	44.07	12.562
Household Size	2	36	8.33	5.283
Farm Size	0.5	42	4.987	5.502

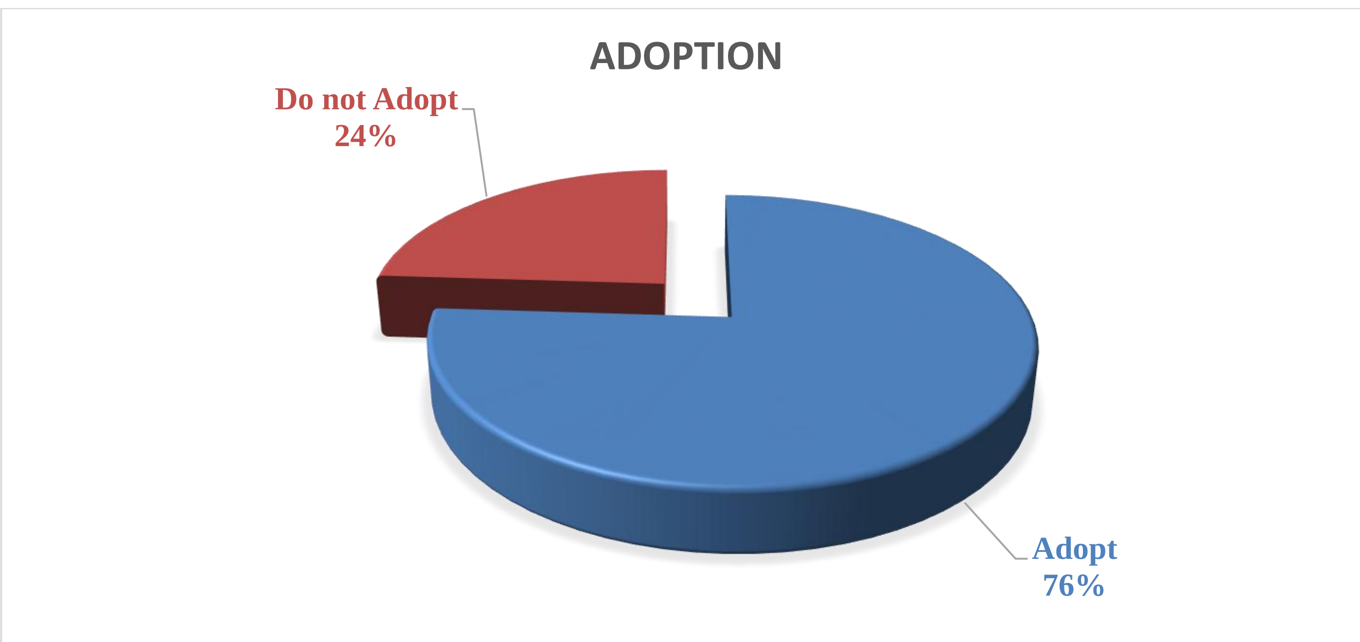
Source: Field Survey, 2017

4.3 Types of Agroforestry Technologies Adopted

With agroforestry technology adoption, majority of the smallholder farmers and farming households constituting (76%) out of the 300 respondents were revealed to have adopted some agroforestry technologies and the level of adoption among farmers in the study communities was positive and significant as against the farmers and farm families who did not adopt the technologies (24%), Figure 4.1.

Pattanayak et al., (2003), establish that demographic characteristics, intra-household homogeneity, resource assets, market incentives, biophysical factors, risk and uncertainty were determinants for agroforestry technology adoption among smallholder farmers and farming households.

Figure 4.1 Agroforestry Technology Adoption



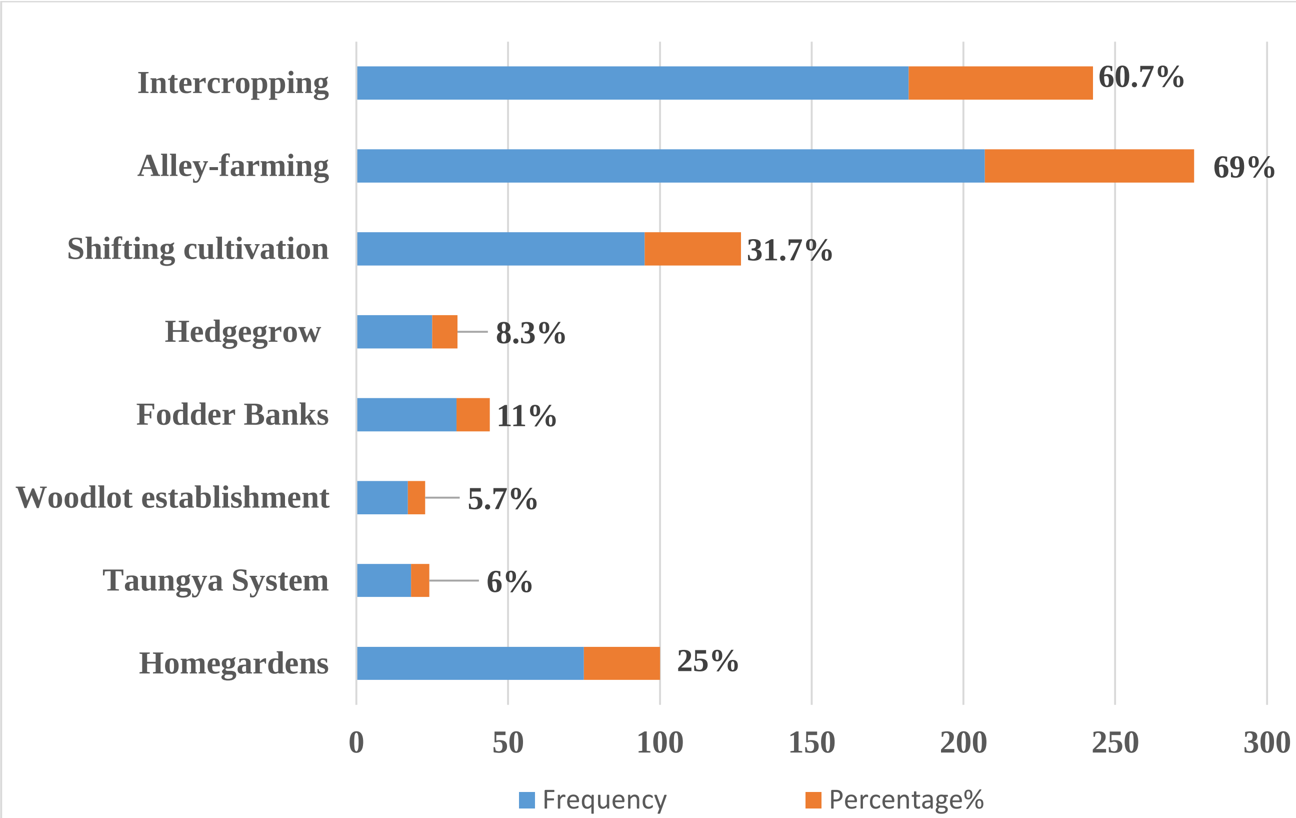
Meanwhile it was revealed with a visit to the farmers' fields that most of the respondents in the study communities have intentionally retained some naturally occurring trees on their farm lands at the time initial land clearing and preparation for agricultural activities which includes mahogany, baobab, neem, mango, eutulyptus, shea, kapok and acacia trees among others. These trees were integrated on the same land management unit with crops.

The main agroforestry technology adopted by smallholder farmers and farming households in the study were; alley-farming, homegarden, taungya system, woodlot establishment, fodder banks, intercropping, hedgegrow, and shifting cultivation. The study found out that majority (69%) of the respondents practiced alley-farming, whereas (5.7%) of the respondents adopted woodlot establishment as an agroforestry technology (Table 4.8).

Alley-farming is an agroforestry technology which comprises of planting of trees in rows at extensive spacing with crops grown in between the rows. It has potential of income diversification, improve crop production and provide protection and conservational benefits to crops. Majority of the respondents adopted alley-farming because of its undoubted benefits. Consequently, 5.7% adopted woodlot agroforestry technology establishment because it comprises of a complex and expensive system, its management involves trees grown in a separate block for livestock feed, green manure and as a source of nectar for bees in honey production which is not a common practice in area of study.

Other agroforestry technologies adopted by smallholder farmers and farming households in the study communities were; intercropping, shifting cultivation, homegardens, fodder banks among other technologies with adoption percentages of 60.7%, 31.7%, 25% and 11% respectively as shown in Figure 4.2 below.

Figure 4.2 Types of Agroforestry Technologies Adopted by Farmers



4.3.1 Types of Tree Species Planted by Respondents

Farmers in the study communities have planted different agroforestry technology tree specie's for several years and have confirmed their readiness to plant more trees upon recommendation and the desired benefits the trees offer to crop and livestock production as well as improve their income generating activities.

4.3.2 Indigenous Tree Species Planted by Respondents

Table 4.8: Characteristics of Some Tree Species in the Study Area

Tree species	Desirable characteristics	Undesirable characteristics
Baobab	leaves are used for preparing soup Is resistant to pest and disease Provide shade for household Powder use for preparing drinks and cake Truck provide shade for livestock All parts of the tree is medicinal	Occupies arable/crop land
Shea	Provide shade butter for preparing food for household consumption Use for carving mortar and farm implements Fruits sheanuts twice in a year Its bark and trunk is medicinal	Too big on farm land Long growth and maturity
Eucalyptus	fast growing source of wood/timber Provide oil for cleaning and as a natural Insecticide Useful for fuel, fragrants, insect repellant	Absence of shade during farming season
Cassia	It is used in herbal medicine	Attracts insects and bees
Mango	provide fruits for household consumption Improves households income from sale Mango fruits Falling leaves decay to provide manure	Attracts insects, pests and diseases on crops
Dawadawa	Ingredient for preparing food Leaves used as fodder for livestock production Leaves improve soil cover	Leaves dries up easily. Long maturity
Neem	medicine for treatment of malaria and typhoid and provide shade for household	Produces few leaves and tries up easily

Source: Field Survey, 2017

4.3.3 Farmers Knowledge on Indigenous Tree Species and its Importance in the Study Area

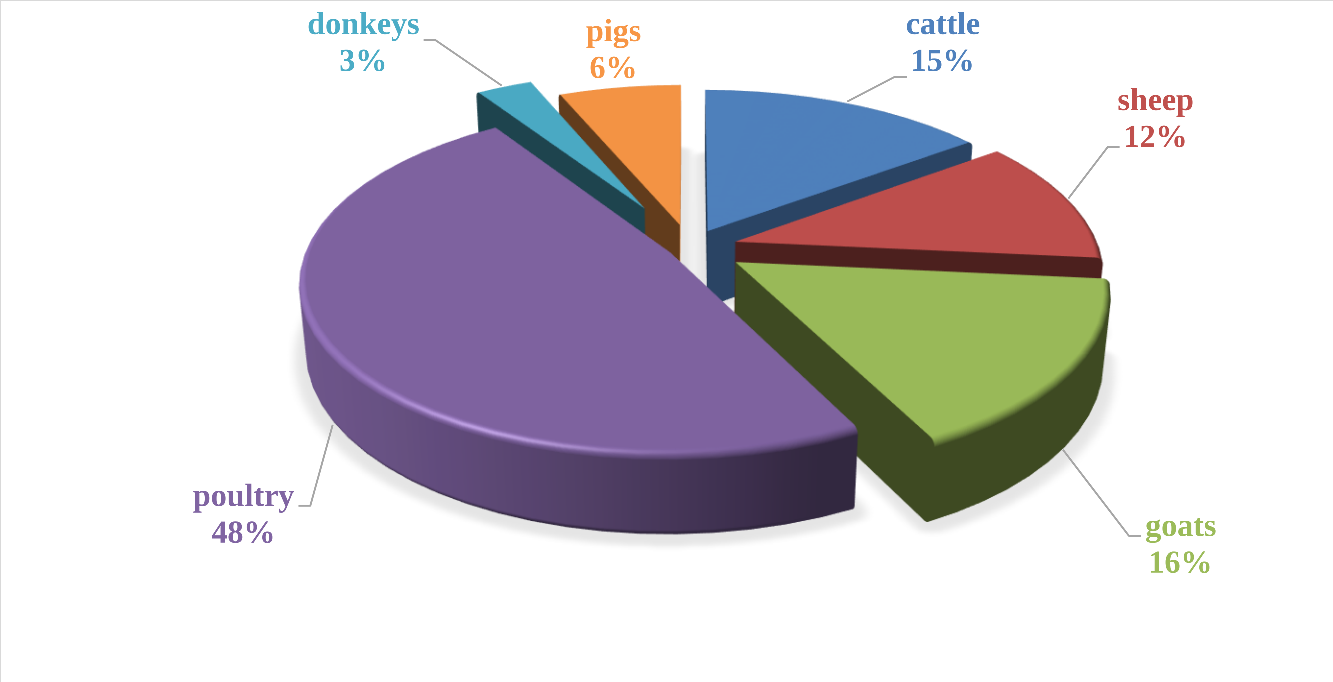
The study revealed that farmers and farming households' ability to identify the importance and medicinal value of most tree species on their farm lands. De Foresta et al., (2000), reported that, centuries in agricultural production, farmers have adequate knowledge and experience of integrating indigenous trees in their farming systems. Emerging new policies for encouraging farmers to grow trees in existing agroforestry systems can be designed if the characteristics of the smallholder farmers and farms in relation to tree planting in existing agroforestry systems are studied (Nair and Dagar, 1991).

4.3.4 Agroforestry and Livestock Production

Animal rearing was noted to be another important component of agroforestry technology in the study, hence farmers were asked to indicate the dominant animal species in their households and six animal species were stated by farmers as the dominant species (Figure 4.3). Among the dominant species, poultry were the most dominant animal species reared by 48% of the smallholder farmers, 16% of the respondents rear goats, 15% rear own cattle, 12% own sheep, 6% and 3% of the respondents rear pigs and donkeys respectively.

Smallholder farmers recounted the main purpose for livestock rearing was traditional/cultural, domestic and commercial. In vulnerable communities farmers keep livestock as a risk reduction strategy to complement crop production and also serve as household nutritional needs (Rosegrant, 2009).

Figure 4.3 Agroforestry and Livestock production



4.4 Respondents Perception on the Benefits (or Otherwise) of Adopting Agroforestry Technologies

Respondents were made to rank a set of statements regarding the benefits of adopting agroforestry technologies ranging from strongly disagree (1) to strongly agree (5). The results of the analysis of this objective is presented in (Table 4.10). From the table, it can be observed that the mean scores representing the mean perception of respondents were generally positive and above average. This implies that farmers had positive perception about the benefits of adopting agroforestry technologies. For example, the mean perception of farmers on statements such as "agroforestry technologies have an economic advantage", "agroforestry technology can reduce soil erosion" and "agroforestry technology adoption leads to improved soil nutrients" were 3.87, 3.59 and 3.45 respectively which represent the top three highly ranked statements by respondents.

Table 4.9 Respondent's Perceptions on Agroforestry Technology Adoption

Statement on Agroforestry Technology	Min.	Max.	Mean Perception	Std. D
Has economic advantage	1	5	3.87	0.908
Can reduce soil erosion	2	5	3.59	0.889
Leads to improved soil nutrients	1	5	3.45	0.919
Leads to improved yield output	1	5	3.44	0.857
Can improve soil cover and fix nitrogen	1	5	3.36	0.836
Leads to water conservation	1	5	3.16	1.025
Can improve food security	1	5	3.15	0.939
Prevents bush fires	1	5	3.14	1.035
Overall perception index			3.40	

Source: Field Survey, 2017

The implication is that farmers' perception about the economic benefits and the role agroforestry technology adoption play in conserving and improving soil fertility is positive and strong and that the farmers were either aware of these benefits or had actually benefited from them. Most of the farmers had actually adopted one or more agroforestry technologies overtime and might have experienced some benefits which may account for their high positive perception toward the adoption of agroforestry technologies.

Other statements such as "agroforestry technology adoption leads to improved yield or output" and "agroforestry technology can improve soil cover and fix nitrogen" were also positive and above average with mean scores of 3.44 and 3.36 respectively. This also implies that farmers saw agroforestry technologies to be beneficial in improving soil fertility and subsequently increasing yield.

However, for statements such as “agroforestry technology adoption leads to water conservation”, “agroforestry technology can improve food security” and “agroforestry technology adoption prevents bush fires”, farmers had average perception about them with mean scores of 3.16, 3.15 and 3.14 respectively. This implies that the farmers were not too convinced about the role of agroforestry technologies in conserving water, enhancing food security and preventing bush fires.

4.5 Factors Influencing Agroforestry Technology Adoption in the Study Area

The socio-economic factors of respondents that affect their decision to adopt agroforestry technologies were identified as: age, gender, marital status, household size, education, agroforestry awareness education, land ownership, land size, nature of land, extension service delivery, access to credit, FBO membership and type of crop. The model used in the analysis was significant at 1% which indicates that the model is fit for the analysis. Also the Pseudo R^2 of the model was (0.6994) which indicates that the independent variables jointly explain about 70% of the variation in the dependent variable.

The findings also revealed that age, marital status, agroforestry education awareness, landownership, land size, nature of land and access to credit were significant variables that influence the decision of smallholder farmers to adopt agroforestry technologies in the study area. This factors has generally influenced majority of the farmers’ decision to adopt agroforestry technologies. Age was found to be significant at 10% which implies, with an increase in age of a farmer, agroforestry technology adoption will likely increase by an average of (0.22338). Marital status was also saw significant value at 10%, which connotes that, agroforestry technology adoption would increase at (1.5833) by smallholder farmers and farming households within the study communities, this confirms the information gathered from farmers as majority of the respondents were households heads and adults, it is a sign of prestige for adults population within the study area to marry after attaining a certain adult age as it contributes also to family and agricultural labour and productivity. Agroforestry education awareness was significant at (3.82205), implying an increase in awareness creation and education about the benefits of agroforestry technology adoption, smallholder farmers' adoption rate will increase by 1%. This confirms studies by Mekoya et al., (2008), who found that agroforestry technologies are knowledge intensive and therefore require enough education in the adoption process. Meanwhile, Lapar and Ehui (2004) and Sheikh *et al*., (2003) have stated that in many studies, education significantly influences adoption of improved soil conservation technologies.

However, education did not have a significant effect on the adoption of agroforestry technologies in the study area. This may be as a result of the low level of education. Stoll-Kleemann and O'riordan (2002), revealed that low level of education was not significant to agroforestry adoption.

However, landownership was significant at (4.5246), implying with an increase in individual land holdings for agroforestry purposes, adoption rate will likely increase by 1%, this confirms the fact thst tenants or occupants of agricultural lands do not have complete ownership and control to plant and own trees. This has made some smallholder farmers unsecure to adopt agroforestry technology as a modern and sustainable tool to contribute to higher productivity all things been equal, since the farmers may not be the custodians and beneficiaries of the technology. This is in line with Wiersum (1984) that, elimination of unfavorable tenure and land use regulations should be considered in order to reduce the risk of tree planting for smallholder farmers, to ensure that they reap the benefits of their efforts.

Nair and Dagar, (1991), found that land tenure does not influence the adoption of agroforestry technologies, and this study is contrary to the findings of this study since it was carried out in some 26 years ago which most of the smallholder farmers dynamics might have changed.

Land size was significant at (0.2309), implying with an increase in land holdings of farmers and farming households' agroforestry technologies adoption might increase by 1% in the study area. Nature of land observed recorded (3.3665), which implies majority of the respondents farms were not degraded and as such supports tree planting and agroforestry technology practices in the study communities at 1%. Credit access was also significant at (1.3280), which means with access to farm credit for the initial investment of the technologies, farmers are most likely to embrace agroforestry technology at 10%. Credit is very important in agricultural and agroforestry technology adoption as farmers can purchase improved tree species, integrated with improved/hybrid seeds for an increased agricultural productivity.

However, some farmers admitted they had some support from some agencies and the ministry of food and agriculture who introduced agroforestry technology to them and that it was a good agricultural component towards increasing crop production and ensuring improved household income. This was because some agencies provided training on agroforestry technology adoption practices, tree species and planting technologies and financial support for establishing the technology. This has positively influenced the adoption rate by (74%) in the study area and has enhance farmers and farming households' enthusiasm to embrace agroforestry technology in the study communities. Rogers. (1995), found that financial support from agencies and Non-Governmental Organization's influences farmers' decision to adopt improved soil conservation technologies.

Table 4.10: Regression Results of Factors Influencing Agroforestry Technology Adoption

Variable	Coefficient	Z-values	Marginal Effects
Age	0.2234*	1.69	0.0123
Age2	-0.0022	-1.5	-0.0001
Gender	0.1689	0.21	0.0098
Marital Status	1.5833*	1.92	0.1518
Household Size	0.0136	0.22	0.0007
Education	0.9542	1.44	0.046
Agroforestry Education	3.8221***	5.63	0.5099
Landownership	4.5248***	5.98	0.6385
Land Size	0.2309**	2.31	0.0127
Nature of land	-3.3666***	-3.7	-0.1536
Extension Services	0.3178	0.43	0.0194
Access to Credit	1.3280*	1.65	0.0524
FBO Membership	0.5307	0.87	0.0282
Crop	-0.4775	-0.75	-0.0239
_cons	-9.7306	-2.92	
Logistic regression		Number of obs	300
		LR chi2(14)	231.24
		Prob > chi2	0.000
Log likelihood = -49.70248		Pseudo R2	0.6994

*, ** and *** are 10%, 5% and 1% significant level

Source: Field Survey, 2017

4.5.1 Farmers' Opinion on Factors Enhancing Adoption of Agroforestry Technologies

Apart from the socio-economic factors discussed earlier that influenced adoption of agroforestry technologies some nine auxiliary statements or measures that could enhance the smallholder farmers' decision to adopt these technologies were presented to them to rank in order of importance (Table 4.11). However, the five topmost measures enhancing adoption of agroforestry technologies by smallholder farmers and farm families were identified in the study communities as; introduce improved species, develop policy which advocates agroforestry, improved extension support, introduce improved demonstration fields and market access. From the factors identified it is clear that introducing improved tree species to farmers like improved grafted mango tree seedlings, improved shea, eucalyptus and mahogany species which is crop friendly to be integrated with crop production for maximum economic benefit, whiles ensuring income diversification. Develop policy which advocates agroforestry was the second highest ranked by the respondents, which calls for a well formulated policy that provide technical guidelines and procedures towards enhancing adoption of agroforestry technologies. This is conforms to the objectives of the national agroforestry policy in late 1980s which was aimed at establishing 350 demonstration centers, 400 nurseries, and 30000 hectares of agroforestry systems nationwide. As at 1992 the project had established 119 demonstration centers, 131 nurseries and 1,642 hectares of agroforestry systems, an achievement of 34%, 33% and 5% respectively of the set target (Tara kawa, 2002).

Improved extension support was ranked as the third enhancing factor to agroforestry technology adoption in the study area by respondents. This implies that, efficient extension service delivery on good agricultural, agronomic and agroforestry practices will enhance tree planting technologies and ensure increased in agricultural production.

Table 4.11: Measures to Enhance Agroforestry Adoption

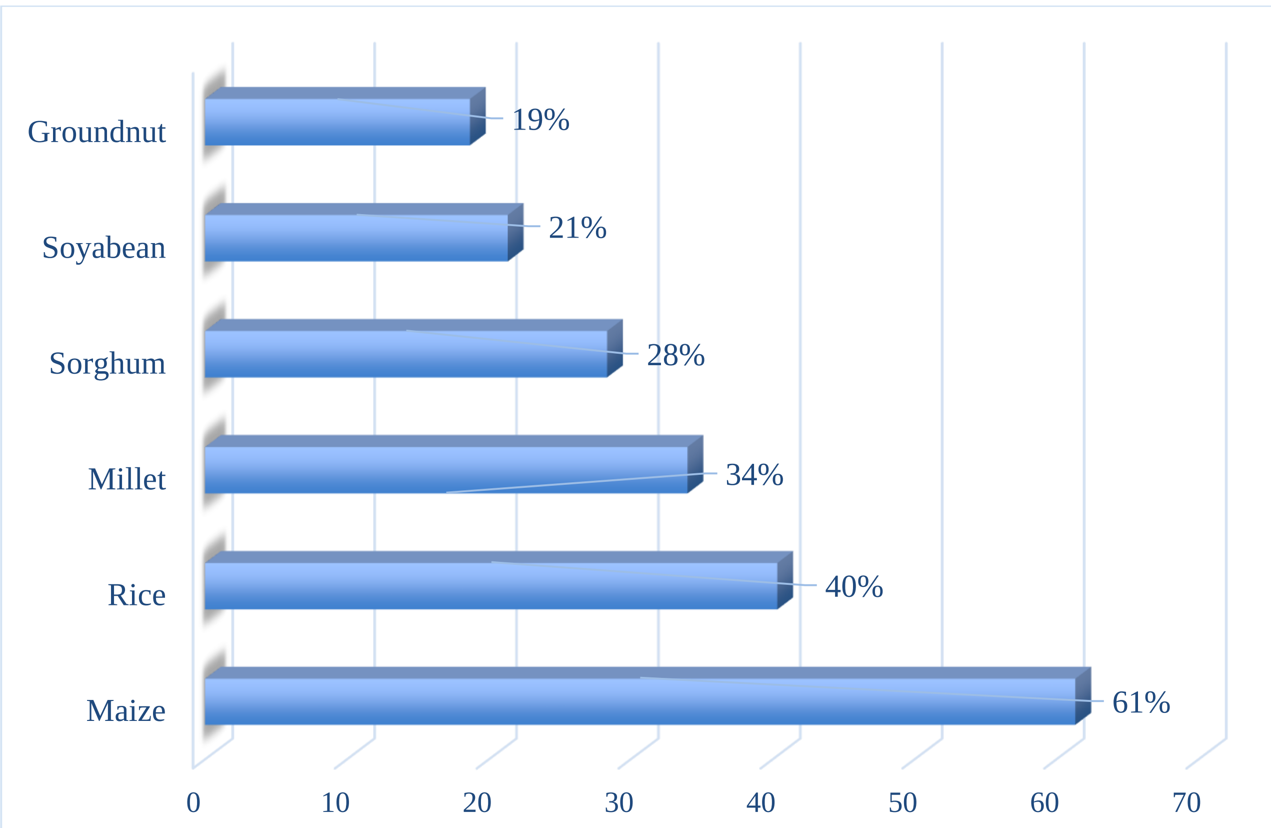
Measure	Mean Scores	Ranks
Introduce improved species	1.84	1st
Develop policy which advocates Agroforestry	3.06	2nd
Improved Extension support	3.84	3rd
Introduce improved demonstration field	4.03	4th
Market access	5.2	5th
Formulate and enforce village bylaws	6	6th
Improve traditional rules	6.1	7th
Improve institutional linkage	6.32	8th
Harmonize land tenure policy	8.61	9th
Kendall's W = 0.552 Chi- Square = 1324.306		

Source: Field Survey, 2017

4.6 Effect of Adopting Agroforestry Technology on Farmers' Crop Productivity

The fourth objective of the study sort to determine the effect of adopting agroforestry technology on farmers' crop productivity in the study area (Table 4.12). Smallholder farmers and farming households face many challenges such as low productivity, high dependence on rain-fed agriculture, insecurity of the traditional land tenure system and environmental degradation among others, due to unsustainable agricultural practices. As a result of these challenges, smallholder farmers' remain at low productivity and this has led to high incidence of poverty among rural smallholder farmers (Opio, 2001). As part of the solution to addressing farmers' low agricultural productivity, is the development of new agroforestry technologies. A quick and easy method for replenishing nitrogen and other trace elements, would be the use of inorganic fertilizers, these are however, beyond most of the rural farmers' budgets. Therefore agroforestry technology offers an alternative solution to resource-constrained smallholder farmers, who in the absence of inorganic fertilizers would otherwise grow crops without addressing nutrient requirements and harvest little or nothing for storage. Hence, the information in table (Table 4.12) seeks to assess the effect of agroforestry technologies adoption on farmers' crop productivity.

Figure 4.4 Major Crops Cultivated in the Study Area



As indicated in (Figure 4.4) farmers in the study communities cultivate a variety of crops for household consumption and supplementing household income. The study identified the six types of crops that are integrated by farmers and farming households. The study a revealed 61% of smallholder farmers and farming households who intercrop with some agroforestry technology on the same land management unit or agricultural field. However, 40% of farmers cultivate rice, 34% cultivated millet with integrated agroforestry technology, while 28%, 21% and 19% of the respondents cultivated sorghum, soybean and groundnut respectively. Respondents recounted their experience of higher crop yields as a result of the integration of agroforestry technology and crop production on the same land management unit.

However, with majority of the smallholder farmers and farming households cultivating 61% and 34% of maize and millet respectively was because maize and millet were the main stable food in the study area, as a result more land and intensive land management practices were adhered with respective to this crops as the surplus produce was always sold to improve household income.

Table 4.12: Effect of Agroforestry Technology Adoption on Farmers' Crop Productivity

Variable	Coefficient	Std. Deviation	Z-values	P-values
Inland size	0.3721***	0.0808	4.60	0.000
Inadoption	0.7276**	0.3627	2.01	0.046
Fertilizer	0.1983	0.1823	1.09	0.278
Agrochemicals	0.8947***	0.3074	2.91	0.004
Inlabour	0.3715***	0.1399	2.66	0.008
_Cons	7.337	0.1536	47.76	0.000
Number of obs =	300	F(5, 294) =28.29	R-Squared = 0.623	
Prob > F = 0.000				

** And *** 5% and 1% significant level

Source: Field Survey, 2017

Factors estimated considered to have an effect on farmer's crop productivity in the study area were; land size, agroforestry technology adoption, fertilizer, agrochemicals and labour.

Four of these factors were revealed to have a positive significant effect on farmers' crop productivity in the study, these are: land size, agroforestry technology adoption, agrochemicals and labour.

However, land size has a positive a value of (0.3721) implying a positive significant effect on farmers' crop productivity at 1%, meaning a unit increase in farmers land size available for agricultural and agroforestry practices, farmers crop productivity will increase by that margin.

This conforms to Cramb et al., (1999), he found that farmers with large farm sizes could invest resources in new technologies and get better returns, which encourage adoption of conservation technologies. This is similar to the findings of Amsalu and Graaff, (2007), who found that in Ethiopia farmers with large farm sizes are more likely to invest in soil conservation measures as the farmers can take more risks, including relatively high investment, and survive crop failure.

Adoption of agroforestry technology were significant at (0.7276) implying that when farmers and farming households adopt agroforestry technology, their productivity may increase by 5% ceteris paribus. This confirms studies by Franzel et al., (2001), who observed high adoption of agroforestry technologies by farmers. Smallholder farmers' use of agrochemicals to increase their crop productivity was significant at (0.8947), implying that agrochemical use have a positive significant effect to increasing agricultural crop productivity at 1%.

Labour also recorded a significant value of (0.3715), which connotes an important factor to increasing farmers' crop productivity at 1%. With the availability of farm labour to engage good agricultural, agronomic and agroforestry technologies which is very intensive and when successful, may lead to increase in farmers' crop productivity. The study indicated that farmers who used their family labour for tree planting were few because of the growing of the agricultural crops. This is in agreement with

Hyman (1983), who mentions that farmers whose main source of income is agriculture might be discouraged from allocating family labour for tree planting activities.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study presented the relevant issues in relation to the adoption of Agroforestry technologies in the Bawku West, Talensi and Nabdam Districts of the Upper East Region of Ghana. The study determined the effect of adopting agroforestry technology on farmers' crop productivity in the study area.

5.2 Summary

This study was set out to investigate agroforestry technology adoption and its effect on farmers' crop productivity in the Bawku West, Talensi and Nabdam Districts of the Upper East region of Ghana. Three hundred farmers from six communities within the study area were interviewed. The study employed descriptive statistics, a five point likert scale using perception index, binary logit model and a Log linear production model employed to analyze the specific objectives of the study.

Results from the study indicated majority (74%) of small holder farmers adopting to agroforestry technologies whiles (26%) were not practicing the technology. The study also identified the major types of agroforestry technologies adopted by farmers as: alley-farming, intercropping, shifting cultivation, homegarden, fodder banks, taungya system, woodlot establishment and hedgegrow.

The study revealed that the farmers in the study area have a positive perception about benefits of agroforestry such as its economic advantage, soil erosion reducing and soil nutrient increasing properties.

The socio-economic factors influencing farmers' decision to adopt agroforestry technologies were age, marital status, agroforestry education awareness, landownership, land size, nature of land and access to credit and these were identified as significant positive variables.

Finally, variables such as land size, labour, fertilizer and agroforestry technology adoption had significant effect on farmers' crop productivity in the study area.

5.3 Conclusions

Conclusions are drawn on the findings based on the discussion made on each specific objective of the study. Respondents recounted their reasons for adopting these technologies as been: provision of food, generation of income, benefits from trees, support from government and NGO's, leaving a legacy for future generations, and free supply of tree seedlings.

Reasons some farmers gave for not adopting agroforestry technologies in the study communities include; inadequate knowledge of agroforestry, inadequate land, long rotation period of most tree species, insecure tree tenure, no interest to practice agroforestry, and felling of trees destroying agricultural crops.

The study revealed significant benefits from statements ranked by respondents regarding the benefits of adopting agroforestry technologies ranging from strongly disagree (1) to strongly agree (5). The implication is that farmers' perception about the economic benefits and the role agroforestry adoption play in conserving and improving the soil is positive and strong and that the farmers were either aware of these benefits or had actually benefited from them.

Most of the farmers had actually adopted one or more agroforestry technologies overtime and might have experienced some benefits which may account for their high significant positive perception towards the adoption of agroforestry technologies. Smallholder farmers were not too convinced about the role of agroforestry technologies in conserving water, enhancing food security and preventing bush fires.

Findings on socio-economic factors such as age, marital status, agroforestry education awareness, landownership, land size, nature of land and access to credit were significant positive variables that influence the decision of smallholder farmers to adopt agroforestry technologies in the study area.

The study revealed three significant factors to have a positive effect on farmers' crop productivity in the study area such as: land size, agroforestry technology adoption and labour. The study indicated that smallholder farmers who used their family labour for tree planting were few because of the growing of the agricultural crops.

5.4 Recommendations

Small holder farmers and farming households are encouraged to adopt more advanced agroforestry technologies and practices, as this study and current literature has pointed out its significant contributions towards increasing productivity. Smallholder farmers in the study area had positive perceptions about the benefits of agroforestry technology adoption.

It is therefore recommended that, Government, Non-governmental Organizations and other relevant stakeholders should further support in the provision of improved tree seedlings and good extension services to improve on farmers' adoption of agroforestry technologies and their economic wellbeing.

Government and NGOs should further promote improve extension services, by allocating sufficient funds to facilitate extension staff to reach farmers frequently to teach new ideas in agroforestry technology adoption. Inclusion of indigenous farmers' knowledge in the design of agroforestry technology interventions in other to ensure effective solutions to the challenges faced at the farm level should be considered.

Agroforestry is a means of increasing food production and at the same time makes wood available to rural dwellers. There is a need to improve both formal and informal agroforestry education among the rural communities, for agroforestry to become more widely accepted by local populations.

Stakeholders such as the chiefs, Government and development partners should mainstream gender perspective policies that would offer females opportunity to make their own decisions to practice agroforestry technology since they play a major role in the promotion of Africa's agriculture crop production and agroforestry.

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APPENDIX

APPENDIX 1: RESEARCH QUESTIONNAIRE

This research questionnaire is to assist in the study on **AGROFORESTRY TECHNOLOGY ADOPTION AND ITS EFFECT ON FARMERS' CROP PRODUCTIVITY IN THE UPPER EAST REGION**. This research forms part of the requirement for the award of MPhil in Agribusiness, a program the researcher is currently pursuing at the University of Ghana, Legon. The finding of this research is solely for academic purpose; respondents are therefore assured of confidentiality regarding any information given in this questionnaire. Your opinion is therefore needed for academic purpose only and will be treated confidential.

Serial Number of Questionnaire ……………………

A. CONTACT INFORMATION ON ENUMERATORS AND RESPONDENTS

Enumerator's Information		***Respondent's Information***			
Name of enumerator		Phone #		Community name	
Contact mobile number		House #		Name of district	
Enumerator's Code		Household name		Name of region	
		Date:			

SECTION A. SOCIOECONOMIC CHARACTERISTICS OF RESPONDENTS

1. Household Basic Characteristics

Questions	***Responses***
1.1 Are you the household head?	(1) Yes [ ] (0) No [ ]
1.2 If no, state your relationship with the household head	(1) Spouse [ ] (2) Child/House-help (3) Farm care-taker [ ] others [ ] …..
1.3 Age of household head/respondent	
1.4 Gender of household head/respondent	(1) Male [ ] (0) Female [ ]
1.5 Marital status of household head/respondent	(1) Married [ ] (2) Single [ ] (3)Separated/divorced [ ]
1.6 Household (HH) size	
1.7 # of people in the household in the following age category(including you)	(1) < 18... (2) 18-35……. (3) 36-60…….. (4) > 60……..
1.8 Is farming your major occupation	(1) Yes [ ] (0) No [ ]

1.9 If no, to question 1.8 above, what is your major occupation?	(1) Trading [ ] (2) Salary worker [ ] (3) Artisan [ ] (4) Other (specify) [ ]…………

Note: household consist of a group of people who live together, not necessarily in the same building; who usually eat from the same pot; and who pool their incomes and other resources to purchase or produce food. A household member is any person who, in the past 12 months, has lived with the household for at least 6 months regardless of whether they have intentions to stay or not. It includes any person attending school away from home, newly born babies, persons who are newly wedded into the household, person who have stayed for less than 6 months but have come to stay with the household.

2.0 Educational Status (Human Capital)

Questions	***Responses***
2.1 Can the household head (HHH) read and write a simple sentence in English?	(1) Yes [ ] (0) No [ ]
2.2 Highest level of education completed by the household head	(1) No Educ. [ ] (2) Primary school [ ] (3) JHS/MSLC [ ] (4) SHS/O &A level [ ] (5) Tech/Voc. [ ] (6) Training Coll./Poly/Univ. [ ]
2.3 Number of years of schooling by household head	

3.0 Types of Agroforestry Systems

3.1 Have you heard about agroforestry?	(1) Yes [ ] (0) No [ ]
3.2 Is agroforestry practiced in your area?	(1) Yes [ ] (0) No [ ]
3.3 Which of the following agroforestry systems do you practice?	1. Agrosilvicultural system(crops and trees) [ ] 2. Agrosilvipastoral system(crops, trees, pasture & animals) [ ] 3. Silvipastoral system (trees, pasture & animals) [ ] 4. Other (specify)…………………………………………

3.4 Which of the following agroforestry technology(s) do you practice?	1. Home garden(small mixed species with intensive management) [ ] 2. Taungya system(crops grown with teak trees) [ ] 3. Wood lot establishment(live fences for crops and vegetables) [ ] 4. Fodder banks(establishment of forage legumes) [ ] 5. Hedgerow(break up land slope to provide green manure) [ ] 6. intercropping(citrus and vegetables) [ ] 7. Alley-farming(rows of trees with all) [ ] 8. Shifting cultivation(sequential system) [ ] 9. Other (specify)…………………..
3.5 What type of trees did you plant yourself?	
3.6 What type of trees generated naturally by themselves?	
3.7 How long have you been practicing agroforestry?	

3b. kindly provide the following information on trees growing on your farm

Types of Trees	Desirable Characteristics	Undesirable Characteristics

4.0 Perception on Agroforestry Technology Adoption (please rank 1-5)

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
4.1 Agroforestry technologies have an economic advantage					
4.2 Agroforestry technology adoption leads to improved yield/output					
4.3 Agroforestry technology adoption leads to improved soil nutrients					
4.4 Agroforestry technology adoption leads to water conservation					

4.5 Agroforestry technology adoption prevents bush fires					
4.6 Agroforestry technology can reduce soil erosion					
4.7 Agroforestry technology can improve soil cover and fix nitrogen					
4.8 Agroforestry technology can improve food security					

5.0 Factors Influencing Agroforestry Adoption

5.1 Does tenant farming affect your decision to adopt agroforestry technology?	(1) Yes [ ] (0) No [ ]
5.2 If yes above, reason	
5.3 How did you obtain your farm land?	1. Purchase [ ] 2. Freehold [ ] 3. Lease [ ] 4. Inherited from family member [ ] 5. Others (Specify) [ ]………………..
5.4 Total land size available for farming	
5.5 Actual farm size cultivated without agroforestry	
5.6 Total land size available for agroforestry	
5.7 Actual farm size in agroforestry	
5. 8 What is the nature of your land	(1) Severely degraded [ ] (0) Not degraded
5.9 Did you have contact with any extension agent during the 2016 production year?	(1) Yes [ ] (0) No [ ] # of times ………………………………………….
5.10 Do you have any training on agroforestry program in your community	(1) Yes [ ] (0) No [ ]
5.11 If yes, what program	
5.12 Are you a member of an FBO/CBO?	(1) Yes [ ] (0) No [ ]
5.13 If yes specify the FBO/CBO	
5.14 What are some services offered by the FBO/CBO	
5.15 Do you have access to credit	(1) Yes [ ] (0) No [ ]
5.16 If yes, sources of credit	
5.17 Do you own livestock	(1) Yes [ ] (0) No [ ]
5.18 What types of animals	

5.19 Do you have access to market information	(1) Yes [ ]	(0) No [ ]
5.20 Do you engage in other activities apart from farming	(1) Yes [ ]	(0) No [ ]

5.21 If you have wood perennial(s) planted on your farm land, what specie type do you have on your farm land?

Technology type	**Specie type**	**Reason for integrating tree**

6.0 Other Sources of Income

Source of off-farm income	Amount per year (GHc)

7.0 Crop Farming

Crop type	**Output(bags) (alonka/50kg bag)**	**Output Value(GH¢)**	**Cropping type (1) mixed ( ) (2) mono ( )**

7.1 What types of crops do you cultivate on the land with agroforestry?

….…………………………………………………………………….

……………………………………………………………………….....................

7.2 Do you apply fertilizer? (1) Yes [ ] (0) No [ ]

…..…………………………………………………………………………………..

7.3 Do you apply agrochemicals (1) Yes [ ] (0) No [ ]

……………………………………………………………………………………...........

8.0 Quantity of labour input

Activities	Number of Workers			Number of days/hours	Total man-days OR Man-hours
	Male	Female	Children		
8.1 Land Preparation					
8.2 Planting					
8.3 Weeding					
8.4 Agrochemical application					
8.5 Harvesting					
8.6 Other(specify)					

9.0 Factors Enhancing Agroforestry technology Adoption

Please rank the measures you think can improve agroforestry in your area with one (1) being the most important and (9) being the least important.

Measures	Rank
9.1 Develop policy which advocates Agroforestry	
9.2 Formulate and enforce village bylaws	
9.3 Harmonize land tenure policy	
9.4 Introduce improved species	
9.5 Improve traditional rules	
9.6 Improve institutional linkage	
9.7 Market access	
9.8 Improved Extension support	
9.9 Introduce improved demonstration field	

END OF INTERVIEW

THANK YOU FOR YOUR VALUABLE INFORMATION AND TIME!

Table 4.9 Respondent's Perceptions on Agroforestry Technology Adoption

Statement on Agroforestry Technology	Min.	Max.	Mean Perception	Std. D
Has economic advantage	1	5	3.87	0.908
Can reduce soil erosion	2	5	3.59	0.889
Leads to improved soil nutrients	1	5	3.45	0.919
Leads to improved yield output	1	5	3.44	0.857
Can improve soil cover and fix nitrogen	1	5	3.36	0.836
Leads to water conservation	1	5	3.16	1.025
Can improve food security	1	5	3.15	0.939
Prevents bush fires	1	5	3.14	1.035
Overall perception index			3.40	

Table 4.10: Regression Results of Factors Influencing Agroforestry Technology Adoption

Variable	Coefficient	Z-values	Marginal Effects
Age	0.2234*	1.69	0.0123
Age2	-0.0022	-1.5	-0.0001
Gender	0.1689	0.21	0.0098
Marital Status	1.5833*	1.92	0.1518
Household Size	0.0136	0.22	0.0007
Education	0.9542	1.44	0.046
Agroforestry Education	3.8221***	5.63	0.5099
Landownership	4.5248***	5.98	0.6385
Land Size	0.2309**	2.31	0.0127
Nature of land	-3.3666***	-3.7	-0.1536
Extension Services	0.3178	0.43	0.0194
Access to Credit	1.3280*	1.65	0.0524
FBO Membership	0.5307	0.87	0.0282
Crop	-0.4775	-0.75	-0.0239
_cons	-9.7306	-2.92	
Logistic regression		**Number of obs**	**300**
		LR chi2(14)	**231.24**
		Prob > chi2	**0.000**
Log likelihood = -49.70248		**Pseudo R2**	**0.6994**

Table 4.11: Measures to Enhance Agroforestry Adoption

Measure	Mean Scores	Ranks
Introduce improved species	1.84	1st
Develop policy which advocates Agroforestry	3.06	2nd
Improved Extension support	3.84	3rd
Introduce improved demonstration field	4.03	4th
Market access	5.2	5th
Formulate and enforce village bylaws	6	6th
Improve traditional rules	6.1	7th
Improve institutional linkage	6.32	8th
Harmonize land tenure policy	8.61	9th
Kendall's W = 0.552 Chi- Square = 1324.306		

Table 4.12: Effect of Agroforestry Technology Adoption on Farmers' Crop Productivity

Variable	Coefficient	Std. Deviation	Z-values	P-values
Inland size	0.3721***	0.0808	4.60	0.000
Inadoption	0.7276**	0.3627	2.01	0.046
Fertilizer	0.1983	0.1823	1.09	0.278
Agrochemicals	0.8947***	0.3074	2.91	0.004
Inlabour	0.3715***	0.1399	2.66	0.008
_Cons	7.337	0.1536	47.76	0.000
Number of obs =	**300**	**F(5, 294) =28.29**	**R-Squared = 0.623**	
Prob > F = 0.000				