American Journal of Agriculture and Forestry
2025, Vol. 13, No. 2, pp. 136-143
https://doi.org/10.11648/j.ajaf.20251302.16

Research Article

Farm Systems and Soil Fertility Management Methods in Relation to Crop Yield of Smallholders in Ekiti State, Nigeria

Oyun Matthew Banji[1], Wole-Alo Felicia Itunnu[2, *], Adeyemo Adebayo Jonathan[3], Mafimisebi Taiwo Ejiola[4], Shamaki Sanusi Bello[5], Ayeni Modupe Janet[6]

[1]Department of Forestry and Wood Technology, Federal University of Technology of Technology Akure, Gaga, Nigeria

[2]Department of Agricultural Extension and Communication, Federal University of Technology of Technology Akure, Gaga, Nigeria

[3]Department of Crop, Soil and Pest Management, Federal University of Technology of Technology Akure, Gaga, Nigeria

[4]Department of Agricultural and Resource Economics, Federal University of Technology of Technology Akure, Gaga, Nigeria

[5]Department of Forestry and Environment, Usmanu Danfodiyo University, Sokoto, Nigeria

[6]Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti, Nigeria

Abstract

This study assesses the demographic and socio-economic characteristics of smallholder farmers and their farm management practices in Ekiti State, Nigeria, with a focus on agroforestry potential. A total of 150 respondents were sampled using multistage sampling procedure. The study revealed among others that the majority of the respondents were male (87.3%), the mean age of the respondents was 55 years. The majority of the respondents (84%) were married, 82.3% of the respondents had one form of education or the other. The majority of the respondents have manageable household size of five (7) persons that can assist on the farm. The result showed that the crops that are mainly grown by the smallholder farmers are cassava (86.7%), yam (76%) and maize (72%). 64.7% of the farmers are familiar with agroforestry practices, multipurpose trees on farmland is the most recognized practice (46%) The result showed that a significant majority (83.3%) of the respondents do not integrate any form of agroforestry practices on their farms. Barriers to adopting agroforestry practices recognized by the farmers include initial cost of implementing agroforestry practices (34%), lack of knowledge (25.3%) and lack of seedlings (16.7%). The findings revealed that 24.7% of the respondents believe that training and education support is necessary for adopting agroforestry, 46% of the respondents indicated that financial support is crucial for adopting agroforestry and 15.3% of respondents believe that access to seedlings is important for adopting agroforestry. This research provides insights into smallholder farm management and offers a foundation for designing tailored agroforestry interventions that can meet the needs of local farmers in Ekiti State, Nigeria.

[*]Corresponding author: fiwolealo@futa.edu.ng (Wole-Alo Felicia Itunnu)

Received: 9 November 2024; **Accepted:** 20 January 2025; **Published:** 28 March 2025

Keywords

Smallholder, Farming, Agroforestry, Farm Management and Crop Yield

1. Introduction

Smallholder farming is crucial for food security and livelihoods in developing regions, supporting over two billion people worldwide (IFAD, [16]. However, smallholder farmers face significant challenges, including soil degradation, water scarcity, and limited access to markets FAO, [7]. Agroforestry which means integrating trees into agricultural landscapes, offers promising solutions to these challenges. The deliberate integration of trees and shrubs into agricultural systems, or agroforestry, provides a sustainable solution to the problems Nigeria's smallholder farmers face. Numerous ecological, financial, and social advantages are offered by agroforestry systems, such as higher soil fertility, increased biodiversity, increased climate change resilience, and diverse revenue sources Nair, [21]. Additionally, agroforestry can mitigate climate change by sequestering carbon Nair et al., [20] and promote biodiversity (Bhagwat et al., [3]. Despite these benefits, the adoption of agroforestry among smallholder farmers remains low due to various constraints, including limited knowledge, inadequate policies, and lack of institutional support (Garrity et al., [10]. To address these challenges, it is essential to assess smallholder farm management practices and crop yields to design context-specific agroforestry interventions.

The broad objective of the study was to assess smallholder farm management and crop yield for the design of fit-for-purpose agroforestry intervention in Ondo state, Nigeria while the specific objectives were to:

1) describe the socioeconomic characteristics of smallholder farmers in Ondo state
2) evaluate the crop management practices in selected smallholder farms;
3) assess the yield of major crops in selected smallholder farms;
4) identify the constraints and challenges faced by smallholder farmers;
5) design agroforestry intervention model suitable for small holder farms

2. Methodology

The study was carried out in Ondo State. A multi-stage sampling procedure was used for this study. The first Stage involved a purposive selection of five (5) local government areas: Ikere, Moba, Ikole, Ado-Ekiti, and Ido-Osi. These areas were chosen due to their diverse vegetation and soil types, which are significant factors influencing agricultural practices and crop yields. The second Stage involved a stratified selection of (15) communities within the identified local government areas. This stratification was based on the characteristics of each community, such as agricultural practices, demographic composition, and existing farm management systems. Second stage consisted of a stratified selection of (15) communities within the identified local government areas. This stratification was based on the characteristics of each community, such as agricultural practices, demographic composition, and existing farm management systems. Third Stage involved a random selection of 10 respondents from each community which gave a total of (150) respondent. Data collected were analyzed using descriptive and inferential statistics.

3. Results and Discussion

Socio-Economic Characteristics of the Respondents Table 1 reveals that the majority of the respondents (42.7%) are aged between 57 and 71 years, 34% are in the age group of 42 and 56 years, 14% are in the age group of 27and 41, and 9% are in the age group of 72 and 86. The average age of the respondents is 55 years which implies that the majority of the respondents were older farmers. A study by Oluwasusi and Tijani [24] supports this, showing that older farmers tend to rely on traditional methods and are slower to adopt innovations like improved agroforestry technologies. Table 1 indicates that the majority of the respondents (87.3%) was male, married (84%) and had one form of education or the other (82.3%). This suggests that education plays a vital role in influencing smallholder farmers' ability to adopt improved agricultural technologies and manage farms effectively. About 99.3% of the respondents earned less than #25,000,000 million Naira in a year, while just 0.7% of the respondents earned above 75,000,0001 Naira annually. According to the world Poverty Clock, 2019 the World Bank classifies a person to be living in extreme poverty if he/she lives below the poverty line of 1.90 USD which translates to 693.5 Naira per day. The mean for the respondents' annual income was 2,128,767 Naira. This implies that the respondents in the study areas were living above poverty line.

Table 1. *Distribution of Socio-Economic Characteristics of Respondents. (n=150).*

Socio-economic characteristics	Frequency	Percentages (%)	Mean
Age			
27-41	21	14.0	
42-56	51	34.0	
57-71	64	42.7	56
72-86	14	9.3	
Sex			
Male	131	87.3	
Female	19	12.7	
Marital status			
Married	126	84.0	
Divorced	1	0.7	
Widow/Widower	17	11.3	
Single	6	4.0	
Educational level			
No formal education	26	17.3	
Primary education	62	41.3	
Secondary education	43	28.7	
Tertiary education	19	12.7	
Income			
#50,000- #25,037,500	149	99.3	#2,128,767
#25,037501- #50,025,000	0	0	
#50,025,001-#75,012,500	0	0	
#75,012,500-#100,000,000	1	0.7	

Source: Field survey, 2024.

Farm Management Practices

The findings revealed that the crops mostly cultivated by smallholder farmers in the study area are cassava (86.7%), yam (76%), and maize (72%). The findings suggest that smallholder farmers may be overly reliant on a limited number of crops, which can lead to vulnerabilities in terms of food security and income. Studies indicate that agroforestry can lead to increased yields and improved soil health, which benefits crop productivity (Nair, [21]. The findings revealed that majority (69.3%) of the respondents practice some form of crop rotation. This suggests that a significant majority of farmers recognize the benefits of crop rotation as a management practice. Larkin et al. [16] found that crop rotation significantly reduced disease incidence and improved soil microbial communities, leading to increased crop yield. The study indicates that majority (77.3%) reported using no fertilizer in their farming practices, while a smaller percentage used fertilizers like NPK (8.7%), Force Up (7.3%), and Parae Force (6.7%). This finding suggests that a significant number of smallholder farmers may be relying on organic or traditional methods of farming rather than chemical inputs. Tittonell & Giller [13] discuss the barriers that prevent African smallholder farmers from accessing inputs like fertilizers, which can lead to significant yield gaps. The survey indicates that the majority of the respondents (84.7%) do not use organic manure. This suggests that the use of organic inputs remains relatively low among smallholder farmers, despite the known benefits of organic manure in improving soil fertility, enhancing crop yields, and supporting sustainable agricultural practices. Sileshi et al. [29] point out that organic inputs, including manure, play a crucial role in maintaining soil fertility in sub-Saharan Africa. In contrast, Tittonell &

Giller [13] argue that poverty and labour constraints can discourage the use of organic manure, as it is labour-intensive to produce and apply in large quantities. The data only 8.7% of the respondents reported using chicken dung, 11.3% use cow dung, and a mere 0.7% use cocoa pods, with the vast majority relying on other or no organic inputs for their farming practices. This finding suggests a low adoption rate of organic waste recycling in smallholder farming systems. Makinde et al. [18] highlight that chicken manure is rich in nitrogen, phosphorus, and potassium, making it an excellent organic fertilizer for promoting plant growth and improving soil structure. In contrast, Mafongoya et al. [17] argue that the adoption of organic manure in smallholder farming is influenced by several factors, including farmers' education, access to training, and the availability of organic materials. The result of the survey reveals that a majority (66.7%) of the respondents predominantly rely on chemical pesticides for pest and disease control, manual removal is practiced by 20.7% of the respondents, followed by 11.3% who use other methods, and a small fraction (1.3%) that employs biological control. This trend indicates a preference for chemical solutions over more sustainable and environmentally friendly pest control practices. The high reliance on chemical pesticides among farmers aligns with the findings of Haggblade et al. [14], who observed that chemical pesticide usage in smallholder farming is prevalent due to its immediate effectiveness in pest elimination. 51.3% of the respondents do not practice any form of soil conservation. According to Tenge et al. [30], the adoption of soil conservation measures in smallholder systems is often constrained by limited access to knowledge, resources, and training. 50.7% of the respondents were engaged in various techniques, including natural fertilizers (21.3%), conservation tillage (12.7%), cover cropping (10%), terracing (6%), and contour ploughing (0.7%). This distribution highlights a significant gap in the adoption of soil conservation techniques, which are critical for sustainable farming practices, particularly among smallholder farmers. According to Tenge et al. [30], the low adoption rate of these methods is often tied to socioeconomic barriers such as limited access to resources, lack of awareness, or education.

Crop Yield and Productivity

Table 2 reveals a low distribution of output across most of these categories. The table shows that 99.3% of the farmers produced tomato yields between 0-8,750 kg, with only 0.7% achieving yields in the range of 26,251-35,000 kg. The average yield of the tomato farmers is 338kg. For cocoa, 98% of the farmers produced between 0-2,500 kg, and only 0.7% achieved yields of 7,501-10,000 kg. The average yield of the respondents on cocoa production is 170kg. Both plantain and cocoyam have similarly low yields, with 90% of plantain farmers producing between 0-750 kg ($\bar{x}$= 223kg) and 92.7% of cocoyam farmers in the same yield range ($\bar{x}$= 113kg). Yam and cassava, which are staple crops in many regions, also show low yields. The table shows that 99.3% of yam farmers fall within the yield category of 0-25000kg ($\bar{x}$= 1533kg) and 89.3% of cassava farmers fall within the lowest yield category of 0-800kg ($\bar{x}$= 356kg). Most farmers producing okro and maize also report low yields, with 95.3% of okro farmers within the range of 0-131kg ($\bar{x}$= 18kg) and 99.3% of maize farmers falling in the lowest yield category of 0-5000kg ($\bar{x}$= 916kg). The table reveals similarly low productivity for rice, kolanut, and pepper, with 99.3% rice farmers are in the lowest yield category of 0-188kg ($\bar{x}$= 6kg), 99.3% of kolanut farmers in 0-563kg ($\bar{x}$= 17kg) and 99.3% of pepper farmers in 0-6250kg ($\bar{x}$= 226kg) for these crops. Across all the crops, a clear pattern emerges that smallholder farmers struggle to achieve high yields, with the vast majority reporting low output. This aligns with studies that highlight the challenges smallholders face, including limited access to inputs, poor soil management, and a lack of mechanization. Pretty et al. [27] argue that sustainable intensification, particularly through agroforestry, can play a key role in addressing these issues. Studies such as Piperno et al. [26] argue that agroforestry practices, particularly the integration of nitrogen-fixing trees, can enhance soil fertility, improving the yield of root and tuber crops like plantain and cocoyam.

The survey reveals that majority (73.3%) of the respondents reported an increase in crop yields over the past five years, 12% experienced a decrease, and 14.7% stated that their yields remained the same. The increase in yield may align with studies that highlight the positive impact of agroforestry and sustainable farming practices on crop productivity. A study by Garrity et al. [12] found that the integration of trees into farming systems can enhance soil fertility, reduce erosion, and improve water retention, all of which contribute to higher crop yields over time. The survey shows that soil fertility is perceived by 47.3% of the respondents as the main factor affecting crop yield, followed by weather conditions (27.3%), pest and diseases (12.7%), lack of input (8%), and other factors (4.7%). This finding is consistent with studies by Lal [15] who highlight how nutrient-depleted soils lead to low productivity in smallholder farms, especially in Sub-Saharan Africa, where the majority of land is farmed under rainfed conditions. The study shows that majority (62.7%) of the respondents do not have access to agricultural extension services. This significant lack of access to extension services is concerning, as these services play a crucial role in improving agricultural practices, particularly among smallholder farmers. Extension services provide information on soil fertility, crop rotation, pest management, and agroforestry, which are key components in enhancing farm sustainability (Anderson & Feder, [2] Majority (62%) of the respondents never receive visits or advice from extension agents, while 5.3% receive monthly visits, 12.0% receive quarterly visits, and 20.7% receive annual visits. This indicates a major gap in the frequency of extension services, which can have a profound impact on farm productivity and the adoption of agroforestry interventions. According to the Food and Agriculture Organization (FAO) [5], access to regular extension

services is essential for smallholder farmers, as it helps in the dissemination of best practices, new technologies, and sustainable farming methods, including agroforestry (FAO, [6]).

Table 2. Distribution of crop yield and income of respondents. (n =150).

Crop yield (kg)	Frequency	Percentages (%)	Mean
Tomato yield			
0-8750	149	99.3	336
8751-17500	0	0	
17501-26250	0	0	
26250-35000	1	0.7	
Cocoa yield			
0-2500	147	98.0	170
2501-5000	2	1.3	
5001-7500	0	0	
7501-10000	1	0.7	
Plantain yield (kg)			
0-750	135	90.0	223
751-1500	9	6.0	
1501-2250	5	3.3	
2251-3000	1	0.7	
Cocoyam yield (kg)			
0-750	139	92.7	113
751-1500	10	6.7	
1501-2250	0	0	
2251-3000	1	0.7	
Yam yield			
0-25000	149	99.3	1533
25001-50000	0	0	
50001-75000	0	0	
75001-100000	1	0.7	
Okro yield			
0-131	143	95.3	18
132-262	2	1.3	
263-393	3	2.0	
394-525	2	1.3	
Maize yield			
0-5000	149	99.3	916
5001-10000	0	0	
10001-15000	0	0	
15001-20000	1	0.7	

Crop yield (kg)	Frequency	Percentages (%)	Mean
Cassava yield			
0-800	134	89.3	356
801-1600	12	8.0	
1601-2400	2	1.3	
2401-3200	2	1.3	
Rice yield			
0-188	149	99.3	6
189-375	0	0	
376-563	0	0	
564-750	1	0.7	
Kolanut yield			
0-563	149	99.3	17
564-1125	0	0	
1126-1688	0	0	
1689-2250	1	0.7	
Pepper yield			
0-6250	149	99.3	226
6251-12500	0	0	
12501-18750	0	0	
18751-25000	1	0.7	

Source: Field Survey, 2024.

Agroforestry Practices and Potential

The survey result reveals that majority (64.7%) of the respondents are familiar with agroforestry practices. This suggests a relatively high level of awareness, but also highlights the need for further efforts to educate the remaining 35.3% who lack familiarity with agroforestry. According to Mercer [19] one of the key challenges in agroforestry adoption is the lack of awareness or misconceptions about its benefits, particularly among smallholder farmers.

The findings on agroforestry practices highlights that 46% of respondents are aware of the practice of growing multi-purpose trees on farmland, followed by 13.3% who know about alley cropping. A smaller percentage are familiar with practices like live fencing (3.3%), apiculture (0.7%), and silvopasture (1.3%). Notably, 35.3% of the respondents are not aware of any agroforestry practices. Studies by Ajayi et al. [1] and Nair [20] support the fact that trees contribute significantly to improving crop productivity and soil health, especially in sub-Saharan Africa. According to Food and Agriculture Organization (FAO, [7] integrating apiculture and silvopasture into agroforestry can provide multiple benefits, including pollination services and improved livestock grazing while preserving forested areas. The study shows that majority (83.3%) of the respondents do not currently practice any form of agroforestry practices. As noted in a previous survey, a significant portion of the respondents were not familiar with agroforestry practices. Ajayi et al. [1] suggest that inadequate extension services and poor access to information are major barriers to agroforestry adoption, particularly in rural communities. 84.7% of the respondents do not practice any form of agroforestry, while a smaller portion adopts specific practices such as multi-purpose trees on farmland (8.7%), alley cropping (4%), and live fencing (2.7%). This aligns with findings from Ajayi et al. [1] and Tittonell and Giller [31], which noted that many farmers remain hesitant to adopt agroforestry due to factors such as inadequate knowledge, financial constraints, and limited access to extension services. Franzel et al. [8] suggested that the initial time and financial investments required to establish agroforestry systems might deter farmers, especially those with limited resources or immediate financial pressures. 78% of the respondents are willing to adopt agroforestry practices if they are demonstrated to improve crop yield and farm sustainability. Rogers' Diffusion of Innovation Theory

[28] explains that farmers are more likely to adopt new technologies if they perceive a clear relative advantage, such as improved crop yields or farm sustainability. Ajayi et al. [1] observed that smallholder farmers are more likely to adopt agroforestry when it directly improves their economic situation, such as increasing yields or providing alternative sources of income. The adoption rates of different trees species vary significantly according to the findings, with Teak (53.3%) and Gmelina (48.7%) being the most commonly adopted species, while other trees like Rubber tree (0.7%), Moringa (0.7%), and Gliricidia sepium (1.3%) are adopted at much lower rates. This variation indicates a clear preference for certain species, likely due to their perceived economic or environmental benefits. This finding is consistent with the study by Franzel et al. [9], which showed that smallholder farmers in Kenya adopted trees like Teak and Gmelina due to their commercial potential. The most significant challenge of the respondents in adopting agroforestry practices as revealed by the study is initial cost of implementation (34%), followed by lack of knowledge or training (25.3%). Other challenges include lack of seedlings or planting materials (16.7%) and various unspecified factors (24%). Mercer [19] notes that the costs associated with establishing agroforestry systems are a critical factor limiting their adoption among smallholder farmers. In contrast, Pagiola et al. [25] *and Garrity et al.* [11] argued that the long gestation period before trees start providing economic benefits is a key reason why many farmers are hesitant to adopt agroforestry despite its long-term sustainability benefits. Financial support is the most critical form of assistance required by smallholder farmers to adopt agroforestry practices, with 46% of respondents indicating this need. Training and education follow, being necessary for 24.7% of respondents, while access to seedlings or planting materials is required by 15.3%. According to Pagiola et al. [25] and Oerke et al. [23], one of the main challenges faced by smallholder farmers is the lack of liquidity to invest in long-term agricultural practices like agroforestry. Mercer [19] also highlights that financial incentives, such as payments for environmental services, can encourage smallholder farmers to adopt agroforestry by offsetting these initial costs. Ajayi et al. [2] highlight that smallholder farmers often lack the technical knowledge to successfully implement agroforestry systems, which may result in poor tree growth or failure to integrate trees effectively into their cropping systems.

Fertility Management Distribution of the Respondents

Weeding is the most commonly adopted fertility management practice among smallholder farmers, with majority (52.7%) of the respondents utilizing this method. Mulching is the second most common practice, used by 16.7% of the respondents, followed by crop rotation (15.3%), and irrigation (12.7%). Interestingly, fertilizer application is practiced by only 2% of respondents, while erosion breaks are adopted by 0.7%. Research supports this finding that smallholder farmers in sub-Saharan Africa and other developing regions often rely on manual weeding as a cost-effective method of soil fertility management, especially in the absence of access to modern inputs such as herbicides and fertilizers (Oerke et al., [22]. However, while weeding is effective in the short term, it is labour-intensive and may not be sufficient for long-term fertility improvement. Studies like those by Blanco-Canqui & Lal [4] suggest that relying solely on weeding may limit the potential for improving soil organic matter and overall soil fertility, which could be better supported by practices such as mulching, crop rotation, or agroforestry systems.

Abbreviations

IFAD	International Fund for Agricultural Development
FAO	Food and Agriculture Organization
NPK	Nitrogen, Phosphorus, and Potassium.
KG	Kilogram
TETFund	Tertiary Education Trust Fund

Acknowledgments

The authors acknowledge the funding received from the Tertiary Education Trust Fund (TETFund) through the 2023 National Research Fund (NRF) grant for this project (TETF/ES/DR & DCE/NRF2023/SETI/AFS/00119. We are deeply appreciative of their dedication to fostering educational excellence and innovation. The Federal University of Technology, Akure, Nigeria is also appreciated for providing conducive environment and facility support.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., Chakeredza, S., Mn'gomba, S., & Ajayi, C. (2007). Adoption of renewable soil fertility replenishment technologies in Southern African region: Lessons learnt and the way forward. Natural Resources Forum, 31(4), 306-317.

[2] Ajayi, O. C., Franzel, S., Kuntashula, E., & Kwesiga, F. (2007). Adoption of improved fallows technology for soil fertility management in Zambia: Empirical studies and emerging issues. Agroforestry Systems, 69(3), 319-332.

[3] Bhagwat, Shonil A., Harrop, Stuart R., Savill, Peter S. (2019). Biodiversity and ecosystem services in agroforestry systems. Agriculture, Ecosystems and Environment, 275, 251- 264.

[4] Blanco-Canqui, H., & Lal, R. (2008). Principles of Soil Conservation and Management. Springer.

[5] Food and Agriculture Organization (FAO). (2010). Agricultural extension services delivery.

[6] Food and Agriculture Organization (FAO). (2010). The role of agroforestry in sustainable agricultural systems.

[7] Food and Agriculture Organization (FAO). (2019). "The State of the World's Biodiversity for Food and Agriculture." FAO.

[8] Franzel, S., & Scherr, S. J. (2004). Tree species for agroforestry in Africa. Agroforestry Systems, 61(3), 303-321.

[9] Franzel, S., Cooper, P. J. M., & Denning, G. L. (2001). Scaling up the benefits of agroforestry research: Lessons learned and research challenges. Development in Practice, 11(4), 524-535.

[10] Garrity, D. P., Akinnifesi, F. K., Ajayi, O. C., Sileshi, G. W., Mowo, J. G., Kalinganire, A.& Bayala, J. (2010). "Evergreen Agriculture: A robust approach to sustainable food security in Africa." Food Security, 2(3), 197-214.

[11] Garrity, D. P., et al. (2010). Evergreen Agriculture: A robust approach to sustainable food security in Africa. Food Security, 2(3), 197-214.

[12] Garrity, D., Akinnifesi, F. K., Ajayi, O. C., (2017). Agroforestry: A solution to global challenges. Agricultural systems, 154, 255-266.

[13] Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. Field Crops Research, 114(1), 23-34.

[14] Haggblade, S., Minten, B., Pray, C., Reardon, T., & Zilberman, D. (2017). The herbicide revolution in developing countries: Patterns, causes, and implications. *The European Journal of Development Research*, 29(3), 533-559.

[15] Lal, R. (2015). Restoring Soil Quality to Mitigate Soil Degradation. Sustainability, 7(5), 5875- 5895.

[16] International Fund for Agricultural Development (2019): Smallholders can feed the world.

[17] Mafongoya, P. L., Kuntashula, E., & Sileshi, G. (2006). Managing soil fertility and nutrient cycles through fertilization in smallholder farming systems. *Agriculture, Ecosystems & Environment*, 116(1-2), 4-12.

[18] Makinde, E. A., Ayoola, O. T., & Akande, M. O. (2011). Effects of organic, organomineral and NPK fertilizer treatments on the nutrient uptake of Amaranthus cruentus on two soil types in Lagos, Nigeria. *Journal of Central European Agriculture*, 12(1), 114-123.

[19] Mercer, D. E. (2004). Adoption of agroforestry innovations in the tropics: A review. Agroforestry Systems, 61(1), 311-328.

[20] Nair, P. K. R. (1993). An Introduction to Agroforestry. Springer Science & Business Media.

[21] Nair, P. K. R. (2012). "Agroforestry Systems in the Tropics." Springer.

[22] Oerke, E. C. (2006). Crop losses to pests. The Journal of Agricultural Science, 144(1), 31-43.

[23] Oerke, E. C., Dehne, H. W., Schönbeck, F., & Weber, A. (2006). Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops. Elsevier.

[24] Oluwasusi, J. O., & Tijani, I. A. (2013). Age and technology adoption in agroforestry. *Journal of Sustainable Development*, 6(3), 12-23.

[25] Pagiola, S., Ramirez, E., Gobbi, J., De Haan, C., Ibrahim, M., Murgueitio, E., & Ruiz, J. P. (2007). Paying for the environmental services of silvopastoral practices in Nicaragua. Ecological Economics, 64(2), 374-385.

[26] Piperno, D. R., McMichael, C., & Bush, M. B. (2015). Amazonia and the Anthropocene: What was the spatial extent and intensity of human landscape modification in the Amazon Basin at the end of prehistory? *Holocene*, 25(10), 1588-1597.

[27] Pretty, J., Toulmin, C., & Williams, S. (2011). Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*, 9(1), 5-24.

[28] Rogers, E. M. (2003). Diffusion of innovations (5th edition). *Free Press*.

[29] Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., & Muys, B. (2008). Meta-analysis of maize yield response to woody and herbaceous legumes in sub-Saharan Africa. *Plant and Soil*, 307, 1-19.

[30] Tenge, A. J., De Graaff, J., & Hella, J. P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara Highlands, Tanzania. *Land Degradation & Development*, 15(2), 99-114.

[31] Tittonell, P., & Giller, K. E. (2013). When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. *Field Crops Research*, 143, 76-90.