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Farm Management Practice, Crop yields and Soil Fertility Maintenance Strategy of Smallholder farms in Ondo State Nigeria

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Abstract
This study assesses the demographic and socio-economic characteristics of smallholder farmers and their farm management practices in Ondo 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 (61.3%), the mean age of the respondents was 57 years. The majority of the respondents (79.3%) were married, 75.3% 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 (68%), maize (54%) and cocoa (41.3%). 34.7% of the farmers are familiar with agroforestry practices, alley cropping is the most recognized practice (27.3%) The result showed that a significant majority (91.3%) of the respondents do not integrate any form of agroforestry practices on their farms. Barriers to adopting agroforestry practices recognized by the farmers include lack of knowledge (59.3%), initial cost of implementing agroforestry practices (52%) and lack of seedlings (27.3%). The findings revealed that 61.3% of the respondents believe that training and education support is necessary for adopting agroforestry, 62.7% of the respondents indicate that financial support is crucial for adopting agroforestry, and 28.7% 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 Ondo State, Nigeria.
Keywords— smallholder farming, agroforestry, farm management, crop yield, sustainability, rural development.
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INTRODUCTION

Smallholder farming is crucial for food security and livelihoods in developing regions, supporting over 2 billion people worldwide (IFAD, 2019). However, smallholder farmers face significant challenges, including soil degradation, water scarcity, and limited access to markets (FAO, 2020). 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, 2020). Additionally, agroforestry can mitigate climate change by sequestering carbon (Nair et al., 2018) and promote biodiversity (Bhagwat et al., 2019).

Despite these benefits, the adoption of agroforestery among smallholder farmers remains low due to various cosntraints, including limited knowledge, inadequate policies, and lack of instituitional support (Garrity et al., 2017). 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:

i. describe the socioeconomic characteristics of smallholder farmers in Ondo state
ii. evaluate the crop management practices in selected smallholder farms;
iii. assess the yield of major crops in selected smallholder farms;
iv. identify the constraints and challenges faced by smallholder farmers;
v. design agroforestry intervention model suitable for small holder farms

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: Ifedore, Akure North, Ondo East, Akure South, and Owo. 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. Third Stage involved a random selection of 10 respondents from each communities which gave a total of (150) respondents. Data collected were analyzed using descriptive and inferential statistics.

RESULTS AND DISCUSSSION

Socio-Economic Characteristics of the Respondents Table 1 reveals that the majority of the respondents (33.3%) were between 56 and 68, 31.3% in the age group of 43 and 55, 23.3% in the age group of 69 and 81, 10% in the age group of 30 and 42 and 2% in the age group of 82-94. years of age. The mean age was 57 years which implies that the majority of the respondents were older farmers. This is in line with Onyekuru and Marchant (2016) found that older farmers, while having greater experience and land ownership, may be slower to embrace innovations due to risk aversion or limited physical capacity. Table 1 indicates that the majority of the respondents (61.3%) was male, married (79.3%) and had one form of education or the other (75.3%). This suggests that education plays a crucial role in smallholder farm management and the adoption of agroforestry practices. About 94.0% of the respondents earned less than #5,000,000 million naira in a year, 4.7% earned between 5,000,001 naira and 10,000,000 naira annually, 0% earned between 10,000,001 naira and 15,000,000 naira annually while just 0.7% of the respondents earned above 15,000,0001 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 1,691,034 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(years)			
30-42	15	10.0	
43-55	47	31.3	
56-68	50	33.3	57
69-81	35	23.3	
82-94	3	2.0	
Sex			
Male	92	61.3	
Female	58	38.7	
Marital status		39.1	
Married	119	79.3	
Divorced	3	2.0	
Widow/Widower	28	16.7	
Educational level			
No formal education	37	24.7	
Primary education	44	29.3	
Secondary education	45	30.0	
Tertiary education	24	16.0	
Income			
#0- #5,000,000	141	94.0	#1,691,034
#5,000,001- #10,000,000	7	4.7	
#10,000,001- #15,000,000	0	0	
#15,000,001- #20,000,000	1	0.7	
#20,000,001- #25,000,000	1	0.7	

Source: Field Survey, 2024.

Farm Management Practices

Findings from the study indicates that cassava (68%)**,** maize (54%), and cocoa (41.3%) are crops that are widely grown by the respondents. Fermont et al. (2009) highlighted cassava's adaptability to diverse ecological conditions and its importance as a food security crop for smallholder farmers. Similarly, maize is an important cereal crop, often intercropped with other plants in agroforestry systems to optimize land use and improve soil fertility, as noted by Ajayi et al. (2011) in their study on the adoption of agroforestry technologies, that maize and cassava are commonly intercropped in agroforestry systems, helping smallholders maximize land productivity while improving soil fertility through nitrogen-fixing plants. However, Gockowski & Sonwa (2011) point out that integrating cocoa with agroforestry systems offers significant benefits such as improved biodiversity and soil health. The study indicates that crop rotation is a prominent practice in the study area as attested to by 68% of the respondents. This findings is in support of Place et al. (2012), who noted that agroforestry practices that include crop rotation can enhance the resilience of smallholder systems, particularly in the face of climate variability. Chemical fertilizer is not commonly used by the respondents as 81.3% acknowledged this. Only 6.7% of the respondents use NPK fertilizer, with 93.3% not using it. Similarly, only 8% use Super Grow, 4.7% use Urea, 1.3% use MPK, and 0.7% use Cocopod, while Atracycline, an antibiotic often used for plant disease control, is used by just 3.3% of the farmers. Place et al. (2003) highlight that smallholders who use organic manure, especially in agroforestry interventions, can significantly improve soil structure and fertility, leading to enhanced crop yields over time. The survey shows that majority of respondents (70.7%) use poultry manure as their primary type of organic manure, followed by cow dung (13.3%), farm compost decay (4.0%), and a small percentage using urea (0.7%). Interestingly, 11.3% of respondents reported using no form of organic manure. A vast majority of the respondents (84%) rely on chemical pesticides for pest and disease control, while only 0.7% use biological control methods, and 3.3% use manual removal. Notably, 12% of respondents do not engage in any form of pest and disease control. This findings is not in tandem with studies like Popp et al. (2013) that argue that while chemical pesticides offer short-term effectiveness, their long-term use can lead to environmental degradation, pesticide resistance, and health hazards for farmers. On the other hand, Pretty (2008) emphasizes the importance of integrating biological and manual control methods as part of sustainable agricultural practices, particularly in agroforestry systems, where biodiversity can naturally regulate pests. 91.3% of the respondents reported that they implement soil conservation measures. Half of the

respondents (50%) utilize natural fertilizers as a method of soil conservation, while contour ploughing (19.3%) and conservation tillage (11.3%) are also prominent practices. Other methods, such as terracing (13.3%) and cover cropping (3.3%), are less commonly employed, with only 2.7% of respondents reporting no use of soil conservation methods at all.

Crop yield and productivity

The data in table 2 presents the distribution of yield categories for five crops (cocoa, palm tree, yam, cassava, and tomato) across smallholder farms. The yield categories were divided using the minimum and maximum values for each crop. For cocoa yield, majority (98%) of the respondents report yields between 0-5000 kg, 1.3% report yields between 5001-10000 kg and only 0.7% report yields between 15001-20000 kg. The average yield of the cocoa farmers is 350kg. For palm tree yield, majority (98.7%) of the respondents report yields between 0-5000 kg, 0.7% report yields between 5001-10000 kg and 15001-20000 kg. The average yield of the respondents producing palm tree is 217kg. For yam yield, majority (99.3%) report yields between 0-3750 kg while only 0.7% report yields between 11251-15000 kg. The average yield produced by the yam farmers is 147kg. For cassava yield, 98% report yields between 0-5000 kg, 0.7% report yields between 5001-10000 kg, 10001-15000 kg, and 15001-20000 kg. The average yield of the cassava farmers is 389kg. Lastly, for tomato yield, majority (99.3%) of the respondents report yields between 0-2500 kg while only 0.7% report yields between 7501-10000 kg. The average yield of tomato farmers in the study area is 82kg. The high concentration in the lower category reflects significant limitations in tomato production for the vast majority of farmers. This is consistent with World Bank (2019), who noted that smallholder farmers in sub-Saharan Africa, particularly those engaged in cocoa and cassava farming, experience significantly lower yields compared to global averages.

85.3% of the smallholder farmers experienced an increase in crop yield over the past five years, while 14% reported a decrease, and 0.7% stated that their yield stayed the same. This positive trend in crop yield growth aligns with studies on agroforestry interventions and improved farm management practices. A study by Place et al. (2015) highlighted that agroforestry techniques, such as integrating trees with crops, can lead to significant improvements in soil quality, which in turn boosts crop productivity. In contrast, according to Oruonye & Musa (2012), smallholder farmers in Nigeria often face challenges related to inadequate infrastructure, limited access to fertilizers, and other farm inputs, which can negatively impact crop productivity. Almost half of the respondents (48.7%) identified weather conditions as a major factor affecting crop yield, 32.7% cited soil fertility as a critical factor influencing crop yield, 16.7% reported that pests and diseases affect their yields, (0.7%) cited lack of inputs, such as seeds and fertilizers, as a factor affecting yield while 1.3% of the respondents recognized that multiple factors contribute to yield variability, indicating a need for a more integrated understanding of the challenges they face. This finding aligns with a study by Thornton et al. (2018) which indicates that smallholder farmers are particularly vulnerable to climate change impacts, leading to fluctuations in yield due to unpredictable rainfall and temperature changes. A significant majority of the respondents (69.3%) do not have access to agricultural extension services. A report by the Food and Agriculture Organization (FAO, 2020) underscores the necessity of strengthening agricultural advisory services to support smallholder farmers in improving their productivity and resilience to climate change. Majority of the respondents (62%) receive advice or visits from extension agents on a weekly basis, 21.3% of respondents reported having no contact with extension agents, while smaller percentages (3.3%) indicated monthly visits, 3.3% reported quarterly visit, and 10% reported annual visits. The high percentage of respondents receiving weekly advice in this study is encouraging, as it aligns with best practices in agricultural extension services, where timely and frequent guidance is linked to increased productivity (Davis et al., 2010).

Table 2: Distribution of crop yield and income of respondents

Crop yield (kg)	Frequency	Percentage	Mean
Cocoa yield			
0-5000	147	98.0	350
5001-10000	2	1.3	
10001-15000	0	0	
15001-20000	1	0.7	
Palm tree yield (kg)			
0-5000	148	98.7	217
5001-10000	1	0.7	
10001-15000	0	0	
15001-20000	1	0.7	
Yam yield (kg)			
0-3750	149	99.3	147
3751-7500	0	0	
7501-11250	0	0	
11251-15000	1	0.7	
Cassava yield (kg)			
0-5000	147	98.0	389
5001-10000	1	0.7	
10001-15000	1	0.7	
15001-20000	1	0.7	
Tomato yield (kg)			
0-2500	149	99.3	82
2501-5000	0	0	
5001-7500	0	0	
7501-10000	1	0.7	

Source: Field Survey, 2024.

Agroforestry practices and potential

The survey result indicates that only 34.7% of the respondents are familiar with agroforestry practices. The findings also underscore the importance of training and capacity-building initiatives tailored to smallholder farmers. As highlighted by Nyanga et al. (2011), targeted agricultural extension programs that focus on educating farmers about agroforestry practices can significantly enhance their knowledge and adoption rates, leading to improved farm management and productivity. Majority (65.3%) of the respondents are not aware of any agroforestry practices. Among those who do have some knowledge, alley cropping is the most recognized practice (27.3%), followed by live fencing (4.7%) and multipurpose trees on farmland (2.7%). Agroforestry systems, such as alley cropping, where crops are planted between rows of trees, and live fencing, which involves planting trees or shrubs to create barriers, can offer numerous benefits, including improved soil fertility, increased biodiversity, and enhanced resilience to climate change (Nair, 2012). The survey result indicates that 60% of the respondents do not practice agroforestry currently. Agroforestry, which integrates trees and shrubs into agricultural landscapes, has been shown to improve soil fertility, increase biodiversity, and enhance resilience to climate change (Garrity et al., 2010). A significant majority (91.3%) of the respondents do not integrate any form of agroforestry practices on their farms. Among those who do practice agroforestry, the most common practice reported is alley cropping (6.7%), followed by multipurpose trees on farmland (1.3%) and live fencing (0.7%). These findings suggest a low level of adoption of agroforestry practices among the smallholder farmers surveyed. Agroforestry, which combines agricultural and forestry practices, has been shown to enhance biodiversity, improve soil health, and increase crop yields (Garrity et al., 2010). 82.7% of the respondents would be willing to adopt agroforestry practices if they were shown to improve crop yield and farm sustainability. In contrast, only 17.3% indicated they would not consider adopting these practices. A study by Jose (2009) highlights that farmers who implement agroforestry systems often experience increased crop yields, reduced erosion, and improved resilience to climate variability. The trees or shrubs that respondents believe would be beneficial to integrate into their farming systems reveal a substantial lack of awareness or preference for specific

species. 5.3% of the respondents recognize the potential benefits of Iroko tree for integration into their farming system, 3.3% of the respondents are aware of the benefits of Obeche, 14.7% acknowledge the benefits of Mahogany, 10.0% recognize the benefits of Gmelina, 18.7% are aware of the benefits of Teak tree, and 16.0% aware of the benefits of Afara tree. The low awareness levels of beneficial tree species among respondents point to a significant barrier to adopting agroforestry practices. According to Aiyeloja and Bello (2006), a lack of knowledge about tree species and their benefits can hinder farmers from adopting agroforestry systems that could improve their crop yields and overall farm sustainability. 59.3% of the respondents cite lack of knowledge as a barrier to adopting agroforestry practices, 52% of the respondents believe that the initial cost of implementing agroforestry practices is a barrier and 27.3% of the respondents identify the lack of seedlings as a challenge. This findings is supported by studies, such as the one by Franzel et al. (2004), that lack of information and awareness about the benefits and practices of agroforestry has been shown to impede its adoption. This finding aligns with other studies that show how financial constraints prevent farmers from adopting agroforestry (Pattanayak et al., 2003). However, for the minority who do face the issue of lack of seedlings, it can still be a significant challenge, as studies like that of Ajayi et al. (2011) highlight that in some regions, the availability of quality seedlings and planting materials is a limiting factor for agroforestry adoption. 61.3% of the respondents believe that training and education support is necessary for adopting agroforestry, 62.7% of the respondents indicate that financial support is crucial for adopting agroforestry, and 28.7% of respondents believe that access to seedlings is important for adopting agroforestry. Franzel et al. (2001) found that extension services and educational programmes significantly increased the uptake of agroforestry technologies among smallholder farmers. The finding that 62.7% of the respondents highlight the need for financial support is consistent with other studies like Pattanayak et al. (2003), who noted that access to credit or financial incentives can mitigate the financial barriers associated with agroforestry, as it often requires upfront investment in seedlings, tools, and labour. Interestingly, only 28.7% of the respondents cite access to seedlings as a necessary support. This is somewhat in contrast with other studies, such as Ajayi et al. (2007), which highlight that in some regions, the availability of seedlings is a significant limiting factor for agroforestry adoption.

Types of Fertility Management Distribution of the Respondents

Majority (84%) of the respondents engage in weeding as part of their fertility management, 40% practice crop rotation, 35.3% of the respondents apply fertilizers, 17.3% of the respondents use irrigation, 2.7% practice growing grass between crops, none of the respondents reported using erosion breaks in their management practices and 6% of the respondents use mulching. Only 17.3% of respondents utilize irrigation, which is relatively low compared to other management practices. This result aligns with studies such as Frenken & Gillet (2012) which emphasized that irrigation can significantly increase crop yields in agroforestry systems, especially in regions where water scarcity is common. Weeding is the most frequently practiced method, with 84% of respondents participating. According to Jose (2009), proper weed management improves the growth of both trees and crops, leading to higher productivity in agroforestry systems. Only 35.3% of respondents apply fertilizers, which is relatively low given the importance of nutrient replenishment in farming. Ajayi et al. (2007) highlight that while agroforestry systems often improve soil fertility naturally through tree-crop interactions, additional fertilizer application can further boost yields.

References

Aiyeloja, A. A., & Bello, A. M. (2006). *The Role of Agroforestry in Sustainable Development of Rural Communities in Nigeria*. *African Journal of Biotechnology*, 5(25), 2410-2414.

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., & Chakeredza, S. (2011). Adoption of renewable soil fertility replenishment technologies in southern African region: Lessons learnt and the way forward. *Natural Resources Forum*, 31(4), 306-317.

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., & Chakeredza, S. (2007). Adoption of agroforestry technologies in southern African regions: A synthesis of lessons learnt and implications for policy. *Natural Resources Forum*, 31(4), 306-317.

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

Davis, K. E., Nkonya, E., Kato, E., & Nampanzira, D. (2010). *Impact of Farmer Field Schools on Agricultural Productivity and Poverty in East Africa*. Agricultural Economics, 41(1), 53-67.

FAO. (2020). *The State of Food and Agriculture: Overcoming Water Challenges in Agriculture*. Food and Agriculture Organization of the United Nations.

Fermont, A. M., Van Asten, P. J., & Tittonell, P. (2009). Closing the cassava yield gap: An analysis from smallholder farms in East Africa. *Field Crops Research*, 112(1), 24-36.

Franzel, S., Cooper, P., & Denning, G. L. (2001). Scaling up the benefits of agroforestry research: Lessons learned and research challenges. *Development in Practice*, 14(3), 1-14.

Franzel, S., Cooper, P., & Denning, G. L. (2004). Scaling up the benefits of agroforestry research: lessons learned and research challenges. *Development in Practice*, 14(3), 1-14.

Frenken, K., & Gillet, V. (2012). Irrigation in Southern and Eastern Africa: Evolution of irrigation development and factors affecting success. *Food and Agriculture Organization (FAO)*.

Garrity, D., Akinnifesi, F. K., Ajayi, O. C., Kalinganire, A., & M. S. (2010). *Evergreen Agriculture: A Compact Overview of the Concept and Its Impacts on Smallholder Livelihoods in Africa*. *World Agroforestry Centre*.

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

Gockowski, J., & Sonwa, D. (2011). Cocoa intensification scenarios and their predicted impact on CO2 emissions, biodiversity conservation, and rural livelihoods in the Guinea rainforest of West Africa. *Environmental Management*, 48(2), 307-321.

International Fund for Agricultural Development (IFAD) (2019). The State of Food Security and Nutrition in the World.

IFPRI (2017). "Smallholder Agriculture: Productivity and Constraints." International Food Policy Research Institute.

Jose, S. (2009). Agroforestry for Ecosystem Services and Environmental Benefits: A Review. Agroforestry Systems, 75(1), 1-14.

Nair, P. K. R. (2012). Agroforestry: The Future of Global Agriculture. Agricultural Research, 1(1), 21-30.

Nair, P. K.R. Ramachandran, Sileshi, Gudeta W., & Mowo, Jeremias G. (2018). Agroforestry and climate change mitigation. Journal of Environmental Quality, 47(5), 831-838.

Nyanga, P. H., Johnsen, F. H., & Aune, J. B. (2011). *Climate Change and Smallholder Farmers: Is a Sustainable Agricultural Development Approach Possible? Environmental Science & Policy*, 14(1), 126-137.

Onyekuru, N. A., & Marchant, R. (2016). Analysis of adoption of climate change adaptation strategies and its effect on the net farm income of smallholder farmers in Southeast Nigeria. *Land Use Policy*, 60, 385-393.

Oruonye, E. D., & Musa, S. D. (2012). "Challenges of Smallholder Farming in Nigeria: A Case Study of Taraba State." *Journal of Agriculture and Biodiversity Research*, 1(2), 27-34.

Pattanayak, S. K., Mercer, D. E., Sills, E. O., & Yang, J. C. (2003). Taking stock of agroforestry adoption studies. *Agroforestry Systems*, 57(3), 173-186.

Place, F., & Otsuka, K. (2017). Tenure, agricultural investment, and productivity in customary tenure sector of Sub-Saharan Africa. *World Development*, 96, 292-303.

Place, F., Ajayi, O. C., Torquebiau, E., Detlefsen, G., Gauthier, M., & Buttoud, G. (2012). Improved policies for facilitating the adoption of agroforestry. *Advances in Agroforestry*, 9, 113-128.

Place, F., Ajayi, O. C., Torquebiau, E., Detlefsen, G., Gauthier, M., & Buttoud, G. (2015). "Improved Policies for Facilitating the Adoption of Agroforestry." *Environmental Sustainability*, 6, 57-62.

Place, F., Ajayi, O. C., Torquebiau, E., Detlefsen, G., Gauthier, M., & Buttoud, G. (2015). "Improved Policies for Facilitating the Adoption of Agroforestry." *Environmental Sustainability*, 6, 57-62.

Place, F., Degrande, A., & H. S. (2009). *The Role of Agroforestry in Sustainable Land Use in Africa*. *Journal of Environmental Management*, 90(4), 1323-1332.

Popp, J., et al. (2013). "The impact of pesticides on agriculture." *Journal of Agriculture and Environment*, 46(2): 45-55.

Pretty, J. (2008). "Agricultural sustainability: concepts, principles, and evidence." *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1491): 447-465.

Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. (2018). *The Role of Climate Change in the Future of Smallholder Agriculture*. Agricultural Systems, 162, 141-153.

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