

SOCIO-ECONOMIC INTERACTIONS BETWEEN NATURAL FORESTS AND AGRICULTURAL LIVELIHOODS AROUND GAMBARI FOREST RESERVE, IBADAN, OYO STATE, NIGERIA

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Abstract

Natural forests play a vital role in sustaining the livelihoods of rural households, yet increasing dependence on forest resources poses significant challenges for environmental sustainability. This study examined the socio-economic interactions between natural forests and agricultural livelihoods among rural households surrounding Gambari Forest Reserve, Ibadan, Oyo State, Nigeria. A descriptive survey research design was adopted, and data were collected from 129 household heads selected through a multistage sampling procedure involving purposive, simple random and systematic random sampling techniques. Primary data were obtained using a structured questionnaire and analysed using descriptive statistics and multiple linear regression. The findings revealed that 52.7% of respondents exhibited a high level of forest dependence (Forest Dependence Index = 3.71). Fuelwood (78.3%), medicinal plants (69.8%) and wild food products (63.6%) were the most utilised forest resources, while soil fertility improvement (72.1%) was the most valued ecosystem service. Income generation (mean = 4.28), food security (mean = 4.16) and livelihood diversification (mean = 4.04) were the major perceived benefits, whereas deforestation (76.7%) and declining forest resources (70.5%) were the principal challenges. Age, household size, farming experience, access to forest resources and institutional support significantly increased household forest dependence, while educational status reduced dependence. The study concludes that strengthening community-based forest management,

promoting sustainable agricultural practices, expanding livelihood diversification opportunities, and improving extension and environmental education are essential for reducing unsustainable forest dependence while sustaining rural livelihoods.

Keywords: community-based forest management, forest dependence, sustainable resource use, rural household livelihoods, livelihood diversification, ecosystem services

JEL classification: Q15, Q23, Q56, O13

1. Introduction

Natural forests remain fundamental to rural livelihoods and agricultural sustainability, particularly in developing countries where rural households depend on forest ecosystems for subsistence, income generation and livelihood resilience (Das & Mallick, 2025). Forest ecosystems provide a wide range of socio-economic and ecological benefits, including fuelwood, medicinal plants, wild food products, timber resources, biodiversity conservation, soil protection and climate regulation (Arabomen & Babalola, 2025). For communities located around forest reserves, these resources often complement agricultural activities by providing essential inputs, alternative income sources and ecosystem services that support household welfare and agricultural productivity (Begazo-Curie & Vranken, 2025). Consequently, understanding the interactions between natural forests and agricultural livelihoods has become increasingly important in the pursuit of sustainable rural development, environmental conservation and climate resilience.

Despite their importance, forest ecosystems in Nigeria are facing increasing pressure from population growth, agricultural expansion, urbanisation and unsustainable exploitation of natural resources (Ibimilua & Ayiti, 2023). The conversion of forest lands for agricultural purposes has contributed substantially to deforestation, biodiversity loss and ecosystem degradation (Alemayehu et al., 2025). However, the relationship between forests and agriculture is complex, as forest ecosystems are not only affected by agricultural activities but also provide critical services that enhance agricultural sustainability. These services include soil fertility improvement, erosion control, watershed protection, pollination, microclimate regulation and the provision of non-timber forest products that support rural households (Aleru et al., 2025). The extent to which households benefit from these interactions is influenced by several socio-economic and institutional factors, including household characteristics, resource accessibility, livelihood strategies, market opportunities, extension support and environmental awareness.

In southwestern Nigeria, rural communities located around forest reserves maintain strong linkages with surrounding natural ecosystems through diverse livelihood activities. Communities around Gambari Forest Reserve in Ibadan, Oyo State, engage in crop production, livestock rearing, fuelwood collection, harvesting of non-timber forest products, hunting and small-scale rural enterprises (Olawuyi et al., 2024).

The forest reserve therefore represents both an ecological asset and an important livelihood resource for neighboring households. However, increasing dependence on forest resources, coupled with limited livelihood alternatives and inadequate resource management practices, raises concerns regarding long-term forest sustainability and household livelihood security (Das & Mallick, 2025). Although the importance of forests to rural livelihoods is widely recognised, empirical evidence on how socio-

economic conditions shape household interactions with forest ecosystems and agricultural activities remains limited, particularly among forest-adjacent communities in southwestern Nigeria.

Previous studies have examined various dimensions of forest conservation, deforestation, biodiversity management and rural livelihoods (Li et al., 2023; Delgado et al., 2023; Adedigba et al., 2025; Akinyemi et al., 2025). However, much of the existing literature has considered forest resource utilisation, agricultural productivity and conservation issues separately, with limited integration of the socio-economic factors connecting forest dependence and agricultural livelihood systems. Consequently, there is insufficient understanding of how household characteristics influence dependence on natural forests, the benefits derived from forest–agriculture interactions, and the challenges associated with resource utilisation among rural households. This knowledge gap limits the ability of policymakers, forestry institutions and rural development practitioners to design interventions that simultaneously promote livelihood improvement and sustainable forest management.

Furthermore, forest-dependent households often experience socio-economic vulnerabilities arising from poverty, declining agricultural productivity, limited access to improved agricultural inputs and environmental degradation (Wakweya, 2025). These vulnerabilities may increase reliance on forest resources as coping mechanisms and supplementary sources of income and household needs. Therefore, understanding the socio-economic dimensions of forest dependence is essential for developing strategies that reduce unsustainable exploitation while strengthening rural livelihood resilience. Evidence from localised studies is particularly important because patterns of forest utilisation and dependence vary according to ecological conditions, institutional arrangements and community livelihood structures.

This study addresses this gap by examining the socio-economic interactions between natural forests and agricultural livelihoods among rural households surrounding Gambari Forest Reserve, Ibadan, Oyo State, Nigeria. Specifically, the study focuses on household socio-economic characteristics, forest resources and ecosystem services utilised, perceived socio-economic benefits and environmental challenges associated with forest resource utilisation, as well as the factors influencing household dependence on natural forest resources.

The general objective of the study was to examine the socio-economic interactions between natural forests and agricultural livelihoods among rural households around Gambari Forest Reserve. Specifically, the study sought to:

1. describe the socio-economic characteristics of rural households around Gambari Forest Reserve;
2. identify the major forest resources and ecosystem services utilised for agricultural livelihood activities;
3. examine the perceived socio-economic benefits derived from forest–agriculture interactions;
4. assess the perceived environmental and livelihood challenges associated with forest resource utilisation; and
5. analyse the relationship between selected socio-economic factors and household dependence on natural forest resources for agricultural livelihoods.

Based on these objectives, the following null hypothesis was tested:

H₀₁: There is no significant relationship between selected socio-economic characteristics of rural households and their dependence on natural forest resources for agricultural livelihoods.

The study contributes to the growing body of knowledge on forest-dependent livelihoods by providing empirical evidence on the relationship between socio-economic characteristics, forest resource utilisation and agricultural livelihood outcomes in a rural Nigerian context. The findings are expected to support policymakers, forestry authorities, agricultural extension agencies and rural development organisations in designing strategies that promote community-based forest management, sustainable agricultural practices and livelihood diversification. By highlighting the factors influencing forest dependence, the study provides insights into approaches that can balance ecosystem conservation with the socio-economic needs of rural households.

The remainder of this manuscript is organised as follows. Section 2 reviews the relevant literature and presents the theoretical framework underpinning the study, highlighting existing knowledge, identifying research gaps and explaining the study's contribution. Section 3 describes the materials and methods, including the study design and context, data sources, sampling procedure, variables and measurements, analytical techniques, and ethical considerations. Section 4 presents the empirical results, while Section 5 discusses the findings in relation to the study objectives, previous literature and the theoretical framework. Section 6 concludes the study by summarising the major findings and contributions, followed by practical and policy implications, the study's limitations, and recommendations for future research.

2. Literature Review and Theoretical Framework

2.1. Forest–Agriculture Interactions and Rural Livelihood Sustainability

The relationship between natural forests and agricultural livelihoods has attracted increasing scholarly attention due to the growing challenges of environmental degradation, rural poverty, food insecurity and climate change. In many developing countries, particularly across sub-Saharan Africa, natural forests represent important livelihood assets that support household welfare through the provision of goods, services and ecological functions (Wakweya, 2025; Das & Mallick, 2025). Forest-dependent households derive direct benefits from timber and non-timber forest products (NTFPs), including fuelwood, medicinal plants, wild foods, fodder and materials for household use and income generation. Beyond these tangible products, forests provide ecosystem services that indirectly sustain agricultural production through soil fertility enhancement, erosion regulation, water conservation, biodiversity maintenance and climate regulation (Derebe & Alemu, 2023; Pradhan et al., 2025).

Although agriculture and forestry are sometimes perceived as competing land-use systems, recent scholarship suggests that their relationship is more interconnected than antagonistic. Rural households frequently combine agricultural activities with forest resource utilisation as part of broader livelihood strategies aimed at reducing economic risks and improving household resilience (Senganimalunje et al., 2022; Mulungu & Manning, 2023). During periods of agricultural uncertainty, declining farm income or climatic stress, forests often function as safety nets by providing alternative sources of food, income and household energy. However, these livelihood benefits may create a paradox whereby forests simultaneously support rural welfare while facing increasing pressure from resource extraction.

In Nigeria, where smallholder agriculture remains the dominant livelihood activity among rural households, forest resources continue to influence household economic decisions and agricultural sustainability (Fadairo et al., 2023). Nevertheless, the sustainability of these interactions depends on the ability of households and institutions to balance livelihood requirements with conservation objectives. This highlights the need for empirical investigations that examine not only the benefits derived from forests but also the socio-economic factors that shape patterns of dependence and resource utilisation.

2.2. Socio-economic Determinants of Household Forest Dependence

Household dependence on natural forest resources is influenced by a combination of demographic, economic and livelihood-related characteristics. Previous studies have proven that variables such as age, education, household size, farming experience, occupation and income status significantly influence how rural households interact with forest ecosystems (Magry, 2026). These characteristics determine households' resource needs, adaptive capacity, environmental awareness and ability to adopt alternative livelihood options.

Age and farming experience are particularly important because older farmers often possess indigenous knowledge regarding forest resource identification, utilisation and management practices (Kom et al., 2023; Armanto et al., 2025). Such knowledge may enhance sustainable resource utilisation but may also increase dependence where traditional livelihoods remain strongly linked to forest resources. Similarly, larger households may exhibit greater dependence on forests due to increased consumption requirements and availability of family labour for resource collection and agricultural activities (Das & Behera, 2023).

Educational attainment has been widely recognised as a critical factor influencing environmental decision-making. Households with higher educational levels are generally more likely to possess greater awareness of conservation practices, access alternative livelihood opportunities and adopt improved agricultural technologies that reduce pressure on forest resources (Ullah et al., 2025). Gender also shapes forest–agriculture interactions, as women in many rural communities are often heavily involved in collecting NTFPs, fuelwood and food resources that contribute to household nutrition and supplementary income (Jalonen et al., 2023). Therefore, understanding household characteristics is essential for explaining variations in forest dependence and designing context-specific interventions.

2.3. Institutional and Environmental Factors Influencing Forest Resource Utilisation

While household characteristics provide important explanations for forest dependence, broader institutional, environmental and market conditions also determine how communities interact with forest ecosystems. Access to forest resources, land tenure arrangements, market opportunities, infrastructure and institutional support influence livelihood choices and resource-use decisions among forest-adjacent households (Aromolaran et al., 2022; Bisui et al., 2023; Barbanente et al., 2024).

Communities located close to forest reserves often depend heavily on forest resources because of limited access to alternative income opportunities, agricultural inputs and livelihood support services (Beckline et al., 2022). Weak governance systems, inadequate enforcement of conservation regulations and limited extension support may encourage unsustainable exploitation practices (Ullah, 2025).

Similarly, declining agricultural productivity and economic shocks can increase household reliance on forests as coping mechanisms (Do et al., 2025).

Conversely, effective institutional arrangements, community participation in forest governance and livelihood development programmes can contribute to sustainable resource management. Evidence suggests that community-based forest management initiatives and livelihood diversification programmes can reduce destructive dependence while improving conservation outcomes (Mengist & Asfaw, 2026). These findings indicate that forest dependence cannot be understood solely from household characteristics but must also be examined within the broader socio-economic and institutional context.

2.4. Benefits and Challenges of Forest–Agriculture Interactions

Natural forests provide multiple livelihood benefits that contribute to household welfare and agricultural resilience. Forest resources enhance income diversification, improve food security, provide employment opportunities and reduce livelihood risks among rural households (Hashmi et al., 2024). NTFPs such as fruits, vegetables, medicinal plants, honey, mushrooms and fuelwood are particularly important for households seeking supplementary income sources during periods of low agricultural returns (Aleru et al., 2025).

Furthermore, ecosystem services provided by forests contribute indirectly to agricultural productivity. Soil nutrient cycling, erosion control, pollination services, water regulation and microclimate moderation support farming systems and improve long-term agricultural sustainability (Diyaolu & Folarin, 2024). These benefits make evident that forests should not be viewed merely as sources of extractive resources but as ecological systems that sustain agricultural production.

However, increasing dependence on forest resources can also generate negative environmental consequences. Unsustainable harvesting, agricultural encroachment and excessive exploitation may contribute to deforestation, biodiversity decline, soil degradation and reduced ecosystem resilience (Mugadza, 2022). In Nigeria, population growth, agricultural expansion, fuelwood demand and weak resource governance have intensified pressure on forest reserves (Oyediji & Adenika, 2022). Declining forest resources may subsequently undermine agricultural productivity and increase livelihood vulnerability, particularly among households with limited economic alternatives (Akanwa et al., 2026).

These competing outcomes reveal the need for approaches that recognise both the livelihood importance of forests and the necessity for sustainable resource management. Integrated strategies such as agroforestry, community-based forest management, environmental education and livelihood diversification have therefore been promoted as pathways for achieving both conservation and livelihood objectives (Fajimi et al., 2025; Moussih et al., 2025).

2.5. Theoretical Framework: Sustainable Livelihood Framework

This study is anchored on the Sustainable Livelihood Framework (SLF), which provides a comprehensive approach for understanding how households utilise available resources to achieve livelihood outcomes under changing social, economic and environmental conditions (Opiyo et al., 2024). The framework, developed by the Department for International Development (DFID), conceptualises livelihoods as being shaped by households' access to different forms of capital, including natural, human, physical, financial and social assets (DFID, 2000).

Within the context of this study, natural forests represent a major component of natural capital, providing resources and ecosystem services that support agricultural livelihoods. Human capital is reflected through household characteristics such as education, farming experience and labour availability, while financial and physical capitals relate to income levels, market access and agricultural resources. Social and institutional factors, including extension services, forest governance and community participation, influence households' ability to access and sustainably utilise forest resources.

The SLF is relevant because it recognises that forest dependence is not merely an environmental issue but a consequence of interactions among livelihood assets, vulnerability conditions and institutional structures. Therefore, household dependence on natural forests around Gambari Forest Reserve is conceptualised as an outcome of the interaction between socio-economic characteristics, access to forest resources, institutional support and livelihood needs.

2.6. Research Gap and Contribution of the Study

Although previous studies have generated valuable insights into forest conservation (West et al, 2023), resource utilization (Beregniak et al., 2023) and rural livelihoods (Ray & Mukherjee, 2023), important knowledge gaps remain. Much of the existing research has examined forest degradation (Zhu et al., 2023), biodiversity conservation (Giakoumi et al., 2025) and agricultural productivity (Dimnwobi et al., 2023) independently, with limited empirical integration of the socio-economic factors linking forest ecosystems and agricultural livelihood systems.

Furthermore, evidence remains limited regarding how household characteristics, institutional conditions and perceived livelihood benefits collectively influence forest dependence among rural households surrounding forest reserves in southwestern Nigeria. Particularly, empirical studies focusing on the Gambari Forest Reserve context are scarce, despite the importance of the reserve as a livelihood and ecological resource for surrounding communities.

This study contributes to existing knowledge by providing an integrated assessment of the socio-economic interactions between natural forests and agricultural livelihoods. By examining forest resource utilisation, ecosystem services, livelihood benefits, environmental challenges and socio-economic determinants of forest dependence within a single analytical framework, the study provides evidence that can support sustainable forest management and rural livelihood development strategies in Nigeria and similar developing-country contexts.

3. Materials and Methods

3.1. Study design and context

This study was conducted around Gambari Forest Reserve, an International Union for Conservation of Nature (IUCN) Category IV forest reserve located in Ibadan, Oyo State, southwestern Nigeria, between latitudes 7°25' and 7°55' N and longitudes 3°53' and 3°09' E (Banjo et al., 2018). The reserve, originally established as Ibadan Forest Reserve in 1899, covers approximately 13,932.18 hectares and comprises five management zones: Mamu, Onigambari, Busogboro, Odo-Ona/Onipe and Olonde. The reserve lies within the Guinea and Derived Savanna ecological zones, characterised by annual rainfall ranging from 1,200 mm to 1,300 mm and an average annual temperature of approximately 27°C. The vegetation

consists of natural and plantation forests containing indigenous tree species as well as exotic species such as *Gmelina arborea* and *Tectona grandis*.

The surrounding communities depend largely on agriculture and forest-related livelihood activities, including crop farming, livestock production, fuelwood collection, hunting and harvesting of non-timber forest products (NTFPs) (Ogundana & Azeez, 2025). The combination of agricultural dependence and close interaction with forest resources makes Gambari Forest Reserve an appropriate setting for examining the socio-economic relationships between natural forests and rural livelihoods.

A descriptive survey research design was adopted because the study aimed to document household characteristics, patterns of forest resource utilisation, perceived livelihood benefits and environmental challenges associated with forest dependence. The design also enabled quantitative assessment of relationships between socio-economic factors and household dependence on natural forest resources.

The study was conducted between November 2025 and January 2026. The target population comprised rural households located within communities surrounding Gambari Forest Reserve whose livelihoods were associated with agricultural production and/or forest resource utilisation.

3.2. Data, variables, and sampling

3.2.1. Data Sources and Instrumentation

Primary data were collected using a structured questionnaire administered to selected rural household heads. The questionnaire consisted of closed- and open-ended questions covering socio-economic characteristics of respondents, agricultural and livelihood activities, forest resources utilized, ecosystem services derived from forests, perceived socio-economic benefits of forest–agriculture interactions, environmental and livelihood challenges associated with forest resource utilisation; and factors influencing household forest dependence.

The questionnaire was reviewed by experts in forestry extension, rural sociology, agricultural economics and natural resource management to establish content and face validity. A pilot test was conducted among 10 household heads from a neighbouring forest-dependent community outside the study area. Feedback obtained from the pilot survey was used to improve clarity and appropriateness of the questionnaire items before the final field survey.

3.2.2. Sampling Procedure and Sample Size

A multistage sampling procedure was employed to select respondents. In the first stage, the Onigambari zone was purposively selected from the five zones of Gambari Forest Reserve because of its high concentration of surrounding settlements, accessibility and the prevalence of forest-dependent livelihood activities.

In the second stage, eight communities were selected from the identified communities within the zone. The selected communities were Onigambari, Onipe, Ibusogboro, Longe, Darley, Olubi, Aba Ibadan and Seriki. The communities were selected based on their proximity to the forest reserve and involvement in agricultural and forest-related activities. Simple random sampling was subsequently applied to ensure adequate representation.

In the third stage, a household sampling frame consisting of households involved in farming and forest-related livelihood activities was developed with assistance from community leaders and agricultural extension personnel. In the final stage, 129 rural household heads were selected proportionately using systematic random sampling. The sampling interval for each community was determined by dividing the total number of eligible households by the required sample size allocated to that community.

Only household heads who had resided in the study communities and were involved in agricultural or forest-related livelihood activities were included. Households without direct engagement with farming or forest resource utilisation were excluded.

3.2.3. Variables and Measurement

Household forest dependence, the dependent variable in this study, was assessed using a composite Forest Dependence Index (FDI) developed from six key livelihood-related indicators that reflect the major forms of interaction between rural households and natural forest resources in the study area. The indicators comprised fuelwood collection, non-timber forest product (NTFP) harvesting, medicinal plant collection, hunting and wildlife resource utilisation, charcoal production, and the use of forest ecosystem services for agricultural production, including soil fertility improvement, water regulation and erosion control. These indicators were selected because they represent the principal forest-based activities and ecosystem services through which households derive livelihood benefits from the reserve.

Respondents were asked to indicate their level of dependence on each indicator using a five-point Likert-type scale, where 1 = Very Low Dependence, 2 = Low Dependence, 3 = Moderate Dependence, 4 = High Dependence, and 5 = Very High Dependence. Scores obtained for the six indicators were subsequently aggregated and averaged to compute the FDI for each respondent. Higher FDI scores indicate greater household reliance on natural forest resources for agricultural production, income generation and household sustenance, whereas lower scores reflect relatively limited dependence.

The Forest Dependence Index for each respondent was calculated formula 1:

$$FDI = \frac{\sum_{i=1}^n X_i}{6} \quad \text{.....eq. (1)}$$

Where:

FDI = Forest Dependence Index;

X_i = score for the i th forest dependence indicator;

6 = number of indicators included in the index.

The resulting FDI ranged from 1.00 to 5.00, with higher values indicating greater household dependence on forest resources. For ease of interpretation, respondents were classified into three levels of forest dependence based on their mean FDI scores: low dependence ($FDI \leq 2.50$), moderate dependence ($FDI = 2.51-3.50$), and high dependence ($FDI > 3.50$). These classification thresholds were adapted from the conventional interpretation of mean scores derived from five-point Likert scales in social science and natural resource research, where values below the midpoint indicate relatively low dependence, values around the midpoint indicate moderate dependence, and values substantially above the midpoint indicate high dependence. The use of a composite index to quantify household dependence on forest resources is consistent with established approaches in forest livelihood studies,

providing a transparent and reliable measure for assessing the extent of reliance on natural forest resources (Das et al., 2022; Das & Mallick, 2025).

The explanatory variables included in the multiple linear regression model were age (measured in years), household size (number of household members), farming experience (years of farming), educational status (highest level of formal education attained), farm size (measured in hectares), access to forest resources (measured on a five-point Likert scale reflecting respondents' ease of access to forest products and ecosystem services), and institutional support (measured on a five-point Likert scale assessing respondents' access to extension services, conservation programmes and community-based forest management support). These variables were selected based on their theoretical relevance within the Sustainable Livelihood Framework and their demonstrated influence on household forest dependence in previous empirical studies on forest-based livelihoods and rural development (Arowosoge et al., 2022; Chukwuone et al., 2021).

3.3. Analytical methods

Data analysis involved descriptive and inferential statistical techniques. All quantitative analyses were conducted using IBM Statistical Package for the Social Sciences (SPSS) version 25.

3.3.1. Descriptive Analysis

Descriptive statistics, comprising frequencies, percentages and mean scores, were used to summarise the socio-economic characteristics of respondents, livelihood activities, forest resources utilised, ecosystem services accessed, perceived socio-economic benefits derived from forest–agriculture interactions, and environmental challenges associated with forest resource utilisation. Perceived benefits, institutional factors and environmental challenges were measured using five-point Likert-type scales, with higher mean scores indicating greater perceived importance, stronger institutional influence or more severe environmental challenges.

3.3.2. Reliability Testing

The internal consistency reliability of the multi-item measurement scales was assessed using Cronbach's Alpha coefficient. The reliability analysis covered the scales measuring perceived socio-economic benefits, environmental challenges, institutional support, access to forest resources and household forest dependence. The overall Cronbach's Alpha coefficient was 0.81, indicating good internal consistency and exceeding the minimum acceptable threshold of 0.70 for social science research, thereby confirming that the instrument was sufficiently reliable for the study.

3.3.3. Multiple Linear Regression Analysis

Multiple linear regression was employed to examine the relationship between selected socio-economic factors and household dependence on natural forest resources.

The model was specified as formula 2

$$\text{Forest Dependence (FD)} = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \varepsilon \quad (2)$$

Where:

FD = Forest Dependence Index (dependent variable)

β_0 = intercept

β_1 – β_7 = regression coefficients

ϵ = error term

The explanatory variables were defined as:

X_1 (Age): Measured in years.

Age reflects respondents' maturity, livelihood experience and indigenous knowledge relating to forest resource utilisation and agricultural activities.

X_2 (Household Size): Measured as the number of persons within the household.

Larger households may exhibit higher dependence on forest resources due to increased household consumption needs and labour availability.

X_3 (Farming Experience): Measured as the number of years engaged in farming activities.

Farming experience may positively influence respondents' understanding of forest ecosystem services and agricultural resource management.

X_4 (Educational Status): Measured by the highest level of formal education attained.

Education is expected to influence environmental awareness, livelihood diversification and sustainable resource utilisation practices.

X_5 (Farm Size): Measured in hectares. Farm size reflects the scale of agricultural production.

Farm size may influence the extent of household reliance on forest resources.

X_6 (Access to Forest Resources): Measured using a five-point Likert-type scale reflecting respondents' ease of access to forest products and ecosystem services. Higher scores indicate greater accessibility to forest resources.

X_7 (Institutional Support): Measured on a five-point Likert-type scale capturing respondents' perceptions of extension services, conservation programmes and community-level forest management support available within the study area.

The statistical significance of individual predictors was tested using t-tests at the 5% significance level ($p < 0.05$). Overall model adequacy was assessed using the coefficient of determination (R^2) and F-statistic. The a priori expectation was that age, household size, farming experience, access to forest resources and institutional support would positively influence forest dependence because they increase resource knowledge, accessibility and livelihood opportunities. Educational status was expected to reduce excessive dependence due to improved awareness and livelihood diversification opportunities, while the effect of farm size could vary depending on agricultural productivity and resource requirements.

3.3.4. Ethical Considerations

The study complied with ethical principles governing research involving human participants. Ethical approval was obtained from the Federal College of Forestry, Ibadan research ethics committee before

commencement of data collection. Participation was voluntary, and informed consent was obtained from all respondents after explaining the objectives, procedures and intended use of the research findings. Respondents were assured of confidentiality, anonymity and their right to withdraw from participation at any stage. No personally identifiable information was collected, and all data were coded and securely stored for research purposes only.

4. Results

4.1 Socioeconomic Characteristics of Respondents

Table 1 presents the socio-economic characteristics of the respondents. The average age of the respondents was 47.6 years, with 58.1% falling within the 36–50 years age category. The mean farming experience was 11.4 years, and 61.2% of the respondents had between 6 and 15 years of farming experience. The average household size was seven persons, with 74.4% of the respondents having households comprising more than five members. Male respondents constituted 63.6% of the sample, while females accounted for 36.4%. Regarding educational attainment, 46.5% had secondary education, 30.2% had primary education, 12.4% had tertiary education and 10.9% had no formal education. Crop farming (82.9%) was the most common livelihood activity, followed by fuelwood collection (70.5%) and non-timber forest product gathering (65.1%). Livestock rearing (44.2%), petty trading (38.0%) and hunting (26.4%) were also reported. The Forest Dependence Index (FDI) indicated that 52.7% of the respondents exhibited a high level of forest dependence, 32.6% had moderate dependence and 14.7% had low dependence. The mean FDI score was 3.71, indicating an overall high level of household dependence on natural forest resources.

Table 1. Socio-Economic Characteristics of Respondents

Socio-Economic Characteristics	Frequency	Percentage
Age of Respondents (Years); Mean = 47.6 Years		
≤35	18	14.0
36–50	75	58.1
>50	36	27.9
Farming Experience (Years); Mean = 11.4 Years		
≤5	21	16.3
6–15	79	61.2
>15	29	22.5
Household Size; (Persons) Mean = 7 Persons		
≤5	33	25.6
>5	96	74.4
Sex of Respondents		
Male	82	63.6
Female	47	36.4
Educational Status		
No Formal Education	14	10.9
Primary Education	39	30.2
Secondary Education	60	46.5
Tertiary Education	16	12.4
Major Livelihood Activities		
Crop Farming	107	82.9
Fuelwood Collection	91	70.5
Non-Timber Forest Product Gathering	84	65.1

Socio-Economic Characteristics	Frequency	Percentage
Livestock Rearing	57	44.2
Petty Trading	49	38.0
Hunting	34	26.4
Forest Dependence Level; Mean FDI Score = 3.71		
Low Dependence (≤ 2.50)	19	14.7
Moderate Dependence (2.51–3.50)	42	32.6
High Dependence (> 3.50)	68	52.7

Source: Authors' calculations based on field survey data (November 2025–January 2026).

4.2 Forest Dependence Indicators

Table 2 presents respondents' dependence on specific forest resources and ecosystem services measured using the Forest Dependence Index. Fuelwood collection recorded the highest mean score (4.32), followed by non-timber forest product harvesting (4.15) and utilisation of forest ecosystem services for agricultural production (4.01). Medicinal plant collection also recorded a relatively high mean score (3.89). Hunting and wildlife resource utilisation recorded a mean score of 3.42, while charcoal production had the lowest mean score (3.18) among the six indicators. Overall, all indicators recorded mean scores above the midpoint of the five-point scale, indicating varying levels of household dependence on different forest resources and services.

Table 2. Forest Dependence Indicators among Rural Households

Forest Dependence Indicator	Mean Score	Rank
Fuelwood Collection	4.32	1 st
Non-Timber Forest Products Harvesting	4.15	2 nd
Forest Ecosystem Services for Agriculture	4.01	3 rd
Medicinal Plant Collection	3.89	4 th
Hunting and Wildlife Resources	3.42	5 th
Charcoal Production	3.18	6 th

Source: Authors' calculations based on field survey data (November 2025–January 2026).

4.3 Major Forest Resources and Ecosystem Services Utilised for Agricultural Livelihoods

The forest resources and ecosystem services utilised by respondents are presented in Table 3. Fuelwood was the most frequently utilised forest resource (78.3%), followed by medicinal plants (69.8%), wild food products (63.6%) and poles and timber products (58.1%). Fruits and honey were utilised by 47.3% of the respondents, while 14.7% reported using other forest resources. Among the ecosystem services, soil fertility improvement was identified by 72.1% of the respondents, followed by erosion control (64.3%), water supply regulation (59.7%), climate regulation (50.4%) and shade and wind protection (41.9%). These results indicate that respondents utilised both forest products and ecosystem services for agricultural and livelihood purposes.

Table 3. Major Forest Resources and Ecosystem Services Utilised

Variables		Frequency	Percentage
Forest Resources Utilised	Fuelwood	101	78.3
	Medicinal Plants	90	69.8
	Wild Food Products	82	63.6
	Poles and Timber Products	75	58.1
	Fruits and Honey	61	47.3
	Others	19	14.7
	Soil Fertility Improvement	93	72.1

Variables		Frequency	Percentage
Ecosystem Services Utilised	Erosion Control	83	64.3
	Water Supply Regulation	77	59.7
	Climate Regulation	65	50.4
	Shade and Wind Protection	54	41.9

Source: Authors' calculations based on field survey data (November 2025–January 2026).

Note: Multiple responses.

4.4 Perceived Socio-Economic Benefits Derived from Forest–Agriculture Interactions

Table 4 presents respondents' perceptions of the socio-economic benefits derived from forest–agriculture interactions. Income generation recorded the highest mean score (4.28), followed by food security support (4.16) and livelihood diversification (4.04). Employment opportunities recorded a mean score of 3.88, while household energy supply had a mean score of 3.75. All benefit indicators recorded mean values above 3.50, indicating that respondents generally perceived natural forests as making substantial contributions to household livelihoods.

Table 4. Perceived Socio-Economic Benefits Derived from Forest–Agriculture Interactions

Perceived Benefits	Mean	Interpretation of Mean Value
Income Generation	4.28	Very high contribution to household income
Food Security Support	4.16	Strong contribution to food availability
Livelihood Diversification	4.04	High contribution to livelihood resilience
Employment Opportunities	3.88	Moderate contribution to employment
Household Energy Supply	3.75	Moderate contribution to domestic energy needs

Source: Authors' calculations based on field survey data (November 2025–January 2026).

4.5 Perceived Environmental and Livelihood Challenges Associated with Forest Resource Utilisation

The environmental and livelihood challenges associated with forest resource utilisation are presented in Table 5. Deforestation was the most frequently reported challenge, accounting for 76.7% of respondents, followed by declining forest resources (70.5%) and land degradation (62.0%). Climate variability was identified by 54.3% of respondents, while 38.8% reported conflicts relating to resource access. Other challenges were reported by 16.3% of the respondents.

Overall, respondents identified multiple environmental and livelihood challenges associated with the utilisation of natural forest resources within the study area.

Table 5. Perceived Environmental and Livelihood Challenges

Perceived Challenges	Frequency	Percentage
Deforestation	99	76.7
Declining Forest Resources	91	70.5
Land Degradation	80	62.0
Climate Variability	70	54.3
Resource Access Conflicts	50	38.8
Others	21	16.3

Source: Authors' calculations based on field survey data (November 2025–January 2026).

Note: Multiple responses.

4.6 Factors Influencing Household Dependence on Natural Forest Resources

The results of the multiple linear regression analysis are presented in Table 6. The model produced an R^2 value of 0.446, indicating that 44.6% of the variation in household forest dependence was explained by the explanatory variables included in the model. The overall regression model was statistically significant ($F = 9.213$, $p < 0.001$). Among the explanatory variables, age ($\beta = 0.184$, $p = 0.012$), household size ($\beta = 0.273$, $p = 0.001$), farming experience ($\beta = 0.316$, $p < 0.001$), access to forest resources ($\beta = 0.402$, $p < 0.001$) and institutional support ($\beta = 0.193$, $p = 0.031$) had positive and statistically significant effects on household forest dependence. In contrast, educational status had a negative and statistically significant effect ($\beta = -0.221$, $p = 0.018$). Farm size showed a positive but statistically non-significant relationship with household forest dependence ($\beta = 0.091$, $p = 0.287$).

Based on these results, the null hypothesis (H_{01}) stating that there is no significant relationship between selected socio-economic characteristics of rural households and their dependence on natural forest resources was rejected. The results indicate that household forest dependence was significantly associated with age, household size, farming experience, educational status, access to forest resources and institutional support, whereas farm size did not exhibit a statistically significant relationship.

Table 6. Factors Influencing Household Dependence on Natural Forest Resources

Variables	β	t	p-value
(Constant)	-1.213	-0.847	0.399
Age	0.184	2.563	0.012**
Household Size	0.273	3.418	0.001***
Farming Experience	0.316	4.802	<0.001***
Educational Status	-0.221	-2.398	0.018**
Farm Size	0.091	1.069	0.287
Access to Forest Resources	0.402	5.921	<0.001***
Institutional Support	0.193	2.184	0.031**
Model Statistics	Value		
R	0.668		
R^2	0.446		
Adjusted R^2	0.411		
F-statistic	9.213		

Source: Authors' calculations based on field survey data (November 2025–January 2026).

Dependent Variable: Household Dependence on Natural Forest Resources

Note: Dependent variable = Household Forest Dependence Index (FDI). B = unstandardized regression coefficient; t = t-statistic; p = probability value; R^2 = coefficient of determination; Adjusted R^2 = adjusted coefficient of determination; F -statistic = overall model significance. Statistical significance was evaluated at the 5% level ($p < 0.05$), with ** indicating $p < 0.05$ and *** indicating $p < 0.001$.

5. Discussion

The findings make evident that forest–agriculture interactions around Gambari Forest Reserve are embedded within complex socio-economic and ecological livelihood systems. The predominance of economically active and experienced farmers suggests that forest dependence is strongly influenced by accumulated ecological knowledge and long-term engagement with local production systems. The significant influence of age and farming experience on forest dependence supports the view that indigenous knowledge shapes household decisions regarding forest utilisation. Similar observations were reported by Wana et al. (2023) in Ethiopia and Roongtawanreongsri et al. (2023) in Vietnam, where older and more experienced farmers demonstrated greater capacity to utilise forest resources

and ecosystem services. However, such dependence may also reflect limited livelihood alternatives, implying that local knowledge can simultaneously enhance adaptive capacity while reinforcing reliance on natural resources.

The influence of household characteristics further highlights the socio-economic drivers of forest dependence. Larger households exhibited greater reliance on forest resources, consistent with findings from Arabomen and Babalola (2025) in Nigeria and Gelan (2023) in Ethiopia, where household size increased demand for forest products and livelihood resources. Conversely, the negative relationship between education and forest dependence suggests that improved human capital can facilitate livelihood diversification and promote sustainable resource-use behaviour. This agrees with Nguyen and Hong (2026), Iqbal et al. (2025), and Ullah et al. (2025), who found that education enhances access to alternative employment opportunities and strengthens environmental awareness.

The high level of forest dependence observed among households indicates that natural forests remain essential livelihood assets, providing energy, food, income, and agricultural support services. This finding aligns with Begazo-Curie and Vranken (2025) in Peru, Beckline et al. (2022) in Cameroon, and Saha and Agarwalla (2025) in Ghana, who demonstrated that forest resources contribute significantly to household resilience, food security, and income diversification. The findings extend existing evidence by showing that, in the Gambari Forest Reserve landscape, forests are not merely supplementary resources but are integrated into everyday agricultural and livelihood strategies. This supports the Sustainable Livelihood Framework, which recognises natural capital as a critical asset that interacts with human, physical, and institutional resources to enhance household resilience (Marion et al., 2026; Das & Mallick, 2025; Nayak et al., 2025).

The dominance of fuelwood, non-timber forest products (NTFPs), and forest ecosystem services further confirms the multifunctional role of forests. Fuelwood dependence reflects persistent rural energy challenges, consistent with Sagali et al. (2024), Das and Mallick (2025), Nayak et al. (2025), and Teli et al. (2026), who reported continued reliance on biomass energy among rural communities. Similarly, the importance of NTFPs supports findings by Gelan (2023), Beckline et al. (2022), and Begazo-Curie and Vranken (2025), which highlight their contribution to household income, nutrition, and livelihood diversification. The recognition of ecosystem services such as soil fertility improvement, erosion control, and climate regulation reinforces ecosystem services theory by demonstrating that forests support agricultural productivity beyond direct resource extraction. Comparable evidence from Vietnam, India, and Peru confirms the role of forest ecosystem services in enhancing agricultural resilience and sustainability (Do et al., 2025; Mulungu & Manning, 2023; Wang et al., 2025).

Despite these benefits, the reported challenges of deforestation, declining forest resources, and land degradation reveal a growing livelihood–conservation dilemma. Similar concerns have been documented in Burkina Faso, Ethiopia, Cameroon, and India, where unsustainable resource exploitation threatens both ecosystem functions and rural welfare (Ouédraogo et al., 2025; Takele, 2024; Gelan, 2023; Beckline et al., 2022; Das & Mallick, 2025; Kashyap et al., 2026). The findings therefore suggest that conservation approaches based solely on restricting access may undermine household welfare unless accompanied by livelihood alternatives and participatory management mechanisms.

The regression results further indicate that forest dependence is shaped by the interaction of demographic, accessibility, and institutional factors. The strong influence of access to forest resources

confirms that proximity and availability remain central determinants of resource utilisation, consistent with findings from India, Vietnam, and Indonesia (Kashyap et al., 2026; Do et al., 2025; Armanto & Wildayana, 2022). Similarly, the significant role of institutional support agrees with Akamani (2023), Gelan (2023), and Senganimalunje et al. (2022), who emphasised the importance of governance structures, extension services, and community participation in sustainable forest management.

As a whole, this study contributes empirically by providing context-specific evidence from southwestern Nigeria on how socio-economic characteristics, ecosystem services, and institutional conditions jointly shape forest-dependent livelihoods. The findings reinforce the need for integrated forest management strategies that combine conservation with livelihood improvement through sustainable NTFP enterprises, agroforestry, climate-smart agriculture, alternative energy solutions, environmental education, and community-based governance. Nevertheless, since the study focused on a single forest reserve, broader generalisation requires comparative research across diverse ecological and institutional settings in Nigeria. Future studies should also incorporate longitudinal and ecological assessments to better understand how changing environmental conditions influence forest dependence and livelihood resilience over time.

6. Conclusions

This study provides evidence of the strong socio-economic and ecological linkages between natural forests and agricultural livelihoods among rural households surrounding Gambari Forest Reserve, Ibadan, Oyo State, Nigeria. The findings establish that forest resources remain essential livelihood assets, supporting household income generation, food security, energy supply, livelihood diversification, and agricultural sustainability. Rural households rely on forests not only through direct utilisation of resources such as fuelwood, non-timber forest products, and medicinal plants but also through ecosystem services that enhance agricultural productivity, including soil fertility improvement, erosion control, and climate regulation.

The study further establishes that forest dependence is shaped by a combination of socio-economic, accessibility, and institutional factors. Household characteristics, including age, household size, farming experience, and educational status, significantly influence the extent of reliance on forest resources, while access to forest resources and institutional support play critical roles in determining household–forest interactions. These findings highlight that forest dependence is not solely a consequence of resource availability but results from the interaction between household capabilities, livelihood needs, environmental accessibility, and governance conditions.

A key contribution of this study is its confirmation of the interconnected nature of forest conservation and rural livelihood development within a Nigerian forest reserve context. The findings extend existing knowledge by showing that forests function simultaneously as livelihood assets and ecological support systems for agricultural communities. However, the increasing challenges of deforestation, declining forest resources, land degradation, and resource pressures indicate that continued dependence without effective management strategies may undermine the long-term sustainability of these benefits.

The study therefore call attention to the need for integrated forest management approaches that balance conservation objectives with local livelihood realities. Strategies that promote sustainable utilisation of forest resources, community-based forest governance, alternative livelihood

opportunities, agroforestry, climate-smart agricultural practices, and environmental education are essential for reducing unsustainable pressure on forest ecosystems while improving household resilience.

Ultimately, maintaining the ecological integrity of Gambari Forest Reserve requires recognising rural communities as important stakeholders in conservation rather than merely users of forest resources. Sustainable outcomes will depend on policies and interventions that strengthen the relationship between forest protection, agricultural sustainability, and rural development. The findings provide useful evidence for policymakers, forestry institutions, and development practitioners seeking to design inclusive approaches for managing forest-dependent landscapes in Nigeria and similar developing-country contexts.

6.1. Practical and policy implications

The findings of this study have important practical, institutional, and policy implications for achieving sustainable management of Gambari Forest Reserve while improving the welfare of surrounding rural households. The results reveal that forest resources remain critical livelihood assets; therefore, conservation interventions that focus exclusively on restricting access and utilisation may undermine household welfare and create conflicts between conservation objectives and livelihood needs. A balanced approach that integrates ecological protection with livelihood improvement is required.

For forestry authorities and conservation agencies, the findings highlight the need to strengthen participatory and community-based forest management approaches. Since local households possess valuable ecological knowledge and depend on forest resources for their livelihoods, involving them in decision-making, monitoring, and sustainable resource management activities can improve conservation compliance and ownership. Management strategies should incorporate sustainable harvesting guidelines for fuelwood and non-timber forest products (NTFPs) to reduce pressure on forest resources while maintaining legitimate livelihood benefits.

The continued dependence on fuelwood indicates the need for rural energy interventions. Relevant stakeholders, including government agencies, development organisations, and local institutions, should promote access to alternative and efficient energy technologies, such as improved cookstoves and other sustainable household energy options, to reduce excessive dependence on forest biomass. Such interventions should be designed alongside awareness programmes to encourage responsible resource utilisation.

The importance of NTFPs in household livelihoods suggests opportunities for strengthening forest-based enterprises. Forestry institutions and rural development agencies should support value addition, processing, market access, and entrepreneurship development for products such as medicinal plants, fruits, honey, and other forest-derived resources. These measures can enhance household income while creating incentives for sustainable forest conservation.

The significant influence of education and institutional support on forest dependence also highlights the importance of capacity building and extension services. Government agencies, research institutions, and non-governmental organisations should intensify environmental education, sustainable agricultural training, and livelihood development programmes among forest-adjacent

communities. Such initiatives should promote climate-smart agriculture, agroforestry practices, and improved resource management techniques that reduce excessive dependence on natural forests.

Given the role of accessibility in shaping forest dependence, forest governance policies should adopt context-specific resource management arrangements rather than uniform restrictions. Regulations should recognise local livelihood realities and establish clear, transparent, and sustainable access mechanisms that balance conservation requirements with household needs. Strengthening collaboration among forestry agencies, local communities, traditional institutions, and development partners will be essential for effective implementation.

At the broader policy level, the findings support the integration of forest conservation into rural development and agricultural policies. Sustainable forest management should be linked with poverty reduction, food security, climate adaptation, and livelihood diversification programmes. Policymakers should therefore promote integrated landscape management approaches that recognise forests and agricultural systems as interconnected components of rural economies.

Altogether, the sustainable future of Gambari Forest Reserve depends on policies that move beyond conservation-oriented restrictions towards inclusive management frameworks that combine ecosystem protection with improved rural livelihoods. By addressing the socio-economic drivers of forest dependence while strengthening community participation and institutional support, stakeholders can enhance both forest resilience and the long-term welfare of surrounding households.

6.2. Limitations and Future Research

Although this study provides important insights into the socio-economic interactions between natural forests and agricultural livelihoods around Gambari Forest Reserve, some limitations should be acknowledged. First, the study was conducted within communities surrounding a single forest reserve; therefore, the findings are context-specific and should be interpreted within the ecological, socio-economic, and institutional conditions of the study area. Variations in forest characteristics, governance structures, market conditions, and livelihood opportunities across different regions may influence patterns of forest dependence and household responses. Consequently, caution should be exercised when generalising the findings to other forest landscapes in Nigeria or beyond.

Second, the study relied primarily on cross-sectional household survey data and respondents' self-reported information regarding forest utilisation, livelihood benefits, and perceived environmental challenges. Although this approach provided valuable insights into household experiences and perceptions, it may be influenced by recall limitations and subjective assessments. Future studies could strengthen evidence by adopting longitudinal approaches to examine changes in forest dependence, livelihood strategies, and ecosystem conditions over time.

Third, the study focused mainly on household-level socio-economic and livelihood dimensions of forest dependence. While this provided useful understanding of human–forest interactions, future research should incorporate more ecological indicators, such as forest cover changes, biodiversity status, resource availability, and ecosystem health assessments, to provide a more integrated evaluation of forest sustainability. Combining household surveys with remote sensing, geographic information systems (GIS), and ecological monitoring would enhance understanding of the relationship between livelihood activities and forest ecosystem dynamics.

Furthermore, the study provides limited attention to gender-specific patterns of forest resource utilisation and decision-making. Given that men and women often engage differently with forest resources, future research should examine gender roles, access, control over forest benefits, and participation in forest governance processes. Such studies would provide deeper insights for designing inclusive and equitable forest management interventions. Future research should also explore the effectiveness of alternative livelihood programmes, community-based forest management initiatives, and climate-smart agricultural practices in reducing unsustainable forest dependence while maintaining household welfare. Comparative studies across multiple forest reserves and ecological zones in Nigeria would further improve understanding of how institutional arrangements, environmental conditions, and socio-economic factors interact to shape forest-dependent livelihoods.

Addressing these limitations through broader, longitudinal, and interdisciplinary research approaches will contribute to more comprehensive evidence for developing sustainable forest management policies that simultaneously promote ecosystem conservation, agricultural resilience, and rural livelihood improvement.

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