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Evaluation of Livelihood Dependence on Ecosystem Services and Willingness to Participate in Payment for Ecosystem Services in Oluwa Forest Reserve, Nigeria

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ABSTRACT
Ecosystem services provided by tropical forests are fundamental to rural livelihoods, yet increasing anthropogenic pressures threaten their sustainability. This study evaluated livelihood dependence on ecosystem services and willingness to participate in Payment for Ecosystem Services (PES) in the Oluwa Forest Reserve, southwestern Nigeria, using an integrated ecosystem service–livelihood–valuation framework. Primary data were collected from 450 households in eight forest-adjacent communities through structured questionnaires, complemented by key informant interviews and field observations. Descriptive statistics, the Livelihood Dependence Index (LDI), economic valuation techniques (market price, contingent valuation and benefit transfer methods), multiple regression and binary logistic regression were employed for data analysis. Provisioning services, particularly fuelwood, food crops, medicinal plants, timber and bushmeat, were the most utilized ecosystem services, while regulating services such as soil fertility maintenance, erosion control and climate regulation were also widely recognized. The mean LDI of 0.54 indicates moderate to high dependence on forest resources. Ecosystem services contributed an estimated annual value of ₦520,000 per household, with provisioning services accounting for the largest share. Age and household size significantly increased livelihood dependence, whereas education, non-forest income and distance from the forest reduced dependence. Education, income and awareness of ecosystem services significantly increased willingness to participate in PES schemes. The study concludes that sustainable management of the Oluwa Forest Reserve requires strengthened community-based forest management, livelihood diversification, environmental education and the implementation of equitable PES schemes to balance ecosystem conservation with rural livelihood improvement.

Keywords: Livelihood diversification; Payment for Ecosystem Services; forest governance; rural households; environmental valuation; socio-ecological systems

INTRODUCTION

Ecosystem services (ES) represent the diverse benefits that humans derive from natural ecosystems and form a critical link between ecological systems and human well-being. These services are broadly categorized into provisioning, regulating, cultural, and supporting services, including food, fuelwood, timber, climate regulation, soil fertility, and biodiversity conservation. Recent global assessments emphasize that ecosystem services are fundamental to sustainable development, poverty reduction, and climate resilience, particularly in forest-dependent regions (Food and Agriculture Organization [FAO], 2022; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2022).

Forests in sub-Saharan Africa play a vital role in sustaining rural livelihoods by providing essential goods and services that support income generation, food security, and socio-cultural stability. Empirical evidence suggests that a significant proportion of rural households depend directly on forest ecosystems for subsistence and economic activities, especially through the exploitation of timber and non-timber forest products (NTFPs) (Angelsen et al., 2014; Wunder et al., 2021). However, increasing demand for agricultural land, fuelwood, and forest products has intensified pressure on forest ecosystems, resulting in widespread degradation and loss of ecosystem services (FAO, 2022).

The Oluwa Forest Reserve, located in Ondo State, represents one of the remaining lowland rainforest ecosystems in southwestern Nigeria, characterized by high biodiversity and significant ecosystem service provision. The reserve supports numerous rural and migrant communities whose livelihoods are intricately linked to forest resources. These communities depend heavily on provisioning services such as fuelwood, bushmeat, medicinal plants, and agricultural land, as well as regulating services including erosion control, carbon sequestration, and microclimate stabilization.

Despite its ecological and socio-economic importance, the Oluwa Forest Reserve is increasingly threatened by anthropogenic pressures such as illegal logging, agricultural encroachment, and unsustainable harvesting of forest resources. These pressures are largely driven by population growth, poverty, weak institutional frameworks, and limited livelihood alternatives. Recent studies on forest landscape restoration emphasize that human activities both depend on and contribute to forest degradation, underscoring the need to understand forests as complex social–ecological systems (Chazdon et al., 2023). The continued degradation of forest ecosystems threatens biodiversity conservation and undermines the sustainability of ecosystem services upon which local livelihoods depend.

In response to these challenges, there is growing global interest in integrating ecosystem service assessment with

economic valuation and livelihood analysis to inform sustainable resource management. The valuation of ecosystem services has gained prominence as a tool for making the contributions of nature visible in economic decision-making and policy processes (Costanza et al., 2017; IPBES, 2022). Such approaches are particularly important in developing countries, where natural capital constitutes a significant component of rural livelihoods but is often excluded from formal economic accounting systems.

Furthermore, incentive-based conservation mechanisms such as Payment for Ecosystem Services (PES) have emerged as promising approaches for aligning environmental conservation with livelihood improvement. PES schemes provide financial or in-kind incentives to individuals or communities for maintaining ecosystem services, thereby promoting sustainable land-use practices. Evidence suggests that well-designed PES interventions can enhance ecosystem conservation while improving rural incomes and reducing poverty (Wunder, 2015; Salzman et al., 2018; World Bank, 2023).

Notwithstanding these advances, there remains a critical gap in integrated empirical studies that simultaneously (i) identify and classify ecosystem services, (ii) assess the extent of livelihood dependence, (iii) estimate the economic value of ecosystem services, and (iv) examine socio-economic drivers and community willingness to participate in conservation initiatives. Existing studies in Nigeria have largely treated these components in isolation, limiting the development of comprehensive and policy-relevant insights for sustainable forest management.

This study addresses this gap by adopting an integrated ecosystem service–livelihood–economic valuation framework to evaluate the ecosystem services of the Oluwa Forest Reserve, assess the dependence of surrounding communities on these services, and estimate their economic value. In alignment with the study objectives, the research further examines the socio-economic determinants of resource dependence and explores community perceptions and willingness to participate in conservation initiatives such as PES. By providing a holistic understanding of the interactions between ecosystem services and human livelihoods, the study contributes to evidence-based policy formulation and sustainable forest management strategies in Nigeria and similar tropical forest landscapes.

MATERIALS AND METHODS

Study Area

The study was conducted in and around the Oluwa Forest Reserve located in Ondo State, southwestern Nigeria. The reserve is a lowland tropical rainforest ecosystem characterized by rich biodiversity and significant ecosystem service provision. Forest ecosystems in tropical regions are widely recognized for their role in supporting livelihoods and providing multiple ecosystem services across provisioning, regulating, cultural, and supporting categories (Osewe et al., 2024).

The surrounding communities, including Ore, Oluwa, Ikaram, Ago-Oyinbo, Temidire Camp, Igbo Camp, Ijoba Camp, and Aba Oyinbo, depend heavily on forest resources for subsistence and income generation, consistent with evidence that forest-edge communities derive substantial livelihood benefits from ecosystem services (Osewe et al., 2024).

Sampling Procedure and Sample Size

A multi-stage sampling technique was employed. First, communities were purposively selected based on proximity to the forest reserve and degree of dependence on forest resources. Second, households were selected using systematic random sampling.

A total of 450 respondents were surveyed. This sample size is consistent with similar ecosystem services and valuation studies that employ household-level surveys ranging between 300 and 500 respondents for robust statistical inference (Chen et al., 2022; Costanza et al., 2017).

The distribution of respondents was proportional to community size and forest dependence (Table1).

Table 1: Distribution of Respondents

S/N	Community	Size Category	Respondents
1	Ore	Large	100
2	Oluwa	Medium	70
3	Ikaram	Medium	60
4	Ago-Oyinbo	Medium	60
5	Aba Oyinbo	Medium	50
6	Temidire Camp	Small (forest camp)	40
7	Igbo Camp	Small (forest camp)	35
8	Ijoba Camp	Small (forest camp)	35
	Total		**450**

This proportional allocation reflects realistic settlement patterns and aligns with participatory and community-based ecosystem service studies that emphasize representativeness across socio-ecological gradients (Rahaman et al., 2025)

Data Collection

Primary data were collected using structured questionnaires, key informant interviews, and field observations. Questionnaire-based household surveys are widely used in ecosystem service assessments because they capture local perceptions, utilization patterns, and socio-economic characteristics (Osewe et al., 2024; Rahaman et al., 2025).

The questionnaire covered:

i. Socio-economic characteristics
ii. Types and classification of ecosystem services
iii. Income from forest and non-forest sources
iv. Livelihood dependence
v. Perceptions of ecosystem service changes
vi. Willingness to participate in PES

Secondary data were obtained from literature, institutional reports, and policy documents.

Analytical Techniques

A combination of descriptive statistics, economic valuation methods, and econometric models was employed, reflecting best practices in ecosystem service assessment (ISA, 2023)

Identification and Classification of Ecosystem Services
Ecosystem services were identified and classified using the Millennium Ecosystem Assessment framework. This classification approach is widely adopted in ecosystem service studies for consistency and comparability across regions (Osewe et al., 2024)

Livelihood Dependence Analysis
Livelihood dependence was assessed using the Livelihood Dependence Index (LDI) expressed as:

$$LDI = \frac{\text{Income from Ecosystem Services}}{\text{Total Household Income}}$$

Where:

i. LDI = Livelihood Dependence Index
ii. Income from Ecosystem Services = Annual income derived from forest ecosystem services (timber, fuelwood, NTFPs, bushmeat, etc.)
iii. Total Household Income = Total annual income from both forest and non-forest livelihood activities.

The index ranges from 0 to 1, where higher values indicate greater dependence on ecosystem services.
This approach is commonly used in forest livelihood studies to quantify the contribution of ecosystem services to household welfare (Osewe et al., 2024)

Economic Valuation of Ecosystem Services
The study employed multiple valuation techniques to capture both market and non-market values:

i. Market Price Method for provisioning services
ii. Contingent Valuation Method (CVM) for non-market services
iii. Benefit Transfer Method for indirect valuation

The CVM is widely accepted for estimating willingness to pay for environmental goods, particularly where market prices are absent (Wunder, 2015)
Similarly, combining valuation methods enhances the robustness of ecosystem service valuation studies (Costanza et al., 2017)

Determinants of Livelihood Dependence
The determinants of livelihood dependence were analyzed using a multiple linear regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon$$

Where:
$Y =$ Livelihood Dependence Index (LDI)$\beta_0 =$ Intercept
$\beta_1 - \beta_5 =$ Regression coefficients
$X_1 =$ Age of respondent
$X_2 =$ Education level
$X_3 =$ Household size
$X_4 =$ Non-forest income
$X_5 =$ Distance to the forest
$\varepsilon =$ Random error term

Regression-based approaches are widely used to explain variations in ecosystem service dependence and valuation outcomes, with variables such as income, education, and household size influencing results (Angelsen et al., 2014; Adedeji et al., 2025)

Willingness to Participate in PES
Willingness to participate in Payment for Ecosystem Services (PES) schemes was analyzed using both descriptive statistics and a binary logistic regression model. The logistic regression approach is appropriate because the dependent variable is dichotomous, capturing whether a respondent is willing to participate in PES (1 = willing, 0 = not willing).

A binary logistic regression model was employed to analyze households' willingness to participate in PES schemes.
The model is specified as:

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where:
$P =$
Probability that a household is willing to participate in PES
$1 - P =$
Probability that a household is not willing to participate
$\frac{P}{1-P} =$ Odds of willingness to participate
$\ln\left(\frac{P}{1-P}\right) =$ Natural logarithm of the odds (Logit)
$\beta_0 =$ Intercept
$\beta_1 - \beta_4 =$ Regression coefficients
$X_1 =$ Education level
$X_2 =$ Household income
$X_3 =$ Awareness of ecosystem services
$X_4 =$ Household size
$\varepsilon =$ Random error term

Based on the study design and empirical estimation, the explanatory variables included:
Education level
Household income
Awareness of ecosystem services
Household size
The logistic regression model estimates the likelihood of participation as a function of these variables, allowing for the identification of key socio-economic drivers influencing engagement in PES initiatives. The coefficients obtained from the model were interpreted in terms of their direction and statistical significance, indicating whether each variable increases or decreases the probability of participation.
This approach is widely used in environmental valuation and PES studies because it effectively captures decision-making behavior under binary outcomes. Logistic regression models have been extensively applied in willingness-to-pay and participation studies to identify determinants of environmental engagement and conservation behavior (Wunder et al. (2021)).

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents
The socio-economic profile of respondents (Table 2) provides critical insight into the structure of livelihoods and the underlying factors shaping dependence on ecosystem services in the Oluwa Forest Reserve. The distribution of respondents across gender, age, education, household size, and primary occupation reflects the demographic and economic realities of forest-dependent communities in southwestern Nigeria.
The gender distribution reveals a clear male dominance, with 66.2% of respondents being male compared to 33.8% female. This pattern suggests that men are more actively engaged in forest-based livelihood activities or are more represented in household decision-making processes related to resource use. This finding is consistent with broader evidence that forest extraction activities such as logging, hunting, and fuelwood collection are typically male-dominated in rural African forest systems, while women often participate in complementary roles such as processing and trading of non-timber forest products (Angelsen et al., 2014; Wunder et al., 2021).
In terms of age distribution, the majority of respondents (55.1%) fall within the economically active age group of 30–50 years, followed by 28.9% above 50 years, and only 16.0% below 30 years. This indicates that livelihood dependence on

ecosystem services is largely concentrated among mature and economically active individuals who possess the physical capacity, experience, and social networks required for forest-based activities. The relatively lower representation of younger individuals may reflect rural–urban migration trends and the gradual shift away from traditional forest-based livelihoods among rural youth (Osewe et al., 2024).

Furthermore, educational attainment among respondents is relatively low, with 30.7% having no formal education and 36.0% possessing only primary education, while 33.3% have secondary education or higher. This distribution highlights limited human capital development within the study area, which has important implications for livelihood diversification and adaptive capacity. In line with existing evidence, lower levels of education are often associated with higher dependence on natural resources, as individuals with limited formal education tend to have reduced access to formal employment opportunities and thus rely more on forest resources for income and subsistence (Chen et al., 2022; Angelsen et al., 2014).

Likewise, household size distribution shows that a majority (51.1%) of respondents belong to households with 5–8 members, while 24.4% each fall within the smaller (1–4) and larger (>8) household categories. Larger household sizes are characteristic of rural settings and can increase dependence on ecosystem services due to higher consumption needs, particularly for fuelwood, food, and income generation. At the same time, larger households may provide additional labor for resource extraction, thereby reinforcing reliance on forest ecosystems, as similarly observed in forest livelihood studies in Sub-Saharan Africa (Osewe et al., 2024; Adedeji et al., 2025).

The occupational distribution further underscores the significance of natural resources to livelihoods in the study area. A significant proportion of respondents (60.0%) are primarily engaged in farming, followed by 21.1% in trading and 18.9% in forestry-related activities. The dominance of farming indicates that agriculture remains the backbone of rural livelihoods, often closely integrated with forest resources through practices such as shifting cultivation, agroforestry, and the harvesting of forest products. This pattern aligns with empirical findings that rural forest-edge livelihoods are typically hybrid systems combining agriculture and forest resource extraction (Angelsen et al., 2014; FAO, 2022).

Findings therefore show that socio-economic characteristics of respondents suggest a population that is moderately educated, largely within the economically active age group, and heavily reliant on natural resource-based livelihoods. These attributes have significant implications for ecosystem service dependence, as they shape both the capacity and necessity for households to utilize forest resources. The observed patterns are consistent with empirical literature indicating that demographic and socio-economic factors, particularly education, household size, income opportunities, and occupation, play a crucial role in determining the extent and nature of dependence on ecosystem services in forest-edge communities (Chen et al., 2022; Osewe et al., 2024; Wunder et al., 2021).

Table 2: Socio-economic Characteristics of Respondents

Variable	Category	Frequency	Percentage (%)
Gender	Male	298	66.2
	Female	152	33.8
Age (years)	<30	72	16.0
	30–50	248	55.1
	>50	130	28.9
Education	No formal education	138	30.7
	Primary	162	36.0
	Secondary & above	150	33.3
Household size	1–4	110	24.4
	5–8	230	51.1
	>8	110	24.4
Primary occupation	Farming	270	60.0
	Trading	95	21.1
	Forestry-related	85	18.9

Identification and Classification of Ecosystem Services

Table 3 depicts the identification and classification of ecosystem services in the study area, revealing the multifaceted role of the Oluwa Forest Reserve in supporting rural livelihoods and ecological stability. The results, structured according to the Millennium Ecosystem Assessment framework, highlight the prominence of provisioning, regulating, cultural, and supporting services, with varying degrees of dependence and recognition among respondents (Millennium Ecosystem Assessment, 2005; Osewe et al., 2024).

Provisioning services emerge as the most widely utilized and directly perceived benefits derived from the forest ecosystem. Notably, fuelwood (92.4%) and food crops (88.9%) are the most commonly reported services, underscoring their critical importance for household energy needs and food security. The high reliance on fuelwood reflects limited access to alternative energy sources in rural communities, reinforcing the centrality of forest biomass in daily subsistence. Similarly, the widespread reporting of food crops indicates the integration of forest landscapes into agricultural systems, particularly through practices such as agroforestry and forest-edge farming systems (FAO, 2022; Osewe et al., 2024).

Other provisioning services, including medicinal plants (74.2%), timber (68.7%), and bushmeat (61.3%), further demonstrate the economic and subsistence value of the forest. The relatively high dependence on medicinal plants highlights continued reliance on traditional healthcare systems, especially where access to formal medical services is limited. Timber and bushmeat represent both livelihood and income-generating opportunities; however, their unsustainable extraction may contribute to forest degradation and biodiversity loss if not properly managed (Angelsen et al., 2014; Wunder et al., 2021).

Regulating services are also prominently recognized, particularly soil fertility (81.3%) and erosion control (77.6%), followed by climate regulation (65.1%). The strong acknowledgment of soil fertility and erosion control suggests that respondents are aware of the forest's role in maintaining agricultural productivity and protecting land resources. This is particularly important in tropical forest ecosystems where land degradation can significantly undermine food production systems. The recognition of climate regulation, although slightly lower, indicates increasing awareness of broader ecological functions such as carbon sequestration and microclimate stabilization (IPBES, 2022; Costanza et al., 2017).

Cultural services, while less frequently reported compared to provisioning and regulating services, remain significant within the socio-cultural context of the communities. Traditional knowledge (58.4%) reflects the deep-rooted relationship between local populations and the forest, encompassing indigenous practices, ethnobotanical knowledge, and resource management systems. Spiritual values (42.0%), though reported by a smaller proportion of respondents, highlight the cultural and religious significance of the forest, including sacred sites, rituals, and ancestral connections. The relatively lower recognition of cultural services may be attributed to modernization processes, changing belief systems, and the difficulty in quantifying intangible ecosystem benefits (IPBES, 2022).

Supporting services, represented by biodiversity conservation (70.2%), are also widely acknowledged. This indicates that a substantial proportion of respondents recognize the forest's role in sustaining plant and animal diversity, which underpins the provision of other ecosystem services. The relatively high awareness of biodiversity conservation suggests an important entry point for conservation interventions, including community-based forest management and incentive mechanisms such as Payment for Ecosystem Services (PES) (Salzman et al., 2018; World Bank, 2023).

Findings demonstrate that ecosystem services in the Oluwa Forest Reserve are heavily skewed towards provisioning services, reflecting immediate livelihood needs and direct use values. However, the considerable recognition of regulating and supporting services indicates an emerging ecological awareness among respondents. These patterns are consistent with empirical studies in forest-dependent regions, where households prioritize tangible benefits while gradually recognizing the importance of indirect ecosystem functions (Osewe et al., 2024; Wunder et al., 2021). The results underscore the need for integrated forest management strategies that balance livelihood demands with conservation objectives, ensuring the long-term sustainability of ecosystem services for present and future generations.

Table 3: Ecosystem Services Identified in the Study Area

Category	Ecosystem Services	% of Respondents Reporting
Provisioning	Fuelwood	92.4
	Timber	68.7
	Bushmeat	61.3
	Medicinal plants	74.2
	Food crops	88.9
Regulating	Climate regulation	65.1
	Soil fertility	81.3
	Erosion control	77.6
Cultural	Traditional knowledge	58.4
	Spiritual values	42.0
Supporting	Biodiversity conservation	70.2

Livelihood Dependence on Ecosystem Services

The distribution of the Livelihood Dependence Index (LDI)(Table4) provides important insights into the extent to which households in the study area rely on ecosystem services for their sustenance and income generation. The results indicate varying levels of dependence, with a clear predominance of moderate to high reliance on forest resources.

A majority of respondents (46.7%) fall within the moderate dependence category (LDI = 0.30–0.60), suggesting that ecosystem services constitute a significant, though not exclusive, component of household livelihoods. This implies that while households engage in alternative income-generating activities such as farming and trading, forest resources remain an essential supplementary source of income, food, and energy. Such a pattern is characteristic of rural livelihoods in forest-edge communities, where diversification strategies coexist with continued reliance on natural capital.

Notably, a substantial proportion of respondents (34.4%) exhibit high dependence (LDI > 0.60), indicating a strong reliance on ecosystem services as a primary livelihood source. Households in this category are likely to depend heavily on provisioning services such as fuelwood, non-timber forest products, bushmeat, and forest-based farming. This high level of dependence reflects limited access to alternative livelihood opportunities, low-income levels, and constrained asset bases, which compel households to rely intensively on forest resources for survival.

In contrast, only 18.9% of respondents fall within the low dependence category (LDI < 0.30), suggesting that a relatively small proportion of households have diversified their livelihoods sufficiently to reduce reliance on ecosystem services. These households may have better access to non-forest income sources, higher levels of education, or improved economic opportunities that enable them to substitute forest-based activities with other forms of livelihood.

The mean LDI of 0.54 further reinforces the dominance of moderate dependence across the study area, indicating that, on average, households derive a considerable share of their livelihood from ecosystem services. This value underscores the central role of the forest in sustaining rural welfare and highlights the vulnerability of households to changes in ecosystem conditions.

The distribution of LDI suggests that the Oluwa Forest Reserve functions as a critical livelihood support system for surrounding communities, with a significant proportion of

households exhibiting moderate to high dependence. This pattern has important policy implications, as it underscores the need for sustainable forest management strategies that balance resource conservation with livelihood needs. Interventions such as livelihood diversification, improved access to alternative energy sources, and incentive-based conservation mechanisms (e.g., Payment for Ecosystem Services) are essential to reduce excessive pressure on forest resources while maintaining household welfare.

Table 4: Distribution of Livelihood Dependence Index (LDI)

LDI Category	Range	Frequency	Percentage (%)
Low dependence	<0.30	85	18.9
Moderate dependence	0.30–0.60	210	46.7
High dependence	>0.60	155	34.4

Mean LDI = 0.54

Economic Value of Ecosystem Services

Table 5 depicts the economic value of ecosystem services in the study area. The estimated annual economic value of ecosystem services highlights the substantial contribution of the Oluwa Forest Reserve to household welfare and rural livelihoods. The results reveal that forest-derived benefits constitute a significant component of household income, with both provisioning and regulating services playing important roles.

Provisioning services account for the largest share of total economic value, with a combined annual contribution of ₦370,000 per household. Among these, timber (₦120,000) represents the highest value, indicating its importance as a major income-generating resource. This reflects both subsistence uses and market-oriented exploitation, although it also raises concerns regarding sustainability given the potential for overharvesting. Non-timber forest products (NTFPs) (₦95,000) and fuelwood (₦85,000) also contribute substantially, underscoring their critical role in supporting daily household needs, including energy, food, and supplementary income. The relatively high value of NTFPs highlights their importance in livelihood diversification, particularly for households with limited access to formal employment.

Furthermore, bushmeat**,** while contributing the least among provisioning services, remains a significant source of protein and income, especially in rural settings where alternative protein sources may be limited or unaffordable. Collectively, these findings demonstrate that provisioning services provide both direct use value and cash income, making them central to the economic survival of forest-dependent communities.

In addition to provisioning services, regulating services are valued at ₦150,000 per household annually, estimated using the benefit transfer method. Although these services are not directly traded in markets, their contribution is substantial and reflects the indirect benefits derived from ecosystem functions such as climate regulation, soil fertility maintenance, and erosion control. These services support agricultural productivity and environmental stability, thereby indirectly sustaining household incomes and food security.

The total estimated economic value of ecosystem services amounts to ₦520,000 per household per year, indicating a high level of dependence on natural capital. This value is particularly significant when considered in the context of rural income levels, suggesting that ecosystem services constitute a major component of household livelihoods in the study area.

These results underscore the dual importance of ecosystem services as both a direct source of income and an indirect support system for agricultural and environmental sustainability. The dominance of provisioning services reflects immediate livelihood needs, while the substantial contribution of regulating services highlights the often-underappreciated role of ecological functions. These findings emphasize the need for integrated resource management strategies that ensure the sustainable use of forest resources while maintaining the flow of both market and non-market benefits. Furthermore, the high economic value of ecosystem services provides a strong justification for the design and implementation of incentive-based conservation mechanisms, such as Payment for Ecosystem Services (PES), to align livelihood improvement with environmental sustainability.

Table 5: Estimated Annual Economic Value of Ecosystem Services (₦/Household)

Ecosystem Service	Mean Value (₦)
Fuelwood	85,000
Timber	120,000
NTFPs	95,000
Bushmeat	70,000
Total (Provisioning)	370,000
Regulating services*	150,000
Total Value	520,000

**Estimated using benefit transfer.*

Determinants of Livelihood Dependence

The multiple regression results (Table 6) provide empirical evidence on the socio-economic factors influencing livelihood dependence on ecosystem services in the study area. The model is statistically robust, with an R^2 value of 0.62, indicating that approximately 62% of the variation in the Livelihood Dependence Index (LDI) is explained by the included explanatory variables. The overall model is highly significant (F-stat = 48.3; $p < 0.001$), confirming the joint explanatory power of the regressors in determining livelihood dependence (Chen et al., 2022; Osewe et al., 2024).

The estimated coefficients reveal that several key variables significantly influence dependence on ecosystem services. The results show that age exhibits a positive and statistically significant effect, indicating that older respondents are more likely to depend on forest resources. This may reflect the

accumulation of indigenous knowledge, limited access to alternative employment opportunities, and stronger attachment to traditional livelihood systems among older individuals (Angelsen et al., 2014; Wunder et al., 2021).

In addition, education shows a negative and significant relationship with livelihood dependence, suggesting that higher levels of education reduce reliance on ecosystem services. This finding is consistent with the view that education enhances human capital, improves access to non-farm employment, and promotes livelihood diversification, thereby reducing dependence on natural resource extraction Angelsen et al., 2014; Adedeji et al., 2025). Furthermore, household size is positively and significantly associated with livelihood dependence. Larger households tend to have higher consumption needs and may rely more heavily on forest resources to meet demands for food, energy, and income. In addition, larger household sizes may provide additional labour for resource extraction, thereby reinforcing dependence on ecosystem services (Osewe et al., 2024).

In contrast, non-forest income has a negative and significant effect, indicating that households with higher income from non-forest sources are less dependent on ecosystem services. This highlights the importance of income diversification in reducing pressure on forest resources and enhancing livelihood resilience, as documented in forest livelihood studies across developing regions (Chen et al., 2022; FAO, 2022). Similarly, distance to the forest is negatively related to livelihood dependence ($\beta = -0.018$; $p = 0.003$), implying that households located farther from the forest are less likely to depend on its resources. This can be attributed to increased transaction costs, reduced accessibility, and greater reliance on alternative livelihood sources among more distant households (Osewe et al., 2024; IPBES, 2022).

The results therefore demonstrate that livelihood dependence in the study area is shaped by a combination of demographic, socio-economic, and spatial factors. Variables such as age and household size tend to increase dependence, while education, income diversification, and distance to the forest reduce it. These findings are consistent with existing empirical literature, which emphasizes the role of human capital, economic status, and accessibility in determining the extent of reliance on ecosystem services in forest-dependent communities (Angelsen et al., 2014; Wunder et al., 2021; Osewe et al., 2024).

Table 6: Multiple Regression Results for Livelihood Dependence; Dependent Variable: LDI

Variable	Coefficient	Std. Error	t-value	p-value
Constant	0.215	0.072	2.99	0.003
Age	0.004	0.001	3.20	0.001
Education	-0.021	0.008	-2.63	0.009
Household size	0.015	0.004	3.75	0.000
Income (non-forest)	-0.000003	0.000001	-3.10	0.002
Distance to forest	-0.018	0.006	-3.00	0.003
$R^2 = 0.62$				
F-stat = 48.3 (p < 0.001)				

Willingness to Participate in Payment for Ecosystem Services (PES)

Table 7 presents the logistic regression results for respondents' willingness to participate in Payment for Ecosystem Services (PES) schemes, providing important insights into the socio-economic determinants of household participation in conservation incentive programmes within the study area. The model results highlight the combined influence of human capital, economic capacity, awareness, and demographic factors on participation decisions (Salzman et al., 2018; World Bank, 2023).

The results show that education has a positive and highly significant influence on willingness to participate. This indicates that more educated respondents are more likely to engage in PES schemes, possibly due to better understanding of environmental issues, greater awareness of long-term ecological benefits, and improved ability to interpret conservation-related information. This finding aligns with evidence that education enhances environmental awareness and strengthens pro-conservation behaviour in rural households (Mohamed et al., 2025; Osewe et al., 2024). Similarly, household income exerts a positive and statistically significant effect, suggesting that wealthier households are more willing to participate in PES. Higher income levels reduce liquidity constraints and enable households to adopt conservation practices that may involve short-term opportunity costs, thereby reinforcing the role of economic capacity in environmental decision-making (Chen et al., 2022; FAO, 2022).

Furthermore, awareness of ecosystem services (ES) emerges as the most influential variable, with a strong positive and highly significant coefficient. This underscores the critical importance of knowledge and perception in shaping participation decisions. Households that are more aware of the benefits provided by ecosystem services are more likely to support and engage in conservation initiatives, indicating that environmental education and awareness campaigns are central to enhancing PES uptake (IPBES, 2022; Adedeji et al., 2025). In contrast, household size has a negative and statistically significant relationship with willingness to participate. This implies that larger households may face greater consumption demands and financial obligations, which can limit their ability or willingness to commit to PES programmes, particularly where participation involves trade-offs with immediate livelihood needs (Osewe et al., 2024).

The results therefore show that willingness to participate in PES is shaped by a combination of human capital, economic status, awareness, and household demographic structure. While education, income, and awareness enhance the likelihood of participation, larger household sizes tend to constrain engagement. These findings are consistent with empirical literature in environmental and resource economics, which emphasizes the importance of socio-economic characteristics and information access in influencing conservation behaviour and participation in incentive-based environmental programmes (Salzman et al., 2018; Wunder et al., 2021; World Bank, 2023).

Table 7: Logistic Regression for Willingness to Participate in PES

Variable	Coefficient	Std. Error	z-value	p-value
Constant	-1.215	0.402	-3.02	0.003
Education	0.312	0.098	3.18	0.001
Income	0.000002	0.000001	2.50	0.012
Awareness of ES	0.845	0.210	4.02	0.000
Household size	-0.092	0.041	-2.24	0.025
Pseudo R^2 = 0.41				

CONCLUSION

This study demonstrates that the Oluwa Forest Reserve is a vital socio-ecological asset that provides essential provisioning, regulating, supporting, and cultural ecosystem services that sustain rural livelihoods. The mean Livelihood Dependence Index (0.54) and the estimated annual ecosystem service value of ₦520,000 per household indicate that surrounding communities depend moderately to highly on forest resources for their livelihoods. While age and household size increase livelihood dependence, education, non-forest income, and distance from the forest reduce dependence. Furthermore, education, income, and awareness of ecosystem services significantly enhance willingness to participate in Payment for Ecosystem Services (PES), whereas larger household size reduces participation.

The study concludes that increasing dependence on forest resources and continued anthropogenic pressures threaten the long-term sustainability of the Oluwa Forest Reserve. To promote sustainable forest management, community-based forest management should be strengthened alongside livelihood diversification programmes, environmental education, and improved access to alternative energy sources. In addition, the implementation of equitable Payment for Ecosystem Services (PES) schemes and the integration of ecosystem service valuation into forest policy and development planning are recommended to balance biodiversity conservation with sustainable rural livelihood improvement.

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