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Economic Valuation of Soil Fertility Management (SFM): An Assessment of Farmers' Willingness to Pay for Sustainable Agricultural Productivity in Southwestern Nigeria

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Abstract

This study assessed farmers' willingness to pay (WTP) for soil fertility management as an ecosystem service in Southwestern Nigeria. Primary data were collected through structured questionnaires administered to farming households in selected areas of Oyo and Ekiti States. A multistage and purposive sampling technique was used to select 384 respondents from Ogbomoso, Ibadan/Atiba, Efon-Alaye, and Gboyin Local Government Area. Data were analyzed using Logit, Probit, and Tobit regression models within the contingent valuation method (CVM) framework to estimate farmers' willingness to pay, assess perceptions, and identify socioeconomic factors influencing WTP. Results showed that 68% of farmers were willing to pay for soil fertility management practices, with mean WTP estimated at ₦3,200 per farming season in Oyo State and ₦2,600 in Ekiti State. Farm income, education, perception of soil fertility importance, extension contact, and farm size significantly increased willingness to pay, while bid amount had a negative and statistically significant effect ($p < 0.01$). Tobit estimates further revealed that higher-income and better-educated farmers were willing to contribute larger amounts. The study concludes that willingness to pay reflects both farmers' economic capacity and awareness of soil fertility as an essential ecosystem service for sustainable agricultural productivity. It therefore recommends strengthening extension services, promoting payment for ecosystem services schemes, and implementing targeted policies to encourage farmer participation in soil fertility management programmes in Southwestern Nigeria. These findings underscore the importance of institutional support, environmental awareness, and inclusive rural financing mechanisms for sustainable land management among smallholder farmers.

Introduction

Soil fertility constitutes a cornerstone of agricultural sustainability, supporting the productivity of farming systems and the resilience of rural livelihoods. Conceptualized as an ecosystem service, soil fertility encompasses the natural capacity of soil to regulate nutrient cycling, water storage, and biological activity in ways that sustain crop growth and maintain ecological balance.

In Southwestern Nigeria, particularly in Ekiti and Oyo States, this service is under increasing pressure due to continuous cultivation, population-driven land fragmentation, and limited investment in soil restoration. While agronomic research has extensively examined the physical and chemical properties of these soils, less attention has been devoted to understanding how farmers themselves perceive, value, and respond to declining soil fertility (Adeyolanu *et al.*, 2020).

Soil fertility management refers to the set of ecological functions and deliberate agronomic actions that maintain or enhance the soil's capacity to supply nutrients, store water, support plant growth, and sustain biological activity over time (Ojo *et al.*, 2023) Framed as an ecosystem service, soil fertility goes beyond immediate crop provisioning to include supporting services (nutrient cycling, soil formation),

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regulating services (water infiltration, erosion control) and cultural services (local knowledge and land stewardship practices). Recognizing soil fertility as an ecosystem service shifts attention from single-season yields to long-term natural capital maintenance and creates the conceptual space for economic valuation and incentive design.

Multiple lines of evidence point to pervasive soil quality constraints such as declining soil organic matter, nutrient depletion under continuous cropping, and localized erosion on sloping landscapes. These biophysical constraints manifest in yield variability, increased input use (frequent inorganic fertilizer application) and growing farmer concern about sustainability. These trends are documented in recent regional soil assessments and agronomic studies (Adeyolanu *et al.*, 2020; Adetunji *et al*., 2022).

Farmer perception and decision-making, however, mediate how ecosystem services delivered by soils are managed on the ground. Recent survey work in southwest Nigeria shows farmers often infer soil condition from crop performance and visual manifestations rather than from formal soil testing, producing a perception–practice gap that influences adoption of restorative practices (e.g., composting, cover cropping) and demand for advisory services. This behavioural lens is important: willingness to adopt or to pay for soil-friendly technologies depends both on objective soil constraints and on how farmers interpret risk, recovery potential, and the costs of alternatives.

Traditional approaches to soil fertility, such as inorganic fertilizer subsidies, have not fully addressed the issue due to affordability, accessibility, and ecological concerns. Thus, understanding the economic value farmers place on soil fertility is essential for designing policies that encourage sustainable soil management. Measuring farmers' Willingness to Pay (WTP) for soil fertility improvements provides insights into their demand for sustainable practices and the socioeconomic factors influencing adoption. This can guide policymakers in aligning incentives, extension services, and conservation programs with farmers' preferences, thereby internalizing the value of soil fertility as an ecosystem service.

The empirical literature also highlights a policy and service-delivery gap: affordable, timely soil testing and context-specific advisory services remain limited for many smallholders, even where demand exists (Woodridge, 2010). Contingent valuation and WTP exercises from Nigeria indicate meaningful willingness among farmers to pay for soil testing and tailored recommendations; although reported mean WTPs are often below prevailing market fees, suggesting potential for cost-recovery models combined with targeted subsidies or bundled services to enhance uptake. Translating these valuation signals into workable programmes requires state-level calibration because heterogeneity across states alters both willingness and capacity to pay.

On the technical front, there are promising, scalable soil fertility management practices that align ecological effectiveness with farmer realities: integrated soil fertility management (combining organic amendments with targeted inorganic inputs), conservation agriculture practices that reduce erosion, and localized agroforestry/cover cropping that rebuilds organic matter. When coupled with decentralized soil testing and extension packages, these practices can improve multiple ecosystem services simultaneously, thereby raising productivity, enhancing resilience to dry spells, and sequestering soil carbon. However, successful scaling depends on incentives, supply chains for organic inputs, and credible financing models that reflect farmers' revealed and stated preferences.

For Ekiti and Oyo States, the research opportunity is compelling because the two states present complementary contexts: Ekiti's predominance of smallholder mixed systems with high landscape heterogeneity contrasts with Oyo's larger production zones and stronger market linkages. This complementarity allows comparative analysis of (a) how biophysical soil constraints interact with socio-economic determinants of WTP, and (b) which delivery and financing mechanisms (vouchers, cost-sharing, private provision) are feasible for different farmer segments. Policy design that ignores these intra-regional differences risks mis-targeting; either pricing services out of reach for poorer farmers or wasting public funds on blanket subsidies.

Thus, treating soil fertility management as an ecosystem service opens analytic pathways to value farmers' preferences, design financeable delivery models, and align extension with ecological restoration goals. A focused WTP study in Ekiti and Oyo has systematically achieved three things: quantified farmers' monetary valuation of soil fertility improvements, identified the socioeconomic and farm-level drivers of that valuation, and hopes to translate findings into actionable policy levers (subsidy design, service bundling, targeted extension). These outputs are adequate to inform state-level programmes that aim to sustain agricultural productivity while preserving the underlying soil capital on which future food security depends. Therefore, the objective of the study is to assess farmers' willingness to pay (WTP) for soil fertility management as an ecosystem service and its implications for sustainable agricultural productivity. The study seeks to specifically: estimate the level of farmers' willingness to pay for soil fertility-enhancing practices; examine farmers' perceptions of soil fertility management as an ecosystem service and determined the socioeconomic factors influencing farmers' WTP.

Research Hypotheses

The following hypotheses were tested:

i. H_o: Farmers significantly recognize soil fertility management as a critical ecosystem service.
ii. H_o: Farmers have a positive willingness to pay for soil fertility improvement practices.
iii. H_o: Socioeconomic factors do not influence WTP.

Materials and Methods

Study Area

The study was conducted in Ekiti and Oyo States, both located in Southwestern Nigeria. Ekiti State lies between latitudes 7°15′ and 8°05′ N, and longitudes 4°45′ and 5°45′ E, covering an estimated land area of 6,353 km². The State is characterized by an undulating landscape, tropical climate with bimodal rainfall (April–October), and mean annual precipitation ranging from 1,200–1,500 mm. Major food crops cultivated include yam, cassava, maize, and rice, while cocoa remains the main cash crop. Soils in Ekiti are predominantly ferruginous tropical soils with marked spatial variability in nutrient content and organic matter, often depleted by continuous cultivation (Akinrinde and Obigbesan, 2019).

Oyo State, on the other hand, is the largest State in Southwestern Nigeria with a landmass of approximately 28,454 km². It is situated between latitudes 7°3′ and 9°12′ N, and longitudes 2°45′ and 4°30′ E. The state is well-known for large-scale cassava and maize production, as well as livestock rearing, especially in the derived savannah zones. Oyo's soils are ferrallitic with moderate to low fertility, requiring nutrient replenishment for sustainable productivity (Amujoyegbe and Akinola, 2021). The two states provide complementary contexts: while Ekiti represents predominantly smallholder, mixed farming systems on relatively smaller plots, Oyo offers more commercial-oriented production with larger average farm sizes and stronger market linkages.

Experimental Design

The study adopted a cross-sectional survey design, combining both quantitative and qualitative approaches. Quantitative data were collected through a structured questionnaire administered to farming households, while qualitative insights were obtained from focus group discussions (FGDs) and key informant interviews (KIIs) with extension agents, community leaders, and local policymakers. This mixed-method approach was instrumental in enriching the understanding of farmers' perceptions, willingness to pay (WTP), and contextual determinants of soil fertility management.

Sampling Technique and Sampling Size

This study employed a multi-stage sampling technique to select respondents across Oyo and Ekiti States. The multi-stage sampling thus guaranteed that the data captured both the geographical diversity of the States and the heterogeneity of farmer characteristics, while remaining focused on those actively engaged in soil fertility management. The two Sates were purposively selected because of their agricultural significance in Southwestern Nigeria and the evident challenges of soil fertility decline that threaten sustainable crop production. In Oyo State, two zones were purposively selected to capture

ecological and farming variations: the Ogbomoso area (North-Central Oyo), characterized by intensive smallholder farming and mixed cropping, and the Ibadan/Atiba area (Southern and Central Oyo), which combines peri-urban farming systems with traditional cultivation practices. In Ekiti State, Efon-Alaye in Efon LGA, and selected farming communities in Gboyin Local Government Area were randomly selected; both of which depend heavily on soil-based livelihoods and are highly vulnerable to fertility depletion due to continuous land use and limited soil conservation practices.

Also, in Oyo State, 4 communities were randomly selected each from the Ogbomoso and Ibadan/Atiba area, giving a total of 8 communities. This was followed by selecting 3 villages from each community, making a total of 24 villages. This was also followed by drawing 8 farming households from each village to arrive at 192 farmers in Oyo State. In Ekiti State, similar pattern was deployed in selecting the respondents. From the two LGAs adopted for the study, 6 communities were randomly selected from Efon while 4 was were selected from Gbonyin LGA, reflecting the larger concentration of farming households in Gbonyin. Within each LGA, communities were first identified, and then lists of active farmers were obtained from extension offices and Farmers' cooperative society. A total of 192 respondents were randomly selected from these lists, ensuring adequate coverage of socioeconomic and farm-level variations within the study area in Ekiti State; thus, arriving at 384 respondents collectively used for the study.

Analytical Technique/ Model Specification

In line with the stated objectives of this study, combination of econometric and statistical techniques were employed to rigorously analyze the data. To estimate farmers' willingness to pay (WTP) for soil fertility management, the Logit model was adopted within the framework of the contingent valuation method (CVM), consistent with Hanemann (1984) and Bateman *et al*. (2002), who highlighted the robustness of binary choice models in eliciting non-market values. In non-market valuation, the binary choice model has several advantages over open-ended or other elicitation formats: the model mimics actual consumer behaviour in markets where individual decides whether or not to purchase a good at a given price. This makes responses more realistic and incentive compatible. Also, the binary choice model asks respondents a simple 'Yes/No' willingness-to-pay (WTP) question for a specified bid amount. This reduces strategic bias, starting-point bias, and over/under statement of WTP. The determinants of farmers' willingness to pay amounts were examined using a Tobit model, which appropriately accounts for the censoring of WTP at zero (Wooldridge, 2010; Greene, 2018). Furthermore, the study employed the Probit regression model to capture the probabilistic nature of WTP participation decisions, in line with earlier applications in environmental economics (Haab and McConnell, 2002).

To assess inter-zonal variations in WTP, Analysis of Variance (ANOVA) and the Kruskal–Wallis non-parametric test were used, following the practice of Carson (2012), who recommends both parametric and distribution-free methods in stated preference research. Finally, to derive policy-relevant insights, the study conducted scenario and sensitivity analyses by simulating aggregate farmer contributions under alternative participation rates, an approach supported by recent empirical applications in ecosystem service valuation (Farber *et al.*, 2021; Pascual *et al*., 2022). These diverse analytical tools collectively ensure that the study provides a comprehensive and methodologically sound assessment of soil fertility management as an ecosystem service in Southwestern Nigeria.

Modelling objective i

In order to realize Objective 1, (that is, to estimate farmers' willingness to pay (WTP) for soil fertility management as an ecosystem service), Contingent Valuation Method (CVM) using a dichotomous choice elicitation format was adopted. The WTP values was estimated using Logit regression models. Mean WTP was derived from the estimated coefficients following Hanemann's (1984) approach.

Assuming farmer $_i$ has latent net benefit (utility) from the soil fertility service U_i. The farmer is presented with a bid (price) BID_i and answers "Yes" if $U_i \geq BID_i$. The latent model is:

$$U_i = \beta_0 + \beta_1 BID_i + \varepsilon_i$$

The observed binary response,

$$Y_i = \begin{cases} 1 \ \ if\ farmer\ says\ \text{"YES"}\ to\ paying\ BID_i \\ 0 \ \ if\ farmer\ says\ \text{"NO"}\ to\ paying\ BID_i \end{cases}$$

Under the Logit assumption, the probability of a "Yes" is:

$$P(Y_i=1|BID_i)=\Lambda(\beta_0+\beta_1 BID_i)= \frac{\exp\ (\beta_0 + \beta_1\ BIDi)}{1+\exp\ (\beta_0 + \beta_1\ BIDi)}$$

Where:

Y_i = Observed binary response variable (1 = Yes; 0 = No).

BID_i = The bid amount offered to farmer i (in Naira per season).

β_0 = Intercept (that is, the baseline log-odds of saying "Yes" when $BID_i = 0$).

β_1 = Bid coefficient (expected to be negative: higher bid results to lower probability of acceptance).

ε_i = Random error term (assumed *i.i.d* logistic).

Modelling Objective ii

In order to capture objective 2, (that is, to determine the average amount farmers are willing to pay (WTP) toward soil fertility management interventions), a tobit (censored) model as the preferred primary estimator was estimated. This is because, WTP amounts are typically left-censored at zero.

The model is specified, such that:

WTP_i = Latent (unobserved) desired maximum willingness to pay (expressed in Naira) by farmer *i.*

$$WTP_i = \begin{cases} WTP_i \ \text{if}\ WTP_i^* > 0 \\ 0 \quad if \quad WTP_i^* \leq 0 \end{cases}$$

The latent variable is modelled as:

$$WTPi* = \gamma_0 + \gamma'_X X_i + \gamma_{bid}\, BID_i + u_i$$

Where:

WTPi = observed WTP amount (Naira; 0 for non-payers).

WTPi∗ = latent desired WTP amount.

BID = the bid amount previously offered in CVM (in Naira). It serves as a control for anchoring.

X_1 = annual farm income (in Naira).

X_2 = hectares cultivated.

X_3 = years of experience

X_4 = years of schooling of household head.

X_5 = perception index of soil fertility importance.

X_6 = extension contacts in the last 1 year.

X_7 = age of household head (years). (ambiguous)

X_8 = gender — dummy (1 = male, 0 = female).

X_9 = State — dummy (1 = Oyo, 0 = Ekiti)

γ_0, γx, γbid = Coefficients to estimate.

σ = error SD.

The econometric models specified in this study rest on several assumptions that ensure unbiased and efficient estimates. First, the functional relationship between the dependent variable and the explanatory variables is assumed to be correctly specified and linear in the parameters. Second, the explanatory variables are non-stochastic and measured without error, with no perfect multicollinearity existing among them. Third, the error term U_i, is assumed to be independently and identically distributed, following a normal distribution with mean zero and constant variance, that is:

Where $u_i \sim N(0, \sigma^2)$.

This implies that the disturbances do not exhibit autocorrelation or heteroskedasticity. Fourth, it is assumed that the observations are randomly drawn from the population of interest, reflecting the probability sampling approach used in the study. Finally, in the case of binary choice models (Logit/Probit), it is assumed that the probability distribution function is appropriately specified, with the logistic or normal cumulative distribution functions mapping the latent utility index to the observed dichotomous outcomes. These assumptions collectively guarantee that the maximum likelihood estimators (for Logit, Probit, and Tobit models) are consistent, asymptotically normal, and efficient. Violations of these assumptions will be addressed through robust standard errors, diagnostic tests for heteroskedasticity, multicollinearity checks, and specification error tests to ensure the reliability of results.

Modelling Objective iii

To capture objective 3, (that is, to describe socioeconomic and farm-level factors influencing the probability that a farmer is willing to pay for soil fertility management services), binary choice models (Probit regression) was used to determine how variables such as age, income, education, farm size, access to extension, farming experience, and household size affect the probability of being willing to pay. Marginal effects were also calculated to

interpret the influence of each factor on WTP likelihood. The model is specified as follow:

Let Y_i, be the binary indicator that farmer $_i$ accepts the CVM bid (that is, is willing to pay): $Y_i = 1$ if Yes, and 0 if No. The latent index formulation becomes:

$Yi = \beta_0 + \beta_1 BID_i + \beta'_X X_i + \varepsilon_i$

Observed:

$$Y_i = \begin{cases} 1 \ if \ Y_i > 0 \\ 0 \ if \ otherwise \end{cases}$$

However, under the probit assumption, $\varepsilon_i \sim N(0, \sigma^2)$ (standard normal), therefore:

$P(Yi = 1|BID_i, X_i) = \Phi(\beta_0 + \beta_1 BID_i + \beta'_X X_i)$

where $\Phi(\cdot)$ = The standard normal CDF.

Yi = binary response: 1 if farmer iii answered *Yes* to the bid, 0 otherwise.

BID_i = The monetary bid offered to farmer *i* (in Naira per intervention).

X_i = Vector of socioeconomic & farm characteristics, including:

X_1 = annual farm income (in Naira).

X_2= hectares cultivated.

X_3 =Years of experience

X_4 = years of schooling of household head.

X_5= perception index of soil fertility importance.

X_6= extension contacts in the last 1 year.

X_7 = age of household head (years). (ambiguous)

X_8 = gender — dummy (1 = male, 0 = female).

X_9 = State — dummy (1 = Oyo, 0 = Ekiti)

β_0, β_1, β_X = Parameters to estimate.

ε_i = Error term.

Results and Discussion

The results are organized around the five specific objectives and are derived from rigorous econometric analyses, including Logit, Tobit, and Probit regression models, Analysis of Variance (ANOVA), and policy simulation techniques, applied to data collected from 384 farming households across Ekiti and Oyo States. The analytical outcomes not only quantify the extent of farmers' willingness to participate financially in soil fertility enhancement programmes but also elucidate the socioeconomic, institutional, and perceptual factors influencing their decisions. Furthermore, the findings provide comparative insights into inter-zonal variations and highlight the potential for participatory financing mechanisms in sustainable soil management. The ensuing discussion interprets these results in the light of economic theory, empirical evidence from related Nigerian and international studies, and the broader policy context of agricultural sustainability and ecosystem service valuation.

Determinants of Farmers' Willingness to Pay (WTP) for Soil Fertility Management as an Ecosystem Service

The Logit regression results presented in Table 1 reveal that the bid amount, farm income, farm size, education level, perception index, extension contact, and state location exerted statistically significant effects on farmers' probability of willingness to pay for soil fertility management in Southwestern Nigeria. As expected, the coefficient of the bid amount was negative and statistically significant at the 1% level, implying that higher bid prices reduce the likelihood of a "Yes" response from farmers. This inverse relationship is consistent with the economic theory of demand, which postulates that as price increases, the probability of acceptance of a proposed payment declines (Hanemann, 1984; Bateman *et al*., 2002). The magnitude of this coefficient underscores the sensitivity of smallholder farmers to price changes and indicates the importance of affordability in the design of soil fertility management programmes. Similar findings were documented by Adetunji *et al*. (2022), who found that Nigerian smallholders displayed significant price elasticity in their stated willingness to pay for soil testing services, reflecting the role of liquidity constraints in environmental valuation outcomes.

Table 1: Logit Regression Estimates of Determinants of WTP for Soil Fertility Management

Variable	Coefficient	Robust Std. Error	Z-statistic	p-value	Marginal Effect
Bid amount (₦)	-0.0045***	0.0012	-3.75	0.000	-0.0021
Income (₦'000)	0.0214**	0.0098	2.18	0.029	0.0095
Farm size (ha)	0.1367**	0.0613	2.23	0.026	0.0581
Education (yrs)	0.0482**	0.0204	2.36	0.019	0.021
Perception index	0.3221***	0.0912	3.53	0.000	0.1463
Extension contacts	0.1744**	0.0827	2.11	0.035	0.0736
Age	-0.0143	0.0108	-1.32	0.186	-0.0061
Gender (1=Male)	0.2296	0.2213	1.04	0.298	0.0975
State (Oyo=1)	0.4417**	0.1892	2.33	0.021	0.1984
Constant	-1.762***	0.613	-2.87	0.004	—
LR X^2 (9)	56.71				
Prob X^2	0.0000				
Pseudo R^2	0.273				
Log-likelihood	-75.682				

Source: Field Survey, 2025

Furthermore, the positive and significant coefficient of annual farm income suggests that farmers with higher incomes are more likely to pay for soil fertility management services. This aligns with empirical evidence in contingent valuation literature, where income often serves as a proxy for both ability and willingness to contribute financially to environmental or agricultural services (Haab and McConnell, 2002; Ogunniyi *et al*., 2019). The elasticity of WTP with respect to income indicates that wealthier households perceive greater marginal benefits from sustaining soil fertility, possibly due to their higher exposure to commercialized agriculture and the longer planning horizons of financially secure farmers. This relationship further emphasizes the potential of differential pricing or tiered payment mechanisms to ensure equity and efficiency in future policy interventions.

Education also exhibited a positive and significant effect on WTP at the 5% level, implying that better-educated farmers are more likely to appreciate the long-term benefits of soil fertility restoration and to invest in it. This outcome corroborates findings by Umar *et al*. (2021), who reported that education enhances comprehension of agricultural innovations and the environmental implications of unsustainable land use. From a behavioral perspective, education broadens farmers' cognitive awareness of ecosystem services, fostering a shift from short-term productivity goals to long-term sustainability concerns. In this context, higher education levels translate into greater environmental stewardship and openness to market-based conservation instruments.

The perception index variable also exhibited a highly significant and positive relationship with WTP. Farmers who attached greater importance to soil fertility as a vital ecosystem service demonstrated stronger likelihood of participation in payment schemes. This reinforces the notion that valuation is not merely an economic act but also a reflection of environmental cognition and perception. According to Adeyolanu *et al*. (2020), farmers' mental models of soil quality often mediate the adoption of conservation technologies. Where soil fertility is viewed as an exhaustible natural capital rather than an infinite input, the incentive to invest in restorative measures increases substantially. The result therefore validates the inclusion of perceptual and attitudinal indicators in

ecosystem service valuation models (Farber *et al*., 2021; Pascual *et al*., 2022).

Additionally, extension contact exhibited a positive and significant coefficient at the 5% level, signifying that access to extension services enhances farmers' readiness to pay for soil fertility management. This outcome is consistent with FAO (2020), which emphasized that advisory services and information dissemination play pivotal roles in strengthening the knowledge–practice link for sustainable soil management. Frequent extension interaction not only informs farmers about appropriate fertility practices but also legitimizes payment schemes by building trust in service providers. Conversely, age and gender were statistically insignificant, suggesting that WTP is not systematically differentiated by age cohort or gender in the study area. Finally, the state dummy (Oyo = 1) was positive and significant, indicating that farmers in Oyo State are more inclined to pay for soil fertility management than those in Ekiti. This may reflect differences in market orientation, access to inputs, or exposure to private extension services.

The model's goodness-of-fit, reflected in the pseudo-R^2 value of 0.273 and a significant likelihood ratio χ^2 statistic ($p < 0.01$), confirms that the explanatory variables collectively explain a substantial proportion of the variation in farmers' WTP decisions. These findings collectively support the hypothesis that socioeconomic, institutional, and perceptual factors significantly influence farmers' willingness to pay for soil fertility improvement practices. From a policy perspective, the results underscore the need for differentiated soil management interventions that integrate income-sensitive pricing, farmer education, and targeted extension delivery. In line with Onyekuru and Marchant (2021), integrating ecosystem service valuation insights into state agricultural planning can enhance the efficiency of subsidy allocation and foster co-financing models that sustain soil fertility as a critical natural asset.

Determinants of the Magnitude of Willingness to Pay (WTP) for Soil Fertility Management

The Tobit regression results presented in Table 2 estimated the factors influencing the amount farmers were willing to pay for soil fertility management services in Ekiti and Oyo States. The results reveal that bid amount, income, farm size, education, perception index, extension contact, and state dummy were statistically significant determinants of the WTP amount, while age and gender were not significant. The negative and statistically significant coefficient of the bid variable (–0.1294, $p < 0.01$) corroborates the findings of the Logit model and conforms to the theoretical expectation that higher bid levels reduce the maximum amount respondents are willing to pay. This inverse relationship underscores the sensitivity of farmers' payment decisions to cost levels, implying that affordability remains a central determinant of participation in soil fertility schemes. In related Nigerian studies, Adetunji *et al*. (2022) and Ogunniyi *et al*. (2019) observed similar bid elasticity effects, reflecting the economic vulnerability and liquidity constraints of smallholders in the face of market-based conservation pricing. Thus, the design of soil management interventions must carefully calibrate cost-sharing thresholds to avoid pricing potential beneficiaries out of participation.

The positive and highly significant coefficient of annual farm income (0.3426, $p < 0.01$) suggests that wealthier farmers are willing to pay more for soil fertility management services. This supports the proposition that income is a major determinant of the intensity of WTP and reflects the principle of economic capacity as an enabling factor for environmental investment (Haab and McConnell, 2002; Wooldridge, 2010). Higher-income farmers are often more commercially oriented, better informed, and more capable of internalizing long-term returns to soil fertility investments. These results align with earlier findings by Ibrahim and Umar (2021), who reported that higher-income smallholders in Northern Nigeria demonstrated greater willingness to pay for agricultural extension services. In the current context, this result implies that soil fertility interventions that incorporate cost-sharing or fee-based service models may initially attract higher-income farmers, suggesting the need for tiered or progressive payment mechanisms that ensure inclusion of poorer households.

Table 2: Tobit Estimates of Factors Influencing WTP Amount for Soil Fertility Management

Variable	Coefficient	Robust Std. Error	z- statistic	p-value
Bid amount (₦)	-0.1294***	0.0432	-2.99	0.003
Income (₦'000)	0.3426***	0.0981	3.49	0.001
Farm size (ha)	0.6311**	0.2473	2.55	0.011
Education (yrs)	0.2415**	0.1097	2.2	0.028
Perception index	1.285***	0.362	3.55	0.0
Extension contacts	0.518*	0.279	1.86	0.063
Age	-0.0942	0.067	-1.4	0.162
Gender (1=Male)	0.328	0.243	1.35	0.177
Constant	-4.962***	1.604	-3.09	0.002

Source: Author's Computation, 2025.

Education also exerted a positive and significant effect on the magnitude of WTP, with a coefficient of 0.2415 ($p < 0.05$). This finding is consistent with previous research highlighting education as a key determinant of environmental awareness and investment behavior (Nkonya *et al*., 2016; Olalekan and Adebayo, 2023). Educated farmers tend to possess higher environmental literacy, enabling them to understand the long-term implications of soil degradation on productivity and livelihood security. This reinforces the argument that education functions as both a cognitive and attitudinal enabler of sustainable soil management (FAO, 2020). Consequently, policy interventions should integrate farmer training and adult literacy programs as components of ecosystem service financing strategies. Moreover, the positive and significant coefficient of the perception index (1.285, $p < 0.01$) highlights that farmers' subjective valuation of soil fertility strongly predicts the monetary amount they are willing to contribute. This aligns with the findings of Adeyolanu *et al*. (2020), who noted that farmers with heightened perception of soil quality constraints were more responsive to conservation messages and more inclined to allocate resources toward fertility management practices.

The coefficient of extension contact was positive and significant at the 10% level (0.518, $p < 0.10$), implying that farmers with more frequent access to agricultural extension services are likely to pay higher amounts for soil fertility management. This result supports the evidence from Ogunniyi *et al*. (2019), and Ibrahim and Umar (2021), who found that institutional access through extension visits enhances farmers' trust, information flow, and willingness to participate in development programmes. Extension contacts bridges the perception–practice gap by transforming abstract awareness of soil degradation into actionable willingness to invest. Similarly, the positive and significant effect of the state dummy (Oyo = 1; coefficient = 0.742, $p < 0.05$) indicates that farmers in Oyo State, on average, were willing to pay higher amounts compared to their counterparts in Ekiti. This difference may be attributed to higher market exposure, relatively better income levels, and the influence of commercial farming in Oyo, consistent with spatial variations observed in regional agricultural valuations (Akinrinde and Obigbesan, 2019; Amujoyegbe and Akinola, 2021).

The model's sigma value of 2.814 and a log-likelihood of –515.342 indicate a good model fit, while the likelihood ratio chi-square statistic ($\chi^2 = 64.29$, $p < 0.01$) confirms that the explanatory variables collectively and significantly influence the observed variation in WTP amounts. The unconditional mean WTP, estimated at approximately ₦2,860 per farmer per season, provides a monetary benchmark for the potential design of farmer co-financing schemes for soil fertility improvement. This estimated value suggests that, despite income constraints, smallholder farmers attach meaningful monetary value to soil fertility services, reinforcing the argument that

ecosystem service markets can emerge even in resource-constrained rural settings (Onyekuru and Marchant, 2021; Pascual *et al*., 2022).

From a policy perspective, the Tobit results highlight that demand for soil fertility management is shaped by both economic and cognitive dimensions. Programs aimed at improving soil productivity should therefore not rely solely on subsidies but rather adopt blended financing models that combine public investment with farmer contributions based on ability to pay. Moreover, as the perception and extension variables emerged significant, it is critical to design information-driven interventions that foster awareness and confidence among farmers. This would align with the recommendations of FAO (2020) and Nkonya *et al*. (2016), which advocate for integrated soil fertility management (ISFM) frameworks anchored on participatory extension, adaptive pricing, and ecosystem-based valuation. Overall, the Tobit findings provide quantitative evidence that soil fertility management as an ecosystem service commands substantial economic value among farmers, and that this value is responsive to socioeconomic and institutional factors.

Socioeconomic and Farm-Level Factors Influencing the Probability of Willingness to Pay (WTP) for Soil Fertility Management

The Probit regression results presented in Table 3 examine the socioeconomic and farm-level characteristics that significantly influence the probability that a farmer is willing to pay for soil fertility management services. The model shows a good overall fit, with a log-likelihood value of –72.918 and a likelihood ratio chi-square of 51.24 ($p < 0.01$), suggesting that the explanatory variables collectively explain a significant proportion of variation in farmers' willingness to pay. The model's pseudo-R^2 value of 0.262 further indicates satisfactory explanatory power for a binary choice model in a cross-sectional context (Wooldridge, 2010; Greene, 2018). The results reveal that bid amount, income, education, perception index, extension contact, farm size, and state location significantly influence the likelihood of willingness to pay, while age and gender were not statistically significant.

The bid coefficient was negative and significant at the 1% level (–0.0039), reaffirming the fundamental inverse relationship between bid level and acceptance probability observed in the Logit and Tobit models. This finding is consistent with microeconomic theory and previous contingent valuation studies (Hanemann, 1984; Bateman *et al*., 2002), which posit that as the cost of a proposed environmental service increases, the likelihood of acceptance decreases. The result highlights the price sensitivity of smallholder farmers and the importance of cost considerations in designing market-based or incentive-compatible soil fertility programmes. It implies that while farmers recognize the value of soil fertility management, their participation depends on the perceived affordability of proposed payment schemes. Thus, introducing flexible payment options or cooperative-based financing could improve adoption rates among resource-constrained farmers, aligning with evidence from Ogunniyi *et al*. (2019), who documented similar findings for sustainable agricultural practice adoption in Nigeria.

Table 3: Probit Regression on Socioeconomic Factors Affecting Likelihood of WTP

Variable	Coefficient	Robust Std. Error	z- statistic	p-value	Marginal Effect
Bid amount (₦)	-0.0039***	0.0011	-3.45	0.001	-0.0017
Income (₦'000)	0.0178**	0.0072	2.47	0.014	0.0076
Education (yrs)	0.0425**	0.0189	2.25	0.026	0.0183
Perception index	0.2918***	0.0805	3.63	0.0	0.1257
Extension contacts	0.1436**	0.0698	2.06	0.041	0.0618
Farm size (ha)	0.1189*	0.0632	1.88	0.06	0.0511
State (Oyo=1)	0.388**	0.175	2.22	0.027	0.1667
Constant	-1.532***	0.551	-2.78	0.005	—

Note: *, **, *** indicate significance level at 1%, 5%, and 10%. Source: Field Survey, 2025.

Income was found to have a positive and significant coefficient (0.0178, $p < 0.05$), suggesting that higher-income farmers are more likely to be willing to pay for soil fertility services. This relationship underscores the role of income as both an enabler and a proxy for risk tolerance in environmental decision-making. According to Nkonya *et al*., (2016), economic capability determines the extent to which farmers can internalize long-term ecological benefits relative to short-term liquidity needs. The result also supports the argument by Ibrahim and Umar (2021) that higher-income households tend to adopt extension-based innovations more readily due to greater access to information and inputs. Consequently, the positive income elasticity of WTP observed in this study provides empirical support for targeted subsidy schemes that differentiate farmers based on income categories, ensuring that financial constraints do not exclude poorer households from soil restoration programs.

Education was another important determinant, showing a positive and statistically significant effect (0.0425, $p < 0.05$). This finding indicates that farmers with more years of formal education are more likely to express willingness to pay for soil fertility management. Education enhances environmental literacy and helps farmers appreciate the long-term productivity implications of soil degradation. It also facilitates comprehension of extension messages and participation in collective soil management initiatives. This aligns with the observations of Adetunji *et al*. (2022) and Olalekan and Adebayo (2023), who both found education to be a key factor shaping farmers' adoption of soil testing and fertility-improving practices in Nigeria. As Onyekuru and Marchant (2021) noted, knowledge influences the perceived value of ecosystem services, thereby shaping the behavioral readiness to invest in conservation. Therefore, integrating environmental education and soil stewardship training into rural extension curricula can strengthen farmers' valuation of soil fertility as a critical ecosystem service.

The perception index also had a positive and highly significant coefficient (0.2918, $p < 0.01$), indicating that farmers who perceive soil fertility as crucial for sustained productivity are significantly more likely to be willing to pay. This result reflects the influence of cognitive and attitudinal factors in environmental valuation, consistent with the behavioral framework advanced by Farber *et al*. (2021), which emphasizes the role of perception and trust in shaping ecosystem service preferences. Farmers with a stronger perception of soil degradation risks are more willing to commit financial resources toward fertility management, recognizing its direct link to livelihood security. This supports the argument of Adeyolanu *et al*. (2020) that perception–practice congruence is essential for translating environmental awareness into concrete conservation action. Furthermore, extension contact exhibited a positive and significant effect (0.1436, $p < 0.05$), reaffirming the role of institutional support in influencing willingness. Frequent contact with extension agents increases farmers' exposure to information about the benefits of soil fertility

management, thus reinforcing confidence and participation. FAO (2020) underscores that interactive extension services act as catalysts for technology adoption and sustainable land management decisions.

Farm size and state of location also contributed significantly to explaining the probability of willingness to pay. The positive coefficient of farm size (0.1189, $p < 0.10$) indicates that larger-scale farmers are more likely to participate in soil fertility payment schemes, possibly because they anticipate higher aggregate benefits from improved soil productivity. This is consistent with Amujoyegbe and Akinola (2021), who found that farm size correlates positively with adoption of improved fertility practices due to economies of scale in technology application. Similarly, the positive and significant state dummy (0.388, $p < 0.05$) suggests that farmers in Oyo State, where agricultural systems are more commercialized, exhibit greater probability of willingness to pay compared to those in Ekiti. This aligns with earlier findings in the Logit and Tobit models and supports spatial differentiation in soil fertility policy formulation. The insignificance of age and gender implies that willingness to pay is a cross-demographic behavioral pattern, emphasizing that both young and older farmers, as well as male and female farmers, recognize the importance of soil fertility conservation when socioeconomic conditions permit.

Thus, the Probit results confirm that farmers' likelihood of willingness to pay for soil fertility management in Southwestern Nigeria is shaped by a combination of economic, cognitive, and institutional factors. This multifaceted influence aligns with the conceptual framework of ecosystem service valuation, which integrates behavioral economics with sustainable resource management (Pascual *et al*., 2022). Policy implications from these findings include the prioritization of farmer education, perception-building campaigns, and targeted extension services as essential complements to financial incentives. Encouragingly, the results demonstrate that farmers' willingness to participate in fertility enhancement programmes is not merely a function of income but also a reflection of awareness, information access, and perception of environmental value. Therefore, a comprehensive approach integrating economic incentives, extension support, and knowledge empowerment is imperative to foster sustainable soil fertility management and rural livelihood resilience in the study area.

Conclusion

This study assessed farmers' willingness to pay (WTP) for soil fertility management as an ecosystem service in Southwestern Nigeria, with specific focus on Ekiti and Oyo States. By employing Logit, Tobit, and Probit regression models alongside ANOVA and policy simulation analyses, the study provided empirical evidence on the determinants, magnitude, and regional variation in farmers' valuation of soil fertility. The findings revealed that while most farmers recognize soil fertility as a critical foundation for sustainable agricultural productivity, their willingness to pay and the amounts they are prepared to contribute are strongly influenced by economic capacity, educational attainment, perception of soil quality, and institutional access through extension services. The consistently negative bid coefficients across models confirm price sensitivity among smallholders, emphasizing affordability as a major determinant of participation in soil management programs.

The results further established significant inter-zonal disparities in WTP, with farmers in Oyo State expressing higher mean willingness and payment amounts than those in Ekiti State. These differences reflect the underlying heterogeneity in market orientation, income distribution, and extension coverage across the two states. The policy simulation component demonstrated that, despite limited resources, smallholder farmers collectively possess considerable potential to co-finance soil fertility enhancement programs. At a 70% participation rate, an estimated ₦518 million could be mobilized annually, indicating that localized co-financing frameworks, when properly designed, can contribute meaningfully to sustainable agricultural funding.

From a policy perspective, the findings underscore the need for context-specific and inclusive strategies to promote sustainable soil fertility management. In higher-income or commercialized zones such as Oyo, market-driven and cooperative-based financing models could be effective, while in relatively low-income areas like Ekiti, public subsidies and donor-supported cost-

sharing mechanisms remain essential. The results highlight that farmers' willingness to pay is not merely a reflection of economic ability but also of cognitive awareness and institutional trust. Consequently, strengthening extension systems, environmental education, and participatory governance structures is vital for translating willingness into sustained action.

Thus, this study affirms that recognizing soil fertility as an ecosystem service provides a robust framework for integrating ecological sustainability with economic incentives in Nigerian agriculture. Farmers expressed WTP demonstrates a growing appreciation of soil as natural capital and an essential input into long-term productivity. Translating this awareness into actionable policies through payment for ecosystem services (PES) models, cooperative financing, and targeted extension support offers a viable pathway toward achieving soil health restoration, food security, and environmental sustainability in Nigeria. Future studies should expand this approach to other agro-ecological zones, exploring dynamic valuation models and longitudinal assessments to better inform national soil fertility management policies.

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