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Determinants of Rural Household Livelihood Vulnerability to Forest Degradation in the Central Zone of Taraba State, Nigeria

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Abstract

Forest degradation increasingly threatens rural livelihoods in sub-Saharan Africa, yet the household characteristics shaping vulnerability remain insufficiently understood. This study examined the determinants of rural household livelihood vulnerability to forest degradation in the Central Zone of Taraba State, Nigeria. A cross-sectional mixed-methods design was adopted. Quantitative data were collected through structured questionnaires administered to 391 systematically selected households in Gashaka, Kurmi, and Sardauna Local Government Areas, while key informant interviews, focus group discussions, and direct observations provided qualitative evidence. Descriptive statistics and multiple linear regression were used for analysis. A Household Livelihood Index, comprising income, food security, access to basic amenities, and perceived well-being, served as the dependent variable. Agricultural expansion, uncontrolled bush burning, population growth, mining, and fuelwood collection were identified as the principal drivers of forest degradation. Reported livelihood effects included reduced fuelwood access, greater crop vulnerability, declining income, scarcity of medicinal plants, and unreliable water supplies. The regression model was statistically significant ($F = 37.342$, $p < 0.001$) and explained 32.8% of the variation in household livelihoods. Forest degradation was the strongest negative predictor ($\beta = -0.408$, $p < 0.001$). Female-headed households ($\beta = -0.138$, $p = 0.001$) and larger households ($\beta = -0.133$, $p = 0.004$) also recorded poorer outcomes, whereas household-head age ($\beta = 0.176$, $p < 0.001$) and education ($\beta = 0.142$, $p = 0.002$) improved livelihood resilience. The study concludes that vulnerability reflects environmental decline and household inequalities. Community-based forest management, livelihood diversification, clean energy access, reforestation, stronger enforcement, and gender-responsive support are recommended to strengthen resilience among forest-dependent households.

Keywords: Forest Degradation, Livelihood Vulnerability, Rural Households, Resilience, Taraba State, Nigeria.

Introduction

Forests are fundamental to the livelihoods of millions of people in developing countries, providing food, medicines, fuelwood, and essential ecosystem services that underpin household welfare and food security [1]. Globally, an estimated 1.6 billion people live within 5 km of a forest and depend directly on forest resources for their livelihoods [1]. In many developing countries, forest-related environmental income accounts for approximately 28% of total household income, with 77% of this derived from natural forests [2]. These resources serve not only as a primary livelihood strategy but also as a critical safety net during periods of economic or environmental stress [3,4]. Forest resources contribute between 20% and 40% of total household income in many developing countries, serving as both a primary livelihood strategy and a critical buffer against shocks [2].

In sub-Saharan Africa, forests and woodlands cover approximately 674 million hectares and support the livelihoods of over 600 million people through the provision of fuelwood, medicinal plants, wild foods, construction materials, and income-generating opportunities [1]. The region's forest ecosystems sustain agricultural productivity, regulate hydrological cycles, and support biodiversity conservation [5]. However, Africa continues to experience among the highest rates of deforestation globally, with nearly 4 million hectares of forest lost annually between 2010 and 2020 [1]. The major drivers include agricultural expansion, which accounts for almost 50% of global deforestation, fuelwood dependence, illegal logging, mining activities, and weak institutional frameworks [5,6]. The consequences include declining biodiversity, soil erosion, disruption of hydrological cycles, and reduced availability of forest products upon which rural households depend [5].

Nigeria presents a particularly acute case of forest degradation within the sub-Saharan African context. Despite possessing one of the richest forest ecosystems in West Africa; comprising tropical rainforests, freshwater swamp forests, mangrove forests, Guinea savannah woodlands, and Sudan savannah vegetation, the country has experienced one of the highest deforestation rates globally [1,6]. Nigeria's forest cover has declined from approximately 23.4% of its total land area in 1990 to less than 10% in recent decades, with an estimated annual loss of 350,000

to 400,000 hectares [6]. This dramatic decline is attributed to extensive conversion of forests into agricultural land, fuelwood extraction, commercial logging, infrastructure expansion, mining, bush burning, and rapid urbanization [6]. The resulting environmental degradation has manifested in declining biodiversity, increasing desertification, flooding, soil erosion, climate variability, and reduced livelihood opportunities for forest-dependent communities [5].

Taraba State in northeastern Nigeria is one of the country's most ecologically diverse states, containing extensive forest reserves, woodland ecosystems, riverine forests, and montane vegetation [7]. The state contains important forest reserves and protected areas, including the Gashaka-Gumti National Park, Africa's largest national park, and the Ngel Nyaki Forest Reserve, which harbour valuable timber species, wildlife, medicinal plants, and numerous non-timber forest products [8]. These forest resources constitute an essential source of livelihood for rural households through farming, hunting, fuelwood collection, charcoal production, timber harvesting, beekeeping, medicinal plant collection, and small-scale forest-based enterprises [7]. However, increasing population growth, agricultural expansion, illegal logging, fuelwood harvesting, charcoal production, mining, and weak institutional enforcement have intensified forest degradation across many parts of Taraba State [9]. Expansion of cultivated land, settlements, and road networks into forested landscapes has accelerated forest loss and habitat fragmentation. Consequently, biodiversity has declined, ecosystem services have been disrupted, and many rural households have experienced diminishing access to forest resources that traditionally supported their livelihoods [7].

The Central Zone of Taraba State, comprising Gashaka, Kurmi, Sardauna, Bali, and Gassol Local Government Areas, possesses extensive forest resources that support agricultural production and rural livelihoods [10]. The zone contains woodland ecosystems, gallery forests, riparian vegetation, and community forests that provide timber, fuelwood, medicinal plants, fruits, fodder, construction materials, and other ecosystem services [11]. A substantial proportion of the rural population depends directly or indirectly on these forest resources for income generation, subsistence, household energy, and cultural activities [7]. Despite their importance, forests within the Central Zone have experienced considerable degradation over recent decades. Rapid population increase, continuous expansion of cultivated land, indiscriminate logging, commercial fuelwood extraction, charcoal production, bush burning, infrastructure development, and increasing demand for land have accelerated the conversion of forests into agricultural fields and settlements [9,11]. The reduction in forest resources has adversely affected rural household livelihoods through declining availability of fuelwood, medicinal plants, wild foods, construction materials, and income derived from forest-based activities [7].

Despite growing recognition of the critical role that forests play in supporting rural livelihoods, there remains a significant gap in empirical understanding of the socio-economic determinants that shape household vulnerability to forest degradation. While extensive research has documented the ecological dimensions of deforestation and land-use change in Nigeria and other tropical regions, relatively few studies have systematically examined how household-level characteristics mediate the impacts of forest degradation on livelihood outcomes [1,2,4-6]. This gap is particularly pronounced in understudied ecological zones such as the Central Zone of Taraba State, where forest-dependent communities face accelerating environmental change and limited alternative livelihood opportunities. The extent to which households depend on forest resources and the degree to which they are affected by forest degradation vary considerably depending on household characteristics such as gender of household head, age, education, household size, and access to alternative livelihood assets [2,12,13].

Previous studies have identified several household-level determinants that influence vulnerability to environmental change. Gender has emerged as a particularly significant factor, with women often bearing a disproportionate burden of forest degradation due to their primary responsibility for collecting fuelwood, water, medicinal plants, and other non-timber forest products for household consumption [14,15]. Female-headed households frequently experience greater livelihood challenges because of limited access to land, credit, education, and decision-making power [14]. Education has been identified as a key component of human capital that enhances livelihood resilience by providing access to diverse livelihood opportunities, better resource management skills, and alternative income sources [12,13]. Household size influences resource pressure, with larger households facing greater competition for limited forest resources and household income [12]. Age of household head is associated with accumulated experience, assets, and social capital, which influence livelihood strategies and outcomes [13]. Despite these insights, relatively few studies in Nigeria have examined the determinants of rural household livelihood vulnerability to forest degradation using integrated approaches that combine perception data with household-level socio-economic analysis [11]. Most existing studies in Taraba State have concentrated on changes in forest cover without adequately examining their implications for livelihood assets, income diversification, food security, and household resilience [7].

The present study addresses this gap by investigating the determinants of rural household livelihood vulnerability to forest degradation in the Central Zone of Taraba State, Nigeria. Specifically, the study examines the relationship between perceived forest degradation and household livelihoods, while exploring how household-level characteristics including gender of household head, age, education, and household size influence vulnerability to environmental change. By integrating perception-based assessment of forest degradation with household survey data, the study provides a comprehensive analysis of the socio-economic determinants of livelihood vulnerability in a context of accelerating forest degradation.

The study is guided by the following research questions: What are the major causes of forest degradation in the study area as perceived by rural households? What is the impact of forest degradation on rural household livelihoods in the study area? What are the household-level determinants of livelihood vulnerability to forest degradation in the study area? What strategies do communities identify for mitigating forest degradation and improving household livelihoods? This study contributes to the growing body of literature on forest-livelihood linkages by providing empirical evidence on the socio-economic determinants of vulnerability and offering evidence-based recommendations for policy and practice.

Description of Study Area

The Central Senatorial District of Taraba State, located in northeastern Nigeria, forms the geographical focus of this investigation. The zone encompasses five Local Government Areas (LGAs): Bali, Gashaka, Gassol, Kurmi, and Sardauna, and is situated between latitudes 6°30'N and 8°30'N and longitudes 10°00'E and 11°30'E [7]. The study area spans approximately 32,110 km² and is bounded internationally by the Republic of Cameroon to the south and domestically by Adamawa State to the northeast.

The region exhibits remarkable physiographic diversity, ranging from the expansive Benue floodplains in the north to the elevated Mambilla Plateau in Sardauna LGA, which rises to over 1,500 meters above sea level [10]. The Mambilla Plateau, Nigeria's highest plateau, enjoys a temperate climate year-round, with temperatures typically reaching 20-23°C during dry season days and dropping to 16-18°C at night [16]. This contrasts sharply with the warmer lowland areas, which experience temperatures ranging from 23-40°C throughout the year [7].

Climatically, the area experiences a tropical sub-humid climate, classified as Aw under the Köppen-Geiger system, characterized by a distinct rainy season from April to October and a dry season from November to March, driven by the seasonal oscillation of the Intertropical Convergence Zone [10]. Mean annual rainfall varies significantly across elevation gradients, ranging from 1,200 mm in the lowland areas of Bali to over 2,500 mm on the Mambilla Plateau in Sardauna. The wet season lasts from March to November in the montane areas, with average annual rainfall exceeding 2,000 mm [16].

The drainage system is dominated by the River Benue and its major tributaries, including the Rivers Taraba, Donga, and Ibi, which rise from the Cameroonian mountains and traverse almost the entire length of the state before linking with the River Niger [7]. The Central Zone spans three major ecological zones: the Mountain Forest zone, the Southern Guinea Savanna, and the Northern Guinea Savanna [10]. The southern and eastern sectors are characterized by tropical rainforest and moist deciduous forest formations, while the northern lowlands are predominated by Sudan savanna woodlands and shrub grasslands [17]. Key protected areas within the zone include the Gashaka-Gumti National Park, Africa's largest national park and a critical haven for wildlife conservation, and the Ngel Nyaki Forest Reserve, a mid-altitude forest renowned for its diverse species composition [8]. The Ngel Nyaki Forest Reserve, situated about 60 km west of Gashaka-Gumti National Park, contains the entire known population of Phrynobatrachus danko and harbors unique species such as Aningeria altissima [8].

Between 2002 and 2020, Taraba State lost approximately 91,100 hectares of tree cover, representing 14% of the state's total forest loss during this period (Global Forest Watch, 2020). The major drivers of deforestation in the zone include logging (49.1% of respondents) and agricultural activities (25.3%), leading to biodiversity loss, soil erosion, and declining ecosystem services (Abba et al., 2021). Several forests, including Ngel Yaki (mean NDVI = 0.24), Gashaka-Gumti (0.23), and Gembu (0.21), have exhibited declining vegetation health, underscoring the urgent need for protection and restoration [7]. Rural communities in the zone depend heavily on forest resources for fuelwood, medicinal plants, timber, and non-timber forest products (NTFPs) [11]. Firewood remains a major source of NTFP income for 99% of respondents in some communities [7]. The study area was selected due to its representative socio-ecological dynamics, encapsulating the tension between forest conservation and rural livelihood demands prevalent across Nigeria's forest-savanna transition zone [16].

Methodology

Research Design

This study employed a cross-sectional mixed-methods survey design to investigate the determinants of rural household livelihood vulnerability to forest degradation in the Central Zone of Taraba State, Nigeria. The cross-sectional approach was appropriate for collecting quantitative and qualitative data on household characteristics, perceptions of forest degradation, livelihood outcomes, and mitigation strategies at a single point in time [18]. The mixed-methods design enabled triangulation of findings from household surveys, key informant interviews, focus group discussions, and direct observations, enhancing the validity and reliability of the results [19].

Population, Sample Size, and Sampling Procedure

The target population comprised all rural households residing in or adjacent to forested areas within Gashaka, Kurmi, and Sardauna LGAs. According to the National Population Commission and National Bureau of Statistics projections, the total population of the three LGAs is approximately 434,294, comprising 72,382 households based on an average household size of six persons [20,21]. The sample size was determined using the Yamane formula: $n = N \div (1 + N(e)^2)$, where n is sample size, N is population size, and e is precision level (0.05). Substituting the values yielded a sample size of 400 [22]. After data cleaning, 391 valid questionnaires were retained, representing a response rate of 97.8%.

A multi-stage sampling technique was employed [23,24]. In the first stage, three LGAs; Gashaka, Kurmi, and Sardauna, were purposively selected based on substantial forest cover, high household dependence on forest resources, and observable evidence of forest degradation. In the second stage, five wards were purposively selected from each LGA based on proximity to forest reserves, resulting in 15 wards. In the third stage, households were systematically sampled from each ward using community household listings. The sampling interval was determined by dividing the total number of households in each ward by the required sample size, with the first household selected through simple random sampling followed by systematic selection of every kth household.

Data Collection Methods

Quantitative data were collected using a structured household questionnaire administered through face-to-face interviews by trained research assistants [18,24]. The instrument was organized into six sections: socio-demographic characteristics; major causes of forest degradation; impacts of forest degradation on rural household livelihoods; contribution of forest resources to rural household livelihoods; mitigation strategies; and household livelihood outcomes. A five-point Likert scale was employed to assess respondents' perceptions [25]. The questionnaire was developed following extensive literature review and expert consultations, and was pilot-tested with 10 respondents from similar communities outside the study area [26]. Internal consistency reliability was assessed using Cronbach's Alpha,

with values of 0.82 for causes of degradation, 0.85 for impacts, 0.79 for contributions, and 0.81 for mitigation strategies, all exceeding the minimum threshold of 0.70 recommended for social science research [27,28]. The questionnaire was translated into Hausa and back-translated to English to ensure semantic equivalence [29].

Qualitative data were collected through key informant interviews (KIIs), focus group discussions (FGDs), and direct observations. A total of 15 KIIs were conducted with officials from the Taraba State Forestry Department, Ministry of Environment, Local Government Forestry Officers, traditional institution representatives, community leaders, and environmental NGOs [30,31]. Semi-structured interview guides covered historical forest trends, causes of degradation, institutional capacity, enforcement challenges, and conservation programmes. Six FGDs (two per LGA) were conducted with 8–12 participants each, including farmers, women fuelwood collectors, youth groups, hunters, and community elders [32,33]. Direct observations were systematically conducted to document land-use patterns, evidence of degradation, and human activities affecting forest resources [34].

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics using SPSS version 26.0 [27,35]. Descriptive statistics (frequencies, percentages, means, standard deviations) summarized respondents' socio-demographic characteristics, perceptions of degradation causes and impacts, forest contributions, and mitigation strategies. The Relative Importance Index (RII) was calculated to rank factors based on respondents' perceptions using the formula $RII = \Sigma(w_i \times f_i) \div (N \times 5)$ [36,37]. Multiple linear regression was employed to examine determinants of livelihood vulnerability, specified as: $HLI = \beta_0 + \beta_1 FDPI + \beta_2 HS + \beta_3 HHA + \beta_4 HHG + \beta_5 EDU + \varepsilon$, where HLI is the Household Livelihood Index (composite measure of income, food security, access to amenities, and perceived well-being), FDPI is Forest Degradation Perception Index, HS is Household Size, HHA is Household Head's Age, HHG is Household Head's Gender, and EDU is Educational Level [12,13,38]. Diagnostic tests confirmed satisfaction of regression assumptions: normality (Shapiro-Wilk, $p = 0.07$), multicollinearity (VIF < 2.31), homoscedasticity (Breusch-Pagan, $p = 0.24$), and autocorrelation (Durbin-Watson = 1.96) [27,35].

Qualitative data from KIIs and FGDs were analyzed thematically using NVivo software, with themes emerging inductively from the data through iterative reading, coding, and interpretation [39].

Ethical Considerations

The study adhered to established ethical guidelines for research involving human subjects [40,41]. Ethical approval was obtained from the Taraba State University Research Ethics Committee. Permission was obtained from the Taraba State Ministry of Environment, Local Government Authorities, and traditional leaders. Informed consent was obtained from all participants before data collection [18]. Participants were informed of the study's purpose, their rights, and that participation was voluntary with the right to withdraw at any time without consequence. Anonymity and confidentiality were maintained throughout the study, with personal identifiers not collected and data stored securely in password-protected files.

Resul of the Findings

Socio-Economic and Demographic Characteristics of Respondents

Table 1 delineates the socio-economic and demographic characteristics of the 391 respondents who participated in the household survey. The results suggest that male respondents constituted the majority with 236 (60%), while female respondents accounted for 155 (40%). The age distribution indicates that respondents aged 21–30 years constituted the highest proportion with 182 (47%), followed by those aged 31–40 years with 119 (30%), those aged 41–50 years with 66 (17%), and those aged 51 years and above with 24 (6%). Regarding marital status, single respondents comprised 183 (47%), followed by married respondents with 161 (41%), divorced with 26 (7%), and widows with 21 (5%).

Table 1: Socio-Economic and Demographic Characteristics of Respondents.

S/No.	Socio-Demographic Characteristics	Frequency	Percentage (%)
1	Gender		
	Male	236	60%
	Female	155	40%
	Total	391	100%
2	Age		
	21-30	182	47%
	31-40	119	30%
	41-50	66	17%
	51 and above	24	6%
	Total	391	100%
3	Marital Status		
	Married	161	41%
	Single	183	47%
	Divorced	26	7%
	Widow	21	5%
	Total	391	100%
4	Household Size		
	0	128	33%
	1-5	164	42%
	6-10	83	21%
	10 and above	16	4%
	Total	391	100%
5	Educational Level		
	Tertiary	118	30%
	Secondary	203	52%
	Primary	28	7%
	No formal Education	42	11%
	Total	391	100%
6	Occupation		

	Farming	109	28%
	Student	168	43%
	Trading	45	12%
	Artisan	15	4%
	Civil Servant	45	12%
	Applicant	9	2%
	Others	0	0%
	Total	391	100%

Source: Field Survey, 2024.

Concerning household size, households with 1–5 members constituted the highest proportion with 164 (42%), followed by households with no dependents (0 members) with 128 (33%), households with 6–10 members with 83 (21%), and households with 10 or more members with 16 (4%). The educational attainment of respondents shows that those with secondary education constituted the majority with 203 (52%), followed by tertiary education with 118 (30%), no formal education with 42 (11%), and primary education with 28 (7%). Regarding occupation, students constituted the highest proportion with 168 (43%), followed by farmers with 109 (28%), traders and civil servants with 45 (12%) each, artisans with 15 (4%), and applicants with 9 (2%).

Major Causes of Forest Degradation

Table 2 delineates respondents' perceptions of the major causes of forest degradation in the study area. Utilization of a five-point Likert scale, ranging from 'Strongly Disagree' to 'Strongly Agree,' suggests the following interpretation of mean scores: 1.00–1.49 (Strongly Disagree); 1.50–2.49 (Disagree); 2.50–3.49 (Undecided); 3.50–4.49 (Agree); and 4.50–5.00 (Strongly Agree).

Table 2: Major Causes of Forest Degradation in Central Taraba.

S/N	Items	N	Mean	SD	Remarks
1	Agricultural expansion for crop farming	391	4.40	.953	Agreed
2	Uncontrolled bush burning	391	4.25	.936	Agreed
3	Fuel wood collection for domestic use	391	4.13	1.016	Agreed
4	Population growth and urban	391	4.17	1.034	Agreed
5	Mining activities (both legal and illegal)	391	4.15	.973	Agreed
6	Climate change effects (e.g., increased droughts)	391	4.05	1.049	Agreed
7	Poverty and lack of alternative livelihoods	391	4.10	1.069	Agreed
8	Weak enforcement of forest protection laws	391	4.01	1.078	Agreed
9	Conflicts between farmers and	391	3.98	1.159	Agreed
10	Lack of awareness about the importance of forest	391	4.08	1.057	Agreed
	Grand Mean		**4.53**		

Source: Field Survey, 2024.

The 10 items were rated as "Agree" by respondents, with mean scores ranging from 3.98 to 4.40, which suggests a broad consensus among the participants. The grand mean of 4.13 indicates that respondents concurred with the listed causes of forest degradation. The highest-ranked drivers included agricultural expansion (mean = 4.40), uncontrolled bush burning (mean = 4.25), population growth (mean = 4.17), mining activities (mean = 4.15), and fuelwood collection (mean = 4.13), suggesting these variables are of particular significance. Weak enforcement of forest protection laws (mean = 4.01) and conflicts between farmers and herders (mean = 3.98) were rated lowest but still within the "Agreed" category.

Impacts of Forest Degradation on Rural Household Livelihoods

Table 3 delineates the respondents' perceptions regarding the impacts of forest degradation on rural household livelihoods in the study area.

Table 3: Impacts of Forest Degradation on Rural Households in Central Taraba.

S/N	Items	N	Mean	SD	Remarks
1	Forest Deforestation has reduced our household's access to fuelwood and heating	391	4.36	.805	Agreed
2	The loss of forest cover has made our crops more vulnerable to pests and diseases	391	4.29	.842	Agreed
3	The decline in forest resources has negatively impacted our household's income.	391	4.15	.965	Agreed
4	Forest loss has made it harder to find medicinal plants we rely on for healthcare	391	4.16	1.043	Agreed
5	Soil erosion due to deforestation has reduced the productivity of our farmland.	391	4.11	.915	Agreed
6	Forest loss has made our water sources less reliable and of poorer quality.	391	4.15	1.005	Agreed

7	Forest Deforestation has reduced grazing areas, negatively impacting our livestock.	391	4.05	.986	Agreed
8	The loss of forest products has forced us to spend more money on alternative materials.	391	3.93	1.022	Agreed
9	Deforestation has reduced our ability to cope with drought periods.	391	4.05	.971	Agreed
10	Forest loss has made our household more vulnerable to the impacts of climate change	391	4.12	.959	Agreed
	Grand Mean		4.13		

Source: Field Survey, 2024.

The ten survey items attained a consensus rating of "Agree" among respondents, with mean scores spanning the range of 3.93 to 4.36; a grand mean of 4.14 suggests that respondents perceive forest degradation to possess significant negative implications for household livelihoods. The highest-ranked impacts were reduced access to fuelwood (mean = 4.36), increased crop vulnerability to pests and diseases (mean = 4.29), reduced availability of medicinal plants (mean = 4.16), negative impact on household income (mean = 4.15), and less reliable water sources (mean = 4.15).

Contribution of Forest Resources to Rural Household Livelihoods

Table 4 provides a delineation of the perceptions of respondents regarding the contribution of forest resources to the sustenance of rural households within the study area.

Table 4: Contribution of Forest Resources to Livelihood of Rural Households in Central Taraba.

S/N	Items	N	Mean	SD	Remarks
1	Forest resources provide a significant source of income	391	4.45	.752	Agreed
2	We rely on forests for fuelwood as our primary source of energy for cooking	391	4.20	.853	Agreed
3	Forest fruits and nuts contribute substantially to our household's diet.	391	4.18	.950	Agreed
4	We collect medicinal plants from the forest for healthcare needs	391	4.19	.944	Agreed
5	Timber from forests is important for our housing and construction needs.	391	4.24	.949	Agreed
6	Hunting forest animals is a crucial source of protein for our family.	391	4.07	.974	Agreed
7	We gather wild honey from the forest as a food source and for sale	391	4.07	.946	Agreed
8	Forest resources provide materials for handicrafts that we sell for income.	391	3.89	1.032	Agreed
9	Grazing our livestock in forested areas is essential for animal feed.	391	3.96	1.048	Agreed
10	Forest resources contribute more to our livelihood than agricultural activities.	391	3.80	1.187	Agreed
	Grand Mean		**4.10**		

Source: Field Survey, 2024.

Respondents rated all ten items as "Agreed", with mean scores ranging from 3.80 to 4.45. The grand mean of 4.10 suggests that respondents perceived forest resources as making substantial contributions to their livelihoods. The highest-ranked contributions were provision of income (mean = 4.45), timber for construction (mean = 4.24), fuelwood for cooking (mean = 4.20), medicinal plants (mean = 4.19), and fruits and nuts (mean = 4.18).

Strategies for Mitigating Forest Degradation

Table 5 delineates the respondents' perceptions regarding the implementation of effective strategies for the mitigation of forest degradation within the study area.

Table 5: Strategies for Mitigating Forest Degradation in Central Taraba.

S/N	Items	N	Mean	SD	Remarks
1	Implementing stricter penalties for illegal logging would effectively reduce forest Deforestation	391	4.48	.730	Agreed
2	Providing alternative energy sources (e.g., solar, biogas) would reduce pressure on forests for fuelwood.	391	4.25	.876	Agreed

3	Implementing reforestation programs would significantly help restore degraded forest areas.	391	4.26	.904	Agreed
4	Providing alternative livelihood options would reduce community dependence on forest resources	391	4.21	.889	Agreed
5	Establishing community-managed forests would improve sustainable forest use	391	4.18	.918	Agreed
6	Educating local communities about sustainable forest management would reduce Deforestation	391	4.19	.934	Agreed
7	Implementing forest certification schemes would promote sustainable timber harvesting.	391	4.01	1.034	Agreed
8	Establishing protected areas with restricted access would effectively conserve forests.	391	3.96	1.041	Agreed
9	Promoting the use of improved cookstoves would reduce demand for fuelwood	391	4.12	.945	Agreed
10	Using satellite monitoring and technology would improve forest protection efforts	391	4.18	.935	Agreed
	Grand Mean		**4.13**		

Source: Field Survey, 2024.

The ten items received a consensus rating of "Agreed" from respondents, with mean scores ranging from 3.96 to 4.48. The grand mean of 4.18 suggests that respondents were in strong agreement with the listed mitigation strategies. The highest-ranked strategies were stricter penalties for illegal logging (mean = 4.48), reforestation programs (mean = 4.26), alternative energy sources (mean = 4.25), alternative livelihood options (mean = 4.21), and community-managed forests (mean = 4.18).

Multiple Regression Analysis of Determinants of Livelihood Vulnerability

Model Specification and Theoretical Foundation

The multiple regression analysis was employed to examine the relationship between perceived forest degradation and rural household livelihoods while controlling for other socio-demographic factors that may influence livelihood outcomes. The regression model was specified as:

$HLI = \beta_0 + \beta_1 FDPI + \beta_2 HS + \beta_3 HHA + \beta_4 HHG + \beta_5 EDU + \varepsilon$

Where HLI is the Household Livelihood Index (dependent variable), FDPI is the Forest Degradation Perception Index, HS is Household Size, HHA is Household Head's Age, HHG is Household Head's Gender (0 = male, 1 = female), EDU is Educational Level (0 = none, 1 = primary, 2 = secondary, 3 = tertiary), β_0 is the Intercept (constant term), β_1–β_5 are the regression coefficients for the independent variables, and ε is the Error term.

Model Performance and Statistical Significance

Table 6 presents the model summary, showing the strength of the relationship between the predictor variables and the Household Livelihood Index. The model demonstrates robust statistical performance, with an R value of 0.573, indicating a moderate to strong correlation between the collective predictor variables and the Household Livelihood Index. An R^2 value of 0.328 suggests that 32.8% of the total variation in the Household Livelihood Index is attributable to the five independent variables within the model. The adjusted R^2 of 0.319 shows that even after adjusting for the number of predictors, the model still explains 31.9% of the variation. This R^2 value is considered substantial in social science research, particularly for cross-sectional household data where numerous unmeasured factors influence outcomes.

Table 6: Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.573[a]	.328	.319	3.826

[a]Predictors: (Constant), Forest Degradation Index, Gender, Household Age, Educational Level, Household Size

Source: Regression Analysis, 2024.

Table 7 presents the analysis of variance (ANOVA) results, suggesting the overall statistical significance of the model. These findings indicate that the model maintains high statistical significance ($F = 37.342$, $p < 0.001$), permitting the rejection of the null hypothesis regarding zero regression coefficients and indicating that at least one predictor variable possesses a significant relationship with the household livelihood index.

Table 7: ANOVA.

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	2733.587	5	546.717	37.342	.000[b]
Residual	5600.490	385	14.547		
Total	8334.077	390			

[a]**Dependent Variable:** Household Livelihood Index

[b]**Predictors:** (Constant), Forest Degradation Index, Gender, Household Age, Educational Level, Household Size

Source: Regression Analysis, 2024.

Individual Variable Effects and Interpretation

Table 8 delineates the individual regression coefficients for each independent variable; the data suggest that these relationships exhibit statistical significance:

Table 8: Coefficients.

Model	Unstandardized Coefficients	Standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta			
1	(Constant)	48.763	1.842		26.472	.000
	Gender	-1.578	0.462	-0.138	-3.416	.001
	Household Age	0.910	0.241	0.176	3.776	.000
	Educational Level	0.814	0.255	0.142	3.192	.002
	Household Size	-0.752	0.259	-0.133	-2.903	.004
	Forest Degradation Index	-0.427	0.044	-0.408	-9.705	.000

[a]**Dependent Variable:** Household Livelihood Index

Source: Regression Analysis, 2024.

The regression analysis delineates the following significant relationships:

Forest Degradation Perception Index (FDPI): This emerged as the most significant predictor of household livelihoods, showing a strong negative relationship with the Household Livelihood Index (β = -0.408, p = 0.000). For every one-unit increase in the Forest Degradation Perception Index, the Household Livelihood Index decreases by 0.427 units. This observation suggests that households perceiving severe forest degradation experience substantially lower livelihood outcomes compared to those perceiving less degradation.

Gender: Gender showed a significant negative relationship with household livelihood (β = -0.138, p = 0.001). The negative coefficient suggests that female-headed households experience lower livelihood outcomes compared to male-headed households, with female-headed households having, on average, 1.578 points lower on the Household Livelihood Index than male-headed households.

Household Head's Age: Age of household head showed a positive and significant relationship with household livelihood (β = 0.176, p = 0.000). Each additional year of household head age is associated with a 0.910 increase in livelihood index, possibly due to accumulated experience, assets, and social capital over time.

Educational Level: Education showed a positive and significant relationship with household livelihood (β = 0.142, p = 0.002). For each unit increase in educational level, the household livelihood index increases by 0.814 units, as education enhances human capital and provides access to diverse livelihood opportunities.

Household Size: Household size showed a negative and statistically significant relationship with household livelihood (β = -0.133, p = 0.004). Each additional household member decreases the livelihood index by 0.752 points, as larger households face greater resource pressure with more individuals competing for limited forest resources and household income.

The regression results reveal the following significant relationships:

Forest Degradation Perception Index (FDPI): This emerged as the most significant predictor of household livelihoods, showing a strong negative relationship with the Household Livelihood Index (β = -0.408, p = 0.000). For every one-unit increase in the forest degradation perception index, the household livelihood index decreases by 0.427 units. This indicates that households perceiving severe forest degradation experience substantially lower livelihood outcomes compared to those perceiving less degradation.

Gender: Gender showed a significant negative relationship with household livelihood (β = -0.138, p = 0.001). The negative coefficient suggests that female-headed households experience lower livelihood outcomes compared to male-headed households, with female-headed households having, on average, 1.578 points lower livelihood index scores than male-headed households.

Household Head's Age: Age of household head showed a positive and significant relationship with household livelihood (β = 0.176, p = 0.000). Each additional year of household head age is associated with a 0.910 increase in livelihood index, possibly due to accumulated experience, assets, and social capital over time.

Discussion

Perceived Causes of Forest Degradation

The study found that agricultural expansion emerged as the most significant perceived cause of forest degradation (mean = 4.40), followed by uncontrolled bush burning (mean = 4.25), population growth (mean = 4.17), mining activities (mean = 4.15), and fuelwood collection (mean = 4.13). The grand mean of 4.53 for all cause-related items indicates that communities possess strong awareness of the factors driving forest degradation in their areas. These findings are consistent with previous studies in Nigeria and other sub-Saharan African contexts. Hansen et al. (2013) reported that agricultural expansion accounts for almost 50% of global deforestation, while FAO (2020) identified agricultural conversion as the primary driver of forest loss in tropical regions. Similarly, Abba found that logging (49.1% of respondents) and agricultural activities (25.3%) were the major drivers of deforestation in Taraba State [11]. Global Forest Watch documented that between 2002 and 2020, Taraba State lost approximately 91,100 hectares of tree cover, representing 14% of the state's total forest loss during this period [9].

The identification of weak enforcement of forest protection laws (mean = 4.01) and lack of awareness about forest conservation (mean = 4.08) as important causes supports the Political Ecology framework, which emphasizes that weak institutions, inadequate

enforcement of forestry regulations, and unequal access to resources contribute significantly to environmental degradation [42]. The study demonstrates that governance failures have allowed illegal logging and uncontrolled exploitation of forest resources to continue. Jatau and Chimbekujwo similarly found that weak institutional frameworks hamper the capacity of forestry officials to enforce forestry legislation in Taraba State [7]. Climate change effects (mean = 4.05) and poverty and lack of alternative livelihoods (mean = 4.10) were also identified as important causes, supporting the findings of IPCC, which reported that climate variability has contributed to declining agricultural productivity, increased food insecurity, and greater dependence on forest resources [5].

Impacts of Forest Degradation on Rural Household Livelihoods

The study found that forest degradation has substantial negative impacts on rural household livelihoods. Respondents identified reduced access to fuelwood (mean = 4.36), increased crop vulnerability to pests and diseases (mean = 4.29), reduced availability of medicinal plants (mean = 4.16), negative impacts on household income (mean = 4.15), and less reliable water sources (mean = 4.15) as the most significant consequences. The grand mean of 4.13 for all impact-related items confirms that forest degradation has substantial negative consequences for household welfare. This finding provides strong empirical support for the Sustainable Livelihoods Framework [38]. According to the framework, forests represent natural capital that supports household income, food security, and resilience. The observed reduction in forest resources therefore weakens livelihood assets and limits opportunities for livelihood diversification [12,13].

The finding that forest degradation has reduced access to fuelwood is consistent with FAO, which reported that approximately 1.6 billion people depend directly on forests for their livelihoods, while more than 2 billion people rely on fuelwood and charcoal as their primary household energy source [1]. Jatau and Chimbekujwo found that firewood remains a major source of NTFP income for 99% of respondents in some communities in Taraba State [7]. The finding that forest degradation has increased crop vulnerability to pests and diseases (mean = 4.29) and reduced farmland productivity through soil erosion (mean = 4.11) is consistent with IPCC, which reported that removal of forest vegetation exposes soils to erosion, reduces organic matter, alters rainfall patterns, and decreases agricultural productivity [5].

Determinants of Livelihood Vulnerability

The multiple regression analysis provides compelling evidence for the determinants of livelihood vulnerability. The model was highly significant ($F = 37.342$, $p < 0.001$), explaining 32.8% of the variation in household livelihood outcomes. The Forest Degradation Perception Index emerged as the most significant predictor ($\beta = -0.408$, $p = 0.000$), confirming that perceived environmental decline directly undermines household welfare. Gender proved to be a significant determinant, with female-headed households experiencing substantially lower livelihood outcomes ($\beta = -0.138$, $p = 0.001$), reflecting systemic gender inequalities in access to resources, land ownership, and economic opportunities.

This finding is consistent with Agarwal, who reported that gender inequalities in access to natural resources reduce women's adaptive capacity and limit their participation in forest governance [14]. Household size also negatively predicted livelihood outcomes ($\beta = -0.133$, $p = 0.004$), as larger households face greater pressure on limited resources. Conversely, household head age ($\beta = 0.176$, $p = 0.000$) and educational level ($\beta = 0.142$, $p = 0.002$) emerged as significant positive predictors, suggesting that accumulated experience, assets, and human capital enhance household resilience to environmental change. Scoones and Ellis identified education as a key component of human capital that influences livelihood strategies and outcomes [12,13].

Conclusion

This study demonstrates that forest degradation in Central Taraba constitutes both an ecological crisis and a profound livelihood emergency. Perceived degradation is the strongest predictor of vulnerability, with female-headed and larger households facing disproportionate burdens while education and age enhance resilience. Rural livelihoods remain intrinsically linked to forest health, making sustainable development unattainable without halting forest loss. Effective action requires integrated interventions addressing socio-economic determinants of vulnerability while promoting sustainable forest management and livelihood diversification. Policy must move beyond purely ecological approaches to address underlying socio-economic vulnerabilities shaping household resilience [43].

Recommendations

Based on the findings, the following recommendations are proposed:

- **Strengthen Community-Based Forest Management:** Legally empower Community Forest Management Committees to oversee local forest resources through devolved stewardship, local monitoring, collective action, and benefit-sharing, addressing weak enforcement by fostering sustainable use through local stewardship.
- **Promote Sustainable Alternative Livelihoods:** Develop and fund programs providing training, start-up capital, and market access for non-forest-dependent income sources such as agroforestry, beekeeping, and ecotourism to tackle poverty and over-dependence on forest extraction.
- **Scale Up Clean Energy Access:** Implement targeted programs distributing improved cookstoves and facilitating community access to solar energy and biogas digesters, providing viable fuelwood alternatives while improving health and economic savings.
- **Integrate Gender-Responsive Interventions:** Include specific provisions supporting female-headed households—credit access, land rights, targeted training—and ensure women's active representation in forest management committees to address gender-based vulnerability.
- **Enhance Enforcement and Monitoring:** Deploy participatory monitoring systems integrating community knowledge with technology to track deforestation and illegal activities, strengthening enforcement through consistent penalties for violations.

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