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Assessing the Impact of Forest Ecosystem Service Categories on the Livelihood Sustainability of Forest Communities in Ondo and Kwara States, Nigeria

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Abstract

Forests provide vital ecosystem services that support rural livelihoods, yet their socio-economic importance remains poorly documented in Nigeria. Increasing deforestation and unsustainable land use threaten these resources and the well-being of forest-dependent communities. This study assessed how different forest ecosystem service categories influence livelihood activities in selected forest communities of Ondo and Kwara States, Nigeria. The research was conducted across three ecological zones Tropical Rainforest, Derived Savanna, and Guinea Savanna. Data were collected from 480 respondents using structured questionnaires administered to households located within 1–2 km of forest reserves. Descriptive statistics were used to analyze the data. Findings revealed significant variation in the contributions of ecosystem services across ecological zones. In the Tropical Rainforest of Ondo State, dependence on forest income was highest in Ajowa (88%), Ala (82%), and Mofere (80%), while Aponmu recorded the lowest at 60%. Communities in the Derived Savanna relied moderately on provisioning services, particularly fuelwood and NTFPs, but also engaged in extractive activities such as granite and clay collection. The Guinea Savanna zone recorded the least benefits, with limited access to provisioning, regulating, and supporting services, underscoring its ecological vulnerability. Cultural services such as sacred groves and spiritual practices were present but declining due to weakened traditional conservation values. The study concludes that forest ecosystem services play a vigorous role in sustaining livelihoods, although their benefits are unevenly distributed across ecological zones. It recommends promoting sustainable forest management, strengthening community-based governance, expanding agroforestry practices, and supporting reforestation to secure the long-term availability of forest ecosystem services in Nigeria.

Keywords: Forest ecosystem services, Livelihood activities, Tropical Rainforest, Derived Savanna, Guinea Savanna and

Introduction: Forests are among the most vital ecosystems supporting human life, particularly for rural communities whose survival and development are closely tied to forest resources. Beyond their ecological role, forests provide essential materials and services that sustain livelihoods, enhance well-being, and ensure ecosystem balance. Globally, an estimated 300 to 350 million people depend almost entirely on forests for nutrition and livelihood support (Bharucha and Pretty, 2019). In Nigeria, forests remain an indispensable resource base for food security, healthcare delivery, employment provision, and poverty alleviation (Onyekwelu *et al.*, 2014). Similarly, Obi-Egbedi *et al*. (2021) noted that forests play crucial roles in supporting livelihoods, regulating the carbon cycle, moderating microclimates, protecting biodiversity, and contributing to sustainable growth. The magnitude of the benefits derived from forests underscores their centrality to the sustainability of rural livelihoods, particularly in forest-adjacent communities. Historically, forests have influenced global patterns of economic development by shaping settlement structures, supporting livelihood strategies, and facilitating transitions in land use and energy systems (Williams, 2020). Before the industrial revolution, forest landscapes served as the primary sources of cultivable land, construction materials, food, fuel, and medicinal resources. Even with technological progress, forests continue to provide indispensable services that complement human development and sustainability. Onyekwelu *et al*. (2014) and Olusola *et al*. (2021) observed that tropical forests host nearly 40% of the world's 275,000 flowering plant species, many of which produce edible fruits, vegetables, and nuts vital for nutrition and income generation. These benefits, both tangible and intangible, emphasize the importance of forests as reservoirs of ecosystem services whose values transcend economic and ecological dimensions.. In contemporary research, the contributions of forests are conceptualized within the framework of **forest ecosystem services (FESs)**, which encompass the goods and functions humans derive from ecological systems. Ecosystem services have been defined as the capacity of natural processes to generate goods and functions that meet human needs directly or indirectly (Meijaard *et al*., 2011). Costanza *et al*. (2020) extended this definition by linking ecosystem services to flows of materials, energy, and information from natural capital, which, when integrated with human inputs, generate societal welfare. Collectively, these processes are categorized into four broad groups: **provisioning, regulating, supporting, and cultural services** (Pastur *et al*., 2018). Each of these service categories contributes uniquely to human survival and community sustainability. Provisioning services include timber, fuelwood, non-timber forest products (NTFPs), medicinal plants, and food. Supporting services underpin ecological stability by sustaining soil formation, nutrient cycling, and biodiversity conservation (Hobbie, 2015). Regulating services involve climate regulation, carbon sequestration, erosion control, and water purification (Nwafor *et al*., 2020; Fedele *et al*., 2017). Cultural services, meanwhile, enrich social identity, spiritual practices, and recreation (Nowak-Olejnik *et al*., 2022; Malik and Ali, 2023). Collectively, these services create a framework through which forests maintain ecological resilience and support socio-economic development. Nigeria, however, is facing critical challenges in maintaining these services due to deforestation, land-use change, and unsustainable exploitation. Ogundele *et al*.

(2016) reported that logging, agricultural expansion, and urbanization are key drivers of forest degradation, leading to biodiversity loss, soil erosion, and disruption of carbon sequestration capacities. Kumar (2022) further emphasized that deforestation undermines supporting services such as nutrient cycling and habitat provision, threatening long-term ecosystem stability. The loss of these services directly affects the livelihood activities of forest-dependent communities, particularly in states like Ondo and Kwara where rural populations rely heavily on NTFPs, agriculture, and cultural uses of forest landscapes for survival.

Despite their central role in sustaining life and livelihoods, forest ecosystems globally are under multiple pressures that compromise their capacity to deliver critical services (Afodu *et al*., 2019). Population growth, poverty, agricultural expansion, and unsustainable exploitation continue to erode forest resources, thereby reducing the flow of ecosystem goods and services. In Nigeria, the impacts of these pressures are particularly severe. Human activities such as indiscriminate logging, shifting cultivation, and fuelwood harvesting have contributed to large-scale forest degradation and deforestation. These processes undermine soil fertility, increase carbon emissions, and exacerbate climate change, with negative implications for agricultural productivity and rural survival. The consequences of ecosystem degradation are far-reaching. Declines in soil organic matter and nutrient levels impair crop yields, while changes in rainfall patterns and microclimatic conditions aggravate food insecurity and rural poverty (Somorin, 2019). For Nigeria, with a population exceeding 180 million people most of whom live in rural areas characterized by poverty, hunger, disease, and limited land holdings (Azeez and Adeniyi, 2016) forests remain a critical buffer against livelihood vulnerability. Yet, there is limited systematic research that quantifies the contributions of forest ecosystem service categories to livelihood sustainability in specific localities.

Although tropical forests in Nigeria are known to be rich in biodiversity and resources (Anwadike, 2020), their economic and ecological contributions are often undervalued or overlooked. The lack of comprehensive, location-specific data on the types, conditions, and importance of ecosystem services contributes to unsustainable exploitation practices. Consequently, many rural households are at risk of losing essential provisioning and regulating services, which threatens their economic empowerment and long-term resilience. Failure to address these gaps could result in escalating socio-economic challenges such as declining agricultural productivity, food insecurity, increased poverty incidence, and greater vulnerability to climate change impacts. The absence of robust, evidence-based insights into the contribution of forest ecosystem services to household livelihoods hinders both policy formulation and sustainable forest management practices in Nigeria.

Forests contribute immensely to global and local livelihoods. Estrada *et al*. (2022), reported that over one billion people rely on forests to varying degrees, with about 60 million indigenous people almost wholly dependent on them. Furthermore, approximately 350 million people living adjacent to dense forests depend on forest resources for subsistence and income. In developing countries, agroforestry practices support about 1.2 billion people, sustaining both agricultural productivity and income generation (FAO, 2020). Forest industries alone provide employment for nearly 60 million people worldwide. These contributions are largely linked to ecosystem goods and services. In Nigeria, however, many of these benefits are either under-documented or unquantified, leading to a lack of appreciation of their socio-economic value. With 11,089,000 hectares of forested land (FAO, 2020; Onyekwelu, 2017), the country possesses significant potential for leveraging ecosystem services to enhance livelihood sustainability. Yet, scanty research exists on the specific contributions of forest ecosystem service categories to poverty reduction, nutrition, employment, and income generation in rural settings. This gap in knowledge hinders efforts to integrate forest ecosystem services into policy and planning for sustainable development.

Methodology: Study Area: This study was carried out in three selected ecological zones which are tropical rainforest, guinea savanna, and derived savanna in Ondo and Kwara States, Nigeria (Figure 1). Kwara State, created in 1967, covers about 36,825 km² with a population of 2,365,353 (2006 census). It lies between latitudes 8°–10°N and longitudes 3°–6°E, sharing boundaries with Niger, Oyo, Osun, Ekiti, and Kogi States. The climate is tropical, with rainy (March–September) and dry (October–March) seasons. Mean annual rainfall ranges from 1,000–1,500 mm, while temperature averages 25–30°C in the rainy season and 33–34°C in the dry season. Relative humidity varies between 35–80%. The state is underlain by Precambrian basement complex rocks with ferruginous tropical soils, which are easy to cultivate but prone to nutrient leaching. Vegetation is largely savanna, lying in the transition between derived savanna and forest zones. Forest and savanna cover about 47.8% and 35% of land area, respectively, with common species including *Vitellaria paradoxa*, *Parkia biglobosa*, and *Afzelia africana*. Kwara is predominantly agrarian, with about 70% of the population engaged in farming. Major crops include yam, cassava, sweet potato, and cereals, although yields remain low, contributing to poor rural livelihoods. Ondo State, created in 1976, lies between latitudes 5°45′–8°15′N and longitudes 4°45′–6°00′E. It covers about 13,595 km² and had a population of 3,441,024 in 2006. It is bordered by Ekiti, Kogi, Edo, Delta, Osun States, and the Atlantic Ocean. The state has a tropical wet-and-dry climate, with rainfall exceeding 2,000 mm in the rainforest and about 1,500 mm in the derived savanna. Temperatures average 27°C in the rainforest and 30°C in the savanna, with relative humidity above 75% in the south and less than 70% in the north. The geology is dominated by basement complex rocks, with well-drained soils suitable for both arable and tree crops. Vegetation ranges from mangroves and freshwater swamp forests in the south, rainforest in the central zone, and derived savanna in the north. Common tree species include *Melicia excelsa*, *Terminalia superba*, and *Lophira procera*. Tree crops such as cocoa, kola, rubber, and oil palm are widespread, with cocoa as the dominant cash crop. However, natural forests have been heavily degraded due to farming and other human activities, now restricted to forest reserves.

Data Collection Methods: Data for this study were collected using a quantitative approach through the administration of structured questionnaires. A total of 12 communities were selected across the Tropical Rainforest, Guinea Savanna, and Derived Savanna ecological zones of Ondo and Kwara States. From each of the three ecological zones, four communities were randomly chosen. In each of the 12 communities, 40 respondents residing within 1–2 km of the forest reserves were interviewed individually, giving a total of 480 respondents. The questionnaires captured information on demographic characteristics, livelihood activities, and the contributions of different categories of forest ecosystem services to household well-being.

Sampling Procedure and Sample Size::A multistage sampling technique was employed to select respondents for this study. The two states, Ondo and Kwara, were first stratified according to their distinct ecological zones to ensure adequate representation of environmental diversity. In Ondo State, the Tropical Rainforest and Derived Savanna zones were identified, while in Kwara State, the Guinea Savanna and Derived Savanna zones were considered. Lists of forest-adjacent communities within each ecological zone were obtained from the respective State Forestry Departments. From these lists, specific communities were purposively selected based on their proximity to forest reserves and active involvement in forest-based livelihood activities.

In the Tropical Rainforest zone of Ondo State, four communities Ajowa, Aponmu, Ala, and Mofere were chosen. From the Derived Savanna zone, Okeluse and Aiyegunle-Akoko were selected. In Kwara State, the Derived Savanna zone included Igbaja and Ipetu, while the Guinea Savanna zone

comprised Dusi, Kugeji, Shonga, and Bacita. In each of the twelve selected communities, forty respondents were randomly chosen, resulting in a total sample size of 480 respondents. This sampling procedure ensured that the data collected captured variations across ecological zones and states, thereby providing a balanced and representative basis for analysis.

Data Analysis: After retrieval, the questionnaire was coded to obtain quantitative values for statistical analysis using SPSS version 26. Each option under each variable (question) on the questionnaire was assigned a value. The study used descriptive statistical tool for data analyses. Descriptive statistics included frequency counts, percentages, mean, and pie charts.

Results Various Livelihood Activities of Forest Ecosystem Services: The results documented in Table 1 revealed the various livelihood activities of forest ecosystem services in the studied area. In the rainforest zone, which includes the communities of Ajowa, Aponmu, Ala, and Mofere, the contribution of forest ecosystem services to livelihoods is consistently high across several provisioning services. Activities such as firewood collection, timber harvesting, fruits gathering, mushrooms, medicinal herbs, and snail picking are ranked at (4). Fishing, rattan collection, and water sourcing are also significant, though slightly lower, with rankings around (3). Services such as forest security and non-timber uses like shelter for abductors are rated much lower, around (1–2). In the derived savanna zone, represented by Okeluse and Aiyegunle-Akoko, the pattern of ecosystem service utilization is similar to the rainforest but with some nuanced shifts in ranking emphasis. Core provisioning services such as timber harvesting, firewood, fishing, snails, and agricultural land access hold steady at (4). However, there is a noticeable elevation in the ranking of extractive and material-based services such as granite collection, clay sourcing, and pebbles, which rise to (3), slightly higher than in the rainforest. Services like medicinal herbs, fruits, and mushrooms remain relevant, also ranking around (3), but their contribution appears slightly moderated compared to the rainforest. Water sourcing and rattan are moderately valued at (2–3), while forest security and forest insects are less important, with rankings of (1–2). In the Guinea savanna zone, which encompasses the communities of Igbaja, Ipetu, Kugeji, Dusi, Shonga, and Bacita, Key services like firewood, fodder collection, fishing, fruits, mushrooms, and medicinal herbs are consistently ranked at (4). What distinguishes the Guinea savanna is the prominence of services such as granite, pebbles, and clay extraction, which also achieve rankings of (4). Agricultural access and forest security are moderately ranked at (3), while services like rattan collection and purified water sourcing receive similar moderate importance. Negative or low-value uses such as shelter for abductors and forest insects remain at the bottom, with rankings of (1–2).

Income Derived from Forest Ecosystem Services: The data from Figure 2 reveals a high level of income dependence on forest ecosystem services among respondents in the ecological zones. Across the tropical rainforest zone of Ondo State, Ajowa recorded the highest proportion of farmers deriving income from forest ecosystem services at 88 percent, closely followed by Ala at 82 percent and Mofere at 80 percent, while Aponmu showed a much lower figure of 60 percent.In the derived savanna, income dependence was lowest in Okeluse at 55 percent, but higher in Aiyegunle-Akoko at 75 percent, with Igbaja and Ipetu in Kwara State also showing relatively high values at 73 and 70 percent respectively.

In the guinea savanna, Shonga stood out with the highest recorded value across all zones at 87 percent, followed by Dusi at 80 percent, while Kugeji and Bacita recorded 65 and 60 percent respectively.

Average Monthly Income from Forest Ecosystem Services: The data in Table 2 shows the distribution of average monthly income derived from forest ecosystem services (FES) across the three ecological zones. In the tropical rainforest zone of Ondo State, Ajowa recorded the highest concentration of respondents earning between ₦41,000 and ₦60,000 at 30 percent, with a substantial proportion also earning between ₦61,000 and ₦80,000 at 25 percent, indicating a relatively strong income base from forest ecosystem services. Aponmu showed a larger share in the lower income brackets, with 25 percent earning less than ₦20,000 and only 7.5 percent earning above ₦81,000. Ala displayed the highest proportion in the ₦41,000–₦60,000 range at 32.5 percent within the zone. In the derived savanna, Okeluse had the largest share of respondents in the lowest income bracket at 30 percent and the least in the higher brackets. Aiyegunle-Akoko showed a stronger presence in the middle-income range, with 30 percent earning between ₦41,000 and ₦60,000, and moderate representation in higher categories. In Kwara State's derived savanna communities, Igbaja and Ipetu both recorded significant portions of respondents in the middle-income range, with 27.5 percent and 25 percent respectively. In the guinea savanna, Shonga stood out with the highest proportion of respondents in the ₦81,000 and above category at 17.5 percent, alongside a strong presence in the ₦61,000–₦80,000 range. Dusi also exhibited balanced earnings with notable proportions in both middle and upper categories, while Kugeji showed a concentration in the ₦21,000–₦40,000 and ₦41,000–₦60,000 ranges. Bacita, however, had the highest proportion of respondents in the lowest bracket at 27.5 percent within the zone.

Availability of Forest Ecosystem Service Within the Past Five (5) Years: From the results presented in Table 3, it is clear that the availability of forest ecosystem services within the past five years varies considerably across the three ecological zones Rainforest, Derived Savanna, and Guinea Savanna with distinct patterns emerging from the Likert ranking. In the Rainforest zone (Ondo State: Aponmu, Ajowa, Ala, Mofere), the values consistently fall within the very high category (Likert 5), with mean scores mostly above 4.7. Services such as timber cutting, collection of fuelwoods, mushrooms, fruits, medicinal herbs, and even regulating services like carbon sequestration, climate change mitigation, and oxygen production are all perceived to be abundantly available. In the Derived Savanna (Ondo State: Okeluse and Aiyegunle-Akoko), the results mostly fall within the high category (Likert 4). While timber extraction, fuelwood collection, and NTFPs (non-timber forest products) like fruits, mushrooms, and herbs remain accessible, the mean scores (3.8–4.4) show a gradual decline compared to the rainforest zone. Services such as watershed protection, collection of snails, and forest seed banks also receive lower ratings here, reflecting increasing resource pressure and reduced ecosystem capacity. In contrast, the Guinea Savanna (Kwara State: Igbaja, Ipetu, Kugeji, Dusi, Shonga, Bacita) demonstrates the weakest availability of ecosystem services. Most mean scores fall within the moderate to high range (Likert 3–4), with some services such as collection of snails, forest seed banks, watershed protection, and water purification dropping into the "moderate" category (Likert 3). In particular, Bacita and Shonga communities record the lowest mean values (2.4–3.5), indicating a notable decline in forest productivity and regulating functions.

Discussion: The results on the various categories of ecosystem services highlight a clear ecological gradient in their availability and significance to local livelihoods across rainforest, derived savanna, and guinea savanna zones. Provisioning services are most abundant in rainforest communities, where food materials, medicinal products, seeds, and raw materials were reported at above 90 percent availability. This pattern is plausibly driven by basic ecophysiology (higher biomass and species richness in rainforests), proximity and access to remnant trees or regrowth patches, and the way local markets and household economies depend on short-term, tangible goods. Forest regrowth and intact forest patches supply wild fruits, leafy vegetables and other NTFPs that directly raise dietary diversity and household food security, so sites with more tree cover are experienced as richer in provisioning services (Rasmussen *et al*. 2023). Where forest cover is lower or highly fragmented (derived and Guinea savanna), households still obtain provisioning resources but at lower frequencies and volumes; increased reliance on farmland and intensive

extraction (charcoal, firewood) reduces stocks and therefore perceived availability (Bolaji *et al*. 2024). Market and value-chain dynamics also structure availability: places closer to trade nodes or with active NTFP markets can sustain higher effective access even if standing forest is modest (Derebe 2023). The results contradict studies that report relatively high provisioning returns from some savanna communities where strong communal tenure or targeted NTFP programmes preserved stocks (for example some case studies in parts of Kwara and neighbouring states). Those apparent contradictions are likely methodological and contextual: studies that find strong provisioning in savannas tend to sample areas with active community management, protected sacred groves or recent restoration interventions, whereas the present communities in the Guinea savanna show more conversion to cropland and charcoal-focused extraction that depress provisioning flows (Adenle 2022; Adewoye *et al*. 2023). Implications are clear for livelihoods: high provisioning in rainforests supports immediate subsistence and income, but where provisioning is already lower (Guinea savanna) households are more vulnerable to shocks and have fewer safety-net resources. Policy responses should therefore protect remaining tree cover, support market development for sustainable NTFP harvesting, promote household- and community-level tree planting (agroforestry/woodlots), and reduce pressure from unsustainable charcoal chains through alternative energy and formalization of supply (Rasmussen *et al*. 2023; Bolaji *et al*. 2024). Regulating services such as water regulation, erosion control, carbon and pollution abatement

Regulating services follow the same spatial gradient: very high ratings in rainforest communities, lower but still meaningful ratings in derived savanna, and the weakest performance in the Guinea savanna. This is predictable because regulating services scale with vegetation cover, structural complexity and soil condition: intact forest landscapes slow runoff, retain soils, buffer floods, and sequester carbon far more effectively than heavily farmed or denuded savanna mosaics. The literature demonstrates that restoring tree cover or protecting intact patches produces measurable improvements in water regulation and sediment control, and that conversion to plantations or farmland reduces those functions. The present lower scores in Guinea savanna communities therefore reflect either long-term conversion of native vegetation to cropland, extensive charcoal extraction that removes woody biomass, or weak watershed governance (Bolaji *et al*. 2024; Adewoye *et al*. 2023). Some recent restoration programmes (for example Regreening Africa and related agroforestry campaigns) show that regulating functions can be recovered at landscape scale within a few years to a decade, which creates an important contrast with the current findings: sites participating in sustained restoration report better regulation than degraded control sites, explaining why some published studies show higher regulating capacity in savanna landscapes where restoration was active (Regreening Africa reports). The livelihood implication is that diminished regulating services in the Guinea savanna will reduce crop resilience, increase erosion and lower dry-season water reliability, thereby undermining agricultural productivity and increasing exposure to climate extremes; reversing these trends requires watershed-scale restoration, stronger tenure and incentive mechanisms, and energy alternatives that reduce tree-fall for fuel (Regreening Africa 2023). Supporting services like habitat, soil formation, seed banks and carbon storage Supporting services showed the steepest decline into the Guinea savanna: wildlife habitat, soil formation and carbon storage were high in rainforest sites, moderately high in derived savanna, and often only moderate in Guinea savanna communities. That pattern aligns with field studies of remnant forest patches and sacred groves that document disproportionately high biodiversity and carbon stocks relative to surrounding matrices (Onyekwelu *et al*. 2024; Sullivan 2024). Sacred groves and culturally protected forest patches often act as seed banks and recruitment hotspots, which explains why locations with strong cultural protection score higher for supporting services even within otherwise degraded landscapes (Ihemezie *et al*. 2023). The disparity with studies that report resilient supporting services in some savanna landscapes is therefore not an ecological contradiction so much as an institutional one: where local norms, sacred protections or active restoration persist, supporting services can be maintained despite broader regional degradation (Adeyanju 2022).

Conversely, where land-use change (expanding cropping frontiers, intensified grazing, charcoal extraction) accelerates, supporting processes such as nutrient cycling and soil formation degrade, undermining long-term productivity and biodiversity. For livelihoods this is gravely important: loss of seed banks and habitat reduces the availability of boon species for future use and erodes options for landscape recovery; conservation of remnant patches, enforcement of protection around sacred groves, and investment in soil-building agroecological practices are therefore critical to sustain both biodiversity and the ecological foundations of farming (Onyekwelu *et al*. 2024; Sullivan 2024). Cultural services which are spiritual, aesthetic, educational and recreational values Cultural services rank highest in the rainforest and derived savanna communities and are lower but still present in the Guinea savanna. The strong scores for spiritual and heritage-linked services in rainforest villages reflect enduring practices that protect sacred groves, ritual sites and culturally important species; numerous studies from southwestern Nigeria confirm that these socio-cultural institutions both sustain cultural identity and deliver tangible conservation outcomes (Ihemezie *et al*. 2023; Onyekwelu *et al*. 2024). The lower cultural ratings in some Guinea savanna communities likely reflect shifts in livelihoods, migration, religious change and the fragmentation of cultural landscapes processes that weaken customary protections and thus the cultural ecosystem services they support (Adenle 2022). The findings contrast with some reports that claim cultural services remain uniformly strong across savannas; such contrasts often arise because cultural attachment is highly local and mediated by history and governance (some communities retain strong sacred-grove protection while others do not). The implication is twofold: first, cultural values remain a powerful entry point for conservation in places where they persist and should be integrated into policy and restoration design; second, where cultural connections are eroding, complementary incentives (community livelihood support, ecotourism, payments for ecosystem services) are needed to substitute for lost customary protections and to re-embed conservation in local economies (Ihemezie *et al*. 2023; Nyathi *et al*. 2024). High provisioning availability in rainforest communities supports immediate food security and income, but unless matched by measures that safeguard regulating and supporting services, those short-term benefits risks being eroded by market-driven land conversion. In the Guinea savanna the simultaneous loss of provisioning, regulating and supporting services reduces households' buffering capacity and resilience to climate shocks, increasing poverty and food insecurity risk. Where published work appears to contradict these findings (for example studies that report robust supplies of NTFPs or stable regulating functions in some savanna locales), the divergence is usually attributable to differences in local governance, recent restoration activities, or study scale: sites with active regreening, sacred-grove protection, or strong communal tenure often outperform degraded neighboring areas (Regreening Africa 2023).

Conclusion and Recommendation: This study has demonstrated that forest ecosystem services remain central to the livelihoods of rural communities in Ondo and Kwara States, though the scale and pattern of benefits vary significantly across ecological zones. In the tropical rainforest communities, provisioning services such as firewood, timber, fruits, mushrooms, medicinal herbs, and snails were abundant, supporting household subsistence and income generation. In the derived savanna, these benefits were moderately available, with increasing reliance on

extractive activities such as granite and clay collection, reflecting mounting resource pressures. The Guinea savanna communities showed the lowest availability of ecosystem services, with marked declines in provisioning, regulating, and supporting services, highlighting the ecological vulnerability of the zone and its communities' heightened exposure to poverty and livelihood risks. Cultural services, particularly sacred groves and ritual landscapes, remained relevant but were found to be weakening in some areas, underscoring the erosion of traditional conservation practices. To safeguard these benefits, it is essential to promote sustainable forest management practices that balance utilization with conservation. Policies should strengthen community-based forest governance, empower households through agroforestry and alternative livelihood options, and support reforestation and restoration efforts in degraded landscapes. Efforts to reduce dependence on unsustainable practices such as indiscriminate fuelwood harvesting and charcoal production are necessary, and these should be complemented by providing affordable alternative energy sources. Cultural values and traditional practices that protect sacred groves and biodiversity should be revitalized and integrated into conservation programs. By recognizing the diverse contributions of forest ecosystem services and addressing the constraints to their sustainability, governments, communities, and development partners can enhance rural livelihoods, reduce poverty, and ensure the long-term resilience of forest ecosystems in Ondo and Kwara States.

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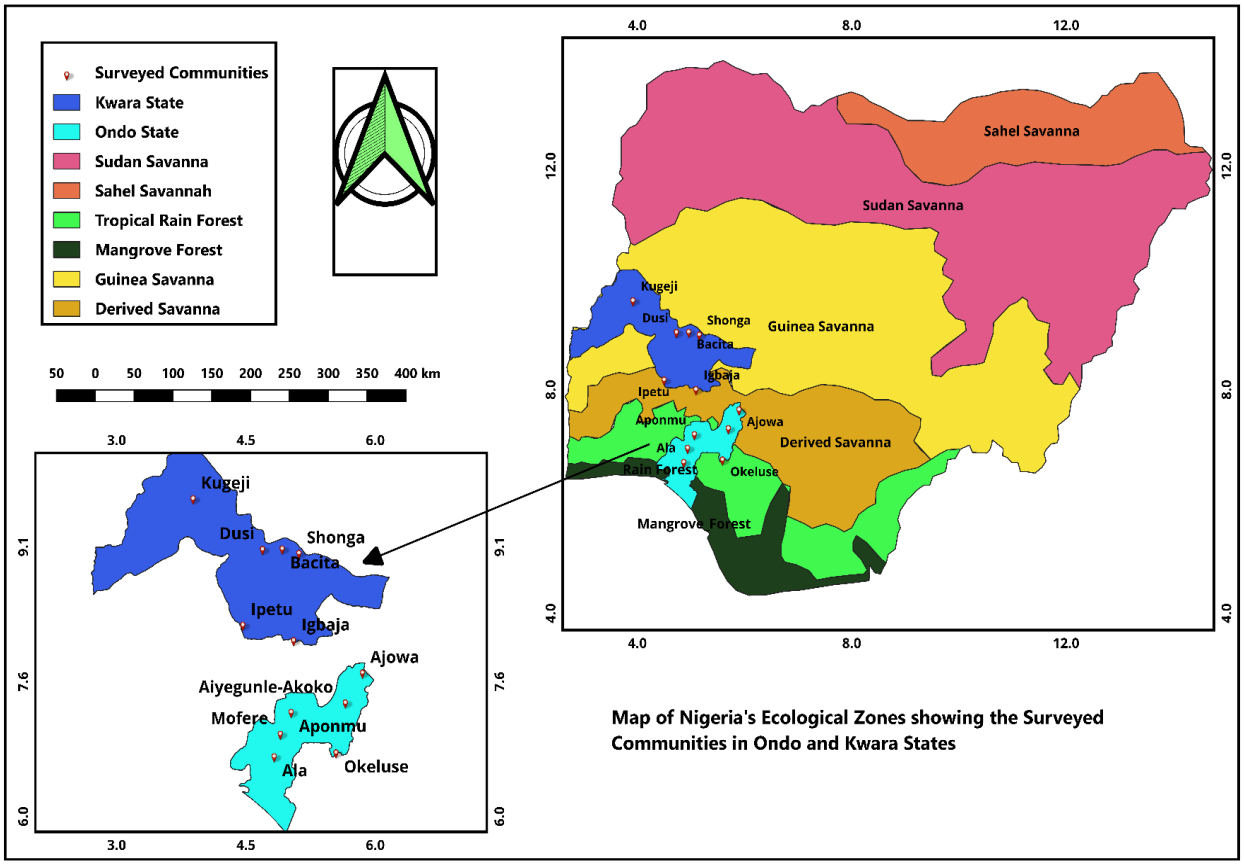
Appendix



Map of Nigeria's Ecological Zones showing the Surveyed Communities in Ondo and Kwara States

Figure 1: Map of Nigeria's ecological zones showing surveyed communities in Ondo and Kwara states

Table 1: Effect of forest ecosystem services on livelihood activities

	Rainforest				**Derived savanna**				**Guinea savanna**			
	Ondo State				Ondo State		Kwara state		Kwara State			
FES Type	Ajowa	Aponmu	Ala	Mofere	Okeluse	Aiyegunle-Akoko	Igbaja	Ipetu	Kugeji	Dusi	Shonga	Bacita
Cutting timber for pole	4.4 (4)	4.2 (4)	4.3 (4)	4.1 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.7 (4)	3.5 (4)	3.6 (4)
Cutting timber for building	4.3 (4)	4.1 (4)	4.2 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.5 (4)	3.6 (4)	3.4 (3)	3.5 (4)
Collection of firewood	4.5 (5)	4.3 (4)	4.4 (4)	4.2 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.7 (4)	3.6 (4)	3.6 (4)
Fishing	4.2 (4)	4.0 (4)	3.8 (4)	3.7 (4)	4.1 (4)	4.0 (4)	3.9 (4)	3.8 (4)	4.0 (4)	4.1 (4)	3.9 (4)	3.8 (4)
Hunting	3.8 (4)	3.6 (4)	3.7 (4)	3.5 (4)	3.6 (4)	3.5 (4)	3.4 (3)	3.3 (3)	3.5 (4)	3.4 (3)	3.3 (3)	3.4 (3)
Collection of snails	4.1 (4)	4.0 (4)	4.2 (4)	4.0 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)
Collection of fodder for livestock	3.6 (4)	3.5 (4)	3.4 (3)	3.5 (4)	3.8 (4)	3.7 (4)	3.9 (4)	4.0 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.7 (4)
Collection of leaves and vegetables	4.0 (4)	3.9 (4)	4.1 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.7 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.7 (4)
Collection of mushrooms	4.0 (4)	3.8 (4)	4.1 (4)	3.8 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.8 (4)
Collection of fruits/seeds	4.2 (4)	4.1 (4)	4.0 (4)	4.0 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.8 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.8 (4)
Collection of granite and pebbles	2.1 (2)	2.3 (2)	2.5 (3)	2.4 (2)	2.8 (3)	2.9 (3)	3.2 (3)	3.3 (3)	3.4 (3)	3.5 (4)	3.6 (4)	3.5 (4)
Collection of medicinal herbs	4.1 (4)	4.0 (4)	4.2 (4)	4.0 (4)	3.8 (4)	3.9 (4)	3.6 (4)	3.7 (4)	3.9 (4)	3.8 (4)	3.7 (4)	3.8 (4)
Farming activities (Taungya)	3.9 (4)	3.7 (4)	4.0 (4)	3.8 (4)	3.7 (4)	3.6 (4)	3.8 (4)	3.9 (4)	3.6 (4)	3.7 (4)	3.5 (4)	3.6 (4)
Sourcing purified water for factory	2.8 (3)	2.6 (3)	2.7 (3)	2.5 (3)	3.0 (3)	3.1 (3)	3.3 (3)	3.4 (3)	2.9 (3)	3.0 (3)	2.8 (3)	2.9 (3)
Forest guards and security	2.9 (3)	2.8 (3)	2.7 (3)	2.6 (3)	2.8 (3)	2.9 (3)	3.0 (3)	3.1 (3)	2.7 (3)	2.8 (3)	2.6 (3)	2.7 (3)
Collection of rattan and bamboo	3.8 (4)	3.6 (4)	3.9 (4)	3.7 (4)	3.5 (4)	3.4 (3)	3.2 (3)	3.1 (3)	3.4 (3)	3.3 (3)	3.2 (3)	3.3 (3)
Sourcing of clay for pot-making	1.8 (2)	1.9 (2)	2.0 (2)	1.9 (2)	2.5 (3)	2.7 (3)	3.3 (3)	3.4 (3)	3.8 (4)	3.9 (4)	3.7 (4)	3.5 (4)
Collection of raw material (other)	3.6 (4)	3.5 (4)	3.7 (4)	3.6 (4)	3.5 (4)	3.4 (3)	3.3 (3)	3.4 (3)	3.6 (4)	3.5 (4)	3.4 (3)	3.5 (4)
Breeding of forest insects	1.6 (2)	1.5 (2)	1.7 (2)	1.6 (2)	1.8 (2)	1.9 (2)	2.0 (2)	2.1 (2)	1.9 (2)	2.0 (2)	1.8 (2)	1.9 (2)
Shelter for hostage and abductors	1.2 (1)	1.3 (1)	1.1 (1)	1.2 (1)	1.4 (1)	1.3 (1)	1.5 (2)	1.6 (2)	1.4 (1)	1.3 (1)	1.5 (2)	1.4 (1)

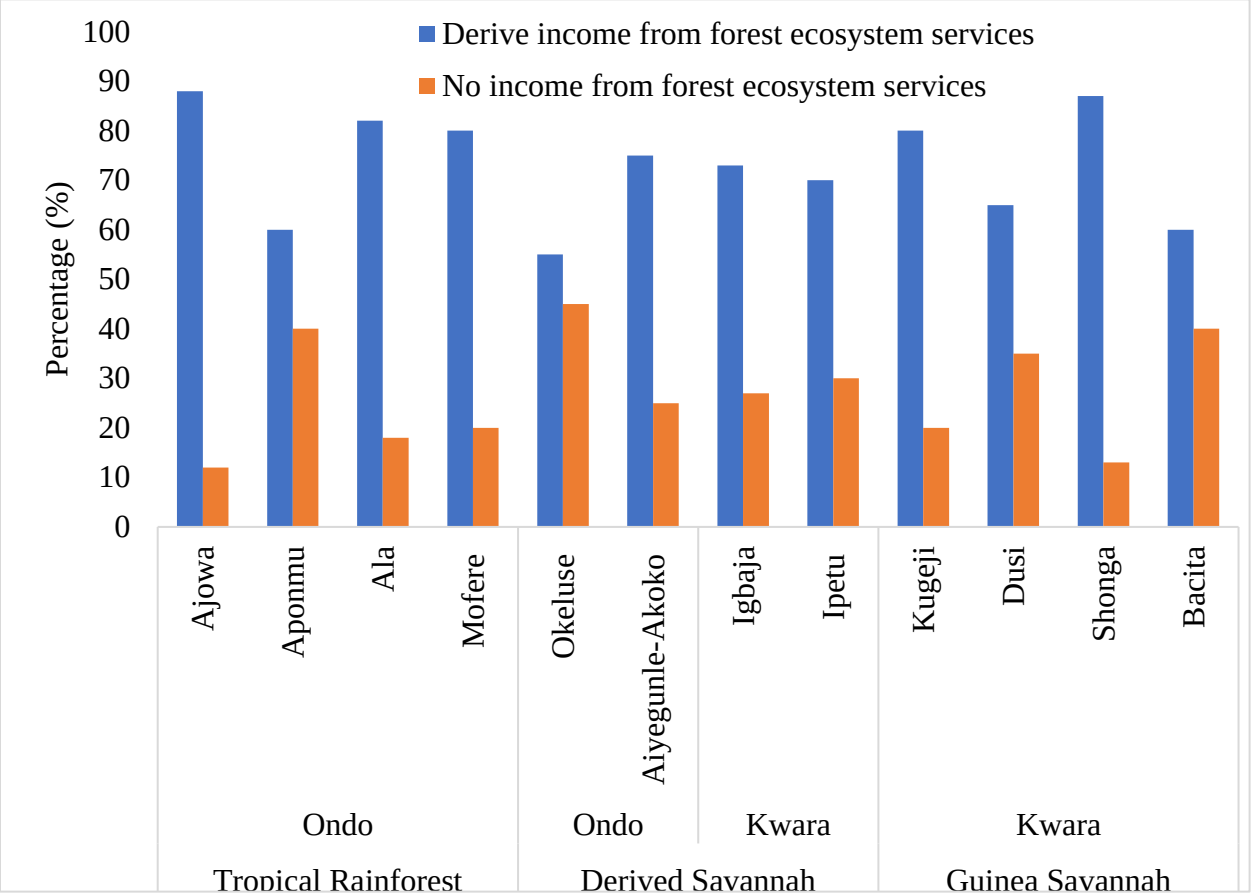


Figure 2: Income derived from forest ecosystem services

Table 2: Average monthly income from Forest Ecosystem Services

Ecological Zone	State	Community	Less than 20,000		21,000 – 40,000		41,000 – 60,000		61,000 – 80,000		81,000 and above	
			Freq	Perc	Freq	Perc	Freq	Perc	Freq	Perc	Freq	Perc
Tropical Rainforest	Ondo	Ajowa	4	10	8	20	12	30	10	25	6	15
		Aponmu	10	25	12	30	9	22.5	6	15	3	7.5
		Ala	5	12.5	9	22.5	13	32.5	8	20	5	12.5
		Mofere	6	15	10	25	12	30	7	17.5	5	12.5
Derived Savanna	Ondo	Okeluse	12	30	13	32.5	8	20	4	10	3	7.5
		Aiyegunle-Akoko	7	17.5	11	27.5	12	30	6	15	4	10
	Kwara	Igbaja	8	20	12	30	11	27.5	6	15	3	7.5
		Ipetu	9	22.5	11	27.5	10	25	6	15	4	10
Guinea Savanna	Kwara	Dusi	5	12.5	9	22.5	11	27.5	9	22.5	6	15

Ecological Zone	State	Community	Less than 20,000		21,000 – 40,000		41,000 – 60,000		61,000 – 80,000		81,000 and above	
			Freq	Perc	Freq	Perc	Freq	Perc	Freq	Perc	Freq	Perc
		Kugeji	7	17.5	12	30	10	25	6	15	5	12.5
		Shonga	4	10	8	20	11	27.5	10	25	7	17.5
		Bacita	11	27.5	12	30	9	22.5	4	10	4	10

Table 3: Availability of forest ecosystem service within the past five (5) years

	Rainforest				Derived savanna				Guinea savanna			
	Ondo state				Ondo state		Kwara state		Kwara state			
Forest Ecosystem Services	Aponmu	Ajowa	Ala	Mofere	Okeluse	Aiyegunle-Akoko	Igbaja	Ipetu	Kugeji	Dusi	Shonga	Bacita
Cutting timber for pole	4.8 (5)	5.0 (5)	4.7 (5)	4.6 (5)	4.2 (4)	4.0 (4)	3.9 (4)	4.0 (4)	3.5 (4)	3.6 (4)	3.8 (4)	3.4 (3)
Cutting timber for building	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	4.3 (5)	4.1 (4)	4.0 (4)	4.1 (4)	3.6 (4)	3.5 (4)	3.9 (4)	3.5 (4)
Collection of fuelwoods	5.0 (5)	5.0 (5)	5.0 (5)	4.9 (5)	4.5 (5)	4.4 (5)	4.3 (5)	4.4 (5)	4.0 (4)	4.1 (4)	4.2 (4)	4.0 (4)
Fishing	4.5 (5)	4.7 (5)	4.6 (5)	4.4 (5)	3.2 (3)	3.0 (3)	3.5 (4)	3.0 (3)	2.8 (3)	3.1 (3)	2.9 (3)	2.7 (3)
Hunting	4.6 (5)	4.8 (5)	4.7 (5)	4.5 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.4 (3)	3.5 (4)	3.6 (4)	3.3 (3)
Source of forage for livestock	4.3 (5)	4.5 (5)	4.4 (5)	4.2 (4)	4.0 (4)	3.8 (4)	3.7 (4)	3.9 (4)	3.5 (4)	3.6 (4)	3.7 (4)	3.5 (4)
Tourism potential	4.7 (5)	4.9 (5)	4.8 (5)	4.6 (5)	3.5 (4)	3.7 (4)	3.2 (3)	3.3 (3)	2.9 (3)	3.4 (3)	3.5 (4)	3.0 (3)
Provision of employment	4.8 (5)	5.0 (5)	4.7 (5)	4.5 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.4 (3)	3.6 (4)	3.7 (4)	3.4 (3)
Collection of mushrooms	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	4.1 (4)	4.0 (4)	3.9 (4)	4.0 (4)	3.6 (4)	3.7 (4)	3.8 (4)	3.5 (4)
Collection of fruits/seeds	4.8 (5)	5.0 (5)	4.9 (5)	4.8 (5)	4.2 (4)	4.1 (4)	4.0 (4)	4.1 (4)	3.7 (4)	3.8 (4)	3.9 (4)	3.6 (4)
Collection of leaves/vegetables	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	4.2 (4)	4.0 (4)	4.0 (4)	4.0 (4)	3.6 (4)	3.7 (4)	3.8 (4)	3.6 (4)
Collection of snails	4.6 (5)	4.8 (5)	4.7 (5)	4.5 (5)	3.0 (3)	3.2 (3)	2.8 (3)	3.0 (3)	2.5 (2)	2.8 (3)	2.9 (3)	2.6 (2)
Collection of medicinal herbs	4.8 (5)	5.0 (5)	4.9 (5)	4.8 (5)	4.1 (4)	4.0 (4)	3.9 (4)	4.0 (4)	3.6 (4)	3.7 (4)	3.8 (4)	3.5 (4)
Farming activities	4.7 (5)	4.9 (5)	4.6 (5)	4.5 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.5 (4)	3.6 (4)	3.7 (4)	3.4 (3)
Erosion control	4.5 (5)	4.8 (5)	4.6 (5)	4.4 (5)	4.0 (4)	3.8 (4)	3.7 (4)	3.8 (4)	3.4 (3)	3.5 (4)	3.6 (4)	3.3 (3)
Provision of windbreak	4.4 (5)	4.6 (5)	4.5 (5)	4.3 (5)	3.9 (4)	3.7 (4)	3.6 (4)	3.7 (4)	3.3 (3)	3.4 (3)	3.5 (4)	3.2 (3)
Watershed protection	4.8 (5)	5.0 (5)	4.7 (5)	4.6 (5)	3.2 (3)	3.3 (3)	3.0 (3)	3.1 (3)	2.7 (3)	3.0 (3)	2.8 (3)	2.6 (2)
Forest seed bank	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	3.0 (3)	3.1 (3)	2.9 (3)	3.0 (3)	2.5 (2)	2.6 (2)	2.7 (3)	2.4 (2)
Materials for handicraft	4.7 (5)	4.9 (5)	4.6 (5)	4.5 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.4 (3)	3.6 (4)	3.7 (4)	3.5 (4)
Carbon sequestration	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	4.1 (4)	4.0 (4)	3.9 (4)	4.0 (4)	3.6 (4)	3.7 (4)	3.8 (4)	3.5 (4)
Climate change mitigation	4.8 (5)	5.0 (5)	4.7 (5)	4.6 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.4 (3)	3.6 (4)	3.7 (4)	3.4 (3)
Provision of clean air (oxygen)	5.0 (5)	5.0 (5)	4.9 (5)	4.8 (5)	4.3 (5)	4.1 (4)	4.0 (4)	4.1 (4)	3.7 (4)	3.8 (4)	3.9 (4)	3.6 (4)

Oxygen production	5.0 (5)	5.0 (5)	4.9 (5)	4.8 (5)	4.3 (5)	4.1 (4)	4.0 (4)	4.1 (4)	3.7 (4)	3.8 (4)	3.9 (4)	3.6 (4)
Air production	5.0 (5)	5.0 (5)	4.9 (5)	4.8 (5)	4.3 (5)	4.1 (4)	4.0 (4)	4.1 (4)	3.7 (4)	3.8 (4)	3.9 (4)	3.6 (4)
Water purification/ conservation	4.9 (5)	5.0 (5)	4.8 (5)	4.7 (5)	3.3 (3)	3.4 (3)	3.1 (3)	3.2 (3)	2.8 (3)	3.0 (3)	2.9 (3)	2.7 (3)
Maintenance of soil fertility	4.8 (5)	5.0 (5)	4.7 (5)	4.6 (5)	4.0 (4)	3.9 (4)	3.8 (4)	3.9 (4)	3.4 (3)	3.6 (4)	3.7 (4)	3.4 (3)