

Contribution of indigenous forest food species to rural livelihoods in communities surrounding Onigambari forest reserve, Oyo State, Nigeria

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Abstract

Indigenous forest food species are vital to rural livelihoods in forest-dependent communities, yet their economic roles remain insufficiently documented in Nigeria. This study assessed their contribution to rural livelihoods in communities surrounding the Onigambari Forest Reserve, Oyo State. A cross-sectional design integrating quantitative and qualitative approaches was employed. Data were collected from 120 households using structured questionnaires, key informant interviews, and field observations, and analyzed using descriptive statistics and thematic analysis. Results show that forest food species contribute substantially to household income, with *Irvingia gabonensis*, honey, and *Garcinia kola* as major income sources. Seasonal availability supports year-round livelihoods, while products such as mushrooms, snails, and leafy vegetables provide regular income streams. Market participation is widespread; however, limited engagement in value addition persists despite its potential to increase income by up to 32%. Livelihood dependence is high, with 41.7% of households deriving at least 40% of their annual income from forest foods. Key constraints include forest degradation, limited market access, inadequate processing technologies, and seasonal scarcity. Despite these challenges, forest food species remain central to household resilience. Strengthening value addition, market access, and sustainable forest management is essential to enhance their contribution to rural livelihoods.

1.0 Introduction

Forests play a critical role in supporting rural livelihoods, particularly in developing countries where millions of people depend directly on forest resources for food, income, and overall well-being. Globally, forest ecosystems provide a wide range of goods and services, including timber and non-timber forest products (NTFPs), which are essential for sustaining livelihoods and enhancing resilience among rural populations. It is estimated that billions of people rely on forests and associated resources for food, medicine, and income generation, underscoring their importance in global food systems and poverty alleviation. In sub-Saharan Africa, forests contribute significantly to household economies by providing diverse edible products such as fruits, nuts, vegetables, honey, and bushmeat, many of which are derived from indigenous species (Olesen *et al.*, 2022).

Indigenous forest food species, in particular, have gained increasing attention due to their multifunctional roles in nutrition, income generation, and ecological sustainability (Akinola *et al.*, 2020). These species are often rich in essential nutrients, including vitamins, minerals, and proteins, making them vital for addressing food and nutrition security in rural communities. Beyond their nutritional value, they also support livelihood diversification by offering opportunities for collection, processing, and marketing. Research has shown that forest foods contribute meaningfully to household diets and incomes, especially in areas where agricultural productivity is limited or seasonal. In many forest-dependent communities, such resources act as safety nets during periods of economic hardship, crop failure, or environmental shocks (Jamnadass *et al.*, 2011; Sunderland, 2011).

Emerging evidence from Nigeria demonstrates that indigenous forest foods contribute to improved nutrition, enhanced market participation, and increased livelihood resilience among rural households (Fungo *et al.*, 2016). Similarly, participation in forest-based activities, including the harvesting and processing of NTFPs, has been linked to improved food security outcomes and poverty reduction in several African countries (Tewari, 2012). These findings align with broader development frameworks that emphasize the integration of natural resource-based livelihoods into strategies for achieving the Sustainable Development Goals (SDGs), particularly those related to poverty eradication, zero hunger, and sustainable ecosystem management.

Despite their importance, the contributions of indigenous forest food species are often undervalued and insufficiently documented in policy and development planning. Rapid deforestation, land-use change, and agricultural expansion continue to threaten forest ecosystems, thereby reducing the availability of valuable forest food resources. Additionally, challenges such as poor market access, inadequate processing technologies, and seasonal variability limit the economic benefits derived from these species. These constraints not only affect household income but also undermine the sustainability of forest-based livelihood systems.

In Nigeria, particularly in forest-rich regions such as Oyo State, rural communities living adjacent to forest reserves depend heavily on indigenous forest food species for both subsistence and income generation. The Onigambari Forest Reserve represents a typical example of such ecosystems, where forest resources play a central role in supporting local livelihoods. However, there is limited empirical information on the extent to which these species contribute to household income, livelihood diversification, and economic resilience in the area.

The study assessed the contribution of indigenous forest food species to rural livelihoods among households in forest-fringe communities surrounding Onigambari Forest Reserve, Oyo State, Nigeria. Specifically, the study examined the diversity of indigenous forest food species utilized by households, estimated income derived from these species, assessed market participation and value addition practices, evaluated household dependence on forest food resources, and identified constraints affecting the livelihood benefits obtained from indigenous forest food species.

2.0 Materials and Methods

Study Area and Population

The study was conducted in selected communities adjacent to the Onigambari Forest Reserve (Figure 1) in Oyo State, southwestern Nigeria. The reserve is a lowland tropical rainforest ecosystem characterized by rich biodiversity and a high dependence of surrounding communities on forest resources for subsistence and income generation. It serves as an important source of non-timber forest products (NTFPs), including a variety of edible plant and animal species that contribute to household nutrition and livelihoods. The study population comprised households residing in forest-fringe communities whose livelihoods are directly or indirectly linked to the collection, processing, and marketing of indigenous forest food species. In addition, key stakeholders such as forest officers, local traders, experienced harvesters, and community elders were included to provide expert knowledge on resource utilization, market dynamics, and traditional practices. The inclusion of diverse respondent groups ensured a comprehensive understanding of the socio-economic role of forest food species.

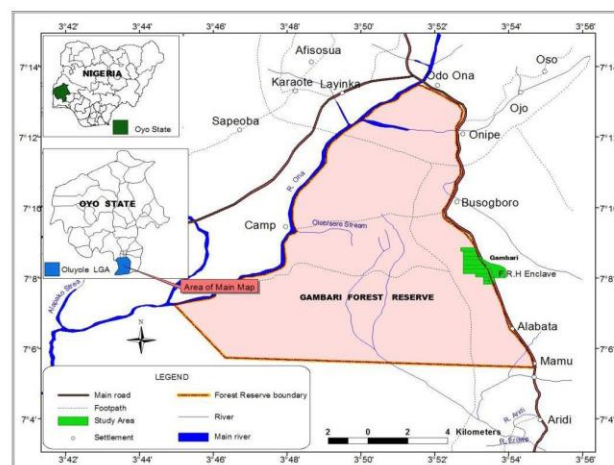


Figure 1: The Map of Onigambari Forest Reserve, Oyo State, Nigeria

Study Design

A cross-sectional research design was adopted to assess the contribution of indigenous forest food species to rural livelihoods in the study area. This design enabled the collection of both quantitative and qualitative data at a single point in time, facilitating an integrated evaluation of livelihood patterns, income sources, and resource dependence. Cross-sectional designs are widely applied in socio-economic and natural resource studies due to their effectiveness in capturing population characteristics and resource-use dynamics within a defined timeframe (Creswell, 2014; Alan Bryman, 2016).

Sampling Procedure

A multistage sampling technique was employed for respondent selection. In the first stage, three forest-fringe communities (Busogboro, Onipe, and Gambari) were purposively selected based on their proximity to the Onigambari Forest Reserve and the recognized dependence of residents on indigenous forest food species and other non-timber forest products for livelihood support. A preliminary household listing conducted with the assistance of community leaders identified approximately 390 households across the three communities, comprising 145 households in Busogboro, 128 in Onipe, and 117 in Gambari. The sample size was determined using the Yamane (1967) formula for finite populations:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the population size, and e is the level of precision.

Using $N = 390$; and $e=0.08$

$$n = \frac{300}{1 + 300(0.08)^2}$$

$$n = 111.6$$

Approximately 112 households.

To improve representativeness and compensate for non-response, increase to 120 households.

Using a population of 390 households and a precision level of 8%, a minimum sample size of 112 households was obtained. To enhance representativeness and compensate for possible non-response, 120 households were selected for the study.

The sample was proportionally allocated among the selected communities, resulting in 45 households from Busogboro, 39 households from Onipe, and 36 households from Gambari. Thereafter, systematic random sampling was employed to select households from each community. The sampling interval was calculated by dividing the total number of households by the allocated sample size, resulting in an interval of approximately three households. Following the selection of a random starting point, every third household was surveyed until the required sample size was achieved. In addition, key informants comprising forest officers, experienced harvesters, traders, and community elders were purposively selected based on their knowledge and

involvement in indigenous forest food species utilization, processing, and marketing.

Data Collection

Primary data were collected using a combination of structured questionnaires, key informant interviews, and field observations. The questionnaire captured information on household socio-economic characteristics, income derived from forest food species, market participation, value addition practices, seasonal patterns of resource utilization, and livelihood strategies. Data collection was conducted through face-to-face interviews administered by trained research assistants in either Yoruba or English, depending on respondents' preferences, to ensure clarity and reliability of responses. Key informant interviews were conducted with forest officers, traders, and experienced harvesters to obtain in-depth information on resource availability, harvesting techniques, market structures, value chains, and constraints affecting the utilization of forest food species. In addition, direct field observations were carried out to validate species presence, identify harvesting locations, and document indigenous processing and preservation methods. The use of multiple data collection methods allowed for triangulation, thereby enhancing the validity and reliability of the data (Carter et al. 2014; Rana and Chimoriya, 2025).

Information on income derived from indigenous forest food species was collected using respondent recall during household interviews. Respondents were asked to estimate the quantity of products harvested, consumed, and sold, as well as the income generated from such activities during the preceding 12 months. The use of a 12-month recall period enabled the inclusion of seasonal products harvested at different times of the year and facilitated estimation of annual income contributions from forest food species. To enhance data reliability, reported income figures were cross-checked against information on harvesting frequency, product quantities, prevailing market prices, and seasonal availability of major species. In addition, information obtained from key informants, including traders and experienced harvesters, was used to verify reported market values and income ranges. Mean annual household income was subsequently estimated from the reported earnings derived from indigenous forest food species.

Data Analysis

Quantitative data were coded, cleaned, and analyzed using descriptive statistical techniques, including frequencies, percentages, and means, to summarize household characteristics, income levels, livelihood activities, and dependence on forest food species. Cross-tabulation analysis was further employed to examine variations in livelihood dependence and economic benefits across the selected communities. Qualitative data obtained from key informant interviews and field observations were transcribed and analyzed using thematic analysis. This involved coding responses, identifying recurring patterns, and organizing them into themes that explain the socio-economic importance, utilization patterns, and constraints associated with indigenous forest food species. The integration of quantitative and qualitative findings provided a comprehensive and nuanced

understanding of the contribution of forest food species to rural livelihoods in the study area.

Household dependence on indigenous forest food species was assessed using the proportion of total annual household income derived from forest food resources. Following approaches commonly used in forest dependency studies, households were categorized according to the relative contribution of indigenous forest food species to total household income. Households obtaining less than 20% of their annual income from indigenous forest food species were classified as having low dependence, those obtaining between 20% and 39% were classified as moderately dependent, while households deriving 40% or more of their income from these resources were classified as highly dependent. The categorization was intended to facilitate comparison among households exhibiting varying levels of reliance on forest-based livelihood activities.

One limitation of this study is that the analysis relied primarily on descriptive statistical techniques. While these methods were adequate for describing patterns of livelihood dependence, income generation, and market participation, they do not permit statistical testing of relationships or differences among variables. Future studies should incorporate inferential analytical approaches, including regression models, chi-square tests, and analysis of variance, to provide more rigorous evaluation of factors influencing rural livelihoods and the economic contributions of indigenous forest food species.

The estimation of household income from indigenous forest food species relied primarily on respondents' recall of harvesting, consumption, and sales activities over a 12-month period. Although efforts were made to validate responses through cross-checking and key informant consultations, the possibility of recall bias and under- or over-estimation of income cannot be entirely ruled out. Consequently, the reported income figures should be interpreted as approximate estimates of household earnings derived from indigenous forest food species.

3.0 Results and Discussions

Household Socio-Economic Characteristics

The socio-economic profile of respondents provides important context for understanding the role of indigenous forest food species in livelihood systems within forest-fringe communities. The mean age of 46.8 years indicates that most household heads are in their economically productive years. This suggests a population with sufficient physical capacity and experience to engage in both farming and forest-based livelihood activities. Similar age structures have been reported in rural natural resource-dependent communities, where middle-aged individuals dominate due to their active involvement in labour-intensive activities such as harvesting and processing of non-timber forest products (NTFPs) (Food and Agriculture Organization, 2018).

The gender distribution shows a predominance of male-headed households (62.5%), although female-headed households (37.5%) also constitute a substantial proportion. This pattern reflects the

gendered nature of rural livelihoods in many parts of sub-Saharan Africa, where men are often recognized as household heads, while women play critical but sometimes underreported roles in the collection, processing, and marketing of forest food species. Existing studies have consistently shown that women contribute to NTFP value chains, particularly in activities such as gathering edible plants, processing, and local trading, thereby enhancing household food security and income diversification (World Bank, 2016; Food and Agriculture Organization, 2020).

Farming emerged as the dominant primary occupation (58.3%), confirming the agrarian nature of the study communities. However, the presence of trading (24.2%), forest product collection (10.8%), and casual labour (6.7%) highlights the diversification of livelihood strategies. Such diversification is a common adaptive response to economic uncertainty and environmental variability, particularly in forest-dependent regions. Indigenous forest food species play a complementary role in this context by providing both subsistence and market opportunities, thereby reducing vulnerability to agricultural shocks (Bhaskar et al. 2016).

The average household size of six persons suggests relatively large family units, which is typical of rural Nigerian communities. Larger household sizes can be advantageous for labour-intensive activities such as harvesting, processing, and marketing of forest food species, as they provide an internal labour pool. However, they may also increase consumption demands, thereby reinforcing reliance on forest resources for both food and income. Studies have shown that household size is often positively associated with dependence on forest products, as larger households tend to exploit a wider range of natural resources to meet their needs (Angelsen et al., 2014).

Overall, the socio-economic characteristics presented in Table 1 indicate that the study population possesses the demographic and occupational attributes necessary to actively engage in forest-based livelihood activities. The combination of an economically active population, diversified income sources, and relatively large household sizes underscores the importance of indigenous forest food species as a critical component of rural livelihoods in the study area. These findings provide a strong foundation for subsequent analysis of income contributions, market participation, and the broader socio-economic significance of forest food resources.

Table 1: Household Socio-Economic Characteristics of Respondents (n = 120)

Variable	Category	Frequency (n)	Percentage (%)
Age of Household Head (years)	20–30	14	11.7
	31–40	28	23.3
	41–50	36	30.0

	51–60	26	21.7
	>60	16	13.3
	Mean Age = 46.8 years		
Gender	Male	75	62.5
	Female	45	37.5
Primary Occupation	Farming	70	58.3
	Trading	29	24.2
	Forest product collection	13	10.8
	Casual labour	8	6.7
Household Size (persons)	1–3	18	15.0
	4–6	52	43.3
	7–9	34	28.3
	≥10	16	13.3
	Mean Household Size = 6 persons		

Mean Annual Income from Indigenous Forest Food Species

The results presented in Table 2 demonstrate that indigenous forest food species constitute a significant source of household income among forest-fringe communities surrounding the Onigambari Forest Reserve. The total mean annual income of ₦349,250 derived from these species highlights their substantial economic value and reinforces their role as an important component of rural livelihood systems. Among the species examined, *Irvingia gabonensis* (bush mango) contributed the highest share (24.8%) of total forest food income. This prominence can be attributed to its strong market demand, both locally and regionally, as well as its multiple uses in household consumption and trade. The kernels are widely used as soup thickening agents, making them highly valued in West African diets. Previous studies have similarly identified bush mango as one of the most commercially viable non-timber forest products in Nigeria and across Central and West Africa due to its high market price and storability (Food and Agriculture Organization, 2018; Bhaskar et al. 2015).

Honey (21.3%) also emerged as a major income contributor, reflecting the growing importance of apiculture as a sustainable forest-based enterprise. Honey production offers relatively high economic returns with minimal ecological disturbance, making it an attractive livelihood option for forest-dependent households. Its contribution in this study aligns with broader findings that

apiculture enhances rural incomes while supporting forest conservation through pollination services and reduced pressure on timber resources (Food and Agriculture Organization, 2020). *Garcinia kola* (bitter kola), accounting for 18.6% of income, remains an economically important species due to its medicinal properties and cultural significance. Its steady demand in both rural and urban markets ensures consistent income for harvesters and traders. Similarly, income from snail collection (16.7%) underscores the importance of wildlife-based forest foods as accessible and profitable livelihood options. Snail harvesting is particularly common in humid forest ecosystems and requires relatively low capital investment, making it suitable for resource-poor households (Panisi et al., 2024).

Wild mushrooms (11.1%) and leafy vegetables (7.7%), although contributing smaller proportions of income, play critical complementary roles. These species are often seasonal but are essential for household nutrition and food security. Their lower monetary contribution does not diminish their overall livelihood importance, as they help reduce food expenditure and provide dietary diversity. Studies have shown that such low-value but widely accessible forest foods are crucial for sustaining rural livelihoods, particularly during periods of agricultural shortfall (Angelsen et al., 2014).

Overall, the distribution of income across different forest food species reflects a diversified livelihood strategy among households. This diversification reduces vulnerability to market and environmental shocks, as reliance is not placed on a single resource. The findings support the broader argument that non-timber forest products, especially edible species, serve as both primary and supplementary income sources in rural economies, contributing to poverty alleviation and livelihood resilience.

Importantly, the economic contributions observed in this study also have implications for sustainable forest management. The high dependence on specific species such as *Irvingia gabonensis* and *Garcinia kola* may lead to overexploitation if not properly managed. Therefore, there is a need for policies and community-based management strategies that promote sustainable harvesting, domestication, and value addition to ensure long-term availability and enhanced income generation. The findings highlight that indigenous forest food species are not merely subsistence resources but are integral to the economic sustainability of forest-dependent households. Their contributions underscore the need to integrate forest food systems into rural development planning and conservation strategies, particularly in regions where livelihoods are closely linked to forest ecosystems.

Table 2. Mean Annual Income from Selected Indigenous Forest Food Species among Respondents

Forest Food Species	Mean Annual Income (₦)	Percentage Contribution to Forest Food Income (%)
Irvingia gabonensis (Bush mango)	86,450	24.75
Garcinia kola (Bitter kola)	64,800	18.55

Snails	58,300	16.69
Honey	74,200	21.25
Wild mushrooms	38,600	11.05
Wild leafy vegetables	26,900	7.70
Total	349,250	100

The substantial income derived from indigenous forest food species highlights the continuing importance of forest resources to household economies in communities surrounding Onigambari Forest Reserve. The limited availability of formal employment opportunities and the relatively low capital requirements associated with harvesting forest products make these resources particularly attractive to rural households. For many respondents, forest food species function not only as supplementary income sources but also as livelihood buffers during periods of low agricultural productivity and economic hardship. This suggests that the forest reserve continues to provide an important economic safety net for nearby communities despite increasing pressures on forest resources. Similar observations have been reported in other forest-dependent regions of Africa (Angelsen *et al.*, 2014; Chama *et al.*, 2023).

Seasonal Availability and Livelihood Contribution

The findings in Table 3 highlight the strong seasonal dynamics of indigenous forest food species and their critical role in sustaining rural livelihoods throughout the year. The staggered availability of these species provides a natural buffer against seasonal income fluctuations, thereby enhancing household resilience in forest-dependent communities. Wild mushrooms recorded the highest level of household participation (72%), particularly during the rainy season (June–September) (Dube *et al.*, 2024). Their widespread availability and low entry barriers make them an accessible source of daily income, especially for women. This supports existing evidence that forest food collection, particularly of perishable products like mushrooms, is often gendered and serves as an important avenue for women’s economic participation in rural economies (Food and Agriculture Organization, 2020). The role of mushrooms in generating frequent, small-scale income underscores their importance in meeting immediate household needs.

Similarly, wild leafy vegetables (63%) contribute to short-term household cash flow and dietary supplementation during their peak season (April–July). Although their market value is relatively low, their high accessibility and frequent use make them vital for both nutrition and income smoothing. These findings align with studies showing that easily accessible forest foods play a crucial role in bridging food and income gaps during agricultural lean periods (Chavula *et al.*, 2026).

The staggered seasonal availability of indigenous forest food species appears to play an important role in stabilizing household access to income throughout the year. While products such as mushrooms and leafy vegetables are predominantly available during the rainy season, species such as bush mango, honey, and *Garcinia kola* become available during different periods of the

year. This seasonal complementarity reduces the likelihood of complete income gaps and enables households to diversify their forest-based livelihood activities across multiple harvesting periods. Within the Onigambari area, this pattern may partially explain the high dependence reported by many households on forest food resources.

Snails, benefiting 67% of households, are available over a relatively extended period (April–October), making them a reliable source of continuous income. Their regular availability supports daily or weekly sales, while home-based processing enhances value and shelf life. This consistency positions snails as a stabilizing livelihood resource compared to more seasonal forest products (Meleko *et al.*, 2025). High-value species such as *Irvingia gabonensis* (48%) and honey (55%) play a different but equally important role. Their peak seasons (December–March and November–February, respectively) coincide with periods when other forest foods are less abundant, thereby contributing to income diversification across seasons. *Irvingia gabonensis*, in particular, offers opportunities for storage and delayed sales, allowing households to benefit from price fluctuations. Honey production, often organized through cooperative structures, provides lump-sum income that can support major household expenditures. These patterns are consistent with findings that high-value NTFPs contribute to income accumulation and investment in rural households (Chama *et al.*, 2023).

Garcinia kola (51%) serves both economic and cultural functions, with its availability spanning part of the dry and early rainy seasons (February–June). Its dual role as a medicinal and commercial product ensures steady demand, contributing to moderate but reliable income streams (Tauchen *et al.*, 2023). The seasonal complementarity of these forest food species reduces livelihood vulnerability by ensuring that income opportunities are distributed throughout the year. This diversification strategy minimizes the risks associated with seasonal unemployment and agricultural uncertainties. The findings reinforce the broader understanding that forest ecosystems function as safety nets for rural households by providing continuous and seasonally adjusted livelihood options (Fiona, 2005). However, the dependence on seasonal availability also highlights potential vulnerabilities to environmental change, such as climate variability and habitat degradation, which may disrupt production cycles. Sustainable management practices, including domestication, improved harvesting techniques, and value addition, are therefore essential to maintain the long-term benefits derived from these species.

Table 3. Seasonal Availability and Livelihood Roles of Key Indigenous Forest Food Species

Species	Peak Availability Season	Primary Livelihood Role	Households Benefiting (%)
Wild mushrooms	June–September	Daily sales; predominantly women-led income activities	72.0

Wild leafy vegetables	April–July	Household cash flow and supplementary income	63.0
<i>Irvingia gabonensis</i>	December–March	High-value sales; storage and processing for off-season use	48.0
Honey	November–February	Cash income through individual and cooperative marketing	55.0
<i>Garcinia kola</i>	February–June	Medium-value sales; medicinal and commercial use	51.0
Snails	April–October	Regular sales and home-based processing	67.0

NB: Multiple responses were allowed; therefore, percentages do not sum to 100%.

Market Participation and Value Addition

The results presented in Table 4 reveal important insights into the commercialization of indigenous forest food species and their contribution to household income. A substantial proportion of respondents (59.2%) participated in direct sales of forest food products in local markets, indicating that market engagement is a common livelihood strategy among forest-dependent households. This finding reflects the accessibility of local markets and the relatively low barriers to entry associated with selling unprocessed forest products (Vuola et al., 2016; FAO, 2003). However, only 21.7% of respondents engaged exclusively in value addition activities, while a smaller proportion (10.8%) combined both processing and direct sales. This suggests that although value addition is recognized as a pathway to increased income, its adoption remains limited. The relatively low level of processing may be attributed to constraints such as lack of technical knowledge, inadequate equipment, and limited access to storage and preservation facilities (Shanley et al., 2002).

The income comparison suggests a potential economic advantage associated with value addition. Households involved in processing earned higher annual incomes (₦349,140) compared to those selling raw products (₦264,500), representing a 32% increase. This substantial margin underscores the importance of post-harvest processing in enhancing product value, extending shelf life, and improving marketability. Similar findings have been reported in studies on non-timber forest products, where value addition increases returns and reduces post-harvest losses (Food and Agriculture Organization, 2018). Processing activities such as drying, slicing, and kernel extraction—particularly for *Irvingia gabonensis*—were among the most common value addition practices. These methods not only enhance product quality but also allow for storage and delayed sales, enabling

households to take advantage of favorable market prices. Similarly, snail processing improves preservation and expands market opportunities beyond immediate local consumption (Mbaeyi-Nwaoha and Akobueze, 2018).

The dominance of direct sales among respondents reflects the structure of local forest food value chains in communities surrounding Onigambari Forest Reserve. Most harvesters operate on a small scale and depend on immediate cash returns to meet household needs. Consequently, products are often sold soon after harvesting rather than processed or stored for future sale. While this strategy provides quick income, it may limit opportunities for capturing higher market values through processing and value addition. The finding suggests that interventions aimed at improving storage facilities, processing equipment, and market access could substantially enhance household earnings from forest food resources.

Despite these benefits, several constraints limit the full realization of income potential. Limited access to storage facilities reduces the ability of households to preserve products for off-season sales, thereby forcing immediate disposal at lower prices. Inadequate market information further constrains decision-making, as producers may lack awareness of price trends and alternative markets. Additionally, price fluctuations, often driven by seasonal supply variations, introduce uncertainty and reduce income stability (Arinloye et al., 2015; Magakwe et al., 2025). The findings suggest that improving access to processing technologies, storage infrastructure, and market information systems could enhance the economic benefits derived from indigenous forest food species. Strengthening cooperative structures and market linkages may also facilitate collective marketing and better price negotiation, particularly for high-value products (Manandhar et al., 2018). The results demonstrate that while market participation is widespread, the transition from raw product sales to value-added processing remains limited but highly beneficial. Promoting value addition represents a critical opportunity for increasing rural incomes, reducing poverty, and enhancing the sustainability of forest-based livelihoods.

The relatively low level of participation in value addition activities may reflect technological, financial, and institutional constraints commonly experienced by rural producers. Processing activities often require specialized equipment, storage facilities, technical knowledge, and access to profitable markets. In the absence of these enabling conditions, many households prefer to sell products in raw form immediately after harvest to meet urgent household cash needs. Similar observations have been reported in studies of non-timber forest product value chains, where limited processing capacity restricts opportunities for income enhancement and market expansion (Gizachew et al., 2025).

The dominance of direct sales in local markets may be explained by the relatively low capital requirements and immediate cash returns associated with this marketing strategy. Local markets provide accessible outlets for forest food products, allowing households to convert harvested products into income without the

additional costs associated with processing, packaging, transportation, or storage (Brown and Miller, 2008).

Table 4. Market Participation, Value Addition Practices, and Income Differentials among Respondents (n = 120)

Variable	Category	Frequency (n)	Percentage (%)
Market Participation	Direct sale in local markets	71	59.2
	Value addition (processing before sale)	26	21.7
	Both direct sale and processing	13	10.8
	No market participation (subsistence use)	10	8.3
Common Value Addition Practices*	Drying	18	15.0
	Slicing	14	11.7
	Bush mango kernel processing	16	13.3
	Snail meat processing	12	10.0
Income Comparison	Mean annual income (raw products) (₦)		264,500
	Mean annual income (processed products) (₦)		349,140
	Income advantage from processing (%)		32.0

Note:

- Multiple responses were recorded for value addition practices; therefore, percentages may not sum to 100%.
- Income values represent mean annual earnings per household from forest food species.

Livelihood Dependence on Forest Food Species

The distribution of households across dependence categories (Table 5) indicates that indigenous forest food species constitute a central pillar of rural livelihoods in the study area. A substantial proportion of respondents (41.7%) fall within the high-dependence category, deriving at least 40% of their annual income from forest foods. This level of reliance underscores the critical role of forest resources as primary income sources rather than mere supplements, particularly among households with limited

access to alternative livelihood opportunities. The 38.3% of households classified as moderately dependent further highlights the integrative role of forest foods within diversified livelihood systems. For these households, forest resources complement agricultural production and off-farm activities, contributing to income stability and risk reduction. This pattern aligns with the widely recognized livelihood diversification strategy in rural economies, where households combine multiple income sources to buffer against environmental and market uncertainties (Musumba et al., 2022).

Only 20% of respondents exhibited low dependence on forest food species, suggesting that a relatively small proportion of households rely minimally on forest-derived income. These households may have greater access to alternative income sources such as salaried employment, larger-scale farming, or more established trading activities. Nevertheless, even within this group, forest foods may still contribute indirectly through subsistence use, thereby reducing household expenditure on food.

An important observation from the results is that households with high dependence on forest food species often engage in multiple livelihood activities, including farming and petty trading. This indicates that high reliance on forest resources does not necessarily imply specialization but rather reflects adaptive diversification strategies. Such households strategically combine forest-based and non-forest-based activities to maximize income and enhance resilience. This finding is consistent with empirical evidence showing that environmental income is often integrated with other livelihood sources to sustain rural households, especially in forest-rich regions (Angelsen et al., 2014).

The high level of dependence observed among many households may be attributed to limited access to alternative income-generating opportunities within the forest-fringe communities. In rural areas where formal employment opportunities are scarce, forest food species often function as readily accessible livelihood resources requiring minimal financial investment for harvesting and marketing. Similar studies have shown that households with lower asset ownership and restricted access to productive resources tend to rely more heavily on forest-based income as a means of reducing livelihood risks and smoothing household consumption (Angelsen et al., 2014; Chama et al., 2023). The proximity of communities to the forest reserve further enhances access to these resources, thereby increasing household dependence on forest-derived products.

Interview participants consistently emphasized the importance of indigenous forest food species as supplementary sources of income, particularly during periods of low agricultural productivity and economic hardship. According to several community elders and experienced harvesters, forest food resources often provide households with immediate income opportunities when farm outputs are insufficient or delayed. These observations support the quantitative findings showing substantial household dependence on forest-derived products. One community elder noted that:

“When farming activities are not bringing enough income, many households depend on bush mango, snails, mushrooms, and other forest products to meet daily needs.”

The high proportion of households exhibiting moderate to high dependence on forest food species suggests that indigenous forest resources remain deeply integrated into local livelihood systems. This level of dependence may reflect the limited diversification opportunities available within the study area, where agriculture remains largely small-scale and seasonal. Consequently, forest food species serve as both income-generating assets and risk-management mechanisms for rural households.

Table 5. Household Livelihood Dependence on Indigenous Forest Food Species (n = 120)

Dependence Category	Definition (Share of Annual Household Income from Forest Foods)	Frequency (n)	Percentage (%)
High dependence	≥ 40%	50	41.7
Moderate dependence	20–39%	46	38.3
Low dependence	< 20%	24	20.0
Total		120	100.0

Note: Dependence categories are based on the proportion of total annual household income derived from indigenous forest food species.

Constraints Affecting Livelihood Benefits

The findings in Table 6 reveal that although indigenous forest food species contribute to rural livelihoods, several constraints limit their full economic potential. The most prominent challenge identified by respondents is the declining availability of forest food species due to forest degradation (75.8%). This reflects ongoing pressures on forest ecosystems, including deforestation, unsustainable harvesting practices, and land-use change. The reduction in resource availability directly affects income generation and threatens the sustainability of forest-dependent livelihoods. Similar patterns have been documented in tropical forest regions, where degradation reduces both biodiversity and the availability of non-timber forest products essential for rural economies (Araujo-Santos *et al.*, 2025).

Limited access to formal markets (56.7%) represents another significant barrier. Many households rely on informal local markets, which often offer lower and more volatile prices due to weak bargaining power and lack of market information. The absence of structured market systems restricts opportunities for scaling up production and accessing more profitable urban or export markets. This constraint is widely recognized in rural development literature as a key factor limiting the

commercialization of non-timber forest products (World Bank, 2016).

The lack of improved processing tools (51.7%) further constrains income generation by limiting value addition. As observed in earlier results, households engaged in processing reported higher mean earnings than those selling raw products; however, inadequate access to appropriate technologies reduces efficiency, product quality, and shelf life. This not only leads to post-harvest losses but also prevents households from fully capitalizing on market opportunities. Addressing this constraint through improved technologies and training could substantially enhance livelihood outcomes (Mbaeyi-Nwaoha and Akobueze, 2018).

Seasonal scarcity (47.5%) also affects the consistency of income derived from forest food species. The seasonal nature of many forest products results in fluctuations in supply and income, creating periods of economic vulnerability. While households attempt to mitigate this through diversification, the lack of adequate storage and preservation methods exacerbates the impact of seasonal variability. Competition from agricultural expansion (40.8%) highlights the increasing pressure on forest lands due to the need for arable land. As farming activities encroach into forest areas, the habitats of many indigenous food species are reduced or degraded. This land-use conflict reflects broader challenges in balancing agricultural development with forest conservation, particularly in regions with growing populations and food demand.

Despite these constraints, respondents consistently emphasized the continued importance of forest food species in supporting household livelihoods. This underscores the role of forest resources as a safety net, providing income and food security even under conditions of environmental and economic stress. The persistence of reliance, despite multiple challenges, highlights both the resilience of forest-based livelihood systems and their vulnerability to external pressures (Vuola *et al.*, 2018). The findings suggest that enhancing the contribution of indigenous forest food species to rural livelihoods requires integrated interventions. These should include sustainable forest management practices, improved access to markets, investment in processing technologies, and policies that balance agricultural expansion with forest conservation. Addressing these constraints is essential to ensure that forest food systems continue to support rural livelihoods in a sustainable manner.

Table 6. Constraints Affecting Livelihood Benefits from Indigenous Forest Food Species (n = 120)

Constraint	Frequency (n)	Percentage (%)
Declining species availability due to forest degradation	91	75.8
Limited access to formal markets	68	56.7
Lack of improved processing tools	62	51.7

Seasonal scarcity of forest food species	57	47.5
Competition from agricultural expansion	49	40.8

Note: Multiple responses were allowed; therefore, percentages do not sum to 100%.

Traders and harvesters identified limited access to larger markets as a major challenge affecting profitability. Most products are sold within nearby rural markets where prices fluctuate considerably depending on seasonal supply and demand conditions. Respondents indicated that poor transportation infrastructure and limited market information reduce opportunities for accessing more profitable urban markets.

A local trader explained:

“Most of the products are sold here because many collectors cannot transport them to bigger markets where prices are usually higher.”

Forest officers and experienced harvesters expressed concern regarding the declining abundance of some indigenous forest food species. Respondents attributed this trend primarily to forest degradation, agricultural encroachment, and unsustainable harvesting practices. Field observations also revealed evidence of land-use conversion in areas previously used for gathering forest products.

One forest officer observed that:

“Some species that were once common are becoming more difficult to find because of increasing pressure on the forest.”

4.0 Conclusions

This study highlights the important contribution of indigenous forest food species to the livelihoods of households surrounding Onigambari Forest Reserve. The findings indicate that forest foods provide significant income, support household food security, and serve as an important livelihood safety net, particularly for households with limited alternative income opportunities. The diversity and seasonal availability of these resources contribute to livelihood diversification and economic stability throughout the year. However, the benefits derived from indigenous forest food species are constrained by declining resource availability, limited market access, inadequate processing technologies, and seasonal fluctuations in supply. Although value addition activities remain limited, they offer considerable potential for enhancing household income and strengthening forest-based enterprises. Therefore, efforts aimed at promoting sustainable harvesting practices, improving value addition and market access, and supporting the conservation of indigenous forest food species are essential for enhancing rural livelihoods and ensuring the long-term sustainability of forest resources in the study area.

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Declaration of conflict of interest

The authors declare no conflicts of interest

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