



Research paper

Livelihood strategies and NTFP utilisation among rural female-headed households in Limpopo Province, South Africa

Lloyd J.S. Baiyegunhi^{a,*}, Linley Chiwona-Karlton^b

^a Discipline of Agricultural Economics, School of Agricultural, Earth and Environmental Studies, University of KwaZulu-Natal, Pietermaritzburg Campus, Private Bag X01, Scottsville 3201, Pietermaritzburg, South Africa

^b Department of Urban and Rural Development, Swedish University of Agricultural Sciences, PO Box 7012, SE-750 07 Uppsala, Sweden

ARTICLE INFO

Edited by R Maconachie

Keywords:

Rural livelihoods
Forest income
Non-timber forest products
Household income diversification
Sustainable livelihood framework

ABSTRACT

Non-Timber Forest Products (NTFPs) play a crucial role in the livelihoods of female-headed households in rural South Africa, though level of utilisation varies. While research highlights their significance, few studies examine how local agro-ecological conditions shape income sources and trade-offs between agriculture and NTFP collection. This study draws on household survey data collected from 240 female-headed households in Limpopo Province. Using the sustainable livelihood framework, households were grouped into livelihood clusters based on NTFP income shares, and the determinants of NTFP utilisation were analyzed with a Multinomial Logit (MNL) regression model. Spearman's rank correlation revealed a negative association between NTFP income and crop, livestock, and wage income but a positive association with social grants and remittances. One-way ANOVA indicated no significant differences in total income across livelihood clusters, suggesting that NTFPs primarily supplement rather than determine household income, with social grants and remittances buffering variations in utilisation. In contrast, crop and livestock income play a smaller role in these household livelihood strategies based on varying levels of NTFP utilisation. Overall, the findings affirm that NTFP collection remains a key livelihood strategy for female-headed households, complementing other income sources. Policies promoting sustainable forest management, capacity building, and improved market access should recognize and support NTFP collection to enhance rural livelihoods. Further research should examine non-income factors, including livelihood stability, resilience, and the long-term sustainability of NTFP-based livelihoods.

1. Introduction

Livelihood strategies encompass the various activities individuals pursue to achieve their livelihood goals, adapting continuously to evolving needs and circumstances (Burchi and De Muro, 2016). Households may diversify across multiple income-generating activities or focus on a few key strategies, leveraging their assets to sustain income and mitigate risks. Rural livelihoods are typically multifaceted, combining economic activities such as agriculture, wage labour, and natural resource use, and their composition varies across households, locations, and time (Angelsen et al., 2014; Shackleton and Luckert, 2015). Understanding these strategies is essential for assessing household resilience, economic stability, and vulnerability to shocks.

Non-Timber Forest Products (NTFPs) form a critical component of rural livelihoods in many developing countries, offering both subsistence and cash income (Pandey et al., 2016; Angelsen et al., 2014).

Globally, NTFPs provide a safety net for households, particularly in low-resource contexts, contributing significantly to total household income and supporting diversification strategies (Ao et al., 2021). In regions with limited agricultural potential or high seasonality, NTFPs serve as a buffer against food insecurity and income fluctuations, complementing other livelihood sources (Wunder et al., 2014).

In the South African context, poverty remains a persistent challenge despite post-apartheid reforms, with women disproportionately affected by economic exclusion. Female-headed households, which constitute a significant portion of rural populations, face heightened vulnerabilities due to structural inequalities in land ownership, financial access, and employment opportunities (Sharaunga et al., 2016; Mokati et al., 2024). Disparities in land tenure restrict women's access to credit, reduce investment in sustainable farming, and limit participation in profitable agricultural activities (Mulusew and Mngyong, 2023). As a result, female-headed households often pursue additional income-generating

* Corresponding author.

E-mail addresses: Baiyegunhil@ukzn.ac.za (L.J.S. Baiyegunhi), Linley.chiwona.karlton@slu.se (L. Chiwona-Karlton).

<https://doi.org/10.1016/j.wdp.2026.100765>

Received 20 May 2025; Received in revised form 23 January 2026; Accepted 25 January 2026

Available online 30 January 2026

2452-2929/© 2026 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

activities beyond agriculture to manage risks, seasonality, and economic insecurity (Bekele and Rajan, 2017).

NTFP collection offers an accessible and culturally significant livelihood option, providing both economic and subsistence benefits. These resources, including firewood, medicinal plants, edible insects, fruits, and resins, are derived from forests and woodlands and contribute to household food security and income (Shackleton and de Vos, 2022; Baiyegunhi and Oppong, 2016). In South Africa, women are central to NTFP collection, processing, and sale, particularly in communities affected by male outmigration for wage labour (Nwosu and Ndinda, 2018). Access to forest resources, however, is uneven, shaped by household socioeconomic status, land tenure, and market opportunities (Suleiman et al., 2017).

While agriculture and NTFPs are generally complementary livelihood strategies, competition can occur when households face constraints in land, labour, or other critical resources (Shackleton et al., 2011; Angelsen et al., 2014). Access to arable land, labour availability, and inputs such as quality seeds, biomass, irrigation, and fertilizers significantly influence the extent to which households can simultaneously engage in both activities (Wunder, 2001; Angelsen & Wunder, 2003). In high-potential agricultural regions, reliable crop yields and sufficient resources often reduce NTFP utilisation, whereas in low-productivity or resource-constrained settings, NTFPs play a critical supplementary role in household income and food security (Wunder et al., 2014; Mugido & Shackleton, 2019). NTFPs with both economic and cultural significance, including firewood, medicinal plants, thatching grass, fruits, and resins, remain vital for rural households. This nuanced perspective highlights that the interplay between agriculture

and NTFPs is context-dependent, shaped by environmental conditions, socio-economic factors, and household access to critical resources.

However, despite recognition of their importance, few studies have specifically examined the role of NTFPs within female-headed households' livelihood portfolios in South Africa. Existing research highlights the significance of NTFPs to household income but is often limited by methodological differences and a lack of focus on gender-specific dynamics. Understanding how female-headed households integrate NTFPs with other income sources, including social grants and agricultural activities, is critical for developing policies and interventions that promote economic resilience and sustainable resource management.

This study addresses this gap by examining the monetary and proportional contribution of NTFPs to the livelihoods of female-headed households in Limpopo Province, South Africa. Guided by the Sustainable Livelihood Framework (Chambers and Conway, 1992; Ellis, 1998), the study explores how these households combine NTFP income with other livelihood sources and how external factors shape their decisions. The findings aim to inform gender-responsive policies and interventions that support sustainable forest resource use, enhance rural livelihoods, and foster inclusive economic growth.

2. Conceptual framework

This study adopts the Sustainable Livelihoods Framework (SLF) (UNDP, 2017) to examine the determinants of rural livelihood strategies in Limpopo Province. The SLF emphasizes households' access to livelihood assets, comprising human, natural, physical, social, and financial capital, and how these interact with institutional structures and

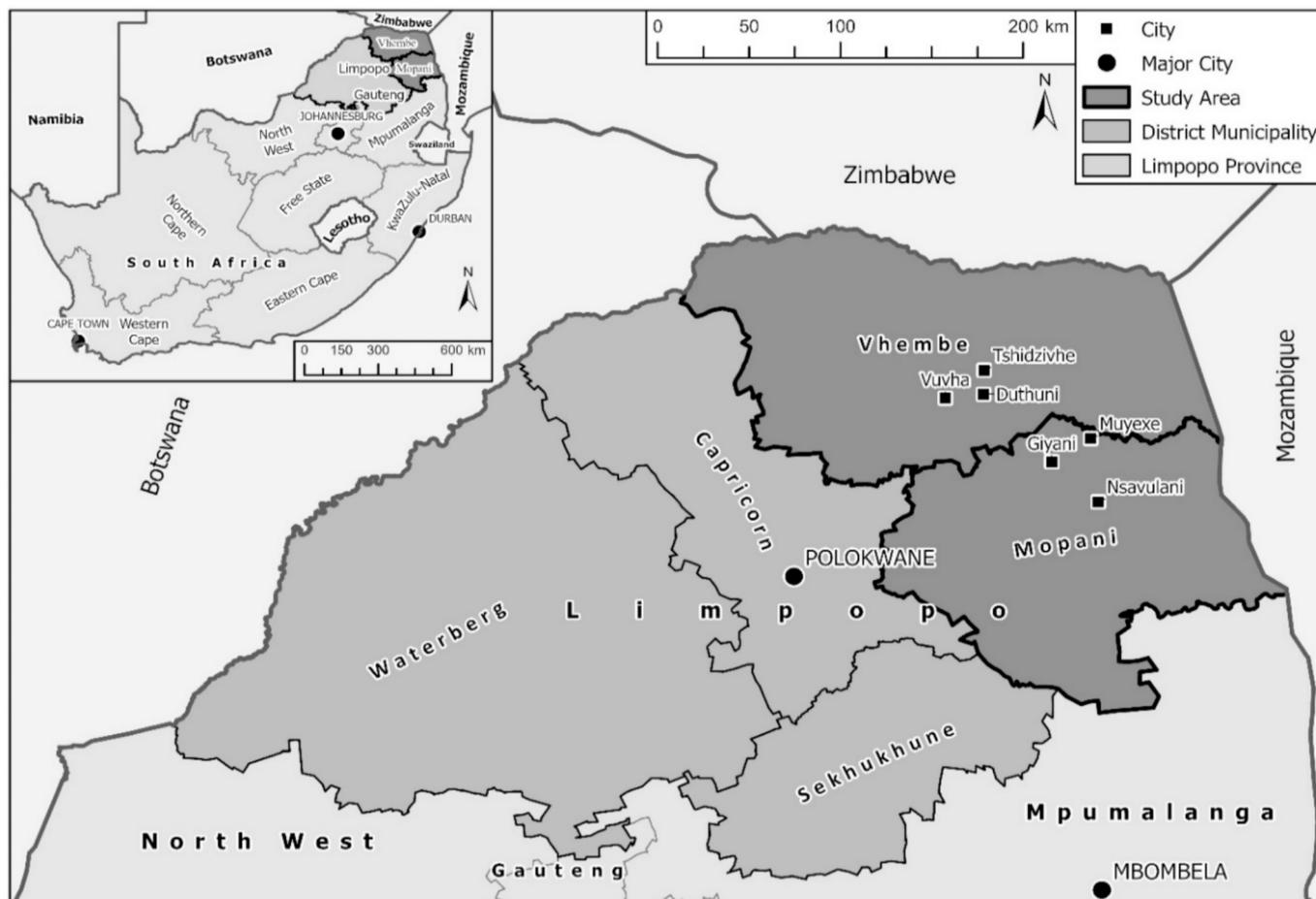


Fig. 1. Map of Limpopo province, South Africa showing the study areas. .
Source: UKZN Geography Department Cartographic Unit, 2024

vulnerability contexts to shape livelihood decisions. In rural environments, households allocate labour and resources across agricultural activities, wage employment, and the utilisation of non-timber forest products (NTFPs), depending on their asset portfolios, demographic characteristics, and exposure to risks. Livelihood outcomes, including income and food security, reinforce or erode asset holdings over time, demonstrating the dynamic and interdependent nature of household adaptation (Fig. 2).

Within this framework, exogenous conditions such as market access, seasonality, environmental shocks, and policy interventions can constrain or expand livelihood opportunities. Households with limited productive resources often rely more heavily on accessible natural resources, such as NTFPs, to supplement income and food supply. Conversely, stronger asset endowments and supportive institutional environments are expected to facilitate greater diversification into higher-return activities.

Guided by these theoretical linkages, the study tests the following hypotheses:

- H1:** Female-headed households with stronger access to livelihood assets are less dependent on NTFPs as a primary income source.
- H2:** Household demographics, including age, education, and household size, significantly influence participation in agriculture and NTFP-related activities.
- H3:** Exogenous factors, including market access and policy support, enhance income diversification and reduce NTFP utilisation as a livelihood safety net.

These hypotheses allow the study to empirically assess how household characteristics and contextual factors shape livelihood strategies and the contribution of NTFPs to rural incomes.

Fig. 2 presents the Sustainable Livelihoods Framework, which underpins the analytical structure of this study. The framework illustrates how livelihood outcomes emerge from the interaction between asset access, institutional arrangements, and vulnerability conditions. Anchored in this structure, the study’s hypotheses operationalise these relationships within the context of rural Limpopo, focusing on how variations in capital assets, market engagement, and demographic profiles influence the utilisation of NTFPs. In particular, the analysis

evaluates whether households facing asset constraints and greater vulnerability, such as female-headed households, demonstrate heightened NTFP utilisation. By translating the conceptual elements of the SLF into measurable indicators, the study advances a testable model for understanding livelihood adaptation in forest–agriculture landscapes.

3. Research methods

3.1. The study area

The study was conducted in the Vhembe and Mopani Districts of Limpopo Province, South Africa, where approximately 90% of the population resides in rural areas. These districts were selected for their diverse livelihood strategies, including agriculture, livestock, formal and informal employment, and significant engagement in non-timber forest product (NTFP) collection (Baiyegunhi and Oppong, 2016; Dalu et al., 2021; Municipalities of South Africa, 2024). The districts share common characteristics such as limited infrastructure, inadequate public services, and restricted economic opportunities. Government welfare support, including grants, provides an important source of income for households.

In 2022, Vhembe District had a population of 1,653,022 with 436,959 households, 51% female-headed, covering 25,597 km². Mopani District had 1,372,873 people and 358,153 households, 49.2% female-headed, covering 20,012 km² (Municipalities of South Africa, 2024). High unemployment drives reliance on welfare grants and remittances, while subsistence farming and NTFPs remain critical for nutrition and income. Poverty and food insecurity rates are high, with 67.5% of adults living in poverty and 63% of households facing food insecurity (StatsSA, 2019). COVID-19 has worsened economic conditions, increasing unemployment and living costs.

The study area, characterized by semi-arid savannah vegetation, receives 500–1000 mm of annual rainfall and frequently experiences droughts that affect dryland farming. Households rely primarily on rain-fed agriculture, growing crops such as maize and sorghum, and raising livestock for subsistence. Forest resources, including timber, medicinal plants, and Mopane caterpillars, provide additional income and subsistence, with NTFPs such as fuelwood, wild fruits, herbs, grass and shrub brooms, edible insects, thatch grass, reeds, and poles frequently

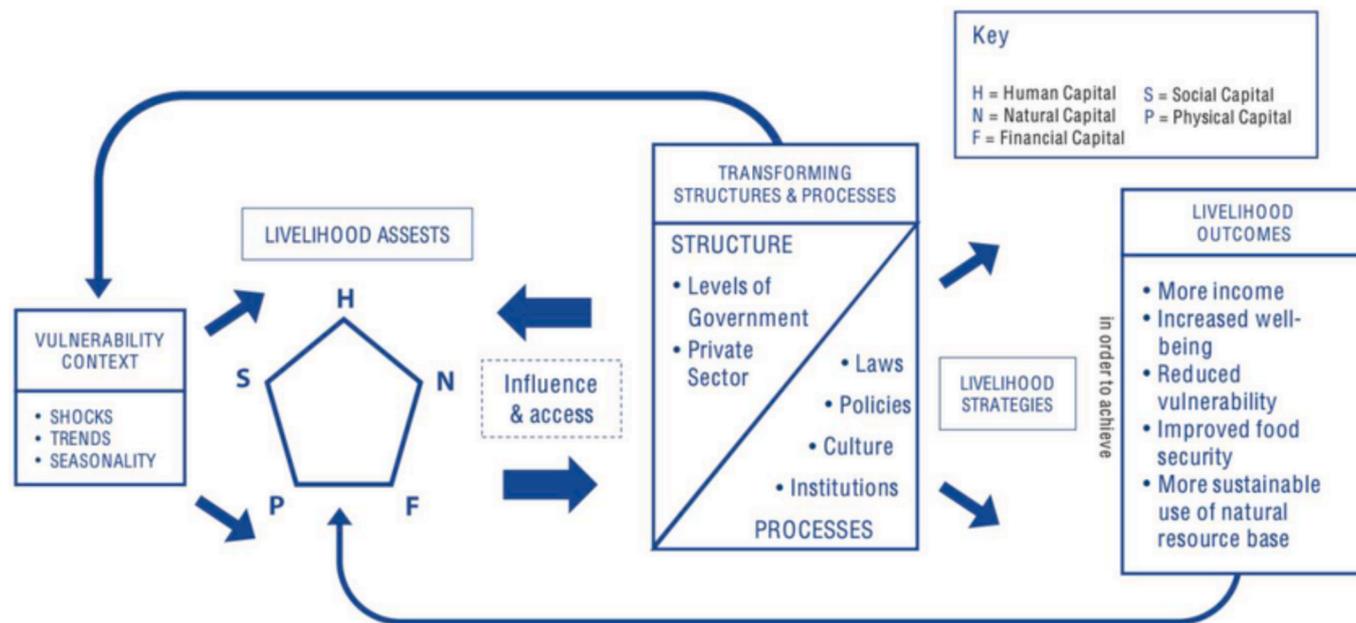


Fig. 2. DFID Sustainable Livelihood Framework. . Source: UNDP 2017

harvested (Mugari and Masundire, 2022). Fig. 1 shows a map of Limpopo Province highlighting the study areas in Vhembe and Mopani Districts.

3.2. Sampling and data collection

This study used a combination of exploratory and participatory methods for data collection. A three-stage sampling technique was applied to select households. First, Vhembe and Mopani districts in Limpopo Province were purposively selected due to their location in the savanna biome. Second, six villages, Tshidzivhe, Duthuni, and Vuvha in Vhembe District, and Giyani, Nsavulani, and Muyeze in Mopani District, were selected based on preliminary field visits and consultations with local authorities to capture diverse livelihood strategies. Third, a list of female-headed households was compiled with help from community leaders, serving as the sampling frame. Using Cochran's (2007) method for a 95% confidence level and 5% margin of error, a random sample of 240 female-headed households was selected for personal interviews, representing 25–30% of households in these villages.

Qualitative data were gathered through focus group discussions (FGDs), key informant interviews, and field observations. Eight female household heads from each village participated in the FGDs, representing diverse livelihood strategies such as crop farming, livestock rearing, petty trading, casual labour, NTFP collection, and small-scale food processing. Key informants, including community leaders and chiefs, provided further insights on livelihood diversification, particularly NTFP collection and trade. Data from these discussions informed the design of a semi-structured questionnaire, which was pilot-tested with 20 randomly selected female-headed households to refine the instrument. Pilot participants were excluded from the final sample to prevent overlap.

Household-level data on livelihood activities over the past 12 months were collected between April and August 2024 using structured interviews. Female household heads were asked about income sources, consumption patterns, NTFP use and trade, wage income, crop and livestock production, social grants, and demographic characteristics. Interviews lasted approximately 45 min, extending up to 1½ hours for households with multiple income streams. Experienced local field assistants, fluent in Tshivenda, Xitsonga, and Northern Sotho (the main languages spoken across Vhembe and Mopani districts), conducted the interviews and assisted with questionnaire translation under the supervision of the lead researcher to ensure data quality. Ethical clearance for this study was obtained from the University of KwaZulu-Natal Research Office (Ref No: HSS/0422/013 M), and informed consent was secured from all participants before data collection.

4. Analytical and estimation procedure

4.1. Accounting for rural female-headed households' income sources

To streamline household income accounting, three key assumptions were made based on methodologies from similar studies (Babulo et al., 2009; Heubach et al., 2011; Mugido and Shackleton, 2019). First, due to the challenge of estimating the opportunity cost of labour time (shadow wage rate) for low-income rural households in areas with limited or absent labour markets, the value of own-labour was not deducted from net income. Instead, own-labour costs were incorporated into the net income calculation. Second, the gross value of income was used, as most resource extraction activities require minimal skills and little capital investment.

Additionally, the opportunity cost of unskilled rural labour is generally low, making capital and labour expenses negligible in such contexts. As a result, the gross value of Non-Timber Forest Product (NTFP) income served as a reliable proxy for natural rent. Lastly, estimating the actual harvest of NTFPs is constrained by either current market prices or values reported by households. Earlier studies (Peters

et al., 1989; Wollenberg, 2000) faced criticism for relying on assumptions about potential harvests or market values. In contrast, recent research emphasizes quantifying actual harvests and assessing the real contribution of NTFPs to rural livelihoods, using either market prices or self-reported values (Babulo et al., 2009; Heubach et al., 2011; Mugido and Shackleton, 2019). Based on these assumptions, five main income sources were recognized and estimated.

Net crop income was determined using local market prices from January to February 2023. The value of various end-period crop items was assessed for each female-headed household over the year. Input costs, including fertilizers, seeds, ploughing services, and hired labour, were totalled, and net crop income was calculated by subtracting these costs from the gross crop income. Since most households rely on hired equipment for cropping purposes, capital and depreciation costs were excluded from the calculation of crop income.

Net livestock income was calculated based on annual gross earnings from cattle, goats, and poultry, including meat, eggs, milk, dung, skins, and services such as drought power. Livestock sales, livestock products, and livestock services were the three primary revenue components. The first two were valued at local market prices, while inflated values were used for cattle services like transport and ploughing. Gross livestock revenue was the sum of these components. To determine total costs, annual expenses such as feed, veterinary care, and hired labour were deducted from the gross livestock income to arrive at net livestock revenue.

Wage income encompassed earnings from employment, small-scale non-farm market production, petty trading, and other cash-generating business ventures. It was recorded for each household member who had earned wages in the preceding year, whether through regular employment, part-time work, or occasional casual labour. Annual wage income was determined based on the actual values reported by households for these activities over the year. Net income was calculated as total earnings minus transportation, childcare, work-related clothing or equipment, and the opportunity cost of time away from household or farm activities (valued at local daily wage equivalents).

Social grants play a vital role in rural households, providing financial support to qualifying South African citizens through various government programs. These grants include state old age pensions, war veterans' grants, child support grants, foster child grants, disability grants, relief of distress grants, and care dependency grants. The number and types of grants received per household were recorded, with the cash value of each grant determined at the national level. In addition to social grants, many households benefited from financial or in-kind transfers from friends, family, NGOs, or government programs. To determine net remittances, the total amount received over the year was summed, and any funds sent out were deducted.

NTFP income focused on naturally occurring non-timber forest products, excluding plantation or commercial forestry income, which is considered investment profit. Data collected from communal forest and pasture sources included the quantities of NTFPs collected, used, exchanged, donated, or sold by each household over a specific recall period. If an NTFP was bartered, its market-equivalent value was recorded. Household-reported values were used to estimate NTFP utilization, reflecting actual household consumption rather than potential use (Babulo et al., 2009). Common NTFPs such as fuelwood, building materials, and wild foods, which are widely traded, were valued using household estimates. For products without direct market prices, including wild vegetables and medicinal plants, focus group discussions were used to estimate values based on similar locally traded products.

4.2. Clustering rural female-headed households' NTFP- income

To examine livelihood activity choices, particularly NTFP utilisation, the sampled female-headed households were divided into three distinct clusters based on the proportion of total income derived from NTFPs.

- Cluster I: Female-headed households that generate 20% or less of their total income from NTFPs, classified as “low NTFP-utilising households.”
- Cluster II: Female-headed households that generate 21% to 39% of their total income from NTFPs, classified as “moderately NTFP-utilising households.”
- Cluster III: Female-headed households that generate ≥ 40% of their total income from NTFPs, designated as “highly NTFP-utilising households.”

The statistical relationship between NTFP income and other income sources was assessed using Spearman's Rank Correlation. Meanwhile, a one-way ANOVA was used to determine the statistical significance of variations in the mean female-headed household income across different categories and between all identified groups.

4.3. The MNL regression model's specification

A multinomial logit (MNL) regression model was used to identify the essential characteristics that statistically distinguished households that employ diverse strategies and primarily rely on forest collection. With the MNL regression, the correlates of access to certain high-return livelihood strategies were identified. If the effect of asset endowments on observed choices is statistically significant, it can be concluded that households with low assets may face limitations accessing high-return activities, thereby opting for livelihood strategies with lower welfare impact.

Following the random utility models (RUM) tradition (Train, 2003), it assumed that a household faces a choice among alternative livelihood activities, the individual household is assumed to consider the full set of offered alternative livelihood activities in a choice situation and has to choose the alternative that maximizes utility (Hensher et al., 2005). Consider a households' choice of a livelihood activity and assume that utility depends on the choice made from a set (j) i.e. the choice set that includes all the possible livelihood activity alternatives. Thus, a household is assumed to have a utility:

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \beta_{ij}X_{ij} + \varepsilon_{ij} \tag{1}$$

where for any household *i*, a given level of utility will be associated with any alternative livelihood activity choice *j*. The utility *U_{ij}* that a household derived from any alternative livelihood activity *j* is decomposable into two components *V_{ij}* and *ε_{ij}*. *V_{ij}* is the portion of *U_{ij}* that depends on the observed attributes of the alternatives, other socioeconomic and agro-ecological factors affecting households' decision, and is modelled using a vector of observable independent variables, denoted as *X_{ij}*, the corresponding vector of utility coefficients is represented by *β_{ij}*. *ε_{ij}* is a random disturbance reflecting intrinsically random choice behaviour, measurement or specification error and unobserved attributes of the alternatives that affect the utility (*U_{ij}*) but are not captured in *V_{ij}*. Choice made among the alternative livelihood activities will be a function of the probability that the utility associated with a particular activity (*j*) is higher than that associated with another alternative livelihood activity. The statistical model of probability *P_{ij}* that alternative *j* is chosen by household *i* is given by:

$$P_{ij} = \text{prob}(U_{ij} > U_{ia}); a = 1, 2, 3, \dots, j; a \neq j \tag{2}$$

Thus, if the *i*th household selects alternative activity *j*, then *U_{ij}* is the highest utility obtainable from among the *j* possible activity choices.

In this study, the response variable is a polychotomous choice variable that includes four distinct unordered livelihood activity alternatives (degree of NTFP utilisation) identified earlier. Hence, the MNL regression model (discrete choice method) (Greene, 2003), is specified as follows:

$$\text{Prob}(Y_i = j) = \frac{\exp(\beta_j X_i)}{\sum_{k=1}^4 \exp(\beta_k X_i)} \text{ with } j = 1, 2, 3, \dots \tag{3}$$

where *Y_i* is the dependent variable representing the type of livelihood activity selected by a household, taking the value 1, 2, or 3 if the household is classified as a ‘low NTFP-utilising household’, ‘moderately NTFP-utilising household’, or ‘highly NTFP-utilising household’, respectively, in terms of NTFP use as a component of livelihood. The ‘highly NTFP-utilising household’ category is used as the reference group. *X_i* represents a vector of explanatory variables that includes socio-economic characteristics, activities’ attributes, market and agroecological factors affecting a household livelihood choice. *β_i* represent vectors of estimated coefficients. The results of MNL model are interpreted in terms of the odds ratios, i.e. the ratios of the probability of choosing one outcome category over the reference category. These ratios are defined as:

$$\ln \left[\frac{P_{ij}}{P_{ik}} \right] = X_i(\beta_j - \beta_k) = X_i\beta_j \text{ if } k = 1 \tag{4}$$

A positive parameter indicates that the relative probability of being in the ‘less dependent’ or ‘moderately dependent’ NTFP categories, as opposed to the ‘highly dependent’ category, increases.

4.4. Description of the explanatory variables

The names, descriptions, and justifications for explanatory variables used in the MNL regression analysis are presented in Table 1. Following the sustainable livelihood framework, these variables capture household

Table 1
Name and definitions of the demographic and asset-based explanatory variables.

Variable name	Definition and measurement	Justification
<i>Human and demographic factors:</i>		
Household head's age	Age in years	Human capital, affects labour availability and decision-making
Marital status	If HH is married: Yes 1; otherwise 0	Influences resource access, labour allocation, and livelihood diversification
Household size	Total number of people in the household	Affects household labour availability and dependency ratio
Educational level	Number of years spent in school	Human capital, impacts skills and employment opportunities
<i>Social capital:</i>		
Group membership	Membership of any group or association Yes 1; 0 otherwise	Social capital, provides access to networks, information, and collective resources
Market access	Distance to the nearest all weather road (in km)	Affects access to markets and livelihood opportunities
<i>Natural capital:</i>		
Field size	Field size in hectares	Natural capital, determines agricultural production potential
Forest access	Unrestricted access to communal forest: Yes 1; 0 otherwise	Natural capital, influences NTFP utilisation
Grazing land access	Access to grazing land: Yes 1; 0 otherwise	Natural capital, affects livestock production and diversification
<i>Physical capital:</i>		
Productive assets value	Value of all productive assets (ZAR)	Physical capital, determines household production capacity
<i>Financial capital:</i>		
Credit access	Access to formal credit: Yes 1; 0 otherwise	Financial capital, enables investment in livelihoods
Savings	Total amount of money saved (ZAR)	Financial capital, buffers shocks and supports diversification
Transfer/remittance/social grant	Received transfer/remittance/social grants: Yes 1; 0 otherwise	Financial support, stabilizes household income and facilitates livelihood choices

endowments across human, social, natural, physical, and financial capital, which influence livelihood activity choices.

Justification for Key Capital Asset Variables:

- *Human and demographic factors:* Older household heads, with larger households, and higher education levels are more likely to diversify livelihood activities and engage in both agriculture and NTFP collection (Baiyegunhi & Oppong, 2016; Nwosu & Ndinda, 2018).
- *Social capital:* Households with group membership or strong social networks are more likely to participate in multiple livelihood strategies, including NTFP collection (Shackleton & Shackleton, 2004; Opiyo et al., 2023).
- *Natural capital:* Access to arable land, field size, grazing land, and communal forests positively influences engagement in crop, livestock, and NTFP-based activities (Mokati et al., 2024; Mulusew & Mngyong, 2023).
- *Physical capital:* Higher values of productive assets determines the capacity for agricultural production and affects reliance on alternative income sources such as NTFPs (Mokati et al., 2024; Mulusew & Mngyong, 2023).
- *Financial capital:* Access to credit, and household savings increase the capacity to engage in diversified livelihood strategies (Angelsen et al., 2014). Receipt of remittances or social grants reduces vulnerability and enables households to invest in multiple livelihood activities, including NTFPs (Baiyegunhi & Oppong, 2016).

These variables were carefully selected to reduce potential endogeneity, ensuring they serve as exogenous or predetermined factors influencing household livelihood strategies. Explicit hypotheses linking these variables to livelihood choices have also been added to Section 2.3.

5. Empirical results and discussion

5.1. NTFP income and livelihood typology in female-headed households

The 240 sampled female-headed households were grouped into three livelihood clusters based on the share of NTFP income in total household income (Table 2). Cluster I households had low NTFP utilisation, relying mainly on social grants and remittances, with minor contributions from crops, livestock, and wages. Cluster II households exhibited moderate NTFP utilisation, with income more evenly split between NTFPs and grants. Cluster III, the largest group, showed high NTFP utilisation, supplemented by grants, and minimal agricultural income. These results highlight NTFPs as a key livelihood strategy, with their relative importance varying across households, while social grants consistently act as a supplementary buffer and crop–livestock activities remain secondary.

Across all households, average NTFP income was R8,850 per annum, representing 37% of total income (Table 2), notably higher than crop (5%) and livestock (4%) contributions. Social grants and remittances were the largest income source, averaging R11,002 (46% of total

income), while wage income averaged R1,913 (8%), ranging from 7% in Cluster III to 14% in Cluster I. Average total household income by cluster indicate that households with higher NTFP utilisation generally achieve comparable overall incomes to those in other clusters. This underscores NTFPs as a critical, supplementary income source rather than a primary determinant, with social grants and remittances offsetting variations in NTFP utilisation.

Explanatory variable statistics used in the MNL regression (Table 3) reveal that households in Cluster III—where NTFP income exceeds 40% of total income—tend to have older female heads with lower education, smaller landholdings (0.41–0.92 ha), and fewer productive assets and savings. These households also face limited access to credit and markets, relying heavily on remittances and social grants. In contrast, Clusters I and II, which emphasize crop and livestock production, generally possess greater natural (land) and physical (productive assets) capital, supporting more diversified and resilient livelihood strategies.

Overall, these results demonstrate that NTFP collection remains a vital livelihood component for female-headed households in rural Limpopo, with its importance shaped by household demographics, asset endowments, and access to social and financial support mechanisms.

5.2. The relationship between NTFP income and other income sources

Spearman’s Rank Correlation tests were conducted to examine the association between household income from non-timber forest products (NTFPs) and other livelihood income sources, including crop, livestock, wage, and social grants income (Table 4). The results reveal statistically significant but weak correlations across these income sources, highlighting nuanced relationships rather than strong dependencies or trade-offs.

Relative NTFP income exhibits weak negative correlations with crop income ($R = -0.0621$) and livestock income ($R = -0.0586$). While these relationships are statistically significant, their small magnitude indicates that households deriving more income from NTFPs may slightly reduce reliance on agricultural activities, yet the effect is limited. These findings align with Mugido and Shackleton (2019), who reported a negative association between NTFP income and livestock income, but contrast with studies suggesting that NTFPs complement crop income or decline as agricultural productivity increases (Babulo et al., 2009; Heubach et al., 2011; Angelsen et al., 2014). This pattern may reflect constraints such as limited land access, labour availability, or the necessity for immediate returns from forest-based activities. However, given the weak correlations, it is important to interpret these results cautiously and recognize that multiple other factors likely influence household income composition.

Similarly, the correlation between NTFP income and wage income is weakly negative ($R = -0.2729$). This suggests that households engaged in NTFP collection generally earn somewhat less from formal or informal employment, potentially due to remoteness, lower educational attainment, or the flexibility required by forest-based income strategies. In

Table 2
Income share of female-headed households by source and level of NTFP utilisation.

Range	Level of NTFP Utilisation	Cluster	Average income shares by source in percentage						
			Households (no)	NTFP Income	Crop Income	Livestock Income	WageIncome	Social grants/ remittances Income	Average Income
≤ 25%	Low	Cluster I	56	6108 (0.42)	2291 (0.09)	1527(0.06)	3563(0.14)	11,962(0.47)	25,450
26 – 40%	Moderate	Cluster II	30	8231(0.36)	0.07(0.07)	1601(0.05)	2287(0.10)	9603(0.42)	22,865
≥ 41%	High	Cluster III	154	9723(0.41)	237(0.01)	949(0.04)	1660(0.07)	10,198(0.43)	23,715
		All sample	240	8850(0.37)	1196 (0.05)	957(0.04)	1913(0.08)	11,002(0.46)	23,918

Note: Numbers in parentheses represent proportions; multiply by 100 to obtain percentages. Values are in South Africa Rands (1Rand=\$18). Calculated from field survey data, 2023.

Table 3
Summary statistics of explanatory variables for female-headed households by cluster.

Explanatory variable	Cluster I		Cluster II		Cluster III		All Households	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	47.24	14.13	46.48	17.06	47.10	13.90	46.51	12.62
Marital status	0.54	0.50	0.28	0.45	0.23	0.42	0.35	0.47
Household size	7.91	1.07	8.33	1.04	3.85	0.96	7.17	2.71
Educational level	5.12	2.78	5.15	2.79	7.14	1.01	5.12	2.78
Group Membership	0.76	0.43	0.28	0.45	0.23	0.42	0.45	0.24
Field size	1.12	0.56	1.05	0.60	0.94	0.66	1.03	0.61
Forest land access	0.50	0.53	0.78	0.41	0.92	0.27	0.79	0.21
Grazing land access	0.47	0.50	0.60	0.50	0.33	0.47	0.45	0.31
Market access (ln)	4.74	0.44	4.48	0.51	3.98	0.94	4.30	0.41
Total asset value (ln)	8.28	1.17	7.91	1.07	4.21	0.96	6.04	1.37
Total household savings (ln)	3.79	0.82	3.85	0.96	2.14	0.62	3.34	1.43
Formal credit access	0.39	0.50	0.32	0.47	0.13	0.34	0.25	0.43
Remittance and grants	0.38	0.39	0.53	1.34	0.56	0.41	0.56	0.39

Calculated from field survey data, 2023.

Table 4
Spearman's Rank Correlation Test for the relationship between NTFP income and other income sources.

Pairs of Livelihood Income Sources	Correlation Coefficient (R)	t(N-2)	p < 0.05	Decision
Relative NTFP income compared to:				
Relative crop income	-0.0621	-6.0423	0.0001	Reject H ₀
Relative livestock income	-0.0586	-6.0267	0.0031	Reject H ₀
Relative wage income	-0.2729	-8.0292	0.0280	Reject H ₀
Relative social grants income	0.3155	5.8071	0.0001	Reject H ₀

Note: R = the Spearman's Rank Correlation Coefficient; N = 240; t(N-2) = the degrees of freedom used in the t-test to determine the statistical significance of the correlation; p < 0.05 = the p-value represent the probability that the observed result (or something more extreme) could have occurred by random chance. If p < 0.05, the result is statistically significant. H₀ = the null hypothesis: relative NTFPs income does not affect relative income from a particular source.

contrast, NTFP income shows a weak positive correlation with social grants (R = 0.3155), indicating that households reliant on NTFPs may also receive some external financial support. The weak strength of this relationship suggests that grants or remittances may serve as complementary income sources rather than primary determinants of NTFP engagement.

Overall, the weak but statistically significant correlations indicate that while there are interactions between NTFP utilisation and other income streams, these are not strongly predictive of household livelihood patterns. The results warrant further investigation to explore contextual factors, such as household demographics, gender of household head, and access to productive assets, that may moderate the relationship between NTFP use and other livelihood sources.

These findings provide a nuanced understanding of household livelihood strategies, particularly among female-headed households in rural Limpopo, and underscore the need to consider NTFPs as part of a diversified income portfolio rather than a sole or primary dependency. They also highlight opportunities for targeted interventions that enhance complementary income-generating activities while supporting sustainable NTFP utilisation.

A one-way ANOVA (Appendix A1) showed no significant differences in mean household income across livelihood clusters, F(2, 327) = 0.142, p = 0.867, indicating that NTFP utilisation does not significantly influence total household income. This reinforces the conclusion that NTFPs primarily serve as a supplementary income source rather than a

primary determinant of household earnings. Households balance variations in NTFP utilisation with other income streams, particularly social grants and remittances, which provide stability, while crop and livestock income contribute less to overall livelihoods. Overall, NTFP collection remains a key livelihood strategy for female-headed households in rural Limpopo, complementing other income sources and supporting household resilience. These findings underscore the need for policies that recognize NTFPs as a complementary income source and support their sustainable use to enhance household resilience and livelihood diversification.

5.3. Results of MNL model of the determinants of livelihood strategies

Table 5 presents the multinomial logit (MNL) regression results examining the determinants of livelihood strategy choices among female-headed households, with the highly NTFP-utilising cluster as the reference category. This specification allows interpretation of how household characteristics affect the likelihood of belonging to the low or moderate NTFP-utilising clusters relative to high NTFP utilisation. The likelihood ratio test [$\chi^2(24) = 243.24$; p < 0.001] indicates that the model fits the data significantly better than a null model, and the overall classification accuracy is 78%. Prediction accuracy is highest for the highly NTFP-utilising cluster (85.2%), followed by the moderate (68%) and low (60%) utilisation clusters. These results demonstrate that the MNL model effectively captures household-level factors that differentiate levels of NTFP utilisation.

The result of the MNL further underscore the complex interplay of household assets, social networks, institutional access, and vulnerability in shaping livelihood strategies among female-headed households in rural Limpopo.

The multinomial logit (MNL) results indicate that households headed by older women, those with limited formal education, smaller asset bases, and restricted access to formal credit are more likely to engage intensively in NTFP collection and utilisation relative to crop or livestock production. This pattern reflects a vulnerability-shaped livelihood choice, in which households with fewer agricultural endowments and limited alternative income opportunities allocate a greater share of their livelihood activities to forest-based resources. Age and accumulated traditional knowledge further reinforce higher NTFP utilisation, as older women often possess extensive experience in identifying, harvesting, and processing forest products, while the physical demands of crop and livestock production may be less suitable (Uberhuaga et al., 2012; Dash et al., 2016; FAO, 2011).

Household size also emerged as an important determinant, with larger households exhibiting higher levels of NTFP utilisation. This finding is consistent with the literature showing that forest-based activities offer flexible and labour-divisible opportunities that can be undertaken by multiple household members, including women, children,

Table 5
MNL results of the determinant of the extent of NTFPs utilisation.

	Cluster I (low NTFP utilisation)			Cluster II (moderate NTFP utilisation)		
	Coefficient	z-value	p-value	Coefficient	z-value	p-value
Age	-0.5448** (0.2239)	-2.43	0.015	-1.8859** (0.800)	-2.36	0.018
Marital status	0.0627(0.0995)	0.63	0.529	-0.0064(0.1067)	-0.06	0.951
Household size	0.0274(0.0208)	1.32	0.188	-0.0428** (0.0177)	-2.41	0.016
Educational level	1.5023** (0.6860)	2.19	0.028	1.2352* (0.6675)	1.85	0.065
Group membership	0.0642(0.0784)	0.82	0.358	-0.1423* (0.0808)	-1.76	0.078
Farm size	0.0385*** (0.0112)	3.44	0.001	0.5476*** (0.1620)	3.38	0.001
Access to forest land	-0.0866*** (-0.0279)	3.10	0.002	-0.0826*** (-0.0349)	2.37	0.018
Access to grazing land	0.6917** (0.2858)	2.42	0.016	0.8991(0.7492)	1.20	0.2302
Access to market	-0.0245* (0.0157)	-1.56	0.090	0.2305(0.6065)	0.38	0.784
Value of assets	6.921** (3.445)	2.00	0.046	2.2496** (0.9034)	2.49	0.013
Access to formal credit	2.4707** (0.8490)	2.91	0.004	0.2225** (0.1029)	2.16	0.031
Remittance/social grant	-1.8599* (1.0608)	-1.75	0.080	-1.3604** (0.7029)	-1.94	0.050
Constant	-1.2848 (-1.5417)	1.20	0.319	-1.5887 (-1.0008)	0.63	0.5260

Number of Observation: 240; Log likelihood = -127.48; Pseudo R² = 0.3932;
Likelihood ratio test: $\chi^2(24) = 243.24$; $prob > \chi^2 = 0.000$ Classification accuracy (correctly predicted)
: Overall model = 78%
High NTFP utilisation = 85%; low NTFP utilisation = 60%; Moderate NTFP utilisation = 68%.

Highly NTFP utilising livelihood (Clusters III) is base category. ***, ** and * denote significant levels at 1, 5 and 10%, respectively; Numbers in parentheses are standard errors (SE). Source: Authors' estimation from the survey data.

and older dependents (Babulo et al., 2009; Belcher et al., 2005; Baiyegunhi et al., 2016a). In this context, NTFPs serve as a supplementary and adaptive livelihood activity, enabling households to balance agricultural production, domestic responsibilities, and income-generating efforts.

Education plays a significant role in shaping livelihood allocation. Female heads with higher levels of education are more likely to engage in formal employment or skilled non-farm activities, which is associated with lower levels of NTFP utilisation. In contrast, lower educational attainment is associated with greater engagement in forest-based activities that draw primarily on experiential and traditional knowledge (Hlaing et al., 2017; Baiyegunhi et al., 2016b). This pattern is consistent with the Sustainable Livelihoods Framework (UNDP, 2017), which highlights the role of human capital in influencing both the selection and intensity of livelihood activities.

Social capital, captured through participation in local associations and informal networks, plays a critical role in shaping livelihood strategies. Strong social networks facilitate access to timely information on resource availability and markets, enable labour sharing during harvesting and processing, and support collective resource pooling—mechanisms particularly important for forest-based livelihoods such as non-timber forest product (NTFP) collection. Unlike crop–livestock activities, which depend more on individual land ownership, physical inputs, and formal extension services, forest-based livelihoods are embedded in common-property systems where coordination, trust, and reciprocity are essential (Meinzen-Dick et al., 2014).

Recent studies further show that social networks reduce transaction costs, improve access to informal credit and safety nets, and enhance adaptive capacity in forest-dependent communities, especially for women and female-headed households who often face barriers to formal institutions (Mao et al., 2021; Leal Filho et al., 2022). Engagement in NTFPs strengthens community cohesion and collective action, creating mechanisms for knowledge sharing, mutual support, and risk management that enhance resilience and subjective well-being. These social capital pathways help explain why forest-based livelihoods are more responsive to network effects than crop–livestock activities, which are generally less dependent on collective arrangements.

Access to land and natural resources remains a central factor in livelihood allocation. Households with larger fields or grazing areas tend to diversify into crop and livestock activities, which is associated with lower intensity of NTFP utilisation (Kaskoyo et al., 2017; Chechina et al., 2018; Sekaran et al., 2021). Conversely, secure access to communal

forest land facilitates NTFP utilisation by reducing harvesting costs and labour requirements (Mujawamariya & Karimov, 2014). Even households with substantial agricultural assets often maintain forest-based activities for cultural, medicinal, and subsistence purposes, highlighting the multidimensional role of NTFPs in supporting livelihoods beyond income generation (Shackleton et al., 2024; Gurung et al., 2021).

External financial support, including remittances and social grants, complements forest-based activities. While such support could theoretically reduce household engagement in NTFPs, our findings show that households continue to integrate forest products alongside grants or remittances, reflecting the flexibility and reliability of NTFPs as a supplementary livelihood component (Pandey et al., 2016; Suleiman et al., 2017; Valencia et al., 2019). These results suggest that policy instruments and social safety nets should recognise and support the complementary role of NTFPs within diversified rural livelihood portfolios rather than framing them as substitutes for agriculture. Higher utilisation of NTFPs among asset-constrained households reflects strategic livelihood choices and the buffering function of forest resources, rather than structural disengagement from crop and livestock production.

Household asset endowments—including productive assets and access to credit—shape the intensity and purpose of NTFP utilisation by influencing the range of available livelihood options. Households with greater endowments are better positioned to combine farming, livestock rearing, and non-farm enterprises while using NTFPs opportunistically or seasonally. In contrast, asset-constrained households rely more heavily on NTFPs as a complementary source of income and consumption smoothing, particularly during agricultural lean periods or income shocks (Abdullah et al., 2016; Vasco et al., 2020; Wale et al., 2022). This distinction underscores the need for integrated interventions that expand asset access while sustaining forest-based safety nets.

Gendered roles and cultural norms further shape patterns of NTFP utilisation, particularly among female-headed households. Women are socially and culturally responsible for collecting fuelwood, wild foods, and medicinal plants—activities that align with their domestic roles and allow for flexible time allocation alongside caregiving responsibilities (Shackleton & Pandey, 2014; Jagger et al., 2022). As a result, NTFPs serve not only as an income source but also as culturally embedded resources that women can mobilise quickly to meet household needs during periods of financial stress.

Beyond their economic value, NTFPs hold social and cultural significance in forest-fringe communities, contributing to food traditions, health practices, and the transmission of indigenous knowledge (Museumwa et al., 2015; He & Gou, 2021; Derebe & Alemu, 2023). These gendered and cultural dimensions help explain why NTFP utilisation remains high among female-headed households even when returns are modest, reinforcing the argument that NTFPs function as complementary livelihood strategies rather than substitutes for agriculture.

Although this study does not explicitly model natural capital or ecological conditions as determinants of NTFP utilisation, the findings can be situated within the natural capital dimension of the Sustainable Livelihoods Framework. Existing ecological and forest-based livelihood studies in the region emphasise that the sustainability of NTFP-based strategies depends on forest condition, species availability, and local management institutions (Shackleton et al., 2011; Leal Filho et al., 2022). From this perspective, livelihood benefits derived from NTFPs must be considered alongside sustainable resource use and conservation objectives.

Consistent with this broader literature, policy and extension interventions that support female-headed households' engagement in NTFPs should be complemented by measures that promote sustainable harvesting practices, agroforestry integration, and community-based forest management. These considerations are not direct findings of the present study but represent important contextual insights that align with regional ecological research on NTFPs. Overall, the results demonstrate that NTFPs function as a complementary and adaptive component of rural livelihood portfolios for vulnerable female-headed households, underscoring the need for multidimensional policies that integrate asset-building, gender-responsive support, market access, and sustainable natural resource governance.

6. Limitations and future study

This study is subject to several limitations. Its exclusive focus on female-headed households limits generalisability to the wider rural population, while reliance on a one-time twelve-month recall survey may introduce recall bias and result in conservative income estimates, particularly for seasonal activities. In addition, the analysis does not distinguish between NTFP and crop outputs consumed within households and those sold in markets, constraining interpretation of market engagement versus subsistence use. Despite these limitations, the focus on relative income patterns across households and sites allows for meaningful comparative insights, as any systematic measurement errors are likely consistent. Future research should incorporate comparative household groups, more detailed measures of production and market participation, and extend the analysis to non-income dimensions such as livelihood stability and resilience. Integrating ecological and natural capital indicators alongside institutional and infrastructural factors would further strengthen understanding of the determinants and outcomes of NTFP utilisation.

7. Conclusions

This study demonstrates that non-timber forest products (NTFPs) constitute an important livelihood component for economically vulnerable female-headed households in rural Limpopo. NTFP utilisation is higher among households headed by older women with limited education, smaller productive asset bases, and restricted access to credit. Larger household sizes and strong social networks are also associated with higher levels of forest resource utilisation, reflecting the role of NTFPs as coping and adaptive strategies. In contrast, households with greater farmland, grazing assets, and improved market access exhibit lower levels of NTFP utilisation, consistent with stronger engagement in crop and livestock activities. Despite these differences, comparable total household incomes across varying levels of NTFP utilisation indicate that forest-based resources function as a mainstream

and complementary element of rural livelihood portfolios rather than a marginal safety net.

Overall, the findings highlight how household vulnerability, asset endowments, and social capital interact to shape livelihood strategies among female-headed households. Secure access to forest resources, combined with supportive social networks and supplementary income sources such as social grants or remittances, enables households to integrate NTFPs into diversified livelihood strategies that enhance resilience. These insights underscore the importance of policy and institutional arrangements that recognise the complementary role of NTFPs and strengthen existing livelihood capacities without overstating utilisation or substitutability.

8. Policy implications and recommendations

This study examined the determinants of non-timber forest product (NTFP) utilisation among rural households, with particular attention to gendered household structures and social capital. Although the analysis does not assess policy targeting mechanisms, infrastructure provision, ecological enforcement, or social protection impacts, the findings offer policy-relevant insights for rural development and biodiversity economy initiatives in South Africa.

Consistent with the Sustainable Livelihoods Framework, the results indicate that NTFPs function as a complementary component of diversified livelihood portfolios rather than as a marginal safety net or a substitute for agriculture. Higher levels of utilisation among female-headed and asset-constrained households reflect constrained opportunity sets and the buffering role of forest-based resources, rather than structural dependence. These insights align with the objectives of South Africa's National Biodiversity Economy Strategy (NBES) (DEA, 2015) and its revised draft, which emphasise inclusive and gender-responsive participation in biodiversity-based livelihoods.

• Institutional and Policy-Level Implications

Rather than advocating new standalone interventions, the findings highlight the importance of strengthening the integration of NTFP-based livelihood strategies within existing biodiversity economy, rural development, and gender-support frameworks. National and provincial departments responsible for environment, agriculture, and rural development—working in collaboration with local municipalities, traditional authorities, and community-based organisations—can leverage existing policy instruments to better recognise and support women's engagement in NTFP activities.

While this study does not directly assess credit access, social grants, infrastructure, or market facilities, the observed association between asset constraints and higher NTFP utilisation underscores the relevance of aligning ongoing asset-building, enterprise support, and livelihood programmes with biodiversity economy initiatives. Such alignment can strengthen livelihood resilience without overstating causal relationships beyond the scope of the analysis.

• Community-Level Implications

At the community level, the study underscores the central role of social capital in shaping NTFP utilisation, particularly among female-headed households. Strong local networks facilitate information exchange, labour coordination, and mutual support—mechanisms that are especially important in forest-based livelihood activities.

Building on these findings, local women's associations, savings groups, producer groups, and other community-based organisations can serve as platforms for collective action related to NTFP engagement. Support from extension services, non-governmental organisations, and municipal development programmes can help strengthen these existing networks, enabling improved coordination, reduced transaction costs, and more stable livelihood outcomes, without implying enforcement or

conservation roles not examined in this study.

• Household-Level Implications

At the household level, the results highlight social networks as a key resilience-enhancing asset for female-headed households engaged in NTFP activities. Initiatives that foster peer learning, informal knowledge sharing, and collective labour arrangements—implemented through existing community structures such as local women’s associations, savings groups, producer groups, and community-based organisations, with support from municipalities, extension services, and NGOs—can strengthen mutual support and adaptive capacity. These measures build directly on observed social structures and livelihood strategies, without introducing new activities or assumptions beyond the scope of the study.

Overall, these policy recommendations are intended to situate the study’s findings within existing institutional and policy arrangements rather than to prescribe specific interventions. By adopting a multi-level perspective, they reflect the nuanced livelihood realities documented in the study areas and support inclusive rural development while remaining consistent with the evidence generated by the analysis.

CRedit authorship contribution statement

Lloyd J.S. Baiyegunhi: Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Project administration,

Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Linley Chiwona-Karlton:** Writing – review & editing, Resources, Project administration, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was conducted under the SASUF Short-term Collaborative Projects programme, a multidisciplinary initiative between South African and Swedish universities. We thank the community participants from six villages for their contributions and appreciate the anonymous reviewers for their valuable feedback.

Consent to participate

All human participants provided their informed consent before participating in this study. Written consent was obtained from each participant, and the study adhered to ethical guidelines.

Appendix A1. One-way ANOVA (for average household income)

Source of variation	Sum of square	Df	MS	F	p-value	Prob > F
Between clusters	126139581.60	2	63069790.80	0.142	0.867	<0.05
Within clusters	105109963627.1	327	443501956.23			
Total	105236103208.65	329				

Calculated from field survey data, 2023.

Data availability

Data will be made available on request.

References

- Abdullah, A. N. M., Stacey, N., Garnett, S. T., & Myers, B. (2016). Economic dependence on mangrove forest resources for livelihoods in the Sundarbans Bangladesh. *Forest Policy and Economics*, 64, 15–24.
- Angelsen, A., & Wunder, S. (2003). *Exploring the forest–poverty link: Key concepts, issues and research implications* (Occasional Paper No. 40). Center for International Forestry Research (CIFOR).
- Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., Börner, J., Smith-Hall, C., & Wunder, S. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development*, 64(S1), S12–S28.
- Ao, G., Xu, Q., Liu, Q., Xiong, L., Wang, F., & Wu, W. (2021). The influence of nontimber forest products development on the economic - ecological coordination – evidence from Lin’an District, Zhejiang Province, China. *Sustainability*, 13(2), 904.
- Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., & Mathijs, E. (2009). The economic contribution of forest resource use to rural livelihoods in Tigray, Northern Ethiopia. *Forest Policy and Economics*, 11(2), 109–117.
- Baiyegunhi, L. J. S., & Oppong, B. B. (2016). Commercialisation of mopane worms (*Imbrasia belina*) in rural households in Limpopo Province, South Africa. *Forest Policy and Economics*, 62, 141–148.
- Baiyegunhi, L. J. S., Oppong, B. B., & Senyolo, G. M. (2016a). Mopane worms (*Imbrasia belina*) and rural household food security in the Limpopo Province, South Africa. *Food Security*, 8(1), 153–165.
- Baiyegunhi, L. J. S., Oppong, B. B., & Senyolo, G. M. (2016b). Socio-economic factors influencing mopane worm (*Imbrasia belina*) harvesting in Limpopo Province, South Africa. *Journal of Forestry Research*, 27(2), 443–452.
- Bekele, S., & Rajan, D. S. (2017). Rural household livelihood strategies choices: The case of Humbo Woreda, Wolaita Zone, Southern Nationalities and Peoples Regional State Ethiopia. *Journal of Economics and Sustainable Development*, 8(3), 69–85.
- Belcher, B., Ruiz Pérez, M., & Achdiawan, R. (2005). Global patterns and trends in the use and management of commercial NTFPs: Implications for livelihoods and conservation. *World Development*, 33(9), 1435–1452.
- Burchi, F., & De Muro, P. (2016). From food availability to nutritional capabilities: Advancing food security analysis. *Food Policy*, 60, 10–19.
- Chambers, R., and Conway, G. R. 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. Institute of Development Studies (IDS) Discussion Paper 296. Brighton, UK: Institute of Development Studies.
- Chechina, M., Neveux, Y., Parkins, J. R., & Hamann, A. (2018). Balancing conservation and livelihoods: A study of forest-dependent communities in the Philippines. *Conservation and Society*, 16, 420–430.
- Cochran, W. G. (2007). *Sampling technique*. Hoboken: John Wiley & Sons.
- Dalu, M. T. B., Gunter, A. W., Makatu, M., Dowo, G. M., Dondofema, F., & Dalu, T. (2021). Contribution of natural forest products to rural livelihoods at Mavunde and Sambandou villages, Vhembe Biosphere Reserve, South Africa. *Sustainability*, 13, 4252.
- Dash, M., Behera, B., & Rahut, D. B. (2016). Determinants of household collection of non-timber forest products (NTFPs) and alternative livelihood activities in Simlipal Tiger Reserve, India. *Forest Policy and Economics*, 73, 215–228.
- Department of Environmental Affairs. (DEA) (2015). *National Biodiversity Economy Strategy (NBES)*. Government of South Africa. Retrieved from <https://www.dfe.gov.za/sites/default/files/reports/nationalbiodiversityeconomystrategy.pdf>. (assessed 22/01/2026).
- Derebe, B., & Alemu, A. (2023). Non-timber forest product types and its income contribution to rural households in the Horn of Africa: A systematic review. *Forest Science and Technology*, 19(3), 210–220.
- Ellis, F. (1998). Household strategies and rural livelihood diversification. *The Journal of Development Studies*, 35(1), 1–38.
- FAO. (2011). The State of Food and Agriculture: Women in Agriculture - Closing the Gender Gap for Development. *Food and Agriculture Organization of the United Nations*.
- Greene, W. (2003). *Econometric Analysis* (5th ed.). Upper Saddle River, New Jersey: Prentice Hall.
- Gurung, L. J., Miller, K. K., Venn, S., & Bryan, B. A. (2021). Contributions of non-timber forest products to people in mountain ecosystems and impacts of recent climate change. *Ecosystem and People*, 17, 447–463.

- He, J., & Guo, N. (2021). Culture and parks: Incorporating cultural ecosystem services into conservation in the Tibetan region of Southwest China. *Ecology and Society*, 26(3), 12.
- Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). *Applied choice analysis: A primer*. Cambridge University Press.
- Heubach, K., Wittig, R., Nuppenau, E. A., & Hahn, K. (2011). The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural West African communities: A case study from northern Benin. *Ecological Economics*, 70(11), 1991–2001.
- Hlaing, Z. C., Kamiyama, C., & Saito, O. (2017). Interaction between rural people's basic needs and forest products: A case study of the Katha District of Myanmar. *International Journal of Forestry Research*, 2017(1), 1–18. Article ID 2105012.
- Jagger, P., Cheek, J. Z., Miller, D., Ryan, C., Shyamsundar, P., & Sills, E. (2022). The role of forests and trees in poverty dynamics. *Forest Policy and Economics*, 140, Article 102750.
- Kaskoyo, H., Mohammed, A., & Inoue, M. (2017). Impact of community forest program in protection forest on livelihood outcomes: A case study of Lampung Province, Indonesia. *Journal of Sustainable Forestry*, 36, 250–263.
- Leal Filho, W., Barbir, J., Gwenzi, J., Ayal, D., Simpson, N. P., Adeleke, L., Tilahun, B., Chirisa, I., Gbedemah, S. F., & Nzengya, D. M. (2022). The role of indigenous knowledge in climate change adaptation in Africa. *Environmental Science and Policy*, 136, 250–260.
- Mao, G., Drury, J., Fernandes-Jesus, M., & Ntontis, E. (2021). How participation in COVID-19 mutual aid groups affects subjective well-being and how political identity moderates these effects. *Analyses of Social Issues and Public Policy*, 21, 1082–1112.
- Meinzen-Dick, R., Quisumbing, A., Behrman, J., & Biermayr-Jenzano, P. (2014). Engendering Agricultural Research, Development, and Extension. *International Food Policy Research Institute (IFPRI)*.
- Mokati, J. T. W., Ncube, A., & Bahta, Y. T. (2024). Is it really feminization of agriculture? The issue of household food security in Lesotho's southern Lowland District. *Journal of Asian and African Studies*, 59(2), 411–424.
- Mugari, E., & Masundire, H. (2022). Consistent changes in land-use/land-cover in semi-arid areas: Implications on ecosystem service delivery and adaptation in the Limpopo Basin, Botswana. *Land*, 1, 1–20.
- Mugido, W., & Shackleton, C. A. (2019). The contribution of NTFPs to rural livelihoods in different agro-ecological zones of South Africa. *Forest Policy and Economics*, 109, Article 101983.
- Mujawamariya, G., & Karimov, A. A. (2014). Importance of socioeconomic factors in the collection of NTFPs: The case of gum-arabic in Kenya. *Forest Policy and Economics*, 42, 24–29.
- Mulusew, A., & Mingyong, H. (2023). An empirical investigation of the dynamic linkages of land access and food security: Evidence from Ethiopia using system GMM approach. *Journal of Agriculture and Food Research*, 11, 1–9.
- Municipalities of South Africa, 2024. Available at <https://municipalities.co.za/>. [Accessed on 12/07/2024].
- Musemwa, L., Muchenje, V., Mushunje, A., Aghdasi, F., & Zhou, L. (2015). Household food insecurity in the poorest province of South Africa: Level, causes and coping strategies. *Food Security*, 7, 647–655.
- Nwosu, C. O., & Ndinda, C. (2018). Gender-based household compositional changes and implications for poverty in South Africa. *Journal of International Women's Studies*, 9(5), 82–94.
- Opiyo, S. B., Opinde, G., & Letema, S. (2023). A perspective of sustainable livelihood framework in analysis of sustainability of rural community livelihoods: Evidence from Migori River watershed in Kenya. *International Journal of River Basin Management*, 1–17.
- Pandey, A. K., Tripathi, Y. C., & Kumar, A. (2016). Non-timber forest products (NTFPs) for sustained livelihood: Challenges and strategies. *Research Journal of Forestry*, 10(1), 1–7.
- Peters, C. M., Gentry, A. H., & Mendelson, R. O. (1989). Valuation of an amazonian rainforest. *Nature*, 339, 655–656.
- Sekaran, U., Lai, L., Ussiri, D. A. N., Kumar, S., & Clay, S. (2021). Role of integrated crop–livestock systems in improving agricultural production and addressing food security: A review. *Journal of Agriculture and Food Research*, 5, 100190.
- Shackleton, C. M., & Shackleton, S. E. (2004). The importance of non-timber forest products in rural livelihood security and as safety nets: A review of evidence from South Africa. *South African Journal of Science*, 100(11–12), 658–664.
- Shackleton, C. M., & de Vos, A. (2022). How many people globally actually use non-timber forest products? *Forest Policy and Economics*, 135, Article 102659.
- Shackleton, S. E., & Luckert, M. (2015). Changing livelihoods and landscapes in the rural Eastern Cape, South Africa: Past influences and future trajectories. *Land*, 4, 1060–1089.
- Shackleton, C. M., & Pandey, A. K. (2014). Positioning non-timber forest products on the development agenda. *Forest Policy and Economics*, 38, 1–7.
- Shackleton, S., Paumgarten, F., Kassa, H., Husselman, M., & Zida, M. (2011). Opportunities for enhancing poor women's socioeconomic empowerment in the value chains of three African non-timber forest products (NTFPs). *International Forestry Review*, 13(2), 136–151.
- Shackleton, C. M., Garekai, H., Sardeshpande, M., Sanni, G. S., & Twine, W. C. (2024). Non-timber forest products as poverty traps: Fact or fiction? *Forest Policy and Economics*, 158, Article 103114.
- Sharaunga, S., Mudhara, M., & Bogale, A. (2016). Effects of women empowerment on household food security in rural KwaZulu-Natal province. *Development Policy Review*, 34(2), 223–252.
- StatsSA. 2019. General Household Survey. Statistics South Africa. Available online at: <https://www.statssa.gov.za/publications/P0318/P03182019.pdf>. (assessed 23/06/2023).
- Suleiman, M.S., Wasonga, V.O., Mbau, J.S., Suleiman, A. and Elhadi, Y.A. 2017. Non-timber forest products and their contribution to household's income around Falgore Game Reserve in Kano, Nigeria. *Ecological Process* (2017), 6 (23).
- Train, K. E. (2003). *Discrete Choice Methods with Simulations*. Berkley, USA: Springer.
- Uberhuaga, P., Smith-Hall, C., & Helles, F. (2012). Forest income and dependency in lowland Bolivia. *Environment, Development and Sustainability*, 14, 3–23.
- United Nations Development Programme. (2017). *Guidance note: Application of the sustainable livelihoods' framework in development projects* (pp. 1–21). United Nations Development Programme. Panama.
- Valencia, V., Wittman, H., & Blesh, J. (2019). Structuring markets for resilient farming systems. *Agronomy for Sustainable Development*, 39(25), 1–14.
- Vasco, C., Valdiviezo, R., Hernández, H., Tafur, V., Eche, D., & Jácome, E. (2020). Off-farm employment, forest clearing and natural resource use: Evidence from the Ecuadorian Amazon. *Sustainability*, 12, 4515.
- Wale, E., Nkoana, M. A., & Mkuna, E. (2022). Determinants of rural household livelihood dependence on non-timber forest products: A case study from Inanda Community, KwaZulu-Natal, South Africa. *Frontiers in Forests and Global Change*, 5, Article 788815.
- Wollenberg, E. (2000). Methods for estimating forest income and their challenges. *Society and Natural Resources*, 13, 777–795.
- Wunder, S. (2001). Poverty alleviation and tropical forests: What scope for synergies? *World Development*, 29(11), 1817–1833.
- Wunder, S., Borner, J., Shively, G., & Wyman, M. (2014). Safety nets, gap filling and forests: A global comparative perspective. *World Development*, 64(Supplement 1), S29–S42.