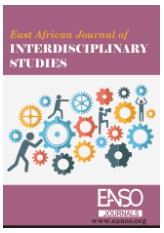

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Original Article

Determinants and Outcomes of Livelihood Diversification among Small-scale Tree Growers in Kilolo District, Tanzania

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Livelihood Diversification Strategies, Herfindahl-Hirschman Index, Multinomial Logistic Regression, Small-scale Tree Growers, Sustainable Livelihood Framework.

ABSTRACT

Small-scale tree growers (SSTGs) are critical in sustainably managing forests and rural livelihoods in Tanzania. Grounded in the Sustainable Livelihood Framework, this study characterises determinants and outcomes of livelihood diversifications among SSTGs in the Kilolo District of Tanzania. Data were collected cross-sectionally using questionnaire surveys administered to 101 households, key informant interviews (KII), and focus groups. T-test analysis reveals that socio-economic characteristics significantly influence the diversification of livelihood strategies. The Herfindahl-Hirschman Index of 0.346 indicates considerable diversification in sources of income. The multinomial logistic regression model classifies 97% of all cases, indicating an excellent fit to the data. The model analysis identifies total mean annual income, entrepreneurship, and Tree Grower Associations (TGAs) membership to be determinants of livelihood diversification among SSTGs. The study recommends that policy, institutional, market, and credit access barriers be identified and addressed to enable SSTGs to improve their highly diversified livelihood status.

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INTRODUCTION

Smallholders are globally becoming important producers of timber, pulpwood, and environmental services (Arvola *et al.*, 2019), as revealed by various case studies conducted in, for example, Nepal, India, the Philippines, Vietnam, and the Solomon Islands (Bertomeu, 2006; Dubey, 2008; Meyfroidt & Lambin, 2008; Regmi & Garforth, 2010; Ashraf *et al*., 2015; Versteeg *et al.*, 2017). Forests have been frequently described as providing resources that alleviate poverty for millions of rural communities through income generation in developing countries (Rasmussen *et al*., 2017; Newton *et al*., 2016), such as Tanzania.

Smallholder forest farmers/small-scale tree growers are engaged with other livelihood activities alongside tree or timber sales around the globe (Rasmussen *et al.*, 2017; Hintz *et al.*, 2021). They are also engaged in agroforestry and entrepreneurship to nourish their income (Rasmussen *et al.*, 2017). There is a co-relationship between the income that farmers accrue and the choice of activities that will improve their well-being and livelihood (Yizengaw *et al.*, 2015). In this case, income acts as a ground for determining livelihood activities (Rakodi, 2014; Hua *et al*., 2017).

In Tanzania, small-scale tree growers contribute significantly to both forest conservation and rural livelihoods (Bardsley *et al*., 2022). Forest dependence in Kilolo District is high due to limited alternative income sources that make livelihood diversification strategies necessary to reduce climatic and economic vulnerabilities (Jalang'o *et al.*, 2019; Angelsen & Wunder, 2003). Livelihood diversification has proven to be effective against vulnerabilities such as floods and droughts that normally affect river irrigation systems and rain-fed agriculture (Nyanga *et al.*, 2020; URT, 2022; Nyombi & Chegere, 2023). Livelihood diversification can be determined by the Herfindahl-Hirschman Index (HHI). HHI greater than 0.2 indicates a high diversification of livelihood strategies (Dereje *et al*., 2024). Regardless of their importance, SSTGs often face numerous challenges related to education, financial assets, and access to institutional support, hindering sustainable livelihood development (Hingi, 2018).

The integration of smallholder forest farmers into broader value chains is critical for enhancing their livelihood and ensuring sustainable forestry practices (Flanagan *et al*., 2020). Statistics of small-scale tree-growing activities rarely exist, and thus, the present and future contribution of smallholders to wood production is difficult to assess, while 1.5 billion smallholder farmers depend on forest and farm landscapes for their livelihood globally (Mayers *et al*., 2016).

Hence, understanding the socio-economic characteristics and livelihood diversification practices of SSTGs is vital in designing interventions that build resilience and improve well-being. This study aims to characterise the socio-economic profile of SSTGs and assess their main livelihood activities to diversify their income. Specifically, this study examines the importance of socio-economic and demographic variables; and diversification in on-farm and off-farm activities and their subsequent impact on the livelihood.

Conceptual Framework

The present study is grounded in the Sustainable Livelihood Framework (SLF), which

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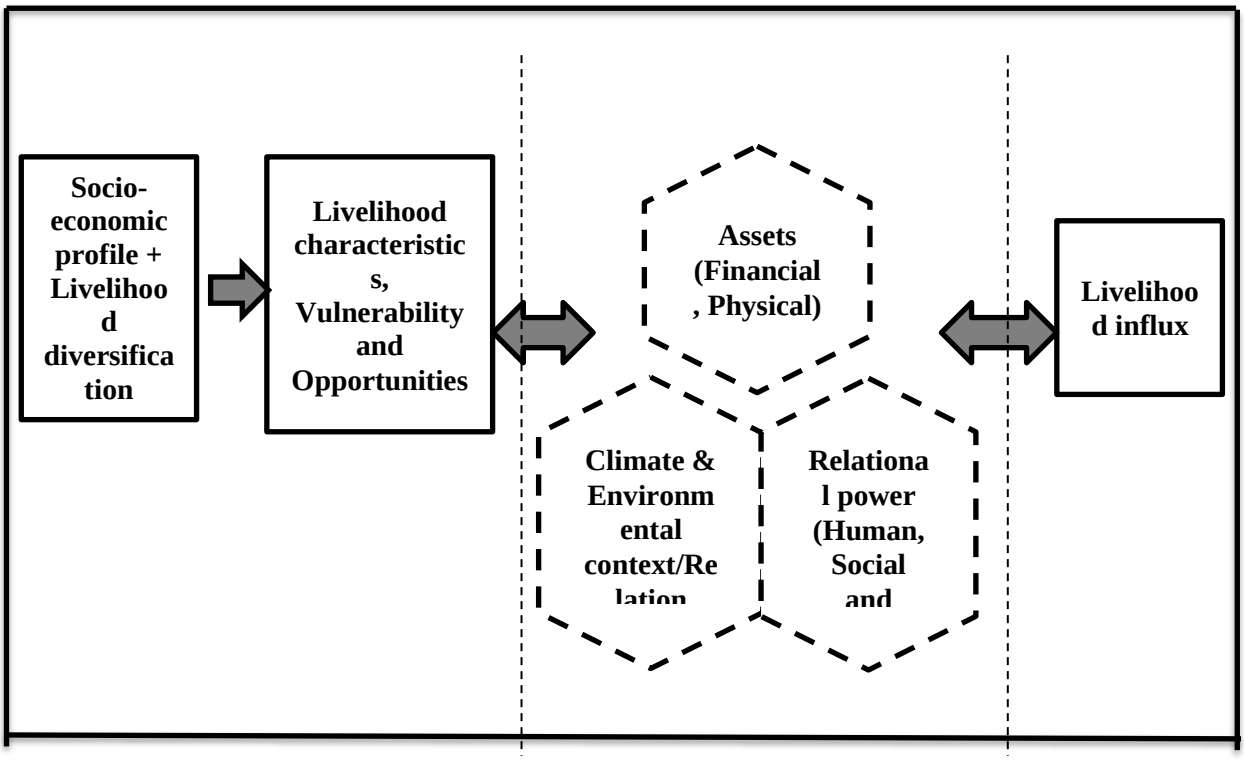
conceptualises the interaction of climate and environment, relational power, climatic factors influencing vulnerability, opportunities, livelihood characteristics, assets, and adaptive capacity (Natarajan *et al.*, 2022; Dabla-Norris, 2015). Smallholder tree growers access these factors differently, affecting their ability to cope with economic and environmental stressors (Barbier, 2010). Physical and financial assets support investments in productive assets such as farming inputs, businesses, entrepreneurship, and land. Relational power, such as education, skills, and membership in Tree Growers Associations (TGAs), enables SSTGs to adopt new livelihood strategies, knowledge sharing, and collective action. This framework aims to analyse how these capitals influence livelihood diversification in the Kilolo District context (Figure 1).

Figure 1: Study Conceptual Framework (Source: Modified 21st Century SLF (Natarajan *et al*., 2022)



MATERIALS AND METHODS

Study Area Settings

Kilolo District is located in the Iringa Region of Tanzania, with 9,243 km². Bordered to the north is Morogoro Region, the west is bordered by Iringa Rural District, and the south is bordered by Mufindi District (Figure 2). Altitude ranges between 900 to 2700 metres above sea level (Anyango *et al.* 2019). There are 3 administrative divisions in the Kilolo district, namely Mazombe, Mahenge, and Kilolo; the Kilolo division covers more than half of the district. In these divisions, there are 106 villages, 24 wards, and 555 hamlets with roughly 46,002 households (NBS, 2022).

Population, People and Livelihoods

Kilolo Division covers more than half of Kilolo District and is more densely populated compared to Mazombe and Mahenge (Anyango *et al.* 2019). Also, recently, there have been five TGAs with more than 80 tree farmers in Lulanzi, Bomalang'ombe, Lyamko, Ng'ang'ange, and Kidabaga villages of Kilolo District (URT, 2022).

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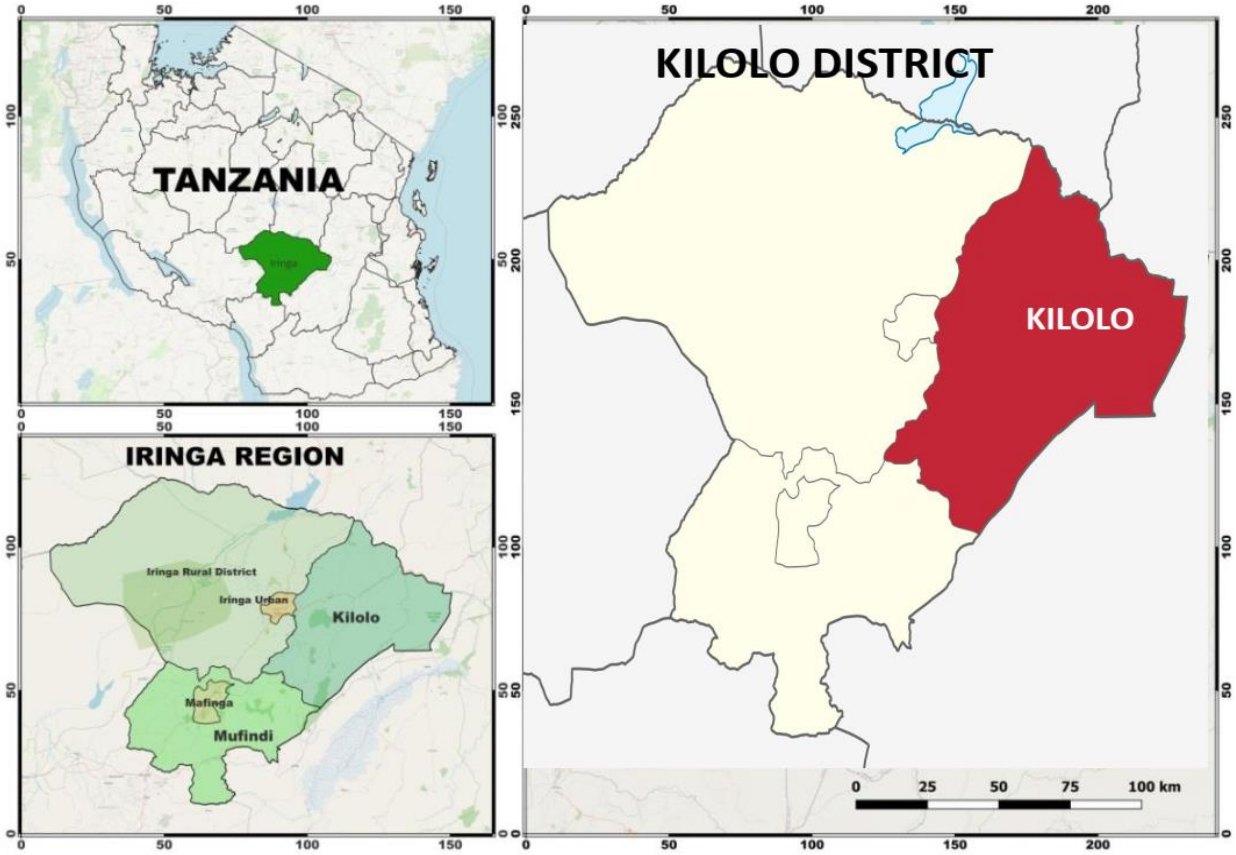
For this reason, three study villages were selected from this division. The population of Kilolo district is 263,559 with a density of 28.51/km², lower than 73.1/km² of Tanzania (NBS, 2022). The district has an annual average population increase of 1.9% compared to 3% in Tanzania by 2022 (NBS, 2022). In Kilolo District, New Forest Company and Panda Miti Kibiashara (PFP2) are among the important partners working with farmers to promote landscape restoration through tree planting and the establishment of TGAs (NBS, 2022; PFP2, 2021).

The purpose of selecting Kilolo District as a study area is: i) the district has a good number of SSTGs and ii) livelihood diversification strategies.

Figure 2: GIS-designed Kilolo District Landscape Map



Source: *Author design, 2023*

Research Design, Sample Size Determination, and Data Collection Methods

This study used a cross-sectional research design (Bryman, 2016) because it was conducted once. Multistage purposive sampling was used in the selection of districts and villages (Shively & Luckert, 2012), while households were selected randomly (Tomas & Gile, 2011).

Three villages (Bomalang'ombe, Kidabaga, and Lulanzi) were selected randomly. These villages had a total of 9,354 households (NBS, 2022). The study engaged 101 respondents (78 males, 23 females) who are SSTGs. The minimum sample size for the household survey within the study villages was statistically obtained using the Yamane (1967) formula (equation 1). The formula minimizes sampling bias and error because it draws a representative sample from the target population (Tomas & Gile, 2011). The sample size should have been 100 rather than 101. This is because random

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sampling can result in more recruitment (Tomas & Gile, 2011).

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

…… (1)

Whereby;

N = Total population size and e = Allowable error (10%)

$$n = \frac{9354}{1+9354\times(0.1)^2} = 100$$

……(2)

Household Surveys

Both open-ended and closed-ended questions were used to gather socio-economic profiles and livelihood diversification strategies from 101 SSTGs in the study area.

Key Informant Interviews and Focus Group Discussions

Village executive officers (VEO), village chairmen, and forest officials were all part of the key informant interviews (KII). In addition, 28 people participated in focus group discussions (FGDs) in the three (3) chosen villages (Kidabaga = 10, Bomalang'ombe = 10, and Lulanzi = 8) to evaluate the impact of socio-economic profiles and livelihood diversification strategies on SSTG's welfare in Kilolo District. Among other issues discussed during the FGD and KII were the demographic factors affecting livelihood diversification, asset capital, trust and TGA performance, income-generating activities, activities associated with membership in TGAs, and the shocks/challenges that SSTGs face in connection with livelihood activities. These key questions were asked to capture information regarding the socio-economic characterisation and livelihood diversification of SSTGs in the study area.

Data Analysis Methods and Interpretation

The Herfindahl-Hirschman Index (HHI), descriptive and multinomial logistic regression were used for analysing data collected from the households. Variables used in the model were tested using independent sample t-tests. The HHI was used to analyse the livelihood diversification status among SSTGs in the study area. Multinomial logistic regression was used to identify the factors that determine the choice of livelihood strategies of SSTGs. The software used to perform the analysis was SPSS version 26.

Herfindahl-Hirschman Index

There are several predictors and indices that are used to measure livelihood diversification, such as the Simpson index, modified entropy index, ogive index, Herfindahl-Hirschman index, and composite entropy index (Shiyani & Pandya, 1998). HHI was used to analyse the livelihood diversification of SSTGs because of its wider applicability. HHI is the inverse of Income Diversification (ID) (Idowu, 2011; Sharma & Singh, 2019; Roy & Basu, 2020).

$$\text{ID} = \frac{1}{\sum Si^2} \quad (3)$$

Where *ID* = income diversification level and *Si* is the income share source *i* in the household's total income.

$$HHI = \sum Si^2 = S1^2 + S2^2 + S3^2 + \ldots\ldots.., N \quad (4)$$

$$\text{Si} = \frac{\text{Xi}}{X} \quad (5)$$

$$\text{X} = \sum \text{Xi} \quad (6)$$

Where *Xi* = total income from source *i*. *X* = total income of households from all sources. *N* is the income source, and the HHI ranges from 1/*N* to 1. A value of HII of 0.15 to 0.25 indicates moderate concentration, while values above 0.25 imply high concentration (Citation 23). If the level of ID = 1, it means no diversification; 1<ID<2 indicates moderate diversification and ID≥2 indicates high

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diversification. Hence, the level of diversification and HHI determined the diversification status.

Variable Selection

Variables that have a chance to influence the choice of livelihood diversification strategies by SSTGs in Kilolo District are shown in Appendix A. It shows the variable type, whether categorical or continuous, the definition in the data set, and the expected outcome of the analysis. Multicollinearity diagnosis was conducted (Appendix B) in which variables with higher multicollinearity (VIF≥10) were omitted from the model and descriptive analysis.

Multinomial Logistic Regression (MLR)

Defining MLR parameters

In multinomial logistic regression, slopes and odds ratios represent the "partial" prediction of the dependent variable. A slope of a given predictor represents the changes in the logit of the Y variable for each unit change in the X variable, holding the effect of other variables constant.

Tests of whether a set of variables for a significant number of variables for multiple logistic regression were conducted using a likelihood ratio test. A comparison was made on the deviance of the model with several predictors compared to a model without any predictors (null model), which is a model with just an intercept in multinomial logistic regression.

The estimated value of the goodness-of-fit test (G^2) is distributed as a chi-squared value with *df* equal to the number of predictors added to the model in the *likelihood ratio test* (LR test). The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Furthermore, to determine livelihood diversification status, a multinomial logistic regression model was used. The MLR was selected because it shows a superior ability to predict livelihood diversification among households and draws up the differences in livelihood diversification among households (Admasu *et al.,* 2022). Also, MLR was selected because the dependent variable has more than two choices (polychotomous), unlike binary logistic regression, where the dependent variable has two choices.

To test the goodness of fit of the model, Pearson and deviance were used; pseudo R-squared, like the Cox & Snell, Nagelkerke, and McFadden, and classification percent were used to test for model performance using multinomial logistic regression analysis.

In this study, the multinomial logistic regression analysis was performed to reveal the determinants and outcomes of livelihood diversification among SSTGs in the study area. This regression model was used because of the multiple categories of the dependent variable that had three responses: "Highly diversified" set as 2, "Moderately diversified" set as 1, and "No diversification" set as 0. Predictor variables for this model were selected based on their significance at $p<0.05$ and the multinomial logistic regression assumptions.

The assumption is that, at a given time, SSTGs have to choose whether the income diversification strategies affect the livelihood of smallholder forest farmers or not. For the *i*th respondent faced with *J* For choices of the livelihood diversification strategies, the utility choice equation is expressed as:

$$\mathrm{Uij} = \mathrm{Z}ij\beta + \varepsilon ij \qquad (7)$$

We assume that the respondent i choose in J in particular, then the Uij is the maximum among the other utilities farmers have in the study area. This makes a basis for a statistical model derivation by the probability that:

$$Prob\ (Uij > Uik) for\ all\ other\ k \neq J \quad \ldots\ldots.(8)$$

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Where Uij is the utility of the ith respondent from the livelihood diversification strategy, J and Uik is the utility of the ith respondent to the livelihood diversification strategy, k. The *i*th farmer had to choose what would maximize their utilities based on their observations among the discrete effects of membership J on the livelihood, which can be expressed as:

$$Maxj = E(Uij) = fj(Xi) + \varepsilon ij; j = 0 \ldots . J \quad (9)$$

For some J categories, let the ith A farmer chooses to maximise utility by choosing jth livelihood diversification strategy and 0 otherwise. The probability that the household with characteristics "x" chooses the livelihood diversification strategy J, Pij is expressed in this model:

$$Pij = \frac{\exp(Xi\beta j)}{\sum_{j=0}^{J} exp(Xi\beta j)}, J = (0 \ldots 3) \quad (10)$$

The probability requirement is that the sum of all the probabilities must be equal to 1. Hence, the $\sum_{j=0}^{J} Pij = 1$ for any ith respondent falling into jth choice among the discrete options. Where Pij is the probability of ith respondent choosing the jth livelihood diversification strategy on the SSTG's livelihoods. Xi = predictor variables of the response probabilities. βj = covariate and factor effects specific to the jth response category, with the last category (no diversification) set as a reference category.

To remove indeterminacy in the model, we assume that $\beta 1 = 0$. Hence, the $\exp(Xi\beta 1) = 1$, giving the implication that equation (5) is equal to:

$$\text{Prob}\left(yi = \frac{j}{Xi}\right) = Pij = Pij = \frac{\exp(Xi\beta j)}{1 + \sum_{j=0}^{J} exp(Xi\beta j)}, for\ j = (0, \ldots J) and$$

$$\text{Prob}\left(yi = \frac{1}{Xi}\right) = Pi1 = \frac{1}{1 + \sum_{j=0}^{J} exp(Xi\beta j)}, \quad (11)$$

Where y is a polytomous outcome variable coded $0 \ldots J$. According to the condition of probability to sum to 1, then, $Pi1 = 1 - \sum Pij$. Hence, we can now compute J log-odds ratios by using this expression:

$$\ln\left[\frac{Pij}{PiJ}\right] = x'(\beta j - \beta j) = x'\beta j, if\ J = 0 \quad (12)$$

RESULTS

Descriptive analytical results show that SSTGs engage in various livelihood diversification activities, including on-farm and off-farm, in the study area (Table 1). Crop cultivation had a higher percentage compared to other activities. This implies food security for SSTGs in the study area.

Table 1: Livelihood Strategies by Percentage (n=101)

SN	Strategies	Percentage (%)
	Item 213 - Business	38.6
	Item 214 – Livestock keeping	80.2
	Item 215 – Crop cultivation	85.1
	Item 216 – Sales of milk	3
	Item 217 – Sales of Irish potatoes	4
	Item 218 - Entrepreneurship	27.7

Livelihood Diversification Using the Herfindahl-Hirschman Index (HHI)

Household livelihood diversification status analysed using *the Herfindahl-Hirschman Index (HHI)* showed high livelihood diversification due to diversification in income sources among SSTGs in the study area (Table 2). A value of HII of 0.346 indicates a high concentration.

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If the level of ID is greater than 2, it indicates a high diversification of livelihood strategies among SSTGs. Hence, the level of diversification and HHI imply high status.

Table 2: Income Diversification (ID) and HHI

	Income sources for SSTGs in TZS						**Total income from all sources (in US$) (X)**
Description	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**	
Total Income from source *i* TZS (Xi)	46 960 993.20 (US$ 18 488.58)	23 743 005.60 (US$ 9 347.64)	49 368 989.40 (US$ 19 436.61)	100 000 (US$39.37)	439 191.40 (US$172.91)	2 073 300 (US$ 816.26)	122 685 505.20 (US$48 301.38)
Income share (Si) (Xi/∑Xi)	0.383	0.194	0.402	0.001	0.00	0.017	1
Income share (Si) in % (Si*100%)	38.28	19.35	40.24	0.08	0.36	1.69	100%
Si^2	0.147	0.037	0.162	0.000	1.28156E-05	0.0002856	
HHI = $\sum Si^2$							0.346
Income diversification (ID) = $1/\sum Si^2$							2.889

Note: Income sources: US$ = US Dollars, Crop cultivation (X_1), Livestock (X_2), Timber Harvesting (X_3), Non-Timber Forest Products (X_4), Business (X_5), Entrepreneurship (X_6).

Source: Author's survey, 2024

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Descriptive Statistics of the Variables in the Study Using a One-sample t-test

Descriptive analytical results (Table 3) using a *t*-test show that age, sex, education, household duration, household size, total annual income, farm size, leased farm ownership, sawn timber sales, duration of forest products trade, trend of trade for the past five years, poultry farming, maize crops type, income from crop cultivation, income from livestock rearing, income from timber harvesting, income from the business, income from entrepreneurship, hours allocated per week for crop cultivation, hours allocated per week for livestock rearing, hours allocated per week for timber harvesting, average yield (number) trees, TGA membership, off-farm strategy – business and off-farm strategy - entrepreneurship are all significant (2-tailed t-test) and they influence the choice of livelihood strategies of SSTGs in the study area with exception of income from non-timber forest products (NTFPs).

Table 3: Descriptive Analytical Results of the Variables in the Study Using *t*-test (n=101)

Independent variables	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Age	38.319	100	0.000	46.792	44.370	49.210
Sex	29.276	100	0.000	1.228	1.140	1.310
Education	19.712	100	0.000	1.386	1.250	1.530
Household size	27.116	100	0.000	5.129	4.750	5.500
Total annual income	8.203	100	0.000	502.257	380.780	623.730
Leased land ownership	5.277	100	0.000	0.218	0.140	0.300
Sawn timber sales	2.031	100	0.045	0.04	0.000	0.080
Duration of the forest products trade	16.655	100	0.000	15.347	13.520	17.170
Trend of the trade for the past five years	13.732	100	0.000	0.653	0.560	0.750
Poultry keeping	30.166	100	0.000	0.901	0.840	0.960
Maize crop farming	31.972	100	0.000	0.911	0.850	0.970
Income from crop cultivation - TZS	7.487	100	0.000	464 960.4 (US$183.06)	341 748.7 (USD$134.55)	588 172.1 (UD$231.56)
Income from livestock rearing - TZS	4.785	100	0.000	235 079.2 (92.55)	137 616.6 (54.18)	332 541.8 (130.92)
Income from timber harvesting - TZS	4.908	100	0.000	488 802 (US$192.44)	291 229.2 (US$114.65)	686 374.7 (US$270.23)
Income from non-timber forest products - TZS	1.000	100	0.320	990.099 (US$0.39)	(TZS-974.23) US$-0.38	2 954.43 (US$1.16)
Income from business – TZS	5.029	100	0.004	73200 (US$28.82)	35787.06 (US$14.09)	110612.93 (US$43.54)
Income from entrepreneurship - TZS	10.869	100	0.000	51 832.5 (US$20.41)	42 186.82(US$16.61)	61 478.178 (US$24.21)
Hours spent in crop cultivation	9.302	100	0.000	23	18.090	27.910
Hours spent in livestock rearing	12.441	100	0.000	12.317	10.350	14.280
Hours spent in timber harvesting	9.777	100	0.000	11.02	8.780	13.260
Trees' average yield per year	9.882	100	0.000	560.743	448.170	673.320
TGA membership	12.349	100	0.000	0.604	0.510	0.700

Note: *** $p < 0.01$, ** $p \leq 0.05$ significant levels. Source: Author's Survey, 2024.

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Parameter Estimations and Model Analytical Results Interpretation

The selected final model fits the data well, as shown in Table 4 (the χ^2-value, *df*, and p-value). The Chi-square (χ^2-value) for goodness of fit with a *p*-value greater than 0.1 shows the model fits well with the data, indicating acceptance and reliance on the model. Above all, chi-square Pearson, deviance values, and the pseudo R^2 (for Cox & Snell, Nagelkerke, and McFadden) also support model fitness.

Variables that significantly influence livelihood diversification are entrepreneurship, membership in TGA, and mean total income (Table 4). Entrepreneurship influences inversely the choice of livelihood strategy of the SSTGs for a moderate livelihood diversification strategy (B1 = -2.279, Wald ($\chi 2$) = 3.647) with a $p < 0.05$ significant level, holding other factors constant. This implies that an increase of 1 unit of livelihood diversification strategy will result in a 2.279 decrease in entrepreneurship choice. Further, membership in TGAs has a positive influence on the choice of livelihood strategy by SSTGs (B1 = 2.631, Wald ($\chi 2$) = 2.873) with a $p < 0.01$ significance level. A positive odds ratio (Exp(B1)) greater than 1 suggests that joining TGAs will result in more of the moderate livelihood diversification strategy category by 2.631 units. This gives us insights that membership in TGAs is one of the determinants of livelihood strategies exploration, but moderate. Mean total annual income also positively influences the choice of a moderate livelihood diversification strategy (B1 = 25.64, Wald ($\chi 2$) = 6.252) with a $p < 0.01$ significant level against the 'no livelihood diversification' category. An odd ratio greater than 1 for mean annual incomes, a one-unit increase in mean annual income influences a choice of livelihood activities by 25.64 for the moderately diversified livelihood strategy of SSTGs in the study area. The findings furthermore indicate that entrepreneurship, membership in TGAs, and mean annual income did not influence the choice of a highly diversified livelihood strategy with 'no livelihood diversification' set constant.

Table 4: Multinomial Logistic Regression Model Analysis Results (n=101)

	Moderate livelihood diversification vs no diversification				Highly livelihood diversification vs no diversification			
Variables	**B_1**	**Std. Error**	**Wald**	**Exp (B_1)**	**B_2**	**Std. Error**	**Wald**	**Exp(B_2)**
Intercept	6.211	2.879**	4.652		-43.775	19362.14	0.000	
Entrepreneurships' livelihood strategy	-2.279	1.193**	3.647	0.102	-0.383	9835.946	0.000	0.682
Membership in TGAs	2.631	1.552***	2.873	13.894	-11.981	15421.02	0.000	0.000
Education	-0.452	1.711	0.07	0.636	5.663	0.000		287.877
Sex	-0.151	0.759	0.04	0.86	0.187	0.000		1.206
Household duration	-0.431	0.757	0.324	0.65	0.837	7936.558	0.000	2.310
Number of children	0.64	1.181	0.294	1.897	-16.984	0.000		0.000
Mean Total Annual Income	25.64	10.254***	6.252	1.37E+11	71.775	20684.61	0.000	1.48E+31
Farm size	1.709	2.074	0.679	5.525	-10.556	16260.59	0.000	0.000
Reason for tree planting - energy balance	-0.986	1.568	0.396	0.373	-2.547	10158.54	0.000	0.078

χ^2-value = 164.462

df = 20, $p < 0.01$

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	Moderate livelihood diversification vs no diversification				Highly livelihood diversification vs no diversification			
Variables	**B_1**	**Std. Error**	**Wald**	**Exp (B_1)**	**B_2**	**Std. Error**	**Wald**	**Exp(B_2)**
Goodness of fit:								
Pearson = 18.660 (*p = 1.00*)								
Deviance = 18.209 (*p = 1.00*)								
Pseudo R^2:								
Cox & Snell = 0.804,								
Nagelkerke = 0.961								
McFadden = 0.900								

Note: *** $p < 0.01$, **$p<0.05$ and * $p < 0.1$ significant levels. Source: Author's Survey, 2024.

Table 5: Classification Table for Multinomial Logistic Regression Model

	No diversification	Moderately diversification	Highly diversified	Percent Correct
No diversification	60	1	0	98.4%
Moderate diversification	2	27	0	93.1%
Highly diversified	0	0	11	100.0%
Overall Percentage	**61.4%**	**27.7%**	**10.9%**	**97.0%**

Findings in Table 5 show that the multinomial logistic model was able to classify and explain about 97% of all cases (no diversification, moderate diversification, and highly diversified categories).

DISCUSSIONS

Off-farm and on-farm activities are crucial in the livelihood diversification strategies of SSTGs in the Kilolo District of Tanzania. This study underscores the economically significant role of both off-farm and on-farm livelihood strategies (Gebru *et al.,* 2020). The findings of this study highlight that SSTGs are engaged in diversified livelihood activities, including on-farm agricultural and forestry, as well as off-farm activities such as business and entrepreneurship. These findings are similar to what was reported by Paudel *et al.* (2017) and Teklemariam (2021), which is normal in rural Tanzanian livelihoods. According to Jatto *et al.* (2021), forest-adjacent communities engage in the collection of forest products, such as Non-Timber Forest Products (NTFPs), as a predominant livelihood among arable land in Nigeria. Findings from this study also concur with Nyombi & Chegere (2023), who reported that diversification of livelihood strategies in rural areas enhances resilience and reduces economic vulnerability. Other studies by Teklemariam (2021), Beckline *et al*. (2022), and Woldie & Tazebew (2023) found that forest products played a vital role in supplementing agricultural earnings in Ethiopia. These empirical studies emphasise that forests in many parts of the world serve as a direct source of income and safety nets for economic shortfalls to the communities. In Kilolo District, tree growing is currently among the most preferred income-generating activities for the majority of the households (Martin *et al.,* 2025). During FGD meetings with local community members, it was evident that there is a fast-growing shift towards avocado farming due to the higher prices fetched (Tweve & Masalu, 2024). These households need to strike a balance between food production and income generation from the planted trees and other non-farm income-generating activities (Martin *et al.,* 2025).

HHI results of this study indicate a high level of diversification (0.346) among SSTGs in the study

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area. Rhoades (1993) and Dereje *et al*. (2024) reported HHI greater than 0.2 indicates a high diversification of livelihood strategies.

T-test results underscore the importance of socio-economic and demographic variables and participation in on-farm and off-farm activities as determinants of livelihood diversification. These findings align with previous research by Barret *et al*. (2001); Babatunde & Qaim (2009), and Nyombi & Chegere (2023), who reported that demographic and socio-economic variables such as asset ownership and resource access are key determinants of livelihood diversification. For example, education, age, and household size were determined to contribute to the forest-related livelihood diversification in Cameroon and Nigeria (Beckline *et al.* 2022). The consistent significance of livelihood activities indicates a robust relationship between these variables and livelihood outcomes of SSTGs in the study landscape. This concurs with the study by Hintz *et al.* (2021) and Hingi (2018).

The significance of mean total annual income, entrepreneurship, and membership in tree growers' associations (TGAs) suggests key determinants of livelihood diversification in the study area. An inverse relationship between livelihood strategies and entrepreneurship aligns with literature that highlights the complexity of the relationship between rural livelihood and entrepreneurship (Goetz & Rupasingha, 2009; Markley & Low, 2012). The multinomial logistic regression results indicate that membership in TGAs positively influences farmers' choice of livelihood strategies. These results concur with those found by Shen *et al.* (2022) and Hintz & Pretzsch (2023a), where membership in TGA played a critical role in enhancing the livelihoods of SSTGs. Access to land, credits, and training, which TGA members are privileged to, are vital components that enable forest farmers to diversify their economic practices and livelihood outcomes, which is similar to the findings reported by Khan *et al*. (2020) and Abera *et al.* (2021). These results underscore the importance of fostering community-based organisations that can provide support and resources to farmers (Irawan & Esthi, 2024). The positive influence of income and TGA membership suggests that both economic and institutional support enhance participation in forest and non-forest livelihood activities. Entrepreneurship, membership in TGAs, and mean annual income did not influence the choice of a highly diversified livelihood strategy, probably due to the barriers related to market access, as most of the farmers sell crops, especially trees, at the farm gate (Hintz & Pretzch, 2023b). This may also be caused by less access to capital, limited specialized skills, and policy constraints. As a result, there must be a broader approach to support SSTG besides financial assistance.

CONCLUSION

The diversification of livelihood among SSTGs in Kilolo District is high. Households, therefore, strategize on both farm and non-farm income-generating activities. This is justified by the integration of SSTGs in both on-farm and off-farm activities such as agriculture, forestry, business, and entrepreneurship. These results were supported by a high HHI of 0.346 (which is above 0.2), implying a high diversification among SSTGs. Despite the observed diversifications, crop farming and timber harvesting remain the biggest contributors to the household's income in Kilolo District. Multinomial logistic regression analytical results and t-test statistics have shown that socio-economic factors, income, and institutional support through TGAs are the key determinants of livelihood diversification, helping SSTGs increase economic resilience and reduce vulnerability in a moderate status. Besides, livelihood strategies may be hindered by institutional and structural barriers.

Recommendations

The study therefore recommends strengthening TGAs to enhance capacity and outreach through information sharing, training, and collective actions to improve diversification. Since entrepreneurship

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has shown significant effects on livelihood diversification, targeted interventions are necessary to facilitate entrepreneurship to complement other farm or forestry-related activities for improving the livelihoods of SSTGs. Institutional support, such as training, access to credit, and markets, can enable SSTGs to advance to highly diversified livelihood strategies. Further, policy frameworks that ensure forest conservation and livelihood improvements need to be reinforced. Furthermore, policy, institutional, market, and credit access barriers should be identified and addressed to enable SSTGs in the study landscape to improve their highly diversified livelihood status.

Disclosure Statement

The authors report there are no competing interests to declare.

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APPENDICES

Appendix A: Study Variables, Definition, and Expected Outcomes

Variables name	Variable types	Definition and unit of measurement	Expected outcome
Dependent variables			
No diversification	Categorical	Study reference category (ID = 0)	
Moderately diversified	Categorical	Diversification level between ID = 0 and ID = 1	
Highly diversified	Categorical	Diversification level between ID = 1 and ID = 2	
Age	Continuous	Mean age of the respondents in years	+
Sex	Dummy	Sex was assigned 1 for male and 0 for female	-
Education	Categorical	Education level, 1 - Primary, 2 - Secondary, 3 - College and 4 - University	+
Household duration	Continuous	Number of years since the household was established	+
Household size	Continuous	Number of people who share meals on a daily basis	+
Number of Children	Continuous	People under 18 years who share meals on a daily basis	+
Total annual income	Continuous	Mean annual income per household in US$	+
Farm size	Continuous	Size of farm for tree or crops farming in acres	+
Leased farm ownership	Categorical	Farm type obtained by leasing (1 for Yes, 0 for otherwise)	-
What sales? Logs	Categorical	What SSTG sale - logs (1 logs, 0 for otherwise)	+
What sales? Sawn timber	Categorical	What SSTG sale - Sawn timber (1 Sawn timber, 0 for otherwise)	+
Duration of forest products trade	Continuous	Number of years of forest products trade	+
Trend of trade for the past five years	Categorical	If the timber trade is increasing or decreasing (1. Increasing, 2. Decreasing)	+/-
Poultry farming	Categorical	Poultry farming activity type by household (1 for Yes, 0 for otherwise)	+
Type of crops - Maize	Categorical	Maize farming activity type by household (1 for Maize, 0 for otherwise)	+
Crop cultivation income	Continuous	Income from crop cultivation in US$	+
Livestock Rearing income	Continuous	Income from livestock rearing in US$	+
Timber Harvesting income	Continuous	Income from timber harvesting in US$	+

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Variables name	Variable types	Definition and unit of measurement	Expected outcome
Income from business	Continuous	Income accrued from business SSTGs are engaged to	+
Income from entrepreneurship	Continuous	Income accrued from entrepreneurship SSTGs are engaged to	+
Hours for Crop Cultivation	Continuous	Hours allocated per week for crop cultivation	+
Hours for Livestock rearing	Continuous	Hours allocated per week for Livestock rearing	+
Hours for Timber Harvesting	Continuous	Hours allocated per week for timber harvesting	+
Average tree yield (number)	Continuous	Average number of Trees in numbers	+
TGA membership	Dummy	Membership in TGA; whether a farmer is a member (1) in TGA or not a member (0)	+

Source: Authors' compilation based on the studies by Yizengaw (2015), Gebru *et al.* (2020), Admansu *et al.* (2022) and Chegere &Nyombi (2023),

Appendix B: Multicollinearity Diagnosis

Coefficients[a]

Model		Collinearity Statistics	
		Tolerance	VIF
1	What is your age?	.565	1.770
	What is the size of your tree farm (in acres)?	.715	1.398
	Business	.731	1.368
	Entrepreneurship	.749	1.335
	How many hours per week do you allocate to each livelihood activity? Livestock rearing	.602	1.662

[a.] Dependent Variable: How is your livelihood diversification?

