

Livelihood diversification in the Kafa coffee forest biosphere reserve in Southwestern Ethiopia

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III. ABBREVIATIONS AND ACRONYMS

AD	Anno Domini
ANOVA	Analysis of Variance
BR	Biosphere Reserve
ETB	Ethiopian Birr
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GIS	Geographic Information System
ha	Hector
HH	households
KII	Key Informant Interview
LDCs	Least Developed Countries
LDI	Livelihood Diversification Index
MAB	Man and the Biosphere Programme
MNL	Multinomial logistic
NGO	Non-Governmental Organization
Nk	Numbers of household in kebele
OLS	Ordinary Least Squares
PPS	Population probability sampling
SDI	Simpson diversification index
SID	Simpson Index
SNNPRS	Southern Nations, Nationalities and Peoples' Regional State
SPSS	Statistical Package for the Social Sciences
Stata	Statistical Analysis Software
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
VIF	Variance Inflation Factor

IV. ABSTRACT

Kafa is the 9th century Ethiopian goatherd known as Kaldi who introduced the cup of coffee to the world by observing his herds were more energetic after eating red coffee berries. Throughout the world, Kafa is recognized as the narrative birthplace of Coffea arabica. Kafa is located in the highlands of southwestern Ethiopia, where the Coffea arabica more commonly known as the Ethiopian Coffee. This study examined household diversification of livelihoods within the Kafa Coffee Forest Biosphere Reserve; a socio-ecological system where biodiversity conservation and sustainable development are closely tied together. The study utilized a mixed-method approach of household surveys, focus group discussions and key informant interviews. The data was analyzed by applying descriptive statistics and multiple regression models. Findings revealed that households derive their income largely from coffee production, forest resource extraction, ecotourism, small business ventures and remittances. The study concludes that diversification of household income provides families with the adaptive capacity needed to cope with environmental and economic shocks, improve their livelihoods and contribute to poverty eradication. The findings highlight ecotourism and the sustainable use of natural resources as vital components for the protection and development of Ethiopia's biosphere reserves. The results have implication for development professionals and policy makers in designing interventions that facilitate sustainable development of each of the Biosphere Reserve areas in Ethiopia.

KeyWords:- *Livelihood Diversification, Kafa Coffee Forest, Ecotourism, Biosphere Reserve and Simpson Diversity Index*

1.INTRODUCTION

1.1. Background and Justification

The concept of biosphere reserves was first articulated at the 1969 UNESCO biosphere conference in Paris, which emphasized the integration of human well-being with environmental conservation (Bridgewater 2016, Busse, Schleper et al. 2017). In 1971 UNESCO launched the man and the biosphere (MAB) programme to foster global cooperation in sustainable development (Rossier, Aisenson et al. 2020). By 1974, biospheres were formally defined as areas combining biodiversity conservation, sustainable development, and scientific research and education. The first reserves were designated in 1976, marking the establishment of the world network of biosphere reserves. Today, this network has expanded to 797 reserves in 145 countries, including 90 in Africa and 6 in Ethiopia (Rossier, Aisenson et al. 2020, Wannemo 2026). The story of coffee arabica begins in the misty highlands of Kafa in Ethiopia where oral tradition and scientific evidence recalls the Ethiopian from Kafa region Kaldi legend around 850 AD (Bond 2011, Morganelli 2006, Pokhrel 2009, Crozier, Ashihara et al. 2011). Kaldi, a humble goat herder, noticed his flock's unusual vitality after eating red cherry from a wild shrub and intrigued, he tasted them himself and the discovery eventually reached local monks who roasted and brewed the beans to sustain long hours of prayers through partly mythical this Kaldi symbolizes Ethiopia's role as the cradle of coffee (Nairon, 1671 (Wagner, Von Rothkirch et al. 2001, Chrystal 2016, Morris 2018)).

Scientific research confirms that coffee arabica is native to Ethiopia's southwest highland, especially the Kafa coffee biosphere reserve which hosts unparalleled genetic diversity (Anthony, Combes et al. 2002, Kerr 2021) (Jackson, Shiferaw et al. 2021, Krishnan, Matsumoto et al. 2021).

Ethiopia's coffee heritage is both legendary and scientific. Kaldi's tale reflects cultural memory while coffee arabica's genetic roots affirm Ethiopia as the true birthplace of coffee, shaping a tradition that continues to influence global culture (Sylvain 1958, YOSHIDA 2025).

Communities in Kafa rely on a diversity strategy, including coffee cultivation, forest product harvesting, small-scale agriculture, and ecotourism, to sustain their livelihood. Understanding these socio-economic developments (Kalmbach 2017, Mohammed 2020). Accordingly, this study investigates how households in the Kafa Coffee Forest Biosphere Reserve diversify their income sources and how such a strategy contributes to resilience, poverty reduction, and sustainable resource management in southwestern Ethiopia.

The definition of livelihood comprises the capabilities, assets, and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base (Wannemo 2026).

The Kafa BR is one of Ethiopia's first two BRs and the first coffee BR in the world, serving as an attraction for coffee lovers worldwide (Taye, Kicha et al. 2026). It makes an important contribution to the conservation of afro-montane forest vegetation types, particularly the afro-montane rainforest and *Coffea arabica*.

1.2. Statement of the Problem

The Kafa Forest is heavily exploited mainly due to agricultural use, livestock rearing, and logging for timber and non-timber forest products to complement household consumption and income generation in the area have progressively converted a few parts of the forest to open cropland and grazing lands (Thomsen, Måren et al. 2025).

The afro-montane forest vegetation has long been considered one of the most threatened eco-regions in the World (Thomsen, Måren et al. 2025).

1.3. Significance of Research

The Kafa Biosphere Reserve is Ethiopia's first biosphere reserve and the first coffee biosphere reserve in the world, which can be recognized as a worldwide attraction for coffee consumers and eco-tourists, so coffee tourism could be a new socio-economic track for Ethiopia (Taye 2020). Therefore, this research could be contributed for government organizations, NGOs, policy makers, and implementers to understand the gaps and to take appropriate actions to improve the existing situation in the reserve. Finally, the conducted research served as a source of reference material for conducting further research in the field.

1.4. Research Objectives

1.4.1. General objective

To investigate the livelihood diversification strategy of households in the Kafa Coffee Forest Biosphere Reserve

1.4.2. Specific objectives

To identify the main livelihood strategies and income sources of households in the Kafa Biosphere Reserve

To assess the level of livelihood diversification among households in the Kafa Biosphere Reserve

2. LITERATURE REVIEW

2.1. Theoretical Concept of Biosphere Reserve

The theoretical concept of biosphere reserves originated with a task force of UNESCO's Man and the Biosphere Programme in 1974 (Fakana, Choudhary et al. 2019). Biosphere reserves under the Man and Biosphere Program were launched in the 1970s by UNESCO to integrate biodiversity conservation, research, education, and sustainable development (Van Cuong, Dart et al. 2017) (Fakana, Choudhary et al. 2019).

2.2. Biosphere Reserves in Ethiopia

Nowadays, Ethiopia has 6 internationally recognized biosphere reserves, namely Kafa Coffee Forest Biosphere Reserve, Yaya Coffee Forest Biosphere Reserve, Sheka Forest Biosphere Reserve, Lake Tana Biosphere Reserve, Majang Forest Biosphere Reserve, and Agnuwa Biosphere Reserve, UNESCO

(2025). Ethiopia possesses considerable biodiversity and natural resources, including high endemism. However, its human population depends greatly on agricultural activities rather than off-farm income sources like ecotourism (Ertiban and Maru 2020). In Ethiopia, biosphere reserves, protected areas, wildlife national parks, natural forests, game reserves, and wildlife sanctuaries are the most suitable for ecotourism potential resources. Ethiopia's nature-based ecotourism income, win-win community livelihood benefit gain and legal participation in conservation with utilization of these endowed resources that provide substantial inputs for the livelihoods of a very large number of people in the country and an estimated annual turn over more than USD 2.3 billion to the national economy (Heide 2012). Forests in the area of a biosphere reserve for future tourism as a tool have to be qualified as ecotourism. Forests are indispensable functional foundations for ecological, social, cultural, and economic development and prosperity (Heide 2012).

2.3. Ecotourism Livelihood Improvement

Ecotourism has the potential to contribute to biodiversity conservation within and outside protected areas, as well as to promote community livelihoods (Pigram and Wahab 2005); (*Awang, Hassan et al. 2009*). Ecotourism is a large industry that supports and contributes to the economic development of many developing countries (*Torres and Momsen 2004*). For the world's 50 poorest countries, tourism is one of the largest contributors to economic development. Also, it is a main source of foreign exchange, exceeding 80 percent of total income for many countries (*Sindaga 1999*); (*SO, Agbelusi et al. 2012*). Ecotourism is one of the sectors that globally has faced the fastest economic growth rates throughout the last decade (*Wunder 1999*). A study in China indicated that ecotourism benefited the local people by its contribution to the local economy for creating job opportunities and income in tourist destination areas (*Ganster 2007*), (*Muhanna 2007*).

2.4. Livelihood Diversification Strategy

Livelihood diversification can be defined as the process by which rural families construct a diverse portfolio of activities and social support capabilities in their struggle for survival and in order to improve their standards of living (*Igwe 2013*). Economic diversification refers to the production of diverse goods and services in the production boundary. Coffee is one of the most important agricultural commodities in the world. Rural livelihood diversification is the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living (Ellis 2000). Diversification can be divided into two categories: on-farm and non-farm diversification. On-farm diversification means maintenance of a diverse spread of crop and livestock production activities that interlock with each other in various ways. Off-farm diversification refers to seeking business or employment opportunities other than traditional crop production and livestock rearing. Household livelihood diversification is a strategy to minimize risk and uncertainty (*Swain and Batabyal 2016*)

3.MATERIALS AND METHODOLOGY

3.1.Review methodologies

This review mainly depends on reviewing secondary data sources from the internet. The steps involved in identifying relevant resources for the review include searching, screening, eligibility, and inclusion. Searching was conducted using the following key terms, including livelihood diversification, on-farm activity, non-farm activity, off-farm activity, and incomes. Screening was done to eliminate non-relevant records by reading the titles, abstracts, and finally the full texts based on the set inclusion/exclusion criteria. The inclusion and exclusion criteria involved three stages. The first step is to download articles related to household choice of livelihood strategies and then retain those published after ten years, and eliminate those published before this specific year (in fact, old definitions and theories in the retained articles were also taken as they were in the original documents). The second stage is reading the abstract of the retained papers, and the last stage is reading the full text of the retained articles. Accordingly, a total of 200 articles were downloaded, of which 98 were reviewed

3.2. Description of the Study Area

3.2.1. Location

Kafa Biosphere Reserve is located between the following latitudes and longitudes: a) Latitude: 35°29'50.55" to 36°47'33.78" East b) Longitude: 35°48'50.57" to 35°44'34.30" East c) Central Point: 36°3'22.51" East & 7°22'13.67" North (*Mohammed 2020*).

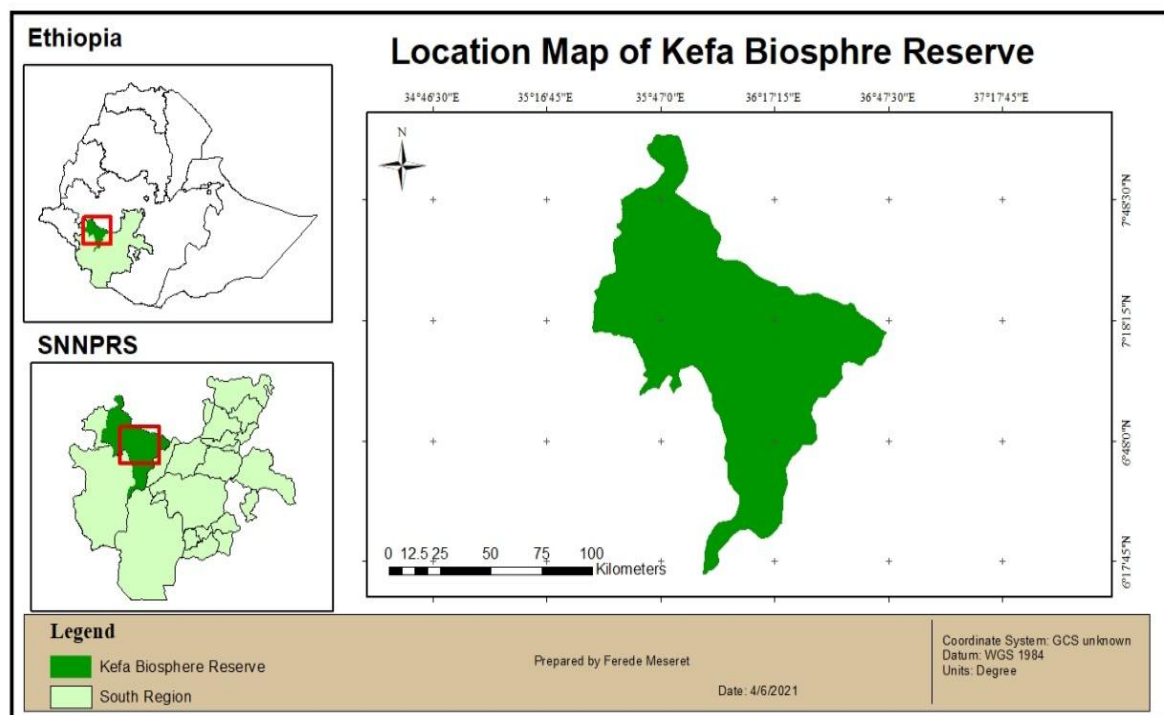


Figure 1: Geographical location of Kafa Biosphere Reserve

The total area of the Kafa Biosphere Reserve is about 760,144 ha, of which currently 422,260 ha (56.6%) belong to eastern afro-montane biodiversity. The core zone covers 41,391.1 ha, the buffer zone covers about 161,427 ha, and the transition zone covers about 337,885 ha. In this zone, all cultural and productive activities, including animal husbandry, are allowed. Kafa Biosphere Reserve in Ethiopia is the birthplace of wild *Coffea arabica* and contains close to 5,000 wild varieties of the plant in this biodiversity hotspot. The last remaining Afro-montane cloud forests that contain wild trees of *Coffea arabica* as a natural part of the ecosystem exist in the region in the Kafa Biosphere Reserve. It is situated in a predominantly highland region covered by evergreen Afro-montane forest in the southwestern part of Ethiopia (Mohammed 2020).

3.3. Research Design and Approach

This study was employed according to (Kogevinas and Chatzi 2015) for research that collects data on relevant variables at one point in time from a sample selected to represent a larger population. A research design was used for collecting, analyzing, and reporting research in both quantitative and qualitative research (Koki 2017). A mixed research approach was employed, encompassing both descriptive and inferential statistics as well as quantitative and qualitative methods.

3.3.1. Research Model

This paper extends the use of the multiple linear regression model to understand the determinants of household livelihood diversification in the Kafa Coffee Forest Biosphere Reserve, Ethiopia. The regression models have been commonly used by researchers in the past few decades to assess determinants or predictors of various livelihood outcomes, such as participation in farming, off-farm income, consumption, changes in livelihood

assets and livelihood diversification (Ellis 2000, Swain and Batabyal 2016). The general form of the linear regression model is presented below:

$$LDI = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon$$

3.3.2. Target Population

The target population for this study was the three district administrations of the local communities living adjacent to Kafa Coffee Forest Biosphere Reserve. Basically, purposely selected three districts (Gimbo, Dacha, and Bonga) was conducted on this study. The target population is approximately 398 household live on the Kafa Coffee Forest Biosphere Reserve (Kafa zonal bureau of statistics 2021).

3.4. Sampling Techniques and Sample Size Determination

The study used a (Bhatt, Jasrotia et al. 2026), so as to select districts, sample kebeles, and households. In the first stage, from the total 14 districts in Kafa Zone, Gimbo, Decha, and Bonga Zuria districts were selected by the purposive sampling technique. The sample size was determined using the following sample size determination formula adapted from (Israel 1992) statistical formulas as follows:

Equation 1 is : $n = N / (1 + N(e)^2)$

Where: n = required sample size = the required sample size = 398 households

N = Household population size = 102,276 households,

E = margin of error (expressed as a decimal, e.g. 0.05 for $\pm 5\%$) = the precision level which is = ($\pm 5\%$), Confidence Level is 95% at $P = \pm 5$ (maxim variability)

Hence, out of the total population of 102,276, a sample size of 398 was taken but on these research only 349 questionnaires were actually distributed for 349 households due to resource constraints. Then the respondent households from each sample kebele were calculated by using the probability proportional to sample size method to determine the sample size to be taken from each kebele. (Getinet and Lorato 2020).

3.5. Methods of Data Collection

General methods of data collection in this study included household questionnaire surveys, key informant interviews, focus group discussions, field observation, and document analysis.

3.5.1. Data sources and collection tools

This study utilized both primary and secondary data sources, with primary data gathered, and both qualitative and quantitative data types were employed to ensure comprehensive and reliable findings (Fida, Baatuuwie et al. 2023)

3.6. Methods of Data Analyses

Qualitative and quantitative data analyses were conducted using SPSS, version 27.0, Stata, and Microsoft Excel, applying descriptive statistics, Chi-square tests, regression, and ANOVA. Additionally, livelihood diversification was measured using the Simpson Index (SID) to capture the extent of income source diversity.

3.7 Ethics statement

All methods were carried out in accordance with relevant guidelines and regulations. Ethical clearance for this PhD research was obtained from the University of Gondar Forest and Livelihood Program. Informed consent was obtained from all participants involved in Household surveys and Interviews. The study adhered to the principles of voluntary participation confidentiality and respect to for local community rights within the kafa coffee forest biosphere reserve

4.RESULTS AND DISCUSSION

4.1.RESULTS

4.1.1.Demographic and Socio-Economic Characteristics

Demographic and socio-economic characteristics of households examined in this study were educational status, sex, main occupation, age,household size, land holding, and living residence years.

Table 1: Descriptive Statistics of respondents with categorical variables

Variable	Obs.	category	count	percentage	Cum.
sex	349	Male	313	89.68	89.68
		Female	36	10.32	100.00
Age group	349	Early working age(15-24)	70	20.06	20.06
		Prime working age(25-54)	174	49.86	69.91
		Mature and elderly age(55 and above)	105	30.09	100.00
Education	349	No formal education	192	55.01	55.01
		Primary education	35	10.03	65.04
		Secondary education	30	8.60	73.64
		Higher and above education	92	26.36	100.00

Source: computed from field survey 2024/5

Table 2: SDI and economic characteristics of households with continuous variables

Variable	Obs.	Mean	Std.Dev.	Min	Max
Household Size	349	4.455587	1.68714	2	9
Landholding Size	349	4.335244	1.686471	1	8
Residence Duration	349	1.873926	.3324099	1	2
Totalincome	348	62320.06	32519.93	9300	195000
SDI	349	.6778705	.0892215	.3132761	1

Table 3: Major and sub-major livelihood strategies in the study areas

Sources Of Income		Total Income	Mean	Income Share	Total Income Share
On-Farm Only	Crops	3757000	10765.04	17.3	34.9
	Non-Crop Agriculture	3822132	10951.67	17.6	
On Farm+Off Farm	Forest Products	5917700	16956.16	27.3	50.5
	Eco-Tourism	5046499	14459.88	23.2	
On Farm+Non Farm	Business	1093299	3132.66	5	13.6
	Salaried Job	599300	1717.19	2.8	
	Remittance	688100	1977.30	3.2	
	Transfer Payment	564400	1617.19	2.6	
On Farm+Off Farm+Non Farm	Laborer	201650	577.79	1	1
Total Income		21690080	62154.88		

Sources: computed from own survey 2024/5.

4.1.2.livelihood diversification index

Model specification

There are different methods of estimating household livelihood diversification, such as Simpson's index of diversity(SID),Herfindahl, Gibbs, and Martin indexes, etc., but the SID is best to show the share of non-farm income in the total household income(Singh 2026). In this study, SID was used to estimate the level of income diversification among farm households in the Kafa Coffee Forest Biosphere Reserve. The SID considered both the number of income sources and how evenly the distribution of income is made between the various sources. Household livelihood diversification was estimated using the Simpson's index of diversity(SID), which is widely applied in rural livelihood studies. According to(Taye, Damtie et al. 2024) (Ayana, Megento et al. 2022), SID was chosen as the most appropriate measure for estimating household livelihood diversification in the Kafa Coffee Forest Biosphere Reserve

The Simpson Diversification Index (SID) considers both the number of income sources and how evenly income is distributed among those sources, making it a robust measure of livelihood diversification (Damtie, Berlie et al. 2022). The value of SID ranges between zero (0) and one (1). Thus, zero denotes complete specialization when there is only one source of income, where $P_i = 1$, and values approaching one indicate greater diversification as the number of sources increases and income shares become more even, and one is the extreme of diversification (Simpson 1949).

Table 4 : Summary of total household income

	Percentiles	Smallest	
1%	12500	9300	
5%	18250	10300	Obs = 348
10%	27400	12200	Sum of Wgt = 348
25%	38850	12500	
50%	58500		Mean = 62320.06
		Largest	Std. Dev = 32519.93
75%	79250	165000	
90%	101000	166000	Variance = 1.06e+09
95%	132000	192000	Skewness = 1.04817
99%	165000	195000	Kurtosis = 4.459988

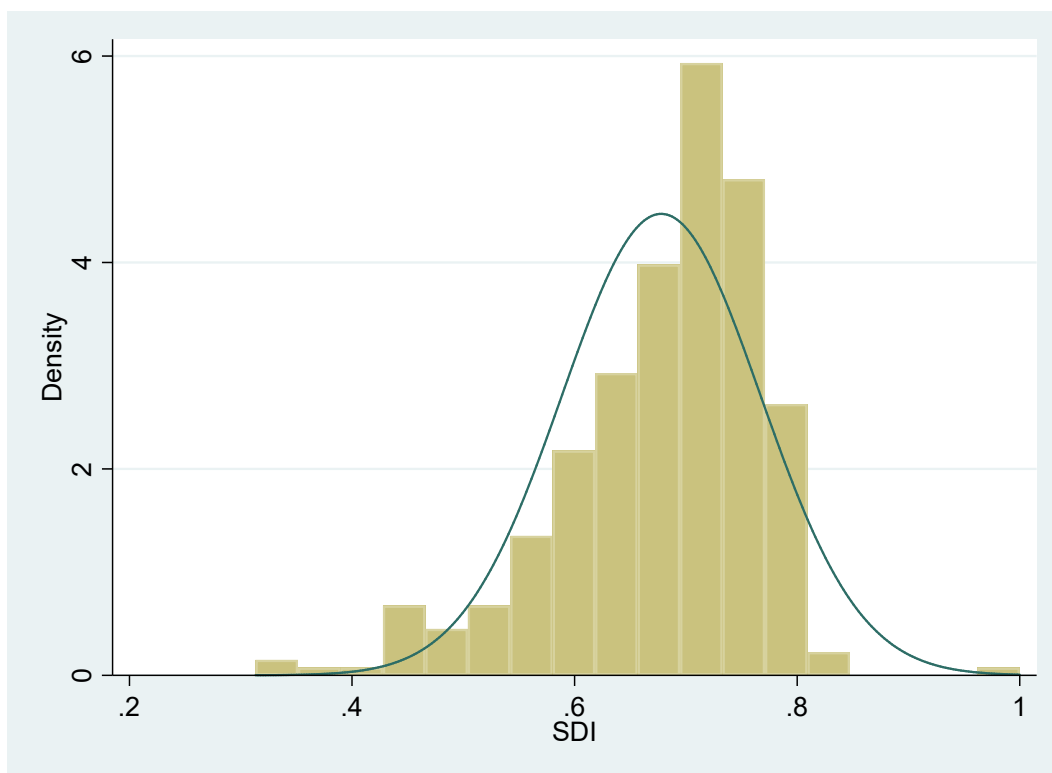


Figure 2: Histogram SDI, normal

Table 5: Simpson diversity index value of respondent households.

SDI value	Intensity of livelihood diversification	Freq	Percent	Cum
< 0.38	Less diversification	2	0.57	0.57
0.38 - 0.68	Moderately diversified	145	41.55	42.12
> 0.68	Highly diversified	202	57.88	100.00
Total(mean SDI 0.6778)		349	100.00	

Source: adopted from (Maji and Saha 2021, Zelelew, Getnet et al. 2024, Gonfa, Kassahun et al. 2025)

Source: household survey 2024/5

Table 6: Multicollinearity Test(VIF)

Variable		VIF	1/VIF
Sex		1.28	0.781588
Age category	(25-54)	4.80	0.208428
	(55 and above)	9.34	0.107025
Household size		1.01	0.989797
Educational category	primary	1.47	0.680104
	secondary	1.13	0.881184
	Higher and above	1.17	0.853886
Landholding size		5.30	0.188624

Residence duration	1.10	0.907102
Total income	1.36	0.736437
Mean VIF	2.80	

Rule : VIF <10 = acceptable

Table 7: Ordinary least squares(OLS)

Source		SS	df	MS	Number of obs	=	348
Model		.068032903	10	.00680329	F(10, 337)	=	0.88
Residual		2.59814942	337	.007709642	Prob > F	=	0.5499
Total		2.66618232	347	.007683523	squared	=	0.0255
					Adj R-squared	=	- 0.0034
					RootMSE	=	.0878
SDI		Coef	Std. Err.	t	P> t	[95%Conf	. Interval]
Sex of household		-.011809	.0177016	-0.67	0.505	-.0466284	.0230105
Age category	(25-54)	.0339694	.0206199	1.65	0.100	-.0065905	.0745294
	(55 and above)	.0421234	.0313449	1.34	0.180	-.019533	.1037798
Household size		-.002923	.0028072	-1.04	0.298	-.0084448	.0025988
Educational category	primary	-.0084348	.0189764	-0.44	0.657	-.0457619	.0288922
	secondary	-.028056	.0178648	-1.57	0.117	-.0631967	.0070846
	Higher and above	-.0000753	.0115503	-0.01	0.995	-.022795	.0226445
Landholding size		-.0093738	.0064276	-1.46	0.146	-.022017	.0032695
Residence duration		.000705	.0148702	0.05	0.962	-.028545	.029955
Total income		1.77e-08	1.69e-07	0.10	0.917	-3.15e-07	3.50e-07
_cons		.7030539	.0338104	20.79	0.000	.6365478	.7695599

Table 8: Robust OLS

Linear regression				Number of obs	=	348
				F(10, 337)	=	0.91
				Prob > F	=	0.5237
				R-squared	=	0.0255
				Root MSE	=	.0878
		Robust				
SDI		Coef	Std. Err	t	P> t	[95%Conf Interval]
Sex of household		-.011809	.0183463	-0.64	0.520	-.0478967 .0242788
Age category	(25-54)	.0339694	.0190301	1.79	0.075	-.0034634 .0714023
	(55 and above)	.0421234	.0305431	1.38	0.169	-.0179557 1022025

	above)						
Household size		-.002923	.0032744	-0.89	0.373	-.0093639	.0035179
Educationa l category	primary	-.0084348	.0213387	-0.40	0.693	-.0504086	.033539
	secondary	-.028056	.0177501	-1.58	0.115	-.0629709	.0068589
	Higher and above	-.0000753	.0120749	-0.01	0.995	-.023827	.0236764
Landholding size		-.0093738	.0061612	-1.52	0.129	-.021493	.0027455
Residence duration		.000705	.0143131	0.05	0.961	-.0274493	.0288593
Total income		1.77e-08	2.22e-07	0.08	0.937	-4.20e-07	4.55e-07
_cons		.7030539	.0333318	21.09	0.000	.6374893	.7686184

Table 9:MM-estimator (Best Model)

Preparing data for subsampling ...done							
Enumerating 41 candidates 0%...20%....40%....60%...80%....100%							
Refining 5 best candidates ...done							
Iterating RLS done							
Fitting empty model ...done							
Computing standard errors done							
MM regression(85% efficiency)				Number of obs = 348			
				Wald chi2(10) = 12.34			
				Prob > chi2 = 0.2630			
				Pseudo R2 = 0.0320			
				Breakdown point = 50			
				estimate:k = 3.4436898			
				estimate:k = 1.547645			
				Scale = 0.06998187			
		Robust					
SDI		Coef	Std. Err.	t	P> t	[95%Conf. Interval]	
Sex of household	Male	0(empty)					
	Female	-.0030783	.0175323	-0.18	0.861	-.0375647	.0314081
Age category	(15-24)	0(empty)					
	(25-54)	.0341474	.018453	1.85	0.065	-.0021501	.0704449
	(55 and above)	.068088	.0264309	2.58	0.010	.0160977	.1200782
Household size		-.0002578	.0023364	0.11	0.912	-.0043379	.0048534
Education al category	No formal education	0(empty)					
	primary	-.0105801	.0173103	-0.61	0.541	-.04463	.0234697
	secondary	-.0271852	.0177755	-1.53	0.127	-.0621501	.0077796
	Higher and above	.0031097	.0108875	0.29	0.775	-.0183062	.0245256
Landholding size		-.0076946	.0057242	-1.34	0.180	-.0189542	.0035651

Residence duration	-.0055469	.0121567	-0.46	0.648	-.0294595	.0183657
Total income	3.12e-07	2.30e-07	1.35	0.176	-1.41e-07	7.64e-07
_cons	.6862974	.0276976	24.78	0.000	.6318155	.7407793
Hausman test of MMagainst S: chi2(10) =8.6464947 prob > chi2 =0.5659						

4.2. Discussion

4.2.1 Demographic and socio-economic characteristics of sample households

The profile of the 349 households sampled in the Kafa Coffee Forest Biosphere Reserve is similar to that reported in other afromontane biosphere reserves of southwest Ethiopia (Hashim, Asrat et al. , Moges and Sahile 2025) and similar to the Kafa survey by (Moges and Sahile 2025) which worked in Gimbo Woreda, another district of the Kafa Biosphere Reserve their study sample of 218 respondents had the same male-headship rate (88.2%) and identified household limitations primarily related to short settlement history, little education, and small landholdings. This study's demographic profile for the 349 surveyed households is similar to the (Betseha, Tolossa et al. 2025) which found household impact strongest when households are middle aged, have at least primary education, and are non-farm-based. The 349 households in this study are far times more likely to be male-headed and have shorter settlement histories than the (Betseha, Tolossa et al. 2025) sample size, which is representative of the 52,012 households surveyed in 212 villages across 8 contracted Ethiopian biosphere reserves (Betseha, Tolossa et al. 2025). A comparative study of the (Angessa 2025), also compares well with the profile of 349 households in this study.

Demonstrates this same demographic template in a different, putatively more comparable, biosphere context, in which socio-economic predictors (sex, age, education, occupation) were strongly associated with community perceptions of ecotourism impacts (Angessa, Lemma et al. 2022), and the more recent (Woldyes 2025). In the more distant (and better studied) cases of (Ogutu 2002, Shi, Zhang et al. 2022).

The very high share of household heads with no formal education (55%) is the single most policy-relevant characteristic in this sample. The 26.4% of Kafa heads with higher education therefore represent a critical human-capital layer through which the reserve's provisioning, regulating and cultural services can be stewarded, while the 55% with no formal schooling face a double constraint they have the highest direct dependence on forest products and the lowest capacity to translate ecotourism into non-extractive livelihoods. This finding is consistent with what (Bires and Raj 2021). Finally, the educational profile also resonates with (Yang 2024). Aseres and Sira's Bale Mountains study ecotourism contributes to conservation in Ethiopia only where the surrounding human-capital base is sufficient to absorb tourism-related employment, and where the lost access to (Aseres and Sira 2021).

The implications of these two findings are twofold. First, the dominance of the 25–54 stratum (49.9%) in the age structure creates a labour base that, in theory, can be mobilised for the more labour-intensive ecotourism activities which is the same segment Bires and Raj identify as the primary beneficiary of tourism-driven diversification in Ethiopian biosphere reserves (Bires and Raj 2021). Second, the substantial mature/elderly share (30.1%) matches what Moges and Sahile report in the same reserve and is consistent with the argument

of Debele Tiki that the participatory-conservation regime has selectively limited the mobility of long-resident households without generating an equivalent stream of ecotourism employment (Mengist, Soromessa et al. 2022). The non-trivial 20.1% share of early-working-age heads points to a forthcoming generation that is better positioned to take up tourism-related employment, provided that the educational constraints identified above are addressed. In this sense the female-headship rate of 10.3% is most similar to that of Moges and Sahile for the same reserve (Moges and Sahile 2025) and to that of Angessa et al. for Wanchi (Angessa, Lemma et al. 2022).

4.2.2. Landholding, household size and length of residence

Much like those in the southeast and which focus on forest usage for agrobusiness to free up land for commercial or largeholder use, but is actually driven by smallholder expansion northward, with the average holder owning a moderate amount of land (4.34 ha) but at the very small plot level (only 11.2% of households are effectively landless, and a further 2.9% own less than 0.1 ha) (Mengist, Soromessa et al. 2022). In southwestern Ethiopia, the social-ecological analysis of Fischer et al. is quite complementary and finds food security and biodiversity conservation coexist only where the smallholder base in the forest fringe possesses a diversified range of non-farm livelihood assets (Fischer, Bergsten et al. 2021). A similar constraint is identified for ecotourism in Southwest Ethiopia by Moges and Sahile, in Kafa: small landholdings are the most important structural constraint on household participation in formal ecotourism (Moges and Sahile 2025). Compellingly, Woldyes, in a study in Wardu-Dandi, shows that it is not the absolute volume of revenue from ecotourism that determines local support, but rather the distributional pattern of benefits (Woldyes 2025).

The high proportion of households (87.4%) who have resided more than ten years in the community and the low mean and standard deviation of the residence duration variable indicates that the households in this sample, on the whole, have had a long-term historical link with the communities, and this indicates that people are a good base resource for natural resource management, specifically forest management, in these areas. This confirms the observations on the same reserve by (Mengist, Soromessa et al. 2022, Tiki 2025) indicates that the long-term residents of the community see the forest as a key to prosperity for their livelihoods because during the long period of residence they have seen and benefited from the contributions of forest provisioning and regulating services to their households and community livelihood strategies. This aligns with (Sunderlin, Angelsen et al. 2005) finding in a review of cross-country literature on livelihoods and forest conservation that forest dependency falls as alternative opportunities arise. In practice, the 12.6% of the households who are newer residents present a potential risk of increased dependency on the forest as they do not have the length of residence to indicate stability.

4.2.3 Total income and (SDI)

The broad distribution of total household income, mean of ETB 62,320 with a standard deviation of ETB 32,520 and a range from ETB 9,300 to ETB 195,000, confirms that the Kafa communities around the biosphere reserve include both very income-poor and relatively income-secure households. The same pattern in income distribution is found in other studies of livelihood in biosphere reserves: Yang's review of community livelihoods in biosphere reserves explicitly highlights income inequality as a key characteristic of these systems, a consequence of the differential accessibility they enjoy to natural, human and financial capital

(Yang 2024). Ecotourism's potential contribution to household income is high; what matters is whose household can actually benefit the structuring characteristics, education, landholding, residence status, that shape such access (Moges and Sahile 2025). The mean SDI of 0.678 with a narrow dispersion (SD 0.089) and a range from 0.313 to 1.0 indicates that most households achieve moderate sustainability performance, with a small but meaningful lower tail (the 0.313 minimum) and a small upper tail (values reaching 1.0). There are clear regions of 'success' (ecotourism drives up the SD score) and 'failure' (ecotourism does not affect the SD score). On the upper side, Angessa et al. show in Wanchi that, where ecotourism is well organised and where local perception of its impacts is positive, the sustainability benefits are tangible at the household level improved income, infrastructure, and sense of stewardship (Angessa, Lemma et al. 2022). On the lower side, Tesfu, Weldemariam and Asersie show in Yayu, just north of Kafa, that the principal threats to biosphere-reserve sustainability are conversion-driven, deforestation-driven and firewood-driven, and that these threats fall disproportionately on the most resource-dependent households (Tesfu et al., 2018). The 30% lower-tail share of the Kafa sample, those with very low education and very small or zero landholdings, falls into exactly this category identified in the Yayu study, and would be the natural target for any equity-oriented ecotourism intervention. The same conclusion is reached by Aseres and Sira for Bale, who argue that the conservation and equity benefits of ecotourism accrue only when distributional safeguards are built in from the outset (Aseres & Sira, 2020), and by Woldyes for Wanchi-Dandi, who recommends group-based benefit-sharing as the most cost-effective way to reach the lower tail (Woldyes, 2025).

Besides the right-size of the community, the results show a large-share of heads with no formal education, a smallholder land base, a meaningful landless minority, and an income distribution that, while centred at a moderate level, contains a non-trivial lower tail at risk of remaining excluded from any ecotourism pathway that is not deliberately inclusive. The Kafa-specific findings (Moges and Sahile 2025) and of Mengist, Soromessa et al. 2022 align closely with this reading, as do the more recent Wanchi-Dandi findings of Woldyes (Woldyes, 2025) and the comparative Wanchi study of Angessa et al. (Angessa et al., 2022).

4.2.4. Household livelihood diversification strategies

The diversification pattern reported in this study, nine sub-activities grouped into four major strategy clusters, with 64% of Kafa households combining farm income with at least one off-farm or non-farm source, is broadly consistent with the broader picture emerging from Ethiopian biosphere reserves and from comparable forest-margin livelihoods work, but its specific distribution carries features that warrant both confirmation and contrast with prior findings.

tourism-linked components. (Bires and Raj 2021) found that tourism-related activities contribute to reducing reliance on natural resource-based components of livelihood in 305 sample households across 2 Ethiopian biosphere reserves. This mixed-strategy sample highlights a broader pattern than seen in their remaining 64% of Kafa households included in this study, which also significantly diversify their income beyond the on-farm stratum. On-farm-only components. (Mengist, Soromessa et al. 2022) conclude that of the remaining 36% of this study sample in Kafa, the forest ecosystem services that shape the livelihoods of Kafa households are valued primarily through direct use (including timber, non-timber forest products, fuelwood), implying that the on-farm-only households in the Kafa sample are highly prone to shocks induced by forest-condition and price volatility-induced changes in agricultural markets and conditions. While certain groups are currently on

their way to a diversified composite livelihood, Yang (2024) concludes that a single-strategy category of households, such as the on-farm-only group found in the present sample, is an intermediate category that far from being an end-state.

On-farm + off-farm (forest products and ecotourism) as the highest-return diversification channel in Kafa. This 18% of households earns the highest mean income among the diversified clusters (forest products 16,956 ETB; ecotourism 14,460 ETB), and together these two sub-activities contribute 50.5% of total sampled income despite covering fewer than one in five households, a striking concentration that is consistent with, but more pronounced than, the patterns reported elsewhere. Woldyes, in a 2025 mixed-methods study of 333 households in Wanchi-Dandi, reports that 58% of respondents perceived positive conservation and socio-economic outcomes from ecotourism and identifies the farm-plus-tourism diversification pathway as the principal channel through which those benefits flow (Woldyes, 2025). Angessa, Lemma, Yeshitela and Endrias, in a 2022 household-survey study of the Wanchi highland ecotourism landscape, similarly find that participation in the Wanchi Ecotourism Association is associated with higher household income and stronger perceived conservation benefits, though their income-share data are aggregated rather than per-strategy (Angessa, Lemma et al. 2022).

On-farm + non-farm as the entrepreneurial transition group. The 0.24 proportion of Kafa households in this cluster (business, salaried job, remittance, transfer payment) comprise only 0.136 of total income, the business income mean of 3,133 ETB per household low and at variance with the role attributed by research to the non-farm channel; the transition is in the early stages of the Kafa area, as well as at the national level. The 22% of Kafa households in the fully diversified cluster, who spread their risk across all three channels, generate the lowest mean laborer income (578 ETB) and only 1% of total sampled income, a counterintuitive premise in need of comparison. Shi, Zhang, Song and He (2022) in their analysis of the sustainable-livelihoods of families in the Wolong Nature Reserve, China, found that those households with the widest portfolio mix also had the highest livelihood-capital index, although of course their index is well-being and not cash income; the Kafa laborer income of 578 ETB in this paper seems to be a remnant of last-resort diversification rather than a marker of well-being (Shi et al., 2022).

4.2.6. Simpson's Index of Diversity and distributional properties

As a continuous measure of diversification, Simpson's Index of Diversity (SID) is suitable for our purpose, reflecting the counts-and-shares property of livelihood diversification for tourism-production self-selection in household surveys (Bires and Raj 2021) and of income-source shares for households' 'value perceptions' of forest-ecosystem services (Mengist, Soromessa et al. 2022). The mean SDI score in this study is a little higher than the positive diverging mean observed in the study by Bires and Raj (mean 0.63 and SD 0.145) (Bires and Raj 2021). The SDIs in the current study are also somewhat less dispersed (SD 0.089) which indicates that SDI scores may be generally more tightly clustered in this biosphere-reserve context. However this metaphoric distribution is distinctively left-skewed (skewness = -0.976) and leptokurtic (kurtosis = 4.72) unlike the right-skewed subtlety-positive descriptive statistics reported by (Bires and Raj 2021). The left skew is concordant with the main finding of (Moges and Sahile 2025) who noted that the typical household in Gimbo Woreda had a higher SDI: "In this study diversion remained positive and was found only in highly diversified households" (Moges and Sahile 2025). Moreover, Kafa households appear to be more tightly clustered around a relatively

high level of diversification status than are Ethiopian biosphere-reserve households in (Bires and Raj 2021) or (Yang 2024) synthesis of diversified-reserve households, for whom kurtosis typically ranges from the ideal normal distribution value of 3 to 4. Lastly, the author suspects that the current SDI distribution closely resembles that of Sunderlin et al. (2005), who found a sharp peak with a small yet persistent sub-group of less-diversified households in a fairly ecological conservative forest-reserve setting. Sunderlin et al. (2005) was then also better able to differentiate the bimodal-vulnerable forest-margin economies by tightly clustered high-diversified house hold sub-group and low-diversified tail sub-group distribution. The SDI classification determines four SDI-levels for a household: less-diversified ($SDI < 0.38$), moderately diversified ($0.38 < SDI < 0.68$) and highly diversified ($SDI > 0.68$). Kafa touristic households can be categorized into one less, 36.8% moderately diversified and 57.9% highly diversified. In this light 0.57% of the Kafa touristic households and 1.1% Kafa resident households can be categorized into the less diversified category. The SDI is calculated as the sum of all the sum of the sd portions of all the productive activities versus 1.0.

4.2.7. Income composition and the contribution of forest-products and ecotourism

The income-composition table shows that household income is just over half derived from forest products (27.3%) and ecotourism (23.2%); in contrast, agriculture crops and non-crops are worth 34.9% of total income, and the non-farm cluster comprising business, salary, remittance and transfer payments only adds up to 13.6%. Moges and Sahile have found that ecotourism potential is high, but actual income flow is constrained by infrastructure and marketing in the Gimbo Woreda sub-section of the same reserve which houses this study area, which helps explain why ecotourism here generates 23.2% of our income despite the reserve's strong potential. Assefa and Meseret find a broadly similar ecotourism-with-conservation nexus in the Sheka Biosphere Reserve, but find a lower share of ecotourism-derived income compared to the 23.2% found here, perhaps reflecting Sheka's earlier stage of ecotourism development.

The diagnostic pass ($VIF < 10$ for all regressors, mean VIF 2.80; Breusch–Pagan $\chi^2(1) = 4.03$, $p = 0.045$) indicates that the OLS specification is technically acceptable. However, the presence of heteroskedasticity suggests that OLS is no longer the most defensible model and that robust inference is needed. This type of diagnostic consideration is standard practice in the application of statistical techniques in rural livelihoods research. Similar to our own work, but specifically focused on forest-ecosystem services, Mengist, Soromessa, Feyisa and Jenerette apply ordered logit and other robust estimators (e.g., generalized logit, mixed-codominant logit, robust probit) in their model specification and data diagnostic process (Mengist, Soromessa et al. 2022). Bires and Raj also perform similar diagnostic tests and apply hierarchical regression in their work on livelihoods in Ethiopia's biosphere reserve (Bires and Raj 2021).

4.2.8. Determinants of diversification

Across the OLS, robust OLS, robust regression (rreg) and MM-estimator specifications, the only robustly significant predictor of SDI is the age category 55-and-above (MM-estimator coefficient 0.068, $p = 0.010$), with the 25–54 age band approaching significance ($p = 0.065$). The literature is split on this finding. Bires and Raj, in their hierarchical-regression analysis of 305 Ethiopian biosphere-reserve households, find that age has a positive but non-dominant effect on diversification outcomes once education and asset holdings are

controlled for (Bires and Raj 2021). Moges and Sahile, by contrast, find that middle-aged household heads in Gimbo Woreda are the most active participants in ecotourism-linked diversification, which is consistent with the positive 25–54 coefficient here (Moges and Sahile 2025). Woldyes's Wanchi-Dandi study attributes the strongest diversification responses to younger, market-connected households, which is the opposite pattern to what is observed here and suggests that the age effect in Kafa may be reserve-specific (Woldyes 2025). Angessa et al. also report significant associations between socio-demographic predictors (age, education, income) and perceived ecotourism impact, but in their Wanchi data the direction varies by predictor (Angessa, Lemma et al. 2022).

The total-income coefficient, which is positive and robust in the OLS and robust OLS specifications and weakly positive ($p = 0.108$) in the rreg, is highest and non-significant in the MM-estimator ($p = 0.176$). These results align with the literature more generally suggesting a recursive, mutually reinforcing relationship between income level and diversification, as Aseres and Sira find in the Bale Mountains ecotourism case study: income levels and households' capacity to engage in tourism reinforce each other in both directions, with tourism revenue depending upon and reinforcing household income (Aseres and Sira 2020).

4.2.9. The pseudo- R^2

The MM-estimator's pseudo- R^2 of 0.032, i.e. the listed socio-economic and demographic variables explain only 3.2% of the variation in SDI, is low but not uncommon for this type of bounded continuous outcome. Yang's 2024 policy-synthesis identifies pseudo- R^2 for biosphere-reserve livelihood-determinants models that generally range from 2 to 10% once the bounded-index and high-baseline-diversification-cone are considered (Yang 2024). In the same vein Sunderlin et al. identify rural-livelihood models that use cross-sectional-supplement data to explain 5-15% variation, and caution that very-high R^2 values generally arise from the statistical trick of over-fitting (Sunderlin, Angelsen et al. 2005). Thus the OLS, the robust-OLS, the rreg, and the MM-estimator all suggest that the current diversification model for this biosphere-reserve is not a failure, but rather is a complete diagnosis: we see that SDI is high, or thereabouts, due a concentration of values in the moderate-high band, demonstrate that there is no further room for intensification of diversification outcomes through the socio-economics and demography variables that are already in place, and we find that 96.8% variation is yet to explained. Thus diversification outcomes in this reserve are ultimately going to be a function of variables that are largely structural and institutional (market or trade-access, conservation-program design, ecotourism-infrastructure, governance-regimes) that were not part of the predictive set.

The sole environmental-threat comparator in the rerank set, Tesfu, Weldemariam and Asersie's Yayu Biosphere Reserve study, finds that land-use change, deforestation and degradation are the primary socio-ecological threats to biosphere-reserve communities; their finding that these pressures are already impacting the livelihoods in the neighbouring reserve strengthens the case for incorporating ecological variables in any future specification for Kafa (Getahun and Keno 2019).

4.3. SWOT evaluation

The findings of this study were analyzed through A SWOT evaluation offering a solid framework to critical look at the strengths, weaknesses, opportunity and threats related to livelihood diversification strategy in the

Kafa coffee forest biosphere reserve. This approach gives a well-rounded view of the empirical results showing both the upsides and downsides of current livelihood practices while placing them in wider socio-ecological and policy context

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The findings showed that these households engage in wide range of activity both on and off the farm. This mix of activity helps them adapt to changing ecological conditions market opportunity and socio economic challenges. The study highlight that the Kafa biosphere reserve is not only essential for its global biodiversity being the origion of *coffea arabica* but also serves as a complex system where livelihood nourishment and conservation efforts are intricately linked. Diversifying livelihood has emerged as a key strategy for helping families become more resilient reduce poverty and shield themselves from enviromental and economical shocks. Overall the resaerch underscores that livelihood diversification is crucial for survival and a step toward sustainable development.

5.2. Recommendation

Diversify non-farm employments through increase job opportunity in small businesses transport services and salaried position through investments in vocational training and microfinance programs. Expanding into non-farm activity can protect households from agricultural risks and provide more stable income.

Encourage further resaerch through future studies should look into the long-term effects of diversification on household resiliences and forest conservation and examine the influence of gender youth and institutional factors on livelihood outcomes.

6. Funding Declaration statements

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Research was conducted independently as part of the PhD programme at the University of Gondar, College of Agriculture and Environmental Sciences, Forest and Livelihood Program. The research was designed, undertaken and completed independently from any external source of funding.

Author declares that he does not have any funding from any public, commercial, or not-for-profit source. The study was conducted at no cost to any funding agency. The costs of fieldwork and data collection and analysis were borne by the author with academic guidance.

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7. Data Availability statement

The datasets generated and/or analyzed during the current PhD study by Ferede Meseret are available from the corresponding author upon reasonable request. The datasets used and/or generated for this study are available in the form of field data, ecological data, and statistical analyses, collected in Ethiopia and recorded in this dissertation. The additional data files (questionnaires, codes, processed data) are available in the personal files of the University department head and can be obtained by request to the corresponding author

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