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Nexus between Livelihood Strategies and Food Security Status in Landslide-prone Areas of the Gammo Highlands, South Ethiopia: A Quantitative Analysis

Lemma Tadesse*, Abera Uncha, and Thomas Toma

Arba Minch University, Department of Geography and Environmental Studies, Ethiopia

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*** Corresponding author:**
E-mail:
tadesse_lemma@yahoo.com

ABSTRACT

Investigating the relationship between various livelihood strategies and food security status is crucial to understanding how different economic activities impact access to food security. This study explores the relationship between multiple livelihood strategies and the food security status among rural households vulnerable to landslide hazards in the Gacho Baba District of the Gammo Highlands South Ethiopia. Data were collected from 289 statistically selected sample households in the district employing multistage sampling techniques. Questionnaires assessed the demographic, socioeconomic, and food security-related data. Meanwhile, livelihood strategies were categorized based on on-farm, off-farm, and non-farm activities. Food security status was assessed using the Household Food Insecurity Access Scale (HFIAS), Food Consumption Score (FCS), and Reduced Coping Strategies Index (RCSI). Pearson correlation and one-way Multivariate Analysis of Variance (MANOVA) were inferential statistical tools used for data analysis. The Pearson correlation analysis revealed significant negative associations between livelihood strategies and food insecurity indicators. This suggests that diversifying livelihood activities is the best way to lower levels of food insecurity. Furthermore, the MANOVA results underscored the substantial impact of livelihood strategies on food security outcomes, underscoring the pivotal role of livelihood diversification in bolstering food security. Post hoc comparisons underscored the benefits of combining on-farm, off-farm, and non-farm activities for improved food security outcomes. The findings emphasize the need for targeted interventions promoting livelihood diversification to mitigate food insecurity risks among vulnerable rural households. Further research is warranted to explore underlying mechanisms and develop tailored strategies addressing multifaceted challenges in accessing nutritious food.

1. INTRODUCTION

The global dialogue surrounding food security emphasizes the critical need to comprehend the relationship between livelihood strategies and food security (FAO, 2023). With millions worldwide grappling with hunger and malnutrition, food security remains a pressing concern (Agostoni et al., 2023; Balehegn et al., 2020). Livelihood strategies, spanning various activities from agricultural practices to off-farm employment opportunities, significantly influence households' ability to obtain food resources (Fitzpatrick et al., 2019). Nevertheless, environmental hazards like landslides present formidable obstacles to food production and distribution, exacerbating food insecurity worldwide (Adu-Baffour et al., 2021).

In Africa, where a significant portion of the population relies on agriculture for livelihood and sustenance, the nexus between livelihood strategies

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and food security assumes heightened importance (Asiedu et al., 2017). Subsistence farming remains prevalent, particularly in rural areas, where smallholder farmers face myriad challenges, including land degradation, erratic rainfall, and limited access to inputs and markets (FAO, 2022). Consequently, food insecurity is pervasive across the continent, with millions grappling with hunger and malnutrition (Alexander et al., 2016).

Within Sub-Saharan Africa, environmental vulnerabilities further compound the challenges of food security (Pawlak and Kolodziejczak, 2020). Landslides, triggered by factors such as deforestation and heavy rainfall, pose a significant threat to livelihoods and food production (Kurnia and Hizbaron, 2020). In countries like Ethiopia, where rugged terrain and climatic variability are prevalent, landslide-prone areas pose unique challenges to food production and distribution (Anderson et al., 2021). Against this backdrop, exploring the interplay between livelihood strategies and food security status has added significance as policymakers and practitioners seek sustainable solutions to address hunger and poverty (Kassegn and Endris, 2021). Understanding how different livelihood strategies affect food security among rural households is crucial for developing effective interventions to enhance food security in these vulnerable communities (USAID, 2022).

In southern Ethiopia, the Gamo Zone is characterized by its diverse topography, ranging from fertile valleys to steep mountain slopes (Yirgu, 2022; Amejo, 2018; Assefa and Bork, 2016). However, this scenic landscape belies the challenges communities face, particularly in areas prone to landslides (Shano et al., 2021). The Gacho Baba district, nestled within the Gamo Zone, exemplifies the complex dynamics, where households struggle with environmental hazards while striving to secure their livelihoods and food security (Cholo et al., 2019). Agriculture serves as the primary livelihood source, but the sustainability of farming practices is threatened by different natural hazards, particularly landslides (Tadesse et al., 2024b). Hence, understanding how livelihood strategies interconnect with food security is paramount in addressing the ongoing crisis regarding food security (Kassegn and Endris, 2021). Therefore, this study investigated the connection between livelihood strategies and food security status. Specifically, (1) to investigate the correlation between households' livelihood strategies and their food security status, (2) to analyze the effect of specific livelihood strategies on household food security status of rural households in the Gacho Baba district of Gamo Highlands South Ethiopia.

2. METHODOLOGY

2.1 Description of the study area

Gach-Baba District, placed within the Gamo Zone of the South Ethiopia Regional State, encompasses the Gamo Highlands. Astronomically, it spans between 5°38'30" and 6°10'50" N latitude and 37°20'30" and 37°31'30" E longitude (Figure 1). The district comprises 11 rural villages: Gatse, Koddo, Wusamo, Merche, Tsayite, Zegiti Bakole, Gerbenssa-Tsenkile, Kuyile, Laka, Zegiti Feriso, and Mazo-Doyisa. Physically, the terrain of the study area is characterized by undulating features that predispose it to various natural hazards. Its topography mainly consists of hills, reaching a maximum elevation of 3,493 meters above sea level, with a general decrease in elevation from west to east. The rugged topography of the Gamo Highlands divides the area into three distinct agroecological zones based on altitude: temperate (37%), cool (39%), and (24%) (Tadesse et al., 2024b).

While agriculture in this region is vulnerable to climate effects, it remains the primary means of sustenance, like many rural areas in Ethiopia, with weaving also being significant within Gamo communities. *Ensete ventricosum* (commonly known as *enset*), potatoes, and cereals, particularly barley, and wheat, form the cornerstone of livelihoods in this region (Massa and Mosa, 2021). However, productivity is hindered by small landholdings, land fragmentation, and poor soil fertility due to various human and natural hazards (Cholo et al., 2018). Consequently, livelihoods in recent times have shifted towards subsistence agriculture and some off-farm economic activities. According to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA, 2021) the population of the Gach-Baba District totaled 101,786, with 51,088 males and 50,697 females. The population structure indicates a young dependency ratio (individuals under the age of 14) of 48.3% and an old dependency ratio (individuals over the age of 64) of 2.7%.

2.2 Methods, data types, and sampling

In the study, a quantitative research approach was utilized to gather and analyze data, a method commonly favored in food security and livelihood strategies studies for its usefulness following the

philosophical underpinnings of post-positivism (Dawadi et al., 2021; Wasti SP et al., 2022). Data were gathered from a statistically determined 289 sample of rural households vulnerable to landslide hazards (Table 1). Thus, the household served was used as the unit of analysis.

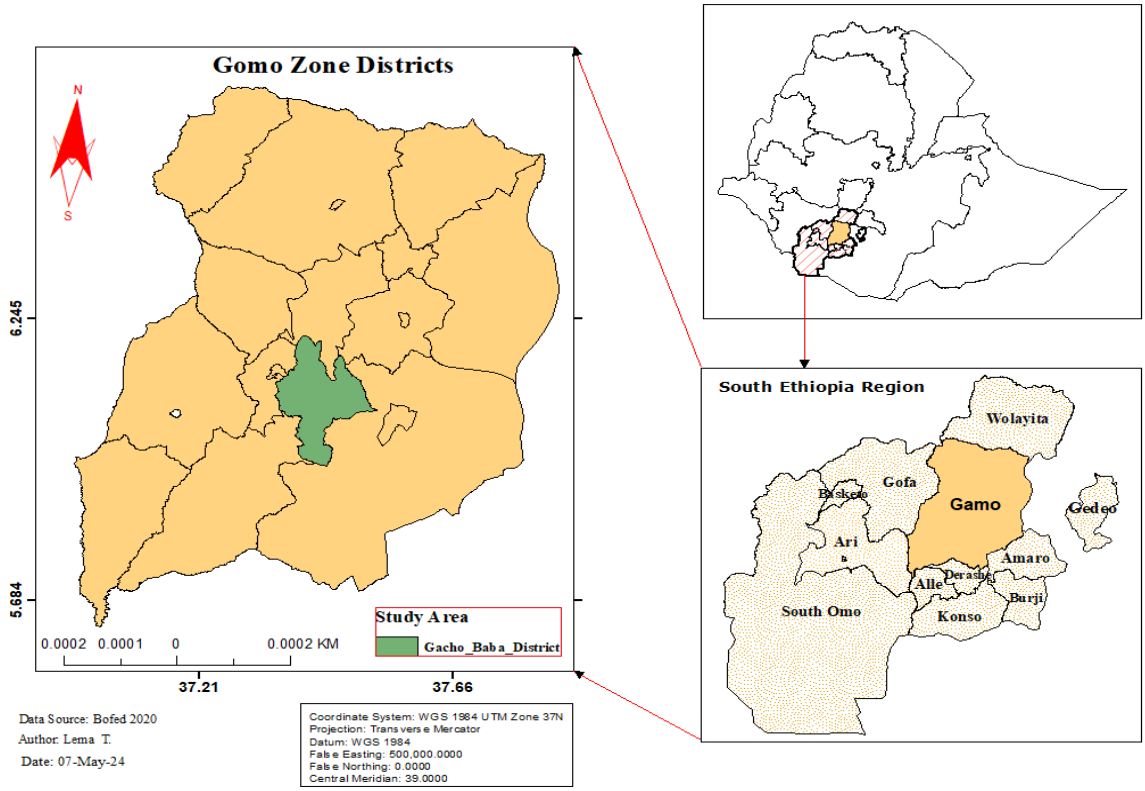

Figure 1. Locational map of the study area

Multistage sampling techniques were utilized, with the non-probability sampling method of purposive sampling being employed to select the study district and sample villages. The Gacho Baba District was purposively chosen due to the researchers' familiarity with its vulnerability to natural hazards. Moreover, the studies have aimed to investigate the linkage between livelihood strategies, and the food security status of rural households in landslide-prone areas. Five out of the 11 villages namely, Gatse, Kodo, Wusamo, Zigiti Merche, and Tsayite, were purposefully selected since these villages are repeatedly affected by landslide hazards negatively impacting livelihood strategies (Tadesse et al., 2024a). Only households in these five villages affected by landslides were included in the study population. After considering various options the required sample size 'n' and the total number of households studied 'N' were determined based on Yamane's (1967) formula, with a precision level (e) of 0.05 and a confidence level of 95% at p = ±5, assuming an existence probability of events as 1.

$$\text{Population, which is illustrated as } = \frac{N}{1+N(e^2)} \text{ Thus, } n = \frac{1{,}045}{1+1{,}045(0.05^2)} = 289 \text{ households} \quad (1)$$

A list of all households' sample frames (N) in each of the five villages was obtained from the records of local administration offices. To ensure gender balance, female and male-headed households were selected using systematic random sampling techniques based on their availability to maintain the proportionality of the sample size. As indicated in Equation 1 the total population list or sample frame becomes 1,045 household heads who had experienced frequent landslide hazards. Consequently, the sample size for each village was selected proportionally using systematic probability sampling techniques (Table 1). As a result, the sample size (n) became 289 household heads.

Table 1. Distribution of the target population, sample, and sampling techniques

No.	Villages (Purposive sampling)	Total HH venerable to landslides hazard (purposive sampling)			Sample HH (Proportional systematic sampling)			Percentage
		M	F	Total	M	F	Total	
1	Gatse	266	1	267	73	1	74	26
2	Kodo	217	3	220	58	3	61	21
3	Wusamo	200	0	200	55	0	55	19
4	Zegiti Merch	199	1	200	54	1	55	19
5	Tsayite	154	4	158	40	4	44	15
Total		1,036	9	1,045	280	9	289	100

To make the process effective, 20 data collectors (5 for each village, but the length of dates of data collection differ based on sample size) and, 5 facilitators (1 for each village) who are properly trained on how to approach respondents and handle the entire data together with the researcher was engaging in the data collection process.

2.3 Instruments of data collection

Questioners composed of closed-ended and open-ended types were this research's primary data collection tools. The questionnaires covered various issues including demographic and socio-economic characteristics of respondents, livelihood strategies, and issues related to food security. Questions related to food security relied on food in/security measurement scores, particularly the Household Food Security Access Scale (HFIAS), the Food Consumption Scale (FCS), and the Reduced Copping Strategies Index (RCSI), obtained from the (Kini, 2022; WFP, 2016; WFP, 2008; USDA, 2000). These are advocated for their quick, precise, and cross-contextual indication of food security (Yenesew and Masresha, 2019).

The questionnaires related to livelihood strategies were also composed of both close-ended and open-ended types of questions that covered various issues regarding livelihood strategies, and related issues. Questions were adapted and developed after reviewing different literature. Before data collection began, the questionnaire was first tested in a pilot study conducted in the rural village of Zegiti-Bakole where actual data collection was not conducted but in similar situations. The objective of the pilot study was to confirm the questionnaires' dependability/internal consistency using Cronbach's alpha to assess the degree to which each item connected with the survey's overall results. It showed the dependability to be 86% for the survey items examining types of livelihood strategies used. Thus, the examination performance of the items verified the validity of the instruments since statistical literature suggests a reliability of 70% and higher for basic research (Haji-Othman et al., 2021; Nunnally, 1978).

2.4 Methods of data analysis

The analysis of this study began with the application of Pearson correlation to examine the relationship between livelihood strategies and various household food security indicators, including HFIAS, FCS, and RCSI. The Pearson correlation coefficient is instrumental in identifying potential associations between variables (Schober et al., 2018). In this context, using Pearson correlation to measure the correlations between household livelihood strategies and food security status is crucial. It quantifies the strength and direction of linear relationships between variables, offering valuable insights into how changes in one variable may be associated with changes in another. According to Nunnally (1978), the Pearson r can be calculated as the mean of the sum of the product of z-scores, mathematically described as:

$$\gamma = \frac{1}{n-1} \sum_{i=1}^{n} \left(\frac{X_i - \bar{X}}{S_X}\right)\left(\frac{Y_i - \bar{Y}}{S_Y}\right) \quad (2)$$

Following these steps, the Pearson correlation coefficient indicates the strength and direction of the linear relationship between the two variables X and Y. The value of r ranges from (-1 to 1), where; r=1 indicates a perfect positive linear relationship, r=-1 indicates a perfect negative linear relationship, and r=0 indicates no linear relationship.

After the correlation analysis, the study proceeded to delve deeper into the examination of the effect of livelihood strategies on households' overall food security status through the utilization of one-way MANOVA (Multivariate Analysis of Variance). With the presence of single with multiple independent

variables (livelihood strategies) and multiple dependent variables (comprising the food security indicators, HFIAS, FCS, and RCSI), for these types of variables, one-way MANOVA emerged as an apt statistical tool (Sadik and Alwan, 2020). Because one-way MANOV facilitated a comprehensive assessment of potential differences in the combined set of dependent variables, reflective of overall food security status, across varying levels of the independent variable distinct livelihood strategies (Khamis and El-Refae, 2020). Therefore the study used one-way MANOVA to find how different livelihood strategies were connected to overall household food security in the study area. To sum up, the study used Pearson correlation and one-way MANOVA to thoroughly understand how different ways households make a living affect their overall food security. By applying these statistical methods, the research finds potential connections and identifies important differences in food security among various livelihood strategies.

3. RESULTS

3.1 Households' livelihood strategies and food security status

Data on households' livelihood strategies were collected using 18 items, which were categorized into on-farm, off-farm, and non-farm activities. The survey findings revealed that the farming households employed a variety of strategies to support their livelihoods (Figure 2). A significant majority of the households, 56% or 163 households, relied exclusively on on-farm activities. These households depended solely on agricultural activities for their income and sustenance, highlighting a strong reliance on traditional farming methods. Another group, comprising 13% of the households, combined on-farm and off-farm activities. These households diversified their income sources by engaging in both agricultural work and supplementary off-farm activities, which might include local employment or other forms of labor outside their farms. Additionally, 12% of the households engaged in both on-farm and non-farm activities.

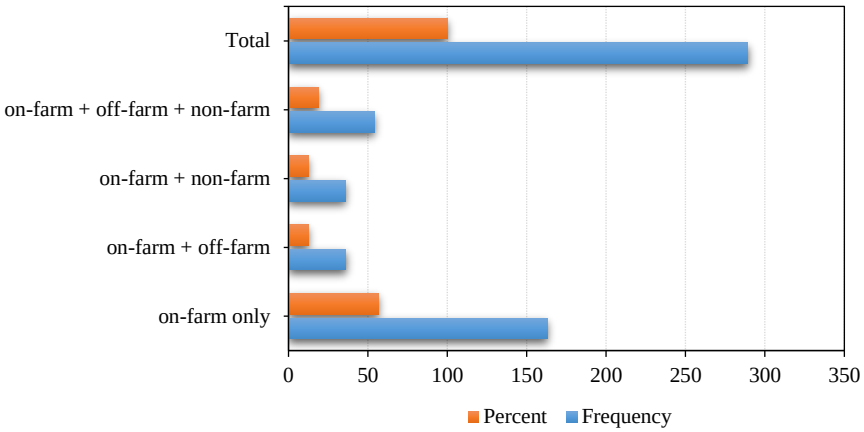

Figure 2. Percentages of household livelihood strategies choice (N=289)

This combination indicates a strategy where households not only rely on farming but also involve themselves in non-agricultural businesses or services, providing a broader base for economic stability. Finally, 19% of the households adopted a holistic approach by incorporating on-farm, off-farm, and non-farm activities. These households utilized a comprehensive strategy to sustain their livelihoods, balancing agricultural work with various other income-generating activities. These findings illustrate the diverse strategies farming households use to support their livelihoods, reflecting their adaptability and resourcefulness in managing economic challenges.

Regarding the food security status of households, data was collected using three food insecurity indicator scales: the Household Food Insecurity Access Scale (HFIAS), the Food Consumption Scores (FCS), and the Reduced Coping Strategies Index (RCSI). The results were presented as follows: The findings from the HFIAS shed light on the varied food security challenges of vulnerable households. Among the households surveyed, a considerable number faced some level of food insecurity. Specifically, 38% of households were food secure, while 12% experienced mild food insecurity. Furthermore, 34% of households were moderately food insecure, and 16% were classified as severely food insecure. These statistics highlight the critical need for targeted interventions to address vulnerable

groups' unique needs and mitigate the adverse effects of food insecurity within communities (Figure 3).

The investigation of food consumption scores (FCS) among households also delineates distinct consumption categories, shedding light on the dietary patterns within the surveyed households (Figure 4). Among the households, 51.3% were classified as "Poor" in terms of food consumption, indicating significant limitations in accessing adequate and diverse food sources. Another 34.9% fell into the "Borderline" category, suggesting precarious food access and potential vulnerability to food insecurity.

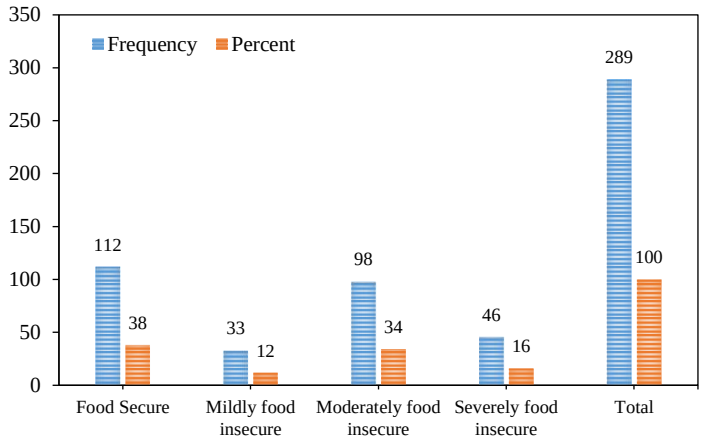

Figure 3. Households' food in/security status (HFIAS) based categorization scheme

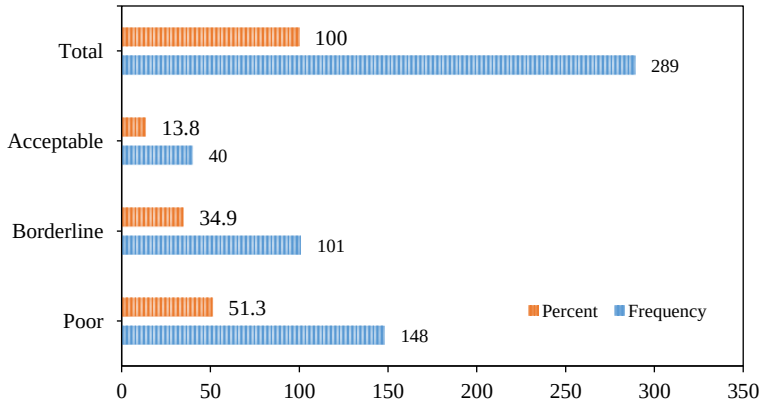

Figure 4. Food consumption score based on food consumption groups of the households

Conversely, 13.8% of households were deemed to have "Acceptable" food consumption levels. These findings underscore the heterogeneous nature of food access and consumption within the community, emphasizing the urgency of targeted interventions to address food insecurity and improve dietary diversity among vulnerable households.

The analysis of consumption coping strategies, measured by the Reduced Coping Strategies Index (RCSI) and its associated severity weights, provides valuable insights into the adaptive mechanisms employed by households facing food insecurity (Figure 5). The severity weights for RCSI were categorized into three levels: low coping (CSI 0-3), medium coping (CSI=4-9), and high coping (CSI≥10). Among the surveyed households, 15.6% exhibited low coping strategies, indicating a relatively lower degree of reliance on coping mechanisms to address food insecurity. In contrast, a larger proportion, constituting 31.1% of households, adopted medium coping strategies, signifying a moderate reliance on coping mechanisms to manage food shortages. Remarkably, the majority of households, comprising 53.3%, demonstrated high coping strategies, indicative of a significant dependence on coping mechanisms to endure severe food insecurity. These findings underscore the adaptive resilience of households in the face of food insecurity challenges, while also highlighting the pressing need for comprehensive interventions to alleviate the underlying causes of food insecurity and reduce households' reliance on coping mechanisms.

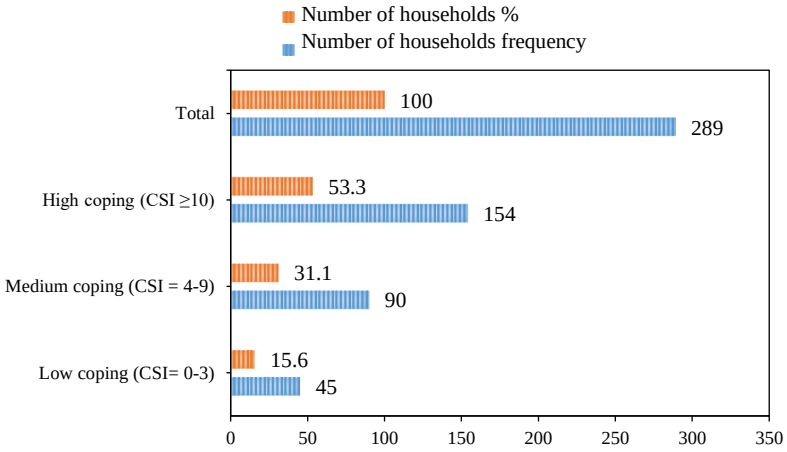

Figure 5. Consumption coping strategies and associated severity weight for RCSI

4. DISCUSSION

4.1 Correlation between households' livelihood strategies and their food security status

In this study, Pearson correlation was utilized to identify whether certain livelihood practices were positively or negatively correlated with food security indicators. Thus, Pearson correlation aids in detecting potential trends and patterns within the data verifying all assumptions, including continuous variables, a linear relationship between variables, the absence of significant outliers, and approximate normal distribution.

As shown in Table 2 the correlation analysis between households' livelihood strategies and food security measures (HFIAS, FCS, and RCSI) revealed significant associations. Households' Livelihood Strategies exhibited a strong negative correlation with HFIAS (r=-0.598, p<0.01), indicating that as Livelihood Strategies increase, the severity of food insecurity access decreases. The result aligns with prior findings (Tadesse et al., 2022; Asfaw et al., 2017) indicating that as livelihood strategies diversify, the severity of food insecurity access decreases. The finding possibly reaffirms the notion that diversified livelihoods are crucial in alleviating food insecurity challenges.

Table 2. Correlations between household's livelihood strategies and food security status

Correlations					
Household livelihood strategies vs food security status		LS	HFIAS	FCS	RCSI
Households livelihood strategies	Pearson correlation	1	-0.598**	0.413**	-0.395**
	Sig. (2-tailed)		0.000	0.000	0.000
	N	289	289	289	289
HFIAS	Pearson correlation	**-0.598****	1	-0.613**	**0.689****
	Sig. (2-tailed)	0.000		0.000	0.000
	N	289	289	289	289
FCS	Pearson correlation	**0.413****	**-0.613****	1	**-0.625****
	Sig. (2-tailed)	0.000	0.000		0.000
	N	289	289	289	289
RCSI	Pearson correlation	-0.395**	0.689**	-0.625**	1
	Sig. (2-tailed)	0.000	0.000	0.000	
	N	289	289	289	289

**Correlation is significant at the 0.01 level (2-tailed).

Additionally, a moderate positive correlation was observed between Livelihood Strategies and FCS (r=0.413, p<0.01), suggesting that households with more diverse livelihood strategies tend to have better food consumption scores. Furthermore, significant negative correlations were found between HFIAS and both FCS (r=-0.613, p<0.01) and RCSI (r=-0.689, p<0.01), indicating that higher levels of food

insecurity access are associated with lower food consumption scores and increased reliance on coping strategies. The moderate positive correlation between livelihood strategies and FCS corroborates earlier research (Giannini et al., 2021) suggesting that households with more diverse livelihood strategies tend to have better food consumption scores. Similarly, the significant negative correlations between HFIAS and both FCS reinforce the understanding that higher levels of food insecurity access are associated with lower food consumption scores and increased reliance on coping strategies, consistent with prior findings (Mekonnen and Gerber, 2017).

Moreover, a significant negative correlation was observed between FCS and RCSI ($r=-0.625$, $p<0.01$), implying that households with better food consumption scores tend to have a lower reliance on coping strategies. The observed negative correlation between FCS and RCSI supports previous research (Almukaddem et al., 2022) indicating that households with better food consumption scores typically have lower reliance on coping strategies. Overall, these findings add to the body of evidence highlighting the intricate relationship between livelihood strategies and various dimensions of food security and underscore the importance of implementing targeted interventions aimed at promoting diversified livelihoods to enhance food security outcomes for vulnerable households.

4.2 The effect of livelihood strategies on the food security status of rural households

One-way Multivariate Analysis of Variance (MANOVA) serves as a crucial statistical tool for investigating the impact of livelihood strategies on the households' food security status (Sadik and Alwan, 2020). simultaneously analyzing multiple dependent variables, such as food insecurity access, consumption patterns, and coping strategies, MANOVA enables a comprehensive assessment of the complex dynamics underlying household food security in rural settings (Finch, 2022; Shone et al., 2017). Moreover, MANOVA's ability to account for correlations between dependent variables and identify multivariate patterns allows for a more nuanced understanding of the relationship between livelihood strategies and food security, thereby guiding efforts to enhance the well-being of rural communities facing food insecurity challenges (Khamis and El-Refae, 2020).

Firstly, as shown in Table 3 the summary of the one-way MANOVA model was run to cheeks the assumption, and the output provides valuable insights into the overall significance of the Intercept and LS (Households Livelihood Strategies) which are independent variable effects on the food security indicators which are dependent variables. The multivariate tests, including Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, offer comprehensive assessments of the relationships between the independent and dependent variables. As the result revealed for the Intercept effect, all multivariate test statistics exhibit extremely low p-values (Sig.=0.00), indicating highly significant effects. This suggests that there are significant differences between groups in terms of the combined dependent variables. The large values of Pillai's Trace, Hotelling's Trace, and Roy's Largest Root also further affirm the substantial effect of the intercept (Finch, 2022; Maposa et al., 2010).

Table 3. Model summary of one-way MANOVA (multivariate tests)

Multivariate tests						
Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	0.952	1865.218[b]	3.000	283.000	0.000
	Wilks' Lambda	0.048	1865.218[b]	3.000	283.000	0.000
	Hotelling's Trace	19.773	1865.218[b]	3.000	283.000	0.000
	Roy's Largest Root	19.773	1865.218[b]	3.000	283.000	0.000
LS	Pillai's Trace	0.526	20.200	9.000	855.000	0.000
	Wilks' Lambda	0.486	26.433	9.000	688.898	0.000
	Hotelling's Trace	1.034	32.365	9.000	845.000	0.000
	Roy's Largest Root	1.010	95.982[c]	3.000	285.000	0.000

[a]Design: Intercept + LS; [b]Exact statistic; [c]The statistic is an upper bound on F that yields a lower bound on the significance level.

Moving to the LS effect, again, all multivariate test statistics demonstrate highly significant results (Sig.=0.000). This implies that there are significant differences between groups regarding the dependent variables when considering the LS variable (Landler et al., 2022; Barnett, 2020). The values of Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root indicate the magnitude of the LS effect on the dependent variables (Ates et al., 2019; Brown, 2014; Tabachnick and Fidell, 2013). The design statement clarifies the composition of the model, indicating that both the intercept and LS variables are included in the analysis. The notation about exact statistics (b. Exact statistic) suggests that the reported values are precise rather than approximations. Furthermore, the note about Roy's Largest Root (c. The statistic is an upper bound on F that yields a lower bound on the significance level) provides additional context for interpreting this statistic, indicating its conservative estimate of significance (Sadik and Alwan, 2020; Maposa et al., 2010).

Overall, the results from the Multivariate Tests table confirm that both the intercept and LS variables have significant effects on the dependent variables. These findings underscore the importance of considering both the baseline (intercept) and the LS variable when analyzing the multivariate relationship between the independent and dependent variables. The highly significant results suggest that these effects are not due to random chance but reflect meaningful differences between groups in terms of the combined dependent variables.

Secondly, the analysis of the one-way MANOVA (Table 4) regarding the effect of livelihood strategies on the food security status of rural households reveals significant conclusions across multiple dependent variables. The tests of between-subjects effects indicate substantial impacts of livelihood strategies on household food security, as reflected in the Type III Sum of Squares and associated F-statistics. For the HFIAS, FCS, and RCSI, the Type III Sum of Squares values are notable, with corresponding F-statistics indicating highly significant effects ($p<0.001$). These results emphasize the importance of considering livelihood strategies in understanding variations in food security outcomes among rural households. The finding allied with the findings of (Landler et al., 2022) that endorse the higher R-squared indicates significant relationships between variables. In this regard, the higher R-squared values in this analysis that is 0.492 for HFIAS, 0.265 for FCS, and 0.268 for RCSI suggest that a substantial proportion of the variance in food security status can be attributed to differences in livelihood strategies. Additionally, the adjusted R-squared values provide further confirmation of the robustness of these relationships, indicating that the effects of livelihood strategies on food security remain significant even after adjusting for potential confounding factors. Overall, these findings highlight the critical importance of addressing livelihood strategies in developing interventions and policies aimed at enhancing food security and resilience among rural households.

Table 4. Summary of One-way MANOVA about the effect of livelihood strategies on the food security status of rural households

Tests of between-subjects effects						
Independent variable	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.
Livelihood strategies	HFIAS	66.917	3	22.306	92.029	0.000
	FCS	49.777	3	16.592	34.264	0.000
	RCSI	52.457	3	17.486	34.854	0.000
a. R Squared=0.492 (Adjusted R squared=0.487)						
b. R Squared=0.265 (Adjusted R squared=0.257)						
c. R Squared=0.268 (Adjusted R squared=0.261)						

Finally, the post hoc comparisons following the one-way MANOVA (Table 5) analysis provide detailed insights into the specific differences in food security status among rural households based on their adopted livelihood strategies (Landler et al., 2018). Using the Bonferroni correction method, post hoc comparisons were conducted for variations in food security outcomes across different combinations of livelihood strategies and HFIAS, FCS, and RCSI scores (Table 5). The comparisons reveal significant mean differences between various combinations of livelihood strategies. Notably, households engaging in a combination of on-farm, off-farm, and non-farm activities consistently show the most favorable food

security outcomes across all three variables, with significantly lower HFIAS scores, higher FCS scores, and fewer RCSI employed compared to households with other livelihoods strategies. Conversely, households solely relying on on-farm activities tend to experience higher levels of food insecurity, lower food consumption scores, and more pronounced coping strategies, highlighting the potential benefits of livelihood diversification in improving food security among rural households, which is aligned with findings of (Tesema and Berhanu, 2018; FAO et al., 2014) revealing the positive impact of diversified income sources on household resilience and food security.

Moreover, the post hoc comparisons underscore the importance of considering the additive effects of different livelihood strategies on food security outcomes. Such as households combining on-farm and off-farm activities demonstrate significantly better food security indicators compared to those solely engaged in on-farm activities, indicating the potential synergistic benefits of diversifying livelihood sources. These findings align with (Kassegn and Endris, 2021) emphasizing the positive associations between livelihood diversification and food security, as diverse income streams can buffer households against agricultural shocks and income volatility, ultimately improving overall food access and dietary diversity.

Table 5. The post hoc comparison of One-way MANOVA about the effect of livelihood strategies on the food security status of rural households

Multiple comparisons							
Bonferroni							
Dependent variable	(I) Households livelihood strategies	(J) Households livelihood strategies	Mean difference (I-J)	Std. error	Sig.	95% Confidence interval	
						Lower bound	Upper bound
HFIAS	On-farm only	On-farm + off-farm	0.0198	0.09066	1.000	-0.2211	0.2607
		On-farm + non-farm	0.0723	0.09066	1.000	-0.1686	0.3131
		On-farm + off-farm + non-farm	1.2472*	0.07730	**0.000**	1.0418	1.4525
	On-farm + off-farm	On-farm only	-0.0198	0.09066	1.000	-0.2607	0.2211
		On-farm + non-farm	0.0525	0.11604	1.000	-0.2558	0.3608
		On-farm + off-farm + non-farm	1.2274*	0.10593	0.000	0.9459	1.5088
	On-farm + non-farm	On-farm only	-0.0723	0.09066	1.000	-0.3131	0.1686
		On-farm + off-farm	-0.0525	0.11604	1.000	-0.3608	0.2558
		On-farm + off-farm + non-farm	1.1749*	0.10593	**0.000**	0.8935	1.4563
	On-farm + off-farm + non-farm	On-farm only	-1.2472*	0.07730	**0.000**	-1.4525	-1.0418
		On-farm + off-farm	-1.2274*	0.10593	**0.000**	-1.5088	-0.9459
		On-farm + non-farm	-1.1749*	0.10593	**0.000**	-1.4563	-0.8935
FCS	On-farm only	On-farm + off-farm	-0.0776	0.12815	1.000	-0.4181	0.2628
		On-farm + non-farm	0.0821	0.12815	1.000	-0.2584	0.4226
		On-farm + off-farm + non-farm	-1.0591*	0.10926	**0.000**	-1.3494	-0.7688
	On-farm + off-farm	On-farm only	0.0776	0.12815	1.000	-0.2628	0.4181
		On-farm + non-farm	0.1597	0.16402	1.000	-0.2761	0.5955
		On-farm + off-farm + non-farm	-0.9815*	0.14973	**0.000**	-1.3793	-0.5837
	On-farm + non-farm	On-farm only	-0.0821	0.12815	1.000	-0.4226	0.2584
		On-farm + off-farm	-0.1597	0.16402	1.000	-0.5955	0.2761
		On-farm + off-farm + non-farm	-1.1412*	0.14973	**0.000**	-1.5390	-0.7434
	On-farm + off-farm + non-farm	On-farm only	1.0591*	0.10926	**0.000**	0.7688	1.3494
		On-farm + off-farm	0.9815*	0.14973	**0.000**	0.5837	1.3793
		On-farm + non-farm	1.1412*	0.14973	**0.000**	0.7434	1.5390

Table 5. The post hoc comparison of One-way MANOVA about the effect of livelihood strategies on the food security status of rural households (cont.)

Multiple comparisons							
Bonferroni							
Dependent variable	(I) Households livelihood strategies	(J) Households livelihood strategies	Mean difference (I-J)	Std. error	Sig.	95% Confidence interval	
						Lower bound	Upper bound
RCSI	On-farm only	On-farm + off-farm	-0.1752	0.13044	1.000	-0.5218	0.1713
		On-farm + non-farm	-0.0919	0.13044	1.000	-0.4384	0.2547
		On-farm + off-farm + non-farm	1.0414*	0.11121	**0.000**	0.7460	1.3369
	On-farm + off-farm	On-farm only	0.1752	0.13044	1.000	-0.1713	0.5218
		On-farm + non-farm	0.0833	0.16695	1.000	-0.3602	0.5269
		On-farm + off-farm + non-farm	1.2167*	0.15240	**0.000**	0.8118	1.6216
	On-farm + non-farm	On-farm only	0.0919	0.13044	1.000	-0.2547	0.4384
		On-farm + off-farm	-0.0833	0.16695	1.000	-0.5269	0.3602
		On-farm + off-farm + non-farm	1.1333*	0.15240	**0.000**	0.7284	1.5382
	On-farm + off-farm + non-farm	On-farm only	-1.0414*	0.11121	**0.000**	-1.3369	-0.7460
		On-farm + off-farm	-1.2167*	0.15240	**0.000**	-1.6216	-0.8118
		On-farm + non-farm	-1.1333*	0.15240	**0.000**	-1.5382	-0.7284

Based on observed means. The error term is mean square (error) = 0.502.

*The mean difference is significant at the 0.05 level.

In conclusion, the post hoc comparisons following the one-way MANOVA analysis provide valuable insights into the complex relationships between livelihood strategies and food security outcomes among rural households. By elucidating the differential impacts of various livelihood combinations on food security indicators, these findings offer actionable guidance for policymakers and development practitioners seeking to design effective interventions to promote food security and resilience in the study areas. However, further research is needed to explore the underlying mechanisms driving these observed differences and to develop targeted strategies that address the multifaceted challenges facing rural households in accessing adequate and nutritious food.

5. CONCLUSION AND RECOMMENDATION

The study provided valuable insights into how different livelihood strategies affect food security among rural households, in landslide-prone areas employing food security measurement scores such as the Household Food Insecurity Access Scale (HFIAS), Food Consumption Score (FCS), and Reduced Coping Strategies Index (RCSI) to measure various aspects of food security. The comprehensive data gathered from these tools allowed for a nuanced understanding of the complex relationships between livelihood strategies and food security outcomes, offering critical information for developing targeted interventions to enhance food security among vulnerable rural communities. The study found that households used various livelihood strategies, significantly impacting food security. Most households depended solely on farming, but those that combined farming with off-farm and non-farm activities had better food security outcomes. The study also revealed that households with diversified livelihoods had less food insecurity, better food consumption scores, and fewer coping mechanisms. Those engaged in a mix of farming, off-farm, and non-farm activities showed better food security indicators. This highlights the importance of diversifying livelihood strategies to improve resilience against food insecurity.

Using one-way MANOVA, the study showed that different livelihood strategies had significant impacts on various dimensions of food security. The findings emphasized the need for interventions that consider the diverse livelihood strategies of households, especially those that promote diversification and income-generating activities. Post hoc comparisons gave detailed insights into how different livelihood combinations affected food

security, helping policymakers design better-targeted interventions to improve food access and resilience.

Finally, the study highlights the importance of diversifying livelihood strategies for improving food security in rural, landslide-prone areas. Policymakers should prioritize programs that encourage households to engage in a mix of farming, off-farm, and non-farm activities. This could involve providing training, resources, and incentives for rural communities to diversify their income sources, which in turn could enhance their resilience to food insecurity. It also calls for additional research to better understand the mechanisms through which livelihood strategies affect food security. Policymakers should support and fund research initiatives that explore these dynamics, particularly about environmental factors like landslides, to inform more comprehensive and effective food security strategies.

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DECLARATIONS

Ethics approval and consent to participate: Approval to conduct research and collect data from respondents was obtained from Arba Minch University Department of Geography and Environmental Studies with a research permit of GeEs 07/16-2023, and carried out by the relevant guidelines listed in the ethics statement. Furthermore, respondents were requested to provide informed consent before taking part in the interview.

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