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Household Resilience to Food Insecurity: the case of Chencha Zuriya District, Southern Ethiopia

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Abstract

Fragmented landholding, recurring drought, food price inflation, and continued conflicts in the northern parts of Ethiopia have increased incidences of food insecurity shocks in the highland areas of the country. This study investigated food insecurity shocks and major sources of household resilience in southern Ethiopia. Using a resilience strategy, the study employed a cross-sectional design that included a household survey of 303 rural households in the wake of COVID-19 and related shocks, corroborated with focus group discussions and key informant interviews. Descriptive statistics and multivariate analytical methods, such as principal component analysis, were used to analyze the data. The findings reveal that food insecurity in the area is caused by factors like inflation, family illness, low farm production, and drought. A resilience analysis identifies six dimensions that significantly contribute to household resilience, with access to Social Safety Net, basic services, and non-agricultural assets being crucial. All but the stability dimension positively and significantly contributed to resilience. The multivariate analysis showed that 59.7% of households were non-resilient, while 40.3% were resilient at various levels. Based on factor loading and beta coefficient, access to Social Safety Net, basic services, and non-agricultural assets are crucial for promoting household resilience against food insecurity. The study suggests strengthening and improving the targeting system and quality of social safety services, increasing access to basic public services, and supporting agricultural intensification to enhance household resilience to food insecurity. Furthermore, policymakers should also prioritize the strengthening of key resilience dimensions and address frequently encountered shocks and stresses to enhance household resilience in the area.

Keywords/Phrases: Chencha, Food insecurity, Household resilience, Livelihood, Shock, Stress

1 Background

Food security is a global concern that originated in the 1970s during the global food crisis (FAO, 1996). The concept has evolved over time, with over 200 definitions (Maxwell *et al*., 2013). Food security is defined as having access to adequate food for all people, at all times, for an active and healthy life (FAO, 1996; El Bilali *et al*., 2019). However, hunger and undernourishment remain pressing issues, with 820 million hungry people worldwide and an estimated 670 million still expected to be hungry by 2030, putting the Sustainable Development Goal 2030 (SDG) agenda of eliminating poverty and malnutrition at risk (Boliko, 2019; WFP, 2022).

Food security exists when everyone has physical, social, and economic access to enough, safe, and nourishing food that satisfies their dietary needs and food choices for an active and healthy life. When this requirement is not met, food insecurity results (Camire, 2021). Food insecurity is disproportionately distributed, with Africa comprising 28.05% of the food insecure population globally, and Sub-Saharan Africa (SSA) and Asia alone accounting for 95% of the global food insecure populations (Zereyesus *et al*., 2022). Climate change, COVID-19, and wars have exacerbated this issue in Sub-Saharan Africa (Baptista *et al*., 2022). Conflict, climate change, and global market failure are major contributors to hunger and malnutrition (Degefa, 2015; Caroline & Kristina, 2022), with 70% of food insecurity occurring in conflict areas.

Ethiopia is grappling with humanitarian emergencies and food insecurity due to factors such as conflict, recurring droughts every 3-5 years, rain-fed agriculture, population pressure, limited infrastructure, irregular rainfall, and seasonal fluctuations (Devereux, 2000; MoARD, 2009; Meskerem & Degefa, 2015; Anantharam *et al*., 2021). The major causes of food shortage in Ethiopia are associated with its traditional backward farm practices (lack of adopting improved seed and animal breeds, low adoption of chemical fertilizers, lack of farming technology adoption), rain-fed dependence, and lack of large-scale irrigation practices (Mulugeta, 2009). Recent reviews reveal that despite a decrease in food insecurity in Ethiopia, 32.7% of the population still suffers from food insecurity, and the food gap is higher than in other African countries due to several factors (Ayele, 2020). In Ethiopia, food insecurity is primarily caused by factors such as recurring drought risk, environmental degradation, demographic pressure, rural-urban migration, and conflict.

Chencha Zuria district in Gamo zone, with 82% highland ecology, experiences 3-6 months of food insecurity particularly during the periods of April to May and September to November (Hassen, 2019; Tadesse *et al*., 2021). This is primarily due to fragmented landholdings and seasonal food shortages. To cope, people in the district use risk management measures like livelihood diversification, cultivation of drought-resistant crops (*Enset* and *Qoltso*), weaving, and outmigration (Abera, 2014; Utallo *et al*., 2019). However, empirical evidence on household resilience remains limited.

Food insecurity remains a significant challenge for many individuals, as highlighted in the previous paragraphs, necessitating ongoing research. Food security analysis has long aimed to enhance analytical techniques for predicting vulnerability to food insecurity (Løvendahl *et al*., 2004). However, resilience, a cohesive academic and policy concept, encourages collaboration among various disciplines, policymakers, and practitioners to address food insecurity issues (Alinovi *et al*., 2008; Schipper & Langston, 2015). Resilience measures a system's ability to handle the negative effects of unpredictable shocks, rather than predicting a crisis. According to Bahadur *et al*. (2015) and Winderl (2014), resilience indicators are used as a measure of program success. Resilience refers to a system's ability to maintain a specific standard of living, such as food security, despite shocks and stresses, based on available means of subsistence and risk-taking.

Resilience and vulnerability share two common elements: the shocks and stresses, and the adaptive capacity (Alinovi *et al*, 2010). Resilience concerns examining, investing, and taking actions on existing capacities as a new normal towards attaining food security (Frankenberger & Nelson, 2013). The conventional risk management approach is disjointed, while resilience promotes cooperation in analysis, planning, and implementation (Constas and Barrett, 2013), linking short-term humanitarian efforts with long-term development activities for better outcomes (Fan *et al*., 2014). Resilience provides a fresh perspective on the factors and dynamics of resilience to food insecurity, enabling individuals to utilize their existing strengths (Adane, 2018).

Resilience is context-specific (FAO, 2014), but food security studies in general are rare in Chencha (Eshetu & Mekonnen, 2016; Tadesse, Y. *et al*., 2019). However, there are no previous studies on the subject of resilience in the area. Eshetu and Mekonnen's (2016) study found that off-farm participation reduces household poverty, while Essa's (2019) study revealed significant differences in food security between adopters and non-adopters of soil and water conservation practices. Yenenesh *et al*. (2019) discovered that the adoption of improved potato varieties enhances households' livelihoods, but no studies have explored resilience to food insecurity.

The resilience approach is a long-term development strategy that analyzes shocks and stresses, plans, and evaluates food security programs to achieve sustained progress (Constas *et al.*, 2014). The analysis of resilience studies in Ethiopia is limited in number and broad in scope, considering diverse livelihood contexts and different measurement approaches. This study aims to narrow the focus on weaving-based households, exploring the multidimensional nature of household resilience sources and the factors determining the capacity to withstand, recover, and respond to food insecurity.

The literature suggests that integrated assessment approaches at national, local, and household levels are necessary for context-specific vulnerability and resilience studies to address specific geographic problems (Adane, 2018; Shibru *et al.*, 2024). It is against this background that the present study aims to assess rural households' resilience to food insecurity shocks in Chencha Zuriya district, Gamo zone, identifying sources, magnitudes, and determinants. The findings can then guide policymakers in determining effective investments in resilience.

2 Materials and Methods

2.1 Description of the Study Area

The study examined household resilience to food insecurity in Chencha Zuriya district, a Gamo zone in Southern Ethiopia. The district is located between 6^o8'55" and 6^o25'30" North latitude and 37^o29'57" to 37^o39'36" East longitude. It is situated at an elevation of 1,600-2,732 meters above sea level, with mean annual rainfall ranging from 750mm to 1,000mm. The district is 521 km south of Addis Ababa and 37 km from Arba Minch town.

Chencha Zuriya district has a predominantly highland (Dega) (82%) agro-ecology, with the remaining 18% being midland (Woyna-Dega) (Hassen, 2019). The district comprises 33 kebeles (the smallest administrative unit) and 3 transition towns, with 65% of the area having a mountainous topography (CSA, 2011; Hassen, 2019).

The district experiences a 3-6 months food shortage due to population growth, land degradation, unpredictable rainfall, crop diseases, and limited market access, primarily due to rain-fed subsistence agriculture (CWARDO, 2014). The study evaluates household resilience to food insecurity in Chencha Zuriya district, focusing on weaving-based livelihood groups. Limited livestock ownership and coping strategies, such as Enset production, are explored. Empirical studies on sources and magnitudes of household resilience to food insecurity shocks have not been conducted in the area.

2.2 Data Sources and Sampling Techniques

This study utilized both qualitative and quantitative data to understand livelihood conditions, food security, external shocks, and household resilience to food insecurity. The primary data sources were households, key informants, and focus group discussants, while secondary data was collected from national statistical reports, documents, and literature.

To obtain representative and reliable information and draw sound conclusions, a multistage sampling method was employed. In the first stage, Chencha Zuriya district was selected due to the high concentration of weaving activities in the region and throughout the nation (Waktole, 2016; Alyahat, 2018). Weaving is the primary source of income to supplement the highly dispersed subsistence farming in the area.

In the second stage, four kebeles with relatively dominant weaving households were purposively selected based on a preliminary survey and key informant interviews. The selected kebeles were Doko Danbo, Doko Loosha, Lakana Maldo, and Setena Borcha.

The sample respondents were chosen in the third stage using systematic random sampling techniques. The sample size of respondents was determined using the formula proposed by Yemane (1967):

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

Where:
n = the sample size
N = the total population size (2,485 households)
e = the level of precision (0.05)

Applying this formula, the sample size (n) was calculated to be 303 households. The representative sample respondents were then identified based on probability proportion to the population from the four selected kebeles using a systematic random sampling technique, with every 8^{th} household being selected.

The study utilized cross-sectional data collection methods, including quantitative and qualitative techniques such as household surveys, focus group discussions (FGDs), key informant interviews (KIIs), field observations, and secondary source analysis. Before conducting the data collection activities, an official letter of consent and approval concerning ethical matters and the primary objective of the research was obtained from the Institutional Review Board (IRB) of Addis Ababa University's College of Development Studies. Informed written consent was also obtained from the respondents for interviews, focus groups, and surveys. Ethical approval (approval number: 029/01/2023) was granted by the Addis Ababa University's Academic Commission and the Institutional Review Board on October 20, 2023.

2.3 Data Analysis

This study aimed to explore livelihood-threatening shocks and stresses, as well as sources of household resilience to food insecurity in the Chencha district. However, amid the emerging research and development use of resilience (Constas & Barrett, 2013), many aspects remain unclear regarding how the concept can be measured (Vaitla *et al.*, 2012). There is a lack of consensus on the indicators to be used and how they can be combined (Maxwell *et al.*, 2013; Mulat & Negussie, 2013; Mulugeta, 2014; Guyu & Muluneh, 2015; Adane, 2018; Gebrerufael, 2019; Debebe, 2021).

Resilience is a latent variable that cannot be directly observed. It was determined in this study by adopting the Resilience Index Measurement and Analysis-II (RIMA-II) approach (WFP, 2022), which consists of eight components: access to basic services (ABS), agricultural assets (AA), income and food access (IFA), non-agricultural assets (NAA), adaptive capacity (AC), social safety nets (SSN), and stability (S). The RIMA-II approach involves theoretical concept development, variable identification, standardization, weighting, and uncertainty metrics assessment (Dhraief *et al.*, 2019; WFP, 2022). The mathematical model for measuring household resilience can be expressed as:

$$RI = f(ABS, IFA, NA, ATP, AC, SC, S)$$

Where, RI is the resilience index, IFA is income and food access, ABS is access to basic services, AA is agricultural asset possession, NA is non-agricultural assets, ATP is agricultural technological and practices adoption, AC is adaptive capacity, SC is social capital, and S refers to household exposure to shocks or stability.

The study determined the resilience index (RI) using multivariate techniques, specifically principal component analysis (PCA), considering the lack of consensus among researchers on this approach (Dhraief *et al.*, 2019; Maxwell *et al.*, 2013). Some studies have employed qualitative techniques of measurement (Niemistö, 2011), while others have used quantitative statistical methods. This study used quantitative methods to estimate household resilience to food insecurity, transforming qualitative scales into standard ones using optimal scaling for easier principal component analysis.

The analysis followed a two-stage factor analysis strategy. First, each component was estimated individually using PCA. In the second stage, the interacting components were used as covariates, and the resilience index was calculated as a weighted sum of factors using Bartlett's scoring method (Bartlett, 1937), with the weights being the proportions of variance explained by each factor:

$$RIn = Wj_1Fi_1 + Wj_2Fj_2 + Wj_3Fj_4 + ... + Wj_nFj_n$$

Where, RI is the resilience index of the nth household, Wj is the variance explained by factor j, and Fn is the factor retained based on an eigenvalue greater than 1.

Data compatibility for PCA analysis, including singularity and sampling adequacy, was checked using Bartlett's Sphericity test and the Kaiser-Meyer-Olkin (KMO) criteria of sampling adequacy (Field, 2005). Bartlett's test of Sphericity should generally be less than 0.05, and the KMO test of sampling adequacy should be above the recommended cutting point of 0.5. However, the cutting points to categorize households into different resilience levels may vary across studies.

The resilience index (RI) score ranges from negative to positive values. However, there is a lack of consensus in the resilience literature on the use of cutting points to categorize households. Some studies have categorized households into two groups: resilient (RI > 0.00) and non-resilient (RI < 0) (Cheber, 2021a; Gebrerufael, 2019). Others have used a four-level categorization: non-resilient, moderately resilient, resilient, and highly resilient (Adane, 2018; Beyene, 2016; Dhraief *et al.*, 2019).

Rather than making a rough division into two groups, this study is inclined to use a more descriptive four-category classification: non-resilient (RI < 0), moderately resilient ($0 < RI \leq 0.50$), resilient ($0.50 < RI \leq 1.0$), and highly resilient (RI > 1.0) (Adane, 2018; Beyene, 2016).

The determination of the final household resilience index has employed directly observed variables to determine the different pillars of the household resilience index, such as the Household Food Insecurity Access Scale (HFIAS) and the Food Consumption Score (FCS). Each of these variables was derived through the use of different data analysis techniques.

The HFIAS is a food security analysis tool used to measure the access component of household food insecurity. It was developed between 2001 and 2006 by the USAID-funded Food and Nutrition Technical Assistance (FANTA) project. The data is collected through nine occurrences and nine frequencies of occurrence questions that capture the behavioral and psychological experiences of households regarding food access over the past 30 days (Coates *et al.*, 2007).

The Food Consumption Score (FCS) used in the principal component analysis is a composite measure used to assess household food security by evaluating dietary diversity, food frequency, and the nutritional importance of different food groups. The FCS is calculated based on the frequency of consumption of various food groups over the past seven days. Each food group is assigned a weight reflecting its nutritional value, with foods high in energy and protein receiving higher weights. The total score is derived by summing the weighted frequencies of consumption across all food groups (Coates *et al.*, 2007). These scores of the HFIAS and FCS indicators were then used as directly observed variables to determine the pillars of resilience, particularly the Income and Food Access (IFA) component.

3 Results and Discussions

3.1 Descriptive Statistics

Households in Chencha face significant chronic and seasonal food deficits due to low agricultural production on fragmented landholdings (Abera *et al.*, 2019). The current study found very small average land (1.1 ha) and livestock (2.95 TLU) holdings. The households rely on weaving as an essential income source, with 90.75% using diverse income sources and an average annual income of 44,474.63 ETB. Formal employment (75,025.66 ETB), weaving (38,162 ETB), and barber services (24,500 ETB) have higher average annual income returns. However, external shocks threaten these livelihoods. Government-designed Productive Safety Net Program (PSNP) support helps address the food shortage, providing food for work and free aid access.

Rural households in developing countries face challenges from environmental, socio-economic, and ecological shocks (Tefera & Kayitakire, 2015) requiring resilience to recover from food insecurity (Folke, 2006; Walker *et al.*, 2004). Understanding the capacity of the food system is crucial for humanitarian development planning interventions (Holling, 1973; Diamond & Morlino, 2004).

The household survey, key informant interviews, and focus group discussions concurrently identified climate, demographic, and market-related stressors as the primary causes of food insecurity in the study area in the last 5 years since 2022. Factors such as population pressure, food price inflation, the COVID-19 pandemic; drought, crop pests, and livestock deaths contribute to the issue. Health extension services have reduced health problems, but poor individuals still face health issues. Long-term threats include low technology adoption, soil erosion, and over-reliance on rain-fed agriculture (Figure 1).

As to 2022 Early warning office report of Chencha Zuria district experiences 3-6 months of food shortages annually, primarily in April, May, June, September, and October. Coping strategies include transitory food aid, PSNP, soil and water conservations, and weaving activities.

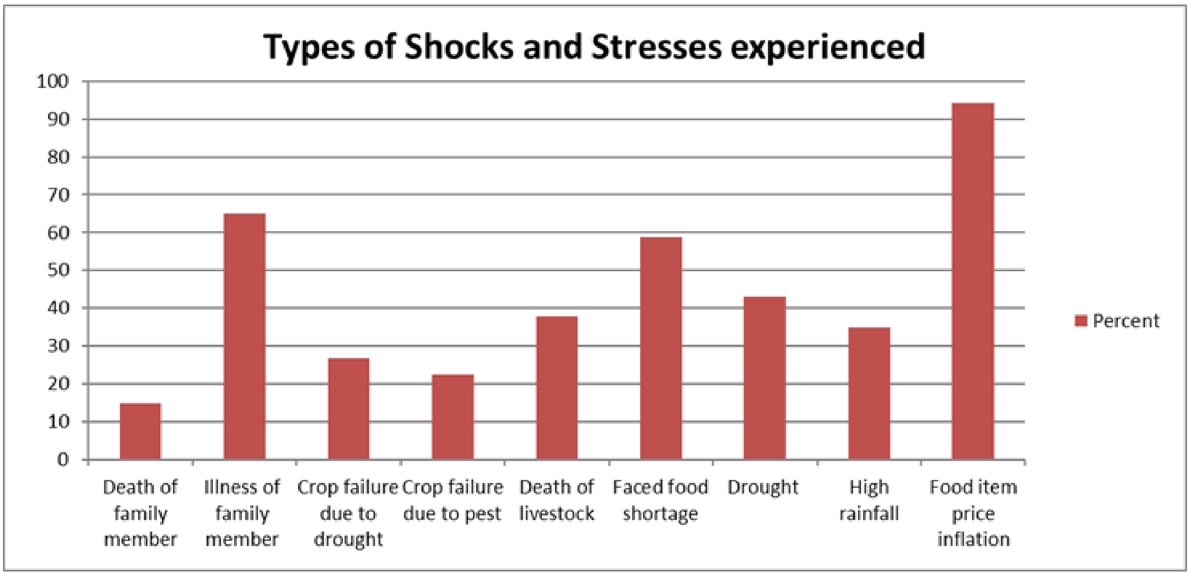

Figure 1. Major shock challenges faced by the surveyed households

70% of respondents believe their current food consumption levels cannot be maintained during a drought, highlighting the need for identifying sources of resilience and determining the key factors in development planning and intervention.

3.2 Estimation of the Latent Indicators

This section examines household resilience to food insecurity using the principal component analysis method. Eight resilience building blocks are identified, and latent variables are computed using multivariate analysis (Alinovi *et al*., 2009), factor loadings, eigenvalue criteria, and Kaiser-Meyer-Olkin (KMO) statistics (Field, 2005). The final aggregate resilience index is then computed.

3.2.1 Income and Food Access (IFA)

Income and food access (IFA) are crucial for a household's resilience against external livelihood shocks and food insecurity. The IFA component is computed from 9 variables (Table 1). The PCA analysis retained four factors based on the eigenvalue criteria greater than 1.0.

Factor 1 is determined by the Food Consumption Score (FCS), the Household Food Insecurity Access Scale (HFIAS), and household food worry. Factor 2 is defined by household food expenditure and food consumed from own production. Factor 3 is defined by food consumed from credit and assistance. Factor 4 is determined by the contribution of annual per capita household income and the percentage of total household income spent on food for consumption.

Based on the factor loading and Beta coefficient size, the IFA index is primarily influenced by household per capita income, with negative correlations with the HFIAS score and the percentage of income spent on food consumption. The KMO test of sampling adequacy (0.559) and Bartlett's test of Sphericity ($p<0.0001$, chi-square=215.785) showed that the variance defined is 60.46%, which indicates significant variance contributions from the four factors. This suggests that the principal component analysis technique is suitable for dimension reduction.

The IFA index is calculated as:

$$IFA = 0.3364factor1 + 0.25769factor2 + 0.2202factor3 + 0.1857factor4 \ldots Equ(4)$$

Table 1. Component Factor Loading for Income and Food Access (IFA)

Variables	Comp1	Comp2	Comp3	Comp4
FCS	0.5493			
HFIAS	-0.6369			
Worried to feed family	0.5278			
Food Expenditure		0.6498		
Food consumed from neighbor		0.6749		
Food from credit			0.6897	
Food from Gift			0.6812	
Per capita income				0.8366
Income spent on food (%)				-0.4351
Eigenvalues	1.83104	1.40214	1.19751	1.01052
Variances	0.2034	0.1558	0.1331	0.1123
Cumulative variance	0.2034	0.3592	0.4923	0.6046
Variance (%) =60.46%				
KMO test of sampling adequacy=0.559				
Determinant of correlation matrix Det=0.485				
Bartlett's test of Sphericity is significant at p=0.0001; chi-square=215.785				
Degree of freedom=26				
Extraction method: Principal Component Analysis				

Source: Own survey, 2022

3.2.2. Social Safety Net or Social Capital (SSN)

The Social Safety Net (SSN) is a crucial resource for the poor (WFP, 2016), providing access to assistance from both formal and informal sources (Ciani & Romano, 2014; Guyu & Muluneh, 2015). It is often the last resort for those facing food insecurity. Ten variables were used for the index determination (Table 2), with insignificant variables dropped out. Variables in dummy and categorical forms were converted into standard forms using optimal scaling for easier principal component analysis.

The data set meets the KMO and Bartlett's tests for sampling adequacy and Sphericity (Table 3), and the index for the Social Safety Net variable is estimated as follows:

SSN = (0.1678factor1 + 0.1589factor2 + 0.1177factor3 + 0.1065factor4) ... Equ(5)

The PCA approach identified four latent variables (factors 1, 2, 3, and 4) that accounted for 55.09% of the variance in the estimation of the latent variable SSN.

The study uses factor rotation to identify important variables, retaining loading values larger than 0.4 (James, 2002). Most variables are positively correlated with the Social Safety Net (SSN), except for community supportiveness and lending (Table 2). Support from safety nets and other organizations are more crucial than other forms in determining Factor 1. Membership in religious associations, social support from neighbors, and support from non-governmental organizations are important variables.

Table 2. Principal Component factor loadings of Social Safety Nets (SSN)

Variables	Components			
	Comp1	Comp2	Comp3	Comp 4
Supportiveness of people	-0.4812			
Safety net Gov't	0.5567			
Other supports NGO	0.6202			
No. Close friends		0.5828		
Neighbors to feed children		0.5758		
Edir membership			0.6175	
Church membership			0.7501	
No. individuals lend 100 birr				-0.5999
Supportive neighbor				0.6892
Eigenvalues	1.67755	1.58876	1.17745	1.06496
Variances	0.1678	0.1589	0.1177	0.1065
Cumulative variance	0.1678	0.3266	0.4444	0.5509

Variance (%) =55.09%

KMO test of sampling adequacy=0.554

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=194.638

Degree of freedom=45

Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.3. Access to Agricultural Assets (AA)

Access to agricultural assets (AA), including land, livestock, and labor, is crucial for rural households to diversify income sources, withstand food shortages, and build resilience to food insecurity. This study estimated the index for AA using eight (8) observable variables. As shown in Table 3, the principal component analysis (PCA) test results show good suitability, with three factors retained defining 66.18% of the variation in the AA index, based on the KMO criterion of eigenvalues greater than 1 (Field, 2005).

Landholding, Tropical Livestock Units (TLU), and productive labor sizes correlated with Factor 1. Factor 2 was determined by cash income from crop harvest, matured Eucalyptus trees, and fruit harvest. Factor 3 was influenced by mature Enset crops ready to harvest and their expected years of feeding (James, 2002). Mature Enset, expected fruit harvest, and productive family labor are the most crucial agricultural assets for household resilience to food insecurity. The AA index is defined as:

AGRI = 0.2446factor1 + 0.2158factor2 + 0.1547*factor3 ... Equ(6)

Table 3. Principal Component factor loadings for Access to Agricultural Asset

Variables	Comp1	Comp2	Comp3
Land holding size in hectare	0.5224		
Livestock holding in TLU	0.5283		
Number of matured Enset			0.7519
Number of Years to feed the family			0.5520
Expected crop harvest in ETB		0.5149	
Monetary value of mature Eucalyptus tree		0.4627	
Mature fruit ready for harvest in ETB		0.6473	
Productive family labour (>15 and <65)	0.5974		
Eigenvalues	2.62675	1.2579	1.03642
Variances	0.3283	0.1572	0.1296
Cumulative variance	0.3283	0.4855	0.6151
Variance (%) =61.51%			
KMO test of sampling adequacy=0.728			
Bartlett's test of Sphericity is significant at p=0.0001; chi-square=423.813			
Det =0.242			
Degree of freedom=28			
Extraction method: Principal Component Analysis			

Source: Own survey, 2022

3.2.4. Agricultural Input and Technology Adoption (AITA)

Applying improved agricultural methods and technologies to rural household farms is critical to increasing agricultural productivity, thereby fulfilling the food shortfall and improving household resilience to food insecurity in a growing population and dwindling land yield (Adane, 2018). For this purpose, the AITA index is estimated using five (5) agricultural technology-related variables (Table 4). The PCA model's compatibility test yielded positive results, with three factors retained explaining 89.53% of the variance in the AITA index determination.

The PCA analysis revealed that all variables have a positive correlation with the AITA index. Access to farmer trainings, development agent (DA) contacts, and veterinary services positively correlated with Factor 1. The use of improved seeds and pesticides influenced Factor 2, while access to chemical fertilizer and herbicides determined Factor 3. The study highlights improved seed access and chemical fertilizer use as crucial agricultural technologies, with higher factor loading values determining the AITA latent variable index. The survey results are consistent with the information gathered from Key Informant Interviews (KII), Focus Group Discussions (FGD), and researcher field observations. The latent variable index for AITA is determined using the following method:

AGRTECHAI = 0.2964factor1 + 0.1786factor2 + 0.1721*factor3 ... Equ(7)

Table 4. Principal Component factor lodging for Agricultural Technology Adoption (ATA)

Variables	Comp1	Comp2	Comp3
FTC service	0.5889		
DA contact	0.5316		
Veterinary services	0.5944		
Improved seed use		0.8215	
Pesticide use		0.4314	
Chemical fertilizer use			0.7112
Herbicides			0.6907
Eigenvalues	2.26868	1.20849	1.05298
Variances	0.3241	0.1726	0.1504
Cumulative variance	0.3241	0.4967	0.6472

Variance (%) =64.72%

KMO test of sampling adequacy=0.692

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=461.133

Degree of freedom=21

Factor Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.5. Non-agricultural or Physical Assets (NAA)

In rural areas, ownership of non-agricultural assets is a sign of wealth status (Dhraief *et al*., 2019) and an important source of livelihood risk management. Based on the literature and the researcher's experience, 11 variables were used, all measured in the current economic value in Ethiopian Birr (ETB), which are suitable for principal component analysis (Table 5).

The PCA analysis retained four components, explaining 57.52% of the variance in the NAA latent variable index (Field, 2005; Kaiser, 1964).

The NAA index is calculated as follows;

NNAi = 0.2516*Factor 1 + 0.1166*Factor 2 + 0.1041*Factor 3 + 0.1029*Factor 4 …….Equ (8)

Table 5. Component loadings of variables to estimate (NNA) component of resilience

Variables	Component			
	Comp1	Comp 2	Comp3	Comp4
Bed	0.4866			
Stove owned	0.4193			-0.4591
Jewelry		0.6934		
Watch		0.6790		
Mobile phone			0.5498	
Bicycle			0.7119	
Radio				0.8121
Eigenvalues	2.86857	1.28787	1.11104	1.06
Variances	0.2608	0.1171	0.1010	0.0964
Cumulative variance	0.2608	0.3779	0.4789	0.5752

Variance (%) =57.52%

KMO test of sampling adequacy=0.696

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=513.121

Determinant of the correlation matrix Det = 0.178

Degree of freedom=55

Extraction method: Principal Component Analysis

Source: Own computation from survey, 2022

3.2.6. Adaptive Capacity (AC)

Adaptive capacity is a crucial aspect of household resilience, allowing households to absorb, adapt, or react to shocks (Alinovi *et al*., 2009; Alinovi *et al*., 2010). The literature treats adaptive capacity differently from resilience analysis, with some treating it as a separate component (Walker *et al*., 2004) and others as part of resilience analysis (Pisano, 2012; Frankenberger *et al*., 2014; Abebe, 2018; Debessa, 2018). This study treats adaptive capacity as a determinant component for household resilience to food insecurity, following previous works (Alinovi *et al*., 2009; Alinovi *et al*., 2010; Guyu & Muluneh, 2015; Debessa, 2018).

For ease of PCA analysis, optimal scaling (mean = 0 and variance = 1) was carried out for dummy and categorical variables. Statistical requirements were checked and found suitable, and seven components were retained that explain 58.81% of the variance in adaptive capacity (AC) determination using PCA analysis (Table 6).

Except for the number of ill members in the household, the study found that household adaptive ability, particularly reading and writing capacity, spiritual education, and monetary deposits, have positive and higher correlations with the AC index, implying greater resilience to food insecurity.

AC = 0.0931factor1 + 0.0888factor2 + 0.0884factor3 + 0.0877factor4 + 0.0847factor5 + 0.0777factor6 + 0.0676*factor7 ... Equ(9)

Table 6. Component loadings of variables to estimate Adaptive Capacity

Variables	Component						
	Comp 1	Comp 2	Comp 3	Comp 4	Comp 5	Comp 6	Comp 7
HH ability to read/write	0.7090						
HH Years of schooling	0.6010						
Ill members		-0.5079					
Number of disable		0.5780					
Income sources			0.4907				
Agri income source			0.5110				
Number of crops grown			0.5162				
Single and Earning				0.5426			
Salary/wage				0.6075			
Spiritual education attn.					0.6776		
Transfers					0.4479		
Family business						0.6332	
Cash deposit							0.6460
Eigenvalues	2.82781	1.82181	1.57836	1.43022	1.34778	1.11136	1.05599
Variances	0.0931	0.0888	0.0884	0.0877	0.0847	0.0777	0.0676
Cumulative variance	0.1488	0.2447	0.3278	0.4031	0.4740	0.5325	0.5881

Variance (%) =58.81%

KMO test of sampling adequacy=0.604

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=866.269

Degree of freedom=171

Extraction method: Principal Component Analysis

Source: Own survey, 2022

3.2.7. Access to Basic Services (ABS)

Access to basic services (ABS) or public services delivered by national governments and supporting organizations enhances households' resilience to external shocks by providing in-kind and in-service supports, improving their overall quality of life (Alinovi *et al.*, 2010). Dummy and categorical variables were changed to continuous form using optimal scaling for the convenience of PCA analysis. Four components were retained, explaining 68.18% of the variance in the ABS index estimation (Table 7).

ABSI = 0.1609factor1 + 0.1168factor2 + 0.1163factor3 + 0.1097factor4 + 0.0960*factor5 ... Equ(10)

The study reveals that access to primary and secondary schools is highly correlated with Factor 1. Attaining preparatory school and mobile access have negative and positive correlations with Factor 2, respectively. The correlation of access to the main road and microfinance services with Component 3 is highly positive, indicating a strong connection between these variables. Access to domestic water and markets has a positive correlation with Component 4. Component 5 is determined by the positive correlation between 'Access to Electricity' and 'Access to Potable Water'. The most crucial public services in the area are access to electricity, domestic water, and secondary school, as determined by the factor loadings (Table 7).

Table 7. Component loadings of variables to estimate (ABS) component of resilience

Variables	Comp1	Comp2	Comp3	Comp4	Comp5
Primary school	0.6530				
Secondary school	0.6602				
preparatory school		-0.5761			
Access to mobile phone		0.5869			
Access to main road			0.5149		
Access to microfinance			0.5858		
Access to water for domestic use				0.7479	
Access to market				0.4560	
Access to Electricity					0.8349
Access to potable water					0.4377
Eigenvalues	1.93116	1.40125	1.39586	1.31583	1.1524
Variances	0.1609	0.1168	0.1163	0.1097	0.0960
Cumulative variance	0.1609	0.2777	0.3940	0.5037	0.5997

Variance (%) =59.97%

KMO test of sampling adequacy=0.6240

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=523.174

Det =0.171

Degree of freedom=66

Extraction method: Principal Component Analysis: Principal Component Analysis

Source: Own survey, 2022

3.2.8. Stability

Stability, a cross-sectional dimension of resilience to food insecurity, refers to the stability of the food supply and socio-economic factors in the face of different adverse external shocks and stresses (Alinovi *et al*., 2010). Following similar previous studies and taking into account the particular study area context, this study has used human health issues like the frequency of visits to clinics due to illness, death of a family member, climatic shocks like drought, high rainfall, death of livestock, crop failure due to disease and pest, and socio-economic changes such as food item price inflation and the perceived capacity of the household head to maintain the current level of consumption if a drought occurs in the coming production season. Some variables in dummy and categorical forms were transformed into continuous forms using optimal scaling (mean = 0 and variance = 1). PCA analysis showed the compatibility of the data set (Table 8), with three components retained, explaining 69.15% of the variance in stability (S) estimation.

All variables except family member illness were significant, i.e., the absolute value of loadings was greater than 0.4 (Stevens, 2002), affecting household resilience capacity negatively. However, as expected, the capacity to maintain the current food consumption if a drought occurs is negatively correlated with the S latent variable, indicating a potential drought-related impact.

Stability Index= 0.3922*Factor1 + 0.1683*Factor2 + 0.1309*Factor3 .... Equ(11)

The results showed that Factor 1 was positively correlated with drought, heavy rainfall, and crop loss caused by drought; Factor 2 was positively correlated with family members and livestock deaths; and Factor 3 was positively correlated with the effect of rising commodity prices and negatively correlated with households' ability to continue their current level of consumption into the future. Depending on the degree of factor loading of variables, rising food prices and animal deaths are important stability factors or shocks to families.

Table 8. Component loadings of variables to estimate stability (S) component

Variables	Comp1	Comp2	Comp3
Drought	0.5401		
High rainfall	0.5388		
Crop failure due to drought	0.5424		
Family member death		0.5793	
Livestock death		0.7483	
Food item price rise			0.7599
Able to keep current food consumption?			-4602
Eigenvalues	3.1377	1.34678	1.04759
Variances	0.3922	0.1683	0.1309
Cumulative variance	0.3922	0.5606	0.6915
Variance (%) =69.15%			
KMO test of sampling adequacy=0.762			
Det = 0.093			
Bartlett's test of Sphericity is significant at p=0.0001; chi-square=791.088			
Degree of freedom=28			
Extraction method: Principal Component Analysis			

Source: Own survey, 2022

3.3 Household Resilience to Food Insecurity

Two steps were involved in determining household resilience: first, indices for each of the eight constituent pillars (IFA, SSN, AA, AITA, NAA, AC, ABS, and S) were computed; second, the household resilience index was determined by using the pillars that were defined in the first stage as covariates in PCA analysis.

RI = 0.2712Factor1 + 0.1565Factor2 + 0.1423*Factor3 ... Equ(12)

Field's PCA data compatibility recommendation yielded promising results (Field, 2005) (Table 9), with six out of eight variables significantly contributing to three retained components with loading values greater than 0.4 (Stevens, 2002). However, households' access to Agricultural Technology Innovation and Adaptive Capacity showed weak access and need for strengthening.

The factor loadings can be utilized as a correlation coefficient or a regression coefficient, which analyzes PCA assumptions using orthogonal rotation (Field, 2005). The PCA result showed that access to AA, IFA, and NAA are positively correlated with Factor 1; access to SSN positively determined Factor 2; ABS and S positively and negatively correlated with or determined Factor 3, respectively. As in other studies by Adane (2018), Alinovi *et al.* (2009), Alinovi *et al.* (2010), Beyene (2016), and Debebe (2021), the size of the beta coefficient is used to establish the relative importance of pillars to household resilience to food insecurity. In this regard, access to SSN (0.8283), ABS (0.7808), and NAA (0.5523) is the factor that contributes most strongly to household resilience to food insecurity in the study area, according to the size of the beta coefficient of loadings. The KII and FGD results also support the quantitative result with informal social support systems in the case of social, economic, or environmental shock responses.

Table 9. Component Loadings of Variables to Estimate Household Resilience (RCI)

Variables	Comp1	Comp2	Comp3
Agricultural Assets	0.4542		
Access to Non-agricultural Assets	0.5523		
Income and Food Access	0.4631		
Social Safety Nets		0.8283	
Access to Basic Services			0.7808
Stability			-0.5301
Eigenvalues	2.16977	1.25211	1.1386
Variances	0.2712	0.1565	0.1423
Cumulative variance	0.2712	0.4277	0.5701

Variance (%) =57.01%

KMO test of sampling adequacy=0.691

Bartlett's test of Sphericity is significant at p=0.0001; chi-square=295.986, Det. R-Matrix=0.371

Degree of freedom=28

Extraction method: Principal Component Analysis

Source: Own survey, 2022

The findings of the PCA analysis finally categorized households into different resilience levels. The study found that 179 (59.06%) of the respondents were non-resilient, and 124 (40.94%) were resilient at different levels, with an average resilience score of -3.30033E-10, indicating a non-resilient mean resilience score (Table 10).

Table 10. Level of Household Resilience to Food Insecurity

Resilience index	Resilience status				
	Non-resilient (RI≤0.00)	Moderately resilient (0.00<RI≤0.50)	Resilient (0.50<RI≤1.00)	Highly resilient (RI≥1.00)	Total
No. respondents	179	76	33	15	303
Percent	59.74%	24.42%	10.89%	4.95%	100
Minimum	-1.1014280	0.0147597	0.5030434	1.0250580	-59.9659144
Maximum	-0.0000952	0.4913051	0.9766411	1.8484960	18.1485606
Mean	-0.335005108	0.238796850	0.675617052	1.301466067	22.2953627
Std. Dev.	0.2374532536	0.1506310020	0.1295782057	0.2240763545	19.5219910

Source: Own survey, 2022

4 Conclusion and Recommendation

The study highlights food insecurity in a district as a significant development challenge due to livelihood shock and stress factors such as small landholding size, food item price rise, drought, family illness, crop pests, and disease. It examined household resilience and threatening shocks using one-time cross-sectional data; however, it lacks consideration of temporal and geographical dynamics. It provides insights for policymakers to plan and implement lasting development policies in changing socio-economic conditions.

The study reveals that social safety net, basic services, and non-agricultural assets are key factors in enhancing household resilience to food insecurity, while agricultural technology and adaptive capacity are less influential. Finally, the PCA shows that most households (59.76%) were non-resilient to food insecurity shocks.

The study highlights areas for enhancing households' resilience to food insecurity in the district and proposes the following policy suggestions for long-term strategies to address these challenges:

- Resilience studies reveal access to social safety nets, basic services, and non-agricultural assets as key resilience sources. Strengthening non-agricultural asset ownership and refining policies to expand social safety net and basic services can enhance household resilience against food insecurity.
- Household resilience is largely influenced by their adaptability and access to agricultural technology, however found to be the least contributed factor in the study. A well-designed agricultural extension program can enhance resilience by focusing on education, income generation, health services, and social and technical skills for responding to environmental and socio-economic changes.
- The FGD, KII, and PCA results highlight the issue of fragmented landholding and restricted agricultural ownership due to population pressure, leading to food production shortfalls. It suggests that policymakers should increase off-farm activities for young people and households with working age, and explore small-farmland-based agricultural techniques as a solution for food insecurity.

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