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A MULTI-INDICATOR ASSESSMENT OF RURAL HOUSEHOLD FOOD SECURITY IN ADA'A DISTRICT, CENTRAL ETHIOPIA

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ABSTRACT

This study *assessed household food security, examined the consistency of indicators, and analyzed determinants via composite metrics in Ada'a District, Central Ethiopia.* Cross-sectional survey data from 430 households were analyzed with descriptive statistics and econometric models (*binary and multinomial logit*). The findings revealed that 39.3% of the households were food insecure, with dietary deficiencies revealing hidden vulnerability. A composite indicator based on FCS and MAHFP offered the most reliable classification. The key determinants included *cooperative membership*, *off-farm income*, and *education,* which support *sustainable livelihood resilience*. Paradoxically, *larger farms* and *male-headed households* were more vulnerable. These findings highlight the need for interventions that *strengthen social networks*, *diversify livelihoods*, and *promote inclusive policies aligned with SDG 2 (Zero Hunger)*. *Addressing these challenges requires an integrated sustainability approach, balancing social equity, economic diversification, and environmental stewardship to ensure lasting improvements in food security***.** Future research should further *explore the landholding–food security nexus to guide evidence-based strategies*.

Keywords: Central Ethiopia, composite metrics, food consumption score (FCS), months of adequate household food provisioning (MAHFP), SDG 2 (Zero Hunger), sustainable food security, sustainable livelihoods

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INTRODUCTION

Access to adequate, nutritious, safe, and consistent food is a critical global challenge, with governments striving to achieve 'Zero Hunger' by 2030, as outlined in Sustainable Development Goal 2 (SDG-2) within the broader sustainable development framework. Food security is not only a matter of availability and access, but also of building long-term resilience and the sustainability of food systems. However, five years from the target, achieving this goal seems unlikely. The primary drivers of global food insecurity are conflict, economic fluctuations, climate change, poor diets, and inequality (FAO et al., 2024). In the past five decades, advancements in agricultural productivity and sustainable food security have been achieved across different regions, driven by the expansion of crop land, improved irrigation, supportive policies and institutional efforts (Wudil et al., 2022). Despite years of ongoing efforts to increase food production and quality globally, food insecurity remains a significant challenge, particularly in African nations, where ensuring sustainable access to adequate nutrition is especially difficult. In 2024, an estimated 733 million people globally experience hunger, with Africa having the highest prevalence at 20.4%, compared with 8.1% in Asia and 6.2% in Latin America, where many face challenges in accessing the nutritious food necessary for a healthy and active life (FAO et al., 2024). There was no change in moderate or severe food insecurity levels in Africa from 2022 - 2023, with the region remaining disproportionately affected. In 2022, sub-Saharan Africa also recorded the highest global rate of severe food insecurity, with 22.5% of its population (310.6 million people) experiencing chronic hunger (FAO, 2023).

Ethiopia, similar to many other sub-Saharan African nations, confronts a major challenge of food insecurity. Ethiopia ranks 100th out of 113 countries on the 2022 Global Food Security Index, reflecting ongoing difficulties with food access, utilization, and stability (Economist Impact, 2022). The proportion of Ethiopians experiencing moderate or severe food insecurity increased from 47.7% in 2014 to 52.1% by 2019, whereas the percentage of those experiencing severe food insecurity increased from 12.0% to 15.8% (Telila & Sima, 2024). This highlights the ongoing challenge of food insecurity. Moreover, hunger has remained a critical concern in the country, and in 2023 alone, an estimated 20.1 million people were suffering from chronic hunger, including 7.4 million severely undernourished children and women (WFP, 2023). However, Ethiopia has made significant progress in food security and increased investments in essential services over the past two decades (WFP, 2024). However, these macrolevel improvements need to be analyzed within the context of the sustainable development lens, as progress in access and services alone does not necessarily guarantee the long-term resilience or sustainability of local food systems.

A large portion of the research on food security in Ethiopia has focused on regions experiencing food stress or those vulnerable to drought, environmental degradation, or conflict, which aligns with the concept that Degefa (2005) calls the "*degradation school of thought*." Although many studies have focused on food insecurity in regions prone to food stress or vulnerability, research on areas in Ethiopia that are presumed to be food secure is limited. Such contexts often pose unique challenges that go unnoticed, despite being presumed stable. Previous studies (Kassie, Yimer & Gidelew, 2024; Gobena & Girma, 2019; Hailu, 2023; Derara & Tolossa, 2016) have challenged the assumption that agricultural

surplus guarantees food security, revealing significant levels of food insecurity in agriculturally productive districts. For example, Kassie et al. (2024) reported that 43% of households in Dera district, Northwest Ethiopia, were food insecure. Gobena and Girma (2019) highlighted food insecurity in Haramaya district, Eastern Ethiopia, despite surplus production. Hailu (2023) reported that 37% of households in Minjar Shenkora and Ada'a districts, Central Ethiopia, were food insecure, consuming 34% fewer kilocalories than food secure households did, and Derara & Tolossa (2016) reported that approximately 38% of households in Becho district, Central Ethiopia, were food insecure (13% mildly, 10% moderately, 8% highly, and 7% severely). The findings suggest the need for further investigation into food security in areas presumed to be food secure areas, such as Ada'a district of Central Ethiopia. This finding indicates that even in agriculturally productive regions, hidden food insecurity or vulnerability may persist. This raises a critical question about the resilience and sustainability of local food systems. Addressing this requires context-based targeting and evidence-based interventions that contribute not only to short-term food access but also to the sustainable development goals of ending hunger without leaving anyone behind.

Food security is multifaceted, yet past assessments have often relied on unidimensional approaches (Agazhi, Mada & Alemu, 2024; Manikas, Ali & Sundarakani, 2023). This narrow focus overlooks how food security is deeply tied to sustainable development, where economic, social, and environmental dimensions intersect to shape household resilience. Specifically, Manikas et al. (2023) reported that 22% of 78 articles analyzed used calorie adequacy alone, while dietary diversity (44%) and experience-based indicators (40%) were also prevalent. Food utilization (13%) and stability (18%) were infrequently viewed, with only three studies incorporating all four dimensions. Neglecting these broader dimensions means that policies risk addressing symptoms rather than building sustainable solutions that strengthen livelihoods, reduce inequalities, and promote climate-smart agriculture. Such a limited approach can misrepresent household food security, and the interventions needed. Therefore, combining indicators provides a more comprehensive understanding of the multidimensional nature of food security (Afework, Minale & Teketay et al., 2024; Kassie et al., 2024; Manikas et al., 2023; Wineman, 2016). Multidimensional measures, in turn, help identify varying levels of insecurity, inform tailored program interventions, and shape policies aimed at creating a resilient food system and eliminating hunger (Maxwell, Coates & Vatila, 2013; Atara, 2018; Ogundari, 2017; Manikas et al., 2023).

The shift to multidimensional indicators in Ethiopia has improved accuracy, as shown in several studies. For example, Gadiso, Alemu & Shete (2023) used availability, accessibility, utilization, and stability indicators to assess rural household food security, challenging estimates on the basis of single indicators. In addition, Kassie et al. (2024) argued that no one metric can fully encompass the complexities of food security, highlighting the importance of using multiple indicators. Kerbo, Degaga & Beyene (2024) developed a composite indicator derived from the Household Food Insecurity Access Scale (HFIAS) and Food Consumption Score (FCS). The researchers identified three food security levels and reported that 24.8% of households could be incorrectly classified if only one indicator was used. Almukaddem et al. (2022) examined three indicators, including the consolidated approach for reporting indicators of food security (CARI), the FCS, and the reduced coping strategies index (rCSI). The authors reported that using

multiple indicators reduces misclassification and provides insight into food security. On the other hand, Afework et al. (2024), Mutea et al. (2019), and Sahu, Chuzho & Das (2017) developed composite indices with equal weights for all indicators, oversimplifying food security by ignoring the varying significance of different dimensions. In conclusion, research emphasizes the value of multidimensional indicators but highlights the lack of a '*gold standard*,' stressing the need for context-specific approaches.

This study addresses a methodological gap in Ada'a district by utilizing four indicators: the months of adequate household food provisioning (MAHFP) (Bilinsky & Swindale, 2010), the food consumption score (FCS) (WFP, 2008), and the composite indicator CARI (WFP, 2015), along with an additional composite indicator (FCSMAHFP) derived from the FCS and MAHFP. In contrast to previous studies that relied on unidimensional measures, this study provides a more comprehensive assessment of the food security conditions in Ada'a district. This study contributes to the methodology through the use of a multi-indicator approach to assess perceived versus measured food security, indicator consistency, and the convergence of demographic, socioeconomic, institutional and infrastructural determinants across composite food security measures and analytical models. To examine the food security situation in Ada'a district, which is presumed to be food secure, this study employed a multi-indicator approach. To achieve this goal, this study aimed to answer three research questions: *How does the perceived food security status in Ada'a district align with the actual food security experiences of rural households, as measured by FCS, CARI, MAHFP, and the composite indicator derived from FCS and MAHFP (i.e., FCSMAHFP)? How consistent are the FCS, CARI, MAHFP, and the composite indicator derived from FCS and MAHFP (FCSMAHFP) in classifying household food security across sampled households in Ada'a district? To what extent do the demographic, socio-economic, institutional and infrastructural factors influencing household food security converge across composite food security indicators, including CARI and FCSMAHFP, and analytical models in Ada'a*? To address these questions, this study aimed to provide a comprehensive understanding of the food security situation in the district.

LITERATURE REVIEW

Food Security Concept

Food security was initially outlined at the 1996 World Food Summit (Fouileux, Bricas & Alpha, 2017), and the FAO reaffirmed it in the 2009 Food Security Declaration of the World Summit (Shetty, 2015). Food security is generally described as a condition in which everyone has reliable access to safe and nutritious food that satisfies their dietary requirements and supports a healthy lifestyle (FAO, 2003). Food security comprises four interconnected pillars: availability, access, utilization (including dietary intake and nutrient absorption), and stability, with availability as the foundation. The food stability dimension addresses temporal factors across the other pillars (Clapp et al., 2022; Peng & Elliot, 2018). On the other hand, food insecurity refers to the absence of reliable access to adequate, safe, and nutritious food necessary for an active, healthy life, occurring when the four dimensions of food security are unmet (BMC Medicine, 2023). Food insecurity can be chronic, with long-term unmet needs, or transitory with short-term shortages, whereas cyclical food insecurity, such as seasonal shortages, falls between these. Some researchers have argued that expanding the framework to six pillars, by adding food agency, food sovereignty (i.e., communities' right

to govern their food systems), and sustainability to better inform policy and global responses to food security challenges (Makombe, 2023).

Clapp et al. (2022) noted that food security analysis has progressed from the global level to the household and individual levels, focusing on households and individuals, and emphasizing food availability, access, usage, and stability. The concept of food security now incorporates a broader "livelihood" perspective that connects food security with socioeconomic development and is a significant component of the sustainable livelihood development framework (Jessup-Varnum, 2018). It has grown to encompass both objective food shortages and subjective perceptions of food insecurity, as well as market dynamics and consumer behavior. The growing focus on nutrition, food safety, environmental concerns, inclusivity, and sustainable food systems has further reshaped the field (Fanzo et al., 2024; Varzakas & Smaoui, 2024). As a result, the landscape of food production and consumption is evolving, paving the way for a more resilient and equitable future. These changes emphasize the need for a holistic approach that incorporates individual, community, and systemic factors. Effective interventions for food insecurity require multidimensional policies that address not only the food supply but also broader social, economic, and environmental contexts (Maletta, 2024).

Theoretical Framework

Food security is a broad and multifaceted notion that requires the integration of various theoretical frameworks for a comprehensive understanding. Food availability decline (FAD) theory, one of the earliest famine theories, suggests that famine is caused by a decrease in the food supply because of natural shocks such as floods or drought, or by population pressure, as conceptualized by (Demissie & Yalew, 2024; Agazhi et al., 2024; Vadala, 2009). The FAD model, nevertheless, has limitations because it does not account for household-level food access, use, or equity. From a sustainability perspective, the FAD is limited because it focuses only on immediate supply deficits, failing to address the underlying, long-term environmental degradation and climate change impacts that drive these declines. On the other hand, Amartya Sen's (1981) food entitlement decline (FED) theory shifts focus to individuals' access to food, emphasizing entitlement, ownership, production, and trade. The FED framework argues that famine can occur even if enough food is produced, as a lack of access (entitlements) rather than the food supply is the key factor. Sen provides examples such as the 1943 Bengal Famine, the 1973 Ethiopian Famine, and the 1970s Sahel Famines, where food was available, but political instability, inflation, and poor distribution systems restricted access. Subsequent famines, including the 1992 Somalia famine, the 2011 Horn of Africa famine, and the 2022-2023 Horn of Africa drought, demonstrate how inadequate food access, political conflict, and economic factors worsen food insecurity. These occurrences support entitlement theory, demonstrating that famine is often caused by unequal access rather than food shortages alone. The authors highlight that the essential components of food insecurity are availability and access (Sen, 1981). Nevertheless, the FED model overstresses economic factors, neglects the role of events such as drought, floods, and war, and overlooks the relevance of household distribution and relief mechanisms in addressing food security gaps (Demissie & Yalew, 2024).

The political-economic approach examines how power relations, market structures, governance, and policies shape food access, exacerbating food insecurity (Salifu & Salifu, 2024; Antilahy et al., 2023). For example, Mechiche-Alami, Yagoub & Nicholas (2021) reported that the likelihood of land conflicts and deforestation increased in 83% of large-scale land acquisitions across 38 African countries, while failing to enhance food security. In a similar vein, Kebede, Emana & Tesfaye (2023) highlight how displacement from large-scale agricultural investments worsens food insecurity for smallholders in Ethiopia. Guyalo, Alemu & Degaga (2022) also show that investments in Gambella, Ethiopia, diminish local food availability by prioritizing export crops over subsistence farming. These findings emphasize the nexus between the political economy and food security, illustrating how unequal power dynamics, corporate interests, and policy failures deepen inequalities, disrupt local food systems, and increase dependence on global markets. These findings directly challenge the principles of sustainable development by prioritizing short-term economic gains over long-term environmental integrity, social equity, and the resilience of local food systems. Although these theories provide valuable insights, they often fail to comprehend the interconnected aspects of food security challenges, which require a broader perspective.

Food systems theory, introduced in the late 1990s, offers a comprehensive view of food security and sustainability within broader social, economic, and environmental contexts. Food systems theory highlights the interconnected process from farm to table (Willett et al., 2019). This framework is particularly useful for integrating the environmental dimensions of sustainability, as it allows for the analysis of waste, energy use, and ecological impact across the entire value chain. On the other hand, resilience theory emphasizes the importance of absorptive, adaptive, and transformative capacities for managing and recovering from shocks, promoting long-term sustainability (TANGO International, 2018). These viewpoints emphasize the importance of adaptability for ensuring long-term food security (Folke et al., 2021). These resilience and food system approaches are crucial for operationalizing sustainability, shifting the focus from simply meeting immediate needs to building durable, environmentally sound, and equitable food systems that align with the SDGs. Finally, the capability approach, proposed by Sen, and the sustainable livelihoods framework provide valuable insights into individual empowerment and asset utilization. In Ada'a district, mixed subsistence farming dominates, and no single theoretical framework fully captures the food security challenges. As a result, this study combines the FAD model for food supply, the FED theory for access barriers, and the food systems theory for interconnected factors, offering a comprehensive understanding of food security in the district.

Analytical Model

The analytical framework of the study, shown in Figure 1, draws on the relevant literature to address the research questions. The analytical framework includes four food security indicators: two singular indicators, the Food Consumption Score (FCS) and Months of Adequate Household Food Provisioning (MAHFP), and two composite indicators. The FCS measures availability and utilization, whereas the MAHFP assesses availability and stability. CARI) is a composite index measuring availability, access, and stability. In contrast, FCSMAHFP assesses availability, utilization, and stability. These composite indicators help analyze the convergence of demographic, socioeconomic, institutional, and infrastructural determinants across models. The four indicators have been converted

into binary categories, classifying households as food secure or food insecure, as defined by WFP (205) and Maxwell et al. (2013). Food secure households may still face food shortages, with the severity varying. This connects food insecurity to deficit periods, as illustrated by the red dotted lines.

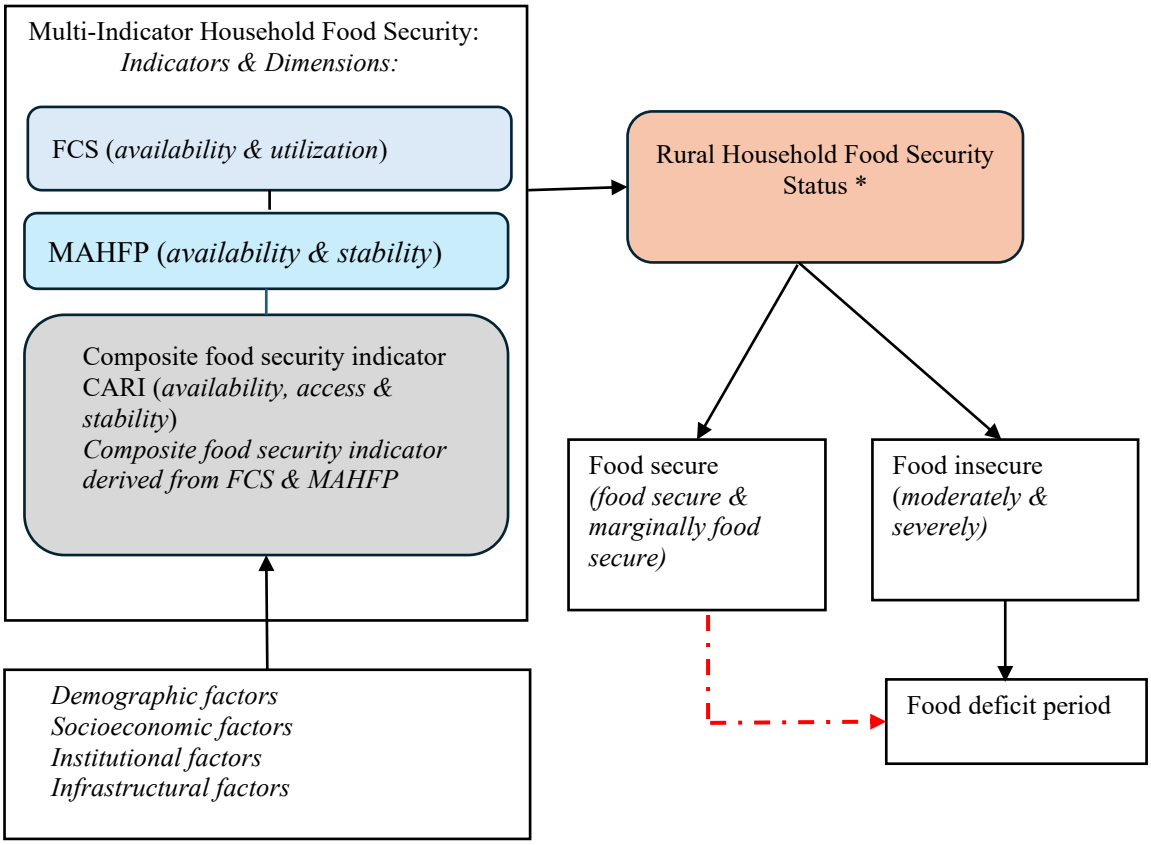

Figure 1: Analytical framework of the study.
*Source: Author's own construction; * binary classification adapted from WFP (2015) & Maxwell et al. (2013)*

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Ada'a district, 45 kilometers southeast of Addis Ababa, in the East Shewa Zone of Oromia (Figure 2). Ada'a district has a subtropical climate, with altitudes varying from 1,500 to over 2,000 mt above sea level, and it receives annual average rainfall of 839 mm (Birhanu, Tsehay & Alemu, 2022). Bishotu is a town that serves as an administrative center. The primary rainy season lasts from mid-June to September, with short rains in February and March (Belay, 2018). Ada'a has a population of 149,139, with 46% females. Ada'a district consists of 26 Kebeles (twenty-two rural and four urban). The economy of the district is based on mixed farming, with subsistence crop farming (teff, wheat, maize, barley, chickpea) and livestock production (cattle, sheep, goats, poultry) as the main livelihoods (Belay, 2018).

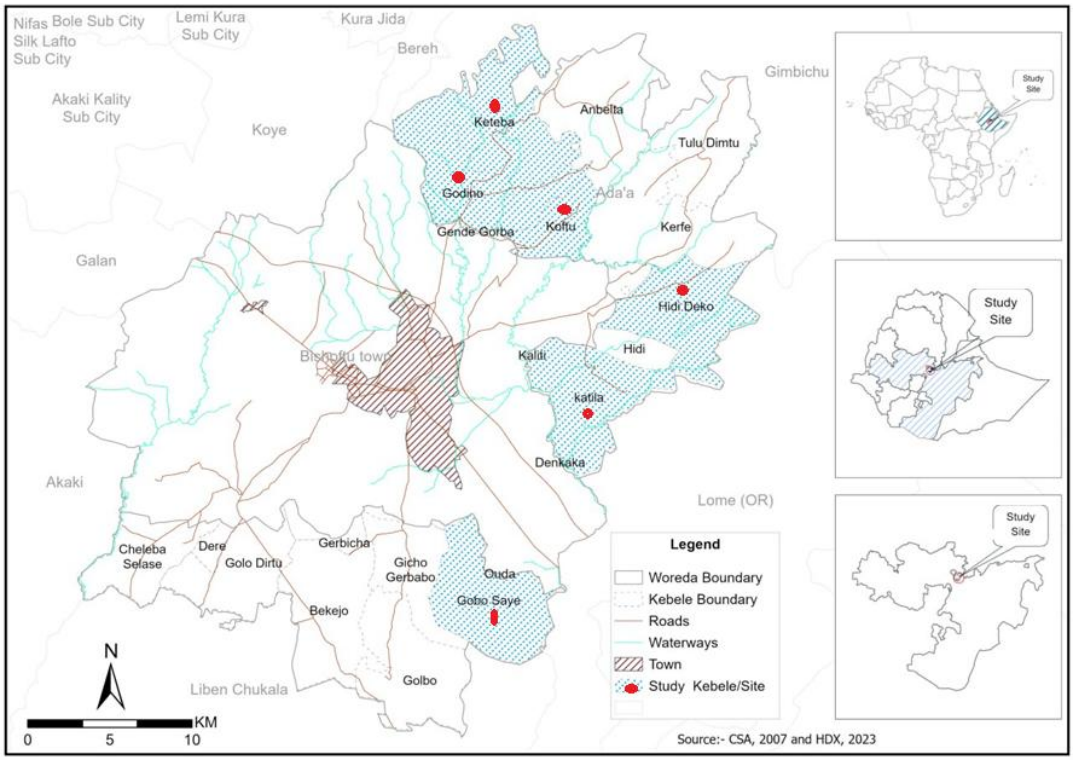

Figure 2: Map of Ada'a district showing study Kebeles
Source: Adapted from CSA (2007) and Humanitarian Data Exchange (HDX) (2024).

Sampling Strategy and Data Collection

The sampling procedure involved both probability sampling techniques (stratified and simple random) and purposive sampling. A three-stage approach was applied to select rural households for the study. First, Ada'a District was purposefully selected because of its high cereal production potential and presumed food surplus status, making it ideal for studying multidimensional food security. Stratification was subsequently performed on the basis of the Ada'a District Agriculture Bureau's classification of *high*, *medium,* and *low* cereal production potential. Among the 22 rural Kebeles, six were randomly selected (see Table 1). Finally, proportionate random sampling was used to select households from the lists obtained from the chosen Kebeles. The target population was rural households engaged in mixed farming across these six Kebeles (Table 1). Yamane's (1967) formula was used to compute the sample size, with N=5,563 (total rural households in selected Kebeles) and a 5% margin of error.

$$n = \frac{N}{1 + Ne^2}$$

The minimum required sample size was 374 households. This was adjusted for a 15% nonresponse rate, following Bujang's (2021) guidelines. As a result, the final sample size was 430 households.

Table 1: Sample size determination

Agricultural potential	Rural *Kebele*	Total household size	Percentage	Household size/Kebele*
Low	Gobesay	810	15	63
	Deko	815	15	63
Medium	Godino	1,013	18	78
	Koftu	567	10	44
High	Keteba	1,126	20	87
	Katila	1,232	22	95
	Total	**5,563**	**100**	**430**

*Source: * Author's construction (2024) on the basis of data from the Ada'a District Agriculture Office*

Primary cross-sectional data were gathered via structured in-person surveys administered by trained enumerators under the researcher's supervision. A pretest survey with 30 respondents was used to assess reliability and validity. This led to revisions for clarity and adjustments to the interview duration. Data were collected between April and May 2024, avoiding local fasting periods to ensure accurate food consumption data. This timing also facilitated greater household availability, reduced security risks, and minimized extreme food scarcity or surplus, thereby enhancing data reliability. In addition, qualitative data were gathered through six key informant interviews (KIIs). These interviews were conducted with government officials, farmers, local elders, agricultural extension workers, and experts. Six focus group discussions (FGDs) were also conducted with female and male groups. We selected participants for both the KIIs and FGDs on the basis of their expertise, age, sex, farming experience, and knowledge of food production challenges. We also collected secondary data from credible published sources on livelihoods, food security, and agricultural shocks to triangulate the survey results and ensure accuracy.

Household Food Security Measurement

Food security is a multifaceted concept that necessitates the use of composite measurements to account for dimensions such as availability, access, use, and stability. We used four indicators: the Food Consumption Score (FCS; WFP, 2008), the Consolidated Approach for Reporting Indicators of Food Security (CARI; WFP, 2015), Months of Adequate Household Food Provisioning (MAHFP; Bilinsky & Swindale, 2010), and a composite indicator (FCSMAHFP) derived from FCS and MAHFP. FCS measures caloric availability and utilization, CARI assesses availability, access, and stability (through economic vulnerability and coping strategies), and MAHFP reflects availability and stability (Mutea et al., 2019). These indicators collectively address all four dimensions of food security.

***Months of Adequate Household Food Provision (MAHFP)*:** This indicator measures food availability over a year, regardless of source, and is a proxy for household food access (Africare, 2007; Bilinsky & Swindale, 2010). It captures dimensions of stability and availability (Mutea et al., 2019). The participants reported their food availability via a questionnaire adapted from Bilinsky & Swindale (2010). The number of months with adequate food provision was

determined by subtracting the months of food shortages from twelve. This information was then used to categorize households into four categories of food adequacy (Table 2).

***Food Consumption Score (FCS)*:** The FCS measures access to food by considering the dietary frequency, variety, and nutritional value of eight food groups (WFP, 2008). As shown in Table 2, the FCS was calculated using a 7-day recall period. The consumption frequency of each food group was multiplied by its respective standard nutritional weight (2 for cereals, 3 for pulses, 1 for vegetables and fruits, 4 for meat and fish, and milk products, and 0.5 for sugar and oils) (WFP, 2008). Households were then classified according to WFP guidelines (Table 2).

***Food Expenditure Share (FES)*:** The FES, used as a proxy for economic vulnerability, represents the percentage of a household's monthly spending relative to its total monthly expenditure. The FES was calculated by dividing total food expenditures (purchased and non-purchased) by total household expenditures. Nonpurchased foods were valued using the local market or average Kebele prices. Households reported expenditures (cash and credit) over the past 30 days and six months, from which monthly food expenditure (MFE), nonfood monthly expenditure (NFME-1), and nonfood expenditure (NFME-2) were derived. The FES was calculated as the MFE divided by the sum of the MFE, NFME-1, and NFME-2. Higher FES values indicate greater economic vulnerability, with households classified on the basis of the WFP (2015) thresholds (Table 2).

***Livelihood Coping Strategies – Food Security (LCS-FS)**:* The LCS-FS measures households' medium- and long-term resilience to future shocks by examining their coping strategies used in the past 30 days or the exhaustion of strategies in the past year (WFP, 2015).The ten questions about livelihood stress and asset depletion classify coping strategies into three categories: stress (e.g., borrowing money), crisis (e.g., consuming seed stock), and emergency (e.g., selling or renting land). Households were categorized on the basis of the most severe strategy used. For example, if a household employed both a 'stress' strategy and a 'crisis' strategy, it was classified under the 'crisis' category, as 'crisis' is more severe than 'stress.' Households that did not use any coping strategy were categorized as food secure. As presented in Table 2, households were classified into four groups (Food Security Cluster, 2021).

Consolidated Approach for Reporting Indicators of Food Security (CARI): Table 2 summarizes acceptable food security indicator combinations for the CARI console. According to WFP (2015), CARI produces a composite multidimensional Food Security Index (FSI) by consolidating household-level indicators into two domains: '*Current Status*' and '*Coping Capacity*.'

Table 2: Acceptable indicator combinations for the CARI console and descriptions.

Domain		Indicator	**Food Secure (1)**	**Marginally Food Secure (2)**	**Moderately Food Insecure (3)**	**Severely Food Insecure (4)**
Current Status	Food Consumption	Food Consumption Score (FCS)	Acceptable consumption *(FCS≥35)*	-	Borderline consumption *(21.5 ≤FCS < 35)*	Poor consumption *(FCS ≤ 21)*
Coping Capacity	Economic Vulnerability	Food Expenditure Share (FES)	< 50%	50% - 65%	65% - 75%	≥ 75%
	Asset Depletion	Livelihood Coping Strategies for Food Security (LCS-FS)	None	Applied Stress Strategies	Applied Crisis Strategies	Applied Emergency Strategies
CARI -Food Security Index (FSI)						

Sources: Indicators, thresholds, table color and design adapted from WFP (2015, p.8)

The food consumption score (FCS) measures food availability and access, and represents the '*Current Status*' domain. The stability dimension assesses the '*Coping Capacity*' domain through the Food Expenditure Share (FES) and Livelihood Coping Strategies - Food Security (LCS-FS) (WFP, 2015). In accordance with the WFP (2008) guidelines, FCSs are categorized into *poor* [0–21], *borderline* [21.5–35], and *acceptable* [35.5–112], with corresponding scores of 4, 3, and 1, respectively. The '*Coping Capacity*' is determined by averaging the scores for LCS-FS and FES. The overall CARI score, calculated as (Current Status + Coping Capacity)/2 and rounded, classifies households as food secure (0–1.25), marginally food secure (1.50–2.25), moderately food insecure (2.50–3.25), or severely food insecure (3.50–4.00) (WFP, 2015). These categories are summarized in Table 2.

Table 3 presents a binary classification based on WFP (2015) and Maxwell et al. (2013). In this classification, food secure and marginally food secure households are combined into the "*food secure*" category. Moderately and severely food-insecure households are grouped into the "*food insecure*" category.

Table 3: Description of CARI food security classification

Food security category*	Description*	Food secure/Food insecure**
1=Food secure	Can meet food needs without reducing consumption or using coping strategies	Food secure (1 & 2)
2=Marginally food secure	Experiences slight food consumption issues, relies on reduced coping and applies stress coping strategies	
3=Moderate food insecure	Faces food consumption gaps and needs crisis coping strategies to meet food requirements	Food insecure (3 & 4)
4=Severely food insecure	Faces extreme food consumption gaps or severe loss of livelihood assets, leading to critical food insecurity.	

*Source: *Adapted from WFP (2015, p.29); **Maxwell et al (2013) & WFP (2015; p.29)*

Composite Indicator Derived from FCS & MAHFP (FCSMAHFP): We developed a composite food security indicator with four categories using binary classifications. Category 1 includes households classified as food insecure by FCS and MAHFP, indicating severe food insecurity. Category 2 includes households that are food insecure according to the MAHFP but food secure according to the FCS. This group indicates challenges in providing adequate

food, despite food consumption appearing sufficient. Category 3 includes households that are food secure by the MAHFP but food insecure by the FCS, indicating they have adequate food provisioning but face challenges in maintaining sufficient food consumption. Category 4 represents households classified as food secure by the FCS and the MAHFP, indicating stable food security. The use of a composite indicator with four categories, rather than a binary classification from either FCS or MAHFP alone, not only provides a better understanding of food security but also allows for more accurate identification of vulnerability levels and the specific types of interventions required to address food insecurity (Maxwell et al., 2013).

Data Analysis

Descriptive Analysis: Descriptive statistics, such as the means, standard deviations, and percentages, were used to depict the food security situation. Spearman's correlation was used to examine coherence among food security indicators. The analysis followed established guidelines for the FCS (WFP, 2008), CARI (WFP, 2015), and MAHFP (Bilinsky & Swindale, 2010).

Econometric Analysis

Multinomial and binary logit regressions were used to assess the convergence of demographic, socioeconomic, institutional, and infrastructural factors across composite food security indicators and models. The analysis was conducted using SPSS version 26, Stata 15.0, and Microsoft Excel. The binary logistic regression model is specified as follows:

$$logit\big(P(X)\big) = log\ log\ \left(\frac{P(X)}{1-P(X)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_{10} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where: $P(Y = 1|X)$ is the probability that a household is food secure (i.e., CARI =1) given the predictors X_1, X_2, …, X_{10} ; β_0 is the intercept term; β_1, β_2, …, β_{10} are the coefficients for the demographic, socioeconomic, and institutional variables X_1, X_2, …, X_{10}.

A composite indicator (FCSMAHFP), which is based on binary FCS and MAHFP, was classified into four categories: Category 1 (food insecure by both the FCS and the MAHFP); Category 2 (food insecure by the MAHFP but food secure by the FCS); Category 3 (food secure by the MAHFP but food insecure by the FCS); and Category 4 (food secure by both). Since the categories are unordered, a multinomial logistic (MNL) regression model was used to examine the effects of ten predictors on the composite food security indicators, with Category 4 as the reference group. The MNL model is expressed as:

$$log\left(\frac{P(X)}{P(X)}\right) = = \beta_{0j} + \beta_{1j} X_1 + \beta_{2j} X_2 + \cdots + \beta_{10j} X_{10} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where: $P(X)$ is the probability that a household falls into category j (for j = 1, 2, 3) given the predictors X_1, X_2, …, X_{10}, and where β_{0j}, β_{1j}, …, β_{10j} are the coefficients for the intercept term and predictors. Equations (1) and (3) were estimated using the maximum likelihood method. We computed marginal effects for both models to assess how

changes in predictors impact the likelihood of the outcomes, as estimated regression coefficients may not accurately reflect the impact of changes.

Definition of Variables

This section provides definitions of the variables used in the study. Table 4 summarizes the two outcome variables: a composite binary value of CARI (i.e., BINCARI) and the four-level composite FCSMAHFP, along with ten selected predictors for the binary logistic and multinomial regression analyses, respectively. Table 4 summarizes the predictors and their expected hypotheses.

Table 4: Variables and expected signs for household food security analysis

Variables	Description of the variables	Expected sign
Outcome Variables		
BINCARI	A composite binary indicator (BINCARI), Consolidated Approach for Reporting Indicators of Food Security, BINCARI (1= food secure, 0 = food insecure)	
FCSMAHFP	A composite indicator (FCSMAHFP) derived from binary FCS and binary MAHFP, categorized into four unordered values: Category 1 (food insecure by both FCS & MAHFP), Category 2 (food insecure by MAHFP & food secure by FCS), Category 3 (food secure by MAHFP & food insecure by FCS), and Category 4 (food secure by both FCS & MAHFP).	
Predictors		
MRTSTATUS	Household head's marital status (1 = married, 0 = single, which includes never married, divorced, and widowed).	Positive
EDUC	Household head's highest educational level (years)	Positive
OFFARM	Participation of household head in off-farm activities (1=yes, 0=no)	Positive
SEX	Household head's sex (1= male, 0 = female)	Negative
AGEHHDD	Household head's age (years)	Positive/negative
THHDSIZE	Total number of household size	Positive/negative
FARMSIZE	Total farm size (hectares)	Positive
DISTMRKT	Distance from farm to nearest market (in walking minutes)	Negative
MEMCOOP	Household head's membership in farmers' cooperative (1=yes, 0=no)	Positive
CREDITACCS	Access to credit services (1 = yes, 0= no)	Positive

Source: Author's own construction

RESULTS AND DISCUSSION

Characteristics of the sample households

Table 5 illustrates key differences between food-secure (FS) and food-insecure (FI) households across five continuous variables. The independent sample t-test reveals that FS households have significantly older household heads (48.39 years) than FI households (45.99 years). This finding is statistically significant at $p < 0.01$ across the three indicators, suggesting that older household heads may have more experience and resources, contributing to better food security. Older individuals may also have established networks and financial stability, factors that enhance their ability to secure

consistent access to food. However, this reliance on the experience of older generations highlights a potential challenge to the long-term sustainability of the food system if knowledge transfer and resource security for younger farmers (the future food producers) are inadequate, threatening intergenerational equity. Our findings are consistent with those of Weeks, Mykyta & Madans (2023), who reported that, compared with younger adults, only 3.5% of adults aged 65+ lived in food insecure households in 2021. The household size variable shows mixed results, with marginally significant differences in some measures (e.g., t = –1.99 for FCS at p-value < 0.10) and statistically insignificant associations with MAHFP and CARI. This result suggests a modest influence of household size on food security. Surprisingly, FI households have larger landholdings (1.36 - 1.6 hectares) than do FS households (0.94 - 0.99 hectares), with all t-tests being significant at $p < 0.01$. This finding implies that larger land sizes may not ensure food security, potentially because poor land utilization, restricted access to resources, or insufficient infrastructure affect optimal agricultural output. This inverse relationship between land size and food security suggests a profound lack of sustainable land management practices and poor productivity (low yield per hectare) in larger plots, which prevents the environmental pillar of sustainable development from making efficient use of agricultural resources. This highlights the need for sustainable food system interventions that prioritize inputs, training in ecological farming methods, and infrastructure over merely increasing land size to achieve both productivity and environmental stewardship

Table 5: Descriptive statistics of continuous variables and their relationships with food security indicators

Continuous variables	Food security status	MAHFP		FCS		CARI/FSI	
		Mean (±SD)	t-test	Mean (±SD)	t-test	Mean (±SD)	t-test
AGEHHDD	FS	48.39 (8.90)	-2.72 **	48.37 (8.60)	-2.60 **	48.53 (8.93)	-3.75**
	FI	45.99 (8.23)		46.09 (8.85)		45.03 (7.69)	
FARMSIZE	FS	0.97 (0.64)	5.51**	0.99 (.64)	4.49**	0.94 (0.63)	7.68**
	FI	1.42 (1.07)		1.36 (1.08)		1.60 (1.1)	
THHDSIZE	FS	5.01 (1.79)	-1.51 ^{NS}	5.04 (1.78)	-1.99*	4.84 (1.70)	1.56 ^{NS}
	FI	4.74 (1.74)		4.69 (1.76)		5.14 (1.97)	
EDUC	FS	3.89 (1.41)	-3.80**	3.84 (1.40)	-2.75*	4.04 (1.31)	-7.99**
	FI	3.30 (1.78)		3.41 (1.82)		2.77 (1.83)	
DISTMRKT	FS	49.86 (24.29)	0.95^{NS}	49.70 (23.51)	-1.37^{NS}	48.27 (23.33)	0.43 ^{NS}
	FI	46.03 (21.61)		46.44(23.31)		49.36 (23.90)	

*Source: Own survey (2024); NS = not significant; SD = standard deviation; FS = food secure; FI = food insecure; ** p < 0.01; * p < 0.10*

Higher education levels are significantly associated with food secure (FS) households across all three food security indicators. This underscores the role of education in improving income opportunities and decision-making. Farmers with higher education levels are likely to apply better agricultural methods and diversify income sources. Education, particularly in agricultural innovation and resource management, is a critical pillar of sustainable development and a sustainable food system, enabling farmers to adopt climate-smart and environmentally sound practices that increase long-term resilience. For example, Mutisya et al. (2016) reported that every additional year of schooling reduced the

likelihood of food insecurity by 0.019, even when accounting for household wealth. On the other hand, the distance from the farm to the nearest market shows no significant difference between FS and food-insecure (FI) households. This finding indicates that market proximity is not a key factor for food security in this context. The irrelevance of market distance may suggest that local supply chains and informal markets are resilient, which is a desirable characteristic of a sustainable food system that reduces dependence on distant, high-carbon transportation networks. Overall, age, farmland size, and education are key predictors, whereas household size and market distance have less influence in this context.

Table 6 shows statistically significant differences between food-secure (FS) and food-insecure (FI) households across the five categorical variables. FS households have higher marriage rates (59% vs. 23%, $p < 0.01$), greater participation in off-farm activities (54% vs. 22%, $p < 0.01$), and greater cooperative membership (57% vs. 21%, $p < 0.01$). The strong role of off-farm activities and cooperative membership signals that resilient and sustainable livelihoods rely heavily on diversified income streams and robust social capital, reducing sole dependence on climate-vulnerable subsistence farming. In addition, FS households have better access to credit (59% vs. 41%), which supports their economic resilience. Access to credit is crucial for sustainable development, as it allows households to invest in long-term, productivity-enhancing measures such as improved seeds, irrigation, or climate-smart technologies rather than resorting to short-term, unsustainable coping mechanisms. The household head's sex was not significantly correlated with food security. These factors highlight the importance of social and financial support systems in improving food security.

Table 6: Descriptive statistics of categorical variables and their associations with binary food security indicators

Variables	Indicator	Overall %	MAHFP (%)		Pearson Chi square	FCS (%)		Pearson Chi square	BINCARI (%)		Pearson Chi square	FCSMAHFP (%)		Pearson Chi square
			FS	FI		FS	FI		FS	FI		FS	FI	
MRTSTATUS	Married	81.9	59	23	32.99[(a)]	60	22	50.32[(a)]	70	12	151.54[(a)]	55	27	35.78[(a)]
	Single	18.1	7	11		6	13		3	15		6	12	
SEX	Male	79.3	52	27	0.07 [NS]	50	29	2.13 [NS]	55	24	10.68[(a)]	47	32	0.23[NS]
	Female	20.7	14	7		15	6		18	3		13	8	
OFFARM	Yes	76.3	54	22	12.27[(a)]	55	21	31.76 [(a)]	65	11	115.82 [(a)]	51	25	19.27[(a)]
	No	23.7	12	12		10	14		8	16		10	14	
MEMCOOP	Yes	77.7	57	21	33.50 [(a)]	58	20	52.36 [(a)]	68	10	161.77 [(a)]	54	24	41.81 [(a)]
	No	22.3	9	13		7	15		5	17		7	15	
CREDITACCS	Yes	59.1	40	19	0.57 [NS]	42	17	8.34 [(a)]	47	12	11.09 [(a)]	38	21	3.89 [(b)]
	No	40.9	26	15		24	17		26	15		23	18	

Source: Own survey (2024); NS = not significant; FS = food secure; FI=food insecure; (a) significant at 1% level; (b) significant at $p < 0.01$

Household Food Security Measures

We computed food security indicators to assess households' actual food security status, enabling comparison with traditional perceptions.

Food Consumption Score (FCS)

Our finding of the FCS indicator (Table 9) indicates that nearly 65% of the households surveyed were food secure, 26% were borderline, and 9% faced poor food consumption. This finding indicates that approximately 35% of the households are food insecure according to FCS measures. This challenges the assumptions of food surplus production in the study area. This significant prevalence of food insecurity, despite perceived surplus, suggests that current production practices may be environmentally or economically unsustainable for many households, leading to unequal access and a lack of long-term resilience. Our findings align with those from other seemingly food secure areas: Derara & Tolossa (2016) reported 38% food insecurity in Becho, Central Ethiopia, Markos et al. (2024) reported 31.7% food insecurity in the Konso Zone, southwestern Ethiopia, and Kerbo et al. (2024) reported 36% food insecurity in the Gurage Zone, South Central Ethiopia. These results suggest that even areas perceived as food secure can experience significant food insecurity. Although the food security level measured by the FCS appears relatively better, our findings reinforce that such regions can still exhibit notable food insecurity.

The results of the analysis of the food groups consumed and the percentage of households using each are summarized in Table 7. Almost all households (99.8%) consumed cereals for five or more days in the week before the survey, reflecting a strong reliance on staple foods such as '*Injera*' and bread made from grains such as 'teff', wheat, maize, and barley. While this ensures energy intake, it limits dietary diversity. Our findings are consistent with those of Kerbo et al. (2024), who reported that 97.1% of households in the Gurage Zone, Ethiopia, relied on cereals and starchy tubers. Similarly, Gobena and Girma (2019) reported that households in the Haramaya district, Eastern Ethiopia, primarily consumed cereal grains, highlighting limited dietary diversity and potential food insecurity despite availability. The 2019 CSA and WFP analysis of Ethiopia revealed that starchy staples accounted for 71.4% of total calorie consumption, reinforcing concerns about inadequate nutrition. Similarly, Gadiso et al. (2023) similarly reported that cereals were the most consumed food group (96.4%), followed by pulses (82%). The findings from these studies emphasize the prevalent reliance on a narrow range of foods, raising concerns about nutritional adequacy and the risk of food insecurity, despite the apparent availability of food. In contrast, 53.7% of households consumed pulses and legumes for five or more days, with 27.9% consuming them for 3-4 days, and 18.4% consuming them for 1-2 days. This intake provides essential protein, fiber, and micronutrients, although it does not fully offset the low utilization of protein-rich foods such as eggs, fish, meat and milk. Our findings on milk/dairy consumption are consistent with Kerbo et al. (2024), who reported that 38.9% of households in the Gurage Zone consumed milk or dairy for 3-4 days. In addition, 92.8% of households did not consume fruit seven days before the survey date, while 25.1% consumed pulses for more than five days, and 57.4% consumed them for 3-4 days (Kerbo et al., 2024). The extremely low consumption of diverse food groups such as fruits, vegetables, and animal source proteins indicates a failure of the

food system to deliver nutritious, sustainable diets, directly impeding the achievement of SDG 2 targets related to improved nutrition. Addressing this systemic failure requires promoting diversified, regenerative agricultural practices to ensure a shift toward sustainable and resilient nutrition security.

Table 7: Share of food groups consumed by all study households in the past 7 days (percentages)

	Days eaten in the past 7 days (percentage)			
Food groups	0 day	1-2 days	3-4 days	≥ 5 days
Main staples/cereals	0.0	0.0	0.2	99.8
Pulses and legumes	0.0	18.4	27.9	53.7
Milk and dairy	17.4	33.7	37.0	11.9
Meat, egg, and fish	27.0	52.6	17.0	3.5
Vegetables and leaves	15.6	26.5	42.6	15.3
Fruits	51.6	39.1	7.0	2.3
Oil and fat	14.7	22.3	49.1	14.0
Sugar	2.6	57.7	15.1	24.7

Source: Own survey (2024)

In Ada'a district, despite its mixed agriculture, dairy, meat, eggs, fish, fruits, and vegetables are consumed in low quantities. Approximately 34% of the participants consumed milk and dairy products for 1-2 days, and 37% consumed them for 3-4 days, with only 12% consuming them for more than five days. Meat, eggs, and fish were rarely consumed, with 53% eating them for 1-2 days and 27% not consuming them at all. Vegetable intake was moderate, but fruit consumption was particularly low, with 52% reporting no intake. Focus group discussions with female farmers revealed the following: "*We mainly prepare and consume meat during religious holidays. Vegetables and fruits are primarily grown for sale to cover nonfood household expenses. Similarly, eggs and poultry are often sold or reserved for special occasions*." Oil and fat were consumed by 49% for 3-4 days a week, and 58% consumed sugar for 1-2 days. These practices, rooted in tradition and economic necessity, contribute to diets lacking diversity and essential nutrients. Our findings are consistent with those of Jateno et al. (2023), who reported that Ethiopian households consume a limited variety of nutrient-rich foods such as lean meat, vegetables, and fruits. According to Jateno et al. (2023), despite livestock being a primary livelihood source, the intake of livestock products remains low. This finding highlights the need for greater dietary diversity to address the inadequate intake of protein, dairy, fruits, and vegetables, as noted by Jateno et al. (2023).

Food Expenditure Share (FES)

Food security analysis via the FES threshold within the CARI framework (Table 9) revealed that 51.2% of the households were classified as food secure. The remaining households were categorized as marginally food secure (19.8%), moderately food insecure (11.4%), or severely food insecure (17.6%). According to the binary classification method outlined by WFP (2015) and Maxwell et al. (2013), 71% of the households were classified as food secure, whereas 29% were categorized as food insecure, indicating significant food insecurity among the sampled households. These households spend an unsustainably large share of their income on food, leaving little for essential investments

in education, health, or productive assets. This heavy reliance on food expenditure as a coping strategy limits their ability to build resilience and escape the cycle of poverty.

Livelihood Coping Strategies for Food Security (LCS-FS)

The analysis of strategies for coping with livelihood challenges in Ada'a district (Table 8) revealed that 70.2% of households did not use stress, crisis, or emergency coping strategies (i.e., food secure), indicating some stability. In contrast, 10.9% of the households employed stress coping strategies (marginally food secure), 7.7% used crisis strategies (moderately food insecure), and 11.2% relied on emergency strategies (severely food insecure). The most common stress-related strategies included selling household assets (54.65%), selling nonproductive animals (48.37%), and borrowing money or food (34.88%). This reflects a preference for liquidating assets rather than seeking external aid. While stress strategies offer short-term relief, their repeated use depletes household reserves and makes livelihoods less sustainable over time. In comparison, a study in Tigray reported that 41%, 27%, and 21% of households coped with food insecurity by selling nonproductive assets, borrowing money, and spending savings, respectively (Gebrihet, Gebrselassie & Gebreselassie, 2025). Similarly, Almukaddem, Alali & Habib (2022) reported that 46%, 35.3%, and 5.6% of households, respectively, used savings, borrowed money, or sold more nonproductive animals. These studies suggest that asset liquidation and borrowing are more common coping strategies than savings.

For crisis strategies, 39.30% of households reduced their spending on fertilizers and pesticides, and 25% sold productive assets or cut health and education expenses, highlighting the trade-off between immediate needs and long-term investments. The reduction in spending on critical agricultural inputs and the sale of productive assets severely undermines the economic and environmental pillars of sustainable development by reducing future yields and eroding the productive capacity of the farm. Moreover, reducing health and education expenses sacrifices human capital, which threatens the long-term social sustainability and prosperity of the household. These findings suggest that while most households demonstrate resilience, a significant portion rely on strategies that could undermine future agricultural productivity and human capital. The reliance on asset liquidation indicates limited access to formal support systems, emphasizing the need for interventions to enhance sustainable livelihoods and reduce long-term vulnerabilities. Our findings align with the 2021 UNHCR report on coping strategies, although with lower proportions, 54% of households reduced health expenditures, and 29% reduced education spending (UNHCR, 2021). An analysis of emergency coping strategies revealed that 46.98% of households sold their last female animal, and 47.21% reported that at least one family member had migrated to a nearby town, underscoring the seriousness of their situation. Emergency strategies typically represent a permanent, and catastrophic disinvestment in the livelihood base that drastically reduces the household's future ability to self-recover, indicating a complete failure of resilient and sustainable food systems in these cases. In addition, 31.63% of the households rented out their farmland, highlighting how families are compelled to adapt to extreme circumstances.

Table 8: Proportion of farm households in Ada'a district adopting livelihood coping strategies

Livelihood Coping Strategies		Overall %
None	No stress, crisis and emergency strategies adopted	70.23
Stress Coping Strategies	Stress 1 - Spent savings	32.56
	Stress 2 - Sold more nonproductive animals	48.37
	Stress 3 - Borrowed money/food	34.88
	Stress 4 - Sold household assets/goods	54.65
Crisis Coping Strategies	Crisis 1- Sold productive assets/means of transport	25.58
	Crisis 2- Reduced nonfood expenditure on health & education	25.58
	Crisis 3 - Decreased expenditure on fertilizer, pesticide, fodder,	39.30
Emergency Coping Strategies	Emergency 1- Rented out the farmland	31.63
	Emergency 2 - Sold last female animal	46.98
	Emergency 3 – At least one family member migrated to a nearby town	47.21

Source: Own survey (2024)

Months of Adequate Household Food Provision (MAHFP)

The MAHFP scores (Figure 3) indicate that 62.6% of the households are food secure, 3.7% are marginally food secure, 7.4% are moderately food insecure, and 26.3% are severely food insecure. On the basis of WFP (2015) and Maxwell et al. (2013), binary classification revealed that 66.3% of households had adequate food, whereas 33.7% were food insecure. On average, households faced a food gap of 1.71 months, indicating they had sufficient food for 10.29 months annually. In comparison, Guyalo et al. (2022) reported that households in the Gambela region of western Ethiopia managed to have sufficient food for 8.8 months, and Matavel et al. (2022) reported that only 6.2% of households in South Wello Zone, Ethiopia could feed their families year-round. These differences highlight regional disparities in food security, highlighting the importance of tailored interventions.

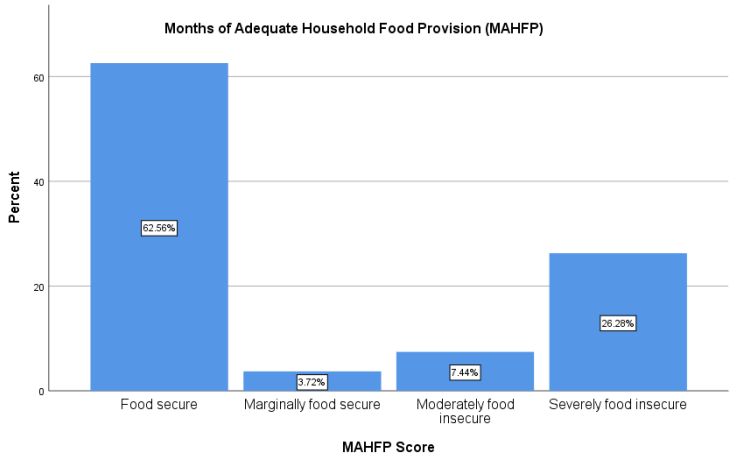

Figure 3: Months of Adequate Household Food Provision; Source: Own survey (2024)

Consolidated Approach for Reporting Indicators of Food Security (CARI)

The composite CARI Food Security Index (FSI) revealed that 72.8% of the households sampled in the six Kebeles were food secure and marginally food secure. Of these, approximately 46% fell into the marginally food insecure category. This finding indicates that, without targeted intervention, these households are at a significant risk of falling into food insecurity. On the other hand, 27.2% of the households were classified as food insecure (moderate to severe) (Table 9).

Table 9: Results of the CARI/Food Security Index (FSI) in Ada'a District ($n = 430$)

Domain		Indicator	**Food Secure (1)**	**Marginally Food Secure (2)**	**Moderately Food Insecure (3)**	**Severely Food Insecure (4)**
Current Status	Food Consumption	Food Consumption Score (FCS)	65.3%	-	25.6%	9.1%
Coping Capacity	Economic Vulnerability	Food Expenditure Share (FES)	51.2%	19.8%	11.4%	17.6%
	Asset Depletion	Livelihood Coping Strategies for Food Security (LCS-FS)	70.2%	10.9%	7.7%	11.2%
CARI - Food Security Index (FSI)			**26.5%**	**46.3%**	**19.8%**	**7.4%**

Sources: Own survey (2024); table color & design adapted from WFP (2015)

Derived Composite Indicator FCSMAHFP

Table 10 shows that 29% of households are food insecure according to the FCS and MAHFP, indicating both short-term dietary deficiencies and long-term food availability issues. Approximately 5% of households are food insecure by the MAHFP but food secure by the FCS, suggesting adequate short-term consumption despite provisioning challenges. On the other hand, 6% are food secure according to the MAHFP but food insecure according to the FCS, indicating sufficient food provisioning but dietary deficiencies. The remaining 61% are food secure on both indicators. This analysis highlights that a composite indicator provides a more complete view of food security by combining the strengths of FCS and MAHFP. For example, while the MAHFP indicator classifies 66.3% of households as food secure, the composite indicator shows that 60.7% are food secure on both the FCS and the MAHFP, with 5.6% food secure by the MAHFP but food insecure by the FCS. The composite indicator provides a more accurate assessment, enhancing the targeting and effectiveness of food security interventions in Ada'a district and beyond. By improving targeting accuracy, the use of composite indicators enhances the efficiency of resource use, which is a key tenet of sustainable intervention and policy.

Table 10: Proportion of households based on the derived composite indicator of FCS and MAHFP

Binary classification of MAHFP (percentage)	Binary classification of FCS (percentage)		Total (percentage)
	Food insecure	Food secure	
Food insecure	29.0	4.7	**33.7**
Food secure	5.6	60.7	**66.3**
Total	**34.6**	**65.4**	**100**

Source: Own survey 2024

The Pearson chi-square test result of 256.80 (p-value < 0.001) reveals a significant relationship between MAHFP and FCS, indicating a strong alignment in classifying households as food insecure or secure. Nevertheless, 4.7% and 5.6% of households are classified differently, suggesting that using a single indicator may not fully capture food security. Combining both indicators provides a more comprehensive assessment. A Phi value of 0.773 indicates a strong positive association between the two variables. The study shows that while the four food security measures are similar, each produces different estimates of food insecurity prevalence for the same population. This implies that relying on a single indicator is insufficient, as food security is a complex issue that necessitates the use of multiple indicators to capture its different dimensions. The observed discrepancies and the resulting need for multiple indicators underscore that achieving sustainable food systems requires holistic, multidimensional assessment frameworks that go beyond simple yield or availability measures. The findings from the FCS, MAHFP, CARI, and FCSMAHFP highlight the discrepancy between perceived food and actual security, with many households facing food insecurity despite the district's relatively secure reputation. Failure to use comprehensive, multi-indicator assessments risks misallocating sustainable development resources, potentially directing aid to the wrong areas or ignoring critical, hidden vulnerabilities

Comparative Analysis of Food Security Indicators

We compared how the FCS, CARI, MAHFP, and FCSMAHFP indicators reflect household food insecurity and classify households similarly. To accomplish this, we converted the four measures into binary categories of "food secure" and "food insecure," following the approach of WFP (2015) and Maxwell et al. (2013), as shown in Table 11. For the composite FCSMAHFP indicator, we combined the food security statuses of both MAHFP and FCS. Households were classified as food insecure (0) if either indicator showed insecurity; they were classified as food secure (1) only if both indicators showed security.

Table 11: Classification and comparative analysis of food security indicators

Indicator	CARI four-point base category	CARI four-point base qualitative label	Proportion of households**	Transformed binary classification*	Proportion of households**
FCS	1	Acceptable	65.3	Food secure	65.3
	3	Borderline	25.6		
	4	Poor	9.1	Food insecure	**34.7**
MAHFP	1	Food secure	62.6		
	2	Marginally food secure	3.7	Food secure	66.3
	3	Moderately food insecure	7.4		
	4	Severely food insecure	26.3	Food insecure	**33.7**
Composite CARI	1	Food secure	26.5	Food secure	72.8
	2	Marginally food secure	46.3		
	3	Moderately food insecure	19.8		
	4	Severely food insecure	7.4	Food insecure	**27.2**
Composite FCSMAHFP***	1	Food insecure by both FCS & MAHFP	29.0	Food insecure	**39.3**
	2	Food insecure by MAHFP & food secure by FCS	4.7		
	3	Food secure by MAHFP & food insecure by FCS	5.6		
	4	Food secure by both MAHFP & FCS	60.7	Food secure	60.7

*Sources: * WFP (2015) & Maxwell et al. (2013); **Own survey (2024); *** FCSMAHFP author categorization*

The multi-indicator assessment of food security (Table 11), which uses binary classifications, provides a comprehensive understanding of the different dimensions of food security. The composite FCSMAHFP indicator, which combines short-term consumption of food quantity, quality and diversity and long-term provisioning, identifies the largest percentage of food-insecure households at 39.3%. This complexity proves that a sustainable food system needs multifaceted solutions. This reflects the complexity of food insecurity, where many households face immediate food access and long-term sustainability challenges. The FCS indicator reveals that 34.7% of households are food insecure, mainly due to short-term access issues, with 25.6% in the borderline category. The analysis of the MAHFP indicator reveals that 33.7% of households are food insecure, indicating long-term provisioning issues, with 26.3% experiencing severe insecurity. The CARI identifies 37% of households as food-insecure, focusing on those employing coping strategies, and revealing vulnerabilities in both consumption and resilience. Therefore, a multi-indicator approach is crucial. This highlights the need for interventions that balance immediate access with long-term environmental and economic sustainability. Households that appear food secure under one indicator may still be vulnerable under another. Using multiple indicators improves the accuracy of targeting, ensuring efficient, sustainable allocation of development aid. Using multiple indicators allows policies and aid in targeting households with varied needs more effectively, strengthening resilience in the community. The four food insecurity indicators (Table 12) measure different dimensions of food security and produce varying estimates. To examine their consistency, we calculated Spearman's correlation coefficient for all four indicators on the basis of their binary values, labeled binFCS, binMAHFP, binCARI, and binFCSMAHFP (Table 12).

Table 12: Spearman's correlation between food security indicators

Binary indicators	binFCS	binMAHFP	binCARI	binFCSMAHFP
binFCS	1			
binMAHFP	0.7728*	1		
binCARI	0.5651*	0.4592*	1	
binFCSMAHFP	0.9049*	0.8864*	0.5137*	1

**Correlation is significant at the 0.01 level (2-tailed); Source: Own survey (2024)*

Table 12 shows the Spearman's rho correlation between food security indicators, highlighting the strength of their relationships and the variance explained. The correlation coefficient between binFCS and binFCSMAHFP is 0.9049, accounting for 81.9% of the variance, and the correlation coefficient between binFCS and binMAHFP is 0.7728, accounting for 59.7% of the variance, both of which are statistically significant at the 0.01 level. Similarly, the correlation between binCARI and binFCS is 0.5651, which explains 31.9% of the variance, whereas the correlation coefficient between binCARI and binMAHFP is 0.4592, which explains 21.1% of the variance, with all correlations being statistically significant at the 0.01 level. These moderate correlations for binCARI imply that it captures unique dimensions, specifically economic vulnerability and asset depletion (coping capacities), which are not fully measured by consumption or availability indicators alone. These coping capacities are central to livelihood resilience; their inclusion in the assessment allows for a more sustainable development focus, moving beyond immediate deficits to analyze systemic vulnerabilities that undermine long-term stability.

The binFCSMAHFP indicator shows strong correlations with all other indicators, especially with binFCS and binMAHFP, indicating a high level of consistency. Although these indicators measure different dimensions of food security, the significant correlations among the four measures provide consistent evidence for classifying households similarly. Therefore, combining these indicators offers a more comprehensive understanding of food insecurity (Maxwell et al., 2013). This multi-indicator approach, by integrating consumption (FCS), long-term stability (MAHFP), and resilience/coping (CARI), creates a robust assessment essential for informing policies that promote a holistic, sustainable food system that addresses all four pillars of food security. This approach ensures that immediate consumption issues and long-term provisioning challenges, along with coping capacities, are accounted for. This approach strengthens the consistency and reliability of food security classifications across different measures. In addition, we validated this consistency by calculating Cohen's Kappa (κ) to gauge the agreement among the four food security measures in classifying households as either food insecure or food secure. The findings of this analysis are presented in Table 13. The widely accepted thresholds for interpreting Cohen's Kappa values suggest that a value below zero represents poor agreement, 0 to 0.2 represents slight agreement, 0.21 to 0.4 represents fair agreement, 0.41 to 0.6 represents moderate agreement, 0.61 to 0.80 represents substantial agreement, and 0.81 to 1.00 represents almost perfect agreement (Cohen, 1960).

Table 13: Cohen Kappa coefficients for pairwise food security indicators

Binary food security indicator pairs	Agreement (%)	Expected agreement (%)	Kappa (κ)	Std. Err.	z	prob > z
binFCS vs. binMAHFP	89.77	55.00	**0.7726**	0.0482	16.02	0.000
binFCS vs binCARI	80.93	57.00	**0.5566**	0.0475	11.72	0.000
binFCS vs binFCSMAHFP	95.35	53.28	**0.9004**	0.0480	18.77	0.000
binMAHFP vs binCARI	76.74	57.42	**0.4538**	0.0477	9.52	0.000
binMAHFP vs. binFCSMAHFP	94.42	53.48	**0.8800**	0.0479	18.38	0.000
binCARI vs. binFCSMAHFP	77.21	54.88	**0.4949**	0.0465	10.65	0.000

Source: Own survey (2024)

The Cohen's Kappa values in Table 13 reveal the level of agreement between different binary food security indicators. The binFCS vs. binFCSMAHFP pair shows almost perfect agreement with a Kappa of 0.9004, whereas the binFCS vs. binMAHFP pair demonstrates substantial agreement at 0.7726, aligning with the strong Pearson correlation of 0.7728. The binFCS vs. binCARI pair has moderate agreement (Kappa = 0.5566), which is consistent with the moderate Pearson correlation of 0.5651. Similarly, binMAHFP vs. binCARI shows fair agreement (Kappa = 0.4538), matching the Pearson correlation of 0.4592. The binMAHFP vs. binFCSMAHFP pair also has almost perfect agreement (Kappa = 0.8800), and the binCARI vs. binFCSMAHFP pair shows moderate agreement (Kappa = 0.4949), which is somewhat consistent with a moderate Pearson correlation of 0.5137. These Kappa values, along with the Pearson correlations, confirm that the indicators provide similar evidence for classifying households comparably. Despite measuring different dimensions of food security, the indicators show consistent results. The high levels of agreement reinforce the reliability and consistency of food security classifications, suggesting that combining these indicators offers thorough and precise insights into food insecurity.

Examining the Convergence of Determinants of Household Food Security across Composite Indicators in Ada'a District

Multinomial and binary logistic regressions were applied to assess the convergence of household food security determinants across the composite CARI and FCSMAHFP indicators. Model diagnostics for the multinomial logistic (MNL) regression were conducted to determine its fitness. The Hausman test for the independence of irrelevant alternatives (IIA) assumption yielded p-values between 0.946 and 1.000, strongly supporting that the IIA assumption holds. This confirms the appropriateness of the MNL model, which is consistent with Hausman and McFadden (1984), Long and Freese (2014), and Vijverberg (2011). The model's overall fit was evaluated using the likelihood ratio (LR) test, which produced a chi-square value of 356.64 ($p < 0.01$), indicating a good fit. The Akaike Information Criterion (AIC) was 741.4817, and the Bayesian Information Criterion (BIC) was 887.778. The log-likelihood values for the null and estimated models were -415.3607 and -334.7409, respectively, indicating a better fit for the model with predictors. A pseudo-R^2 value of 0.1941 indicates that the model explains 19.41% of the variation in the outcome variable.

Multicollinearity in the binary and MNL regression models was assessed using variance inflation factor (VIF). The VIF values ranged from 1.02 to 1.33, with a mean of 1.13, well below the threshold of 5, indicating no multicollinearity issues. The logit model's predictive ability was assessed by comparing overall classification accuracy (OCA) with proportional by chance accuracy (PCA). Following El-Habil (2012) and White (2013), the OCA should exceed 1.25 times the PCA. With an OCA of 71.16% and a PCA of 53.51%, the OCA exceeds the 66.89% threshold, indicating that the model has acceptable predictive performance. To test the binary logit model's robustness, the AIC and BIC were computed as 168.7439 and 213.4456, respectively. The receiver operating characteristic (ROC) curve was plotted to evaluate predictive accuracy, with an area under the curve (AUC) of 0.9811, indicating excellent model classification (Figure 4). This demonstrates strong performance in classifying food-secure and insecure households, aligning with AUC thresholds: $0.9 \leq$ AUC (excellent), $0.8 \leq$ AUC < 0.9 (considerable), $0.7 \leq$ AUC < 0.8 (fair), $0.6 \leq$ AUC < 0.7 (poor), and $0.5 \leq$ AUC < 0.6 (fail) (Çorbacıoğlu & Aksel, 2023).

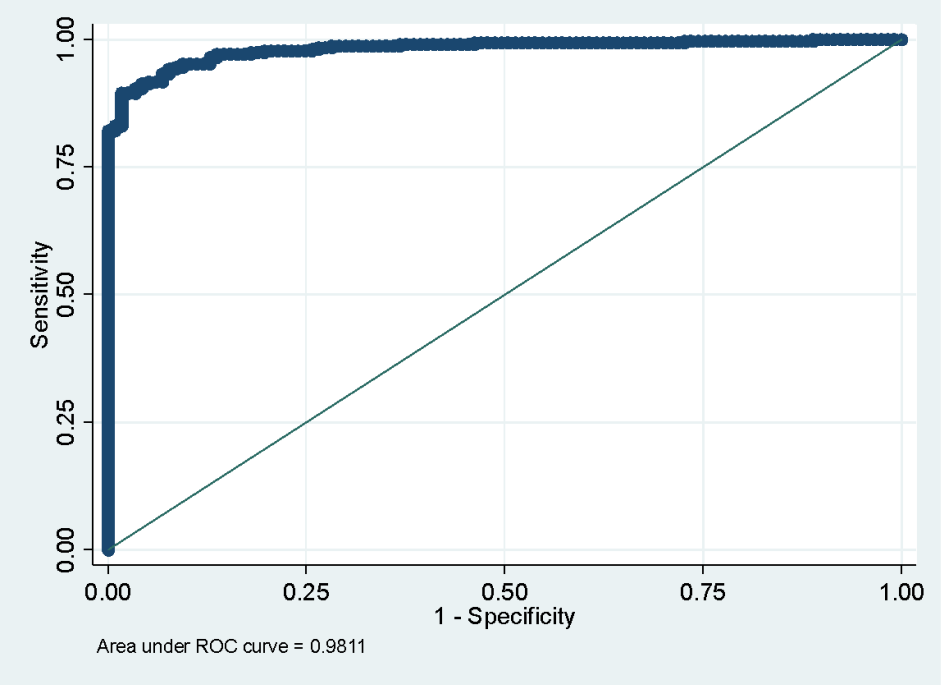

Figure 4: Receiver operating characteristic (ROC) curve; Source: own survey (2024)

We assessed the convergence of factors in determining food security status by comparing the marginal coefficients and statistical significance of predictors in both binary and multinomial logistic regression models. Table 14 presents the maximum likelihood estimates of a logit model with robust standard errors. Using a binary CARI outcome (1 = food secure, 0 = food insecure), nine out of ten predictors significantly influenced household food security in Ada'a district.

Marital status of the household head (MRTSTATUS): The marital status of the household head (MRTSTATUS) is positively associated with food security, with an average marginal effect of 0.1850 ($z = 8.17$, $p < 0.01$). This result indicates that being married increases the probability of food security by 18.5%. This may be due to factors like shared

resources or a stable household structure, which enhance food access. This finding aligns with that ofTantu et al. (2017), who reported that married households were less likely to experience food insecurity, whereas single-headed households were four times more vulnerable to food insecurity. From a social sustainability perspective, this finding underscores the critical role of stable social structures and shared domestic labor in building household resilience. While not a direct policy target, understanding that family structures enhance resource pooling and buffer against shocks is key to developing socially sustainable and effective food security programs.

Table 14: Maximum likelihood estimates of the binary logit model

Variables	Coefficient	Robust Std. Err. (S.E.)	z	$p > \|z\|$	Average Marginal Effects		
					$\frac{dy}{dx}$	z	$p > \|z\|$
MRTSTATUS (1=married)	3.7086	0.7297	5.08	0.000***	0.1850***	8.17	0.000
EDUC (years)	0.6126	0.1776	3.45	0.001***	0.0306***	4.13	0.000
OFFARM (1 = yes)	3.2414	0.5711	5.68	0.000***	0.2392***	5.19	0.000
SEX (1 = male)	-2.2180	0.8679	-2.56	0.011**	-0.1002***	-2.95	0.003
AGEHHD (years)	0.0608	0.0260	2.34	0.019**	0.0030 **	2.59	0.010
THHDSIZE	-0.3214	0.1262	-2.55	0.011**	-0.0160***	-2.71	0.007
FARMSIZE (hectare)	-1.1100	0.2121	-5.23	0.000***	-0.0554***	-5.69	0.000
DISTMRKT (minutes)	-0.0018	0.0108	-0.16	0.870 NS	-0.0001 NS	-0.16	0.870
MEMCOOP (1=yes)	2.8724	0.5318	5.40	0.000***	0.2251***	4.91	0.000
CREDITACCS (1= yes)	1.0701	0.4619	2.32	0.021**	0.0543**	2.40	0.016
Constant	-6.6119	2.1048	-3.14	0.002***			
Dependent variable = Binary CARI		Wald chi2(10) = 60.36					
Log pseudolikelihood = -73.3719		Pseudo R2 = 0.7085					
Number of observations = 430		Prob > chi2 = 0.0000					
AIC = 168.7439		BIC = 213.4456					

*Source: Own survey (2024); S.E.= standard error; NS = not significant; ** p < 0.05; *** P < 0.01*
AIC = Akaike's Information Criterion; BIC = Bayesian Information Criterion

Educational status of the household head (EDUC): The educational status of the household head (EDUC) is positively associated with food security, with each additional year of education increasing the probability of food security by 3.06% (marginal effect = 0.0306, z = 4.13, p < 0.01). Education likely enhances economic opportunities and decision-making, contributing to better food security. Education is a core driver of sustainable development, empowering heads to adopt climate-smart and resource-efficient agricultural practices, and ensuring long-term resilience. This finding supports Hailu (2023), who reported that each additional year of education increased the odds of food security by 0.914, and Assefa and Abide (2023), who reported that educated households in rural areas were 2.376 times less likely to experience food insecurity.

Participation in off-farm activities (OFFARM): Participating in off-farm work (OFFARM) is positively associated with food security, with a marginal effect of 0.2392 ($z = 5.19$, $p < 0.01$), indicating that a 23.92% greater probability of food security for off-farm participants. Off-farm employment may provide additional income, improving food security. Reliance on diversified income is a hallmark of resilient and sustainable livelihoods, buffering households against shocks and reducing pressure on land resources. This finding aligns with Hailu (2023), who found that each additional Ethiopian Birr in off-farm income increased the odds of food security by 1.039, and Lolaso et al. (2024), who reported that households engaged in off-farm activities were 4.55 times more likely to be food secure. Policies supporting nonfarm opportunities are crucial for fostering economic diversification, a key pillar of sustainable development.

Sex of household head (SEX): Research shows mixed results on the link between a household head's sex and food security, with most indicating that male-headed households are more food secure. In contrast, our study revealed a significant negative association between the sex of the household head and food security ($p < 0.05$). The marginal effect of being male is -0.1002 ($z = -2.95$, $p < 0.05$). This finding indicates that being male decreases the probability of being food secure by approximately 10.02%, suggesting that, in our context, males are less likely to be food secure than females are. "*Although men may have more access to land and capital, women's roles as primary caregivers and food managers often make them more successful in ensuring household food security. Women prioritize nutrition and invest in their families' well-being. They also engage in income-generating activities, such as poultry and small ruminant rearing (goats and sheep), selling them to purchase household necessities. This combination of knowledge and additional income sources helps women better sustain food security for their families*." (Focus Group Discussion, May 2024). Cross-tabulation revealed that 87.6% of women-headed households are members of farmers' cooperatives, whereas 75.1% of male-headed households are members of cooperatives (Pearson chi-square = 6.4279, $p = 0.011$). This finding indicates that women's greater cooperative participation improves resource access, potentially enhancing food security. This highlights that gender equality and women's empowerment (SDG 5) are fundamentally linked to food security and the establishment of sustainable food systems. Women's demonstrated efficiency in terms of resource management, nutrition prioritization, and cooperative engagement make them crucial agents of change for building long-term social and nutritional sustainability in the community. Our findings are consistent with studies showing that women-headed households (WHHs) are more food secure than male-headed households (MHHs) are (Egah et al., 2023; Taruvinga et al., 2013; Kassie et al., 2015; Cheteni et al., 2020). Egah et al. (2023) reported that WHHs are less exposed to food insecurity, while Taruvinga et al. (2013) reported that WHHs achieve greater dietary diversity. Kassie et al. (2024) noted that WHHs are more food secure when they have equal resource access. Cheteni et al. (2020) reported that female-headed households are 0.310 times more likely to be food secure. Similarly, Abafita and Kim (2014) reported that males had a 3.2% lower likelihood of being food secure (odds ratio = 0.968, $p < 0.01$). Therefore, policy interventions aimed at sustainable development must actively promote women's access to land, credit, and cooperative leadership to maximize their positive influence on household food security and resilience.

Age of household head (AGEHHD): Age of the household head (AGEHHD) is positively associated with food security ($z = 2.59$, $p < 0.05$). Each additional year increases the likelihood of food security by 0.30% (marginal effect

= 0.0030). This finding suggests that older household heads may have more experience in resource management. While this experience enhances current food security and local resource knowledge, reliance on age poses a threat to intergenerational sustainability**.** Our findings are consistent with Assefa and Abide (2023), who reported that each additional year of age increases the odds of being food secure by 6.141. For a truly sustainable food system, effective mechanisms, such as farmer-to-farmer training programs, mentorship schemes, access to land and credit for young farmers, cooperative membership, and knowledge sharing platforms, are necessary to transfer agricultural experience and ensure resource access to younger generations, thereby maintaining long-term resilience.

Total household size (THHDSIZE): Total household size (THHDSIZE) is negatively associated with food security (coefficient = -0.0160, p = 0.007), with larger households having a 1.60% lower probability of being food secure (z = -2.71), likely due to higher resource demands. Our findings align with those of Awoke et al. (2023), Assefa and Abide (2023), and Alemayehu & Tesfaye (2024), who reported a significant negative relationship between household size and food security. Addressing this requires interventions that boost productivity and resource efficiency (economic sustainability) while supporting health and family planning initiatives (social sustainability).

Farmland size in hectares (FARMSIZE): Our analysis reveals a negative relationship between farm size and food security. This finding implies that each additional hectare reduces the likelihood of food security by 5.54% (marginal effect = -0.0554, z = -5.69, p = 0.000). Larger farms may face food security challenges due to market dependencies, high input costs, and productivity issues. This inverse relationship critically undermines the economic and environmental pillars of sustainable development; it proves that simply holding more land does not equate to sustainable production or improved welfare**.** A key informant interviewee from Gobesay Kebele, a 58-year-old farmer, highlighted this issue. He said, "*I have 2.1 hectares of land, but its fertility has been declining yearly*. *In our village, we say, 'A large field does not fill an empty belly.' I've seen this truth in my own life. Once fertile here, land fails to produce much. The skyrocketing prices of fertilizers make available resources seem futile. The earth gives less each season, and despite working tirelessly, we find ourselves with little production. 'A hungry stomach has no ears,' we say, and it's true, when you're hungry, nothing else matters*." The farmer's testimony underscores a crisis of ecological and economic sustainability: declining soil fertility and high input costs negate the benefit of land ownership, signaling the urgent need for a shift toward resource-efficient, regenerative agricultural practices to build long-term food system resilience. Our findings are consistent with those of Awoke et al. (2022), who reported a negative and statistically significant relationship between land size and food security, with an odds ratio of 0.52, indicating that each additional hectare reduces the odds of food security by 48%. Geda et al. (2024) reported an inverse relationship, although it was not statistically significant. A cross-tabulation of farm size (above and below the mean of 1.2 hectares) and food security revealed a significant association (Pearson chi-square = 72.93, p = 0.000). Among 310 households, 84.2% with farm sizes less than 1.2 hectares were food secure whereas 43.3% of those with larger farms were food secure. This finding suggests that smaller farms may enhance food security, potentially because of lower input costs or more efficient management, which is supported by Wassie et al. (2019), who reported that smaller farms are more

productive. This reinforces the concept of sustainable intensification and is critical for sustainable development, as it promotes resource efficiency and higher productivity per unit of land, aligning with ecological farming principles.

Distance from the farm to the nearest market in walking minutes (DISTMRKT): The farm's proximity to the market affects access to resources and transportation costs. The marginal effect of distance to the market is -0.0001, with a p-value of 0.870, indicating that distance does not significantly impact food security in this context. This finding suggests that market accessibility may not be a significant barrier for the study population. Therefore, improving food security in this context may require interventions beyond market access, focusing instead on factors such as production efficiency, resource management, and resilience-building.

Membership in cooperatives (MEMCOOP): Membership in cooperatives (MEMCOOP) increases the probability of food security by 22.51% (marginal effect = 0.2251, z = 4.91, p = 0.000), suggesting that membership provides access to resources and support, enhancing food security. Cooperative networks enhance social cohesion and provide shared resources. They also improve household economic resilience, supporting both the social and economic dimensions of sustainable development. Our findings are consistent with those of Hailu (2023).

Access to credit services (CREDITACCS): Access to credit services (CREDITACCS) increases the probability of food security by 5.43% (marginal effect = 0.0543, z = 2.40, p = 0.016). Financial access enables households to invest in agricultural inputs and secure food. When used for sustainable farming practices, credit also contributes to environmental sustainability while strengthening economic resilience. This finding supports the conclusions of Hailu (2023) and Awoke et al. (2022).

Table 15 summarizes the marginal effect estimation of the multinomial logit model. Seven predictors significantly affect Category 1 (food insecure by FCS and MAHFP). Two predictors affect Category 2 (food insecure by MAHFP and food secure by FCS). Four predictors impact Category 3 (food secure by the MAHFP and food insecure by FCS). Five predictors influence Category 4 (food secure by both FCS and MAHFP). The predictors and their effects on the outcome variable are detailed below.

Marital status of the household head (MRTSTATUS): The marginal effect for MRTSTATUS in Category 1 is -0.198 (p = 0.002), indicating that marriage reduces the likelihood of being food insecure by 19.8%. This finding suggests that married individuals are less likely to experience food insecurity in FCS and MAHFP. In Category 3, the marginal effect is +0.056 (p = 0.000), indicating that the probability of food being secure by the MAHFP but food insecure by the FCS is 5.6%, implying that marriage may improve food access but not necessarily food diversity or quality. In Category 4, the marginal effect is +0.161 (p = 0.014), indicating that marriage increases the likelihood of being food secure by both the FCS and the MAHFP by 16.1%. These findings suggest that marriage strengthens the social dimension through household stability and cooperation, and the economic dimension by improving overall food

access and resilience, thus supporting sustainable livelihoods. These findings partially align with those of Tantu et al. (2017), who reported that married households are less likely to experience food insecurity.

Household head's educational level (EDUC): EDUC is negatively associated with the probability of being in Category 1 (food insecure by both the FCS and MAHFP) and Category 3 (food secure by the MAHFP, food insecure by the FCS). Specifically, each additional year of schooling decreases the probability of being in Category 1 by 2.2% ($p < 0.10$) and Category 3 by 1.1% ($p < 0.10$). This finding reflects how education enhances access to information, income, and employment, which strengthens both the social and economic dimensions of sustainability and improves overall food security. However, higher education increases the probability of being in Category 2 (food insecure by FCS, food secure by MAHFP) by 1.8% ($p < 0.05$), suggesting that while education supports food access and resilience, it may not fully ensure dietary diversity. These findings are consistent with those of Hailu (2023) and Assefa and Abide (2023).

Table 15: Marginal effect estimation of the multinomial logit model

	Category 1			Category 2			Category 3			Category 4		
Predictors	dy/dx	Robust S.E.	P>|z|	dy/dx	Robust S.E.	P>|z|	dy/dx	Robust S.E.	P>|z|	dy/dx	Robust S.E.	P>|z|
MRTSTATUS	-0.198	0.063	**0.002**	-0.019	0.034	0.574	0.056	0.012	**0.000**	0.161	0.065	**0.014**
EDUC	-0.022	0.013	**0.095**	0.018	0.007	**0.013**	-0.011	0.007	**0.085**	0.015	0.014	0.262
OFFARM	-0.099	0.055	**0.069**	-0.039	0.027	0.143	0.059	0.013	**0.000**	0.079	0.056	0.161
SEX	0.012	0.050	0.809	0.008	0.026	0.768	-0.053	0.032	0.103	0.033	0.056	0.558
AGEHHD	-0.002	0.002	0.307	0.000	0.002	0.796	-0.002	0.001	0.205	0.005	0.003	**0.088**
THHDSIZE	-0.021	0.010	**0.045**	-0.003	0.006	0.616	0.001	0.006	0.889	0.023	0.012	**0.047**
FARMSIZE	0.066	0.023	**0.004**	-0.008	0.016	0.598	0.024	0.015	0.115	-0.082	0.026	**0.002**
DISTMRKT	-0.002	0.001	**0.052**	0.000	0.001	0.793	0.000	0.001	0.918	0.002	0.001	0.105
MEMCOOPR	-0.170	0.058	**0.003**	-0.048	0.030	0.106	0.007	0.023	0.768	0.211	0.060	**0.000**
CREDITACCS	-0.043	0.041	0.300	-0.054	0.025	**0.029**	0.033	0.019	**0.078**	0.064	0.045	0.151

Source: Own survey (2024)

Participation in off-farm activities (OFFARM): OFFARM decreases the likelihood of being in Category 1 (food insecure by both the FCS and the MAHFP) by 9.9% ($p < 0.10$) and increases the probability of being in Category 3 (food secure by the MAHFP, food insecure by the FCS) by 5.9% ($p < 0.01$). This finding suggests that off-farm employment alleviates severe food insecurity but may not fully address issues related to food quality or diversity. While it helps diversify income, it does not resolve all aspects of food insecurity, especially dietary diversity. These findings align with those of Lolaso et al. (2024) and Hailu (2023).

Household head's age (AGEHHD): AGEHHD has mixed implications for food security. While younger heads may lack experience and stable income, older heads may face challenges such as declining health. In this study, age has a statistically significant and positive effect, increasing the probability of being in Category 4 (food secure by both FCS and MAHFP) by 0.5% ($p < 0.10$). This finding suggests that older household heads may have better resource

management skills, contributing to improved food security. Our findings are consistent with those of Assefa and Abide (2023).

Total household size (THHDSIZE): Household size can impact food security in various ways, with larger households facing higher demands but potentially benefiting from pooled resources. Larger households are 2.1% less likely to be in Category 1 (food insecure by both FCS and MAHFP) and 2.3% more likely to be in Category 4 (food secure by both FCS and MAHFP) ($p < 0.05$). This finding suggests that larger households may have more support, benefit from pooled resources, and experience reduced food insecurity. These findings align with those of Alemayehu and Tesfaye (2024).

Total farmland size (FARMSIZE): Existing studies suggest that larger farms generally improve food security by increasing food availability and income stability. However, our findings indicate that larger farms may face inefficiencies that worsen food insecurity. Larger farms increase the likelihood of being in Category 1 (food insecure by both FCS and MAHFP) by 6.6% ($p < 0.01$) and decrease the probability of being in Category 4 (food secure) by 8.2% ($p < 0.05$). This finding suggests that factors such as resource management and external risk, rather than farm size alone, are key to food security. This finding is in agreement with Awoke et al. (2024) and Wassie et al. (2019).

Distance from farm to the nearest market (DISTMRKT): Food security studies suggest that greater market distance negatively impacts food security by increasing transportation costs and limiting market access. Our findings show that a greater distance from the market decreases the likelihood of a household being in Category 1 (food insecure by both FCS and MAHFP) by 0.2% ($p < 0.10$). This implies that households farther from markets may experience slightly less food insecurity, possibly due to increased self-sufficiency. This aligns with Sani & Kemaw (2019), who reported a 1.12% increase in food security for each additional kilometer from the market, and Gemechu et al. (2016), who reported 0.340 fold decrease in the odds of food security for each additional hour of walking distance to the market.

Membership in cooperative (MEMCOOPR): The literature suggests that cooperatives enhance food security by providing access to resources, shared knowledge, and collective marketing. Our findings show that cooperative membership decreases the probability of a household being in Category 1 (food insecure by both FCS & MAHFP) by 17% ($p < 0.01$) and increases the likelihood of being in Category 4 (food secure by both FCS & MAHFP) by 21.1% ($p < 0.01$). This finding highlights the positive impact of cooperatives on food security. Similarly, Kehinde & Kehinde (2020) reported that cooperative membership increased food security by 1,445.650 kilocalories per person per day in southwestern Nigeria.

Credit access (CREDITACCS): Credit access improves food security by enabling investment in agriculture, increasing income stability, and enhancing food access. Our findings illustrate that credit access reduces the probability of households being in Category 2 (food secure by the FCS but food insecure by the MAHFP) by 5.4%,

improving food stability and access. It also increases the probability of being in Category 3 (food insecure by FCS but food secure by the MAHFP) by 3.3%, indicating that credit helps improve food availability, especially when food access is adequate but that consumption is lacking. This finding aligns with that of Kehinde & Kehinde (2020), who reported that credit access increased food security by 1,495.854 kcal per person per day in southwestern Nigeria.

In general, the comparison between the binary logit and multinomial logit models reveals both similarities and differences in their results. Both models identify similar significant predictors of food security, such as MRTSTATUS, EDUCATION, OFFARM, and MEMCOOPR. However, the statistical significance of these predictors varies across models. For example, MRTSTATUS is significant in both models, but its significance level varies across categories in the multinomial logit model, whereas it remains consistently significant in the binary logit model. The binary logit model also exhibits a higher pseudo-R^2 (0.7085) and a lower log-likelihood (-73.37), suggesting a better overall fit and more substantial explanatory power than the multinomial logit model, which has a pseudo-R^2 of 0.1702 and a higher log-likelihood of -344.65. In addition, when comparing the AIC and BIC values, the binary logit model performs much better. Its AIC (171.83) and BIC (21.47) are considerably lower than the multinomial logit model's AIC (749.30) and BIC (871.22), further indicating that the binary logit model is a more parsimonious and well-fitting model. In summary, the binary logit model is preferable in this analysis, as it provides stronger statistical significance, a better model fit, and more efficient use of data. Compared with the multidimensional logit model, the binary logit model explains food security outcomes more effectively and is more reliable in terms of model performance and predictive power.

CONCLUSION AND RECOMMENDATIONS

This study assessed household food security, examined the consistency of indicators, and analyzed determinants using composite metrics in Ada'a District, Central Ethiopia. In contrast to the district's agricultural reputation, 39.3% of households were categorized as food-insecure using the composite FCSMAHFP (integrating dietary diversity [FCS] and food provisioning stability [MAHFP]), surpassing individual metrics (FCS: 34.7%; MAHFP: 33.7%) and the current consumption and coping-focused CARI (27.2%). The dietary diversity was critically low: 99.8% relied on cereals, 92.8% consumed no fruit, and 27% lacked meat/eggs/fish. A novel finding was that more extensive landholdings were linked to food insecurity (FI households: 1.36–1.6 ha vs. FS: 0.94–0.99 ha), suggesting inefficiencies in land use or market dependencies. The inverse relationship suggests small farms are more productive than large farms are, highlighting the need for further studies to assess whether this supports redistributive land policies in the context of the study area. These findings also emphasize the importance of sustainable land management practices to optimize productivity, enhance economic resilience, and support long-term food security.

The composite indicator demonstrated superior classification accuracy, with FCSMAHFP showing near-perfect agreement with FCS ($\kappa = 0.9004$) and substantial agreement with MAHFP ($\kappa = 0.8800$). In contrast, the CARI was weakly correlated (Spearman's $\rho = 0.5651$ with the FCS). Specifically, 29% of the households were consistently food

insecure across the FCS and MAHFP, whereas 10.3% exhibited divergent classifications, underscoring the need for multidimensional frameworks. Cohen's Kappa and Spearman's rho correlations demonstrated statistically significant correlations and very high agreement among the indicators, indicating comparable evidence for classifying households. This underscores the sustainability relevance of multi-indicator approaches, which integrate social and nutritional dimensions and economic (food provisioning stability) dimensions to better inform interventions for resilient livelihoods.

The comparison between the binary logit and multinomial logit models reveals both convergence and divergence in their results. The binary logit model outperformed the multinomial logit model in terms of predictive accuracy and parsimony, with a superior AUC of 0.9811, a lower AIC/BIC (171.83/21.47 vs. 749.30/871.22), and greater statistical significance. This finding highlights its utility for policy targeting in similar contexts. The binary logit model also exhibits a higher pseudo-R^2 (0.7085) and a lower log-likelihood (-73.37), suggesting a better overall fit and stronger explanatory power than the multinomial logit model, which has a pseudo-R^2 of 0.1702 and a higher log-likelihood of -344.65. In addition, when comparing the AIC and BIC values, the binary logit model performs much better. The logit model's AIC (171.83) and BIC (21.47) are considerably lower than the multinomial logit model's AIC (749.30) and BIC (871.22), further indicating that the binary logit model is a more parsimonious and well-fitting model. In conclusion, the binary logit model is preferable in this analysis, as it provides stronger statistical significance, a better model fit, and more efficient use of data. Compared with the multinomial logit model, the binary logit model explains food security outcomes more effectively and is more reliable in terms of model performance and predictive power.

Although the statistical significance of these predictors varies across models, both models identify similar key factors that significantly affect food security. The household head's marital status, education, off-farm activities, and cooperative membership were consistently positive predictors. In particular, male-headed households were 10% less likely to be food secure (binary model: marginal effect = -0.1002, $p < 0.05$), challenging conventional assumptions, possibly due to women's involvement in dietary management and greater cooperative participation (87.6% vs. 75.1% for males). A larger household size and farm size unexpectedly reduced food security (e.g., each additional hectare decreased the likelihood of food security by 5.5%, $p < 0.01$), which was linked to productivity declines and input cost challenges. Key determinants such as cooperative membership, off-farm income, education, and marital status emerged as strong drivers of food security, whereas larger household size and farm size inversely impacted outcomes. These findings highlight the need for interventions that strengthen social networks (cooperatives), diversify livelihoods (off-farm activities), and improve human capital (education), all of which enhance resilience, equity, and long-term food security. The study recommends that interventions promoting cooperative engagement, off-farm livelihood diversification, gender-sensitive resource access, and nutrition education could bridge the gap in food security. Paradoxically, larger landholdings and male-headed households were associated with greater food insecurity, challenging conventional assumptions about resource access and gender roles. The inverse finding on the nexus between farmland size and food security may imply a redistributive land policy, which is worthy of investigation in

further research. Such policy considerations align with sustainability objectives, as they aim to optimize land use efficiency, promote equitable access, and strengthen economic and social resilience.

This study has several limitations, including its cross-sectional design, which may not capture long-term food insecurity trends, and its focus on households rather than intrahousehold food security. It also relied on retrospective evaluations, which could introduce recall bias, and social desirability bias may have influenced responses, although anonymity and nonjudgmental interviews helped mitigate this bias. The study underscores the need for a multifaceted approach to food insecurity in Ada'a District, combining socioeconomic resilience and equitable access. Integrating sustainability principles in future interventions, focusing on social equity, economic resilience, and environmental stewardship, can enhance the effectiveness and long-term impact of food security programs. Future research should expand geographically, use longitudinal designs to explore trends and causality, and examine socioeconomic disparities, seasonal fluctuations, coping mechanisms, and gender implications.

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REFERENCES

Abafita, J., & Kim, K. R. (2014). Determinants of household food security in rural Ethiopia: an empirical analysis. *Journal of Rural Development/Nongchon-Gyeongje, 37(2), 129-157., 37*(2), 129-157.

Africare. (2007). Guidance: How to measure months of adequate household food provisioning (MAHFP) based on participatory rural appraisals in food security interventions. *Africare Food Security Review, No. 1* .

Afework, A., Minale, A. S., & Teketay, D. (2024). Comparative multidimensional analysis of agroforestery's impact on food security: A study of households in the Awi Zone Highlands, Ethiopia. *International Journal on Food System Dynamics, 15*(5), 508-525.

Agazhi, Z. D., Mada, M., & Alemu, M. (2024). Vulnerability to multidimensional food insecurity: Empirical evidence from wheat farmers in the Arsi Zone of Ethiopia. *Discover Sustainability, 5*(1).

Alemayehu, A., & Tesfaye, A. (2024). Food security determinants and coping strategies in Central Highlands of Ethiopia. *Advances in Agriculture, 1*.

Almukaddem, L., Alali, J., & Habib, W. (2022). An analytical study of food security indicators for farm households in the coastal area of Syria. *Journal of Aridland Agriculture, 8*, 14-19.

Antilahy, E., Andriamisaina, A., Carson, S., Nash, M., Rojas, S., & Wyatt, A. (2023). *Political economy analysis of resilience, food and nutrition security, and poverty in Madagascar. West Lafayette.*

Atara, A. (2018). *Rural households' resilience to food insecurity in Southern Ethiopia: The case of Boricha Woreda in Sidama Zone.* Addis Ababa University.

Belay, C. S. (2018). The effects of crop market participation in improving food security among smallholder crop producer farmers: The case of Central Ethiopia, Adaa Woreda. *Journal of Development and Agricultural Economics, 10*(9), 298-316. doi:10.5897/JDAE2018.0953

Bilinsky, P., & Swindale, A. (2010). *Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access: Indicator Guide.* Washington, D.C. USA: FANTA III - Food and Nutrition Technical Assistance/FHI360.

BMC Medicine. (2023). Food insecurity: A neglected public health issue requiring multisectoral action. *BMC Med, 21*(130). doi:https://doi.org/10.1186/s12916-023-02845-3

Birhanu, F. Z., Tsehay, A. S., & Alemu Bimerew, D. (2022). Cereal production practices and technical efficiency among farm households in major "teff" growing mixed farming areas of Ethiopia: A stochastic meta-frontier approach. Cogent Economics & Finance, 10(1), 2012986.

Bujang, M. (2021). A step-by-step process on sample size determination for medical research. *The Malaysian Journal of Medical Sciences: MJMS, 28*(2), 15.

Clapp, J., Moseley, W. G., Burlingame, B., & Termine, P. (2022). The case for a six-dimensional food security framework. *Food Policy, 106*.

Çorbacıoğlu, Ş. K., & Aksel, G. (2023). Receiver operating characteristic curve analysis in diagnostic accuracy studies: A guide to interpreting the area under the curve value. *Turkish Journal of Emergency Medicine, 23*(4), 195-198.

CSA & WFP. (2019). *Comprehensive Food Security and Vulnerability Analysis, Ethiopia.* . Addis Ababa: Central Statistical Agency.

Degefa Tolossa. (2005). *Rural Livelihoods, Poverty , and Food Insecurity in Ethiopia: A case study at Erenssa and Garbi Communities in Oromia Zone, Amhara National regional State. Doctoral Thesis for the degree of Philosofiae, Trodeim.*

Derara, F., & Tolossa, D. (2016). Household Food Security Situation in Central Oromia, Ethiopia: A Case Study from Becho Wereda in South West Shewa Zone. *Global Journal of Human-Social Science, 16 Issue* (2 Version 1.0).

Economist Impact. (2022). *Global Food Security Index 2022: Country Profiles. Economist Impact 2022.* Retrieved from https://impact.economist.com/sustainability/project/food-security-index/explore-countries. Accessed on November 23, 2024

Fanzo, J., de Steenhuijsen Piters, B., Soto-Caro, A., Saint Ville, A., Mainuddin, M., & Battersby, J. (2024). Global and local perspectives on food security and food systems. *Communications Earth & Environment, 5*(1).

FAO. (1996). *Rome Declaration on World Food Security and World Food Summit Plan of Action : World Food Summit, 13-17 November 1996, Rome, Italy.* Rome. Retrieved October 22, 2022

FAO, IFAD, UNICEF, WFP and WHO. (2024). *The State of Food Security and Nutrition in the World 2024 - Financing to end hunger, food insecurity and malnutrition in all its forms.* Rome. doi:https://doi.org/10.4060/cd1254en

Folke, C., Haider, L., Lade, S., Norstrom, A., & Rocha , J. (2021). Resilience and social-ecological systems: a handful of frontiers. *Global Envrion Change*. doi:https:// doi. org/ 10. 1016/j. gloenvcha. 2021. 102400

Food Security Cluster (2021). *Food Security Cluster Annual Report 2021.*

Fouileux, E., Bricas, N., & Alpha, A. (2017). Feeding 9 billion people: Global food security debates and the productionist trap. *Journal of European Public Policy, 24*(11), 1658-1677. doi:10.1080/13501763.2017.1334084

Gadiso, W. J., Alemu, B. A., & Shete, M. (2023). Unpacking regional variations of multidimensional food security in rural Ethiopia: insights for policy. *International Journal of Social Economics, 51*(5), 585-603. doi:DOI:10.1108/IJSE-02-2023-0139

Gebrihet, H. G., Gebresilassie, Y. H., & Gebreselassie, M. A. (2025). Food insecurity and coping strategies in war-affected urban settings of Tigray, Ethiopia. *Economies, 13*(1).

Gobena, D. A., & Girma, A. (2019). Paradox of food and nutrition insecurity in the food surplus area of Haramaya district, Eastern Ethiopia. *Turkish Journal of Agriculture - Food Science and Technology, 7*(10), 1538-1540. doi:https://doi.org/10.24925/turjaf.v7i10.1538-1540.2527

Guyalo, A. K., Alemu, E. A., & Degaga, D. T. (2022). Impact of large-scale agricultural investments on the food security status of local communities in Gambella region, Ethiopia. *Agriculture and Food Security, 11*(43).

Hailu, M. (2023). Assessment of Household Food Security and Its Determinants in Minjar Shenkora and Ada'a woredas of Central Ethiopia. *NASS Journal of Agricultural Sciences, 5*(1), 1-7.

Jessup-Varnum, M. (2018). *Food security and the sustainable livelihood approach to development in Uganda.* Portland State University.

Kassie, K. E., Yimer, D. T., & Gidelew, G. E. (2024). Multidimensional food security status of households and its determinants in Dera Woreda, North West Ethiopia. *Journal of Agriculture and Environmental Sciences, 9*(2), 33-48.

Kebede, D., Emana, B., & Tesfay, G. (2023). Impact of land acquisition for large-scale agricultural investments on food security status of displaced households: The case of Ethiopia. *Land Use Policy, 126*.

Kehinde, A., & Kehinde, M. (2020). The impact of credit access and cooperative membership on food security of rural households in South-Western Nigeria. *Journal of Agribusiness and Rural Development, 57*(3), 255-268.

Kerbo, A. A., Degaga, D. T., & Beyene, A. D. (2024). Analysis of food security among eucalyptus tree farming smallholder farmers in Gurage Zone, Ethiopia: An application of a composite food security indicator. *Heliyon, 10*(7).

Makombe, G. (2023). The food security concept. *Africa Development, 48*(4), 53-80.

Maletta, H. E. (2024). *From hunger to food security: A conceptual history (2024 revision). Available at SSRN 2484166.* Universidado Del Pacifico.

Manikas, I., Ali, B. M., & Sundarakani, B. (2023). A systematic literature review of indicators measuring food security. *Agriculture & Food Security, 12*(1).

Markos, K., Dake, S. K., Bisetegn, F. S., & Nane, D. (2024). Level of food consumption score and associated factors among households in Konso Zone, Southwestern Ethiopia: A community-based cross-sectional study. *Frontiers in Nutrition, 11*.

Matavel, C., Hoffmann, H., Rybak, C., Steinke, J., Sieber , S., & Muller, K. (2022). Understanding the drivers of food security among agriculture-based households in Gurue District, Central Mozambique. *Agriculture & Food Security, 1*.

Maxwell, D., Coates, J., & Vatila, B. (2013). How Do Different Indicators of Household Food Security Compare? Empirical Evidence from Tigray. *Feinstein International Center, Tufts University: Medford, USA.*

Mechiche-Alami, A., Yagoubi, J., & Nicholas, K. A. (2021). Agricultural land acquisitions unlikely to address the food security needs of African countries. *World Development, 141*.

Mutea, E., Bottazzi, P., Jacobi, J., Kiteme, B., Speranza, C., & Rist, S. (2019). Livelihoods and Food Security Among Rural Households in the North-Western Mount Kenya Region. *Frontiers Sustainable Food Systems, 3*.

Mutisya, M., Ngware, M. W., Karibu, C. W., & et al. (2016). The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis. *Food Security*. doi:doi.org/10.1007/s12571-016-0589-3

Ogundari, K. (2017). Categorizing households into different food security states in Nigeria: the socioeconomic and demographic determinants. *Agricultural and Food Economics, 5*(20).

Peng, W., & Elliot, B. (2018). The Concept of Food Security. doi:10.1016/B978-0-08-100596-5.22314-7

Sahu, A; Chuzho, Z; Das, S. (2017). Measuring Household Food Security Index for High Hill Tribal Community of Nagaland, India. *Journal of Food Security*, 155-161. doi:10.12691/jfs-5-5-1

Salifu, G. A., & Salifu , Z. (2024). The political economy of income diversification and food security in Northern Ghana. *Cogent Food & Agriculture, 10*(1). doi:https://doi.org/10.1080/23311932.2024.2325205

Sen, A. (1981). *An essay on entitlement and deprivation. Poverty and Famines.*

Shetty, P. (2015). From food security to food and nutrition security: role of agriculture and farming systems for nutrition. *Current Science, 109*(3), 456-462.

TANGO International . (2018). *Resilience and Resilience Capacities Measurement Options: Full Approach - Enumerator Guidance, A Guide for Implementing a Resilience Instrument. .* TANGO International as part of the Resilience Evaluation, Analysis and Learning (REAL) Associated Award.

Telila, H. F., & Sima, E. A. (2024). Quantifying food insecurity in Ethiopia: Prevalence, drivers, and policy implications. *Cogent Social Sciences, 10*(1).

UNHCR. (2021). *VASyR 2021 - Coping Strategies.* United Nations High Commissioner for Refugees (UNHCR). doi:https://ialebanon.unhcr.org/vasyr/files/vasyr_chapters/2021/VASyR%202021%20-%20Coping%20Strategies.pdf

Vadala, A. (2009). Understanding famine in Ethiopia: Poverty, politics and human rights. Political Perspectives. *International Conference of Ethiopian Studies.* Trondheim.

Varzakas, T., & Smaoui, A. (2024). Global food security and sustainability issues: The road to 2030 from nutrition and sustainable healthy diets to food systems change. *Foods, 13*(2).

Weeks, J. D., Mykyta, L., & Madans, J. H. (2023). *Adults living in families experiencing food insecurity in the past 30 days: United States, 2021.* Hyattsville, MD: National Center for Health Statistics. doi:https://dx.doi.org/10.15620/cdc:125707. CS338616

WFP. (1996). World Food Summit Plan of Action, World Food Summit, 13-17 November 1996, Rome, Italy. Rome, FAO. 43 p. *1. World Food Summit, 1996. World Food Summit Plan of Action, paragraph 1. In: Rome Declaration on World Food Security and World Food Summit Plan of Action; World Food Summit, 13-17 November 1996, Rome, Italy. Rome, FAO. 43 p.* Rome, Italy: FAO.

WFP. (2008). *World Food Program, Food Consumption Analysis - Calculation and Use of the Food Consumption Score in Food Security Analysis .* Rome, Italy: Vulnerability Analysis and Mapping Branch, WFP.

WFP. (2015). *Consolidated Approach for Measuring Indicators of Food Security (CARI) Guidelines.* Rome, Italy: World Food Program .
WFP. (2023). *Livelihood Coping Strategies Indicator for Food Security Guidance Note.* World Food Program .
Willett, W., Rockstrom, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., . . . Murray, C. J. (2019). Food in the Anthropocene: The EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet, 393*(10170), 447-492. doi:https://doi.org/10.1016/S0140-6736(18)31788-4
Wineman, A. (2016). Multidimensional household food security measurement in rural Zambia. *Agricultural Economics Research, Policy and Practice in Southern Africa, 553*, 278-301.
Wudil, A. H., Usman, M., Rosak-Szyrocka, J., Pilar, L., & Boye, M. (2022). Reversing years for global food security: A review of the food security situation in Sub-Saharan Africa (SSA). *International Journal of Environment Research and Public Health, 19*(22).
Yamane, Y. (1967). Mathematical formulae for sample size determination. *Journal of Mathematics, 1*, 1-29.

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