Dynamics and Determinants of Welfare Inequality and Resilience to Food Insecurity in Ethiopia: Evidence from *Enset* Producing and Non-Producing Households in Central Ethiopia Region

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This is to certify that the thesis prepared by Tsegamariam Dula Sherka, entitled: *"Dynamics and Determinants of Welfare Inequality and Resilience to Food Insecurity in Ethiopia: Evidence from Enset Producing and Non-Producing Households in Central Ethiopia Region"* and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy (Development Studies) complies with the regulations of the university and meets the accepted standards concerning originality and quality.

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I, Tsegamariam Dula, hereby declare that this PhD dissertation is my original research work. The materials in this research work, neither the whole nor any part of it, were not submitted for the attainment of any academic degree elsewhere. All reference materials from other authors have been fully acknowledged and the reporting procedures do comply with the expected standards and regulations of the university.

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LIST OF ABBREVIATIONS

AEZ	Agro Ecological Zone
CARI	Consolidate Approach to Reporting Indicators of Food Security
CC	Coping Capacity
CS	Current Status
CSA	Central Statistical Authority
ESS	Ethiopian Statistical Survey
FAO	Food and Agriculture Organization
FCS	Food Consumption Score
FES	Food expenditure share
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Geographical Positioning System
GTP	Growth and Transformation Program
GZARDD	Gurage Zone Agriculture and Rural Development Department
GZFEDD	Gurage Zone Finance and Economic Development Department
HDI	Human Development Index
HHS	Household Size
LCS-FS	Coping Strategies – Food Security
LSMS	Living Standards Measurement Study
rCSI	Reduced coping Strategies Index
SDG	Sustainable Development Goals
SNNPR	Southern Nation, Nationalities and People Regional State
TLU	Tropical Livestock Unit
UN	United Nations
UNDP	United Nations Development Program
WB	World Bank
WFP	World Food Program

ABSTRACT

Reducing welfare inequality and ensuring food security remain critical global challenges, particularly in agrarian economies like Ethiopia. The persistent disparities in household welfare between Enset-producing and non-producing households in Central Ethiopia highlight the need for an in-depth analysis of inequality dynamics, resilience, and food insecurity. Therefore, this dissertation investigates the intertemporal dynamics and determinants of welfare inequality and resilience to food insecurity. The research utilizes a mixed-methods approach, drawing on panel data from 270 households across two Ethiopian Living Standards Measurement Surveys (2018/19 & 2021/22) and additional primary data for 2023/24, tracking the same household using GPS coordinates accessed from the Central Statistical Service. Quantitative analysis includes the Atkinson index, fixed-effects regression, and quantile regression to assess determinants and welfare inequality in expenditure and asset value, while multidimensional inequality indices and fixed-effects models explore intertemporal dynamics of multidimensional inequality. Food security and resilience are analyzed using the Consolidated Approach to Reporting Food Security Indicators (CARI) and the Resilience Index Measurement and Analysis (RIMA) framework, respectively. Qualitative data is gathered through household surveys, focus group discussions, and key informant interviews and analyzed using thematic analysis. Besides, Statistical methods, such as t-tests, chi-square tests, and ordered logit models, are used to examine food insecurity and coping strategies. Principal Component Analysis (PCA) and Three-Stage Least Squares (3SLS) regression explore the link between welfare, food security, and resilience, while the Endogenous Switching Regression (ESR) model assesses the impact of Enset production on food security and calorie intake. The findings reveal significant disparities between Enset-producing and non-producing households. The Atkinson index shows that inequality among non-producers increases from 0.356 in 2019 to 0.781 in 2024, while among producers, it rises from 0.262 to 0.582. Non-producers face greater fluctuations in expenditure inequality, influenced by factors such as household size, education, credit access, and income levels, while Enset-producing households demonstrate more stability. Producers also exhibit stronger food security, with higher calorie intake of 2,995 kcal per adult/day compared to that of 1,893 kcal pre adult/day for non-producers) and greater annual food expenditure (96,157.46 ETB vs. 89,098.07 ETB). Enset producers are also less likely to sell assets during times of stress (6.38% vs. 31.25% for non-producers). Furthermore, 75.3% of Enset producers recover from food insecurity between survey waves, compared to only 49.6% of non-producers. Resilience is closely tied to asset ownership, access to services, and adaptive capacity. Endogenous switching regression model confirms that Enset production increases calorie intake by 35.2% among producers, while non-producers would experience a 55.7% decline in calorie intake if they cultivated Enset. Social safety nets and education play a greater role in resilience among non-producers, whereas asset accumulation and land size are more crucial for Enset producers. Enset production is shown to reduce welfare inequality, improve food security, and enhance resilience to food insecurity, though disparities persist due to differences in income diversification, credit access, and exposure to external shocks. In conclusion, Enset production reduces welfare inequality, boosts food security, and strengthens household resilience. Producing households enjoy more stable incomes and better coping mechanisms, yet welfare gaps persist due to disparities in income, financial access, and exposure to shocks. Non-producing households remain more vulnerable, underscoring the need for targeted support. Policies promoting Enset cultivation, expanding credit access, and supporting income diversification can help bridge the gap. Future strategies should focus on enhancing education, financial inclusion, and technological access to ensure long-term improvements in welfare and food security.

Keywords: *Welfare inequality, Food insecurity, Resilience, Enset production, endogenous regression model, Atkinson index, 3SLS, Central Ethiopia region*

CHAPTER 1: INTRODUCTION

1.1.Background of the Study

Welfare Inequality and Resilience have been among the most debated areas for welfare and development in recent years. These aspects are closely tied with food security because welfare encompasses the complete well-being of individuals and households; education, health services, income, and nutrition are all considered within it. Various reports have indicated that too much inequality damages political stability, social cohesion, and economic development (OECD, 2020; World Bank, 2016). Improving household resilience to shocks, narrowing the inequality gap, and making sure everyone is food-secure, issues that are engineering new global and national development agendas. The notion of food security has evolved continuously since the middle of the 20th century, when it was overly focused on food production and, by extension, self-sufficiency (Lang & Barling, 2012). It has become broader over time and has become quite complex, addressing all aspects of availability, access, stability, and utilization. Nowadays, food security means availability, access, stability, and utilization globally (Lebedys, 2008). Sustainable Development Goals (SDGs), which are being Approved by all countries that are part of the United Nations since 2015, define poverty eradication (Goal 1), inequality reduction (Goal 10), and zero hunger attainment (Goal 2) (Nations, 2015). At the national level, Ethiopia has been working on efforts to align the nation's policies and strategies with the SDGs, such as the Growth and Transformation Plan (GTP), the Ten-Year Development Plan, and the Seqota Declaration.

At the core of Ethiopia's policy implementation programs has been a set of agricultural productivity improvement programs to deal with disparity and poverty. It includes those such as the Growth and Transformation Plan (GTP) initiated in 2010 to accelerate agricultural growth complemented by food security and social safety nets to vulnerable households (MoFED, 2010). Among others, the Seqota Declaration of 2015 aimed at ending malnutrition in children by the year 2030 in Ethiopia. Yet, there are still challenges of a rapidly growing population, climate change, land degradation, and inadequate access to resources which all lead to food insecurity in Ethiopia (WFP, 2021).

The national policy document which confines the ten-year Ethiopian development plan (2021-2030) has a very clear-cut vision, goals, objectives, and strategies of government for achieving its sustainable and inclusive growth, social development, and environmental protection targets. The

plan has a total of six objectives of which one reads as 'to ensure food security for all citizens using increasing agricultural productivity, strengthening social protection systems, and addressing the root causes of hunger'. The plan's aims also include reducing poverty and income inequality through pro-poor and equitable growth, creating decent jobs and livelihood opportunities, improving governance and accountability, and fostering social cohesion and peace (PDC, 2021).. This study derives its direction from the direction of the 10-year Ethiopian development plan because it offers evidence-based analysis and recommendations for improving food security, resilience, and inequality of household welfare in Central Ethiopia region.

Historically, different frameworks positing a range of conceptualizations about inequality have sought to mitigate its effect on welfare and food security. Starting from the historical perspective, unequal distribution of resources that benefits a section of society to the detriment of others has been a persistent challenge. About the Central Ethiopia region, the historical engagement in *Enset* production has spelled dichotomous consequences on household welfare. According to (Bonso et al., 2022), studies on Ethiopia has shown that the *Enset* producers are relatively more food secure compared to their counterparts. To combat poverty, Ethiopia's second Growth and Transformation Plan (GTP II, 2015/16-2019/20) placed a strong emphasis on the growth of the agricultural sector. This includes *Enset* production and other agricultural practices that ensure food security and help to reduce welfare (asset ownership, education, health access and income) disparities.

The policy frameworks for inequality, welfare, food security, and resilience in Ethiopia include various laws, regulations, strategies, plans, and programs that have been developed and implemented by the government and its partners to address these issues at different levels. Some examples of these policy frameworks are: the Constitution of the Federal Democratic Republic of Ethiopia (1995), which guarantees the right to adequate food and prohibits any form of discrimination; the Food Security Strategy (2002), which Aims to enhance food security at the household level through agricultural development-led industrialization; the Productive Safety Net Programme (2005-present), which provides cash or food transfers to chronically food insecure households in exchange for public works or direct support; the National Nutrition Strategy (2008), which aims to reduce malnutrition among vulnerable groups through multi-sectoral interventions; the Growth and Transformation Plan I (2010-2015) and II (2016-2020), which set ambitious targets for economic growth, poverty reduction, social development and environmental

sustainability; the Food and Nutrition Policy (2018), which provides a framework for ensuring food and nutrition security for all citizens; and the Homegrown Economic Reform Agenda (2019-present), which seeks to address macroeconomic imbalances, structural bottlenecks and social challenges through fiscal consolidation, monetary stabilization, debt sustainability, structural transformation and human capital development.

In the central Ethiopia region, where *Enset* production is concentrated, there is a need to better understand the drivers of resilience to food insecurity, inequality in welfare, and food security among *Enset*-producing and non-producing households. Enset (*Ensete ventricosum*), commonly known as the "false banana," is a drought-tolerant, perennial crop indigenous to Ethiopia and serves as a major staple food for over 20 million people, particularly in the Southern and Central highlands (Borrell et al., 2019). Unlike cereal crops, Enset is cultivated mainly for its pseudostem and underground corm, which are processed into *kocho* and *bulla*—nutritious and storable food products that contribute significantly to household food security (Bonso et al., 2022). Enset's unique characteristics, including its capacity for in-ground storage, multi-year harvesting flexibility, and resistance to climate shocks, make it a strategic crop for resilience in rainfed farming systems (Olango et al., 2014). The crop also provides critical non-food benefits such as animal fodder, fiber for household use, and cultural value within many farming communities (Bassa et al., 2024). Despite its resilience and versatility, Enset production is not uniformly practiced across households due to agroecological limitations, limited access to propagation material, and differences in traditional agricultural practices (Sahle et al., 2018). These differences offer a valuable opportunity to study the comparative dynamics of welfare, food security, and resilience between Enset-producing and non-producing households in Central Ethiopia.

This study contributes to understanding the relationship between *Enset* production, household welfare, food security, and resilience in central Ethiopia. In addition, the study provides insights into the determinants of food insecurity and the factors that influence the welfare of households in the area. The study also offers recommendations for policymakers and stakeholders to improve the welfare of food security and resilience to food insecurity in the central Ethiopia region.

1.2.Problem Statement

Welfare stands for the well-being and prosperity of individuals, groups, or even organizations (Wang, F. et al., 2017). Welfare inequality, which refers to differences in income, consumption,

assets, and poverty, is, indeed, a global problem for both rich and poor countries (Belay, 2022a). The World Inequality Report of 2022 stated that the income share by the top 10% of the population had increased from 44% to 52% from 1980 to 2020, as compared to a decrease of the bottom 50% share from 16% down to 8%. These inequalities were worsened by the COVID-19 pandemic, which saw a rise in the shares of global billionaires' wealth from 2.5% to 3.4%, the highest on record, in 2020. This gap has repercussions for food availability, accessibility, utilization, and stability of food among all at all times (Righettini & Bordin, 2023). The United Nations indicated that levels of global hunger are mentioned as 828 million in 2021, attributing it largely to conflict (disruption of food production and distribution), climate extremes (failures of crops), and shocks in the economy, with inequality aggravating the situation (FOOD & AFFORDABLE, 2022).

Socio-economic disparities, especially income inequality, persist globally, affecting regions like Africa deeply (Africa, 2023; World Bank, 2022b). In Ethiopia, welfare and food security challenges remain, despite governmental efforts (World Food Programme, 2023). Ethiopia still faces inequality in welfare, despite efforts to reduce poverty and improve living standards (World Bank., 2020). The Ethiopian government aims to reduce these gaps through economic growth, education access, and social protection programs, but challenges remain. The central Ethiopia region, which relies on agriculture, suffers from significant welfare inequalities, requiring a detailed investigation to find the causes and solutions (Namara et al., 2008; Yigezu Wendimu, 2021). Existing research highlights substantial inequalities, which prevent communities from adapting to industrial changes and worsen welfare and food security problems (Islam & Winkel, 2017).

Although Ethiopia reduced poverty from 45.5% in 1995 to 23.5% in 2016 (World Bank, 2016), and further to 19.6% in 2019 based on the national poverty line, income inequality remains a challenge particularly in rural areas. This is reflected in the rise of the Gini coefficient from 0.29 in 1995 to 0.336 in 2015/2016 (Central Statistical Agency (CSA), 2023). Globally, Ethiopia continues to face significant welfare challenges, with high rates of multidimensional poverty and vulnerability, especially among rural households. Income inequalities, asset disparities, and food insecurity are also some of the problems suffered by rural households in Ethiopia, especially in the Central Ethiopia region (Degye Goshu, 2013; Tadele & Gella, 2012). Existing studies recognize household-level inequalities in this region (World Bank, 2016; Debebe & Zekarias, 2020), but fail

to address the gap between welfare and food security outcomes, which is evident from the high malnutrition rate. In addition, existing studies (Degye Goshu, 2013; Tadele & Gella, 2012) do not capture the intertemporal dynamics of inequality in welfare and food security. This study fills this gap by using innovative methods and panel data to examine temporal variations in both *Enset* producer and non-producer households. It also considers the determinants of inequality and food insecurity specific to these households. Furthermore, studies (B. Belete & Bayu, 2023; Kasaye et al., 2019; Shiferaw, 2017; Tigistu & Hegena, 2022) have discussed the determinants of welfare and food security in Ethiopia, but there is a need to consider factors related to agricultural practices, access to resources, and household resilience, especially for *Enset* producer and non-producer households.

Furthermore, food insecurity is a serious issue in Ethiopia, affecting millions of people and requiring urgent attention (Tora, 2023). Chronic food insecurity in Ethiopia, caused by economic, climatic, and socio-cultural factors, needs a focused examination, especially in regions like central Ethiopia (Mohamed, 2017). Besides, assessing coping strategies during food scarcity is vital for creating sustainable policies and programs that enhance community resilience (Kpadé et al., 2023). Localized studies are key to understanding regional variables influencing food security, such as agricultural systems, socio-economic attributes, and cultural preferences (Meadows & Randers, 2012). Existing literature covers various aspects of food insecurity in Ethiopia, including causes, consequences, indicators, and policies. However, the literature does not explore all dimensions of food insecurity and coping mechanisms together for how households adapt to changing conditions. This study aims to contribute by incorporating all dimensions by using panel data to identify the intertemporal dynamics of food insecurity and coping strategies among *Enset*-producer and non-producer households in central Ethiopia. As well, methodological and conceptual gaps exist in existing literature, such as variations in food security indicators and cut-offs.

Agriculture significantly contributes to Ethiopia's Food security, GDP, and employment (World Bank, 2019), and comprehending the impact of a crucial agricultural product informs poverty alleviation and sustainable development strategies. Among agricultural production, *Enset (Ensete ventricosum)* is a vital food crop in the central Ethiopian region, accounting for a significant proportion of the total caloric intake for approximately 20 million Ethiopians (Olango et al., 2014). Previous research on Enset and food security can be grouped into three broad areas: studies

focusing on its contribution to household food availability Negash & Niehof (2004), Sahle et al., (2018) & Bonso et al. (2022), agronomic and cultural perspectives (Bassa et al., 2024), Sirany et al. (2022) & Tolola (2023), and policy-related discussions (MOHAMMED et al., 2023). However, these studies fall short of addressing key gaps. Conceptually, they lack a analysis of welfare inequality, especially in terms of education, healthcare, and social safety nets among Enset-producing and non-producing households. Spatially, they are often limited to specific areas without broader comparative insights. Methodologically, few employ panel data and advanced econometric approaches to explore causal relationships, and temporally, many rely on cross-sectional data.

Resilience[1] of rural households to food insecurity is another critical issue for ensuring food security, as a basic human right. Large proportions of rural households in developing countries depend primarily on farming activities which have over time proved to be unstable due to climatic changes, and market volatilities among other factors. Understanding the resilience of *Enset* producer households to food insecurity can provide insights into the effectiveness of *Enset* cultivation as a food security strategy. While studies in Ethiopia, such as those by (Demsie, 2024; Dereje et al., 2024; Gambo Boukary et al., 2016; Kpadé et al., 2023; T. Melketo et al., 2021; Zerihun et al., 2024), have shed light on food insecurity and determinants of resilience, a substantial research gap remains. The existing literature lacks a detailed exploration of the intertemporal dynamics of resilience to food insecurity. While some studies offer valuable insights into the determinants of resilience and food security, they fall short in understanding how these factors evolve.

Further, Existing research, such as studies by (Barrett, 2010) on food security, (Béné et al., 2012) on resilience, and (Deaton, 1980)Deaton (1997) on welfare economics, while shedding light on various dimensions of resilience, welfare and food security, falls short in providing a nexus understanding of the interconnected dynamics among these three variables over time and a significant methodological gap exists. Conceptually, the literature lacks a framework that integrates welfare, food security, and resilience to food insecurity, specifically, considering the unique role of *Enset* cultivation.

[1] Resilience in the context of food security is defined as the ability of a household to resist, absorb, accommodate, and recover from shocks without incurring irreversible damage to its structure and functions (Dereje et al., 2024)

Therefore, this study aims to address these critical gaps by providing an integrated analysis of welfare inequality, food security, and resilience among Enset-producer and non-producer households in Central Ethiopia. By employing panel data and advanced econometric techniques such as the Endogenous Switching Regression model and the Three-Stage Regression model, the study was capture intertemporal dynamics, account for self-selection bias, and examine causal relationships. The study introduces the Atkinson Index, a welfare-based (both in expenditure and asset value, and multidimensional index approach) measure of inequality that better incorporates social welfare preferences compared to the Gini coefficient and applies the Consolidated Approach to Reporting Food Security Indicators (CARI) for a consistent and multidimensional assessment of food insecurity and coping strategies. Furthermore, by focusing on the resilience capacities of households in the face of climatic, economic, and market instabilities, this research offered actionable insights into how Enset cultivation serves as a sustainable pathway to improve welfare and food security outcomes. The findings aim to guide policymakers and development practitioners in designing targeted interventions that address the distinct needs of both Enset-producing and non-producing households, contributing to equitable and resilient rural development in Central Ethiopia.

1.3.Research Questions

1. How has household welfare outcome evolved overtime among *Enset*-producing and non-*Enset*-producing households in the central Ethiopia region?
2. How has household welfare outcome inequality evolved overtime among *Enset*-producing and non-*Enset*-producing households in the central Ethiopia region?
3. What are the level of food insecurity and coping strategies adopted by *Enset*-producing and non-producing households in the central Ethiopia region?
4. How does *Enset* production impact household food security in the central Ethiopia region?
5. What are the determinants of inequality in welfare among *Enset* producer and non-producer households in the central Ethiopia region?
6. How resilient are *Enset* producers and non-producers to food insecurity in the central Ethiopia region over time?
7. What is the extent of relationship between welfare, food security, and resilience to food insecurity among *Enset* producer and non-producer households in the central Ethiopia region

1.4.Objective of the Study

1.4.1. General Objective

The general objective of this study was to examine inequality in welfare and resilience to food insecurity among Enset producers and non-producers households in the central Ethiopia region using panel data.

1.4.2. Specific Objectives

1. To examine the intertemporal dynamics of welfare among *Enset* Producer and non-producer Households in the central Ethiopia region
2. To analyze the intertemporal dynamics of inequality in welfare among *Enset* Producer and non-producer Households in the central Ethiopia region
3. To analyze food insecurity and coping strategies of *Enset*-producer and non-producer households in the central Ethiopia region.
4. To examine the impact of *Enset* production on household food security in the central Ethiopian region.
5. To identify determinants of inequality in welfare among *Enset* producer and non-producer households in the central Ethiopia region.
6. To examine the intertemporal dynamics of resilience to food insecurity among *Enset* producer and non-producer households in the central Ethiopia region.
7. To identify the magnitude of relationship between welfare, food security, and resilience to food insecurity among *Enset* producer and non-producer households in the central Ethiopia region.

1.5.Scope and Delimitation of the Study

The intertemporal dynamics and inequality in welfare, the impact of *Enset* production on food security, the level of food insecurity and coping mechanisms, the factors that contribute to inequality in welfare and food security, and household resilience to food insecurity are its main themes. The study employed primary data collected by researcher and LSMS data from ESS and World Bank, which have representative sample sizes, appropriate quantitative and qualitative data collection and analysis methods and tools, and relevant measurement techniques. Atkinson, endogenous switching regression model, CARI approach (CS and CC), Quantile regression,

random effect logit model, and econometric modeling were applied. Geographically, the study was focused on *Enset* producers and non-producers in the central Ethiopian region. Temporally, the study covers three waves of data collection: 2018/19, 2021/22, and 2023/24. Delimitation: The study did not compare the food insecurity problem between urban and rural Kebeles. The study did not cover other regions of Ethiopia outside of the central Ethiopia region.

1.6.Limitations of the Study

While this study provides valuable insights into the dynamics of welfare inequality and resilience to food insecurity among Enset-producing and non-producing households in Central Ethiopia, several limitations should be noted. First, the geographic scope is restricted to the Central Ethiopia region, which limits the generalizability of the findings to other regions of the country. Second, although panel data were used, some degree of household attrition occurred across survey waves, potentially introducing selection bias. Third, the study relied on secondary data for part of the analysis, which limited the inclusion of certain variables such as health status, market access, and cultural practices. Lastly, despite using robust econometric techniques such as Endogenous Switching Regression and Three-Stage Least Squares (3SLS), the analysis is subject to the inherent assumptions of these models, which may affect the interpretation of causal relationships.

1.7.Significance of the study

This study is significant because it sheds light on the degree of inequality in welfare and resilience to food insecurity among *Enset* producers and non-producers in the central Ethiopia region using panel data. It also, specifically, examined the impact of *Enset* production on household food security, the status of food insecurity and coping mechanisms, the determinants of welfare and inequality, and household resilience to food insecurity among *Enset* producers and non-producers. The study's conclusions can guide policies and programs that seek to lessen inequality while enhancing the region's food security and resilience. In addition, the study offers an opportunity to explore additional analyses using the same conceptual and methodological approaches employed in this research. Moreover, the understanding gained from the results holds significant conceptual, regulatory, managerial, and operational advantages for academia, researchers, and research organizations. It also benefits National and local agricultural departments, NGOs, private sector players in agriculture, technical experts, and extension workers.

1.8. Research Methodology

1.8.1. Description of the Study Area

The Central Ethiopia Region[2] is the most recently established regional state in Ethiopia, created through administrative reorganization in 2021/22. It is situated in the southwest part of the nation, geographically positioned between 7°40' to 8°30' North latitude and 37°30' to 38°40' East longitude (ArcGIS 10.3). The region shares borders with South Ethiopia Regional State to the south and Oromia Regional State to the north and southwest, forming an important transitional zone between these major regions. The Central Ethiopia region comprises seven administrative zones (Gurage, Eastern Gurage, Hadiya, Kembata, Silti, Alaba, and Yem) and three special woredas (Kebena, Mareko, and Tembaro). This region was formed from parts of the former Southern Nations, Nationalities, and Peoples' Region (SNNPR). The region exhibits significant demographic diversity, with a total estimated population of 7-8 million people, showing a balanced gender distribution of approximately 50.2% female and 49.8% male (Central Statistical Agency (CSA, 2023). The linguistic and ethnic composition of the region reflects its cultural richness. The predominant languages include Guragigna, Kebatigna, Hadiyagna, and Silitigna, representing the major ethnic groups. Additionally, significant populations speaking Amharic and Oromifa contribute to the region's diverse cultural tapestry. This multilingual environment underscores the region's historical role as a cultural and economic crossroads in Ethiopia.

Climate condition: The climate is sub-humid to humid, with an annual rainfall of 1,000 to 1,800 mm and a mean annual temperature of 15 to 20°C. While the mid-highland climate covers 65.3 percent of the whole area. Average temperatures range from 3 °C in the high mountains of Gurage to 28 °C in the Ghibe Valley. Small showers typically start in March and April, with the major rainy season lasting from June through September. During the "Belg" season, rainfall amounts range from 30 to 40 percent (i.e., February to May). The main growing season lasts between 90 and 180 days, the "Belg" is between 60 and 90 days, and the main dry season is between October and February (Irish Aid & Unit, 2018).

[2] Note: This study focused on the newly established Central Ethiopia region, which has not been explicitly analyzed in prior published data. The information was sourced from Central Statistics Agency (CSA), the southern Nations Nationalities, and Peoples' (SNNP) region. The researcher recalculated and adapted data for the Central Ethiopia region based on the SNNP region, as all the administrative zones and specials woredas (districts) in this region were previously part of the SNNP region.

Socio economics: The socioeconomic characteristics of the region vary according to the level of development, infrastructure, and access to services. The region has a higher road density, electricity access, and non-farm employment than the other zones. However, it also has a lower average landholding and livestock ownership per household than the regional average.

Farming System: The farming system in these areas is mainly crop-livestock mixed farming, with *Enset* (a type of banana) being the most important crop. Wheat, maize, teff, barley, and Irish potato are also grown, depending on the agroecology and altitude. *Enset* is a multipurpose crop that provides food, feed, fiber, and medicine for the local people. It is also a symbol of cultural identity and social cohesion. Farmers have a wealth of indigenous knowledge on *Enset* cultivation, classification, utilization, and management. In the coverage of farmer participation in *Enset* production in the Gurage Zone, Eastern Gurage Zone, Seltie Zone, and Hadia Zone, above 80% of all farmers in rural and small towns are engaged in *Enset* production (SNNP, 2022).

In the study area, despite sharing similar agroecological conditions, households show variation in adopting *Enset* or alternative crops due to multiple interrelated factors. Enset (*Ensete ventricosum*), known as the "tree against hunger," plays a central role in household food security, offering drought tolerance, year-round harvestability, and long-term food storage options that annual crops like maize, teff, or wheat cannot provide (Wambui, 2024). Its unique capacity to withstand climatic shocks makes it a reliable buffer during periods of food scarcity (Negash & Niehof, 2004). In addition to its food value, Enset supports livelihoods by providing animal fodder, fiber, and construction materials, while also integrating well with livestock production systems, which further stabilizes income and resilience (Cherif et al., 2024). Thus, Enset producers benefit from a more stable and diversified livelihood base compared to those who rely mainly on cereals, which are more vulnerable to environmental fluctuations and market risks.

However, not all households engage in Enset production, even within the same agroecological setting. The divergence often reflects differences in household labor availability, landholding size, access to indigenous knowledge, cultural preferences, market orientation, and institutional support (T. Abebe et al., 2013). Enset cultivation is labor-intensive, particularly during propagation, harvesting, and processing, which may discourage labor-constrained households. Moreover, some households prioritize short-term income generation and prefer annual cash crops that offer quicker financial returns, while others may lack the intergenerational knowledge critical for managing

Enset cultivation and processing (Wambui, 2024). Institutional factors such as land tenure insecurity, limited extension services, and poor credit access also hinder investment in perennial crops like Enset. As a result, both producers and non-producers coexist in the study area, driven by a complex interaction of economic, cultural, institutional, and agroecological factors.

Challenges: In the central Ethiopia region, farmers face various challenges related to welfare inequality, food security, and resilience to food insecurity. These challenges include the shortage of farmland, climate change impact, land fragmentation, inadequate infrastructure, and limited access to resources, modern technology, and market linkages. Moreover, depending on rain-fed farming exposes the sector to unpredictable weather, which results in inconsistent crop yields. Smallholder farmers, who make up the majority, struggle with land tenure issues, lack of access to credit and finance, and small land sizes, which hamper sustainable crop production. Despite these challenges, the region holds immense potential for growth and development in the agriculture sector (Yigezu Wendimu, 2021).

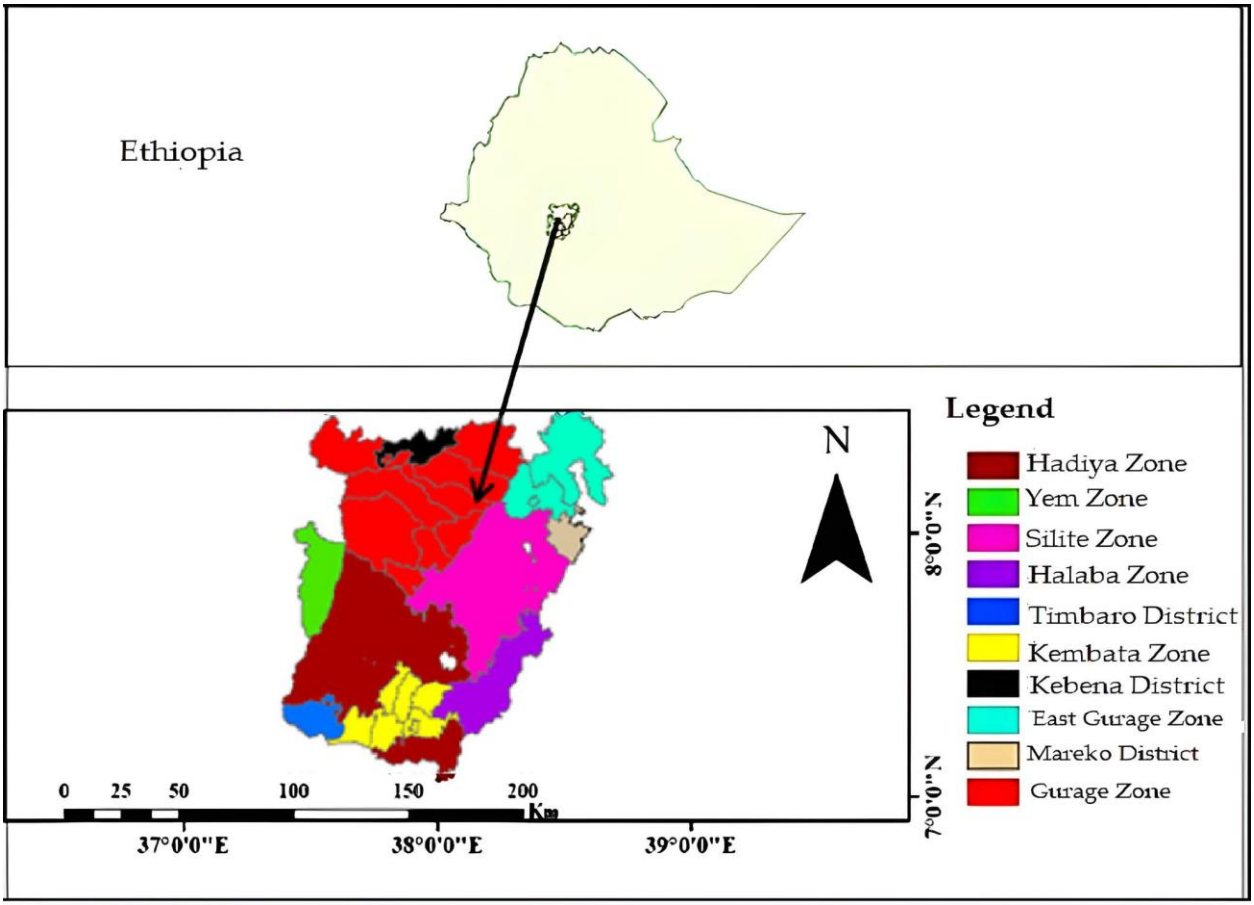

Figure 1.1: Map of the study area (Central Ethiopia Region)

1.8.2. Philosophical Orientation/Stances

The study employed the pragmatism knowledge claim from a philosophical standpoint, which seeks to quantify and understand how people comprehend and interpret their experiences (Hjelm, 2014). According to the nature of the research subject, pragmatics can include both positivist and interpretivist viewpoints within the scope of a single study (Saunders, 2009). Specifically, this research will take on the stance that inequality, food security, and resilience are the results of social constructs that are influenced by socioeconomic, cultural, and political factors.

According to incompatibility theory, current research has an increasing interest in utilizing both quantitative and qualitative methodologies, despite the variances in their capacity to be systematic and "scientific". The limitations in understanding an issue thoroughly, either qualitatively or quantitatively, call for a blending of both approaches, encapsulated as a singular outlook (Leavy, 2022). Mixed-method studies amalgamate the quantitative and qualitative techniques in unified research. Thus, this study deployed a mixed method, leaning towards quantitative predominance, influenced by the research issue's nature and experiences. The recent focus on mixed-method investigation has been equally discernible in development studies, including welfare examination. The critical contribution of mixed-methods research in exploring problems like poverty, food and nutrition insecurity, and destitution is now extensively recognized (Copestake, 2024).

Pragmatism can be regarded as the philosophical foundation steering the mixed paradigm. Pragmatists typically use an abductive reasoning process, which alternates between inductive and deductive reasoning. They also support the concept of intersubjectivity. Since it includes features of both methodologies, it applies the mode of inquiry based on the inherent research questions rather than predetermined biases related to specific paradigms.

1.8.3. Research Approach and Design

The choice of the research approach and design depends on the nature of the research problem, the objectives, the questions, the hypotheses, the assumptions, the limitations, and the resources of the study (Debebe & Zekarias, 2020). This study used a mixed approach methods combining quantitative and qualitative data collection and analysis methods. This allows an understanding of both numerical trends and lived experiences. Simultaneously, the research design used a mixed (quantitative and qualitative) research design with longitudinal/panel data set. Longitudinal (panel) data set following the same households over multiple periods (years). This controls for

unobserved heterogeneity and tracks temporal changes. The study likely adopts a longitudinal perspective to analyze the dynamics of welfare inequality and resilience to food insecurity. It also utilized multiple rounds of household panel surveys to understand the changes and determinants of these phenomena over time(Yayo Negasi, 2021).

Specifically, the study was employed different research designs for each specific objective. The first two objectives sought to explore and analyze the intertemporal dynamics of welfare and inequality of households and thus followed a longitudinal and descriptive research design. Assessment of the effects of *Enset* production on household food security in the region followed a longitudinal and quasi-experimental design for the third objective. The fourth objective analyzed food insecurity and coping strategies of households, and thus adopted a concurrent triangulation research design. A correlational and longitudinal research design was implemented to achieve the fifth objective: identify the determinants of inequality in welfare. Longitudinal panel study design was applied for the sixth objective of probing resilience to food insecurity among *Enset* producer and non-producer households. Correlational research, lastly, approached the seventh objective, which identified the magnitude of the relationship among welfare and food security and the resilience to food insecurity.

1.8.4. Data Sources, Types, and Description

This study utilized Household quantitative data from the Living Standard Measurement Study (LSMS)[3], sourced from the Ethiopian Socioeconomic Survey (ESS) conducted by the Central Statistics Agency of Ethiopia with technical and financial support provided by the World Bank. The data spanned two waves: 2018/19 and 2021/22, and additional data was collected by the researchers in 2023/2024 using the same ESS methodology. These data waves, collected at two-year intervals, minimized missing data and accounted for unobserved heterogeneity, enhancing the reliability of longitudinal analysis (World Bank, 2022a).

The ESS gathers data through multiple survey sections, covering the demographic and socioeconomic characteristics of households in Ethiopia. Key variables include demographics, education, health, labor, time use, expenditures, food security, shock exposure, safety nets, assets,

[3] Surveys are conducted every two years. Visits were made to the targeted households in 2011–12, 2013–14, 2015–16, 2018–19, and 2021/22. The following resources are accessible for free download: data, questionnaire designs, interviewer guides, basic information sheets, and survey reports.: https://www.worldbank.org/en/programs/lsms/initiatives/lsms-ISA#2

and housing. Geographic information, such as GPS coordinates, field gradients, altitude, and potential wetness index, enriches the dataset by enabling integration with geospatial data. For this study, households were selected from the central Ethiopia region. Researchers adhered to a consistent research design, employing the same sampling techniques, maintaining a similar sample size, and using identical data collection tools across all waves.

The researcher selected all samples from the previous region named SNNP region, which was allocated to the central Ethiopia region part as indicated in Table 1.1 because the central Ethiopia region was part of it. Then, sampled households with incomplete data were excluded, resulting in a final sample of 319 households in 2018/19, 307 in 2021/22, and 270 in 2023/24, with an annual attrition rate of 1.18%. Among the surveyed households, 75% were identified as *Enset* producers, while the remaining 25% were non-producers, based on the total sampled population. Sampling weights were applied to adjust for the disproportionate representation within the sample group to mitigate potential biases arising from the exclusion of households with missing data. This methodological approach aligns with best practices in survey research, ensuring more reliable and generalizable findings (Lohr, 2021).

Table 1.1: Distribution of final sample households for primary data based on the ESS sampling frame

Region Code	Region Name	Zone code	Zone name	Distribution of Households		
				Total Sample HH	Producer (N=202)	Non-producer (N=68)
13 (From cod 7)	Central Ethiopia Region	1	Gurage Zone (Gurage zone, Eastern Gurage zone, Marako special woreda, kebena secial woreda)	59	44	15
		2	Hadiya zone	58	44	14
		3	Kembata & Tembaro zone (Kembata zone and tembaro special woreda)	36	27	9
		12	Yem special woreda now it is Yem special zone	36	27	9
		20	Silti zone	58	43	15
		21	Alaba special woreda now it is called Alaba Zone	23	17	6
			Total	270	202	68

Moreover, sampling weights were applied to ensure sample representativeness. For survey data, sampling weights (Pw) are typically the most appropriate choice as they account for the probability of selection and ensure that estimates reflect the population accurately (Valliant & Dever, 2018).

The LSMS dataset included sampling weights (e.g., pw_w4, pw_w5) (2018/19 & 2021/22) to account for the probability of selection, survey design features, and attrition. Besides, Regional weights were recalibrated for subnational analysis by normalizing the original weights based on the region's population size. This involved multiplying the original weights by the ratio of the region's total population and dividing by the sum of the sampled household weights. Attrition adjustments were also made by dividing the original weight by the retention proportion in each wave, ensuring continuity in representation despite changes in the sample over time. For panel data, further adjustments were made to adjust for attrition, since some of the households could fall between waves. Attrition-adjusted weights for still-existing households were determined through the division of the original weight by the actual proportion of the sample retained in the particular wave (Solon et al., 2015). The final region-specific weights were generated and normalized using Stata. We have calculated the sampling weight for the three years (2018/19, 2021/22, and 2023/24) across various areas (Appendix 1 Table 1.1a). Further, to adjust for attrition in the sample weights for 2023/2024 data, we applied the attrition adjustment factor (AAF) to maintain comparability across survey waves (LSMS).

In addition, the 2023/24 data were collected using the same procedures as the ESS, including tracking the same households recorded with GPS coordinates in previous waves. Since this GPS coordinate of the sampled household is not publicly available, the researcher obtained it through a formal request to the ESS. This consistent methodology ensures that the 2023/24 data are directly comparable to earlier datasets, facilitating meaningful analysis within the broader socioeconomic context of the Central Ethiopia region.

Focus group discussions and key informant interviews were conducted for the qualitative aspect of the study. The purpose of conducting focus group discussions and key informant interviews is to gather qualitative data that can provide rich and nuanced information about the study topics (Akhter, 2022). By engaging with participants who are actively involved and deeply concerned about the issues at hand, we aim to capture a range of perspectives and experiences. This qualitative data complements the quantitative aspects of the study and contributes to a more understanding of the research questions. The researchers conducted three focus group discussions, each consisting of a minimum of six participants who possess in-depth knowledge and expertise related to the study topics. The participants were selected based on their involvement and volunteerism in the

issues being investigated. The aim was to gather diverse perspectives and insights from a range of individuals who can provide valuable input. Key informant interviews were conducted that involved a total of 22 participants, comprising 7 women, 10 men, and 5 government administrators. The selection of key informants was based on their volunteerism and expertise in the specific areas relevant to the study. These individuals are expected to possess valuable insights and firsthand knowledge of the issues under investigation.

1.8.5. Methods of Data Analysis

The data analysis combines descriptive statistics, inference statistics, and econometric models to obtain the dynamic and determining factors of welfare inequality and resilience to food insecurity in the Central Ethiopia region. The methodologies provide an all-rounded analytical framework to examine disparities between *Enset*-producing and non-producing households. Descriptive statistics summarize and present certain key features of the data and give an initial understanding of the variables under study. Measures of central tendencies and dispersion like mean, percentages, and standard deviation give an overview of the welfare indicators of households regarding food security and resilience. In addition, some specialized statistical approaches are employed, such as the Atkinson Index, which is a measure of inequality in household welfare, taking into account income distribution sensitivity (Atkinson, 1970); CARI, the Consolidated Approach for Reporting Indicators of Food Security, in assessing food insecurity status by classifying households into various levels of food security (WFP, 2021); and PCA, Principal Component Analysis, to reduce dimensionality and estimate multidimensional inequality in household welfare (Jolliffe, 2002).

In the analysis, the use of inferential statistical techniques has been made in testing hypotheses on significant differences between *Enset*-producing and non-producing households. The methods used include t-tests, which test mean differences in key indicators between groups (Student, 1908), Chi-square tests to test the significance of association between categorical variables (Pearson 1900), and F-tests on comparing more than two means (A. W. F. Edwards, 2005). The latter makes use of Factor Analysis, which seeks latent variables explaining the relationships among the observed variables (Thurstone, 1931), whereas the MIMIC Model or RIMA framework estimates household resilience by considering both observed and latent indicators (FAO, 2016b).

This study used a variety of econometric models (Table 1.2). These include the Quintile Regression, which can be used to estimate determinants of inequality across different welfare levels (Koenker & Bassett Jr, 1978); Fixed Effects Model, which controls for unobserved heterogeneity in order to determine welfare and food security (Wooldridge, 2010); and the Endogenous Switching Regression Model, which allows one to assess the impact of *Enset* production on household food security, considering the potential selection bias (Maddala, 1983). The Ordered Logit Model determines the determinants of the status of food security (McKelvey & Zavoina, 1975); the Random Effect Logit Model estimates the factors affecting participation in *Enset* production (Greene, 2008); while the Probit Model analyzes household resilience linked with food insecurity (Wooldridge, 2010). Furthermore, resilience-food security-welfare nexus is explored with the help of a Simultaneous Regression Model, controlling for endogeneity, namely Three-Stage Least Squares-3SLS, by Zellner, (1962).

Before the running of models, diagnostic post-estimation tests were carried out to ensure the validity in the results obtained. For estimating the determinants of inequality in welfare, Breusch-Pagan LM tests for heteroskedasticity and Pesaran scaled LM and Pesaran CD tests for cross-sectional dependency were used. For the determinants of a multi-dimensional approach to welfare inequality, Hausman was used to test heteroskedasticity and autocorrelation. Variance Inflation Factor (VIF) checks multicollinearity during food security determinants estimation. In household participation within *Enset* production, Hausman tests for heteroskedasticity and autocorrelation. Finally, the normality regarding the nexus of welfare, food security, and resilience can be tested by the Jarque-Bera test; heteroskedasticity and autocorrelation were tested per model by the Breusch-Pagan LM test for these variables under consideration.

Qualitative data analysis is carried out through thematic analysis- a systematic process of identification and interpretation of patterns within key informant interviews and focus group discussions (Braun & Clarke, 2006). Recurring ideas, concepts, and themes were categorized to give deeper insights into the socio-economic and cultural dynamics influencing household welfare, food security, and resilience. These combined analytical methods will make sure of a robust examination of welfare inequality and food insecurity resilience in Central Ethiopia, with empirical evidence that informs policy and development interventions.

Table 1.2: Summary of Quantitative Data analysis Methods

Chapter	Methods of Data Analysis	Brief Model Specification	References	Justifications
3. The intertemporal dynamics of welfare in the Expenditure & Asset Approach	Atkinson Index	$A = 1 - [(\frac{1}{n}) * \sum((\frac{yi}{\mu})^{1-\varepsilon})]^{(\frac{1}{1}-\varepsilon)}$	(Afonso & Cabrita, 2015; Mulamba, 2022)	Provides a flexible, and decomposable estimation of Inequality. it allows for the analysis of contextual effects and the decomposition of the variance into different 'levels'
	Quintile regression	$Q_\tau ln(\frac{y_i}{x_i}) = x_i\beta_\tau + \varepsilon_{i,\tau}$	(Cameron & Trivedi, 2005; Buchinsky, 1998)	Considers the entire distribution of an outcome variable, enabling the assessment of inequality by quantifying the relationships at different points (quantiles) instead of just analyzing the mean.
	Factor analysis	$\mathrm{Ai} = \mathrm{b1} \cdot \mathrm{a1i} + \mathrm{b2} \cdot \mathrm{a2i} + \cdots + \mathrm{bk} \cdot \mathrm{aki}$	(Vollmer & Alkire, 2020)	It effectively captures the latent structure of asset ownership, allowing for the identification of underlying factors.
4. The intertemporal dynamics of welfare inequality: Multidimensional approach	PCA	$PC = Z.V$	(Asselin, 2009; Constas et al., 2014).	It efficiently reduces the dimensionality of large datasets while preserving as much variance as possible, thus facilitating easier interpretation and visualization of complex relationships among variables.
	Fixed effects model	$y_{it} = \alpha_i + \beta x_{it}' + \varepsilon_{it}$	(Hsiao, 2022)	It effectively controls for all time-invariant omitted variables, thereby reducing bias in estimates when the unobserved effects are correlated with the independent variables.
5. Food Insecurity and Coping strategies: using a CARI	CARI approach	CARI=CS (FCS+ rCSI) + CC (FES + LCS-FS)	(WFP, 2021)	• Handle the multi-dimensionality of food insecurity. It offers a robust, quantitative tool to measure the severity and frequency of behaviors households employ when they face food scarcity.
	Ordered logit model	$f(\gamma j(x)) = \log(\frac{f(\gamma j(x)}{1-f(\gamma j(x)}) = \log(\frac{pr(y \le jX}{pr(y>jx)}) = \alpha j + \beta x, j = 1,2 \ldots k-1$ $\gamma j(x) = \frac{e^{\alpha j+\beta x}}{1+e^{\alpha j+\beta x}}$	(Astemir, 2014; Muche & Tolossa, 2022).	It effectively handles ordinal dependent variables, allowing for the analysis of multiple factors influencing varying levels of food security among households.
6. Exploring the impact of *Enset* (*ensete*	The endogenous switching regression model	outcomes equations $Y1i = \beta 1Xi + \epsilon 1i \quad if\ Pi = 1$	(Toyiba shafi, Jema Haji, Lemma Zemedu,	It addresses potential selection bias and endogeneity, allowing for a more accurate

ventricosum)production on household food security in Central Ethiopia region		$Y2i = \beta 2Xi + \epsilon 2i \quad if\ Pi = 0$ logarithmic likelihood function $lnL = \sum_{i} (Ii\ \omega i\ [\ \ln(F(\mu 1i)) + \ln\left(f\frac{\left(\frac{\epsilon 1i}{\sigma 1}\right)}{\sigma 1}\right)] +$ $(1\text{-}Ii)\ \omega i\ [\ \ln(1\text{-}F(\mu 2i)) + \ln\left(\frac{f\left(\epsilon\frac{2i}{\sigma 2}\right)}{\sigma 2}\right)])$	2023; Lokshin & Sajaia, 2004)	estimation of the causal effects of *Enset* production on these outcomes.
7. Dynamics of Resilience to Food Insecurity among *Enset (Ensete Ventricosum)*Producing & Non-Producing Households	Multiple Indicators Multiple Causes (MIMIC) Model (RIMA)	Food consumption, Dietary diversity $= [\Lambda 1, \Lambda 2][RCI] + [\epsilon 1, \epsilon 2$ $[RCI] = [\beta 1, \beta 2, \beta 3, \beta 4][ABS,\ AC, SSN,\ AST, IFA, S] + \epsilon 3$	(Bollen et al., 2010)	It allows for the simultaneous examination of multiple indicators of resilience while accounting for the underlying latent variables and various causal factors influencing the relationship.
	Probit Model	$\text{Prob (loss in FS}t, t+1) = \Phi(\text{RCI}j, t, \text{X}j, t)$	(Pangaribowo et al., 2013)	It is well-suited for analyzing binary outcomes, such as the presence or absence of food security, while accounting for the influence of resilience-related factors.
	Random Effect Logit Model	$\log\left(\frac{P(Y_{it}=1)}{1-P(Y_{it}=1)}\right) = \beta_0 + \beta_1 X_{it} + u_i$	(Irfan et al., 2018)	It accounts for both individual-level unobserved heterogeneity and the binary nature of resilience outcomes across different groups or time periods.
8. Nexus of Welfare, Food Security & Resilience	simultaneous regression model (three stages of least squares)	W = α1 + β1F + β2R + β3E + β4Z + u1 F = α2 + γ1W + γ2R + γ3E + γ4Z + u2 R = α3 + δ1W + δ2F + δ3E + δ4Z + u3 Step 1: W* = π1 + π2E + π3Z + π4F* + π5R* Step 2: W = α1 + β1F* + β2R* + β3E + β4Z + u1 Step 3: $\beta = (Z'\Sigma^{-1}Z)^{-1}Z'\Sigma^{-1}y$	Egamberdiev, B., et al., 2023	Due to the nested structure of the data, where households are nested within groups, allowing for the exploration of group-level and individual-level factors influencing the relationship.

1.9. Data Reliability, Validity and Ethical Considerations

Data reliability is ensured by the consistency and accuracy of measurements over time and between various data collection mechanisms. Data reliability in this research is enhanced through LSMS (2018/19 & 2021/22) panel data from the Ethiopian Socioeconomic Survey (ESS), enabling the same individuals or households to be followed over several waves, limiting measurement errors and ensuring data robustness.

The validity of 2023/24 data is also guaranteed by the consistent methodologies and procedures employed in gathering the data. Similarly, data validity is created by the extent to which the data accurately measures the concepts and variables in question. Data validity in this study is ensured through the use of LSMS survey instruments and questionnaires that are meant to capture relevant variables of welfare inequality, food insecurity, and resilience. These questions are constructed based on established indicators and concepts and continue to be in line with standardized measurement principles. Besides, validity is maintained by adhering to a uniform research design, standardized sampling procedures, and valid data collection tools so that comparability and accuracy prevail in measuring welfare inequality and resistance to food insecurity.

Ethical concerns are also addressed in this study. Informed consent is achieved when the participants are well informed of the aim of the study, data collection procedures, and risks or benefits, but with the freedom to withdraw at any time without consequences. Confidentiality and anonymity are provided by safely keeping identifying data in a separate place and reporting findings as an aggregation or pseudonymization. Ethical clearance and approval are obtained from the College of development studies of Addis Abeba University boards to guarantee respect for ethical standards and participants' rights. The respect of participants is ensured by honoring their opinions, depicting their experiences as they are, and being mindful of culture. Finally, data protection policies are adhered to, including secure storage, access limitation, and proper anonymization or destruction of data upon study completion.

1.10. Organization of the Dissertation

This Dissertation is organized into nine chapters, each addressing different dimensions of welfare inequality, food security, and resilience among *Enset*-producing and non-producing households in Central Ethiopia. Chapter one introduces the study by providing background information, identifying the research problem, outlining objectives, and posing key research questions. It also

highlights the significance and scope of the study. Chapter Two presents a literature review, covering both theoretical and empirical perspectives relevant to welfare inequality, food security, and resilience. This chapter establishes the conceptual framework and contextualizes the study within existing scholarship.

Chapters Three to Eight delve into the core empirical analysis. Chapter Three examines the intertemporal dynamics and determinants of welfare inequality by analyzing expenditure and asset values. Chapter Four extends this analysis using a multidimensional approach. Chapter Five investigates food insecurity and coping strategies through the CARI method. Chapter Six assesses the impact of *Enset* production on household food security, while Chapter Seven explores the dynamics of resilience to food insecurity using panel data. Chapter Eight synthesizes the relationship between welfare, food security, and resilience, comparing *Enset*-producing and non-producing households. Finally, Chapter Nine provides a synthesis of findings, policy implications, study limitations, and suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

2.1 . Theoretical Literature Review

This part includes fundamental ideas and an overview of practical research concepts, measurements, and theories related to the connection between inequality, welfare issues, food security, and resilience to food insecurity. It helps in developing an understanding of contemporary theories and research and suggests future investigations into a previously neglected or inadequately studied field.

2.1.1. Inequality

Inequality describes the imbalance in access to resources and opportunities among people or groups in a society (Koh, 2020). It manifests in various forms, including income inequality, wealth inequality, and inequality of opportunity (Rietveld & Patel, 2022). While income inequality is often the primary focus, wealth inequality—reflecting disparities in accumulated assets—provides a more understanding of well-being variations within societies (Semega & Kollar, 2022). Inequality is commonly categorized into income inequality, which refers to differences in earnings among individuals or households; wealth inequality, which highlights uneven accumulation of assets such as property, savings, and investments; and inequality of opportunity, which encompasses disparities in access to resources like education, healthcare, and employment that influence individuals' life outcomes (Rietveld & Patel, 2022).

Various indices have been developed to measure inequality. The Gini Index, the most widely used indicator, ranges from 0 (perfect equality) to 1 (perfect inequality) and quantifies income disparity by assessing the average difference between all pairs of incomes relative to the mean income (Semega & Kollar, 2022). The Atkinson Index emphasizes social welfare by assigning different weights to changes in different parts of the income distribution. The Theil Index, derived from information theory, measures entropy and is decomposable, allowing for an analysis of inequality within and between groups. The Palma Ratio focuses on the income share of the top 10% compared to the bottom 40%, emphasizing extremes in the income distribution (Koh, 2020).

Inequality has been analyzed through various theoretical lenses. The Functionalist Theory, proposed by Oakes & Rossi (2003) argues that inequality is essential for societal functioning, as it motivates individuals to fulfill diverse roles requiring varying skills and rewards. Conflict Theory, rooted in Karl Marx's ideas, views inequality as a result of class conflict, where capitalism enables the wealthy to exploit the working class (Tumin, 1953). Max Weber's Multidimensional Theory expanded on Marx's work by suggesting that inequality arises not only from economic capital but also from social status and political power (Weber, 2019). Francis Fukuyama's Neo-Orthodox Theory emphasizes the role of strong physical and legal infrastructure in reducing inequality (Fukuyama, 2011). Modernization Theory posits that underdeveloped nations can alleviate inequality by emulating developed countries, whereas Dependency Theory argues that global inequalities result from exploitative relationships between rich and poor nations (So, 1990). Inequality remains a complex and multifaceted issue, shaped by economic, social, and political factors. Understanding its different forms, measurement tools, and theoretical foundations provides a framework for addressing disparities and promoting equity within societies.

Therefore, this study focused on inequality in welfare among *Enset*-producer and non-producer households using the Atkinson model, which considers the social aspect more than other indices. The Atkinson Index is a welfare-based measure of income inequality that takes into account the social aspect of how people value different levels of income. Unlike other indices, such as the Gini coefficient or the Theil Index, the Atkinson Index allows the analyst to specify a parameter that reflects the degree of inequality aversion in society. This parameter determines how sensitive the index is to changes in income distribution at different parts of the income scale. For example, a higher parameter value implies that society is more concerned about the welfare of the poor than the rich, and vice versa. The Atkinson Index also has a normative interpretation in terms of the equally distributed equivalent income, which is the level of income that, if received by everyone, would generate the same social welfare as the actual income distribution (Chakravarty & Lugo, 2019).

2.1.2. Food security

According to the FAO (2006), there is food security when all people, at all times, have physical and financial access to enough, safe, nutritious food to match their dietary needs and food preferences for an active and healthy life. Accessibility, use, stability, and availability are its four

primary constituents. When we talk about availability, we mean that there is always enough food available. Access is related to having enough money to buy the right foods for a balanced diet. Utilization refers to the sensible use of food through a healthy diet, access to clean water, sanitary conditions, and medical treatment. The ability to always have access to enough food is referred to as stability.

Assessing food production and consumption alone is not enough to fully capture the complexity and complexities of measuring food security. The Economist Intelligence Unit (EIU) developed the Global Food Security Index, which uses 28 distinct metrics to assess food security in 113 different nations. These include the cost, accessibility, food quality, and food safety. The Food Insecurity Experience Scale (FIES) was created by the FAO of the United Nations to measure the access aspect of food security. This scale gauges food security at the individual or household level through a series of questions about experiences of lack, uncertainty, and anxiety about food supply (FAO, 2017). In addition, the Consolidated Approach for Reporting Indicators of Food Security (CARI) is a tool developed by the World Food Program (WFP) to measure and analyze food security at the household level (WFP, 2021). CARI considers two key components: (1) Current status consisting of both quality and quantity of food consumed. This components includes Food Consumption Score (FCS) and reduced coping strategies index (rCSI); (2) Coping Capacity (CC) it indicates economic capacity to access food, where various indices such as amount of debt, reliance on purchasing food, frequency of negative coping strategies, number of income sources, and asset ownership are taken into account to assess vulnerability (Devereux et al., 2017); stability of other factors affecting food access, looking at how factors such as income and production fluctuate over time. CC includes FES or ECMS and household livelihood coping for food strategies (WFP, 2021). These indicators are computed together to provide a view of a household's food security status. The score for each indicator is calculated, and households are then categorized as food secure, marginally food secure, moderately food insecure, or severely food insecure.

There are several theories associated with food security. The Malthusian theory combines the principles of population growth and food supply. According to Malthus, unchecked population growth would outpace the ability of our resources to support it. However, this theory has received considerable criticism as technological advancements have allowed food production to increase and keep pace with population growth (Simon & Kahn, 1984). Another key theory is Amartya

Sen’s entitlement theory, which argues that people's ability to access food depends not solely on production but also on the 'entitlements' they possess (such as the ability to trade, sell labor, or own property). According to Sen, lacking these entitlements can result in famine, even when food is abundant (Sen, 1982). Finally, the food regime theory provides a historical materialist perspective on global food security challenges. It draws upon political, economic, and sociological considerations to explain dominant systems of food production and consumption (Friedmann & McMichael, 1989).

Since food security is a complicated and multifaceted phenomenon, measuring and monitoring it calls for an all-encompassing strategy. A single household food security survey's basic results are analyzed using the standardized WFP approach known as the Consolidated Approach for Reporting Indicators of Food Security (CARI), which also classifies individual households according to their level of food security. Additionally, it can be utilized to determine WFP program targeting criteria and do household vulnerability profiling (Security, 2015). To address the shortcomings of earlier approaches that relied on single indicators or composite indices, the World Food Programme (WFP) established the CARI in 2015, and it was revised in 2021 (WFP, 2021).

CARI was the primary method utilized in this study to evaluate the population's food security position and to pinpoint the most vulnerable populations among *Enset* producer and non-producer households. By combining four essential indicators—Food Consumption Score (FCS), Reduced Coping Strategies Index (rCSI), Economic Capacity to Meet Essential Needs (ECMN), and Food Security Experience Scale—CARI will give a complete picture of the state of food security (FSES). These variables cover various aspects of food security, including dietary quality and variety, coping strategies, financial accessibility, and individual perspective. Each household will be assigned to one of four food security groups, including "food secure," "marginally food secure," "moderately food insecure," or "severely food insecure," depending on these indicators.

2.1.3. Welfare

The concept of welfare refers to the well-being or utility of individuals or groups in a society. Welfare can be influenced by various factors, such as income, consumption, health, education, and happiness (Deaton, 1980). It can be assessed through various factors including personal happiness,

economic security, physical and mental health, opportunities for personal development, and social respect for one's rights and freedoms (Elgar, 2005).

There are various approaches to measuring welfare. One traditional way is through the Gross Domestic Product (GDP), which measures the economic production of a country. Critics, however, argue that GDP fails to account for inequalities, environmental degradation, and non-market activities like volunteer work and domestic labor. This led to the conception of alternatives like the Human Development Index (HDI), which considers life expectancy, education level, and per capita income, and the Genuine Progress Indicator (GPI), which takes into account socioeconomic factors and environmental impacts (Denniss, 2012). Another approach is subjective well-being, which uses surveys to measure the happiness or satisfaction of individuals. It is a self-reported measure and gives insight into individual perceptions of their lifestyles (Moore, 2019).

There are different theories on how to improve or maintain welfare. The utilitarian theory, for example, proposes that a policy is good if it maximizes utility or happiness for the greatest number of people (Sen, 1979). Amartya Sen’s conceptualization known as the capability approach, argues that welfare is about more than income or consumption; it's about the capabilities people have to function in society - their core freedoms to do and be what they value in life (Klein, 2018). Rawls's theory of justice as fairness posits that a policy is just if it improves the welfare of the least advantaged members of society (Bankston, 2010).

2.1.4. Resilience to food insecurity

Resilience to food insecurity is a multidimensional concept that reflects the ability of households and communities to withstand, adapt to, and recover from shocks threatening their food security (Ansah et al., 2019). Several key components contribute to this resilience: stable income sources and access to food are critical for ensuring food security, while the availability of diverse assets such as natural, physical, human, financial, and social capital enhances a household's capacity to cope with crises (Ladaninezhad et al., 2023). Social safety nets play an essential role by providing support during times of need, helping households maintain food security despite economic shocks. Additionally, access to basic services like healthcare, education, and sanitation significantly influences resilience by improving overall well-being (d’Errico et al., 2023). Stability in income

and resources over time reduces vulnerability to sudden changes, while adaptive capacity refers to the ability of households to adjust their strategies in response to changing conditions or shocks.

Measuring resilience involves various methodologies that assess how well households can cope with food insecurity. The Resilience Index Measurement and Analysis (RIMA) framework developed by the Food and Agriculture Organization (FAO) is also widely used, with RIMA-I offering a simpler approach based on six resilience pillars and RIMA-II providing a more complex analysis requiring extensive data (Ladaninezhad et al., 2023). Common indicators for measuring resilience include the Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), and food expenditure (d'Errico et al., 2023). Statistical techniques such as factor analysis help identify key attributes contributing to resilience, while regression models analyze the relationship between these attributes and food security outcomes (Ansah et al., 2019). This study utilized the MIMIC (Multiple Indicators Multiple Causes) approach because it allows for analysis of resilience by incorporating multiple indicators that reflect different dimensions of food security and the various factors influencing it.

The theoretical frameworks surrounding resilience in food security have evolved over time. Early studies focused on static measures of resilience, but this study emphasize dynamic aspects—how resilience changes over time in response to varying conditions. Different studies define and measure resilience to food insecurity differently, leading to challenges in comparing results across contexts. Some researchers advocate for a unified conceptualization that incorporates both stability and adaptability as core components of resilience. Increasingly, resilience is viewed as a capacity indexed against specific development outcomes such as poverty reduction and health improvement, highlighting the need for subjective measures that capture individual perceptions of resilience (Béné et al., 2023). Understanding these dimensions allows policymakers to design effective interventions aimed at enhancing the resilience of vulnerable populations against food insecurity challenges.

2.1.5. The Nexus between Welfare, Food Security, and Resilience in Households

Theoretical linkages between welfare, food security, and resilience in households are rooted in the interconnected dynamics of resource allocation, risk management, and adaptive capacities. Welfare, broadly defined as the state of well-being and access to basic needs, directly influences

food security, which encompasses the availability, access, utilization, and stability of food. Households with higher welfare levels are generally better equipped to secure food resources and buffer against shocks. Resilience, defined as the capacity to withstand, adapt to, and recover from adverse conditions, mediates this relationship by enabling households to maintain or regain food security despite economic, environmental, or social disturbances. Theoretical frameworks such as the Sustainable Livelihoods Framework and the Resilience Theory emphasize the role of assets (human, social, natural, financial, and physical) in strengthening both welfare and resilience, ultimately shaping food security outcomes (Chambers & Conway, 1992; Walker et al., 2004). These linkages highlight the need for integrated approaches to policy and intervention design that enhance household well-being, adaptive capacities, and food security resilience.

The theoretical underpinning of the link between household welfare, food security and resilience to food insecurity is based on the concept of resilience, which refers to the capacity of a system to withstand, adapt and recover from shocks and stressors without compromising its long-term functioning and development. Resilience can be applied to analyze the food and nutrition security of households, which depends on their access to sufficient, safe and nutritious food at all times.
Several studies have empirically tested the link between household resilience and food security outcomes, using different methods and data sources. For example, d'Errico et al., (2018) used a panel of household surveys from Tanzania and Uganda to estimate the resilience capacity index and its effect on food security status and recovery. Egamberdiev et al., (2023) applied a similar approach to analyze the case of Kyrgyzstan. Both studies found that resilience capacity was positively and significantly related to food security outcomes and that it mitigated the negative effects of shocks. Other studies have also explored the determinants and consequences of household resilience to food insecurity in different contexts, such as Ethiopia, Kenya, Malawi, etc.

Despite the growing interest in the link between household welfare, food security and resilience to food insecurity, there is a lack of empirical research that examines how these three concepts are related and what factors influence them. This study aims to fill this gap by testing the hypothesis that household welfare, measured by indicators such as income, expenditure, health insurance and asset number, has a positive effect on food security and resilience of *Enset* producing and households in central Ethiopia region.

2.1.6. Linking *Enset* Production with Welfare and Food Security

Enset (Ensete ventricosum) is a staple food crop that is widely grown in Ethiopia, particularly in the Southern and Southwestern regions of the country. *Enset* is a drought-tolerant crop that can grow in a range of agro ecological zones and is therefore well-suited to the often-challenging growing conditions in Ethiopia. The crop is highly versatile and used to produce a range of food products, including bread, porridge, and fermented alcoholic beverages. *Enset* contributes significantly to the food security and welfare of millions of Ethiopians, particularly those living in rural areas. *Enset* production can contribute to welfare and food security in several ways. Firstly, *Enset* is a reliable source of food, even during periods of drought or other environmental stresses, which can help to ensure that people have access to a stable supply of food (FAO, 2016b). Secondly, *Enset* used to produce a range of food products, which can help to diversify diets and improve nutrition. The crop is rich in carbohydrates, dietary fiber, and micronutrients such as potassium, calcium, and iron (Fanta & Neela, 2019). Finally, *Enset* production can provide income-generating opportunities for smallholder farmers, which can help to reduce poverty and improve overall welfare (Bonso et al., 2022).

There are several theories around *Enset's* potential to improve household wealth, food security, and resilience to food insecurity. The sustainable livelihoods framework, for example, argues that *Enset's* multi-functionality (food, fiber, medicinal uses, etc.) provides households with numerous resources that can be utilized to develop and maintain sustainable livelihoods in the face of shocks and stressors (Feyisa et al., 2022). Furthermore, the food sovereignty theory also supports the *Enset*-livelihood nexus, asserting that *Enset* crop increases households' control over their food supply, thereby enhancing food sovereignty and local resilience (Wezel et al., 2020). In addition to its nutritional and economic benefits, *Enset* also plays an important cultural and social role in Ethiopian communities (Wondimu & Kebede, 2022).

Enset (*Ensete* ventricosum), often referred to as the "tree against hunger," plays a vital role in enhancing resilience, welfare, and food security, particularly in the Ethiopian highlands where it is a staple crop. Its drought-tolerant and perennial nature enables households to withstand environmental shocks, contributing to resilience by ensuring a steady supply of food and income even during adverse conditions (Brandt et al., 1997). *Enset* production also supports welfare by diversifying livelihoods and acting as a financial buffer, as surplus produce can be sold to meet

other household needs (Negash & Niehof, 2004). Furthermore, the crop's high nutritional value and capacity to yield food year-round directly bolster food security by improving dietary stability and reducing seasonal hunger (Fanta & Neela, 2019). These linkages highlight *Enset's* potential as a sustainable agricultural practice to enhance household well-being, particularly among resource-constrained communities.

Therefore, this study focuses on the Impact of *Enset* Production on Household Food Security, bringing novelty to the field by employing panel data and an endogenous switching regression model. This approach allows for a dynamic analysis of how *Enset* production influences food security over time, addressing potential endogeneity issues that arise from unobserved heterogeneity and self-selection bias. By capturing the temporal dimension and accounting for the dual regimes of *Enset* producers and non-producers, this study provides robust insights into the causal relationship between *Enset* production and food security outcomes. This methodological advancement contributes to the literature by offering a nuanced understanding of the role of *Enset* in mitigating food insecurity, particularly in the context of the Ethiopian highlands.

2.2. Review of Empirical Studies

2.2.1. Dynamics of Food insecurity coping mechanism

Food insecurity has become another critical issue in Ethiopia. Studies conducted in Ethiopia show that something like food insecurity has also been viewed through the lens of socio-economic, environmental, and political structural factors whereby the bottom line varies across time. In a large study that employed data from the Gallup World Poll spanning 2014 to 2019, it was found that about 52.1% were reported to have been moderately or severely food insecure by 2019 as compared to 47.7% in 2014 (World Bank, 2024a). Notably, the report indicated that these populations mainly composed the age group aged 35 to 44 years and the second lowest income quintile; thus, demonstrating that it indeed identified the major demographic categories that could affect food insecurity in the country. Interestingly, it has also been noted that nearly 37% of under-five children were stunted under chronic malnutrition, indicating an urgent need for implementing measures geared or directed towards food security and nutrition among vulnerable populations (Telila & Sima, 2024). Dercon & Krishnan, (2000) examined dynamics of household food consumption in Ethiopia, with strong lenses towards shocks such as drought. As Shishay K. W. & Dawit G. T. (2018) discussed in their study on weather variability impacts on food security across

rural households dependent on rain-fed agriculture, they both studied this much needing factor very well.

Much research has focused on the causes and coping strategies of food insecurity within different regions and contexts. Melese et al. (2021) conducted a descriptive and econometric analysis of the determinants and coping mechanisms of household food insecurity in Analemmo district of southern Ethiopia. They found that food insecurity was notably affected by variables including agroecology, demographic aspects (such as age and education), the number of oxen owned, implementation of soil and water conservation measures, availability of credit, land area, and receipt of remittances. They also identified the most common coping strategies, such as relying on less preferred and less expensive food, borrowing food or money, and purchasing food on credit. In contrast, Biadgilign, S. (2023) used a consumption coping strategy index to assess the food access situation of urban households in Addis Ababa, Ethiopia. They found that food-insecure households were more likely to rely on help from relatives or friends, limit portions at mealtimes, and have no access to financial services. However, coping strategies are not always sufficient or sustainable to ensure food security. Therefore, there is a need to address the underlying causes and consequences of food insecurity and to improve the resilience of households. Sani & Kemaw, (2019) reviewed the historical and current situation of food insecurity in Ethiopia, including its causes, effects, and coping strategies. They discussed the role of different actors, such as the government, NGOs, and donors, in addressing food insecurity. Similarly, Mumed et al. (2023) reviewed the research results of various studies that focused on identifying the causes and coping strategies of food insecurity in different parts of rural Ethiopia. However, they presented no comparative perspective concerning food security dynamics along different agricultural systems, such as *Enset*-producing and non-producing households.

Despite substantial research on food insecurity, most studies have predominantly employed cross-sectional data and conventional food security indicators, which fail to capture the temporal dynamics and diverse coping strategies adopted by households. For example, Wubetie et al. (2023) analyzed food insecurity in Ethiopia using household surveys, but the focus was limited to static measurements without exploring the intertemporal changes in food security status. Similarly, Demie & Gessese (2023) employed econometric methods to analyze food security determinants but did not consider the qualitative dimensions of coping strategies or their long-term implications.

These gaps underscore the need for integrative approaches that combine quantitative and qualitative data to analyze food insecurity over time.

Furthermore, previous studies have often overlooked the role of indigenous crops like *Enset* (*Ensete* ventricosum) in enhancing household resilience to food insecurity. *Enset*, often referred to as the "tree against hunger," has unique agronomic and cultural significance, yet its contribution to food security has not been adequately explored in comparative studies. Studies such as Borrell et al. (2020) highlighted *Enset's* potential in food systems but focused primarily on its agronomic properties rather than its impact on food insecurity dynamics. This limitation calls for a deeper investigation into how *Enset* production shapes food security outcomes compared to non-producing households.

Additionally, methodological limitations in previous research have constrained the understanding of food insecurity. Traditional metrics such as the Household Food Insecurity Access Scale (HFIAS) or the Food Consumption Score (FCS) have been widely used but fail to integrate multiple dimensions of food security. The Consolidated Approach to Reporting Indicators of Food Security (CARI), a novel methodology, provides a more comprehensive framework for analyzing food insecurity by integrating coping mechanism and all dimensions.

To address these gaps, the current study employs a comparative approach, integrating quantitative and qualitative data to investigate the status of food insecurity and coping strategies among *Enset*-producing and non-producing households. By using the CARI methodology, this research offers a novel lens to examine the complexities of food insecurity and its temporal evolution, providing a more nuanced understanding of the challenges and adaptive mechanisms in the Central Ethiopia region. This study not only fills critical empirical and methodological gaps but also contributes to the broader discourse on sustainable food systems and resilience.

2.2.2. Inequality in welfare

In recent years there has been much discussion on empirical research of welfare inequality with a specific emphasis on developing economies like Ethiopia. It is critical to emphasize the aspect of inequality in welfare because it does not only reflect income but also covers critical multidimensional configurations including education, health, and living standards. Recent studies have indicated that, although reduced overall poverty rates, there remains a strong pressure of

inequality in Ethiopia. For example, a case in point was a World Bank report which indicated that though national poverty rates decreased, urban-rural gaps widened, marking a very important area of inequality in itself that warrants more investigation (World Bank., 2020).

Studies reveal a gap that is increasingly becoming notable in their earlier findings. This concerns insufficient examinations of the intertemporal dynamics of inequality among different household types. *Enset* producers haven't been distinguished from the non-producers in most intertemporal inequality analyses. Some welfare disparities are analyzed from purely monetary perspectives while ignoring the multidimensionality facet of poverty and inequality. For example, (G. Y. Belete, 2022) mentions the use of both the monetary and non-monetary poverty indicators for analysis 'because then one understands the totality of poverty in urban Ethiopia. Such gaps allow room for inventiveness in conceiving ways by which the complexities in welfare temporal dynamics are captured. Thus, taking this into account, the present study shall adopt comparative and panel data techniques to evaluate the intertemporal dynamics of inequality between *Enset*-producing and non-producing households in the highlands of central Ethiopia. Our analysis will draw a multi-dimensional and monetary perspective into the process of measuring inequality with the objective of giving a more holistic picture of welfare disparity. At the heart of it, the multidimensional poverty index (MPI) is an important tool through which an appropriate understanding can be made of actual welfare inequalities based on various factors (Kedir, 2014).

We further present a new methodology for research by inserting the Atkinson Index into the measurement of inequality. The index offers sensitivity to changes in a population's income distribution, resulting in a clear understanding of how welfare is distributed among households. Previous studies have mainly dealt with traditional measures, like the Gini coefficient, that fail to grapple with the realities of welfare distribution across nations such as Ethiopia (Dula et al., 2023). Using this index within the framework of our analysis, we hope to bridge this methodological gap and strengthen our findings.

The role of *Enset* as a critical crop in Ethiopian agriculture also warrants attention in discussions of welfare inequality. Studies indicate that *Enset* farming is synonymous with a gender-tied resource and labor access among households (Katie et al., 2013). It is important to understand such dynamics in addressing inequalities originating in agricultural practice and market participation. In addition, previous studies such as (Tadele & Gella, 2012)(Degye Goshu, 2013)(Debebe &

Zekarias, 2020) mostly looked at urban settings while not considering and giving due attention to rural contexts, where the *Enset* is primarily grown. Such an oversight denies a full understanding of how agricultural practices influence well-being inequalities across different geographical areas. The rural-urban household duality, considering both rural and urban households engaged with *Enset* production, is found in the present study to bridge the gap in regional welfare outcome disparities (Gebre et al., 2022).

This study presents a strong contribution to the debate on welfare inequality in Ethiopia, by addressing some gaps through a thoroughly comparative appraisal of the *Enset* producers and non-producers. With modern techniques including panel data analysis, the Atkinson Index, and multidimensional assessment, the researchers seek to understand better the ways intertemporal dynamics help shape inequalities across households over time. This work thus enriches academic learning and understanding but also will equip itself with adequate material for intervention policy formations towards reducing gaps, as well as channeling inclusive growth across the agricultural sector in Ethiopia.

2.2.3. The role of *Enset* production on household food security

In Ethiopia, empirical studies on the effects of *Enset (Ensete ventricosum)* production on household food security have become very relevant. The essence of this crop is such that it assures food security for millions. *Enset* is referred to as "the tree against hunger" because of its strength in bearing food in a severe climate. Previous research results revealed that the cultivation of *Enset* has a considerable contribution to food security, income generation, and overall community resilience in Southern Ethiopia. For instance, a study showed that households that relied on *Enset* as a staple food can mitigate the risks of crop failure, keeping a steady supply of food year-round (Borrell et al., 2020).

Despite the recognition of *Enset's* importance, gaps remain in understanding its full impact on food security across different regions and socio-economic contexts. Many studies have primarily focused on cross-sectional data, which limits the ability to draw causal inferences about the relationship between *Enset* production and food security outcomes. For example, while some research indicates that participation in the *Enset* value chain positively affects household income

and food security, these findings often lack robust methodological approaches to account for selection bias (A. Haile et al., 2020).

This highlights a critical gap in empirical literature where longitudinal data and advanced econometric techniques are needed to better understand these dynamics. To address these gaps, recent studies have employed novel methodologies such as the endogenous switching regression (ESR) model. This approach allows researchers to account for potential selection biases by distinguishing between households that choose to engage in *Enset* production and those that do not. By applying this method, researchers can more accurately assess the causal effects of *Enset* production on food security outcomes. For instance, for analysis using panel data could reveal how variations in *Enset* cultivation practices influence daily caloric intake and overall food security status among households in Central Ethiopia (Haji et al., 2024).

Additionally, measuring food security through calorie intake provides a more nuanced understanding of how *Enset* contribute to nutritional adequacy. Traditional assessments of food security often neglect the qualitative aspects of diet diversity and nutrition. Measurement of kilocalories can now facilitate the assessment of *Enset* production on quantity and quality of foods available to households. Such findings conform to previous studies underscoring the nutritional advantages of *Enset* as a source of high-carbohydrate, vitamin-rich foods (Sirany et al., 2022).

Furthermore, it is essential to explore how socio-economic factors influence household decisions regarding *Enset* production. Factors such as market access, education levels, and local agricultural policies play significant roles in determining whether households can effectively engage in *Enset* cultivation. Studies have indicated that improving market linkages and reducing transaction costs can enhance smallholder farmers' participation in the *Enset* value chain, thereby increasing their food security and income levels (Wambui, 2024). This underscores the need for targeted interventions that support both agricultural practices and market development. In conclusion, while existing literature highlights the critical role of *Enset* in enhancing household food security in Ethiopia, significant gaps remain regarding the methodologies employed and the socio-economic contexts considered. The use of panel data combined with advanced econometric models like ESR offers a promising avenue for future research. The objective of such studies is to determine not only how much *Enset* produced affects the food security levels of the households in which it is

produced, but also the very conditions underlying the positive or negative relationship such as why and towards what food insecurity coping mechanism it constitutes.

2.2.4. Household resilience for food insecurity

The resilience of households to food insecurity has been an issue of increasing relevance in discussions about regions of the world most affected by climate change, economic shocks, and political instability. In the context of food security, resilience at the household level typically denotes the ability to withstand, recover from, and adapt to shocks that disrupt household access to sufficient, safe and nutritious food (Upton et al., 2016). Several cross-section studies on resilience to food insecurity in Ethiopia have identified several important findings. Previous studies utilizing cross-sectional datasets to examine resilience to food insecurity in Ethiopia have revealed several key findings. A study in the Mekiet district highlighted the significance of a system's ability to absorb shocks and adapt to change for resilience, while noting a negative association with transformative capacity, suggesting a need for targeted resilience programs (Demsie, 2024). Research in the northeastern highlands identified agricultural assets and social capital as critical factors influencing resilience, with many households classified as non-resilient, indicating a pressing need for effective interventions (T. Asfaw, 2022). In Southern Ethiopia, determinants of resilience were explored, providing insights into how various socio-economic factors impact food security outcomes (Zerihun et al., 2024).

Additionally, a study in the Majang Zone emphasized the challenges households face in maintaining food security and suggested policy interventions (Zerihun et al., 2024). While empirical studies about adapting to food insecurity have focused on measuring and understanding household capacity by which certain factors affect that adaptability, research has been limiting because of a lack of methodology especially when cross-sectional data are employed (Demsie, 2024; Zerihun et al., 2024; Demisse et al., 2024; Mossie et al., 2024; Asfaw, 2022). Such designs overlook dynamic changes in resilience over time. Panel data which is observed over time across several periods within a specific household offers special insights into household resilience by showing change or a sequence of changes across shocks and adaptations over time by households. Very few studies have included panel data in the context of Ethiopian Agriculture, thus leaving the issue of importance of food security in the areas. Thus, the present study, through the

longitudinal panel data, delves into the dynamics of resilience among *Enset*-producing and non-producing household types in central Ethiopia.

The paradigm shift in resilience research is the complex statistical modeling with the Multiple Indicator Multiple Causes (MIMIC) model. The new scale enables the estimation of more than one latent variable at a time. Thus, it works well as a view of resilience capturing changes moving through time for it. Earlier models treat resilience as a static outcome, which does not mirror constantly changing real-world conditions influencing resilience (T. Asfaw, 2022). Recent studies emphasize that it is worth adopting latent variable models like MIMIC for the different facets of resilience, which include an array of economic, social, and environmental factors. Resilience has been shown to be affected specifically by household socio-economic characteristics, external shocks, and particular farm practices, such as *Enset* cultivation. MIMIC model analysis describes interactions of such factors with contribution to household resilience for food insecurity (Alinovi et al., 2010). This novel approach allows for a more exploration of resilience, considering both observable factors (such as income and education) and unobservable factors (like psychological resilience). The MIMIC model's ability to integrate these diverse elements enhances our understanding of how households can absorb shocks and maintain stability in challenging situations

Previous studies on resilience to food insecurity in Ethiopia have largely been cross-sectional, focusing on specific shocks or crises without accounting for long-term adaptive capacities or the ongoing accumulation of resilience over time (Demsie, 2024). These studies often rely on simple statistical models that assume a uniform response to shocks across different household types, which neglects the heterogeneity of resilience capacities across different population groups. This study fills this gap by employing a Random Effects Ordered Logistic Regression model to assess household-level determinants of resilience to food insecurity. This model allows for the inclusion of household-specific unobserved heterogeneity, improving the robustness of the results. By incorporating panel data, the study can also account for temporal changes in resilience and how different households respond to recurring and unexpected shocks such as droughts, price volatility, and political instability.

Another gap in the literature concerns the specific relationship between resilience and food security. While many studies have looked at the impacts of resilience on food security outcomes,

there is a lack of clarity about the mechanisms that link these two concepts. Resilience is often conceptualized as a latent trait, while food security is typically treated as an observable outcome (Rajiv & Aliev, 2024). To address this, the current study uses a Probit model to explore the connection between resilience and food security, providing a more direct examination of how resilience affects food security outcomes at the household level. This approach allows for the exploration of whether higher resilience directly translates into improved food security, as well as how different resilience-building factors, such as diversification of income sources or access to *Enset*-based agricultural systems, influence food security. This is a key contribution, as the majority of prior research has not specifically linked resilience to food security through advanced econometric techniques.

In Ethiopia, food insecurity is a chronic condition affecting millions of households that go through regular crises, drought, conflict, and market instability (WFP, 2024). Despite efforts to foster food security through various agricultural interventions, they make resilience an under-researched concept in Ethiopian food security literature. The well-known drought-resistant and unique crop is *Enset,* which is considered one of the most important factors in household resilience in central Ethiopia, specifically in the Southern Nations, Nationalities, and Peoples' Region (SNNPR). Empirical evidence shows that *Enset* production significantly contributes to food security by providing a consistent source of food even during the drought period (Bonso et al., 2022). However, there lack detailed information comparing the resiliency of *Enset* growing and non-growing households over time. This study tried to fill the gap by comparing the dynamics of resilience to food insecurity or food-related risks among *Enset*-growing and non-growing households, which offer some insight into the long-term effects of *Enset* cultivation on food security and resilience.

In addition, despite the growing literature on resilience, most of it has focused on rural households, especially in Sub-Saharan Africa. Little is therefore known about the specific agricultural practices, such as *Enset* cultivation, and their interaction with broader socio-economic and environmental attributes to really understand the level of resilience to food insecurity. Prior studies have established a significant argument on diversification in acquiring improved resilience; little effort, however, has been made explaining how *Enset* farming households might differ from those that do not produce this crop in terms of their adaptive capacity (Z Yemataw et al., 2018). Creating

comparative studies is where the present work fits in to better understand how *Enset* cultivation is a resilience driver or coping mechanism against food insecurity. The results show that households involved in *Enset* production are, on average; characterized by higher resilience scores due to the capability of this crop to buffer against environmental shocks, such as drought, while allowing income diversification.

2.2.5. Determinants of inequality in welfare

Welfare inequality is an extremely complex issue. Many factors that are very different from each other in terms of differences based on international, continental, and national context can be at play in determining such asymmetric welfare levels. This section reviews recent studies to provide empirical evidence on the different determinants of welfare inequality with emphasis on Ethiopia and other broader settings.

According to recent international studies, macro-level factors such as GDP per capita, levels of education, and labor market conditions largely determine income inequality at the global level. In an analysis based on panel data from 52 high- and middle-income countries, a U-shaped relationship was observed between GDP per capita and income inequality, signifying that, as economic growth takes place, it increases inequality in the short term but will eventually reduce it over a longer timeframe in countries that have more per capita GDP5. More average educational attainment, on the one hand, had an association with lower income inequality, while on the other hand, factors such as international trade and unemployment rates increased those disparities (Gliebus & Salamurovic, 2024).

Social welfare inequality on a continental scale, especially in Africa, has expressed itself in demographic changes, urbanization, and accessibility to resources. A study on South Africa indicated that government spending on social grants would have a significant effect on income inequality. The results have indicated that improvement in the social welfare programs and initiatives focusing on job creation are both critical in overcoming these inequalities (Seabela et al., 2024). The research noted further that those areas with rapid population growth require specific economic development policies that will work at mitigating further worsening of inequality.

In Ethiopia, the determinants of welfare inequality have been extensively studied. A recent analysis indicated that the Gini coefficient for income inequality increased from 0.29 to 0.33 between 1995

and 2016, reflecting rising disparities despite overall economic growth (Yirga, 2021). Factors contributing to this trend include urban-rural divides in asset accumulation, access to education and healthcare services, and demographic characteristics such as household size and composition (Dula et al., 2023). The distinction between urban and rural welfare inequality in Ethiopia is particularly pronounced. Studies utilizing data from the Living Standards Measurement Surveys (LSMS) revealed that rural households experience higher levels of welfare inequality compared to their urban counterparts. Key determinants identified include asset ownership, access to health services, and savings behavior among rural households. In contrast, urban households' welfare is significantly influenced by livestock ownership and household size (Dula et al., 2023)

Education comes as one of the most important determinant of welfare dissimilarity in any location. However, in Ethiopia, high education attainment of household heads relates to better household welfare (Belay, 2022b). This correspondence conforms to the above evidence of international works that postulate more on education as an avenue of poverty-reduction and economic-increase enhancing pathway (Biyase & Zwane, 2018). Hence, investment in education becomes a core for addressing inequality in welfare. Access to financial resources is also among the important determinants of welfare outcomes. Studies in Ethiopia by remittances have shown that it is centered on access to credit positively be linked to household indicators of welfare (Yirga, 2021). The microfinance institution becomes increasingly scarce in the sense of improving the inclusion of marginalized populations in further financial access, reducing welfare inequality2. It should be recommended for policymakers to improve the access to these financial arrangements in wider poverty alleviation strategies. Access to Health Services Another major determinant in welfare inequality is access to health services. Studies have suggested that households with greater access to health services have been less deprived and have better welfare outcomes (Dula et al., 2023). The COVID-19 pandemic accentuated the necessity of extensive health systems to enforce inequalities; therefore, strengthening health systems will remain imperative for equity in development.

There are several empirical studies on the determinants of inequality in welfare in Ethiopia. However, most of the studies focus on income inequality. One such study analyzed the determinants of income inequality in Ethiopia from 1988 to 2018 (Belay, 2022b). Another study found that unequal income distribution slows down economic progress and exacerbates poverty in

the area (Wolde et al., 2022). A third study conducted a regression-based inequality decomposition to identify the determinants of income inequality in transitional economies, including Ethiopia (Tsaurai, 2020). However, there is a lack of empirical studies that specifically focus on the determinants of inequality in welfare in Ethiopia. There is also a lack of using panel data and comparative study. Therefore this study used panel data, comparative study, and quantile regressions.

Panel data has been extensively employed to accommodate unobserved heterogeneity and endogeneity from the viewpoint of households. One South African study, for example, utilizes a fixed-effect model and a random-effect one in the study of determinants of poverty and household welfare, thus reinforcing the finding of time-series analysis having a qualified underheld aspect concerning the purely individual characteristics like education level or employment status about welfare outcomes over time (Biyase & Zwane, 2018). Even with the strength of methodologies using years-long data, the people who perform research still exhibit a strong inclination to use the OLS regression techniques, which are not cut out for the complex design of welfare dynamics.

Quantile regression models are piercingly penetrating in delving into how the causes of welfare inequalities impact different strata of the population. This is the advantage of estimating variable effects across different points of the income distribution as opposed to merely ascertaining their mean effect. For instance, the findings from the studies using quantile regression in Ethiopia indicate that asset ownership affects households with different income levels in very specific ways (Dula et al., 2023). While this development, there is yet a lack of widespread international application of quantile regression models, which could provide significant differences in how inequality manifests itself in different populations.

Previous studies conducted on the southern region have either dealt with *Enset*-producing households or with 'non-*Enset*' households, but hardly ever comparative studies on the two research households. One clear gap in the literature is the absence of dynamic and longitudinal assessments of the extent to which welfare inequality changes over time in this context. For instance, studies like those of (Tadesse et al., 2018) and (Borrell et al., 2020; A. Haile et al., 2020; MOHAMMED et al., 2023) highlight agricultural practices including *Enset* production in enhance household resilience and welfare but do not attempt to compare *Enset* producers and non-producers

in terms of their resultant welfare nor include the changing dynamics of inequality among those households.

This present study thus significantly contributes to filling a gap in the literature through a comparative approach using panel data, providing a nuanced understanding of welfare inequality determinants over time by capturing intertemporal differences in addition to cross-sectional variation in household welfare. By observing changes over several periods, the analysis offers a richer depiction of the influence of *Enset* production on the welfare inequality picture than previous studies that relied mainly on cross-sectional data, irrespective of the scope of the agricultural practice itself. On top of these, this study identifies the determinants by expanding the bounded monetary definitions of welfare inequality by moving toward money and multidimensional indices of welfare disparity. This dimension becomes even more salient in Ethiopia, where income dimensions are not the sole riches to capturing overall well-being, and accessible to food security, education, and health. *Enset* production may be income-generating, but it is also postulated to increase food security and augment resilience, both of which are necessary elements of welfare (Wambui, 2024). Bringing together income and other multidimensional measures, this study captures much more regarding causal elements of welfare inequality.

2.3. Conceptual Framework

The conceptual framework in Figure 2.1 provides a robust structure for analyzing the dynamics and determinants of welfare inequality and resilience to food insecurity among *Enset*-producing and non-producing households in Central Ethiopia. It captures the intricate relationships between welfare, resilience, and food security over time, with *Enset* production as a mediating factor. This approach is grounded in theoretical and empirical literature emphasizing the importance of agricultural practices, household-level disparities, and resilience-building strategies in addressing food security challenges.

At its core, the framework distinguishes between baseline outcomes (Y_0) and subsequent changes over time (Y_1) in resilience (R), welfare (W), and food security status (FS). This temporal dimension aligns with longitudinal studies, such as Barrett & Constas (2014), who argue that resilience is inherently dynamic and shaped by time-variant and time-invariant factors. The framework also integrates multidimensional inequality, including education, income, health service access, and exposure to shocks, to reflect how structural disparities influence welfare and

resilience outcomes. Empirical studies, such as those by Dercon (2004) and Carter & Barrett (2006), have demonstrated that households with better access to education, health services, and assets are more likely to recover from shocks and achieve long-term food security

The inclusion of *Enset* production as a key mediating factor highlights its potential to address welfare inequality and enhance resilience. *Enset*, a drought-resistant crop, has been shown to provide a steady source of food and income, particularly in areas prone to climatic shocks (Feyisa et al., 2022). Empirical findings by Senbeta et al. (2022) illustrate that *Enset*-producing households in Ethiopia are more likely to withstand periods of food scarcity compared to non-producing households, owing to the crop's versatility and cultural significance. The green arrows in the framework emphasize this transformative role of *Enset* production, showing its direct and indirect impacts on improving welfare and food security outcomes over time.

The framework also connects the welfare-food security-resilience interface- into which those junctions are reflected by the blue arrows showing the feedback loops. A bidirectional relationship between food security and resilience, noting that improvements on either dimension usually bring progress to the other, has been reported by Béné et al. (2018) and Alinovi et al. (2010). Such households on improved food security may invest more in their children education and health, and productive assets that would make them better in recovery from shocks and better welfare sustainability.

The analytical approach presented in this framework is particularly relevant for addressing the research problem of "Dynamics and Determinants of Welfare Inequality and Resilience to Food Insecurity in Central Ethiopia." By separating baseline and change outcomes, the framework allows for the identification of factors influencing both static and dynamic aspects of resilience and welfare. For instance, studies by Barrett & Swallow (2006) and (Chegini et al., 2021) suggest that monetary and multidimensional inequalities are significant predictors of household welfare and resilience, and that addressing these inequalities requires targeted interventions that account for both structural and temporal dynamics.

Additionally, the integration of time-variant and time-invariant characteristics provides a lens for understanding the drivers of welfare inequality and resilience. Time-invariant factors, such as land ownership, cultural practices, livestock ownership, soil quality and geographic location, have been

identified as critical determinants of baseline welfare outcomes, while time-variant factors, such as market access education level, household consumption, crop yield and influence households' ability to adapt and recover from shocks over time. Altogether, the pattern offers a very empirical view to the welfare-food security-resilience nexus: It highlights much how *Enset* production could contribute to changing welfare diversities while increasing resilience on the side of food security, putting efforts into addressing multidimensional inequalities for more sustainable food outcomes. In this light, it has contributed to being better informed about how resilience and welfare dynamics relate to agricultural systems and household-level disparities in Central Ethiopia.

The interrelationship between the dependent, independent variables and intermediate variables is grounded in how different household and demographic factors influence economic and social outcomes. Demographic factors such as age, gender, education, and family size (Independent Variable) have been found to impact welfare and income expenditure (Ahmad et al., 2021). Older individuals or larger families, for instance, may have higher expenditures or different expenditure patterns due to differing needs. Similarly, an individual's level of education can affect their income level and thus their welfare (Mou, 2023).

Socio-economic factors like Assets can also directly impact welfare, as these resources may translate into income if properly utilized. These resources, along with institutional factors like credit and extension services, can influence food security as resources allow for food production or purchase, while access to credit can enable investments in food production or securing food in times of scarcity (Barrett, 2010).

Enset production, a specific form of agricultural production, is likely to be directly related to food security. The increased production can lead to increased food availability and a direct source of income, thus improving resilience and reducing household inequality (Headey & Ecker, 2013). Likewise, institutional factors such as market access and information can significantly impact a household's food security status by providing opportunities for income generation and trade. Infrastructural factors like roads and communication facilities play a pivotal role in shaping resilience and food security. Improved infrastructure can enhance access to markets, reduce transportation costs, and boost incomes, benefiting both the welfare and food security of households (Jouanjean, 2013). Besides, the changes of assets over time, which are influenced by the variation of household and socio-economic characteristics, affect how households can access

enough food, how they can cope with income shocks, and how they can reduce the gap between the rich and the poor.

Dependent variables, in this case, welfare inequality, food security, and resilience to food insecurity, are often directly or indirectly impacted by independent variables. In the instance of inequality among households, demographic factors like age, gender, education, and family size can substantially contribute to income inequalities. For instance, larger families might struggle with income allocation compared to smaller families due to the larger number of resources needed. Similarly, gender inequality in education and employment opportunities could result in income disparity across households. Household resource endowment and allocation, including land, labor, and capital can also significantly influence income and asset-building disparities. Households with larger landholdings or extensive capital resources may have higher incomes and invest more in food, health, education, and housing, leading to greater wealth accumulation.

The household's engagement in productivity activities, like *Enset* production, can determine the household's earnings, influencing cash income, food consumption, and expenses on non-food items. A household that produces more *Enset* or has a significant portion of their production marketable may have a higher income, undergo less food insecurity, invest more in education or health, and build more assets (Olipa, 2019). Moreover, institutional factors such as access to credit and extension services, market information, and membership in cooperative societies can moderate the effects of resource endowment on income inequality. For instance, better access to credit can allow a household to invest more in productive activities, reducing income disparity if accessed by poorer households. Information about the market could aid the household in making informed decisions that yield maximum returns and reduce income disparity. Finally, infrastructural variables like the availability of roads and communication services in the area where the household resides can affect household income. Households located in areas with better infrastructure are likely to have access to better market opportunities, thus increasing their earnings by reducing transportation costs and time. While all these independent variables interact in diverse ways to influence the dependent variables, the level and degree of their interaction often vary. For instance, in some contexts, institutional factors may hold a higher influence on income disparities compared to demographic factors or vice versa.

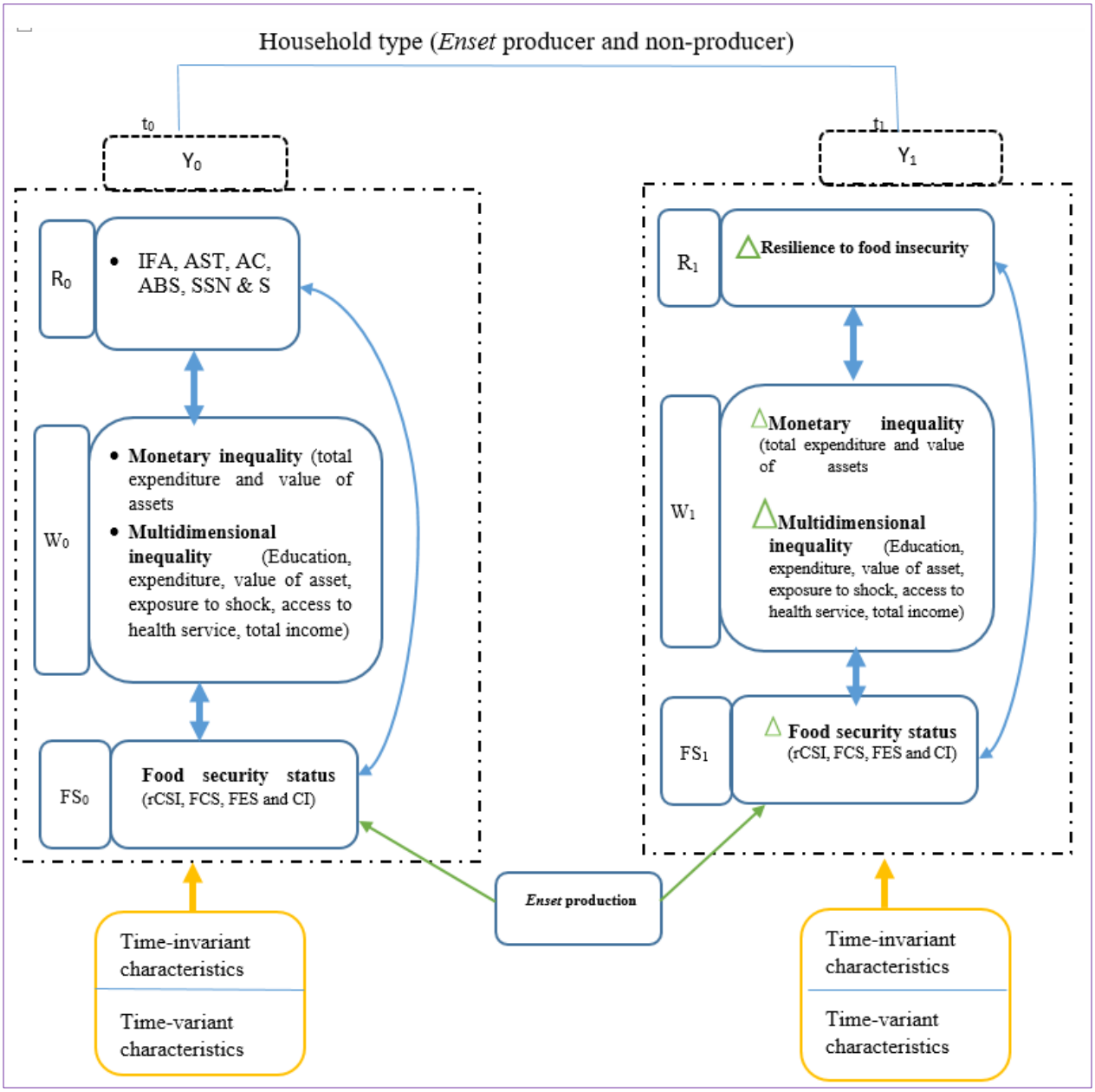

Figure 2.1: Conceptual framework of resilience and food security linkage over time

Source: Own drawing based on related literature, 2024

Key

- Yellow arrows indicate independent variables effect on outcome variables (resilience, welfare, food security) over time
- Blue arrows indicate the nexus between resilience, welfare, and food security over time
- Green arrow shows *Enset* production impact on food security over time

Where: △ shows change in; **t_0**=base year; **t_1**=2021/22 and 2023/24; **Y_0**=base outcome; **Y_1**= outcome for 2021/22 and 2023/24; **R_0** = base year resilience to food insecurity, **W_0** = base year welfare; **FS_0**= base year food security status; **R_1** = change in resilience to food insecurity, **W_1**= change in welfare; **FS_1**= change in food security status; **ABS**=access to basic services; **AST**=assets; **SSN**=social safety nets; **AC**=adaptive capacity; **S**=stability; **IFA**=income and food access; **rCSI**=reducing coping strategies index; **FCS**=food consumption index; **FES**=food expenditure share; **CI**=calorie intake

2.4. Descriptions of Variables and Measurements

Household income: within the context of this study, it is conceptually defined as the total amount of earnings and other monetary income gained from all household members capable of wellbeing and food security. This includes salaries, wages, benefits, rent, profit earned from farm products such as *Enset*, as well as other sources of income. With regards to both *Enset*-producing and non-producing households, it signifies the power for their needs and investments in growth opportunities. Household income is measured on household basis in the local currency, which is the Ethiopian Birr for Ethiopia. Usually, it is measured within a defined period, week, month, or year. Sometimes, this is, however, modified into a per capita basis, or into the equivalent income per adult, to capture the measure relevant in comparison (Chegini et al., 2021).

Household consumption: refers to the aggregate expenses incurred by a household on goods and services consumed, including food, clothing, housing, utilities, transportation, healthcare, education, etc. It also can incorporate expenses related to recreational and leisure activities. Household consumption plays an integral role in evaluating living conditions and can serve as an indicator of a household's economic well-being, contributing to food security and inequality assessments. In the context of both *Enset* producer and non-producer households in the Central Ethiopia region, it would entail expenditures related to the consumption of both *Enset* and other goods and services. Household consumption can be measured by totaling the monetary expenses incurred on consumption during a specific time. However, precision can be challenging due to the potential for underreporting or miser collection of expenses. Hence, consumption data may also be gathered by calculating the value of all goods used, including those produced at home (like *Enset*), those received in kind, and those purchased during a specific period. The commonly used units of consumption measurement are usually local currency units, such as Ethiopian Birr per week/month/year (Otaki, 2013).

Age of Household head: refers to the age of the person who is the primary decision-maker and provider for the household. It is an important demographic characteristic that can affect household income, education, health, and food security. Household head age can be measured in years (Eshetu & Guye, 2021).

Education level of household head: refers to the highest level of formal education attained by the household head or other household members. It is an important indicator of human capital and can

affect household income, health, and food security. Education level can be measured in Years of schooling completed (Bidisha et al., 2021).

Sex of household head: refers to the biological and physiological characteristics that define males and females. It is an important demographic characteristic that can affect household income, education, health, and food security. Sex can be measured as a binary variable, with two categories: Male and Female (Eshetu & Guye, 2021).

Asset: refers to the tangible and intangible resources owned by a household, such as land, livestock, savings, education, and social networks. It is an important indicator of household wealth and can affect household income, food security, and well-being (Quisumbing et al., 2015). Asset was measured by counting the household items and constricting the index using PCA.

Farm size: refers to the physical extent of land cultivated or managed by a farm. It is an important variable that can influence agricultural productivity, income, and food security. Farm size can have contrasting effects on farm incomes and food production, with output per unit of land potentially declining as farm size increases, while farmer income and consumption may increase (Noack & Larsen, 2019). Farm size was measured in hectares (ha) units Hectares (ha).

Household size: refers to the number of people living in a household. It is an important demographic characteristic that can affect household income, food security, and well-being. Household size can influence the amount of food needed, the availability of labor for farming, and the sharing of resources within the household (Zhou et al., 2019). Household size was measured as a count of the number of people living in a household.

Number of livestock: refers to the count of domesticated animals owned by a household, such as cattle, sheep, goats, pigs, and chickens. It is an important variable that can influence household income, food security, and nutrition. Livestock ownership can provide a source of income through the sale of animals or animal products, such as milk, meat, and eggs. Livestock can also be used for plowing fields, transportation, and as a form of savings (Mosites et al., 2016). The number of livestock was measured as a count of the number of animals owned by a household, for each type of animal (e.g., cattle, sheep, goats, pigs, and chickens) and converted to TLU.

Health insurance: refers to a system of protection against the financial risk of medical expenses. It is an important variable that can affect household welfare and food security by reducing the out-

of-pocket costs of healthcare and increasing access to medical services. Health insurance can be measured as a binary variable, with two categories: Insured and Uninsured (Hossain et al., 2020).

Saving: refers to the act of setting aside a portion of income or resources for future use or emergencies. It is an important variable that can impact household welfare and food security by providing a financial buffer and enabling households to meet their basic needs during times of economic uncertainty or shocks (Holleman & Conti, 2020). . Saving was measured in Ethiopian Birr the amount saved over a specific time (annually).

Market access: refers to the ability of households to participate in and benefit from markets, including the availability of transportation, infrastructure, and information necessary for engaging in economic activities. It is an important variable that can influence household welfare and food security by providing opportunities for income generation, trade, and access to a variety of goods and services (Usman & Callo-Concha, 2021). Market access was measured in Distance to markets by kilometers.

Employment: refers to the state of being employed or having a job. It is an important variable that can influence household income, food security, and well-being. Employment can provide a source of income and access to social benefits, such as health insurance and retirement savings. It can also affect the availability of time and resources for food production and consumption (Bidisha et al., 2021). Employment will be measured as a binary variable, with two categories: Employed or Unemployed.

Own mobile phone refers to the possession of a mobile phone by a household. It is an important variable that can affect household welfare and food security by providing access to information, communication, and market opportunities. Mobile phones can be used to access weather forecasts, market prices, and health information, as well as to communicate with family members, friends, and business partners (Bassa et al., 2024). Own mobile phone was measured as a binary variable, with two categories: Owns mobile phone or does not own mobile phone.

Social assistance programs are government or NGO programs that provide support to individuals and families in need. These programs can take many forms, including cash transfers, food assistance, and healthcare subsidies (T. A. Melketo, 2023). The units of measurement were the amount of cash in ETB received by the household or the frequency of cash disbursement.

Types of farmers: in this study refers to households that either produce or do not produce *Enset*, a key staple food crop in the region. *Enset* is an important crop for about 20% of the Ethiopian population, particularly in the southern and southwestern parts of the country (Wondimu & Kebede, 2022). The units of measurement for the variable types of farmers could be binary, with households categorized as either *Enset* producers or non-producers.

***Enset* production quantity:** refers to the amount of *Enset* harvested or grown by farmers within a specific timeframe. This could be measured in terms of Hectares (ha), a unit that captures the size of the area dedicated to *Enset* farming, signifying it as a continuous independent variable. Assessed in kilograms, it estimates the quantity of *Enset* cultivated. In the case of SNNP, it is anticipated to produce roughly 10 tons of *Enset* per hectare (Shank, R., & Ertiro, C., 1996).

Table 2.1: Description and measurement of variables

Variables	Types of variables	Description and units of measurement of the variable
Outcome variables		
Welfare	Continuous	Measured in income/expenditure in ETB
Food Security Level	Dummy	Measured using CARI (CS+CC)
Resilience to food insecurity	Composite index	Measured in ABS, AST, IFA, AC, SSN and STB
Household head characteristics		
Sex	Dummy	takes the value of 1 if the household head is male and 0 if female
Age	Discrete	Measures the age of the head of the household
Marital Status	Categorical	Will be Categorized as married and unmarried
Religion	categorical	Will be categorized based on household's religion
Migration status	Dummy	takes the value of 1 if the household head is an immigrant and 0 otherwise
Education level	Discrete	Year of schooling
Employment	Dummy	It takes a value of 1 if the HH is employed for the last 12 months and 0 if not
Type of Farmer	Categorical	takes a value of 1 if the HH is an *Enset* producer and 0 if not
Household size	count	number of household members
Socio-Economic		
Asset	Continuous	Number of assets that the household has Valued in Financial form (ETB)
Own Mobile phone	Dummy	It takes a value of 1 if the HH has its mobile phone and 0 if not. It has a positive effect on welfare inequality
HH Farm Size	Continuous	Measured in Hector
Number of livestock	Continuous	Refers to the total number of livestock owned by the household in TLU
HH income	Continuous	Measured in Ethiopian Birr (currency of Ethiopia). This would be the total yearly income of all earners in the household.
HH Consumption	Continuous	Measured in Ethiopian Birr The amount of expenditure by household
Enset Production Quantity	Continuous	Amount of *Enset* crop produced by the household measured in area coverage (measured in number of *Enset* per hectare).
Institutional and policy factors		
Health insurance	Categorical	takes the value of 1 if the HH has access to health insurance service and 0 if not
Saving	Dummy	takes a value of 1 if the HH saves money and 0 if not
Access to credit	Dummy	takes a value of 1 if the HH has access and 0 if not
Access to Agricultural Input	Ordinal	Quantified by assessing access to tools, seeds, fertilizers, etc. This can be scored on an ordinal scale (from 1 to 5).
Market Access	Ordinal	A score for how easily farmers can sell their products and purchase necessary goods, perhaps on a scale from 1 (very difficult) to 5 (very easy).

2.5. Dissertation Contribution

This thesis makes several key contributions, as summarized in Table 2.2. These contributions provide valuable insights into the research topic and its implications.

Table 2.2: Dissertation Contributions

Chapter	Research gap	Contribution
3. The intertemporal dynamics of welfare in the Expenditure & Asset Approach	• Insufficient exploration of welfare beyond income, neglecting assets and expenditure. • Few studies compare welfare inequality between *Enset* producers and non-producers • Limited longitudinal analysis to capture intertemporal changes. • Insufficient use of detailed and sensitive methodologies for analyzing welfare inequality	• Introduce an asset and expenditure-based conceptual framework for analyzing welfare inequality. • Provide empirical insights into the temporal trends of welfare inequality among *Enset* producers and non-producers. • Advanced methods for measuring welfare inequality measurement across different population segments. • Recommend strategies for policymakers to address welfare inequality by identifying key determinants in two groups
4. The intertemporal dynamics of welfare inequality: A Multidimensional approach	• Limited research on welfare inequality beyond income, neglecting health, education, exposure to shock, and asset • Lack of intertemporal dynamic studies capturing multidimensional inequality over time. • Lack of studies comparing multidimensional inequality between *Enset-producing* and non-producing. • Insufficient use of detailed tools like multidimensional indices and fixed-effect models for measuring inequality	• Develops a multidimensional framework to analyze welfare inequality. • Provides evidence on dynamics of multidimensional inequality from 2018/19 to 2023/2024. • Utilizes advanced tools like multidimensional inequality indices, fixed-effect models, and factor analysis for precise assessments • Recommends strategies for policymakers to promote *Enset* farming, improve credit access, and address specific welfare determinants
5. Food Insecurity and Coping strategies of *enset*-producing & non-producing households : using a CARI	• Previous studies have not adequately compared food security outcomes between *Enset*-producing and non-producing households using multidimensional indicators • Limited use of CARI framework • Insufficient focus on coping strategies	• Integrates The CARI framework to advance the conceptual understanding of food security in all its multidimensional perspectives and coping strategies. • Give Evidence on disparities in food insecurity and coping mechanisms across *Enset*-producing and non-producing households. • The adoption of a mixed-method approach, application of the CARI framework, and estimation by an ordered logit model enrich the food security analytical literature. • It avails the necessary insight into promoting *Enset* cultivation and targeted intervention in agricultural extension services and social safety nets for better food security and resilience.
6. Exploring the impact of *Enset*	• Lacking longitudinal insights into trends and casual relationships	• Identifies *Enset* as a multifunctional crop that boosts calorie intake reduces food insecurity,

(*ensete ventricosum*) production on household food security	between *Enset* production and food security. • Earlier research focused on small study areas, missing broader regional dynamics of the issue • Previous studies employed simpler methods like PSM, which did not adequately address endogeneity and self-selection bias. • Prior studies overlooked key variables such as gender, education, and asset value, limiting understanding of their impact on *Enset* production and food security.	and enhances socioeconomic resilience in central Ethiopia. • Provide empirical insights into using panel data to show that *Enset* production raises household calorie intake by 35.2%. • It introduces the ESR model to analyze the causal impacts of *Enset* production on food security while addressing self-selection bias and endogeneity. • Identifies Significant variables and their implication for policy
7. Dynamics of Resilience to Food Insecurity	• Limited longitudinal (dynamic) analysis of resilience to food insecurity in Enset farming systems • Limited use of , multidimensional analytical models to estimate resilience capacity	• This study employs panel data across three survey waves • This study applies the Multiple Indicators Multiple Causes (MIMIC) model
8. Nexus of Welfare, Food Security & Resilience	• Limited research examines the interdependent dynamics among welfare, food security, and resilience. • Temporal gap to capture the evolving relationships between welfare, food security, and resilience overtime • Underexplored of the role of *Enset* in the nexus of the three variables. • Previous studies lacked robust models to address endogenity and simultaneity, requiring advanced approaches like 3SLS.	• Enhances understanding of the interplay between, welfare, food security, and resilience using a framework. • Provides comparative evidence on *Enset*'s role in improving food security, resilience, and welare. • Applies 3SLS model to address endogenity and integrates quantitative and qualitative data for a deeper analysis of household dynamics. • Policy Contribution: Supports the encouragement of *Enset* farming, together with tailored intervention-for instance, asset-building for producers and education for non-producers-to raise welfare and resilience.

CHAPTER 3: INTERTEMPORAL DYNAMICS AND DETERMINANTS OF WELFARE INEQUALITY AMONG *ENSET*-PRODUCING AND NON-PRODUCING HOUSEHOLDS IN CENTRAL ETHIOPIA: INSIGHTS FROM PANEL DATA

Abstract

Reducing inequality is a critical sustainable development goal (SDG), yet welfare inequality remains a persistent challenge for development and food security in developing countries. This study investigates the dynamics and determinants of welfare inequality among Enset-producing and non-producing households in Central Ethiopia from 2019--2024. Using panel data from 270 households across three waves (2018/19, 2021/22, 2023/24), the study employs descriptive statistics, factor analysis, the Atkinson index, and quantile regression models to analyze trends in welfare (asset and expenditure) inequality. The findings reveal that non-producer households consistently exhibited greater asset inequality, with the Atkinson index rising from 0.356 in 2019 to 0.781 in 2024, compared with an increase from 0.262 to 0.582 among producers. However, expenditure inequality for non-producers has steadily increased and fluctuations for producers over time. The determinants of inequality vary across groups and quantiles. For non-producers, education, sex, household size, age, credit access, income, and shocks significantly influence expenditure inequality. Among producers, factors such as education, remittances, land size, credit access, income, and shocks play pivotal roles. Asset inequality was similarly influenced by education, marital status, remittances, shocks, and land size, particularly in higher quantiles. These results highlight the heterogeneous effects of socioeconomic characteristics on welfare inequality, underscoring the need for targeted policies. Interventions should focus on improving education, credit access, and income opportunities; supporting shock-affected households; and promoting equitable land distribution and effective use of remittances to reduce growing inequalities in diverse household contexts.

***Keywords**: Atkinson index, inequality, quantile regression, welfare*

3.1.Introduction

Reducing inequality remains a global priority, emphasized in Sustainable Development Goals (SDGs) number 10, as disparities in welfare[4] directly undermine inclusive development and food security efforts. Across the globe, welfare inequality manifests through unequal access to income, resources, and essential services, often exacerbating poverty and reducing opportunities for vulnerable populations (World Bank, 2022a). In sub-Saharan Africa, inequality is particularly pronounced, with agricultural dependency, limited access to technology, and climate vulnerabilities exacerbating disparities in rural communities (FAO, 2017). Ethiopia, like many developing nations, grapples with stark welfare disparities despite recent economic growth, and

[4] The concept of welfare refers to the well-being or utility of individuals or groups in a society. Welfare can be influenced by various factors, such as income, consumption, health, education, and happiness (Deaton, 1980).

understanding the factors driving these inequalities is critical to devising effective interventions (World Bank, 2020c).

Agriculture is the cornerstone of rural livelihoods in Ethiopia and directly impacts welfare outcomes. However, the type of agricultural practices employed varies, influencing household welfare and regional disparities. *Enset (Ensete ventricosum)*[5], a drought-resistant perennial crop, acknowledged as an important driver of food security and economic stability in Central Ethiopia (Blomme et al., 2023b). Households producing *Enset* often experience greater stability in terms of food security and income than non-producers do because of the adaptability and nutritional value of *Enset* (Bonso et al., 2022). However, few empirical studies have explored how *Enset* production influences welfare inequality over time.

Ethiopia's policy frameworks, including the Growth and Transformation Plans (GTP I and II), Food Security Strategy (2002), and the Productive Safety Net Programme (2005–present), have aimed to reduce welfare disparities through targeted agricultural and social protection programmes. These initiatives recognize the importance of equitable resource distribution and agricultural development in addressing inequality. However, disparities persist in access to education, health, and productive resources, disproportionately affecting rural households (Debebe & Zekarias, 2020).

Although welfare inequality in Ethiopia has been studied, the literature has notable gaps. Many studies rely on cross-sectional data (Argaw & Desta, 2022; Z. Berhane, 2015; Berhanu et al., 2024; Debebe & Zekarias, 2020; Hailu & Nagaraja, 2017; Kasaye et al., 2019; Teka et al., 2022; Teshome et al., 2021; Thiede, 2014), limiting their ability to capture the intertemporal dynamics of welfare inequality (Argaw & Desta, 2022; Teshome et al., 2021). Additionally, a predominant focus on income as the sole welfare indicator overlooks broader dimensions such as household assets and expenditures, which provides a more understanding of well-being (Haughton & Khandker, 2009). Conventional measures, such as the Gini coefficient, often fail to capture disparities among lower-

[5] *Enset*, scientifically known as *Ensete ventricosum*, is a large perennial herbaceous plant native to Ethiopia, often referred to as the "false banana" or "Ethiopian banana." Despite its tree-like appearance, it is not a tree but rather a giant herb that can grow up to 10 meters tall with leaves reaching lengths of up to 5 meters (Borrell et al., 2020).

income groups, necessitating more nuanced approaches such as the Atkinson index, which is sensitive to changes in welfare among the poor (Mulamba, 2022).

Moreover, understanding the determinants of welfare inequality is pivotal for addressing socioeconomic disparities and achieving sustainable development goals. Welfare inequality is shaped by a range of factors, including income, education, employment, and geographical location. For example, income disparities influence access to essential services such as food, healthcare, and education, while employment stability and education level are strongly correlated with improved welfare outcomes. Geographic location also plays a significant role, with rural and urban households facing distinct challenges related to food access and affordability (Dula et al., 2023). Additionally, factors such as social protection programs, gender, ethnicity, and access to resources such as land and credit further exacerbate or mitigate welfare disparities (Gundersen & Ziliak, 2015). Previous studies have explored these determinants globally and in Ethiopia, focusing primarily on determinants of income inequality (Belay, 2022a). However, few studies have investigated welfare inequality via broader indicators such as household expenditures and assets, particularly through a comparative approach. This study aims to address these gaps by examining the dynamics and determinants of welfare inequality among *Enset-producing* and nonproducing households in Central Ethiopia. Using panel data, the study explores intertemporal changes in welfare inequality, incorporating household expenditures, assets, and income as key indicators. By comparing *Enset-producing* and nonproducing households, this research seeks to highlight the role of *Enset-production* practices in shaping welfare disparities and to provide evidence-based insights for policymakers. In doing so, it contributes to a deeper understanding of the socioeconomic dimensions of inequality and offers a foundation for targeted interventions aimed at promoting equitable development.

3.2.Conceptual framework

The analytical framework presents a coherent structure for addressing examining the determinants of welfare inequality among *Enset-producing* and nonproducing households in Central Ethiopia through a monetary lens, utilizing panel data (Figure 3.1).

Monetary inequality refers to changes in monetary measures, such as total expenditure and the number of household assets/properties, assessed at time point's t_0 and t_1. The initial monetary variables (Y_0) and baseline monetary status (W_0) are critical in understanding future changes in

monetary inequality (Belay, 2022a). Distinguishing between *Enset*-producing and nonproducing households is essential, as *Enset* production—a significant crop in the central Ethiopian region—affects economic activities, resource allocation, and ultimately welfare inequality status (Blomme, 2023). Welfare inequality status reflects changes in welfare inequality, which is influenced by monetary inequality and measures differences in total expenditures and the number of assets among households (Alem & Söderbom, 2012). Time-invariant characteristics (e.g., geographical location, cultural practices) remain constant, whereas time-variant characteristics (e.g., demographic, institutional, and socioeconomic characteristics) change over time and affect welfare dynamics.

The framework outlines a pathway from initial monetary inequality at t_0, through the differentiation between producers and non-producers, to changes in monetary inequality at t_1. These changes impact welfare inequality status, considering both time-invariant and time-variant characteristics. The distinction between producers and non-producers is pivotal, as it affects resource management and utilization and thereby economic outcomes and welfare status over time.

The impact of *Enset* production is significant, potentially providing a stable food source and income and influencing total expenditure and asset accumulation. *Enset* producers may experience different economic stability and growth levels than non-producers do, affecting overall welfare inequality status. By focusing on monetary variables, this study quantifies economic disparities and their effects on welfare inequality, with panel data offering a dynamic view of households' economic conditions and welfare inequality evolution over time. Understanding these determinants can inform targeted policies to reduce economic disparities, support *Enset* production, improve resource allocation, or provide financial assistance to non-producing households. Analyzing both time-invariant and time-variant characteristics helps understand the persistent and changing factors contributing to economic and welfare disparities.

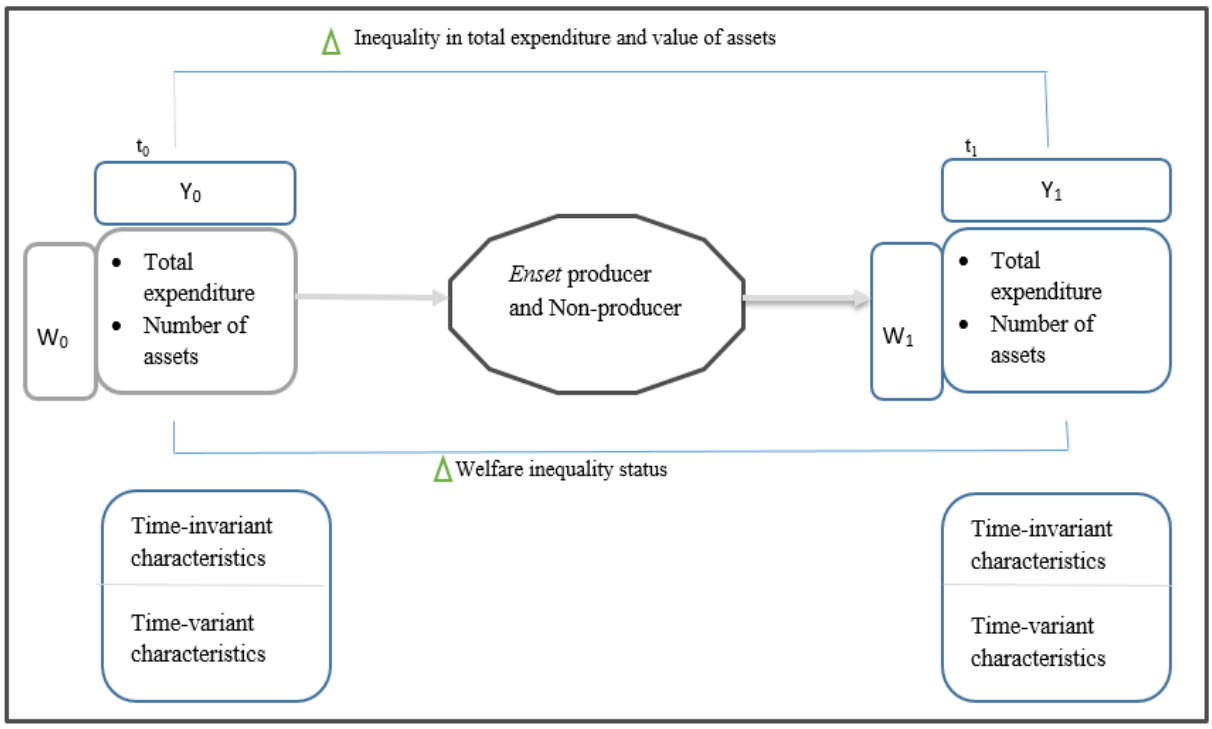

Figure 3.1: Conceptual framework of the dynamics and determinants of welfare inequality
Source: Authors' drawing on related literature (D. Haile et al., 2021) FAO (2016)

3.3. Materials and Methods

3.3.1. Methods of Data Analysis

Data analysis for this study was conducted via Stata version 17, following a thorough process of data cleaning and merging to ensure consistency and accuracy. A combination of descriptive statistics and econometric models was employed to extract meaningful insights from the dataset. Descriptive statistics, including measures such as the means, percentages, standard deviations, and indices, were used to summarize and present the key characteristics of the data. These measures provide a concise overview of central tendencies, variations, and distributions, facilitating an understanding of the dataset (Gujarati & Porter, 2003).

To estimate the determinants of welfare inequality, quantile regression was employed as a primary econometric tool. This method offered significant advantages, including the ability to analyze the entire distribution of welfare outcomes, robustness to outliers, and enhanced insights into how socioeconomic factors impact different population segments. By focusing on specific quantiles, this approach supported a nuanced understanding of disparities and informed targeted policy interventions to foster equitable welfare outcomes (Koenker, 2004)(Koenker, 2020). Additionally,

the Atkinson indices were applied to quantify inequality in household welfare, focusing on dimensions such as total expenditure and asset ownership. These indices serve as crucial metrics for evaluating the extent and nature of welfare disparities, enriching the analysis of inequality in the study population (Atkinson, 1970).

3.3.1.1. Measurement of Inequality in Welfare

This study examined the evolution of welfare inequality over time by analyzing household expenditure[6] data from Ethiopian Birr (ETB). By utilizing data from two waves of the ESS (2018/19 and 2021/22) along with an additional 2023/24 primary dataset, this research provides a detailed view of how welfare inequality has developed and varied across different periods. This approach offers understanding of the temporal changes in inequality. To assess these dynamics, the Atkinson index was employed as an alternative to the traditional Gini coefficient. The Atkinson Index, introduced in 1970 by British economist Anthony B. Atkinson focuses on overall well-being and emphasizes prioritizing the needs of the most vulnerable individuals over the average income, aiming for a more equitable distribution of resources (Afonso & Cabrita, 2015).

The Atkinson index is a measure of inequality that is based on the concept of social welfare. It reflects the trade-off between efficiency and equity in a society by incorporating a parameter that represents the degree of aversion to inequality. The higher the parameter is, the greater the weight given to the welfare of the poorer households (Oancea & Pirjol, 2019). The Theil index and the Gini coefficient are measures of inequality that are based on the concepts of information theory and relative mean difference, respectively. They do not explicitly account for the social welfare implications of inequality, nor do they allow for varying degrees of aversion to inequality. They are also less sensitive to changes in the lower tail of the distribution, where most of the *Enset* producer households are likely to be located (Park et al., 2021). Therefore, the Atkinson index may be more suitable for analyzing inequality in welfare and food security among *Enset* producer and nonproducer households in Central Ethiopia: A comparative study, as it can capture social welfare losses due to inequality and reflect different preferences for redistribution. The Atkinson index can also be decomposed into within- and between-group components, similar to the Theil index, which

[6] Total household expenditure refers to the total value of consumption expenditures made by households, encompassing both purchased goods and services as well as those produced and consumed within the household.

can provide more insights into the sources and patterns of inequality across different groups and regions.

The Atkinson index is a prominent instrument utilized to evaluate income inequality across diverse socio-demographic parameters and has potential value in assessing inequality in the welfare of household assets[7] among *Enset* producer and non-producer households in Central Ethiopia.

The Atkinson Index (A), Atkinson AB. (1970), is calculated via the following formula:

$$A = 1 - [\left(\frac{1}{n}\right) * \sum((\frac{yi}{\mu})^{1-\varepsilon})]\hat{}(\frac{1}{1} - \varepsilon)\ ) \quad (3.1)$$

Where 'yi' refers to expenditures or the number of assets indicator, 'n' is the total number of observations, 'μ' is the mean welfare (expenditure or number of assets), and 'ε' is the inequality aversion parameter. The inequality aversion parameter is important because it reflects the weight given to different parts of the distribution (Atkinson, 1970). A high value of ε implies more weight given to the lower end of the distribution and a higher level of inequality aversion. To apply the Atkinson formula to welfare or food security indicators among *Enset*-producing and nonproducing households, the collection of relevant data is key. This might include income levels, access to food, and level of food security, among others. Once data are collected, they are sorted in ascending order of wealth/food security measures. The above formula is subsequently used to calculate the Atkinson index. The resulting number lies in the range between 0 (perfect equality) and 1 (maximum inequality) (Kakwani, 1977).

3.3.1.2. Estimation of the determinants of inequality in welfare

The Ordinary Least Squares (OLS) regression technique operates under the assumption that the impact of explanatory variables remains consistent across the entire conditional distribution of the dependent variable. For instance, it presumes that the influence of education on household welfare is uniform across both the lower and upper ends of the welfare spectrum. However, if these impacts differ across various points of the welfare distribution, quantile regression offers a more efficient approach by modeling different percentiles, thereby providing a view of the distribution.

[7] Household assets refer to the total value of owned resources and properties held by individuals or members of a household, including cash, house, and personal belongings. These assets are calculated by subtracting household liabilities from the total value of the assets, providing a measure of the household's net worth

Given a set of explanatory variables, the condition mean of the consumption expenditure and asset value is estimated using the ordinary least square (OLS) approach in linear regression. The regression's calculated coefficients show the average change in the pertinent explanatory variables. At different points along the spending distribution, poverty determinants are assessed using the quantile regression model (Koenker & Hallock, 2001). It has the advantage of allowing for parameter change between quantiles of the consumption expenditure distribution. Since the estimated coefficients of quantile regression are less vulnerable to outliers of the dependent variable than OLS, the quantile estimator is a robust approach that outperforms linear regression when errors are not regularly distributed (Saad et al., 2023).

The specification of the quantile regression is as follows:

$$\boldsymbol{Q}_{\boldsymbol{\tau}}\left(\frac{\boldsymbol{Yi,t}}{\boldsymbol{X}_{i,t}}\right) = \boldsymbol{\alpha}\tau + \boldsymbol{x}_{\boldsymbol{i}}\beta_{\tau}\,\gamma i + \varepsilon i, t, \tau \qquad (3.2)$$

where Y i, t represents either total expenditure or the number of assets in the household; X i,t represents a vector of explanatory variables, including education level, sex of the head, age of the head, marital status, receiving remittance, access to credit, access to health insurance, employed in the GO, exposure to shock, household size, total income, total annual consumption, land size, and TLU; τ represents the conditional quantile of interest; α_τ and β_τ are the quintile-specific intercept and coefficient parameters, respectively; and $\varepsilon i, t, \tau$ is the error term.

The researchers also used OLS regression with one-way fixed effect models to control for unobserved time-invariant heterogeneity and to account for both household and time fixed effects. With the

$$Exp. = \alpha + \beta 1Xi, t + \beta 2Xi, t + \beta 3Xi, t + \cdots + \beta ni, t + \varepsilon it \qquad (3.3)$$

Where expenditure is the dependent variable for household i in year t, α is the intercept, β1 to βn are the coefficients of our independent variables and $\varepsilon_{i,t}$ is the error term.

$$Number\ of\ assets. = \alpha + \beta 1Xi, t + \beta 2Xi, t + \beta 3Xi, t + \cdots + \beta ni, t \qquad (3.4)$$

Where the number of assets is the dependent variable for household i in year t, α is the intercept, β1 to βn are the coefficients of our independent variables and $\varepsilon_{i,t}$ is the error term.

3.3.1.3. Approaches to Household Welfare Measurement

This study utilized two approaches—consumption expenditure and asset ownership—to measure household welfare. This dual methodology is supported by the literature highlighting the importance of diverse indicators for accurately assessing welfare levels (Blundell et al., 1994; Cao et al., 2023; Hussen & Mohamed, 2023; Lanjouw & Hentschel, 1999; Terefe et al., 2024). Research indicates that while consumption expenditure provides insights into immediate economic well-being, asset ownership reflects long-term stability and the resources available to households. By using these measures, this study aims to offer a more understanding of household welfare dynamics.

Consumption Expenditure: This approach considers total household consumption expenditure as a proxy for welfare. Consumption data capture a household's ability to meet basic needs and sustain a certain living standard. By aggregating expenditures on food, housing, education, health, and other essentials, this measure reflects both income levels and consumption behavior. It provides a dynamic perspective of welfare, responsive to short-term economic changes and shocks (Deaton & Muellbauer, 1980).

Asset: Asset-based welfare measurement evaluates household welfare by assessing accumulated wealth, including land, livestock, durable goods, and housing quality, to capture stability and resilience to economic fluctuations (M. R. Carter & Barrett, 2006a). This approach complements consumption expenditure by offering a broader view of welfare and addressing structural inequalities in wealth distribution. Factor analysis (FA), a statistical method for identifying latent constructs underlying observed variables, is often employed to construct asset indices. By modeling observed variables as linear combinations of latent factors and error terms, FA enables researchers to quantify relationships and patterns in data, enhancing the understanding of complex socioeconomic phenomena (Vollmer & Alkire, 2020). The mathematical representation of this relationship can be expressed as

$$\mathrm{Ai} = \mathrm{b1} \cdot \mathrm{a1i} + \mathrm{b2} \cdot \mathrm{a2i} + \cdots + \mathrm{bk} \cdot \mathrm{aki} \quad (5)$$

Where A_i is the household i's asset index, a_{ji} are asset value indicators, and b_j are the factor loadings derived from the factor analysis. Each observed variable is thus modeled as a combination of common factors plus an error term, allowing researchers to identify and quantify the underlying constructs that explain the correlations among observed data

3.4. Findings and Discussion

3.4.1. Household characteristics over time

Table 3.1 provides a detailed comparison of socioeconomic and agricultural variables for *Enset-producing* and nonproducing households over three periods (2018/19, 2021/22, and 2023/24). These results highlight the differences in household characteristics, resource access, and welfare outcomes, offering insights into the dynamics of *Enset* farming's contribution to rural livelihoods.

The mean age of household heads remains relatively stable across the three periods, ranging between 42 and 45 years for both producers and non-producers. This reflects the persistence of agriculture as a primary livelihood among middle-aged populations, which is consistent with the findings of (Dercon & Hill, 2009), who reported that middle-aged farmers are often more experienced and likely to remain engaged in farming activities in rural Ethiopia than younger age group. *Compared with non-producers, Enset-producing* households consistently exhibit larger household sizes (mean ~5.11–5.52) (~4.14–4.52), with the difference being statistically significant ($p < 0.05$). Larger household sizes may be indicative of the labor-intensive nature of *Enset* farming, which requires more family members to contribute labor. This aligns with the findings of (Bonso et al., 2022), who emphasized that household labor availability significantly influences agricultural productivity in Ethiopia. The education levels of household heads are slightly higher among producers (mean ~9 years) than among non-producers (mean ~7–8 years), although these differences are not statistically significant.

Enset producers consistently report higher total consumption and income levels than non-producers. In 2023/24, the differences in both consumption and income are statistically significant ($p < 0.05$). This demonstrates the role of *Enset* farming in enhancing household welfare, supporting findings by (Borrell et al., 2020), who noted that *Enset* production contributes to both food security and income diversification in Ethiopia. Non-producers, with lower consumption and income, may face greater vulnerabilities to food insecurity and poverty. Producers score significantly higher on the infrastructure index, which measures access to essential services such as electricity, piped water, and transportation. These differences ($p < 0.05$) highlight the enabling role of infrastructure in enhancing agricultural productivity and rural welfare, as supported by (Barrett et al., 2010), who found strong links between infrastructure development and agricultural growth in developing countries. The distances to schools and markets differ minimally between producers and non-

producers, reflecting the broader national challenges of limited rural infrastructure development. This finding aligns with that of (World Bank, 2019), which highlighted Ethiopia's need for improved rural connectivity to increase access to education and markets.

Producers present significantly higher agricultural asset indices ($p < 0.05$), reflecting better access to critical inputs such as tools and irrigation facilities. This finding supports the notion that *Enset* farming is resource-intensive, requiring adequate tools and inputs to maximize productivity (Tolola, 2023). Non-producers, with limited agricultural assets, may face barriers to improving their productivity and resilience. Producers consistently show higher wealth levels and livestock ownership, with the differences being statistically significant in some periods. Wealth and livestock are critical indicators of rural household resilience, as livestock often serve as both an income source and a buffer against shocks (Acosta et al., 2021). Higher wealth levels among producers suggest the economic benefits of *Enset* farming. Land size is significantly larger among producers than non-producers ($p < 0.05$), which is consistent with findings from (FAO, 2019), which emphasized the importance of landholding size in determining rural welfare. Larger landholdings enable producers to cultivate *Enset* at scale, enhancing food security and income opportunities.

The household size among *Enset* producers (~5.5) exceeds the African average (~4.9) reported by the (UN, 2021). The infrastructure disparities among non-producers reflect patterns observed in other low-income countries (World Bank, 2019), underscoring the need for targeted interventions. The findings underscore the multifaceted benefits of *Enset* production for household welfare, food security, and resilience. However, the significant disparities between producers and non-producers highlight the need for targeted policies to bridge these gaps. Investments in infrastructure, agricultural inputs, and education for non-producers could reduce inequalities and promote inclusive rural development, aligning with Ethiopia's national development goals (Ethiopian Ministry of Agriculture, 2020).

In addition, the summary statistics of the dummy variable (in percentages) results reveal notable differences in several socioeconomic characteristics, with some showing statistical significance, shedding light on the role of energy production in rural livelihoods.

The proportion of male-headed households is consistently greater among *Enset* producers (80.15% to 80.88%) than among non-producers (56.25% to 58.33%), with a statistically significant difference ($p<0.01$). This pattern aligns with studies on rural Ethiopia, which highlight male dominance in agricultural decision-making (Mulatu, 2020b). Similarly, marital status also shows significant differences ($p<0.01$), with a greater proportion of married household heads among producers (77.45% to 81.89%) than among non-producers (63.83% to 65.96%). Marriage often signifies increased household labor availability, which benefits agricultural productivity (Lam et al., 2012; Tolola, 2023). The percentage of households receiving remittances is generally low across both groups, with no significant differences observed. This indicates a limited reliance on external income sources, a trend noted in rural Ethiopian households (Mihrete & Eshete, 2019). In terms of access to health services, producers consistently report slightly higher levels of access than non-producers do, but the differences are statistically insignificant.

Income diversification is more prevalent among *Enset* producers (75.56% to 76.56%) than among non-producers (56.5% to 59.5%), although the difference is not statistically significant. Diversified income streams are vital for mitigating risks and reducing vulnerability in rural settings, as noted previously (Sirany et al., 2022). Similarly, access to credit services is marginally greater among producers (56.3% to 50.92%) than among non-producers (54.23% to 41.3%), although the difference is not significant. Limited credit access due to infrastructural and institutional barriers remains a common challenge in Ethiopia (Ethiopian Ministry of Agriculture, 2020).

A significant finding is related to food security shocks, where *Enset* producers consistently report lower exposure (2.21% to 1.74%) than non-producers do (4.17% to 7.45%), with highly significant differences ($p<0.01$). This underscores the critical role of *Enset* as a drought-resilient crop that is crucial for ensuring food security during crises (Gebre et al., 2022). Losses from livestock and crops are minimal for both groups, showing no significant differences, a trend consistent with findings on climate-resilient agricultural systems (FAO, 2019). Finally, exposure to other shocks is significantly lower for *Enset* producers (11.5% to 15.25%) than for non-producers (12.5% to 38%), particularly in 2023–24 ($p<0.01$). This highlights the stabilizing effect of *Enset* production under socioeconomic and environmental adversities, reinforcing its role in building household resilience.

Table 3.1: Summary statistics of the variables over time

	2018/19		2021/22		2023/24		
Description of continuous Variables	Producer M (S. D.)	Non-Producer M (S. D.)	Producer M (S. D.)	Non-Producer M (S. D.)	Producer M (S. D.)	Non-Producer M (S. D.)	t- test/X^2
Age of HH head	42.838 (13.818)	42.85 (15.91)	45.53 (13.64)	45.21 (15.22)	43.05 (14.22)	43.12 (16.23)	-0.083
Household size	5.11(2.32)	4.14(2.72)	5.52(2.35)	4.41(2.64)	5.52(2.35)	4.52 (2.82)	-2.320**
Education level of HH head (year)	9.23(2.47)	7(5.72)	9.89(4.85)	8.44(8.39)	9.92(2.47)	9.81(5.72)	1.974
Total consumption (ETB)	62781.76 (51739.54)	43613.78 (4836.42)	75914.2 (8315.67)	44391 (11665.8)	78547.96 (5209.12)	43879.81 (48363.42)	-2.203**
Total income (ETB)	64466.13 (674.63)	45715 (843.71)	78648.65 (2525.37)	45577.3 (4210.83)	73951.35 (2674.03)	68042.21 (1843.71)	-2.212**
Infrastructure Index (toilet, electricity, home condition, piped water, car, motors cycle access)	0.213(0.012)	-0.102(0.23)	0.283(0.231)	-0.182(0.423)	0.267(0.241)	-0.202(0.03)	0.256**
Distance to school (in km)	6.51(5.56)	6.95(5.56)	6.5(5.56)	6.5(5.96)	6.5(5.56)	6.96(5.906)	5.68
Distance to market (in km)	3.71(6.75)	3.45 (5.56)	3.71(6.75)	6.5(5.96)	3.71(6.75)	6.96(5.906)	5.68
Agricultural asset index (agricultural tools, access to irrigation)	0.26 (0.425)	0.012(0.23)	0.32 (0.83)	0.12(0.45)	0.551 (0.45)	0.193(0.522)	0.241**
Wealth index (home all tools)	0.592(0.984)	0.116 (0.95)	0.792(1.58)	0.252(2.19)	0.653(0.256)	0.184(0.971)	-2.527***
Livestock (TLU unit)	3.36(2.12)	3.34(2.24)	3.06(0.22)	3.14(0.34)	0.31 (0.232	0.28 (0.257)	2.012**
Land size (ha)	0.998(0.349)	0.854(0.59)	0.932(0.459)	0.12(0.245)	0.923(0.47)	0.897(0.54)	0.231**
Description of dummy variables (in percentage)							
Sex of HH head (Male)	80.15	56.25	80.74	58.33	80.88	56.25	11.319**
Marital status (married)	77.45	63.83	81.89	65.96	81.89	65.96	13.967**
Receiving remittance (yes)	0.75	4.26	3.01	2.08	0.74	4.9	2.684
Health service (yes)	23.53	18.75	27.21	10.42	22.79	13	0.341
Income diversification (yes)	75.56	55.6	76.42	58.3	76.56	59.5	24.23
Access to credit service (yes)	56.3	54.23	58.3	47.3	59.02	41.3	4.5
Access to mobile phone (yes)	62.3	64.3	63.6	62.5	69.7	59.3	4.51
Livestock loss (yes)	0.06	0.04	0.712	0.019	0.026	0.12	0.123
Crop loss (yes)	1.6	1.85	1.76	1.89	1.76	2.1	0.23
Exposed to food security shock (yes)	2.21	4.17	0.75	8.33	1.74	7.45	66.331***
Other shocks (yes)	11.5	13	22.5	34	15.25	38	4.22**

Standard deviation in parentheses, *** p<0.01, ** p<0.05, * p<0.01

3.4.2. Asset dynamics among *Enset-producing* and non-producing households

The researcher used a two-stage factor analysis to estimate the household asset index. In the first stage, factor analysis was used to estimate the other agricultural and household asset indices (Appendix 8 from Table 8.2b – Table 8.5e). In the second stage, these indices were combined to compute the total asset index (Table 3.2). The factor analysis results in Table 3.2 further highlight the distinct asset ownership patterns between *Enset* producers and non-producers. For the *Enset*

producers, a single factor explained 93% of the variance in asset ownership. The agricultural asset index had a strong factor loading (0.796) and low uniqueness (0.366), emphasizing the significant role of farm assets in the welfare of producers. Similarly, the household asset index showed moderate loading (0.682) and uniqueness (0.536), reinforcing the importance of non-agricultural assets in producers' overall asset profiles. In contrast, for non-producers, a single factor explained 94% of the variance in assets. Both the agricultural asset index (loading: 0.642, uniqueness: 0.588) and the household asset index (loading: 0.612, uniqueness: 0.625) demonstrated slightly lower factor loadings and greater uniqueness than did producers. This indicates a less cohesive asset structure among non-producers, potentially reflecting greater heterogeneity in their asset ownership.

The summary statistics of the total asset index for *Enset-producing* and non-producing households over three time periods (2019, 2022, and 2024) indicate a consistent disparity in asset ownership between the two groups, with producers having a higher mean asset index across all years. In 2019, producers recorded a mean (M) of 0.52 (SD = 5.21), whereas non-producers had a mean of 0.25 (SD = 2.55). This gap persists in 2022 and 2024, with producers' mean asset index increasing more rapidly than non-producers did (Table 3.2).

The observed growth in asset indices for both groups over time suggests overall economic improvement. However, the greater increase among producers may be attributed to the economic advantages associated with *Enset* production, such as greater resilience to food insecurity and greater income-generating potential, as highlighted by (M. R. Carter & Barrett, 2006a). These findings suggest that agricultural assets are critical for the economic stability of *Enset* producers, whereas non-producers rely more broadly on diverse asset types. Policies aimed at enhancing asset ownership, particularly agricultural assets for non-producers, could play a pivotal role in reducing welfare inequality and improving household well-being.

Table 3.2: Factor analysis results for assets (AST) by the *Enset* producers and non-producers

	Enset producer		Non-producer	
	Factor 1	uniqueness	Factor 1	Uniqueness
Agricultural asset index	0.796	0.366	0.642	0.588
Other Household asset index	0.682	0.536	0.612	0.625

Note: One factor was used to estimate AST for producers, accounting for 93% of the variance in the variable. Similarly, a single factor was utilized to estimate AST for non-producers, explaining 94% of the variance in that variable.

3.4.3. The trend of inequality in asset value approach

Household assets, encompassing both tangible assets such as homes, vehicles, and appliances and intangible assets such as financial investments, constitute a critical component of household welfare. It represents the material foundation upon which families build their lives, offering security, comfort, and the means to improve living standards. The value of these assets, often referred to as household wealth, directly impacts the welfare of individuals by providing economic stability and the potential for future prosperity (Fischersworring et al., 2015). Figure 3.2 below shows that 2019 producers had an inequality index of 0.26, whereas non-producers had an inequality index of 0.356718, indicating greater inequality among non-producers. By 2022, there was a significant increase in inequality for both groups, with producers at 0.481146 and non-producers at a much higher value of 0.69108. In 2024, the trend continued, with producers at 0.582111 and non-producers at 0.78122, suggesting a growing disparity in asset ownership over time.

Triangulating these results with those of other studies, it is evident that household property is a significant determinant of welfare inequality. Studies have shown that increases in housing costs, for example, can lead to greater income inequality (Farzanegan & Gholipour, 2016). Moreover, housing market financialization, indicated by higher housing prices and volatility, is associated with increased deprivation for renters and low-income owners (Dewilde, 2022). These findings align with the observed trends in the Atkinson index data, where non-producers, potentially with less access to property ownership, face higher inequality levels. In conclusion, the Atkinson index data reveal a concerning increase in welfare inequality among producer and non-producer households, with non-producers being disproportionately affected. This analysis underscores the importance of considering household property in welfare assessments and the need for policies that address the growing disparities in asset distribution to foster a more equitable society.

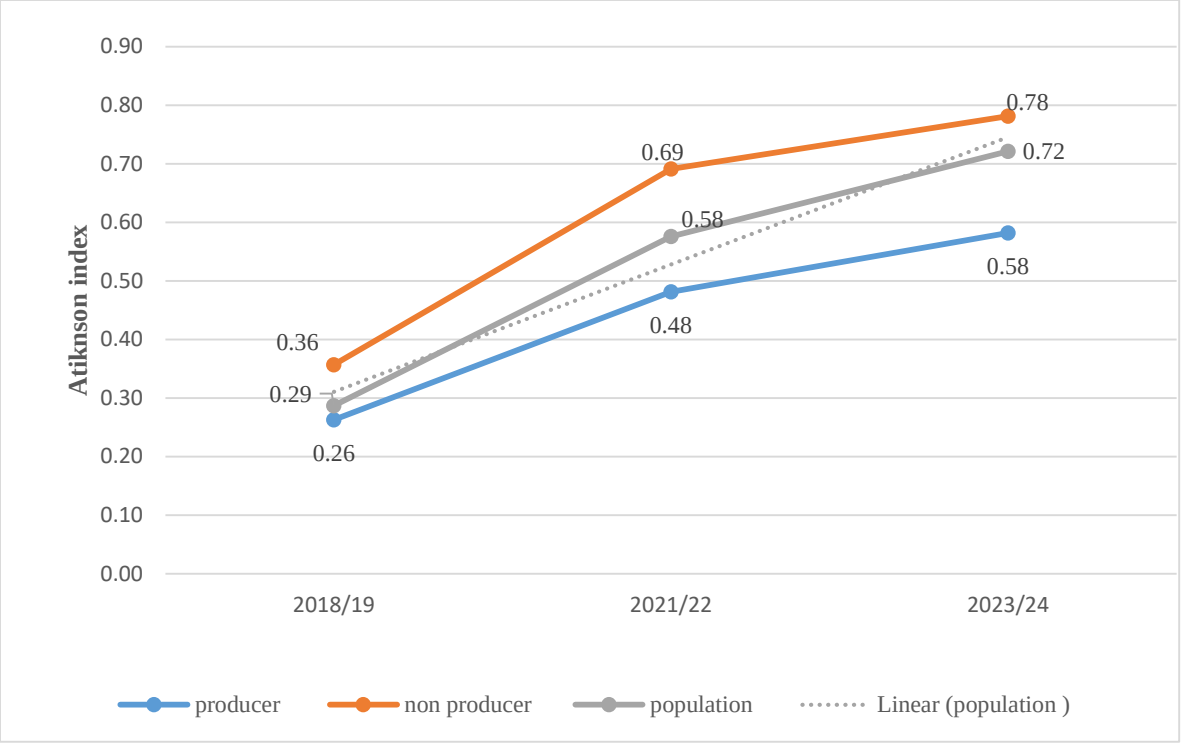

Figure 3.2: Atkinson index for inequality in asset value

3.4.4. Trend of welfare inequality in the expenditure approach

The Atkinson index values for the producer group show a decreasing trend over the years, indicating a reduction in expenditure/consumption inequality among producer households. The values for 2019 are the highest, followed by a decline in 2022 and then a slight increase in 2024. In contrast, the non-producer group exhibited an increasing trend in welfare inequality in expenditure/consumption variables, with the highest values in 2024 and the lowest in 2019. Compared with the non-producer group, the producer group consistently has lower expenditure/consumption inequality. This suggests that producer households tend to have more equal welfare distributions in the expenditure/consumption approach than non-producer households. The overall population's expenditure/consumption inequality follows a similar pattern to that of the producer group, with decreasing inequality in 2019 and 2022 and a slight increase in 2024 (Table 3.3).

The results indicate that welfare inequality in the expenditure/consumption approach is greater among non-producer households than among producer households. This could be due to various factors, such as differences in income, access to resources, or social and economic conditions. The

decreasing trend in welfare inequality among producer households might be attributed to policies or initiatives that have improved the distribution of welfare among these households. In contrast, the increasing trend in welfare inequality among non-producer households could be a result of various factors, including changes in economic conditions, social policies, or demographic shifts.

The results suggest that welfare inequality in the expenditure/consumption approach is greater among non-producer households than among producer households in the study area. While producer households have experienced an increase in inequality, peaking in 2019 and then declining with a slight rise in 2024, non-producer households have experienced an increase, with 2024 marking the highest inequality. This divergence aligns with global findings, such as those from Ghana, where gender-based disparities in food consumption expenditure and vulnerability to food poverty are significant. Similarly, in India, financial inclusion has been linked to diversified consumption expenditures, suggesting improvements in household welfare (Chakrabarty & Mukherjee, 2022). These studies corroborate the Ethiopian case, indicating that factors such as gender, financial access, and policy interventions play crucial roles in shaping welfare inequality based on expenditure/consumption trends across different household groups.

Table 3.3: Atkinson index for inequality in welfare (expenditure)

Index= Atkinson index
Parameter Epsilon= 0.5

Year	Group	Estimate	STE	LB	UB
2019	Producer	0.11192	0.01625	0.07987	0.14397
	Non-producer	0.2299	0.022	0.18651	0.2733
	Population	0.14356	0.01469	0.11458	0.17254
2022	Producer	0.08992	0.01033	0.06954	0.1103
	Non-producer	0.16415	0.03145	0.10211	0.22619
	Population	0.12033	0.01487	0.091	0.14965
2024	Producer	0.12774	0.00827	0.11149	0.14399
	Non-producer	0.24867	0.02445	0.20064	0.2967
	Population	0.15852	0.00895	0.14095	0.17609

Note: STE: standard error, LB: lower bound, UB: upper bound
Source: WB, ESS and own dataset, 2024

3.4.5. Differences between the Atkinson indices for welfare inequality in assets and expenditures value

Table 3.4 presents the differences in the Atkinson indices for welfare in asset and expenditure inequalities among *Enset* producers and non-producers. It also compares the differences between asset and expenditure inequalities for each group. The Atkinson indices measure inequality, with higher values indicating greater inequality. Statistical significance is indicated, suggesting robust findings. For *Enset* producers, the Atkinson index for expenditure (ATK_D1) is 0.161, whereas for non-producers, it is 0.282. Both are statistically significant, indicating that expenditure inequality is significantly lower among *Enset* producers than non-producers. Similarly, asset inequality (ATK_D2) is lower for producers (0.329) than for non-producers (0.593). The difference between asset and expenditure inequalities (diff.) is also statistically significant for both groups, although it is greater for non-producers (0.311) than for producers (0.168).

The results reveal stark differences between *Enset* producers and non-producers. *Enset* producers exhibit lower inequality in expenditure and asset ownership than non-producers do. The smaller expenditure inequality among producers suggests that *energy* production may stabilize consumption, potentially by providing consistent food and income sources. Moreover, the lower asset inequality for producers might reflect the relatively equitable distribution of *Enset* cultivation resources, such as land allocated for *Enset* farming. In contrast, non-producers face higher levels of inequality in both expenditures and assets. This could be due to greater reliance on less stable and more variable income sources, as well as systemic barriers to accessing productive resources. The larger gap between asset and expenditure inequalities among non-producers (0.311) suggests that while some community or external mechanisms might alleviate consumption disparities, structural inequalities in wealth persist.

These findings are consistent with those in the Ethiopian context, where *Enset* production has been recognized as a resilience-enhancing crop. Studies by (Senbeta et al., 2022) highlight the role of *Enset* in providing stable food supplies and income, particularly in the face of climatic shocks. The ability of *Enset* producers to maintain relatively equitable consumption patterns aligns with evidence that *Enset*-based systems enhance household food security and reduce income variability (Bonso et al., 2022; Brandt et al., 1997). In international contexts, similar trends are observed in agrarian societies that rely on staple crops. For example, maize production in southern Africa has

been linked to lower expenditure inequalities among farming households (Jayne et al., 2018). However, as in Ethiopia, structural inequalities in asset distribution persist due to systemic barriers such as limited access to land and credit (Ravallion, 2015). The greater inequality among non-producers parallels findings in non-agrarian households in rural Sub-Saharan Africa, where a lack of access to stable income sources exacerbates disparities in consumption and wealth. This finding reinforces the importance of promoting sustainable agricultural practices such as *Enset* cultivation to address both immediate consumption needs and long-term structural inequalities. The results underscore the critical role of *Enset* production in reducing expenditure and asset inequalities. Policymakers should prioritize *Enset*-based interventions to increase equity, particularly in asset distribution. Efforts to expand access to *Enset* cultivation resources, combined with broader structural reforms such as equitable land policies, could reduce disparities among rural households in Ethiopia. These findings also highlight the broader relevance of promoting sustainable and resilient agricultural systems to address inequalities in rural economies globally.

Table 3.4: Atkinson indices difference in household welfare between asset value and expenditure

Difference between Atkinson indices	*Enset*-producer	Non-producer
	Estimate Atkinson indices (Std.Err.)	Estimate Atkinson indices (Std.Err.)
ATK._D1 (Expenditure)	0.161 (0.026)**	0.282 (0.142)***
ATK._D2 (Assets)	0.329 (0.091)***	0.593 (0.463)***
diff. (Assets-Expenditure)	0.168 (0.218)**	0.311 (0.234)***

3.4.6. Econometric results

Before running the model, tests for cross-sectional dependence and heteroskedasticity were conducted. Ignoring heteroskedasticity can lead to less efficient parameter estimates (Andrews, 1991). Therefore, fixed effects estimation yields standard errors that are both reliable and consistent, should be corrected for heteroskedasticity. Using a cross-sectional dependency test for panel data analysis is crucial, as it helps identify whether cross-sectional units are correlated, which can significantly impact the accuracy and efficiency of regression estimations. Ignoring cross-sectional dependence may lead to biased test statistics and misleading inferences. For instance, (Pesaran, 2015) underlines the significance of addressing cross-sectional interdependence when working with panel datasets. Properly addressing this dependence allows for more robust and reliable estimation and inference in the presence of common shocks or unobserved common factors that affect multiple units simultaneously.

Table 3.5 presents the test results before quartile regression. The result shows that there is no cross-sectional dependency on the data. The Breusch–Pagan LM test is a type of Lagrange multiplier test used to detect heteroskedasticity in a linear regression model and indicates no significant cross-sectional dependency and no heterogeneity issues. The Pesaran scaled LM test suggests marginal of cross-sectional dependency, which is significant at the 10% level but not at the 5% level. The bias-corrected scaled LM test and the Pesaran CD test indicate no significant cross-sectional dependency. Given these results, particularly the lack of significant cross-sectional dependency from most tests, it appears that cross-sectional dependency is not a major concern for these panel data.

Table 3.5: Cross-sectional dependency test

Test	Statistic	d.f	Prob.
Breusc-pegan LM	25.43	289	0.153
Pesaran scaled LM	28.23		0.078
Bias-corrected scaled LM	28.23		0.203
Pesaran CD	26.01		0.123

Note: d.f: degree of freedom, CD: cross-sectional dependency, LM: Lagrange multiplier

3.4.7. Determinants of inequality in welfare (the value of assets)

Table 3.6 presents a quartile regression analysis examining the factors influencing inequality in the value of assets among producer and non-producer households. First, pooled ordinary least squares (POLS) regression is used to provide a baseline model by assuming homogeneity across units and time. This method is simple and easy to interpret, offering an initial overview of the relationships between variables. POLS helps detect heterogeneity, and significant differences between POLS and quantile regression results highlight variability across the distribution of the dependent variable, supporting the need for more advanced methods such as quantile regression.

The analysis of the quantile regression of determinants of inequality welfare in asset value among *Enset* producer and non-producer households reveals significant insights. For non-producer households, education level plays a crucial role; a one-unit increase in the household head's education level leads to an increase in asset value at the lower, middle, and upper quantiles (0.308, 0.038, and 0.249, respectively), suggesting that higher education is associated with better asset accumulation and reduced inequality, particularly at higher quantiles. Gender disparity is evident,

as female-headed households have lower asset values at the lower and upper quantiles (–0.896 and –1.468, respectively), indicating that female-headed households tend to accumulate fewer assets. The age of the household head positively influences asset value at the lower quantile (0.0238), implying that older heads tend to accumulate more assets, although the effect weakens at higher quantiles. Marital status has a significant effect, with married households showing a negative effect at the lower quantile (–0.580) but a positive effect at the middle quantile (0.338), indicating greater stability in asset accumulation among married households, especially in the middle range. Receiving remittances significantly boosts asset value, notably at the upper quantile (2.734), indicating their critical role in wealthier non-producer households. Access to health insurance is associated with higher asset values at the lower (0.898) and middle quantiles (1.284), emphasizing the importance of health coverage for asset growth. Exposure to shocks negatively affects asset value, particularly at the lower quantile (–0.424), reflecting the heightened vulnerability of nonproducer households to external disturbances. Finally, total income is positively correlated with asset accumulation at all quantiles, with a notable impact at the upper quantile (0.0956), confirming that income is a key determinant for asset growth and reducing inequality.

For producer households, education is a significant determinant of asset value, with a particularly strong positive effect at the upper quantile (0.976), indicating that higher education levels greatly contribute to asset accumulation, especially among better-off households. Marital status also plays a crucial role, showing a strong positive effect at both the middle (0.419) and upper quantiles (1.185), suggesting that married households are better positioned for accumulating assets. The receipt of remittances significantly boosts asset value, particularly at the upper quantile (7.022), highlighting their importance for wealthier households. Access to health insurance positively influences asset value at the lower (0.0743) and middle quantiles (0.0756), underscoring its role in supporting asset accumulation, especially among poorer households. Finally, total income has a strong and consistent positive effect on asset value, particularly at the middle (0.930) and upper quantiles (1.457), confirming that income is a primary driver of asset accumulation among producer households.

The quartile regression analysis reveals distinct determinants of welfare in asset value inequality among *Enset* producers and non-producers. For non-producer households, education significantly influences asset accumulation across all quantiles, suggesting that educational attainment is crucial

for reducing inequality. This finding aligns with the literature indicating that education enhances economic opportunities and asset accumulation, particularly in developing contexts (Marzagora, 2024). Gender disparities are evident, as female-headed households consistently present lower asset values, reflecting broader societal inequalities that affect women's access to resources (Adugna, 2019). The positive correlation between total income and asset accumulation at all quantiles further underscores the critical role of economic resources in mitigating inequality. In contrast, for producer households, education also plays a significant role but is most pronounced at the upper quantile, indicating that higher education levels are particularly beneficial for wealthier households. Marital status emerges as a crucial factor, with married households being better positioned to accumulate assets, reflecting stability and resource pooling within families (Adugna, 2019; Marzagora, 2024). The substantial impact of remittances on asset values, especially at the upper quantile for both household types, highlights their importance in enhancing financial resilience and wealth accumulation.

In the Ethiopian context, the findings resonate with broader trends observed in national studies. Ethiopia has experienced significant economic growth; however, this growth has not been uniformly distributed, leading to persistent inequalities (World Bank, 2024b). The World Bank noted that while infrastructure investments have improved living standards for many people, external shocks such as droughts and conflicts exacerbate vulnerabilities among marginalized groups. The emphasis on education as a determinant of asset value aligns with Ethiopia's national strategies aimed at improving educational access as a means to reduce poverty and inequality (Mouton & Boshoff, 2008). Furthermore, gender disparities in asset ownership reflect ongoing challenges within Ethiopian society, where cultural norms often limit women's economic participation (Adugna, 2019). Internationally, the determinants identified in this analysis reflect patterns observed in various developing nations. Studies have consistently shown that education is a powerful tool for reducing inequality across different contexts (ETHIOPIA, FDRC, 2022). The negative impact of gender on asset accumulation is also a common theme globally, where female-headed households often face systemic barriers to wealth accumulation compared with their male counterparts (T. G. Haile, 2015).

Table 3.6: Quartile regression analysis of determinants of inequality in value of assets

		Non-Producer				Producer		
		Lower Q	Middle Q	Upper Q		Lower Q	Middle Q	Upper Q
VARIABLES	**POLS**	**10th**	**50th**	**90th**	**POLS**	**10th**	**50th**	**90th**
Education level	0.308**	0.0380**	0.201	0.249**	0.414**	0.295**	0.511**	0.976*
	(0.185)	(0.231)	(0.154)	(0.141)	(0.224)	(0.140)	(0.237)	(0.563)
Sex of head (female)	-0.896**	-1.553***	-1.487**	-1.468	-1.400	-1.449	-1.361**	-1.171
	(1.825)	(3.112)	(2.030)	(1.891)	(2.330)	(1.878)	(3.077)	(7.541)
Age of head	-0.0238**	-0.0184	-0.00242	0.00229**	0.0185**	0.00684**	0.0281**	-0.0738
	(0.0504)	(0.0809)	(0.0529)	(0.0492)	(0.0593)	(0.0489)	(0.0803)	(0.196)
Marital status (married)	-0.580**	0.338	0.0742	-0.00370***	-0.272***	-0.0788	-0.429**	-1.185***
	(0.554)	(0.816)	(0.535)	(0.496)	(0.685)	(0.493)	(0.813)	(1.980)
Receiving remittance (yes)	2.457***	-5.555	-3.377	2.734***	2.520**	-2.114	3.780**	7.022***
	(4.835)	(6.042)	(3.959)	(3.674)	(6.426)	(3.652)	(6.026)	(14.66)
Borrow/Access to credit (no)	-4.459**	1.822	-0.0581***	-0.613	-2.524**	-1.148	-3.646**	-9.032***
	(2.476)	(4.197)	(2.762)	(2.554)	(2.767)	(2.541)	(4.219)	(10.19)
Access to health insurance (yes)	0.898	1.284	1.127	1.081	0.921	1.036	0.828	0.379
	(1.636)	(2.408)	(1.570)	(1.463)	(1.829)	(1.453)	(2.381)	(5.834)
Employed in GO (no)	9.842***	-0.130***	3.851	5.026	9.071	6.159	11.45	22.85
	(5.626)	(4.379)	(2.941)	(2.673)	(5.593)	(2.668)	(4.564)	(10.68)
Exposure to shock (no)	0.424**(1.671)	-3.321(4.674)	-4.247(3.053)	4.520***(2.841)	5.461*(3.224)	4.784**(2.822)	6.014(4.636)	8.667***(11.33)
Household size	-0.193**	-0.207	-0.241**	-0.251***	-0.285	-0.260	-0.305**	-0.402
	(0.301)	(0.482)	(0.315)	(0.293)	(0.363)	(0.291)	(0.477)	(1.168)
Total income	-0.0956	-0.0138	0.0502**	0.0106**	0.0297**	0.0159***	0.041***	0.0950***
	(0.765)	(0.0130)	(0.0849)	(0.0791)	(0.0944)	(0.0786)	(0.0129)	(0.0315)
Total annual consumption	-	Omitted			-	Omitted		
Land size	0.006*(0.389)	-0.206(0.591)	-0.209(0.385)	0.209**(0.359)	0.0212(0.447)	-0.210(0.356)	0.213**(0.584)	0.219***(1.431)
Year dummy (2018/19)	-0.276 (1.4)	-0.302(0.57)	0.036(0.91)	0.14 (0.78)	0.002 (0.87)	-0.302(45.57)	0.002(5.85)	0.036 (0.24)
Year dummy (2021/22)	0.120**(0.21)	0.012(0.023)	0.002(0.023)	0.023(0.23)	0.001(0.057)	0.004(0.013)	0.001(0.057)	-0.001(0.02)
Year dummy (2023/24	-0.036(0.324)	0.27(0.121)	-0.036(0.91)	-0.14(0.28)	-0.002(087)	0.302(0.579)	-0.002(0.87)	-0.036(0.24)
TLU	-0.106*	0.406	0.219**	0.319	-0.232	0.220	0.443***	0.339***
	(0.324)	(0.421)	(0.495)	(0.369)	(0.237)	(0.546)	(0.454)	(0.151)
Cons	21.92***	13.01***	21.03***	32.023***	28.59	23.12***	25.23***	56.27***
	(15.36)	(0.303)	(1.221)	(1.460)	(18.03)	(0.0898)	(0.313)	(1.665)
Ps. R^2 (R^2 for POLS)	0.172	0.353	0.241	0.423	0.253	0.753	0.732	0.853

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, POLS: pooled ordinary least squares, Q: quintile

Source: LSMS and own dataset, 2024

3.4.8. Determinants of inequality in welfare (total consumption approach)

Table 3.7 shows the results of a quantile regression (MM-QR) analysis, which examines the determinants of welfare inequality using total expenditure among *Enset*-producing and nonproducing households. Pooled OLS provides a baseline for understanding the general relationship between independent variables and total consumption. However, this model assumes homogeneous effects across the distribution of total consumption, which may not capture the full complexity of the relationships. Therefore, the analysis disaggregates results across lower (10th), middle (50th), and upper (90th) quantiles to capture the heterogeneity of factors influencing welfare (total expenditure) at different levels of household expenditures.

For nonproducing households, several significant variables emerge. The education level of the non-producer household head plays a critical role in reducing welfare inequality, as a one-unit increase in education results in increased total expenditures of 0.0396, 0.0115, and 0.01405 units at the lower, middle, and upper quantiles, respectively. This finding indicates that education has a stronger effect on improving welfare for households at the lower quantile, emphasizing its potential to address disparities among the poorest. However, female-headed households face significant disadvantages. At the lower quantile, being a female-headed household decreases total expenditure by 0.1417 units, highlighting the gender-based disparities in welfare outcomes. Receiving remittances also contributes to reducing welfare inequality, particularly for poorer households. A one-unit increase in remittance receipt increases total expenditure by 0.2568 units at the lower quantile, although this effect diminishes at higher quantiles. This underscores the importance of remittances in supporting vulnerable households. Similarly, access to credit plays a vital role in mitigating inequality, as households without credit access experience reduced total expenditures by 0.0767 and 0.0541 units at the lower and middle quantiles, respectively. Exposure to shocks has a consistently negative effect on welfare, reducing total expenditure by 0.0865, 0.0279, and 0.0277 units at the lower, middle, and upper quantiles, respectively. This finding indicates that shocks adversely affect non-producer households across all welfare levels, although the effect is more pronounced at the lower quantile. Finally, total income emerges as a key determinant in reducing welfare inequality, with a one-unit increase in income resulting in increased total expenditures of 0.521, 0.621, and 0.721 units at the lower, middle, and upper quantiles, respectively. This finding highlights the centrality of income in improving non-producer

household welfare and addressing inequality across all expenditure levels.

For *Enset*-producing households, education level emerges as a key determinant in reducing welfare inequality. A one-unit increase in education increases total expenditure by 0.0237, 0.0330, and 0.0410 units at the lower, middle, and upper quantiles, respectively, with its effect being more pronounced at higher welfare levels. Marital status also plays a significant role, as being married increases welfare and reduces inequality by increasing total expenditure by 0.0111 units at the lower quantile and 0.0848 units at the middle quantile, underscoring the stability and economic advantages associated with marriage. Receiving remittances, however, shows a different pattern; it increases welfare inequality by boosting total expenditure by 0.0540 units at the upper quantile, suggesting a more substantial impact on wealthier households within the producer group. Access to health insurance proves vital in enhancing welfare, particularly for poorer households, as it increases total expenditure by 0.0743 and 0.0756 units at the lower and middle quantiles, respectively. Finally, total income is a crucial factor in reducing welfare inequality, with a one-unit increase in income significantly increasing total expenditure by 0.920 and 0.930 units at the middle and upper quantiles, respectively. This finding highlights income's critical role in improving welfare across all expenditure levels among *Enset* producers.

The year dummy variables highlight a reduction in inequality over time, with the 2023/24 period showing significant decreases in inequality, particularly at the upper quantile. This reflects the potential impact of policy interventions or broader economic changes that have favored welfare improvements. The year dummies similarly point to consistent reductions in inequality across all quantiles, with notable improvements in 2023/24, especially for the upper quantile. The higher baseline welfare levels, indicated by the constant term, suggest that producers generally experience better welfare than non-producers do, but this is coupled with greater inequality at the upper quantile, reflecting disparities among wealthier producer households. The pooled OLS (POLS) results reinforce the overall negative association between LUs and welfare inequality, implying that larger landholdings generally reduce inequality on average, although this effect varies across quantiles. The results highlight the significant role of *Enset* production in moderating welfare inequality, particularly for lower-income households, while also revealing persistent disparities among wealthier groups.

These findings align with the literature on welfare inequality. For example, education’s significant

role in reducing inequality is consistent with studies (Asadullah & Yalonetzky, 2012), which highlight education as a critical factor for economic mobility and poverty reduction. Similarly, the importance of remittances for poorer households matches findings by (Adams Jr & Page, 2005), who emphasize that remittances alleviate poverty and inequality in low-income settings. The negative effects of shocks on welfare mirror (Dercon & Krishnan, 2000b)those of , who discuss how exposure to shocks exacerbates inequality and reduces consumption levels. The role of access to credit and health insurance in mitigating inequality aligns with studies such as (A. Asfaw et al., 2004), which emphasize these mechanisms in reducing vulnerability and enhancing welfare.

In Ethiopia, welfare inequality is largely influenced by education, shocks, and access to resources. The positive role of education found in this analysis is consistent with Ethiopia's national development policies, including the Education Sector Development Program (World Bank, 2020a), which highlights education as a driver of economic equity. The negative impact of shocks aligns with Ethiopia's vulnerability to climate shocks, as highlighted by (Dercon & Krishnan, 2000b). Furthermore, the critical role of income aligns with national poverty assessments by the Ethiopian Central Statistical Agency (CSA), which identify income growth as central to reducing inequality and improving welfare.

Globally, the role of education and income in reducing welfare inequality mirrors findings in developing countries. Studies (Bourguignon, 2003) emphasize the centrality of education in bridging income gaps. Access to health insurance and credit aligns with findings from developing economies in Asia and Africa, where financial inclusion and social safety nets are crucial for poverty reduction (Ravallion, 2010). The impact of remittances on inequality is consistent with studies in South Asia, where remittances primarily benefit wealthier households, widening the gap at higher income levels (Omar & Inaba, 2020).

Table 3.7: Quartile regression analysis of determinants of inequality in total expenditure/consumption

VARIABLES	POLS	Non-Producer			Producer			
		Lower Q	Middle Q	Upper Q	POLS	Lower Q	Middle Q	Upper Q
		10th	50th	90th		10th	50th	90th
Education level	0.154.7**(8361)	0.0396**(0.0224)	0.0115(0.0294)	0.01405**(0.059)	0.3785***(0.94)	0.0237(0.04)	0.033(0.55)	0.04***(0.076)
Sex of head (Female)	-0.14179**	-0.0920	-0.0698	-0.0589**	0.37896**	-0.0293	0.0881**	0.0937
	(5,770)	(0.0929)	(0.0698)	(0.0599)	(6,767)	(0.0443)	(0.0553)	(0.0768)
Age of head	671.2***(173.1)	-0.00224(0.0218)	-0.002(0.0164)	-0.02**(0.0140)	0.710***(181.3)	-0.011**(0.0104)	-0.0641(0.0130)	-0.2306(0.0180)
Marital status (married)	-0.8034***	-0.0406	-0.0104***	0.0440	-0.11,477***	0.0448	0.0848***	0.0117
	(1855)	(0.0238)	(0.0179)	(0.0153)	(0.2308)	(0.0113)	(0.0142)	(0.0197)
Receiving remittance (yes)	0.25680**	-0.00103	-0.0727	-0.0579	-0.7221**	-0.0178	0.0220***	0.0540***
	(17003)	(0.00191)	(0.00143)	(0.00123)	(0.2661)	(0.000911)	(0.00114)	(0.0158)***
Borrow/access to credit (No)	0.8656***	-0.0767***	-0.0561***	-0.0461**	0.2247***	-0.0187**	0.0842	0.0303
	(6937)	(0.0724)	(0.0544)	(0.0467)	(632.4)	(0.0346)	(0.0431)	(0.0599)
Access to health insurance (yes)	-0.10377**	-0.000717	0.00726**	-0.0731	-0.10369*	0.0743**	0.0756**	-0.0766
	(5394)	(0.00699)	(0.0525)	(0.0450)	(0.5855)	(0.0333)	(0.0416)	(0.0578)
Employed on GO (no)	0.103(14,862)	-0.000952(0.001)	-0.0009(0.0007)	-0.0009(0.0006)	0.11***(0.135)	-0.0008*(0.0005)	-0.0008(0.0006)	-0.0008(0.0008)
Exposed to shock (no)	-0.25163***	-0.0865**	0.0185	-0.0279***	-0.23444***	0.0537**	0.0793**	0.0998***
	(8,296)	(0.00162)	(0.00122)	(0.00104)	(0.7919)	(0.000773)	(0.000965)	(0.00134)
Household size	0.1761**	-0.0424**	-0.0311***	-0.0255**	0.1368***	-0.0105**	0.0450***	0.0165
	(918.4)	(0.0123)	(0.0924)	(0.0792)	(0.1017)	(0.0586)	(0.0732)	(0.0102)
Total income	-3.737***	0.521***	0.621***	0.721***	-0.4203**	0.920***	0.720***	0.930***
	(3.717)	(0.0715)	(0.0558)	(0.0495)	(0.3910)	(0.0381)	(0.0444)	(0.0593)
Land size	0.235**(918.4)	-0.0328(0.0156)	-0.0238(0.0117)	0.0193**(0.0122)	0.537(0.667)	-0.0728(0.0743)	0.0471**(0.0929)	0.0144**(0.0129)
Value of assets	-3.452***	-0.0207	-0.0137	-0.0103	-3.452***	-0.0108	0.0210	0.0155
	(3.523)	(0.0195)	(0.0147)	(0.0126)	(3.523)	(0.0934)	(0.0116)	(0.0161)
TLU	-3.123***(3.235)	0.0103**(0.0019)	-0.0727(0.001)	-0.0579(0.001)	-3.123***(3.24)	-0.021(0.091)	0.0220***(0.011)	0.0540(0.0158)
Year dummy (2018/19)	-0.0023***(0.0069)	0.0066 (0.0046)	-0.0023*** (0.0069)	-0.0079 (0.0044)	-187.46 (955.41)	499.95(1384)	-187.46 (9558.41)	-1688.3(3888)
Year dummy (2021/22)	833.4*** (216.8)	6399.04(361.51)	83603.4***(216.8)	1118.5*** (40032)	745.42***(167.5)	427.14***(34.2)	7452.42***(1678.245)	13161***(6018.8)
Year dummy (2023/24)	-36999.2**(1846)	-172(321.24)	-369.2**(1846)	-6809.3(354.58)	-2754.16***(717)	-8800.53(87.53)	-2754.16***(7171.56)	-8777.3***(259.5)
Cons	21,229***	18,787***	27,796***	105,880***	23,365***	33,635***	55,991***	163,321***
	(51,679)	(933.0)	(1,322)	(1,511)	(61,679)	(3,163)	(5,081)	(11,477)
Ps. R^2 (R^2 for POLS)	0.156	0.253	0.252	0.563	0.2065	0.632	0.752	0.712

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.01

3.5. Conclusion and recommendation

This study highlights significant disparities in welfare inequality between *Enset*-producing and non-producing households in Central Ethiopia over time. Compared with non-producers, producers consistently exhibited lower levels of both asset and expenditure inequality, suggesting that *Enset* cultivation plays a critical role in stabilizing and improving household welfare. The Atkinson index revealed growing inequality among non-producers, whereas producers experienced relatively stable trends. The key determinants of welfare inequality included education; household characteristics; and access to credit, remittances, and exposure to shocks. Education emerged as a pivotal factor across all households, underscoring its transformative potential in reducing inequality. However, disparities in resource access, gender inequalities, and vulnerability to shocks persist, particularly among non-producer households. These findings emphasize the importance of targeted interventions to address these inequalities and promote inclusive development.

3.5.1. Recommendations

To reduce welfare inequality in Central Ethiopia region, tailored interventions are needed for both *Enset*-producing and non-producing households. For producers, improving *Enset* productivity, market access, and financial inclusion through credit and remittance support can help sustain and enhance their welfare stability. Education and climate resilience strategies should also be strengthened. For non-producing households, expanding access to *Enset* cultivation where feasible, along with social protection programs, vocational training, and livelihood diversification, is essential. Addressing gender and resource access inequalities will further support inclusive development. Overall, coordinated, multi-sectorial efforts are required to promote equitable and resilient rural livelihoods.

Furthermore, further research should focus on identifying the structural barriers that limit non-producers' ability to accumulate assets and improve overall welfare. This will inform the design of more effective, targeted policies and programs that address the root causes of inequality and promote inclusive growth.

CHAPTER 4: INTERTEMPORAL DYNAMICS AND DETERMINANTS OF WELFARE INEQUALITY AMONG *ENSET* PRODUCING AND NON-PRODUCING HOUSEHOLDS IN CENTRAL ETHIOPIA: A MULTIDIMENSIONAL APPROACH

Abstract

Welfare inequality is a persistent challenge in developing regions like Ethiopia, where disparities in income, resources, and quality of life are widespread. This study examines the intertemporal dynamics and determinants of welfare inequality among Enset-producing and non-producing households in Central Ethiopia. Using a multidimensional approach, the research analyses panel data from the Ethiopian Living Standards Measurement Survey (2019, 2022) and data collected in 2024. The study employs fixed-effects models, a multidimensional inequality index, and t-tests to understand welfare inequality dynamics over time. The findings reveal distinct intertemporal dynamics: Enset-producing households maintained stable and relatively low welfare inequality (index of 0.109), benefiting from resilience to shocks and steady improvements in income (ETB 17,303) and education (1.43 additional years). In contrast, non-producing households exhibited higher and more volatile inequality levels (index of 0.405), with slower income growth (ETB 12,270) and education gains (0.27 additional years). Determinants of welfare inequality varied: Enset producers were influenced by remittances, land size, and access to mobile phones, while non-producers were impacted by employment status, household size, and limited technological access. The study concludes that Enset cultivation significantly reduces welfare inequality and enhances resilience, while non-producing households remain vulnerable. Therefore, promoting Enset cultivation through technical support and market access, addressing group-specific determinants, and improving access to education, credit, and technology. Policymakers should integrate intertemporal insights into strategies for reducing inequality and fostering inclusive development, with continuous monitoring to ensure long-term impact.

Keywords*: Enset production, fixed effect, multidimensional approach, welfare inequality*

4.1.Introduction

Welfare inequality is a pressing global issue characterized by significant disparities in income, access to resources, and quality of life (Chancel et al., 2022). These disparities are particularly severe in developing regions such as Africa, where most of the population relies heavily on agriculture for their livelihoods. Despite the centrality of agriculture to economic sustenance, the sector remains underdeveloped, with many smallholder farmers facing challenges such as low productivity, limited access to markets, and vulnerability to climate change. These challenges exacerbate economic inequalities, leading to widespread poverty and limiting opportunities for social mobility (World Bank, 2020b). Globally, efforts to reduce welfare inequality have been met with varying degrees of success, but in regions such as Africa, progress has been slow and uneven, highlighting the need for more targeted and effective interventions (United Nation, 2019).

In the African context, the severity of welfare inequality is compounded by structural challenges such as unequal land distribution, lack of access to modern agricultural inputs, and inadequate infrastructure. These issues are particularly pronounced in rural areas, where the majority of the population lives and works in agriculture. For example, in sub-Saharan Africa, agricultural productivity remains low compared with that in other regions, which has direct implications for income levels and welfare (Dercon & Gollin, 2014). In Ethiopia, one of Africa's most populous countries, the agricultural sector plays a critical role in the economy, employing approximately 70% of the labor force and contributing significantly to GDP. However, the sector is characterized by significant inequalities, especially between different regions and agricultural systems, leading to stark differences in household welfare (Ministry of Finance and Economic Development, 2020).

The extent of welfare inequality in Ethiopia is particularly evident when different agricultural systems, such as those based on *Enset* production versus non-*Enset* production, are compared. *Enset*, a staple crop in central Ethiopia, is associated with specific agricultural practices that impact the livelihoods of farming households. The reliance on *Enset* can lead to different economic outcomes compared to households engaged in other forms of agriculture. Studies indicate that regions focusing on *Enset* production tend to showcase better resilience against food insecurity and poverty due to the crop's adaptability to local conditions and its nutritional benefits (Gebre-Selassie & Bekele, 2012). In contrast, non-*Enset* agricultural systems do not provide similar sustenance or economic stability, thereby exacerbating welfare inequality. *Enset,* also known as the "false banana," is a staple crop in southern and central Ethiopia and is known for its resilience to drought and its contribution to food security (Borrell et al., 2020). However, despite its importance, there are marked differences in welfare outcomes between households that rely on *Enset* and those that do not. Various factors, including access to markets, landholding size, and the availability of agricultural inputs influence these differences. The persistence of such disparities underscores the need for a deeper understanding of the dynamics at play in these different agricultural systems and their impact on household welfare.

Studying welfare inequality among *Enset*-producing and non-producing households in Central Ethiopia has broader national relevance. Understanding the drivers of welfare inequality is critical for designing effective policies to promote equitable growth and reduce poverty across Ethiopia, where rural livelihoods, predominantly reliant on agriculture, account for approximately 80% of

the population (CSA, 2012). National-level disparities in welfare among agricultural households have significant implications for poverty reduction and sustainable development, given that agriculture contributes over 30% to Ethiopia's GDP and remains the primary source of employment (Geffersa & Tabe-Ojong, 2024). In Ethiopia, where the majority of the population is rural and dependent on agriculture, addressing inequalities in this sector is essential for improving overall welfare (G. Berhane et al., 2017). The justification for studying welfare inequality among *Enset*-producing and nonproducing households in the Central Ethiopia region is multifaceted. First, understanding the factors that drive welfare inequality is crucial for designing effective policies that can promote equitable growth and reduce poverty. Given that the majority of Ethiopia's population is rural and dependent on agriculture, addressing inequalities in this sector is essential for improving overall welfare (G. Berhane et al., 2017). Second, *Enset* is a crop that has received relatively little attention in Ethiopia's broader discourse on agricultural development, despite its significance for food security and resilience to climate change.

Focusing on the dynamics and determinants of welfare inequality in central Ethiopia, the study brings clear dividends to policy and development interventions. Inequalities within Ethiopia have evolved, and recent studies including Tigre, (2020)Tigre and Yirga, (2021) have indeed advanced the use of multidimensional approaches to analyze poverty and inequality in Ethiopia. While these studies have made significant progress at the national and urban level, this study builds on this by focusing on intertemporal dynamics of multidimensional welfare inequality specifically among Enset-producing and non-producing rural households a context and comparative lens not previously examined in depth. Thus, it helps the scholars and policymakers to understand how change in welfare inequality evolves over time and what drives this change. Additionally, the study area, Central Ethiopia, is characterized by a unique agrarian livelihood system where *Enset* serves not only as a staple food crop but also as a critical asset for coping with food insecurity and climate shocks (Borrell et al., 2020). This dual role of *Enset* highlights its significance in the region’s socioeconomic and ecological context, setting it apart from other crops prioritized in Ethiopia’s agricultural policies.

By focusing on the dynamics and determinants of welfare inequality in this context, this study can provide valuable insights that are directly applicable to policy and development initiatives.

Furthermore, there is a critical need for empirical research that utilizes a multidimensional approach to understanding welfare inequality. Most existing studies on inequality in Ethiopia have focused on income as the primary measure, often overlooking other important dimensions, such as health, education, exposure to shock, and access to health insurance (Bigsten et al., 2005). By using panel data, this study aims to capture the complexity of welfare inequality over time, providing a more nuanced understanding of the factors contributing to disparities in different agricultural systems. This approach is not only innovative but also necessary for developing targeted interventions that can address the root causes of inequality and promote sustainable development in rural Ethiopia.

4.2.Conceptual Framework

The conceptual framework presented in Figure 4.1 offers an approach to analysing the dynamics and determinants of welfare inequality among *Enset*-producing and nonproducing households in Central Ethiopia. By employing a multidimensional lens, this framework assesses welfare inequality through various factors that influence household welfare over time.

The key components of the framework begin with the initial welfare status (W_0) and its determinants (Y_0), which include several critical factors. Total household expenditure serves as a direct indicator of welfare, capturing consumption levels and overall spending; however, (Sen, 1999) stresses that income and consumption alone are insufficient measures without considering broader capabilities. Asset ownership reflects a household's wealth and capacity to withstand economic shocks, a point emphasized by (Bebbington, 1999) in his discussion on the role of assets in enhancing livelihoods and reducing vulnerability in rural areas. Education, as a fundamental aspect of human capital, significantly influences earning potential and social mobility, with (Schultz, 1961) highlighting its role in improving labor productivity and economic outcomes. The framework also considers the impact of economic, environmental, or health shocks, which, as (Dercon, 2004) noted, can have a severe negative effect on welfare, particularly in developing countries where such shocks often perpetuate poverty and inequality. Total income, encompassing all earnings sources, is identified as a primary determinant of welfare, with (Ravallion, 1997) noting the critical influence of income distribution on poverty levels and welfare inequality. Finally, access to health insurance plays a crucial role in managing health-related risks, as demonstrated by studies such as (Wagstaff & Lindelow, 2008), which show that health shocks can lead to catastrophic expenditures, further exacerbating inequality.

The framework differentiates between *Enset*-producing and nonproducing households, a crucial distinction given that *Enset* production is linked to greater resilience against food insecurity and increased economic stability in Ethiopia. (Borrell et al., 2020) highlights the importance of sustaining livelihoods in southern Ethiopia, particularly during droughts, where they play a key role in mitigating welfare decline. Additionally, the framework considers both time-variant and time-invariant characteristics. Time-variant factors, such as economic policies, market conditions, and environmental changes, influence household welfare at different points in time (t_0 and t_1), with the life-course approach, as discussed by (Elder Jr, 1998), emphasizing the significance of timing and sequencing in shaping welfare trajectories. In contrast, time-invariant factors such as geographic location and cultural practices remain constant over time and have a lasting impact on welfare status, often contributing to long-term structural inequalities, as noted (Barrett & Carter, 2013).

The framework explores changes in welfare status (ΔW) between two time periods (t_0 and t_1), with these changes influenced by household type and shifts in welfare determinants (Y_0 to Y_1). It also addresses multidimensional inequality in welfare, considering disparities across various dimensions and aligning with the (Sen, 1999) capability approach, which advocates for a broader view of welfare beyond just income. By distinguishing between *Enset*-producing and nonproducing households and incorporating both time-variant and time-invariant characteristics, the framework offers a nuanced understanding of the evolution of welfare inequality over time. This approach aligns with multidimensional welfare analysis and recognizes the intricate relationships among agricultural practices, economic conditions, and social factors in shaping welfare outcomes in Central Ethiopia.

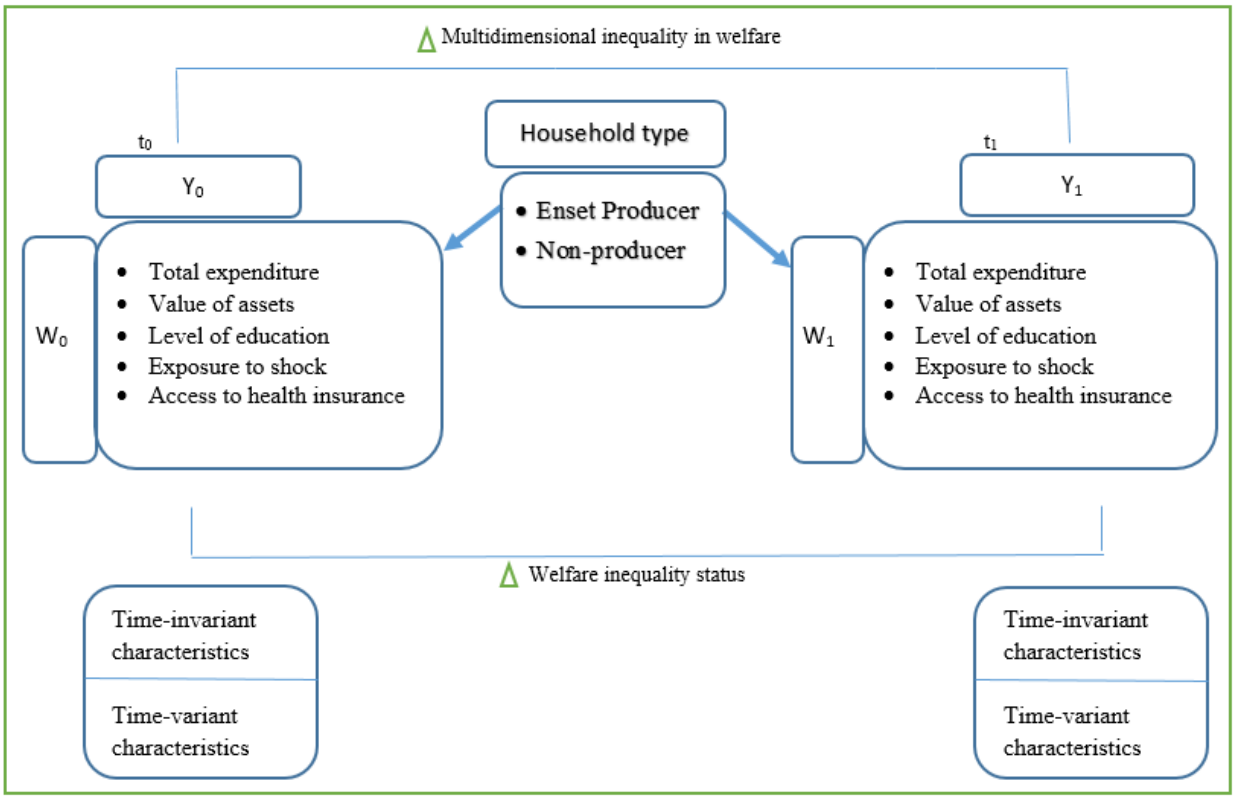

Figure 4.1: Conceptual framework

Source: Own drawing on related literature (D. Haile, 2023)

4.3. Research Method

4.3.1. Methods of Data Analysis

Data analysis was performed using Stata version 17. Before analysis, datasets were meticulously cleaned and merged to ensure accuracy and consistency. A combination of descriptive statistics and econometric models was applied to examine the data. Descriptive statistics, such as means, percentages, standard deviations, and indices, were utilized to succinctly summarize and present the key characteristics of the dataset. These measures offer valuable insights into central tendencies, variability, and distribution patterns, providing a solid foundation for deeper analytical exploration. To build on this foundational understanding, the following sections focus on the methodologies and metrics specifically employed to assess inequality in welfare.

4.3.1.1. Measurement of Inequality in Welfare

Using a multidimensional index to measure inequality in welfare provides a more nuanced understanding of disparities by incorporating various dimensions of well-being beyond just income. This approach captures multiple factors, such as education, health, housing, and access to essential services, which together offer a fuller picture of an individual's or household's overall welfare. Unlike traditional income-based measures, a multidimensional index accounts for the fact that people may experience different forms of inequality simultaneously, making it possible to identify and address inequalities that are not evident when considering income alone. For example, the Gini coefficient, a widely used approach for constructing such indices, allows for the identification of overlapping inequality and provides a more detailed analysis of poverty and inequality (Alkire & Foster, 2011). This method's ability to reflect the complex and interconnected nature of human well-being makes it an essential tool for informing policy decisions aimed at reducing inequality and improving overall quality of life (Sen, 1999).

Multidimensional indices are valuable for assessing welfare concisely and transparently when multiple dimensions are relevant. In this study, we explore a broad class of such indices that include and extend several existing approaches. We utilized Factor Analysis (FA) and Principal Component Analysis (PCA) to estimate the multidimensional welfare status of households, incorporating various indicators such as total consumption, assets, health services, education level, and exposure to shocks. Initially, FA was employed to reduce the number of observed variables related to asset value, education level, health services, and exposure to shocks. Following this, PCA was applied for the overall estimation of the welfare index.

The mathematical representation of FA can be expressed as: $X = \Lambda F + E$ In this equation, X represents the matrix of observed variables, Λ denotes the matrix of factor loadings (which indicate the strength and direction of the relationship between each observed variable and the latent factors), F represents the matrix of latent factors, and E represents the unique error terms associated with each observed variable. Each observed variable is thus specified as a combination of common factors plus an error term, allowing researchers to identify and quantify the underlying constructs that explain the correlations among observed data.

FA and PCA were combined to effectively reduce dimensionality and identify meaningful structures in the data (Dutta et al., 2021). FA helps uncover latent relationships between observed

variables, clustering them into factors that simplify the data without losing significant information. These factors, derived through FA, are then used in PCA, which focuses on maximizing the variance explained by the data. This sequential approach ensures that the components utilized in PCA represent meaningful constructs rather than being arbitrary statistical outputs, enhancing the interpretability and relevance of the resulting welfare index (Chumney, 2012).

FA and PCA were chosen for their robustness and suitability in analyzing multidimensional data, especially when capturing complex interrelationships among variables (Dutta et al., 2021; Moser & Felton, 2007). These methods provide an assessment of welfare by integrating various dimensions into a single index. Additionally, they are flexible and can handle both continuous and categorical data types, making them versatile tools for constructing indices that reflect diverse household characteristics (Asselin, 2009; Constas et al., 2014). Furthermore, PCA has been empirically validated in numerous studies as a reliable method for creating socio-economic status indices, offering a balance of capturing critical aspects of household welfare while maintaining simplicity in both data collection and analysis (Howe et al., 2008). Alternative methods, such as cluster analysis or machine learning algorithms, could also analyze multidimensional data. However, these approaches often lack interpretability or require extensive parameter tuning. FA and PCA offer transparent, statistically grounded techniques that are particularly suitable for welfare studies, where clear and interpretable results are essential (Ezzrari & Verme, 2013).

The model specification for PCA can be outlined as follows:

Data Matrix: Let X be an M*N data matrix, where M represents the number of observations (samples) and N represents the number of variables (features). Each column of X corresponds to a different variable, and each row corresponds to an observation.

Standardization: Standardizing the data matrix X to have a mean of 0 and a standard deviation of 1 for each variable is common practice. This step ensures that variables with larger scales do not dominate the PCA results. The standardized data matrix can be denoted as Z.

Covariance matrix: Compute the covariance matrix C of the standardized data matrix Z:

$$C = \frac{1}{M-1} Z^T Z \quad (1)$$

This matrix captures the variance and relationships between the variables.

Eigenvalue decomposition: Eigenvalue decomposition is performed on the covariance matrix C to obtain the eigenvalues and eigenvectors. The eigenvalues indicate the amount of variance captured

by each principal component, whereas the eigenvectors (also known as loadings) represent the direction of the principal components in the feature space.

Principal Components: The principal components of a PC can be calculated as:

$$PC = Z.V \tag{2}$$

Where V is the matrix of eigenvectors, each principal component is a linear combination of the original variables, and the number of principal components is less than or equal to the number of original variables.

4.3.1.2.Determinants of multidimensional welfare inequality

To estimate the determinants of multidimensional welfare inequality using panel data analysis, we employed a fixed effects model. This approach was chosen after conducting the Hausman test, which confirmed the suitability of fixed effects by indicating that the fixed effects model provides consistent and efficient estimates compared to the random effects model. The fixed effects model effectively controls for unobserved factors that are constant over time but vary between entities (e.g., households). This is crucial in our analysis as it allows us to isolate the effects of time-varying predictors on welfare inequality, thereby reducing bias from omitted variable effects that could confound the results (Millimet & Bellemare, 2023). By using fixed effects, we concentrate on variations within entities over time rather than between them. This focus enhances the robustness of our findings regarding how changes in specific variables influence welfare inequality within each entity, providing a clearer picture of causal relationships (McLean-Shinaman, 2016). Fixed effects models inherently control for all time-invariant characteristics of the entities in our dataset, allowing us to examine only the impact of variables that change over time.

The fixed effects model accounts for time-invariant heterogeneity by allowing each household to have its intercept. This is particularly useful when analysing panel data, where unobserved characteristics that do not change over time may correlate with the independent variables (Hsiao, 2022).

$$y_{it} = \alpha_i + \beta x_{it}^{'} + \varepsilon_{it} \tag{3}$$

where y_{it} is a dependent variable observed for unit i at time t, $x_{it}^{'}$ is a k-dimensional vector of explanatory variables for unit i at time t, β is a vector of coefficients to be estimated, α_i denotes unobserved unit-specific effects, and ε_{it} is the disturbance term. In the standard case, ε_{it} is assumed

to be independent and identically distributed over individuals and time, with a mean of zero and a variance ofσ_ε^2. If we treat α_i as N fixed unknown parameters, the model in the above equation is referred to as the standard fixed-effect model. The model is simply a linear regression model in which the intercept terms vary over the individual units i. What makes fixed effects differ from random effects models is the assumption behind the relationship between x_{it} and α_i. The fixed effects approach assumes that α_i is treated as nonrandom and hence makes the correlation between the observed explanatory variables x_{it} and α_i possible. On the other hand, the random effects are applicable under the assumption that α_i is random and not correlated with x_{it} and put it into the error term (Wooldridge, 2013).

4.4. Results and Discussion

4.4.1. Principal component analysis (PCA) results

The principal component analysis (PCA) output indicates the underlying structure of welfare-related variables in a sample of 810 observations (Table 4.1). PCA was conducted on five key welfare-related variables: Total Expenditure, Education Level, Health Service, Asset Value, and Exposure to Shock. Before conducting PCA, Factor Analysis was performed to compute indices for Education, Health, Asset, and Shock (the result is provided in Appendix 8 from Table 8.2a to Table 8.7g). Factor Analysis helped reduce dimensionality within these sub-domains, creating robust and interpretable measures that were then used as inputs for PCA. The PCA results reveal valuable insights into the underlying structure of these variables and their contributions to overall welfare. PCA is particularly suitable for identifying latent dimensions by reducing the complexity of multidimensional datasets into fewer components, each capturing a proportion of the variance in the data.

The eigenvalues represent the amount of variance explained by each principal component. According to the results, the first principal component (Comp1) has an eigenvalue of 1.817, explaining 36.3% of the variance. This component is the most dominant, capturing the core dimension of welfare. The second principal component (Comp2) has an eigenvalue of 1.366, accounting for 27.3% of the variance. Together, these two components explain 63.7% of the total variance in the data, indicating that they are sufficient to summarize the majority of the information embedded in the variables. The subsequent components, Comp3, Comp4, and Comp5, have eigenvalues of 0.910, 0.651, and 0.255, respectively. Since their eigenvalues are less than 1, they

contribute less to the explanation of variance and are typically considered less critical in welfare analysis, based on the Kaiser Criterion. This criterion, widely used in PCA applications, recommends retaining components with eigenvalues greater than 1, as these components explain more variance than an individual variable. Literature by (Jolliffe, 2002; Kaiser, 1960) supports this methodological approach.

The contribution of each variable to the principal components is reflected in the eigenvectors. For Comp1, Education Level (0.552), Health Service (0.472), and Asset Value (0.586) are the primary contributors. These variables represent critical dimensions of welfare, highlighting their significance in shaping the well-being of households. Comp2, the second most significant component, is dominated by Total Expenditure (0.745) and negatively associated with Exposure to Shock (-0.466). This suggests that Comp2 reflects a financial resilience dimension, where higher expenditure levels are associated with reduced vulnerability to shocks. Comp3 primarily captures health-related aspects, with Health Service having the strongest contribution (0.597). Comp4 is closely linked to vulnerability, as indicated by the strong positive loading of Exposure to Shock (0.653). Finally, Comp5 is negatively correlated with Education Level (-0.647), capturing an inverse relationship that may indicate disparities in education access among households.

The result of PCA are consistent with prior studies. For instance,(Howe et al., 2008) (Krishnan, 2010) (Vieira et al., 2022) (Filmer & Pritchett, 2001) demonstrated the robustness of asset-based indices generated through PCA in welfare analysis. Similarly, (Vyas & Kumaranayake, 2006) highlighted the effectiveness of PCA in summarizing multidimensional welfare data into composite indices. In the Ethiopian context, where rural households face unique challenges, (Abson et al., 2013) found that PCA effectively identified key dimensions of resilience, with education, health access, and asset ownership playing significant roles. These findings triangulate well with the current study, emphasizing the universal importance of education, health, and assets in determining welfare. The results underscore the multidimensional nature of welfare. The dominance of Comp1, driven by Education, Health, and Assets, illustrates the foundational role of these factors in household well-being. The negative loading of Exposure to Shock in Comp2 and its positive loading in Comp4 reveal the complex interplay between resilience and vulnerability. These findings align with theoretical perspectives that highlight the importance of resilience in mitigating the impact of shocks on household welfare.

Table 4.1: Principal component analysis of the welfare index

Principal components/correlation — Number of obs = 810; Number of comp. = 5; Trace = 5; Rho = 1.0000

Rotation: (Un rotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.817	0.452	0.363	0.363
Comp2	1.366	0.456	0.273	0.637
Comp3	0.910	0.259	0.182	0.819
Comp4	0.651	0.396	0.130	0.949
Comp5	0.255	.	0.051	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
Total expenditure	0.033	0.745	0.315	0.397	0.433	0
Education level	0.552	0.441	-0.281	0.056	-0.647	0
Health Service	0.472	0.013	0.597	-0.641	0.096	0
Asset value	0.586	-0.182	-0.510	0.042	0.601	0
Exposure to shock	0.358	-0.466	0.452	0.653	-0.153	0

4.4.2. Intertemporal Dynamic of the Welfare Matrix

Table 4.2 illustrates the intertemporal dynamics of welfare variables for two groups of households (*Enset* Producers and Non-Producers). These variables encompass changes in education, assets, access to health services, exposure to shocks, total consumption, and total income. Key estimation methods likely include calculating change variables as the difference between panel years (2019, 2022 & 2024), using mean and standard deviation (SD) to represent the central tendency and variability of each welfare indicator, and conducting t-tests to evaluate the statistical significance of differences in means between *Enset* Producers and Non-Producers for each variable.

The table presents intertemporal changes in welfare variables, comparing *Enset* Producers and Non-Producers across panel years (2019, 2022, and 2024). Changes in education levels show moderate improvements for both groups, with *Enset* Producers gaining 0.36 years from 2019 to 2022 and an additional 1.43 years between 2022 and 2024. Overall, they achieved a total increase of 0.69 years over the entire period. Non-Producers experienced smaller gains initially but a more substantial increase (2.81 years) from 2019 to 2024. However, these differences were not statistically significant, indicating similar educational progress between the groups. These trends align with existing literature, highlighting slow but steady advancements in rural education due to

policy interventions, although challenges such as poverty and opportunity costs persist (World bank, 2020).

In terms of asset value, *Enset* Producers demonstrated relatively better performance. They experienced an increase of 0.51 asset units per household per annum from 2019 to 2022, although slight declines followed this in later periods. Non-Producers, by contrast, exhibited consistent asset value declines across all periods. The statistically significant differences observed in the early period (2019–2022) suggest that Producers' reliance on *Enset* as a drought-resistant crop might have contributed to better asset retention. Studies corroborate the importance of *Enset* in enhancing household resilience by providing both food security and a safety net during economic shocks (Blomme et al., 2023b).

For access to health services, changes were negligible for both groups, with no significant differences over time. The marginal improvements for Non-Producers in the longer term (2019–2024) indicate some progress, but overall access remains limited. Structural barriers such as distance to healthcare facilities, high costs, and inadequate infrastructure have been widely documented as persistent challenges for rural communities in Ethiopia (ETHIOPIA, FDRC, 2022). Similarly, the exposure to shocks index showed minimal changes across periods for both groups, reflecting ongoing vulnerability to economic and climatic shocks. This finding aligns with studies emphasizing the susceptibility of rural households to external disruptions, which often offset welfare gains (Dercon, 2004; Senbeta et al., 2022).

Consumption and income dynamics reveal contrasting trends between the groups. *Enset* Producers recorded significant increases in total consumption (ETB 13,132.44) per household per annum from 2019 to 2022, though these gains diminished in later periods. Non-Producers, however, experienced a decline in consumption over the entire period. Income trends were equally divergent. While Producers reported significant income gains (ETB 14,182.52) from 2019 to 2022, their income dropped slightly (-ETB 100.69) per household per annum from 2022 to 2024. On the other hand, non-producers achieved a substantial increase in income (ETB 22,464.91) per household per annum during the same period, suggesting better financial outcomes in the short term. However, despite rising incomes, Non-Producers' declining consumption proportions hint at potential priorities such as debt repayment or saving, rather than immediate welfare improvements.

The proportion of consumption expenditure to total income provides a more nuanced perspective on household welfare. For *Enset* Producers, this proportion remained consistently high across the years, exceeding 90% in most cases. In 2022–2024, when income slightly declined, Producers likely relied on savings or borrowing to maintain consumption levels. Non-Producers exhibited a more varied trend, with the proportion reaching 95.40% in 2019 but dropping significantly to 64.49% by 2024 due to their improved income. These figures suggest that Producers rely heavily on income for immediate consumption, reflecting financial vulnerability and limited capacity for savings or investments. On the other hand, non-producers appear to have diversified income sources, allowing for more flexibility in managing consumption and savings.

Total consumption patterns provide valuable insights into the welfare status of households over time. *Enset* Producers consistently exhibited higher levels of consumption compared to Non-Producers across all panel years, with a notable increase of ETB 13,132.44 from 2019 to 2022. This reflects the stabilizing role of *Enset* in ensuring food security and supporting consistent consumption, even during periods of income volatility (Blomme et al., 2023b). However, the growth in consumption among Producers slowed between 2022 and 2024, increasing by only ETB 2,633.76, suggesting potential constraints in income growth or rising consumption costs. Non-producers, on the other hand, experienced a decline in consumption across all periods, with a significant reduction of ETB 266.03 between 2019 and 2024. This declining trend indicates that Non-Producers prioritized savings or debt repayment over immediate consumption, possibly due to their improved income in later years (Sirany et al., 2022). The consistent consumption patterns among *Enset* Producers emphasize the critical role of *Enset* in helping households to maintain a steady standard of living during economic and climatic challenges (Refera et al., 2023). These findings align with prior studies that underscore the importance of *Enset* in enhancing food security and consumption stability in rural Ethiopia.

Table 4.2: Intertemporal Dynamic of the Welfare Matrix

		Household groups		
Welfare variables	year	*Enset* Producers (Mean & SD)	Non-Producers (Mean & SD)	t-test
Change in Education Level (Years)	2022 - 2019	0.359(1.617)	0.2(1.892)	0.064
	2024 - 2022	1.43(1.37)	0.27(0.11)	0.844
	2024 - 2019	0.69 (2.47	2.81 (1.53)	-0.730
Change in value of assets (count)	2022 - 2019	0.513 (3.2)	0.42 (1.2)	1.027**
	2024 - 2022	0.487 (2.65)	-0.61 (4.23)	0.220
	2024 - 2019	0.453(0.352)	0.232(0.521)	0.062
Change in access to health service (count)	2022 - 2019	0.049 (0.576)	0.083 (0.078)	-0.058
	2024 - 2022	0.004 (0.03)	0.002 (0.29)	0.048
	2024 - 2019	0.053 (0.053)	0.06 (0.035)	0.12
Change in exposure to Shocks (count)	2022 - 2019	0.04(0.15)	0.02(0.051)	-0.260
	2024 - 2022	0.02(0.009)	0.09(0.12)	-0.079
	2024 - 2019	0.03(0.09)	0.04(0.012)	-0.110
Change in total consumption (ETB)	2022 - 2019	13132.44 (2576.13	-77.22 (367.62)	5.076***
	2024 - 2022	2633.76 (3106.55)	511.19 (369.62)	-0.524
	2024 - 2019	15766.2 (530.42)	-266.03 (27)	30.186**
Change in total income (ETB)	2022 - 2019	14182.52 (674.63)	-137.7 (198.45)	20.188**
	2024 - 2022	-100.69 (74.03)	22464.91(1843.71)	-8.363***
	2024 - 2019	14081.83 (1853.11)	22327.21(1753.81)	-5.033**

4.4.3. Multidimensional inequality in welfare

Figure 4.2 illustrates the Multidimensional Inequality (MDI) Index trends among *Enset* producers, non-producers, and the general population from 2019 to 2024. Overall, the general population exhibits the highest MDI values, increasing from 0.46 in 2022 to 0.802 in 2024, indicating growing inequality. Non-producers show a dynamic trend, with a sharp decline in MDI from 0.625 in 2019 to 0.352 in 2022, followed by a rise to 0.48 in 2024. In contrast, *Enset* producers maintain consistently lower MDI values, dropping slightly from 0.213 in 2019 to 0.152 in 2022, and recovering marginally to 0.153 in 2024, suggesting a relatively stable and equitable welfare distribution within this group.

The trends highlight key differences between the groups. *Enset* producers consistently experience lower inequality, likely due to the resilience provided by *Enset* farming, which serves as a drought-resistant and sustainable livelihood source. Non-producers, however, show the most variability, reflecting vulnerability to external factors such as unequal resource distribution, market instability, or climate-related challenges. The sharp decline in their MDI between 2019 and 2022 may be attributed to targeted interventions or improved access to resources. However, the subsequent rise by 2024 suggests external shocks or policy gaps may have undermined these gains.

The resilience of *Enset* producers aligns with findings from studies such as Tsegaye et al. (2014), which emphasize the role of *Enset* farming in stabilizing income and reducing vulnerability. Similarly, Gebrehiwot et al. (2019) and FAO (2021) highlight the challenges faced by non-producers reliant on rain-fed agriculture, which exposes them to greater risks. The rising inequality post-2022, particularly for non-producers, is consistent with Dercon et al. (2020), who attribute such trends to economic shocks and uneven policy impacts. These findings underscore the importance of promoting equitable interventions and diversifying livelihoods to address rising inequality, particularly for non-producer households.

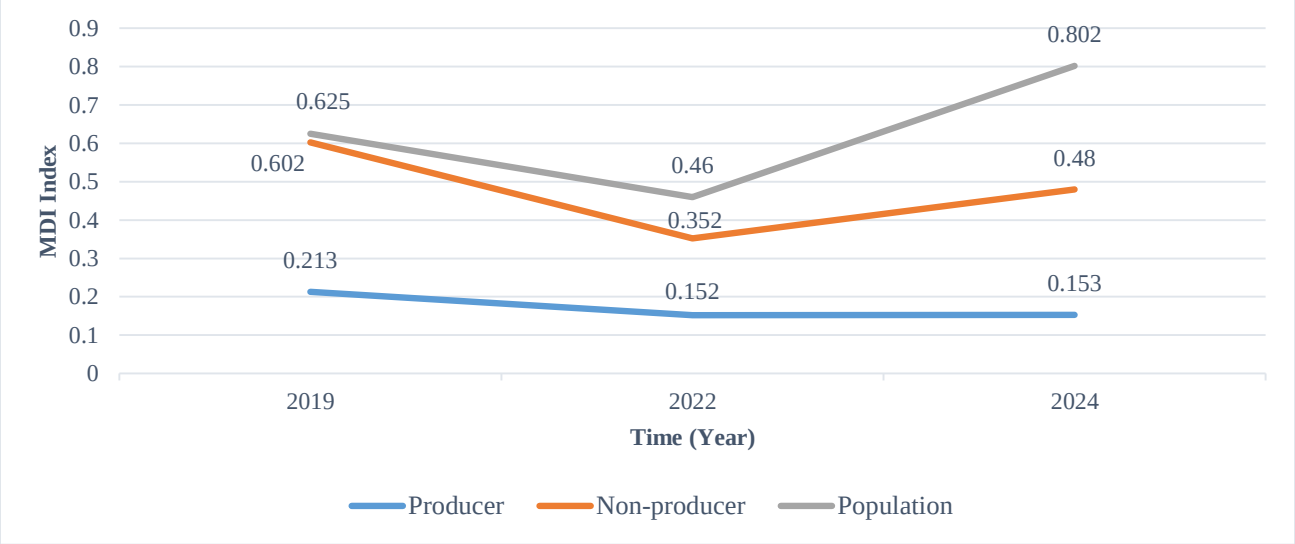

Figure 4.2: Multidimensional inequality in welfare

4.4.4. Average Relative Contributions of the Components to MDI

Figure 4.3 illustrates the average relative contributions of five components—total expenditure, education level, health service, value of assets, and exposure to shocks—to the Multidimensional Inequality (MDI) Index for three groups: producers, non-producers, and the general population. Overall, total expenditure contributes the largest share to MDI across all groups, followed by education level and the value of assets. Health services and exposure to shocks contribute minimally to inequality in all groups. The contributions vary between producers and non-producers, with non-producers experiencing the highest contribution from total expenditure (56.06%) and education level (42.59%) In contrast, producers have more balanced contributions across total expenditure (47.4%), education (27.56%), and the value of assets (18.91%). The

relative contributions appear more evenly distributed for the general population, with total expenditure and education remaining dominant but lower in magnitude than non-producers.

Total expenditure stands out as the primary driver of inequality, peaking at 56.06% for non-producers, suggesting their high dependency on volatile income sources, particularly rain-fed agriculture, which is more sensitive to climatic and market shocks. For producers, total expenditure contributes 47.4%, reflecting the relative stability provided by *Enset* farming, a drought-resistant crop that ensures a more predictable income stream. The value of assets contributes more to producers (18.91%) compared to non-producers (13.09%) and the general population (18.34%), highlighting the role of asset ownership in reducing inequality among agricultural households. This difference may reflect the capacity of *Enset* farming to promote long-term wealth accumulation and resilience against shocks. Education level is the second largest contributor across all groups, peaking for non-producers (42.59%), indicating significant disparities in educational opportunities and access. This aligns with findings from (García & Weiss, 2017; Omic & Halb, 2018), which emphasize the limited educational infrastructure in rural areas and its disproportionate impact on non-producers.

The contributions of health services and exposure to shocks are consistently low across all groups. Health services contribute 2.75% for producers, 9.17% for non-producers, and 3.51% for the general population, indicating that healthcare access may not vary significantly or that other factors dominate the inequality index. Exposure to shocks contributes the least, with values ranging from 1.61% for producers to 4.01% for non-producers and 2.06% for the general population. This suggests that while shocks affect welfare, their overall contribution to multidimensional inequality is relatively minor, potentially due to the buffering effects of communal support systems or targeted interventions.

The observed trends can be triangulated with other studies. The high contributions of total expenditure and education among non-producers are consistent with findings from (García & Weiss, 2017), who highlight the instability of income and limited access to education in rain-fed agricultural communities. Similarly, the relatively stable contributions of asset value and lower inequality among producers align with (Borrell et al., 2020), who emphasize the role of *Enset* farming in enhancing household resilience and wealth accumulation. Moreover, the minimal contributions of health services and exposure to shocks across different groups support the

argument made by various scholars that systemic factors such as income and education disparities often overshadow the effects of healthcare access and shocks on multidimensional inequality. For instance, studies have indicated that while *Enset* farming contributes positively to household income, broader socio-economic factors play a more significant role in shaping overall household resilience and vulnerability (Gebre et al., 2022; Samuel et al., 2015).

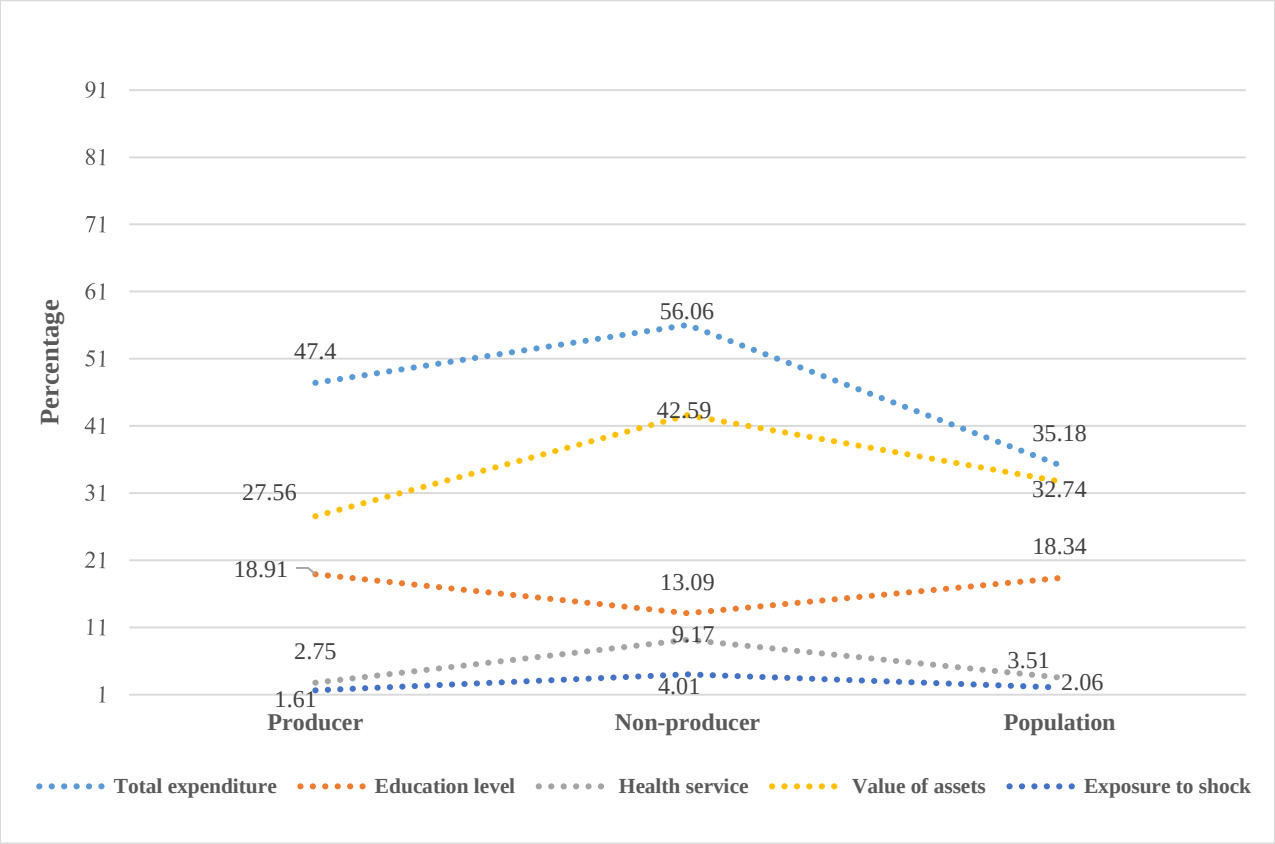

Figure 4.3: Average Relative Contributions of (in %) of the variables to MDI

4.4.5. Determinants of multidimensional inequality in welfare

Table 4.3 shows the outcome of determinants of multidimensional inequality in welfare using fixed-effect regression analysis. Individual effects were uncorrelated with other regressors in the model, according to the Hausman test (see Appendix 4 Table 4.1a). Additionally, the chi-square probability is less than 0.05. As a result, a fixed effect model is chosen, and the null hypothesis is rejected. Using Wald (Greene, 2012) statistics, the model is then diagnosed for heteroskedasticity and autocorrelation (see Appendix 4 Table 4.2b and 4.3c). The model effectively controls for unobserved heterogeneity by focusing on variations within individuals over time, which allows for a more accurate estimation of the impact of the independent variables on the dependent variable.

The overall R-squared values indicate that the model explains a significant portion of the variance in multidimensional inequality, with values of 0.56 for *Enset* producers, 0.45 for non-producers, and 0.52 overall population. This suggests that the model is relatively robust, especially for the producer group, where the independent variables account for a larger share of the variance in welfare inequality. The within R-squared values, ranging from 0.32 to 0.53, highlight the model's ability to capture variations in welfare inequality within entities over time. Additionally, the significant values for Prob > chi2 across all groups (p=0.000) demonstrate the model's overall robustness and reliability.

The coefficients in the table represent the extent to which changes in each independent variable affect welfare multidimensional inequality, holding other factors constant. The results reveal several statistically significant variables with meaningful impacts.

Access to mobile phones emerges as one of the most influential determinants of welfare multidimensional inequality across all groups. For *Enset* producers, having access to mobile phones increases welfare inequality by 0.309 units, with a highly significant p-value at the 1% level. Among non-producers, the effect is even more pronounced, with a coefficient of 0.563, also significant at the 1% level. For the overall population, the coefficient is 0.405, again significant at the 1% level. This variable highlights how disparities in digital access can exacerbate welfare gaps, particularly among non-producers who may lack alternative resources to mitigate inequalities.

Receiving remittances also has a positive but smaller effect on welfare inequality. For *Enset* producers, receiving remittances increases inequality by 0.025 units, significant at the 5% level. Among non-producers, the impact is slightly larger, with a coefficient of 0.055, significant at the 1% level. For the overall population, the coefficient is 0.033, significant at the 5% level. These findings suggest that remittances, while beneficial for some households, may unevenly benefit certain groups, thereby widening inequality.

Employment in government organizations (GO) has a significant negative effect on welfare inequality. For *Enset* producers, employment in GO reduces inequality by 0.0947 units, significant at the 10% level. The effect is much stronger among non-producers, where the coefficient is -0.795, significant at the 1% level. For the overall population, the coefficient is -0.364, also significant at the 1% level. This suggests that stable employment in government organizations

plays a critical role in reducing welfare disparities, particularly among non-producers who might otherwise lack stable income sources.

Time dummy variables also indicate significant trends in welfare inequality over the years. The 2024 dummy variable, in particular, shows a significant increase in inequality across all groups. The effect is strongest for non-producers, with a coefficient of 0.420, followed by *Enset* producers (0.125) and the overall population (0.105). This reflects a potential structural shift in inequality over time, necessitating targeted interventions.

The importance of these significant variables can be contextualized by drawing insights from prior studies. Access to mobile phones is particularly noteworthy, as it underscores the role of digital technology in modern economies. Mobile phones facilitate access to financial services, markets, and information, potentially improving livelihoods. However, their unequal distribution can exacerbate existing disparities. This finding aligns with research by (Aker & Mbiti, 2010), which highlights that while mobile phone adoption in Sub-Saharan Africa has expanded economic opportunities, it can also deepen inequality due to barriers like affordability, digital literacy, and network availability.

Receiving remittances also plays a complex role in welfare inequality. While remittances provide additional income, their benefits are not uniformly distributed across households. Wealthier households may use remittances for investments, while poorer households rely on them for basic consumption. This dual impact is supported by (Adams Jr & Page, 2005), who found that remittances reduce poverty but can simultaneously increase inequality within countries.

Employment in government organizations emerges as a critical equalizer, significantly reducing welfare inequality. Stable and formal employment provides predictable income and often includes social benefits, which help mitigate disparities. This finding is consistent with studies like (Mazundar, 1999), which emphasize the role of formal sector employment in addressing income inequality in developing economies.

The results provide a broader perspective on the drivers of multidimensional welfare inequality and their implications. The significant positive effect of mobile phone access on inequality highlights the challenges of digital inclusion. According to (Hilbert, 2011), while digital technologies can bridge some gaps, they can also exacerbate inequalities in rural and underprivileged areas where access and literacy remain limited. This underscores the need for

policies aimed at equitable digital infrastructure development. The role of remittances in increasing inequality is consistent with findings by (Taylor et al., 2008), who noted that remittances have uneven effects, benefiting certain households more than others. This calls for interventions to ensure that remittances are complemented by broader income redistribution mechanisms. The negative impact of employment in government organizations on inequality highlights the importance of formal sector employment as a stabilizing force in economies. This aligns with the (World Bank., 2018) emphasis on social protection and labor market policies in reducing inequality. Finally, the upward trend in welfare inequality over time, as indicated by the significant 2024 dummy variable, echoes the broader findings of (Piketty, 2014), who argued that economic systems tend toward inequality without deliberate policy interventions. This trend underscores the urgency of addressing structural factors that drive inequality.

Table 4.3: Determinants of multidimensional inequality in welfare-fixed effects

VARIABLES	*Enset* Producer	Non-producer	Overall population
	Coef. & SE	Coef. & SE	Coef. & SE
Sex of HH head (Female Headed)	0.016 (0.00247)	0.0326 (0.032)	0.021(0.0213)
Age of HH head	0.0028 (0.063)	0.0931 (0.0096)	0.045(0.056)
Marital status (Married)	0.0179 (0.069)	0.0011 (0.009)	0.012(0.0214)
Receiving remittance (Yes)	0.025** (0.018)	0.055*** (0.0812)	0.035**(0.045)
Access to credit/borrow (Yes)	0.048 (0.083)	0.0125** (0.056)	0.203**(0.213)
Access to mobile phone (yes)	0.309*** (0.423)	0.563*** (0.091)	0.405(0.485)
Employed on GO (Yes)	-0.0947* (0.0567)	-0.795*** (0.00943)	-0.364**(0.425)
Household size	0.045 (0.0452)	0.031** (0.081)	0.046(0.065)
TLU	0.05(0.105)	0.106***(0.203)	0.08(0.105)
Land size	0.027** (0.057)	0.029 (0.059)	0.032(0.0563)
Year (2019 dummy)	0.092(0.056)	0.324**(0.534)	0.023(0.203)
Year (2022 dummy)	0.052(0.203)	0.132(0.52)	0.130(0.421)
Year (2024 dummy)	0.125**(0.53)	0.420***(0.256)	0.105**(0.23)
Constant	-0.545*** (0.0181)	-0.824*** (0.623)	-0.563***(0.532)
Sigma_u	0.0042	0.06	1.244
Sigma_e	0.0143	0.05	0.241
Rho	0.1029	0.22	0.785
Mean dependent var	0.091	-0.223	1.348
Overall r-squared	0.56	0.45	0.52
R-squared within	0.32	0.23	0.53
SD dependent var	1.339	1.617	1.561
Number of obs	608	202	810
Prob > chi2	0.000	0.000	0.000
R-squared between	0.570	0.524	0.652
Akaike crit. (AIC)	17.52	13.21	21.848
Bayesian crit. (BIC)	23.21	15.23	24.519

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.5.Conclusion and Recommendations

This study explored the intertemporal dynamics and determinants of welfare inequality among *Enset*-producing and non-producing households in Central Ethiopia using a multidimensional approach. The findings highlight significant differences in welfare inequality between the two groups and provide insights into the temporal patterns influencing welfare outcomes over time. The intertemporal dynamics reveal that *Enset*-producing households have maintained relatively stable welfare inequality levels over time, owing to the resilience of *Enset* as a crop that supports food security and income stability. Conversely, non-producing households exhibited higher and more volatile levels of welfare inequality, reflecting greater vulnerability to shocks and limited access to sustainable livelihoods. Temporal factors such as advancements in technology (e.g., mobile phones) and policy changes (e.g., land reforms) played pivotal roles in influencing welfare inequality across both groups.

In terms of the determinants of multidimensional welfare inequality, the study identified distinct factors for each group:

- For *Enset*-producing households, access to mobile phones, remittances, and land size were critical in reducing welfare inequality. These determinants reflect the significance of both productive assets and connectivity in stabilizing welfare outcomes.
- For non-producing households, access to mobile phones, employment status, and household size were the primary determinants. These factors emphasize the importance of labor market opportunities and social dynamics in shaping welfare inequality.
- For the overall population, access to credit, mobile phones, and land size emerged as consistent determinants, highlighting their overarching importance in addressing welfare inequality across diverse household types.

The results underscore the multifaceted nature of welfare inequality, shaped by structural, demographic, and technological factors, with group-specific and temporal differences influencing outcomes.

To reduce welfare inequality and promote sustainable development in Central Ethiopia, policymakers should expand support for *Enset* cultivation by providing improved varieties, technical training, and promoting its role as a climate-resilient crop. Group-specific interventions are essential: *Enset* producers would benefit from enhanced land access, remittance facilitation,

and improved rural connectivity, while non-producers require targeted efforts in employment creation, family planning, and technological access. Expanding financial inclusion through affordable credit and fostering mobile connectivity can address disparities for both groups. Adopting a multidimensional welfare approach that includes education, health, and social capital is critical to tackling the root causes of inequality. Additionally, targeted programs for non-producers should focus on income diversification and asset building to reduce their vulnerability. Policies must also incorporate intertemporal insights to address both immediate and long-term challenges, with regular monitoring to evaluate trends and explore scalable solutions such as *Enset* production in other regions. In addition, future research should further investigate the sustainability of *Enset* production and explore its scalability in other regions experiencing similar inequality challenges.

CHAPTER 5: FOOD INSECURITY AND COPING STRATEGIES OF *ENSET*-PRODUCING AND NON-PRODUCING HOUSEHOLDS IN THE CENTRAL ETHIOPIA REGION: USING A CARI

Abstract

This study examines food insecurity and coping strategies in Enset (Ensete ventricosum) - producing versus non-producing households in central Ethiopia, highlighting agriculture's importance in addressing the Sustainable Development Goal of Zero Hunger. The study employs a mixed-methods approach, combining quantitative and qualitative data. A cross-sectional household survey was conducted with 270 respondents, supplemented by focus group discussions and interviews with 11 key informants. Inferential statistics were used to analyze food security determinants, including t-tests, chi-square tests, and an ordered logit model. Thematic analysis was applied to qualitative data, and the Consolidated Approach to Reporting Food Security Indicators (CARI) framework was used to assess food security levels. The results indicate that Enset-producing households have 4.725 consumption rates of pulses and 2.36 days fats compared to non-producers, who consume 2. 354 days of pulse and 0.875 days of fat per week. Enset producer households also had higher mean total food expenditure (96,157.46 ETB) per year compared to non-producers (89,098.07 ETB). Coping strategies revealed that 6.38% of Enset producers sell assets under stress, compared to 31.25% of non-producers. The CARI index showed that 3.52% of Enset producers are food secure, while none of the non-producers are food secure. The study concludes that Enset producers are more food secure, and recommends promoting Enset cultivation to enhance food security in central Ethiopia region.

***Keywords**: Food insecurity, coping strategies, CARI, Enset production, ordered logit*

5.1. Introduction

The Sustainable Development Goals (SDGs), adopted by all United Nations Member States in 2015, emphasize key objectives including achieving zero hunger (Goal 2) (Nations, 2015). These global targets are particularly relevant to Ethiopia, where the government has been implementing strategies like the Growth and Transformation Plan (GTP), the Ten Years Development Plan, and the Seqota Declaration to enhance agricultural productivity, reduce poverty, and improve food security. Despite these initiatives, Ethiopia continues to face significant challenges in combating food insecurity due to factors such as high population growth, climate change, and limited access to resources (WFP, 2021). The ten-year Ethiopian development plan (2021-2030) is a policy framework aimed at achieving sustainable and inclusive growth while ensuring food security for all citizens (Wazza, 2022). This study aligns with the goals of this plan by providing an evidence-based analysis of food security dynamics and coping strategies in the central Ethiopia region, focusing specifically on the *Enset* producer and non-producer households.

Food insecurity remains a pervasive issue globally, with an estimated 828 million people suffering from hunger in 2021 (FAO, IFAD, UNICEF, WFP, 2022). Sub-Saharan Africa, where more than 20% of the population experiences chronic food insecurity, remains the region with the highest prevalence of hunger worldwide (World Bank, 2022b). Ethiopia, in particular, has long been vulnerable to food insecurity due to recurrent droughts, political instability, and economic challenges, especially in rural areas where agriculture is the primary livelihood (ReliefWeb, 2022). In regions such as central Ethiopia, where traditional crops like *Enset* play a critical role, understanding the link between agricultural practices and food security is essential.

Enset (*E. ventricosum*), commonly known as the "tree against hunger," is a staple crop in the southern and central highlands of Ethiopia, providing food security for millions of households (Gebre et al., 2022). Its resilience to drought and year-round harvesting capacity make it a crucial buffer against food insecurity in these regions. Despite its importance, there is limited research comparing the food security outcomes and coping strategies of *Enset*-producing households with those who do not engage in *Enset* cultivation. Addressing this gap is critical for designing effective interventions to enhance food security.

While previous studies such as (Aneseyee et al., 2022; Bassa et al., 2024; Blomme et al., 2023b; Bonso et al., 2022; Borrell et al., 2020; Brandt, 1997; Feyisa et al., 2022; Gebre et al., 2022; A. Haile et al., 2020; Tsegaye & Struik, 2001; Yemata, 2020) have explored the role of *Enset* production in food security, they have not adequately addressed the determinants of food security and coping strategies for food insecurity in a comparative context between *Enset*-producing and non-producing households. Additionally, existing research lacks a deep analysis of factors such as exposure to shock, and demographic and socioeconomic that influence food security outcomes. Furthermore, an assessment using multidimensional indicators, such as the Consolidated Approach to Reporting Indicators of Food Security (CARI)-which is currently being developed by World Food Program (WFP, 2021), has not been widely applied in these contexts, limiting the ability to fully understand household well-being.

Given the persistent challenges of food insecurity in Ethiopia, especially in the central Ethiopia region where *Enset* is a key crop, there is a need for research that fills the existing gaps. Understanding the disparities in food security between *Enset* producers and non-producers can provide insights into the effectiveness of *Enset* cultivation as a food security strategy. By applying

the CARI framework, which combines short-term and long-term food security indicators, this study offers an analysis of the factors driving food insecurity and the coping strategies adopted by households. This approach ensures that the study provides nuanced insights into varying food security levels across different household types, thereby addressing critical knowledge gaps.

This study specifically focuses on assessing the differences in food insecurity and coping strategies between *Enset*-producing and non-producing households in the central Ethiopia region using the CARI framework. It aims to provide a multidimensional analysis that captures both immediate and underlying factors influencing food security. Unlike previous studies that narrowly focus on single indicators or lack comparative analysis, this research systematically evaluates the food security role of *Enset*-producing households. The findings will offer new insights into the role of *Enset* as a food security crop and inform agricultural and food security policies in Ethiopia. In addition, this study addresses the urgent need to better understand food security dynamics in central Ethiopia by focusing on *Enset* cultivation through the lens of the CARI framework. By comparing *Enset*-producing and non-producing households, the research will generate valuable evidence on the effectiveness of *Enset* as a food security crop and provide an analysis of coping strategies in the region. The findings will contribute to the academic discourse on food security while offering actionable insights for policymakers and development practitioners aiming to enhance reducing food insecurity in Ethiopia.

5.2.Conceptual framework of the study

In assessing food insecurity, numerous indicators have been developed to measure its extent and impact. The Food Insecurity Experience Scale (FIES) and the Household Food Security Survey Module (HFSSM) are commonly used tools that consider both qualitative and quantitative aspects of food access (FAO, 2020). This study utilizes a consolidated approach (CARI) to food security reporting, which allows for a more comprehensive analysis of the coping strategies of *Enset*-producer and non-producer households. Such an approach facilitates a detailed understanding of how agricultural practices and household characteristics contribute to food security outcomes in the study area. Since food insecurity is a complicated and multifaceted phenomenon, measuring and monitoring it calls for an all-encompassing strategy. A single household food security survey's basic results are analyzed using the standardized WFP approach known as the Consolidated Approach for Reporting Indicators of Food Security (CARI), which also classifies individual

households according to their level of food security. Additionally, it can be utilized to determine WFP program targeting criteria and do household vulnerability profiling. To address the shortcomings of earlier approaches that relied on single indicators or composite indices, the World Food Programme (WFP) established the CARI in 2015, and it was revised in 2021 (WFP, 2021).

CARI was utilized in this study to evaluate the population's food insecurity position and to pinpoint the most vulnerable populations and regions. By combining four essential indicators Food Consumption Score (FCS), Reduced Coping Strategies Index (rCSI), Economic Capacity to Meet Essential Needs (ECMN), and Food Security Experience Scale CARI gives a complete picture of the state of food security (FSES). These variables cover various aspects of food security, including dietary quality and variety, coping strategies, financial accessibility, and individual perspective. Each household will be assigned to one of four food security groups, including "food secure," "marginally food secure," "moderately food insecure," or "severely food insecure," depending on these indicators.

The conceptual framework for this study integrates multiple indicators to assess food insecurity and coping strategies among *Enset*-producer and non-producer households in central Ethiopia region (Figure 5.1). The framework utilizes the Food Consumption Score (FCS), Reduced Coping Strategies Index (rCSI), and Food Expenditure Share as primary input indicators. The FCS evaluates dietary diversity, frequency, and nutritional adequacy, providing a quantitative measure of food security status. The rCSI captures the extent of negative coping strategies, such as reducing meal sizes or borrowing food, to manage food shortages, thereby serving as an indicator of food insecurity levels (D Maxwell & Caldwell, 2008). Additionally, the proportion of income allocated to food expenses (Food Expenditure Share) indicates household vulnerability, with a higher share often reflecting financial stress and reduced resilience (Alinovi et al., 2010). By integrating these indicators, the framework assesses economic vulnerabilities that shape households' food security and coping capacity.

The framework further applies the Consolidated Approach to Reporting Indicators (CARI), which synthesizes input indicators to categorize households into distinct food security levels. CARI's color-coded classification offers an assessment, categorizing households from food secure to highly food insecure, supporting targeted interventions (WFP, 2021). This framework is particularly relevant in comparing *Enset*-producer and non-producer households. *Enset*, a drought-

tolerant crop, provides a buffer against food insecurity, likely leading to higher food security levels and reduced coping needs among *Enset*-producers. In contrast, non-producer households face heightened economic vulnerabilities due to reliance on less resilient crops. Understanding these dynamics enables more precise identification of coping strategies—such as reliance on less preferred foods or increased participation in off-farm work—employed by each group. This approach offers valuable insights for designing tailored policies aimed at improving food security across varying household types in central Ethiopia region.

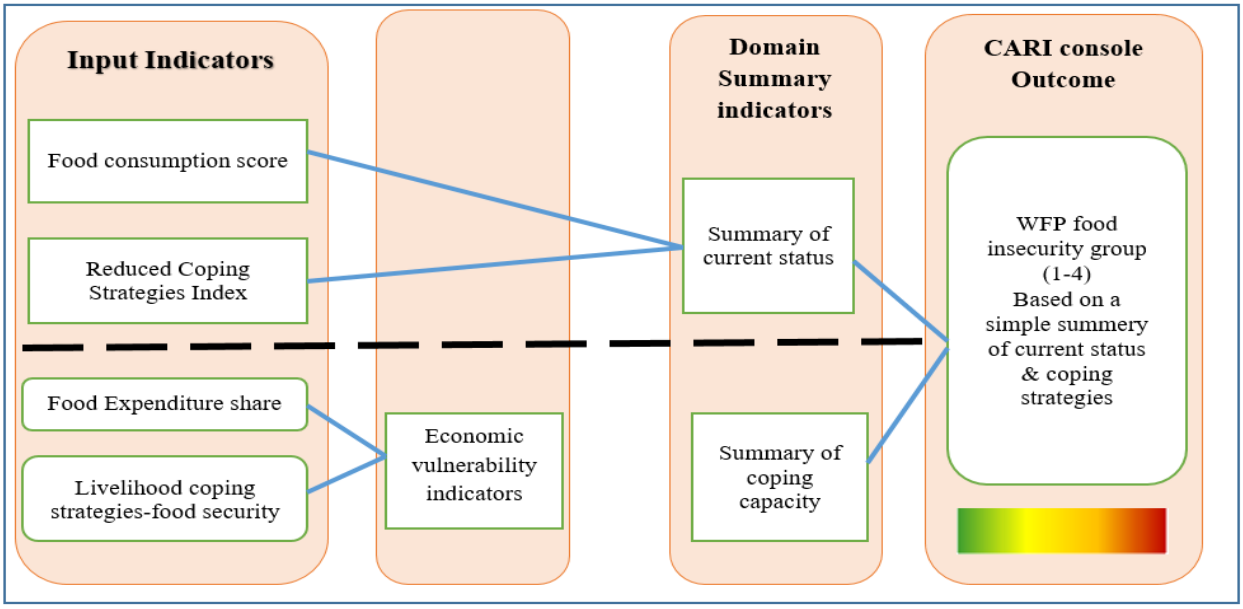

Figure 5.1: Conceptual framework (WFP, 2021)

5.3.Materials and methods

5.3.1. Research design

This study employs a cross-sectional design and adopts a mixed-methods approach, incorporating both quantitative and qualitative data. In this chapter, we have used a cross-sectional dataset because the CARI approach requires detailed and specific information on multiple dimensions of food security such as food consumption score, coping strategies, food expenditure share, and livelihood coping strategies which were comprehensively collected only during the primary data collection round (2023/24). These variables are typically not fully captured in routine panel datasets. Therefore, to apply the full CARI methodology appropriately and ensure accurate classification of households into food security categories, the cross-sectional dataset was most suitable for this part of the analysis.

The research philosophy guiding this study is pragmatism, blending elements of both positivism and constructivism, to offer an understanding of the research problem. The study follows an abductive reasoning approach, which integrates both deductive and inductive methods, enabling a dynamic exploration of the dimensions of household food security. The primary aim of this research is to assess various dimensions of household food security, specifically comparing *Enset*-producing households with non-producing households. To ensure consistency and robustness in the design and methodological approach of the study aligns its design, sampling strategies and data collection strategies with the Living Standards Measurement Study (LSMS) framework, drawing research design from multiple years of the Ethiopian Socioeconomic Survey (ESS) conducted by the World Bank. This research design provides a solid foundation for an evaluation of household food security, facilitating an in-depth analysis of both *Enset*-producing and non-producing households in central Ethiopia region.

5.3.2. Sampling techniques and sample size

To ensure consistency and robustness in the sampling strategies, the researcher aligns the sampling strategies with the Living Standards Measurement Study (LSMS) framework, drawing sampling design from multiple years of the Ethiopian Socioeconomic Survey (ESS) conducted by the World Bank.

The households in the sample were chosen from the preselected group in the LSMS survey conducted by ESS and the World Bank. The study tracked 319 rural households in 2018/19, 307 in 2021/22, and 290 in 2023/24. Despite an annual attrition rate of less than 1%, the final analysis included 270 households surveyed across all waves. The sample comprised 75% of *Enset*-producing households and 25% of non-producer households, proportionally distributed within the overall sample size. The sampling strategy employed ensures that the sample adequately captures variations in practices, perspectives, and socio-economic impacts associated with *Enset* production. Proportionally distributing these groups within the overall sample size enhances the representativeness and validity of the findings, allowing for robust comparative analyses. This approach aligns with recommendations in the literature, such as (Creswell & Creswell, 2017), which emphasizes stratified sampling to ensure critical subgroups are represented in sufficient numbers for meaningful analysis. Additionally, it reflects the importance of addressing heterogeneity within the population, as highlighted by (Etikan & Bala, 2017), who stresses the

need to balance inclusivity and specificity when studying diverse communities. By maintaining proportionality, this strategy minimizes sampling bias and supports an understanding of the research topic.

5.3.3. Data collection tools/methods

Data collection methods included household questionnaires, focus group discussions (FGDs), and key informant interviews, which were consistent with the procedures followed by ESS. The same tools and methodologies were applied across all survey waves to ensure the reliability and comparability of the data. This approach facilitated the effective tracking of *Enset* producer and non-producer household food in/security dynamics. In addition, before data collection, the College of Development Studies of Addis Ababa University approved the data collection tools on March 30, 2024, with letter number 073/04/2024. The time frame for data collection was from April 1, 2024, to June 30, 2024, followed by the analysis period, which took place from July 1, 2024, to September 30, 2024.

5.3.4. Methods of data analysis

Data analysis was performed using descriptive statistics such as mean, percentage, standard deviation, and indices to summarize key data characteristics. Inferential statistics, including t-tests and chi-square tests, were applied, while an ordered logit model was utilized as an econometrics model to identify the determinants of food security. For focus group discussions and key informant interviews, we used thematic analysis to identify and interpret key themes and patterns in the data. The analysis was carried out by integrating quantitative and qualitative data into a study phenomenon. Quantitative data, in this case, numbers from structured surveys while qualitative data from focus group discussion, enriches the analysis with in-depth possible understanding. So that this combination resulted in a more all-rounded, interpretation of the study: a balanced combination of statistical rigor and qualitative depth. The result, therefore, is more robust and applicable.

5.3.4.1. Measuring food insecurity and coping mechanisms

Food security is a fundamental parameter of social stability that is often difficult to quantify due to various subtleties and complexities. A systematic approach to assessing this parameter is crucial, not only to understand the current situation but also to develop strategies to address the current

problems. In this context, this study uses the CARI (Consolidated Approach for Reporting Indicators of Food Security) an approach to understanding the complex dynamics of food security at the household level (WFP, 2021). CARI is a methodology adopted by the World Food Program (WFP) that facilitates the analysis of raw data from individual household food security surveys and classifies households according to their level of food security. In particular, the method also enables the creation of vulnerability profiles of households and helps identify target group criteria that are important for programming. This study aims to delve deeper into the applicability and relevance of CARI in measuring food security, providing valuable insights that could shape future strategies and policies.

In the context of *Enset*-producing and non-producing households in central Ethiopia, CARI's selected indicators—Food Consumption Score (FCS), reduced Coping Strategies Index (rCSI), and Expenditure on Consumption and Nutrition (ECMN)—effectively capture the unique food security challenges faced by these households, particularly considering regional and cultural variations. It provides a robust framework for analyzing food security among *Enset*-producing and non-producing households in central Ethiopia. These indicators not only capture the quantitative aspects of food consumption but also reflect qualitative factors such as dietary diversity and coping strategies influenced by regional and cultural variations. By utilizing these indicators, stakeholders can better understand the complexities of food security challenges in this context and design more effective interventions tailored to the specific needs of different household types (WFP, 2022)

According to the (WFP, 2021), the Consolidated Approach for Reporting Indicators of Food Security (CARI) is a method to classify the food security situation of households into four categories: food secure, marginally food secure, moderately food insecure, and severely food insecure. The CARI is based on two domains: the current status and the coping capacity. The current status domain measures the current food consumption and dietary diversity of households, using the Food Consumption Score (FCS) and the Reduced Coping Strategies Index (rCSI). The coping capacity domain measures the ability of households to cope with food shortages and shocks, using the Food Expenditure Share (FES) and Livelihood Coping Strategies – Food Security (LCS-FS).

Food Consumption Score (FCS) is a composite score created by taking into account how frequently a household eats various food types for the seven days preceding the survey. The FCS

cut-offs of 28 and 42 to be used when sugar and oils are eaten daily should be carefully applied after consideration of the intake of oil and sugar. As a result, the standard numeric FCS cut-offs are the following: Acceptable>35, borderline 21.5 -35, and poor ≤ 21. To convert the Food Consumption Score (FCS) to the CARI's 4-point scale, the process involves several steps. First, calculate the FCS and categorize each household into one of three groups: Poor, Borderline, or Acceptable, using country-specific thresholds. Then, convert these groups into a 4-point scale: 'Acceptable' households become 'Food Secure' with a score of 1, 'Borderline' households become 'Moderately Food Insecure' with a score of 3, and 'Poor' households become 'Severely Food Insecure' with a score of 4. Additionally, households categorized as 'Food Secure' are downgraded to 'Marginally Food Secure' (score 2) if their reduced Coping Strategies Index (rCSI) is 4 or higher. Finally, a frequency analysis is conducted to determine the distribution of households across these categories, and the results are integrated into the CARI console

The formula for the FCS generally takes this form:

$$FCS = \sum (food\ group\ weight * frequency\ of\ consumption) \quad (5.1)$$

The rCSI (reduced Coping Strategies Index): According to the WFP (2021) it is an indicator used to understand households' short-term coping capacity in response to a lack of food or money to buy food. It is a measure of the frequency and severity of food-related coping behaviors that households adopt when they face food shortages. For each coping strategy, the frequency score (0 to 7) is multiplied by the universal severity weight; the weighted frequency scores are summed up to calculate the rCSI. The minimum possible rCSI value is 0, while the maximum is 56. Then the average (mean) is computed (all households should be considered, also those who are not applying any strategies)

$$rCSI = (\sum frequency\ behavior(0-7) * severity\ weight\ 1-3) \quad (5.2)$$

Where: rCSI represents the reduced coping Strategies Index for households. (∑ frequency behavior * severity weight 1-3) represents the calculation of the sum of the frequency of behaviors multiplied by their corresponding severity weights. This study followed the procedure (WFP, 2021) rCSI strategies that households use to cope with food shortages and their corresponding weights. The weights reflect the severity of the strategies, with higher weights indicating more severe coping behaviors. The strategies rely on less preferred and less expensive food (weight =

1), borrowing food or relying on help from relative(s) or friend(s) (weight = 2), limiting portion size at meals (weight = 1), restrict consumption by adults to allow small children to eat (weight = 3), and reduce the number of meals eaten in a day (weight = 1). The rCSI cut-offs are the thresholds that indicate different levels of food insecurity based on the rCSI scores. The IPC has established specific cut-off points for rCSI that categorize food insecurity into different phases: Phase 1 (Minimal): rCSI score of 0-3, Phase 2 (Stressed): rCSI score of 4-18 and Phase 3 (Crisis): rCSI score of ≥19. These thresholds are derived from empirical research and are intended to provide a clear framework for assessing food security levels within households (FEWS NET., 2021)

The FES (food expenditure share) is an indicator used to measure households' economic vulnerability. It determines the economic vulnerability without the need to have a reference to a poverty line or minimum expenditure basket (FAO, 2017). The FES is calculated as the ratio of the total food expenditure to the total consumption expenditure of a household (WFP, 2021). The FES can be expressed as a percentage or a decimal number. The FES is used in the CARI as one of the indicators of the Coping Capacity domain. The Coping Capacity domain reflects the ability of households to cope with shocks and stresses that affect their food security. The higher the share of households' consumption expenditures on food, the more vulnerable the households are to food insecurity. The CARI uses the following cut-offs to categorize households based on their FES (WFP, 2019):

- FES <50% of income = Food Secure
- FES between 50% - 65% of income = Marginally food secure
- FES between 65% - 75% of income = Moderately food insecurity
- FES between ≥75% of income = Severely food insecure

The FES is then combined with other indicators of the Current Status and Coping Capacity domains to classify households into four food security categories: Food Secure, Marginally Food Secure, Moderately Food Insecure, and Severely Food Insecure.

Livelihood coping strategies for food security: According to the WFP (2021) livelihood Coping Strategies – Food Security (LCS-FS) indicator is used to assess how households manage medium- to long-term challenges related to food insecurity or insufficient financial resources to purchase food. It reflects their resilience and capacity to address similar issues in the future. This indicator

is based on responses to a set of questions that explore how households deal with stress and the extent of asset depletion as a means to handle food shortages

To calculate the LCS-FS indicator, we have selected 4 stress strategies, 3 crisis strategies, and 3 emergency strategies that are most relevant to the context. Analysts are encouraged to select the most relevant 10 strategies to their context. Each strategy has a recommended severity score, ranging from 1 (least severe) to 3 (most severe). The LCS-FS indicator is calculated as the sum of the severity scores of the strategies reported by the household, multiplied by the frequency of use of each strategy. The frequency of use can be measured on a scale of 1 (rarely) to 4 (always).

The formula for the LCS-FS indicator is:

$$LCS\_FS = \sum_{i=1}^{n} S_i \times F_i \quad (5.3)$$

Where: LCS_FS is the Livelihood Coping Strategies – Food Security indicator; n is the number of strategies reported by the household; Si is the severity score of the i-th strategy; Fi is the frequency of use of the i-th strategy. The LCS-FS indicator can be used to classify households into four categories of coping capacity: low, medium, high, and very high. The cut-off points for these categories are context-specific and should be determined based on the distribution of the LCS-FS scores and the analysis of the most common strategies used by households.

To calculate the overall CARI, first calculate the four indicators (FCS, FES, LCS-FS, and rCSI) for each household, and then assign them into four categories (Food secure, marginally food secure, moderately food insecure, and severely food insecure) based on the cut-off points for each indicator. This process involves several steps: First, a "summary indicator of Current Status" Is computed by calculating the mean value of household responses (on a 4-point scale) for relevant indicators in the Current Status domain (FCS and rCSI). Next, a "summary indicator of Coping Capacity" is determined by averaging the household's scores for indicators in the Coping Capacity domain (FES and LCS-FS) indicator. The overall food security outcome is then calculated by averaging the Current Status and Coping Capacity summary indicators and rounding the result to the nearest whole number between 1 and 4. The final value represents the household's food security status classification. The formula for the CARI is:

$$CARI = [(CS) + (CC/2)]/2 \quad (5.4)$$

Where: CARI represents the dependent variable for the households. CS represents households' Current Status (including both FCS and rCSI). CC indicates Coping Capacity (includes both FES and LCS-FS) for households.

5.3.4.2. Determinants of food security

The ordered logit model is well-suited for analyzing the determinants of food security due to its ability to handle ordinal dependent variables, its interpretability, and its alignment with the nature of the data collected. The model captures the nuances of varying levels of food security, allowing for a more detailed analysis, and operates under the assumption of proportional odds, which is particularly suitable for food security analysis. The coefficients obtained from the ordered logit model can be interpreted in terms of odds ratios, providing insights into how changes in the explanatory variables influence the likelihood of being in a higher or lower category of food security, which is crucial for policymakers aiming to address food insecurity. While binary logit or probit models could be employed, they would oversimplify the analysis by collapsing the ordinal categories into a binary outcome, leading to less effective interventions. Previous studies have successfully utilized the ordered logit model to analyze food security determinants, demonstrating its effectiveness in capturing the complexity of food security issues across different contexts and populations, reinforcing the choice of the ordered logit model for this analysis (Astemir, 2014; Muche & Tolossa, 2022). To identify the determinants of food security, an ordered logit model is specified due to the ordinal nature of the dependent variable, which consists of four categories: Food Secure, Marginally Food Secure, Moderately Food Insecure, and Severe Food Insecurity. The model can be expressed as follows:

$$f(\gamma j(x)) = log(\frac{f(\gamma j(x)}{1-f(\gamma j(x)}) = log(\frac{pr(y \leq jX}{pr(y>jx}) = \alpha j + \beta x, j = 1,2 \dots k-1$$
$$\gamma j(x) = \frac{e^{\alpha j+\beta x}}{1+e^{\alpha j+\beta x}} \quad (5.5)$$

In this specific formula, j indicates the cut-off points for all categories (k) of the dependent variable, the function f(γj(x) is the link function that links the systematic components (i.e αj+βx) Within the linear model, each α signifies a unique threshold associated with a specific cumulative probability, and β stands for the regression coefficient (McCullagh, 2019).

5.4.Results and discussion

5.4.1. Food consumption pattern among households

Figure 5.2 presents that *Enset*-producing households exhibit higher average days of consumption across most food groups compared to non-producers. For instance, *Enset* producers consume starchy staples (5.296 days) and condiments (5.296 days) nearly every day, reflecting the central role of *Enset* in their diet. This high consumption rate of staples aligns with the essential role of *Enset* as a primary food source, which is processed into various forms like kocho and bulla, providing both energy and nutrition (Tsegaye & Struik, 2001). Additionally, *Enset* producers show relatively high consumption of pulses (4.725 days) and fat (2.359 days), suggesting that these households incorporate a diversity of plant-based foods and cooking fats in their diet. The moderate consumption of vegetables (2.12 days) and dairy products (2.359 days) indicates a degree of dietary variety, though consumption of animal products remains limited. This pattern reflects the common agricultural practice of integrating *Enset* cultivation with other crop and livestock production, yet highlights the constraints on animal protein sources (Getachew, 2019). The lower frequency of fruit consumption (1.514 days) and high condiment use (5.296 days) are consistent with traditional Ethiopian dietary preferences, where spices and flavorings are integral to daily meals (Wendimu & Tekalign, 2022).

In contrast, non-*Enset*-producing households exhibit lower average days of consumption across most food groups. Staples are consumed less frequently (2.854 days) compared to *Enset* producers, indicating a reliance on alternative staple foods such as cereals, which may not be as central to their diet as *Enset* (Tsegaye & Struik, 2001). Pulses and dairy products are also consumed less frequently (2.354 days and 0.875 days, respectively), which could reflect differences in agricultural practices and market access affecting food availability and consumption patterns. Protein sources, including meat and fish, are consumed minimally (0.146 days), highlighting possible constraints in access or affordability of these foods. The lower intake of fat (0.875 days) and sugar (0.146 days) might indicate a more restricted diet or differences in dietary habits compared to *Enset* producers. The increased frequency of fruit consumption (1.792 days) compared to *Enset* producers suggests that non-producers might have better access to diverse fruit sources or different dietary preferences. The lower condiment consumption (2.854 days) reflects a reduced emphasis on traditional flavorings, potentially due to different culinary practices or ingredient availability (Aliyo et al., 2022).

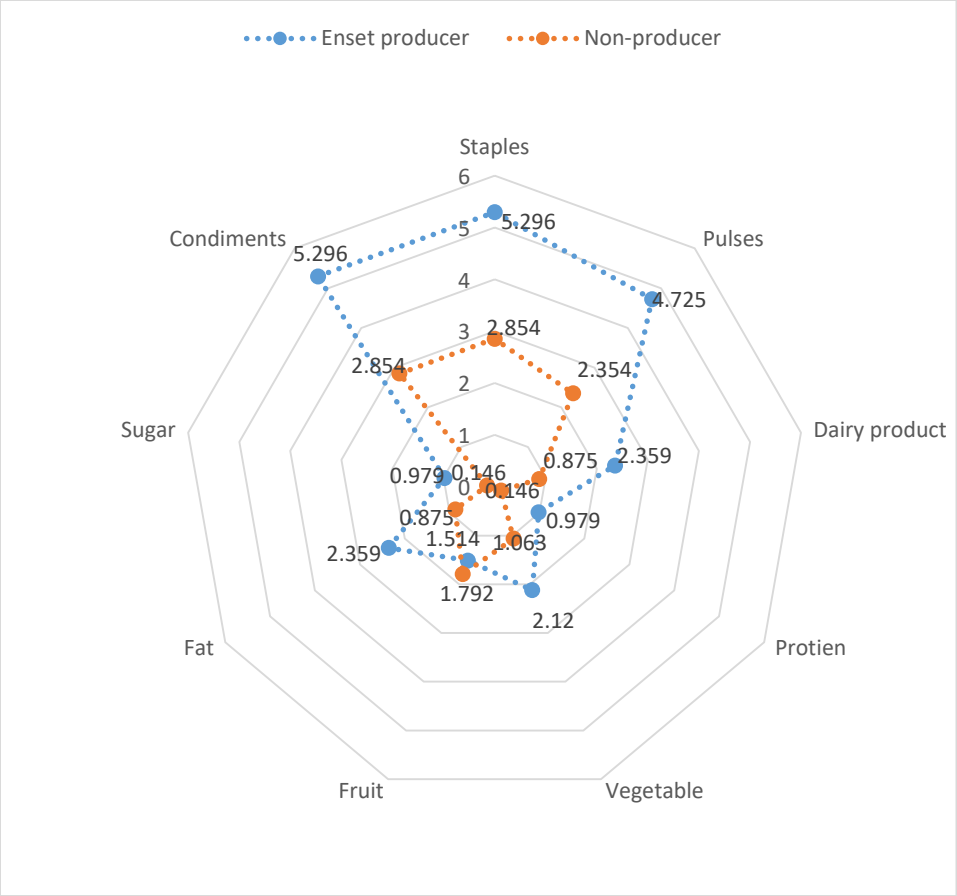

Figure 5.2: Average days of food group consumption

5.4.2. Reduced coping strategies index (rCSI)-short period

Table 5.1 presents the Reduced Coping Strategies Index (rCSI) results for *Enset*-producing and non-producing households, focusing on five key coping behaviors: relying on less preferred or less expensive food, borrowing food or relying on help from others, reducing the number of meals eaten per day, reducing portion sizes at meal times, and restricting adult consumption to prioritize children. For *Enset* producers, the mean score for relying on less preferred food is 2.16, while non-producers have a higher mean of 4.75, indicating greater food insecurity. The availability of *Enset*, known for its resilience and storability, likely reduces the need for such coping strategies among *Enset* producers, as highlighted in studies (Tsegaye & Struik, 2001). When it comes to borrowing food or relying on help, *Enset* producers have a mean score of 1.35 compared to 3.75 for non-producers, reflecting better economic resilience among *Enset* households. Non-producers also show higher scores for reducing the number of meals eaten per day (3.75 versus 1.35), indicating a higher degree of food stress. For reducing portion sizes at mealtime, non-producers have a mean

of 2.75 compared to 0.73 for *Enset* producers, further signaling food insecurity. Additionally, non-producers are more likely to restrict adult consumption to prioritize children, with a mean score of 1.85 compared to 0.51 for *Enset* producers. These findings align with existing literature emphasizing *Enset*'s role in enhancing food security and reducing reliance on severe coping mechanisms due to its storability and drought resilience. Overall, *Enset* producers show better food security, underscoring the importance of promoting *Enset* cultivation to enhance food security and reduce vulnerability in regions prone to food shortages.

Table 5.1: Reduced Coping Strategies Index (rCSI)

		Relied on less preferred, less expensive food (rCSILessQlty)	Borrowed food or relied on help from friends or relatives (rCSIBorrow)	Reduced the number of meals eaten per day (rCSIMealNb)	Reduced portion size of meals at meal time (rCSIMealSize)	Restricted consumption by adults for young children to eat (rCSIMealAdult)
Enset producer	N	202	202	202	202	202
	mean	2.162	1.352	1.352	0.732	0.514
	SD	1.662	1.464	1.464	1.19	0.913
	Min.	0	0	0	0	0
	Max.	6	5	5	4	4
Non-producer	N	68	68	68	68	68
	Mean	4.75	3.75	3.75	2.75	1.854
	SD	1.28	1.28	1.28	1.28	1.031
	Min.	2	1	1	0	0
	Max.	6	5	5	4	3

5.4.3. Food expenditure share

The food expenditure patterns among *Enset* producers and non-producers in the central Ethiopia region reveal significant differences that reflect their economic status and consumption behaviors (Table 5.2). *Enset* producers' results show a mean total food expenditure of 96,157.46 ETB, with a standard deviation of 64,990.00 ETB, indicating a wide variation in food spending among these households. The minimum expenditure recorded was 15,236 ETB, while the maximum reached 504,887.72 ETB. In contrast, of 48 households non-producers had a lower mean total food expenditure of 89,098.07 ETB, with a standard deviation of 96,819.61 ETB, showcasing a similar but slightly less variable spending pattern. Their expenditures ranged from 10,060.73 ETB to 613,377.38 ETB. This comparison suggests that *Enset* producers may have better access to food resources or higher income levels, allowing for greater food expenditure, which is essential for understanding regional food security dynamics (Gebre et al., 2022; Kuma, 2010).

Moreover, the non-food expenditure also presents interesting insights into the economic behavior of these households. *Enset* producers spent an average of 18,432.45 ETB on non-food items, while non-producers allocated a slightly higher average of 19,080.46 ETB. This indicates that while *Enset* producers may have higher food expenditure, their non-food spending is relatively lower, potentially reflecting a prioritization of food security over other expenses. The overall expenditure patterns highlight the critical role of *Enset* production in household economies, particularly in rural settings where food security is paramount. The findings underscore the importance of *Enset* as a staple in the diet of these households, contributing to their overall livelihood and economic stability(Blomme et al., 2023b; A. Haile et al., 2020)

Table 5.2: Food expenditure share

Household type	Food expenditure share	N	mean	SD	Min	Max	t-test
Enset producer	Total food expenditure	202	43751.64	2344.1	15236	504887.7	0.56**
Non-producer		68	49.003.93	2659.97	10060.73	613377.4	
Enset producer	Total non-food expenditure	202	18432.45	21810.93	1510	153052	-0.21
Non-producer		68	19080.46	22249.78	700	102620	

5.4.4. Livelihood coping strategies – food insecurity (long period)

Figure 5.3 comparing livelihood coping strategies between *Enset* producers and Non-producers reveals significant differences in their responses to food security challenges. *Enset* producers consistently show lower percentages across all coping strategies, indicating a better food secure than Non-producers. For instance, only 6.38% of *Enset* producers resort to selling domestic assets under stress, compared to 31.25% of Non-producers. Similarly, 16.2% of *Enset* producers sell seeds in crises, whereas 64.5% of Non-producers do the same. This trend continues in emergency scenarios, with 17.49% of *Enset* producers selling female animals compared to 61.5% of Non-producers. These findings suggest that *Enset* production may provide a more stable and sustainable livelihood, reducing the need for drastic coping measures.

The differences in coping strategies can be attributed to the inherent resilience provided by *Enset* cultivation. *Enset*, often referred to as the "tree against hunger," is known for its drought resistance and ability to provide food security in challenging conditions. Studies have shown that households engaged in diverse agricultural practices, including *Enset* cultivation, are better equipped to withstand economic and environmental shocks (Feyisa et al., 2022). This aligns with the observed

lower reliance on severe coping strategies among *Enset* producers. The data underscores the importance of promoting resilient agricultural practices to enhance food security and reduce vulnerability among rural households (Manlosa et al., 2019).

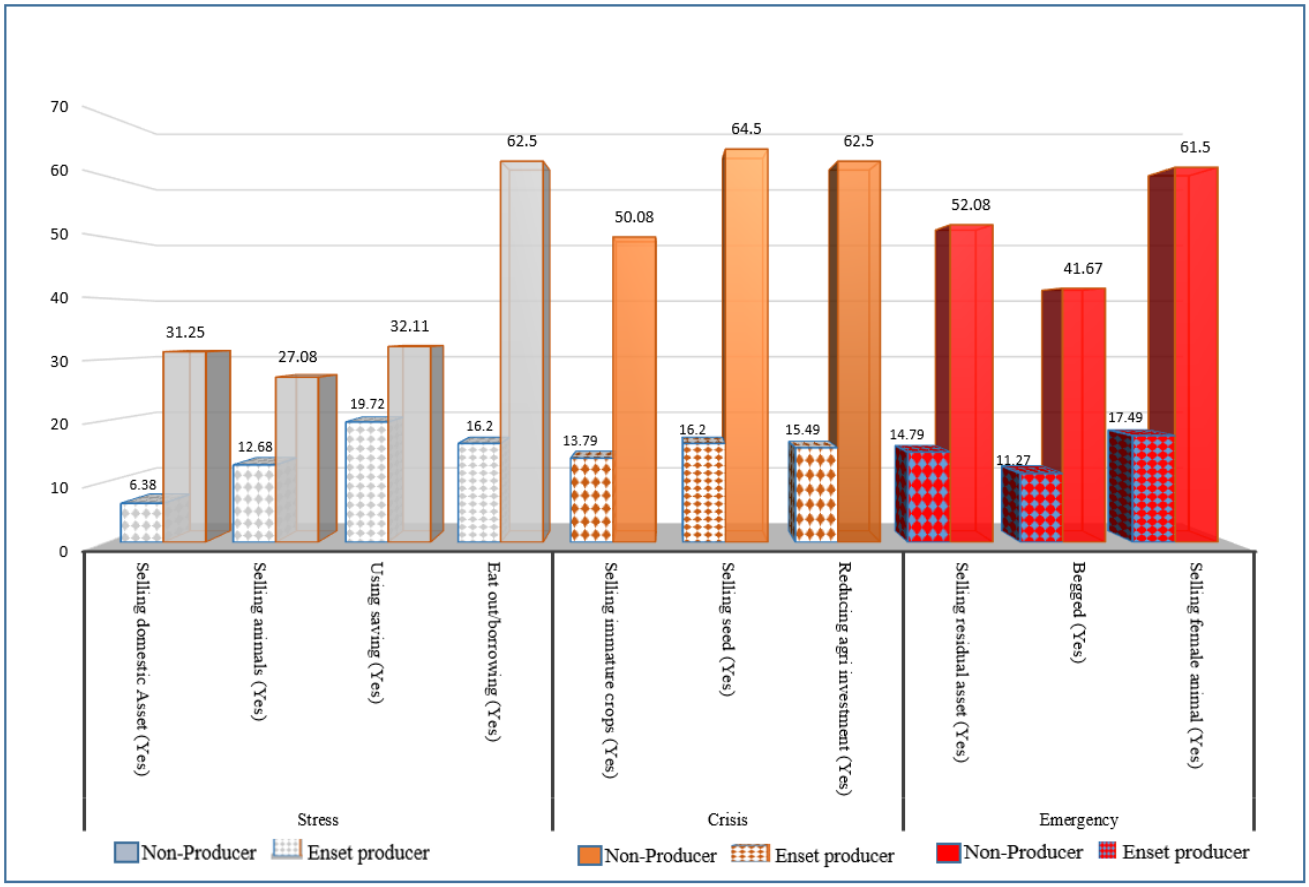

Figure 5.3: The proportion of households relying on each of the livelihood coping strategies

5.4.5. Food security status

Table 5.3 provides an analysis of food security status, economic vulnerability, and livelihood coping strategies for both *Enset*-producing and non-producing households, categorized into four levels: Food Secure, Marginally Food Secure, Moderately Food Insecure, and Severely Food Insecure. For food consumption, only 7.75% of *Enset* producers are classified as food secure with acceptable consumption and a low rCSI, while 46.48% fall into the marginally food secure category with acceptable consumption but high rCSI. On the other hand, 41.55% of *Enset* producers are moderately food insecure, and 4.23% are severely food insecure. In contrast, among non-producers, only 6.25% are food secure, while 33.33% are marginally food secure, 22.92% are moderately food insecure, and a significant 37.5% are severely food insecure.

When examining economic vulnerability based on food expenditure share, only 1.41% of *Enset* producers spend less than 50% of their income on food, indicating low vulnerability, but a concerning 82.39% are in the highest vulnerability category, spending 75% or more of their income on food. Similarly, 77.08% of non-producers fall into this highly vulnerable group. Regarding livelihood coping strategies, 66.9% of *Enset* producers do not adopt any coping strategies, indicating better food secure, while 19.72% are in the emergency coping category. Among non-producers, only 31.25% do not adopt coping strategies, and 66.67% are in the emergency coping category, highlighting their higher vulnerability.

In terms of the CARI index, 3.52% of *Enset* producers are food secure, 33.8% are marginally food secure, 38.73% are moderately food insecure, and 23.94% are severely food insecure. For non-producers, a staggering 81.25% are severely food insecure, with none classified as food secure. These results reveal significant differences between *Enset* producers and non-producers, with *Enset* producers showing lower levels of severe food insecurity and reduced reliance on emergency coping strategies, consistent with studies highlighting *Enset*'s role in enhancing food security due to its drought resistance and storability. Although *Enset* producers still face economic challenges, the availability of *Enset* as a fallback resource provides a critical safety net, reducing their dependence on market purchases. Overall, *Enset* producers demonstrate better food security outcomes than non-producers, underscoring the need to support and expand *Enset* cultivation to mitigate the region's food insecurity and economic vulnerability.

The results reveal significant differences in food security outcomes between *Enset* producers and non-producers. Previous studies suggest that *Enset* (a staple crop in Ethiopia's Southern and central regions) plays a critical role in enhancing food security due to its drought resistance, ability to be stored long-term, and nutritional value (Aneseyee et al., 2022). The findings in this study support these insights, showing that *Enset* producers have lower levels of severe food insecurity compared to non-producers. Additionally, the reliance on emergency coping strategies is significantly lower among *Enset* producers, suggesting better food secure. Similar findings have been reported by other studies that highlight that *Enset* cultivation provides a buffer during food scarcity (Sirany et al., 2022). Moreover, the economic vulnerability analysis shows that *Enset* producers have slightly better control over food expenditure, likely due to the availability of *Enset* as a fallback resource, reducing their dependence on market purchases.

The focus group discussion indicates that *Enset*-producing households have significantly better food security than non-producing households. *Enset* producers enjoy a stable and diverse food consumption pattern, relying less on severe coping strategies like reducing meal sizes or selling assets. Their advantages include better food expenditure and higher income, enhancing their resilience to food insecurity. Conversely, non-producers frequently experience severe food insecurity and depend on formal support and demographic factors to cope. The discussion emphasizes the need to promote *Enset* cultivation to improve food security and suggests targeted interventions for non-producers, such as enhancing access to nutrient-rich foods, diversifying income sources, and strengthening social safety nets. Expanding education, health insurance, and tailored support can further address vulnerabilities and improve food security outcomes in the region.

Key informant interviews corroborate that food insecurity for *Enset* producers has improved over time, leading to a more diverse and consistent food consumption pattern and reduced reliance on severe coping strategies. Non-producers, however, continue to face challenges, relying heavily on formal support mechanisms. To enhance food security, promoting *Enset* cultivation and improving access to nutrient-rich foods are crucial. Support for non-producers should focus on expanding social safety nets, improving food market access, and implementing resilience-building programs. Policymakers should integrate *Enset* cultivation into broader food security strategies, addressing the specific needs of both groups to strengthen overall food security in the region.

Table 5.3: Food security status of *Enset* producers and non-producer: result of CARI console

	Domain	Indicator	Food secure (1)	Marginally Food secure (2)	Moderately Food Insecure (3)	Severely Food Insecurity (4)		
Current Status	Food Consumption	Food Consumption Score and rCSI	Acceptable consumption and rCSI below 4 (%)	Acceptable consumption and rCSI 4 or above (%)	Borderline consumption (%)	Poor consumption (%)	Chi-square	Household type
			7.75	46.48	41.55	4.23	23.26**	*Enset* Producer
			6.25	33.33	22.92	37.5		Non-producer
Coping Capacity	Economic Vulnerability	Food Expenditure Share	**<50%**	**50-65%**	**65-75%**	**>= 75%**		
			1.41	4.23	9.86	82.39	16.3***	*Enset* Producer
			2.08	8.33	12.5	77.08		Non-producer
	Livelihood Coping Strategies	Livelihood coping strategies - food security	**No Coping (%)**	**Stress (%)**	**Crisis (%)**	**Emergency (%)**		
			66.9	13.38		19.72	*51.2***	*Enset* Producer
			31.25	2.08		66.67		Non-producer
	CARI		3.52%	33.80%	38.73%	23.94%	*29.1***	*Enset* Producer
			0%	4.17%	14.58%	81.25%		Non-producer

5.4.6. Distribution of household characteristics by food security status

The characteristics of *Enset*-producing households in Table 5.4 illustrate significant variations in food security status, where income and expenditure emerge as key determinants. Food-secure households exhibit notably higher annual income and spending compared to those with varying degrees of food insecurity, reflecting recent findings that economic resources are critical for food security. Although there is some variation in education levels and asset holdings, these differences are less pronounced, suggesting that income and expenditure are more influential in determining food security than education or assets alone. The relatively stable land size across food security categories indicates that while land is essential, other economic factors might moderate its impact on food security. This supports the view that enhancing income and expenditure can more effectively improve food security than focusing solely on land size or education. Table 5.5 highlights the categorical socioeconomic characteristics among *Enset*-producing households across food security status. Male-headed households tend to be more food secure compared to female-headed households, with a higher percentage of females being severely food insecure. Marital status also plays a crucial role, with widowed and polygamously married individuals experiencing higher food insecurity. Receiving remittances and access to health insurance are associated with better food security, while exposure to shocks and lack of credit access exacerbate food insecurity. These findings align with recent literature emphasizing the importance of socioeconomic support systems in enhancing food security among agricultural household. The chi-square and p-values indicate significant associations between these variables and food security status, underscoring the need for targeted interventions to address these disparities.

The analysis of non-*Enset*-producing households by food security status highlights a pronounced disparity in food security, with a staggering 81.25% of severely food-insecure households, contrasted by a negligible proportion of food-secure households (Table 5.4). The data reveal that severely food-insecure households have notably lower income and expenditure levels, which aligns with recent findings that economic resources are crucial determinants of food security. Furthermore, education levels are markedly lower in severely food-insecure households, echoing recent research that underscores the role of education in enhancing food security. Despite variations in household size and land size, these factors appear less influential than economic and educational variables, consistent with recent studies suggesting income and education are more

robust predictors of food security (Mutisya et al., 2016). This underscores the importance of targeted economic and educational interventions in addressing severe food insecurity.

Table 5.5 also presents categorical characteristics of non-producer households on food security status distribution. The result reveals that Male-headed households show a higher percentage of marginally food-secure individuals compared to female-headed households, who are more likely to be severely food insecure. Marital status also impacts food security, with never-married and polygamously married individuals experiencing higher levels of severe food insecurity. Receiving remittances and access to health insurance are associated with better food security outcomes, while exposure to shocks and lack of credit access exacerbate food insecurity. These findings are consistent with recent literature, which highlights the critical role of socioeconomic support systems in mitigating food insecurity among agricultural households (Zerihun Yemataw et al., 2016). The chi-square and p-values indicate significant associations between these variables and food security status, emphasizing the need for targeted interventions to address these disparities.

Table 5.4: Distribution of sampled households against continuous variables by food security status

	Food secure (N=7)		Marginally Food secure (N=69)		Moderately Food Insecure (N=79)		Severely Food Insecurity (N=48)		
Variable	Mean (SD)	Min(Max)	Mean (SD)	Min(Max)	Mean (SD)	Min(Max)	Mean (SD)	Min(Max)	F-statistic
***Enset* producer**									
Age of HH head	44.727(17.732)	25(88)	40.886(13.972)	16(71)	42.34(12.305)	21(7)	45.186(15.538)	20(85)	0.971
Education level (year)	1.636(3.501)	0(12)	1.686(4.451)	0(23)	.894(1.797)	0(10)	1.116(3.459)	0(19)	0.694**
Asset in ETB	3081.8(15)	42213(65)	2728.6 (12.706)	1056.6(65)	3123.4(15.548)	1245(65)	3279(17.278)	1256(65)	1.46***
HH size	4(1.549)	1(6)	4.971(2.572)	1(12)	5.596(1.884)	2(9)	4.93(2.64)	1(11)	1.203**
Total annual expenditure in ETB	74174.131 (50610.455)	21233.039 (156557.8)	68136.248 (46863.382)	10094.832 (205833)	41565.986 (20945.823)	15996.109 (93123.055)	77483.649 (70154.311)	22092.201 (399654)	7.321***
Total annual income in ETB	90492.441 (61744.756)	25904.39 (191000.52)	83126.222 (57173.327)	12315.695 (251116.27)	50710.503 (25553.905	19515.254 (113610.13)	94530.051 (85588.258)	26952.486 (487577.88)	7.256***
land size in Hector	2.918(1.68)	1(6)	2.524(1.738)	0.2(6)	2.464(1.661)	0.1(6)	2.847(1.736)	0.1(6)	0.62
Non-producer									
Age of HH head	-	-	43.688(17.292)	19 (78)	40.867(12.856)	22(61)	43.824(17.689)	20(75)	0.527
Education level (year)	-	-	2(4.747)	0 (17)	1.133(3.852)	0(15)	4.118(5.644)	0(19)	0.512***
Asset in ETB	-	-	5468.8(15396)	3223 (16500)	2566(15.646)	2025(65)	1358(19.555)	1157(65)	0.231**
HH size	-	-	3.938(2.489)	1(8)	4.6(2.874)	1(10)	3.941(2.926)	1(12)	1.02
Total annual expenditure	-	-	49414.333 (55430.641)	5264 (166716)	20587.051 (10066.876)	1452 (36844)	58472.15 (56003.294)	3110 (161143.38)	7.025**
Total annual income	-	-	60285.486 (67625.38)	6422.08 (203393.52)	25116.203 (12281.588)	1771.44 (44949.68)	71336.024 (68324.02)	3794.2 (196594.92)	6.85**
land size in Hector	-	-	2.781 (2.196)	0.25 (6)	2.933(1.668)	1(6)	2.429(1.578)	0.5(5)	0.43**

Standard errors in parentheses

****p<.01, **p<.05, *p<.1*

Note: Number of sample household for each group;

- For Producer: Food secure (N=7), Marginally Food secure (N=69), Moderately Food Insecure (N=79) & Severely Food Insecurity (N=48)
- For Non-Producer: Food secure (N=7), Marginally Food secure (N=69), Moderately Food Insecure (N=79) & Severely Food Insecurity (N=48)

Table 5.5: Distribution of sampled households against categorical variables

		***Enset* producer**					
Variables	Response	Food secure	Marginally food secure	Moderately food insecure	Severely food insecure	Chi-square	P-value
Sex of HH head	Male	10	26.36	37.27	26.36	8.94	0.03
	Female	0	23.08	23.08	53.85		
Marital status	Never Married	5.56	27.78	16.67	50		
	Married (Monogamous)	8.91	26.73	37.62	26.73	24.15	0.0194
	Married (Polygamous)	0	25	75	0		
	Widowed	0	16.67	25	58.33		
Receiving remittance	Yes	0	0	100	0	1.91	0.001
	No	8.15	25.93	34.07	31.85		
Access to health insurance	Yes	12.9	29.03	25.81	32.26	2.2158	0.0001
	No	6.67	24.76	37.14	31.43		
Exposure to shock	Yes	22.22	11.11	33.33	33.33	3.1945	0.023
	No	7.09	26.77	34.65	31.5		
Access to credit	Yes	11.11	44.44	11.11	33.33	6.3758	0.001
	No	7.63	22.88	38.14	31.36		
		Non-producer					
Sex of HH head	Male		37.04	33.33	29.63	0.9232	0.002
	Female		28.57	28.57	42.86		
Marital status	Never Married		33.33	16.67	50		
	Married (Monogamous)		34.48	31.03	34.48	6.3392	0.012
	Married (Polygamous)		50	0	50		
	Widowed		28.57	28.57	42.86		
Receiving remittance	Yes		0	50	50	1.1081	0.021
	No		35.56	28.89	35.56		
Access to health insurance	Yes		22.22	11.11	66.67	4.9022	0.011
	No		35.9	35.9	28.21		
Exposure to shock	Yes		26.67	36.67	36.67	1.8531	0.003
	No		44.44	22.22	33.33		
Access to credit	Yes		20	0	80	5.1743	0.021
	No		34.88	34.88	30.23		

5.4.7. Determinants of food security

The outcome variable in this research represents the food security/insecurity levels among *Enset* producer and non-producer households, which is measured on an ordinal scale and requires ordinal analysis. Consequently, an ordinal logistic regression model was employed to identify the factors determining food in/security in the study areas. The ordered logistic regression models for *Enset* producers and non-producers show good model fit based on the significant chi-square values ($p < 0.01$). The Akaike Information Criterion (AIC) values (364.036 for producers and 120.728 for non-producers) suggest that the model for non-producers is more parsimonious, reflecting a better balance between model fit and complexity given the smaller sample size. Overall, the models are

statistically robust and provide meaningful insights into the factors influencing food security (Table 5.6) (Appendix 5 Table 5.1a and 5.2b).

Several variables significantly influence food security for both *Enset* producers and non-producers. Sex is a significant predictor for both groups; for *Enset* producers, being male greatly increases the likelihood of better food security (OR=4.845, $p<0.01$), while the effect is positive but smaller for non-producers (OR=1.883, $p<0.01$). Education level is significant only for *Enset* producers (OR=1.014, $p<0.05$), suggesting that more educated individuals within this group are more likely to experience higher food security. Receiving remittances also significantly improves food security for *Enset* producers (OR=1.947, $p<0.05$) but has no significant impact on non-producers. Conversely, exposure to shocks negatively impacts food security for *Enset* producers (OR=0.475, $p<0.01$), indicating that shocks considerably reduce food security within this group. For non-producers, age (OR=1.023, $p<0.05$), household size (OR=1.087, $p<0.05$), and access to health insurance (OR=3.515, $p<0.01$) are significant factors associated with better food security.

Comparing the two groups reveals distinct differences in the factors affecting food security. For *Enset* producers, sex, education, remittances, and exposure to shocks are the key determinants. In contrast, non-producers rely more on demographic factors such as age, household size, and formal mechanisms like health insurance. The stronger association between education, remittances, and food security among *Enset* producers highlights the importance of human capital and external financial support in improving food security within this group. On the other hand, non-producers seem to benefit more from institutional support and household structure.

The findings align with recent literature on the differential impacts of livelihood strategies on food security in rural Ethiopia. Studies indicate that *Enset* cultivation is a key coping mechanism for smallholders, providing stability in food supply during lean periods (Yemata, 2020). *Enset*'s role as a food security buffer is consistent with the significant negative impact of shocks on *Enset* producers, who rely heavily on this crop to mitigate risks. In contrast, non-producers depend more on demographic advantages and formal support systems, such as health insurance, for food security, as highlighted in broader studies of food security in rural areas (Mesfin et al., 2024). These results underscore the need for tailored food security interventions that address the unique vulnerabilities and strengths of different livelihood groups in central Ethiopia region.

Table 5.6: Ordinal logit of the factors influencing household food security

	Enset producer	Non-producer
Food security status	OR (St. Err)	OR (St. Err)
Sex		
Male	4.845(2.564)***	1.883(1.431)***
Female (Ref.)	1.0	1.0
Marital status		
Married	0.829(0.107)	0.864(0.179)
Not married	1.0	1.0
Receiving remittance		
Yes	1.947(3.19)**	.352(0.53)
No (Ref.)	1.0	1.0
Access to credit		
Yes	1.738(0.908)	0.222(0.278)
No (Ref.)	1.0	1.0
Access to health insurance		
Yes	0.742(0.295)	3.515(3.085)***
No (Ref.)	1.0	1.0
Employed in GO		
Yes	2.358(2.01)	1.43
No (Ref.)	1.0	
Exposure to shock		
Yes	0.475(0.331)***	0.734(1.15)
No (Ref.)	1.0	1.0
Age	1.012(0.014)	1.023(0.022)**
Education level (year of Schooling)	1.014(0.058) **	1.084(0.083)
Asset (asset value index)	1.016(0.012)	0.984(0.019)
Household size (number)	1.064(0.084)	1.087(0.138)**
Total Expenditure (ETB)	1.05(0.11)***	1.56(0.25)
Land size (Hector)	1.082(0.109)	0.95(0.172)
Constant	4.39(3.883)***	-4.47(4.2)***
Constant	6.28(3.895)**	-3.023(4.175)***
Constant	7.85(3.915)**	
Mean dependent var	(2.897)	(3.021)
Pseudo r-squared	(0.491)	(0.599)
Chi-square	(17.201)	(10.240)
Akaike crit. (AIC)	(364.036)	(120.728)
SD dependent var	0.945	0.847
Number of obs	202	68
Prob > chi2	0.000***	0.000***

Standard errors in parentheses

*** p<.01, ** p<.05, * p<.1

5.5.Conclusion and policy implication

The analysis reveals that *Enset*-producing households have a more consistent and diverse food consumption pattern, particularly with a higher intake of starchy staples, condiments, pulses, and fats compared to non-*Enset* producers. *Enset* producers exhibit lower reliance on coping strategies such as consuming less preferred foods, borrowing food, and reducing meal sizes, indicating better

food security. They also tend to have higher and more consistent food spending compared to non-producers, suggesting better access to food resources and potentially higher income levels. *Enset* producers have better food security status, with significantly lower reliance on severe measures like selling assets, seeds, or livestock than non-producers.

The ordered logistic regression analysis highlights that *Enset* producers benefit significantly from education, remittances, and the stability provided by *Enset* cultivation, while non-producers rely more on demographic factors and formal support mechanisms like health insurance to improve food security. *Enset* farming, while crucial for food security in central Ethiopia region, has limitations. It thrives in specific agro-ecological zones with high rainfall and fertile soils, making expansion to drier areas difficult. Pests, diseases, labor-intensive processing, and cultural barriers further challenge its scalability. Additionally, limited market development and economic incentives hinder broader adoption.

5.5.1. Policy recommendations

To enhance food security in Central Ethiopia, targeted strategies should be applied for both Enset-producing and non-producing households. For Enset producers, efforts should focus on addressing production challenges through investment in pest and disease control, labor-saving processing technologies, and market development to create stronger economic incentives. Expanding access to education and remittance channels can further strengthen their food security and resilience.

For non-producers, promoting alternative food security strategies is crucial, especially in areas unsuitable for Enset cultivation. This includes improving access to health services, education, and formal support mechanisms like insurance. Diversifying food sources and supporting income-generating activities can reduce reliance on negative coping strategies. Where possible, localized introduction of Enset with proper agro-ecological assessment and community sensitization may also be explored to extend its benefits.

In addition, future research should focus on developing pest-resistant, high-yield Enset varieties, and introduce affordable labor-saving tools to ease Enset processing.

CHAPTER 6: EXPLORING THE IMPACT OF *ENSET* (*Ensete Ventricosum*) PRODUCTION ON HOUSEHOLD FOOD SECURITY IN CENTRAL ETHIOPIA REGION

Abstract

Enset (Ensete ventricosum) is a staple food source for over 20 million people. This study examines Enset production's impact on household food security in Central Ethiopia, employing panel data and endogenous regression models for a thorough analysis. LSMS Data from the Ethiopian Statistics Agency, the World Bank, from 2018/19 to 2021/22, and additional surveys (2023/24) were analyzed using descriptive statistics and econometric models, including the Endogenous Switching Regression model. The findings show that households harvest, on average, about 25 Enset plants annually, producing 425 kg of Kocho and earning an average income of 27,950 ETB from Enset products. Enset producers consume significantly more calories (2,995 kcal) than non-producers (1,893 kcal), a difference of 1,102 kcal. Factors such as male household heads, higher education levels, and asset ownership increase the likelihood of Enset production, as the random-effects probit model reveals. The ESR analysis reveals that education and asset ownership significantly enhance calorie intake among Enset producers, while exposure to shocks reduces calorie intake for both producers and non-producers. Enset production is associated with a 35.2% increase in actual calorie intake among producers. Conversely, if non-producers decided not to engage in Enset production, their calorie intake would be expected to decline by 55.7%. The study concludes that Enset production significantly improves household food security, recommending policies that support Enset cultivation.

***Keywords**: Food security, calorie intake, Enset crop, Endogeneity*

6.1. Introduction

Agriculture is the cornerstone of Ethiopia's economy, significantly contributing to food security and livelihoods across the nation. It accounts for 33.88% of the country's GDP, employs 67% of the workforce, and generates 87% of exports (Muluye, 2021). Key crops include *Enset*, cereals, pulses, oilseeds, vegetables, root crops, fruit crops, chat, coffee, and sugarcane. Among these, *Enset* (*Ensete ventricosum*), a drought-tolerant perennial herb from the banana family, serves as a staple food for over 20 million people (Blomme et al., 2023a), particularly in the central, southern, and southwestern regions of Ethiopia. *Enset* is not only a vital food source but also provides animal fodder, construction materials, and fuel while playing important cultural and environmental roles (Sirany et al., 2022). Its cultivation is widespread, thriving at elevations between 1,200 and 3,100 meters, and it can be grown in areas unsuitable for cereals (Yemata, 2020). The presence of *Enset* in a household signifies wealth and food security, especially in central Ethiopia regions, where it is viewed as a measure of a family's prosperity and self-sufficiency (Negash, 2001). Despite its

potential, research on the impact of *Enset* production on household food security has been limited, highlighting a need for further exploration into how *Enset* production can enhance resilience to food security for smallholder farmers in Ethiopia.

The United Nations' Sustainable Development Goal (SDG) 2 aims to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture (USAID, 2023). This goal aligns closely with Ethiopia's Growth and Transformation Plan (GTP), which prioritizes enhancing agricultural productivity and ensuring food security for its citizens (FDRE, 2016). By understanding the impact of *Enset* production on household food security, this study contributes to the achievement of these global and national goals. Moreover, food insecurity remains a significant challenge in many parts of the world, particularly in sub-Saharan Africa (Morrow et al., 2023). In Ethiopia, despite the country's efforts to improve food security, a substantial portion of the population still faces food shortages and malnutrition (Blomme et al., 2023a). The central Ethiopia region, known for its *Enset*-based agricultural systems, faces persistent food insecurity challenges (Borrell et al., 2020). While *Enset* is a vital crop for the region, the extent to which its production contributes to household food security remains unclear.

The significance of this study lies in its innovative approach to examining the impact of *Enset* production on household food security in the Central Ethiopia region. Unlike previous research, which primarily relied on cross-sectional data (Bassa et al., 2024; Blomme et al., 2023a; Bonso et al., 2022; Morrow et al., 2023), this study utilizes panel data. This approach allows for a more analysis of the dynamic relationships between *Enset* production and food security over time, providing deeper insights into the trends and patterns that may influence outcomes. Additionally, this study employs an endogenous regression model, moving beyond the propensity score matching (PSM) techniques used in earlier research. This methodological (ESR) advancement enables a more robust examination of causal relationships, enhancing the reliability of the findings and their implications for policy and practice.

Other scholars, such as Bonso et al. (2022) and Bassa et al. (2024), have also estimated the impacts of *Enset* production on food security and income using PSM. PSM balances observable covariates between treated and untreated, hence reducing selection bias in impact evaluation. This study overcomes the limitations of the abovementioned studies in that both observable and unobservable factors are accounted for in the ESR model used herein. It also provides causal estimates for both

the observed and counterfactual outcomes, therefore allowing a more robust comparison. In addition, compared to the PSM approach, ESR does not rely on conditional independence assumptions, which makes it more suitable for application in agricultural impact studies, where unobservable factors preference and network-related factors play a crucial role. This study also focused on a broader geographical scope specifically, the Central Ethiopia region rather than limiting the analysis to small districts as seen in previous studies.

This study contributes to the broader understanding of food security in Ethiopia by highlighting the pivotal role of *Enset* production in enhancing food security outcomes and resilience among rural households. The findings also will inform policymakers and Agricultural practitioners about the critical drivers of *Enset* production and its implications for food security. By identifying key factors such as education, and assets. Ownership, and vulnerability to shocks, the study provides actionable insights for designing targeted interventions to promote *Enset* cultivation. Furthermore, the counterfactual analyses emphasize the risks of non-production, underscoring the importance of *Enset* as a strategic crop in Ethiopia's food systems. These contributions align with national and global priorities, such as Ethiopia's Growth and Transformation Plan (GTP) and the United Nations' Sustainable Development Goal 2 (SDG 2), which aims to achieve zero hunger.

6.2. Materials and methods

6.2.1. Research design

This study employed a quasi-experimental research design with a quantitative research approach and a panel data set. The quasi-experimental design fits many situations in which Random Controlled Trial is hard to use for ethical and other reasons. The approach therefore estimates the causal relationships in the presence of real-world complexities that include unobserved factors affecting *Enset* production and food security outcomes. Results from the literature prove that such quasi-experimental designs do work. For example, Di Falco et al. (2011) applied the ESR framework to investigate how climate adaptation impacts food security in Ethiopia, while Abdulai & Huffman (2014) estimated the welfare impacts of soil and water conservation technologies using similar methods. These studies underline the dependability of the quasi-experiment methods in agricultural research, particularly for the control of endogeneity and unobservable factors. Drawing strength from this design, this study brings out critical evidence on the contribution of *Enset* production to household food security and its useful implications for policy and practice.

This study effectively handled biases and other weaknesses, while it generated reliable insights on how the *Enset* production has been impacting the food security of households through its quasi-experimental design with panel data. Without randomization, this study strengthens its analysis with comparison groups, counterfactuals, and controls within a quasi-experimental framework. The *Enset* producers and non-producers enable a direct comparison in measuring the food security outcome. The ESR model constructs counterfactual situations, estimating the level of food security outcomes that would have been experienced by producers in the absence of production and vice versa for non-producers. This again allows for robust causal inference through metrics such as ATT and ATU (Abdulai & Huffman, 2014; Di Falco et al., 2011). In addition, controls for household characteristics, such as education, assets, and shocks, reduce biases from both observable and unobservable factors, hence ensuring reliable estimates. According to (Lokshin & Sajaia, 2004), together, these elements ensure robust causal insights, even without randomization.

6.2.2. Methods of data analysis

The data analysis part of this study operates under a strong methodological framework to analyze the contributions of *Enset* production to food security at the household level in the Central Ethiopia region. The analysis uses panel data from the Ethiopian Socioeconomic Survey (ESS) and supplementary data collected in 2023/24 in descriptive statistics, econometric models, and counterfactual scenarios to give a full appreciation of the dynamics between *Enset* cultivation and food security outcomes. The Endogenous Switching Regression (ESR) model was implemented to overcome the endogeneity and self-selection problem; thus providing a clear assessment of the causal effects of *Enset* production. Eventually, this section provides an update on key findings regarding household characteristics, *Enset* yield, calorie intake, and determinants of *Enset* production, contributing to understanding how *Enset* supports food security and resilience among the smallholder farmers in the region.

6.2.2.1. The impact of Enset Production on the food security of Households

In this section, an Endogenous Switching Regression (ESR) model is applied to assess the causal effect of *Enset* production on food security at the household level, measured by calorie intake. The ESR model is apt for addressing the endogeneity and self-selection biases arising from unobservable factors-e.g., farming skills, cultural inclinations, or risk tolerance-influencing both decision-making on *Enset* production and food security outcome on household levels (Becker et

al., 2022). The ESR model incorporates the heterogeneity of treatment effects, unlike fixed or random effects, by modeling the selection process and accounting for both observable and unobservable confounders (Di Falco et al., 2011). This makes Inferences on the *Enset* production having a causal impact on household food security rather than biased association.

In this study, *Enset* production is treated as a dichotomy (producers versus non-producers) to make possible a lucid counterfactual comparison touching upon the central question: What would happen to a household's caloric intake were it to produce *Enset* and were it not? These represent impacts that are usually evaluated against the assumptions of those who engage in production versus those who do not (Imbens & Wooldridge, 2009). While caloric intake is a continuous manner, the binary treatment serves to draw a perfect line between households in gross *Enset* cultivation (e.g., harvesting 5 or more plants every year) versus those with little or none since studies show that larger *Enset* holdings significantly correlate with calorie intake and food security (Bonso et al., 2022; Morrow et al., 2023).

The ESR model is preferred over Propensity Score Matching (PSM) because PSM relies on the Conditional Independence Assumption (CIA), which assumes that all factors influencing both treatment and outcome are observable (Rosenbaum & Rubin, 1983). However, this assumption is often violated in agricultural contexts due to unobservable factors like farming expertise or cultural practices. The ESR model, by contrast, does not require the CIA and provides more robust estimates by explicitly modeling the selection process and accounting for unobserved heterogeneity (Lokshin & Sajaia, 2004). Additionally, the use of an instrumental variable (IV) approach was considered but deemed impractical due to the lack of a valid instrument that affects *Enset* production but not caloric intake. The ESR model, therefore, offers a more reliable alternative for estimating the Average Treatment Effect (ATE), Average Treatment Effect on the Treated (ATT), and Average Treatment Effect on the Untreated (ATU) without relying on restrictive assumptions. Overall, the ESR model provides a rigorous methodological framework to estimate the causal effect of *Enset* production on food security, addressing both statistical and substantive concerns regarding selection bias and confounding factors.

Model specification

An endogenous switching regression model that accounts for both endogeneity and sample selection was utilized in the study (Lokshin & Sajaia, 2004). In the first stage, this model employs

a probit model to analyze the relationship between participating in *Enset* producing and various household and farm characteristics. In the second stage, separate regression equations are applied to model food security in calorie intake outcomes based on a specified criterion function. To illustrate this method, consider a scenario where a farmer can participate in the value chain. A latent variable, denoted as Bi∗ captures the expected net benefits from *Enset* production. The probit model for engaging on *Enset* production can be specified accordingly. This approach effectively addresses the complexities of estimating treatment effects in the presence of both selection bias and endogeneity, allowing for a more accurate assessment of the impacts on food security. The probit model of participating in *Enset* production

$$\text{Bi} * = \alpha' \text{Zi} + \text{Ui} \text{ with } \text{Bi} = \{1 \text{ if } \text{Di} * > 1, 0 \text{ otherwise} \quad (6.1)$$

In this model, Bi∗ is the unobservable latent variable for participation in *Enset* production, while Bi is the observable dependent variable for participating in *Enset* production, equal to 1 if the farmer is *Enset* producer and 0 otherwise. The variable Z*i* represents a vector of observed explanatory variables that influence participating in *Enset* producing, with coefficient estimates denoted by α. The random disturbances related to participation are represented by U*i*.

The two regression equations related to food security and expenditure, which consider whether farmers are *Enset* producers or non-producers, are defined as follows:

$$\text{Regime 1: } \text{Y1}i = \beta 1 \text{X1}it + \varepsilon 1it \quad \text{if B}i = 1 \quad (6.2)$$

$$\text{Regime 2: } \text{Y2}it = \beta 2 \text{X2}it + \varepsilon 2it \quad \text{if B}i = 0 \quad (6.3)$$

Where: Y*it* represents the household food security in calorie intake for household i at time t. X*it* is a vector of exogenous variables for household i at time t. β1 is the coefficient associated with the exogenous variables. εit is the error term for household i at time t. Bi: A dummy variable indicating market participation (1 if *Enset* producer, 0 if not producer). It is crucial to use exclusion restrictions to identify the ESR (Endogenous Switching Regression) model properly. This means using selection instruments that are not only generated by the nonlinearity of the selection model of participation (equation (Eq) 6.1) but also other variables that directly affect the selection variable (participating in *Enset* production) but not the outcome variable (calorie intake) (Di Falco et al., 2011).

6.2.2.2. Conditional expectation, treatment, and heterogeneity effects

An endogenous switching regression model was employed to analyze the anticipated outcome variables for households that produced *Enset* (Eq. 6.4) versus those that did not produce (Eq. 6.5). It also aimed to investigate the expected food security in counterfactual scenarios: (Eq. 6. 6) where the treated households are assumed to be untreated, and (Eq. 6.7) where the untreated households are assumed to be treated. The conditional expected and average treatment effects are defined for both the actual (observed in the sample) and counterfactual situations as follows:

Actual scenarios

$$\text{Producer} \qquad E\left(\frac{Y1it}{Ait} = 1\right) = X1it\beta1 + \delta1t\lambda1it \tag{6.4}$$

$$\text{Non-producer} \qquad \mathrm{E}\left(\frac{\mathrm{Y2}it}{\mathrm{A}it} = 0\right) = \mathrm{X2}it\beta1 + \delta2t\lambda2it \tag{6.5}$$

Counterfactual scenarios

$$\text{Producer decided not to produce} \qquad \mathrm{E}\left(\frac{\mathrm{Y2}it}{\mathrm{A}it} = 1\right) = \mathrm{X2}it\beta1 + \delta2t\lambda2it \tag{6.6}$$

$$\text{Non-Produce had decide to participate} \qquad E\left(\frac{Y1it}{Ait} = 0\right) = X1it\beta1 + \delta1t\lambda1it \tag{6.7}$$

According to (Heckman et al., 2001), the change in expected calorie intake levels for producers in farm households over time (representing the effect of the treatment on the treated) is calculated by subtracting scenario (6.6) from scenario (6.4).

$$ATT = E\left(\frac{Y1it}{\mathrm{A}it} = 1\right) - E\left(\frac{Y2it}{\mathrm{A}it} = 1\right) = \mathrm{X1}it(\beta1 - \beta2) + (\delta1t\eta - \delta2t\eta)\lambda1it \tag{6.8}$$

$$ATU = E\left(\frac{Y1it}{Ait} = 0\right) - E\left(\frac{Y2it}{Ait} = 0\right) = X2it\,(\beta1 - \delta2) + (\delta1t\eta - \delta2t\eta)\lambda2it \tag{6.9}$$

Equation (9) reflects the impact of *Enset* production on the food security of households actively engaged in it. Similarly, the researchers assess the change in expected food security for households that did not produce *Enset*, known as the average treatment effect on the untreated (ATU), which is determined by the difference between scenario (6.7) and scenario (6.5). In this context, X_{1it} and X_{2it} are the explanatory variables influencing the *Enset* producer in regime 1 and regime 2, respectively. The parameters $\beta1$and $\beta2$ are the values that need to be estimated.

Heterogeneity effect: Farmers who produce *Enset* might had higher food calorie intake compared to those who did not participate, even if they had not chosen to participate. This is due to

unobservable factors that may have influenced household food calorie intake. Following the method described in (D. W. Carter & Milon, 2005; Toyiba shafi, Jema Haji, Lemma Zemedu, 2023), we estimate heterogeneity effects by comparing the anticipated outcomes of farm households that opted to produce and for the farm households who decided not to produce as shown in equations (6.10) and (6.11). Furthermore, we analyze the transitional heterogeneity (TH) effect, which reflects how the impact of *Enset* production varies among producer farm households. This effect is represented by the difference between the average treatment effect on the treated (ATT) and the average treatment effect on the untreated (ATU), as shown in Table 6.1.

$$BH1 = E\left(\frac{Y1it}{Ait} = 1\right) - E\left(\frac{Y1it}{Ait} = 0\right) = (X1it - X2it)\beta 1it + \delta 1\eta\,(\lambda 1it - \lambda 2it) \qquad (6.10)$$

$$BH2 = E\left(\frac{Y2it}{Ait} = 1\right) - E\left(\frac{Y2it}{Ait} = 0\right) = (X1it - X2it)\beta 2i + \delta 2\eta\,(\lambda 1it - \lambda 2it) \qquad (6.11)$$

Table 6.1: Conditional Expected condition, effect of treatment, and heterogeneity effects

	Decision to *Enset* producing		
	To produce	Not to produce	*Enset* production effect
Producer	$E\left(\frac{Y1it}{Ait} = 1\right)$	$E\left(\frac{Y2it}{Ait} = 1\right)$	ATT
Non-Producer	$E\left(\frac{Y1it}{Ait} = 0\right)$	$E\left(\frac{Y2it}{Ait} = 0\right)$	ATU
Heterogeneity effects	BH_1	BH_2	TH

Note: Y_{1it} = Household food calorie intake over time for the producer, Y_{2it} = Household food calorie intake over time for the non-producer; Ai =1 if the households are producer; Ai =0 if households are non-producer; ATT = Average treatment effect on treated; ATU = Average treatment effect on untreated; BU1 = Base heterogeneity effect for the producer; BH2 = Base heterogeneity effect for non-participant; TH = Transitional heterogeneity effect (ATT-ATU)

6.2.2.3. Description of outcome, dependent and independent variables

Measurement of outcome variables: The outcome variable is food security, with kilocalorie intake acting as a proxy for evaluating household food security. Similar metrics have been employed in previous research, either individually or in combination with other indicators (Toyiba shafi, Jema Haji, Lemma Zemedu, 2023). The assessment of household food security was conducted through a direct survey regarding household consumption patterns. The individual responsible for meal preparation was queried about the amount of food prepared for consumption during a specified timeframe, which included food acquired through purchases, storage, gifts, loans, or wages. This study implemented a seven-day recall method, as it typically yields more accurate data compared to the household expenditure approach (EHNRI (Ethiopian Health and

Nutrition Research Institute), 1997) (see Appendix 6 Table 6.2b). The consumption data gathered using a fourteen-day recall method was converted into kilocalories, utilizing a food composition table from the Ethiopian Health and Nutrition Research Institute. To calculate the household's daily caloric intake, the total caloric consumption over the fourteen days was divided by seven. Subsequently, the daily caloric intake per adult equivalent was determined by dividing the daily intake by the adjusted family size.

6.3. Results and discussion

6.3.1. Household characteristics

Table 6.2 provides summary statistics of both continuous and dummy variables for 2018/19, 2021/22, and 2023/24, providing insight into the differences between *Enset* producers and non-producers in Central Ethiopia over time. Across the years, the age of the household head remains similar between the two groups, with no significant differences, indicating that age does not play a major role in determining whether a household engages in *Enset* production. The education level of household heads shows that producers generally have higher education levels than non-producers, but these differences are not statistically significant, suggesting that while education may contribute to *Enset* production, it is not a decisive factor. Household size consistently shows significant differences between the two groups, with *Enset* producers having larger households in all three years. This suggests that *Enset* production may be labor-intensive, requiring more household members, which could positively influence food security (Bonso et al., 2022). In terms of economic factors, *Enset* producers demonstrate significantly higher total consumption and income compared to non-producers in 2018/19 and 2023/24, highlighting the potential financial benefits of *Enset* production. The number of assets also increases for producers over time, particularly in 2023/24, where the difference becomes significant, indicating the accumulation of wealth among producers. Overall, the results indicate that *Enset* production is associated with larger household sizes, higher consumption, and income levels, contributing to better food security outcomes for producers over time.

The result of dummy variables over time reveals significant differences between *Enset* producers and non-producers across several socio-economic and demographic factors. Notably, the sex of the household head shows a consistent and significant difference, with a higher proportion of male-headed households among producers compared to non-producers across all three periods. This

trend suggests that *Enset* production is more prevalent in male-headed households. Additionally, marital status also exhibits a significant difference, with a higher percentage of married household heads among producers than non-producers. These patterns could indicate a possible link between household composition and the decision to engage in *Enset* production. Other variables, such as exposure to shocks, also show significant differences between producers and non-producers, particularly in 2018/19 and 2021/22, where non-producers reported higher exposure. This implies that non-producer households are more vulnerable to external shocks, which could impact their food security and overall welfare.

Table 6.2: Summary statistics of household characteristics over time

Description of Continuous Variables	2018/19 Producer M (S. D.)	2018/19 Non-Producer M (S. D.)	2018/19 t-test/X^2	2021/22 Producer M (S. D.)	2021/22 Non-Producer M (S. D.)	2021/22 t-test/X^2	2023/24 Producer M (S. D.)	2023/24 Non-Producer M (S. D.)	2023/24 t-test/X^2
Age of HH head	42.838 (13.818)	42.85 (15.91)	0.066	45.53 (13.64)	45.21 (15.22)	-0.135	43.05 (14.22)	43.12 (16.23)	-0.083
Education level of HH head (year)	9.23(2.47)	7(5.72)	1.434	9.89(4.85)	8.44(8.39)	-0.821	9.92(2.47)	9.81(5.72)	1.974
Household size	5.11(2.32)	4.14(2.72)	-2.361**	5.52(2.35)	4.41(2.64)	-2.536**	5.52(2.35)	4.52 (2.82)	-2.320**
Value of assets	29.43(25.21)	28.2(26.55)	0.500	34.56(52.23)	28.62(26.33)	-0.430	39.43 (35.21)	28.01(25.61)	-2.233
Land size (ha)	0.998(0.349)	0.854(0.59)	0.552	0.932(0.459)	0.(0.245)	0.401	0.923(0.47)	0.897(0.54)	0.231
TLU (TLU unit)	3.36(2.12)	3.34(2.24)	2.23	3.06(0.22)	3.14(0.34)	2.14	0.31 (0.232	0.28 (0.257)	2.012
Total consumption (ETB)	62781.76 (51739.54)	43613.78 (4836.42)	-2.243**	75914.2 (8315.67)	44391 (11665.8)	-0.416**	78547.96 (5209.12)	43879.81 (48363.42)	-2.203**
Total income (ETB)	64466.13 (674.63)	45715 (843.71)	-2.233**	78648.65 (2525.37)	45577.3 (4210.83)	-0.238	73951.35 (2674.03)	68042.21 (1843.71)	-2.212**
Description of dummy variables (in percentage)									
Sex of HH head (Male)	80.15	56.25	10.507**	80.74	58.33	9.448	80.88	56.25	11.319**
Marital status (married)	77.45	63.83	13.39**	81.89	65.96	8.289	81.89	65.96	13.967**
Borrow (yes)	13.24	10.42	0.258	15.2	18.2	0.245	16.2	19.95	0.257
Access to Health Insurance (yes)	23.53	18.75	0.468	27.21	10.42	5.677**	22.79	13	0.341
Head GO Employment (yes)	3	0	1.076	0	0	1.021	5	0.23	1.814
Exposed to any shock (yes)	2.21	4.17	87.624***	0.75	8.33	60.13***	1.74	7.45	66.331***
Access to credit service (yes)	56.3	54.23	5.6	58.3	47.3	7.5	59.02	41.3	4.5
Access to mobile phone (yes)	62.3	64.3	9.2	63.6	62.5	10.2	69.7	59.3	4.5
Receiving remittance (yes)	0.75	4.26	2.684	3.01	2.08	0.112	0.74	4.9	2.684

Standard deviation in parentheses, *** p<0.01, ** p<0.05, * p<0.01

6.3.2. The average yield of *Enset* products and by-products per year

To estimate the average yield per *Enset* plant and the unit price of *Enset* products, the researcher relied on previous studies (Sahle et al., 2018; Zerihun Yemataw et al., 2021) and data from the Central Statistical Agency of Ethiopia (CSA). This approach combines empirical research findings with statistical data to understand *Enset* production in central Ethiopia. Besides, the By-products (*Kocho, Bula, Amicho, Kancha. Koba*) were estimated based on farmer reports and validated with secondary sources.

Table 6.3 provides a detailed breakdown of the average productivity and economic data for various *Enset* products and by-products. The data indicates that the average number of *Enset* plants harvested per sampled household (HH) per year is 25. This number is consistent across all products, suggesting that households are managing their *Enset* cultivation in a relatively uniform manner. The average yield per *Enset* plant varies significantly among the different products: Kocho yields 17 kg per plant, Bula yields 1 kg per plant, Amicho yields 12 kg per plant, Kacha yields 11 units per plant, and Koba yields 12 units per plant. These yields are crucial for understanding the overall productivity of *Enset* cultivation.

The average yield per sampled HH per year is also provided, ranging from 425 kg of Kocho to 300 kg of Amicho. This indicates that households are producing substantial amounts of *Enset* products, with Kocho being the most significant contributor. The unit price per kg or number of each product is also given: Kocho is priced at 31.5 ETB/kg, Bula at 54.5 ETB/kg, Amicho at 28 ETB/kg, Kacha at 12 ETB/unit, and Koba at 5 ETB/unit. These prices reflect the market value of each product and are essential for calculating the total income generated from *Enset* cultivation. The total income from *Enset* products per year is calculated by multiplying the average yield by the unit price and then summing these values. For the sampled HHs, the total income from *Enset* products is approximately 27,950 ETB per year. The economic data presented in the table highlights the significant contribution of *Enset* to household income in central Ethiopia. The total income from *Enset* products per year is substantial, indicating that *Enset* cultivation is a vital source of livelihood for many households. The highest income contributor is Kocho, which generates approximately 13,387.5 ETB per year per HH. This is followed by Amicho, which contributes around 8,400 ETB annually.

The sustainability of *Enset* cultivation is also underscored by the data. The consistent yields and market prices suggest that *Enset* is a reliable crop for households. The use of *Enset* products as a

staple food and the potential for selling excess products indicate that households can diversify their income streams. Additionally, the high caloric value of *Enset* products, particularly Kocho, which provides up to 211 calories per 100 grams, makes it an essential crop for food security in densely populated areas (EHNRI (Ethiopian Health and Nutrition Research Institute), 1997). Overall, the data supports the importance of *Enset* in central Ethiopian agriculture, both as a food source and as a means of generating income for rural households.

Table 6.3: The average yield of *Enset* product and by-product per year

	The average number of *Enset* /sampled HH/year	Average yield/*Enset* plant	The average yield /sampled HH/year	Unit price /Kg or number	Income (in monetary Value in ETB)
Kocho (in Kg)					
Overall mean	25	17	425.00	31.7	13158.5
Between SD	3.2	0.83	17.18	1.45	859.91
Within SD	1.08	1.41	29.14	2.56	1511.97
Bula (in Kg)					
Overall mean	25	1	27.56	54.5	1362.5
Between SD	3.1	0.06	19.62	2.38	116.75
Within SD	0.53	0.08	22.47	5.12	188.01
Amecho (in Kg)					
Overall mean	25	12	299.45	28	8400
Between SD	5.1	0.63	22.07	1.89	629.53
Within SD	2.06	0.70	31.43	2.43	959.27
Kacha (in Number)					
Overall mean	25	11	275	12	3300
Between SD	3.2	0.60	24.16	0.67	258.28
Within SD	1.08	0.92	24.54	0.94	339.31
Koba (in Number)					
Overall mean	25.05	12	300	5	1500
Between SD	1.23	0.80	15.50	0.25	140.81
Within SD	1.52	1.10	32.29	0.40	161.62
				Total income from *Enset* per year	
				Overall mean	27950
				Between SD	818.00
				Within SD	1910.84

Note. HH = household, Kg = kilo gram, ETB = Ethiopian birr, Overall Mean = Average across all households and years, Between SD = Variation between different households, Within SD = Variation within the same household over time.

6.3.3. Calorie intake among *Enset* producers and non-producers over time

Table 6.4 provides a comparative analysis of calorie intake between *Enset* producers and non-producers in Ethiopia over three agricultural years: 2018/19, 2021/22, and 2023/24. The data reveals significant differences in calorie intake, with *Enset* producers consistently consuming more

kilocalories than non-producers. For instance, in 2023/24, *Enset* producers had an average calorie intake of 2995.021 kcal, while non-producers consumed 1892.945 kcal, a difference of -1102.076 kcal, which is statistically significant (p-value = 0.005). Similar trends were noted in earlier years, with producers consuming 2852.253 kcal in 2021/22, compared to 1814.613 kcal for non-producers (a difference of -1037.64 kcal, p-value = 0.011), and 3004.969 kcal versus 2061.058 kcal in 2018/19 (a difference of -943.911 kcal, p-value = 0.021).

These findings suggest that *Enset* production plays a critical role in enhancing food security among smallholder farmers in Ethiopia. The calorie intake disparities highlight that households involved in *Enset* production consistently surpass the food security threshold of 2100 kcal, while non-producers often fall below this level, indicating a higher likelihood of food insecurity. The results emphasize the importance of *Enset* as a staple crop in supporting food security, particularly in regions with fewer reliable food sources. Additionally, research supports the positive impact of *Enset* on food security, with studies by (Sahle et al., 2018) and (Bonso et al., 2022) reinforcing its role in improving nutritional outcomes and addressing food supply-demand gaps in Ethiopia.

Table 6.4: Average Calorie intake (food security) status over time

		Non-producer	Producer	Diff.	St Err	t-value
Calorie intake (in kilo)	2023/24	1892.945	2995.021	-1102.076	390.528	-2.8***
	2021/22	1814.613	2852.253	-1037.64	403.446	-2.55**
	2018/19	2061.058	3004.969	-943.911	403.894	-2.35**

Note. (Producer-N=202), (Non-producer-N=68)

6.3.4. Determinants of household participation in *Enset* production

The random probit model is particularly suitable for this analysis because the data likely has a hierarchical or panel structure, where observations are clustered within groups. By incorporating random effects, the model accounts for unobserved heterogeneity across these groups (Gebre et al., 2022), leading to more precise estimates. This is particularly relevant as indicated by the Hausman test results provided in Appendix 6 Table 6.1a, which support the use of a random probit model. The result reveals that the overall significance of the model is demonstrated by the Chi-square statistic, which in this case is 43.726 with a p-value of 0.000. This indicates that the model is statistically significant, suggesting that at least one of the predictors plays a crucial role in explaining the variation in the probability of *Enset* production among households (Mulatu, 2020a). In terms of the significant variables, the sex of the household head has a substantial impact, with male-headed households being significantly more likely to engage in *Enset* production. The

marginal effect of 1.689, which is significant at the 1% level, suggests that traditional gender roles may influence agricultural activities. Similarly, the education level of the household head also plays a significant role, with an additional year of education increasing the probability of *Enset* production, as reflected by a marginal effect of 0.071, significant at the 5% level (Table 6.5). This underscores the importance of education in enhancing the household head's ability to adopt and manage agricultural practices.

The number of assets owned by the household is another significant factor, with a marginal effect of 0.017, also significant at the 5% level. This suggests that households with more assets are better equipped to undertake *Enset* production, possibly due to the resources or financial stability that assets provide. Exposure to shocks, such as natural disasters or economic crises, has a particularly strong effect, with a marginal effect of 2.835, highly significant at the 1% level. This indicates that households facing adverse conditions may turn to *Enset* production as a coping strategy, given its resilience, especially in drought-prone areas. Finally, total annual expenditure is another significant predictor, with a marginal effect of 0.12, significant at the 5% level. This suggests that wealthier households, with higher expenditures, are more likely to engage in *Enset* production, possibly due to their ability to invest in the necessary resources.

Table 6.5: Probit model estimations participation on *Enset* production- Random-effect

Variables	Marginal effect (dy/dx)	St.Err.	Z-value	p-value	Sig
Sex of HH head (Male)	1.689	0.539	3.13	0.002	***
Age of HH head	0.002	0.016	0.12	0.901	
Education level of HH head (year)	0.071	0.05	1.40	0.023	**
Value of assets	0.017	0.015	1.15	0.011	**
Receiving remittance	-0.024	1.433	-0.02	0.987	
Borrowing	-0.19	0.845	-0.22	0.822	
Access to health insurance	0.893	0.625	1.43	0.153	
Exposure to shock	2.835	0.531	5.34	0.000	***
Household size	.227	0.151	1.50	0.133	
Total annual expenditure	0.12	0.21	0.76	0.047	**
Land size	0.046	0.135	0.34	0.733	
Frequency of extension contact	0.036	0.123	0.293		
Constant	3.655	3.732	0.98	0.327	
/lnsig2u	2.978	.349			
Mean dependent var	0.737	SD dependent var		0.441	
Number of observation	810	Chi-square		43.726	
Prob > chi2	0.000	Akaike crit. (AIC)		237.574	

**** p<.01, ** p<.05, * p<.1*

6.3.5. Determinants of calorie intake among households

The output provides the results of an Endogenous Switching Regression (ESR) model, estimating the determinants of calorie intake for *Enset* producers and non-producers (Table 6.6). The model differentiates the factors affecting calorie intake between the two groups and assesses the significance of variables. The ESR model estimates the impact of several variables on calorie intake for *Enset* producers and non-producers. The R-squared values indicate how well the independent variables explain the variance in calorie intake. For *Enset* producers, the overall R-squared is 0.345, meaning the model explains 34.5% of the variation in calorie intake. For non-producers, the R-squared is 0.395, showing a slightly better fit as 39.5% of the variation is explained. The Wald chi-square tests for both models are statistically significant (Prob > chi2 = 0.000), indicating that the models, as a whole, are reliable and that the included variables collectively have a significant impact on calorie intake for both groups. The model assumes zero correlation between unobserved factors and the independent variables, indicated by Corr (u_i, X) = 0 for both groups. This assumption is crucial for the validity of the ESR model. The significant Wald chi-square values for both groups (13.69 for producers and 5.34 for non-producers) further confirm that the independent variables have a significant impact on the outcome variable (calorie intake). This suggests the model is robust and appropriate for this analysis.

Sex of HH head: For producers, being male-headed significantly increases calorie intake (coef. 374.8), statistically significant at the 1% level. For non-producers, this effect is much smaller (coef. 9.292) and not significant, indicating that gender plays a larger role in calorie intake for *Enset* producers than for non-producers.

Age: For non-producers, age has a significant negative effect on calorie intake (coef. -6.772), meaning older heads of households tend to consume fewer calories, significant at the 5% level. This suggests a potential decline in labor productivity or health with age among non-producers. Age is not significant for producers.

Education level: Education is significant for both groups. For producers, an additional year of education increases calorie intake by 57.63 units, significant at the 5% level, while for non-producers, it has a smaller but still significant effect (coef. 1.000), significant at the 1% level. This indicates that education plays an important role in improving food security and dietary quality in both groups, with a stronger effect among producers.

Number of assets: For both producers and non-producers, more assets lead to higher calorie intake, significant at the 1% and 5% levels, respectively. This suggests that asset ownership improves household welfare by providing a buffer against shocks or enabling better food access.

Receiving remittance: Among non-producers, receiving remittances significantly increases calorie intake (coef. 676.5), significant at the 5% level, indicating that external financial support helps these households improve their food security. For producers, remittances have a large positive effect but are not statistically significant.

Exposure to shock: For both groups, not being exposed to shocks increases calorie intake. For producers, this is significant at the 5% level (coef. 174.0), while for non-producers, it is significant at the 1% level (coef. 93.79). This implies that households shielded from economic or environmental shocks are better able to maintain or increase their food consumption.

Total expenditure per year: For non-producers, higher total expenditure negatively affects calorie intake (coef. -0.170), significant at the 5% level, which may indicate that non-producer households spend more on non-food items as their income increases, possibly reflecting dietary changes or diversification in spending patterns.

Land size: Land size is only significant for non-producers (coef. 81.35), significant at the 5% level. This suggests that for non-producer households, larger landholdings are associated with higher calorie intake, likely due to better access to agricultural resources or food production. For producers, land size does not play a significant role.

The results indicate notable differences between *Enset* producers and non-producers in terms of calorie intake determinants. For instance, education and asset ownership are significant predictors for both groups, but their impact appears more pronounced in producers. This aligns with findings from other studies indicating that education and asset accumulation enhance food security and nutritional outcomes (M. B. Abebe & Endale, 2023; Kim et al., 2000). Moreover, the influence of remittances is significant for both groups, suggesting that external financial support plays a critical role in enhancing calorie intake. This finding is consistent with literature highlighting the importance of remittances in improving household nutrition and food security (Yu Wang et al., 2023). In contrast, the negative impact of borrowing on calorie intake is more pronounced in non-producers, which may suggest that these households face greater financial constraints that limit

their food access. This is supported by other studies indicating that indebtedness can lead to reduced food consumption (Abdulai & Huffman, 2014).

Table 6.6: Endogenous Switching Regression estimates for determinants of calorie intake

	Producer	Non-Producer
VARIABLES	Coef. (Std. Err)	Coef. (Std. Err)
Sex of HH head (male)	374.8 (332.1)***	9.292 (355.7)
Age	-10.10 (9.533)	-6.772 (10.85)**
Education level (number of years)	57.63 (37.30)**	1.000 (39.33)***
Asset value (in index)	11.20 (8.347)***	4.968(10.03)**
Receiving remittance (yes)	241 (162)	676.5 (911.1)**
Borrowing (yes)	-264.5 (458.5)	-810.8 (661.8)
Access to health insurance (No)	-134.7 (301.0)	-266.1 (455.8)
Employed in GO (Yes)	-19.82 (929.4)	Omitted
Exposure to shock (No)	174.0 (534.3)**	93.79(331.9)
Household size (in number)	89.38 (60.23)	47.71 (64.38)
Total expenditure per year (in ETB)	0.290 (0.189)	0.170 (0.198)**
Land size (in hectares)	-20.38 (73.88)	81.35 (92.26)**
Constant	-28.64 (2,986)	1,987 (2,269)
Observations	606	204
Number of households	202	68
R-squared within/between/ overall	0.147/0.661/0.345	0.591/0.142/0.395
Wald chi2	13.69	5.34
Corr (u_i, X)	0	0
Prob > chi2	0.000	0.000

Standard deviation in parentheses, *** $p<.01$, ** $p<.05$, * $p<.1$

Note. Instrumented variables= *Enset* producer or non-producer, outcome variable= Calorie intake

6.3.6. Impact of *Enset* production on household food security

Table 6.7 presents the impact of *Enset* production on household food security is measured in kilocalories. It compares the actual calorie intake of *Enset* producers and non-producers with counterfactual scenarios (i.e., what would happen if they did not produce *Enset*).

For *Enset* producers, the actual average kilocalorie intake (ATT) is 2951.714 kcal. If they did not produce *Enset*, the counterfactual scenario shows they would consume only 1912.744 kcal. The difference of 1038.969 kcal represents a 35.199% increase in food security due to *Enset*

production. This indicates a significant positive impact of *Enset* production on food security for those engaged in its cultivation. The average kilocalorie intake (ATU) for non-producers is 1935.349 kcal. However, in the counterfactual scenario where they hypothetically produce *Enset*, their intake would rise to 3013.494 kcal. This difference of -1078.145 kcal reflects a 55.7% decrease in food security without *Enset* production. This demonstrates the substantial negative impact of not producing *Enset* on household food security for non-producers.

The heterogeneity effects provide further insight into the differences between producers and non-producers. The base heterogeneity (BH1) for producers is 1016.351, indicating the baseline advantage of *Enset* production on food security. For non-producers, the base heterogeneity (BH0) is -1100.75, showing a disadvantage in food security without *Enset*. The transitional heterogeneity (TH) of -39.176 suggests that the gap between producers and non-producers in food security outcomes is quite large when transitioning from *Enset* production to non-production, further emphasizing *Enset*'s critical role in ensuring household food security.

Table 6.7: Impact of *Enset* production on household food security

		Decision stage			
Outcomes	Choice	Actual /to produce	Counterfactual/ Not to produce	ATE	Change (%)
Kilocalories	Producer (ATT)	2951.714	1912.744	1038.969	35.199
	Non-producer (ATU)	1935.349	3013.494	-1078.145	-55.7
	Heterogeneity effects	BH_1	BH_0	TH	
		1016.351	-1100.75	-39.176	

Note. ATT= Average treatment effect of treatment, ATU= Average treatment effect of untreated, BH1= Base heterogeneity effect for the producer, BH2= Base heterogeneity effect for non-producer, TH=transitional heterogeneity

6.3.6.1. Robustness Check

This study identified that while one-to-one matching provides exact estimates, one-to-many matching, on the other hand, offers a robust framework when dealing with heterogeneous treatment effects since it captures wider ranges of response in the control group (Yizhen Wang et al., 2018). The robustness check using the nearest neighbor one-to-many (one to five) matching technique indicates a significant positive effect of the treatment on calorie intake as shown in (Table 6.8), with an average increase of 968.544 calories. The results are statistically significant ($p < 0.00$), suggesting that the treatment (*Enset* producing) has a meaningful impact on enhancing calorie

consumption among the treated group's main findings. The high standard deviation of the dependent variable indicates considerable diversity in calorie intake across households.

Table 6.8: Robustness check-nearest neighbor one to many

Outcome variables	Coef.	St.Err.	t-value	p-value
Calorie intake	968.544***	211.498	4.58	0.000
Mean dependent var	2681.854	SD dependent var		2410.493

*** p<.01, ** p<.05, * p<.1*

6.4. Conclusion and recommendation

The cultivation of *Enset* plays a vital role in enhancing household food security in central Ethiopia. With an average annual income of approximately 27,950 ETB per household, primarily derived from Kocho, *Enset* not only provides economic benefits but also serves as a highly caloric staple food. The analysis demonstrates that *Enset* producers enjoy a significantly higher calorie intake—over 1,100 kcal more than non-producers—underscoring the crop's importance in improving nutritional outcomes for smallholder farmers. Households cultivating *Enset* consistently exceed the food security threshold of 2,100 kcal, while non-producers often fall short, emphasizing *Enset*'s stabilizing role in food access. Socioeconomic factors, including the sex of the household head, education level, and asset ownership, significantly influence *Enset* production and calorie intake. Male-headed households and those with higher education levels tend to achieve better caloric consumption, while households facing economic or environmental shocks are more likely to adopt *Enset* cultivation as a coping strategy. This highlights the interplay between economic stability and agricultural engagement.

Overall, *Enset* production significantly enhances household food security, with producers experiencing an average calorie intake of 2,951.714 kcal—an increase of 35.2% compared to a counterfactual scenario without *Enset*. In contrast, non-producers face a dramatic decline in food security, with a potential 55.7% decrease in calorie intake if they cease *Enset* cultivation. These findings reinforce the critical role of *Enset* in sustaining food security and highlight the need for policies that support *Enset* production and address the socioeconomic factors influencing its cultivation.

Therefore, policymakers should prioritize the National *Enset* Flagship Development Program (NEtFDP) to enhance *Enset* production, improve processing technologies, and promote research

on pest management. This will ensure that *Enset* remains a strategic crop for food security and economic stability. Expanding *Enset* cultivation beyond its traditional areas can further enhance food security and diversify agricultural practices, necessitating investment in research and development to adapt *Enset* farming methods to various agro-ecological zones across Ethiopia. Efforts should focus on empowering female-headed households through targeted support and education initiatives to increase their participation in *Enset* production. Enhancing access to education and financial resources will significantly boost *Enset* cultivation. Programs providing training and financial assistance can improve the capacity of smallholder farmers to engage effectively in *Enset* cultivation. Policies should also aim to increase educational access and quality for household heads, particularly in rural areas, to enhance food security and dietary quality among *Enset* producers. Initiatives that promote asset ownership, such as access to credit and financial resources, can improve food security and caloric intake for both *Enset* producers and non-producers.

Future research should investigate the effects of different *Enset* varieties and agricultural practices on calorie intake and food security, with a focus on improved processing technologies that could enhance production efficiency. Additionally, studies should explore the socio-economic impacts of expanding *Enset* cultivation into non-producing areas and the potential for *Enset* to contribute to climate resilience and sustainability in agricultural systems.

CHAPTER 7: DYNAMICS OF RESILIENCE TO FOOD INSECURITY AMONG *ENSET (Ensete ventricosum)* PRODUCING AND NON-PRODUCING HOUSEHOLDS IN CENTRAL ETHIOPIA. INSIGHT FROM PANEL DATA

Abstract

Resilience to food insecurity is vital in Ethiopia, where climate shocks and recurrent droughts threaten rural livelihoods. Enset (Ensete ventricosum), a drought-tolerant crop, is integral to food security in Central Ethiopia, yet its role in household resilience remains understudied. This study compares resilience between Enset-producing and nonproducing households via panel data from 270 households across three survey waves (2018/19, 2021/22, 2023/24). A resilience index measurement and analysis (RIMA) framework was employed to estimate the resilience capacity index (RCI), with key resilience pillars identified through factor analysis. A multiple indicators multiple causes (MIMIC) model links these pillars to food security outcomes, whereas random effects ordered logistic regression identifies resilience determinants. The results revealed that, compared with non-producers, Enset-producing households presented 25% greater resilience, with significant advantages in assets (AST = 3.882), access to basic services (ABS = 243.808), and adaptive capacity (AC = 12.149). Producers also had higher food consumption scores (FCS = 0.864) compared to non-producers (0.46). Dynamic analysis revealed that 75.3% of the producers recovered from food insecurity between year t+1 and year t+2, whereas 49.6% of the non-producers did. The study concludes that Enset cultivation significantly enhances household resilience through improved income diversification, financial stability, and food security. However, dependence on external aid negatively affects long-term resilience. Policy recommendations include promoting Enset cultivation, improving rural infrastructure and access to basic services, supporting income diversification for vulnerable households, and implementing shock-responsive social protection systems to mitigate the impacts of climate and economic shocks. These strategies enhance resilience and reduce food insecurity in rural areas of Ethiopia.

Keywords: *Resilience, food security, panel data, Enset crop, central Ethiopia*

7.1.Introduction

Resilience to food insecurity has emerged as a key focus in discussions of global development, particularly following the World Food Conference of 1974, which underscored the importance of food security as a critical global issue. As the impact of climate change intensifies, increasing the frequency and severity of extreme weather events, resilience in food systems has become essential for ensuring stable food supply chains and mitigating agricultural disruptions (Caron et al., 2023). In this context, resilience refers to the ability of households or communities to anticipate, withstand, adapt to, and recover from food security shocks while maintaining or improving their food security status (Barrett & Constas, 2014).

Approximately 828 million people are undernourished worldwide, with food insecurity exacerbated by factors such as conflicts, economic instability, and climate change, especially in

developing regions (Demsie, 2024). Sub-Saharan Africa, in particular, faces significant challenges in achieving food security due to high levels of poverty, frequent droughts, and a reliance on rain-fed agriculture. Ethiopia, as a case point, has seen approximately 20.1 million people requiring humanitarian assistance due to food insecurity, with children and women being the most vulnerable (Borku et al., 2024). While Ethiopia's agricultural sector, which supports more than 80% of the population, plays a vital role in food security, recurrent droughts, land degradation, and limited adaptive capacity in rural farming systems continue to pose substantial threats (World Bank, 2022) & (Zerssa, 2022).

To address these challenges, Ethiopia has implemented various resilience-building strategies, including promoting drought-tolerant crops, improving infrastructure, and diversifying livelihoods. Among these crops, *Enset (Ensete ventricosum)*, also known as the "false banana," plays a particularly crucial role in the southern and central highlands. Owing to its drought resistance and ability to provide a year-round food source, *Enset* contributes significantly to household food security in regions prone to climate shocks, such as Central Ethiopia (Sirany et al., 2022). The importance of *Enset* in stabilizing food systems underscores the need to explore its role in enhancing household resilience to food insecurity.

Ethiopia’s national strategies reflect these priorities. The global understanding of food security now includes availability, access, stability, and utilization, as defined by the Food and Agriculture Organization (FAO, 2008). The sustainable development goals (SDGs), adopted in 2015, emphasize ending poverty (Goal 1) and achieving zero hunger (Goal 2) (United Nations, 2015). At the national level, Ethiopia has launched policies such as the Growth and Transformation Plan (GTP), the Seqota Declaration, and the Ten-Year Development Plan to increase food security. The GTP, introduced in 2010, focuses on agricultural growth for vulnerable populations (MoFED, 2010). The Seqota Declaration aims to eliminate childhood malnutrition by 2030. The Ten-Year Development Plan (2021-2030) seeks to ensure food security by increasing agricultural productivity, strengthening social protection systems, and addressing the root causes of hunger while also aiming to reduce poverty and increase household resilience to food insecurity (PDC, 2021). This study aligns with these national goals by providing evidence-based analysis for improving food security, resilience, and welfare inequality among households in Central Ethiopia.

This study conducts a comparative analysis of resilience to food insecurity among *Enset*-producing and non-producing households in central Ethiopia, highlighting the effectiveness of *Enset* cultivation as a food security strategy. Unlike previous studies by (Beyene & Senapathy, 2023; Demsie, 2024; Dereje et al., 2024; T. Melketo et al., 2021; Mossie et al., 2024), which predominantly used cross-sectional data, this research leverages panel data to capture the dynamic nature of household resilience over time. By employing a longitudinal dataset, this study provides a deeper understanding of how resilience evolves, shedding light on household behaviors and adaptation strategies in response to food insecurity challenges.

Furthermore, this study introduces a comparative framework, analyzing the differences in resilience between *Enset* producers and non-producers, an aspect often overlooked in earlier research. While previous studies have treated *Enset* production as a homogenous factor, this research distinguishes its effects by examining the unique resilience capacities of households that do not engage in *Enset* cultivation. This comparative approach offers crucial insights into how the cultivation of *Enset*, a traditional staple crop, influences a household's ability to withstand food insecurity.

Additionally, this study employs the multiple indicators multiple causes (MIMIC) model, an advanced methodology rarely applied in food insecurity studies. The MIMIC model allows for a more robust estimation of resilience by examining both structural and measurement components. In this analysis, two key indices—income and food access (IFA) and stability (STB)—are introduced during factor analysis, broadening the scope of resilience factors. This study also enhances food security measurement by incorporating the reduced coping strategies index (rCSI) and calorie intake (CI), providing a more wide assessment of household resilience. Through this integration of advanced analytical tools and broader food security metrics, this research addresses critical gaps in the literature and contributes to a deeper understanding of resilience to food insecurity in rural Ethiopia.

The findings of this study are intended to inform policymakers about the resilience capacities of *Enset*-producing and non-producing households in Central Ethiopia. By analyzing dynamic changes in resilience, this study highlights the role of *Enset* cultivation in enhancing food security, providing evidence to support the promotion of drought-tolerant crops such as *Enset* in resilience-

building policies. These insights can guide targeted policy interventions aimed at reducing food insecurity, improving rural livelihoods, and fostering sustainable agricultural practices in Ethiopia.

7.2.Conceptual framework

The conceptual framework in Figure 7.1 illustrates the dynamic relationship between resilience to food insecurity and household food security over time, comparing *Enset* producers and non-producers in Central Ethiopia. At the initial point (t_0), households' food security status (Y_0) is influenced by factors such as income, food access, assets, adaptive capacity, access to services, social safety nets, and stability. These factors determine the initial resilience (R_0) of households. The framework acknowledges that some of these factors, such as geographical location, are time-invariant, whereas others, such as income and household composition, may change over time. Households then face food insecurity shocks, which can stem from events such as droughts, economic disruptions, or policy changes, to test their resilience.

The core of the framework is the response strategies that households employ, differentiating between *Enset* producers and non-producers. *Enset* producers might adopt different coping mechanisms, as *Enset* is known for its drought resistance and significant cultural and nutritional role in Ethiopian communities. The literature suggests that *Enset* production enhances household food security, particularly in areas prone to climate variability (Negash & Niehof, 2004). This comparison between *Enset* producers and non-producers provides critical insights into how production strategies impact resilience to food insecurity.

At the subsequent time (t_1, households' ability to recover and adapt is represented by their resilience to food insecurity (R_1)). Households with better access to resources, assets, and adaptive capacity are expected to show greater resilience. Food security status at this point is reassessed via indicators such as the reduced coping strategies index (rCSI), food consumption score (FCS), food expenditure share (FES), and coping index (CI), which are widely recognized in food security assessments (Daniel Maxwell et al., 2014). These indicators help capture the multidimensional aspects of resilience and food security over time.

This framework is well-aligned with your study, as it allows for the exploration of how resilience changes over time among *Enset* producers and non-producers. Panel data can be used to track these temporal changes and control for unobserved factors that remain constant within households,

providing deeper insights into how agricultural production strategies influence resilience. The use of a multiple indicators multiple causes (MIMIC) model complements this framework by assessing latent variables related to resilience and food security, with a focus on both the structural and measurement components of resilience. Studies have shown that resilience is linked to households' ability to diversify their livelihoods and adopt sustainable practices, making comparisons between *Enset* producers and non-producers particularly relevant (Barrett & Constas, 2014).

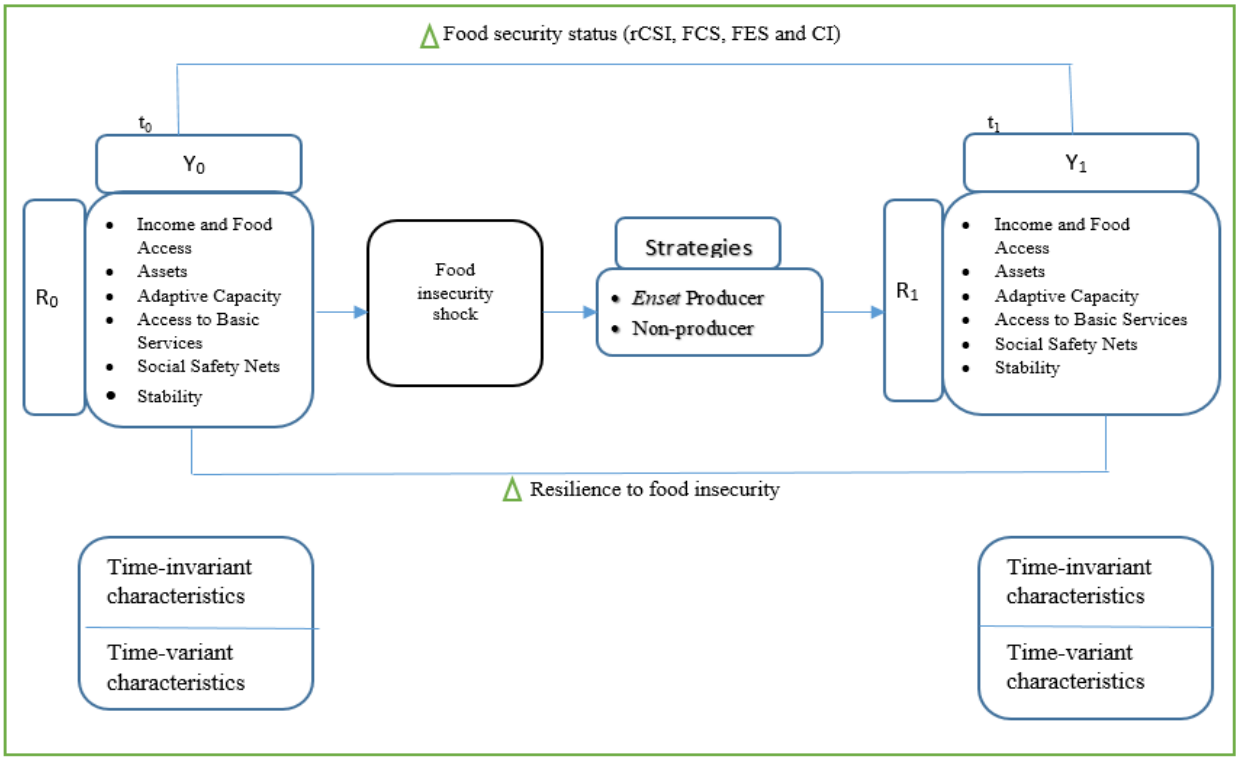

Figure 7.1: Conceptual framework of the relationship between resilience and food security over time
Source: (FAO, 2016b; D. Haile, 2023)

7.3.Research methods

7.3.1. Research Approach and Design

This study employed a longitudinal panel study design with a quantitative research approach, utilizing a panel dataset to analyze resilience to food insecurity among *Enset*-producing and non-producing households. Using panel data offers several advantages. One key benefit is the ability to conduct dynamic analysis, as following the same households over time allows researchers to capture fluctuations in food security and resilience (Caruana et al., 2015). This provides a more nuanced understanding of how these factors evolve in response to external influences or

interventions. Additionally, the longitudinal approach facilitates the identification of long-term trends and patterns in food insecurity, which can be invaluable for informing policy decisions and guiding resource allocation (Fitzmaurice et al., 2012). Furthermore, while establishing causality remains complex, longitudinal designs help mitigate some biases commonly associated with cross-sectional studies by controlling for individual differences that remain constant over time (Baumgartner, 2020). The study employs a positivist knowledge claim from a philosophical perspective, aiming to quantify how individuals understand and interpret their experiences (Hjelm, 2014). Depending on the nature of the research subject, positivism can incorporate various positivist viewpoints within a single study (Saunders, 2009), alongside inductive reasoning.

7.3.2. Methods of Data Analysis

Data analysis was conducted via Stata version 17. Descriptive statistics, including means, percentages, standard deviations, and various indices, were employed to summarize key characteristics of the data. For inferential statistics, t-tests and chi-square tests were utilized. Additionally, probit regression was applied to explore the relationships between resilience and food security outcomes. An ordered logit model was also used as an econometric approach to identify the determinants of resilience to food insecurity.

7.3.2.1.Estimation of household resilience

Resilience is a complex, multilayered concept that is not immediately apparent. Numerous experts frequently use various dimension-reducing methods to calculate resilience (d'Errico et al., 2016; C. M. Edwards et al., 2024; MoFED, 2018; Yang & Li, 2022). This study utilized the resilience index measurement and analysis (RIMA) methodology to estimate the resilience capacity index (RCI) at the household level (FAO, 2016b). This methodology involves a two-stage process (Figure 7.2). In the first stage, factor analysis (FA) was applied (Appendix 7 from Table 7.1a - 7.6f) to determine key attributes—referred to as pillars in the RIMA framework—that contribute to household resilience, starting from observable variables. In this study, the pillars assessed include access to basic services (ABSs), adaptive capacity (AC), social safety nets (SSNs), assets (ASTs), income and food access (IFA), and stability (S). The specific observed variables used to estimate each pillar are listed in Table 7.1 along with their summary statistics. Only the factors that explained at least 95% of the variance were considered for each pillar.

In the second stage, a multiple indicators multiple causes (MIMIC) model was used, following the approach of (Bollen et al., 2010; MoFED, 2018). This model constructs equations that define the analysis explores the associations among a latent, unobservable variable (resilience), food security outcome indicators, and the underlying dimensions of resilience (pillars). In the initial stage, factor analysis operates under the assumption that residual errors, or unique variances, are mutually uncorrelated and also uncorrelated with the latent construct. However, this assumption is often unrealistic in food security analyses because of the high likelihood of intra-dimension correlation. To address this, structural equation modeling, such as the MIMIC approach, allows for the correlation between residual errors (MoFED, 2018).

The MIMIC model consists of two components. The first is the measurement equation (Eq. 7.1), which reflects that the observed food security indicators are imperfect proxies for resilience capacity. The second equation is the structural equation (Eq. 7.2), which links the estimated attributes (pillars) to resilience:

$$\text{Food consumption, Dietary diversity} = [\Lambda 1, \Lambda 2][\text{RCI}] + [\epsilon 1, \epsilon 2] \tag{7.1}$$

$$[RCI] = [\beta 1, \beta 2, \beta 3, \beta 4][ABS,\ AC, SSN,\ AST, IFA, S] + \epsilon 3 \tag{7.2}$$

A cautious approach is necessary when interpreting this latent variable model, particularly concerning causal inference. There is a risk of endogeneity if the latent resilience index is simultaneously determined with the outcome of interest or correlated with the error term. In such cases, parameter estimates may be biased. While the MIMIC model cannot fully eliminate endogeneity, it helps mitigate this issue, as supported by Hausman-Vu tests in this analysis. The RIMA methodology recognizes the MIMIC model as a descriptive tool for understanding the relationship between resilience and its components, with causal analysis deferred to later regression models.

Finally, according to the estimation, the RCI does not linked to a specific measurement scale. To address this, a scale was defined by setting the coefficient of caloric intake loading ($\Lambda 1$) equal to 1. This implies that a one standard deviation increase in the RCI corresponds to a one standard deviation increase in calorie intake. This approach also determines the unit of measurement for the other food security indicators ($\Lambda 1$) and the variance of one food security indicator.

$$\text{Calorie intake} = \Lambda 1\text{RCI} + \varepsilon 1 \quad (7.3)$$

Finally, the min-max scaling transformation is used to normalize the RCI for clarity. The min-max scaling is based on the following formula. Where y represents the y^{th} household.

$$\text{RCIy} = \frac{(RCI_Y - RCI_{Min})}{(RCI_{Max} - RCI_{Min})} * 100 \quad (7.4)$$

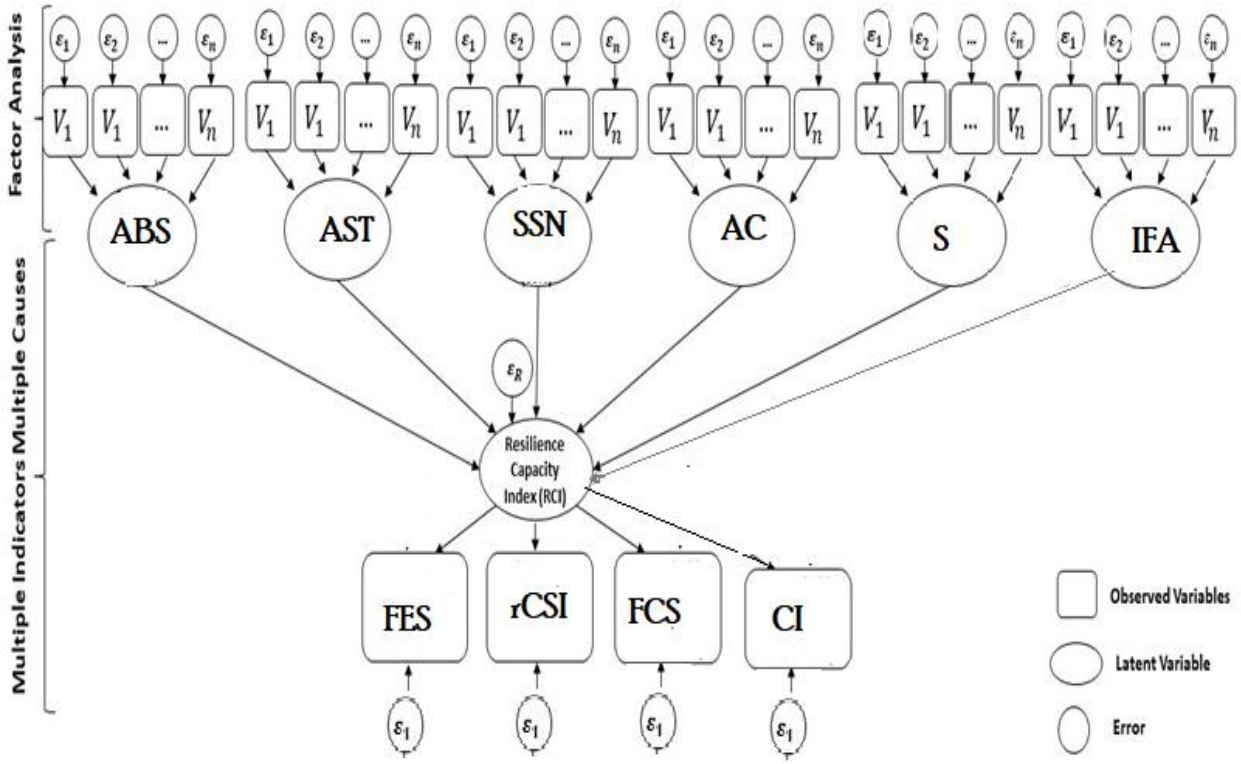

Figure 7.2: Resilience capacity index (RCI) estimation strategy in two steps

Note: (1) factor analysis (FA)-pillars (access to basic services (ABS), assets (AST), social safety nets (SSN), adaptive capacity (AC), stability (S) and income and food access (IFA)), observed variables V_i, residual errors ε_i); (2) multiple indicators multiple causes (MIMIC) model-pillars, food security indicators (food expenditure share (FES), reducing coping strategy index (rCSI), food consumption score (FCS), calorie intake (CI)), residual errors ε_i

The relationship between resilience and food security can be modeled as a relationship between a dependent variable, Y, indicating the status of the unit of analysis (the household), and some independent variables, Xi (i = 1… n), that influence this status.

$$Y = f(X1, X2, \ldots\ldots\ldots\ldots Xn) \quad (7.5)$$

The foundational elements necessary to evaluate a household's resilience generally depend on its capacity for assimilation, adaptation, and transformation, all of which are crucial in determining

how well households can navigate and survive shocks and stressors. The key components of the resilience capacity index (RCI) are as follows. First, access to basic services (ABS) highlights the importance of public infrastructure, with particular emphasis on clean water, electricity, and improved sanitation facilities, as these factors collectively shape the level of exposure a household faces in response to risks (Dawid et al., 2023; Egamberdiev et al., 2023). Second, access to assets (AST) reveals that assets, as opposed to consumption levels, provide a more accurate predictor of future poverty; greater access to land, livestock, and space enhances a household's ability to absorb shocks and manage strains without falling into poverty (Brück et al., 2019; d'Errico et al., 2023).

Moreover, adaptive capacity (AC) encompasses metrics such as food consumption ratios, the number of income sources, and the presence of stable household structures, all of which serve as indicators of a household's ability to withstand and respond to shocks effectively (Knippenberg et al., 2019). Similarly, income and food access (IFA) centers on per capita income as a primary marker of economic capacity; households with higher income are better equipped to diversify their food sources, maintain dietary diversity, and thus bolster their resilience to food insecurity, with studies suggesting that increased income reduces the likelihood of food expenditure declines during adverse periods (Beyene et al., 2023; Ladaninezhad et al., 2023)). In addition, social safety networks (SSNs) include both formal and informal transfers—either in cash or in kind—provided by various channels; participation in productive safety net programs (PSNPs) and remittances are prominent among these types of support (Brück et al., 2019; FAO, 2016b). Furthermore, stability (STB) refers to how rural households' options evolve and uses variables such as the potential wetness index, off-farm skill availability, and food supply stability to assess changes in resilience (Dong et al., 2023).

Finally, the classification of households' resilience to food insecurity is significant, with different scholars proposing various thresholds; for example, (Atara et al., 2020; Guyu & Muluneh, 2015) categorize households as vulnerable if their RCIs are less than 10%, moderately resilient if they are between 10% and 25%, resilient if they are between 25% and 50%, and highly resilient if they are above 50%. Chamdimba et al. (2021) assessed household resilience across quintiles, offering another perspective on resilience categorization.

7.3.2.2.Linking food insecurity and resilience

A broad analytical framework that connects resilience and food security can be understood as a relationship involving a dependent variable, Y, which represents the status of food security (measured through a quantitative indicator that may be either categorical or continuous depending on the specific variable) for the unit of analysis, typically the household. This relationship is influenced by several independent variables, Xi (where i = 1… n), that affect this status.

$$\mathrm{Y} = \mathrm{f}(\mathrm{X1}, \mathrm{X2}, \ldots\ldots \mathrm{Xn}) \tag{7.6}$$

We assume that certain characteristics, either household-specific or context-specific, enable some households to be more resilient to shocks than others. Therefore, it is essential to identify the factors that contribute to this resilience capacity.

$$Y = f[RCI(X1, X2, \ldots\ldots Xn), Xi + 1, Xi + 2, \ldots, Xn] \tag{7.7}$$

In this context, variables X1 to Xn represent factors related to resilience, which subsequently affect status Y (i.e., food security). Moreover, variables *i + 1* to *n* are additional factors that influence Y but do not impact household resilience, i.e., the RCI.

The relationship between resilience and food security is anticipated to be positive. Specifically, a higher RCI at time t is expected to correlate with (a) a reduced likelihood of declining food security between time *t* and *t + 1* and (b) an increased likelihood of recovery between time *t + 1* and *t + 2* for those who experienced a deterioration in food security status between *t* and *t + 1*.

A probit model was used to investigate the connection between resilience and food security. In this model, Φ denotes the cumulative density function (CDF), which follows a normal distribution. The likelihood of experiencing a negative food security outcome, such as a decrease in caloric intake or dietary diversity between time t and *t + 1*, is influenced by the resilience capacity index (RCI) and a set of household characteristics, X, at time t:

$$\text{Prob (loss in FS}t, t + 1) = \Phi(\text{RCI}j, t, \text{X}j, t) \tag{7.8}$$

In addition to per capita caloric intake and food consumption, other outcome variables, such as per capita food expenditure and the food consumption score (MoFED, 2018; Pangaribowo et al., 2013), were used to assess the robustness of the estimates. The overall pattern remains consistent.

Furthermore, equation 7.9 examines how the RCI and other factors influence the likelihood of experiencing food security deterioration during the initial phase of the analysis, regardless of the underlying cause. Nevertheless, a thorough resilience analysis should account for shocks that might impact food security outcomes, whether idiosyncratic (affecting specific individuals or households) or covariate (impacting larger groups or entire communities). Resilience is significant because it reflects a household's ability to sustain or enhance its welfare—specifically food security—in response to human-made and natural shocks and stressors. To assess the influence of these variables, shocks are incorporated into equation 9 as follows:

$$\text{Prob}(\text{loss in FS}t, t+1) = \Phi(\text{RCI}j, t, \text{X}j, t, \text{S}j, t, \text{RCI}j, t * \text{S}h, t) \quad (7.9)$$

In this context, S represents a vector of covariate or idiosyncratic shocks that impact the household between time *t* and *t + 1*. Shocks and stressors, defined as short-term deviations from long-term trends, can be incorporated into a resilience model using either self-reported indicators or those determined externally. Additionally, the model includes interaction terms between the RCI and the shock variables (denoted in equation 7.9 as $\text{RCI}j, t * \text{S}h, t$) to capture the marginal effect of the RCI on how a specific shock influences household food security.

7.3.2.3. Estimating the determinants of resilience to food insecurity.

A random-effects ordered logistic regression model was employed to estimate the determinants of resilience to food insecurity. This statistical method is particularly effective for analyzing categorical data and incorporates two types of effects that influence the probability of outcomes: fixed effects and random effects (Hedeker & Gibbons, 1994). Fixed effects capture the influence of explanatory variables that are consistent across all groups, such as age, gender, or treatment type. In contrast, random effects account for unobserved group-specific factors, such as the quality of a center or the expertise of a trial leader. These random effects are modeled as a random variable with a normal distribution, characterized by a mean of zero and a defined variance (Li et al., 2011).

One key advantage of the random-effects model is its ability to account for both within-group and between-group variations. This dual capability allows for a more nuanced understanding of differences among groups while also acknowledging similarities within them, leading to more accurate estimates of fixed effects (Irfan et al., 2018). Furthermore, the model can incorporate group-level or time-invariant variables—such as center size or trial duration—that remain constant

within groups, which would be excluded in fixed effects models that focus solely on within-group variation. This approach enhances the robustness and interpretability of findings related to food insecurity resilience**.**

Specification of random-effects ordered logistic regression.

The random effect ordered logit model can be expressed by the following equation:

$$\log\left(\frac{P(Y_{it}=1)}{1-P(Y_{it}=1)}\right) = \beta_0 + \beta_1 X_{it} \ldots\ldots + \beta_{n1} X_{nt} + u_i \ldots. + u_n \quad (7.10)$$

Where Y*it* is the binary outcome of resilience to food insecurity for household *i* at time *t,* X*it* is a vector of household-level and time-varying covariates, β0 and β1 are the fixed effects parameters, and *ui* is the household-level random effect, which is assumed to follow a normal distribution with mean zero and variance σu2. In the estimated equation, the dependent variable y_{it} is coded as 1 if households are resilient to food insecurity and 0 if not. The variable X_{it} denotes the independent variables.

7.4.Results and discussion

7.4.1. Summary statistics of variables over time

The summary statistics in Table 7.1 provide insights into the differences between *Enset*-producing and non-producing households' overtime based on three rounds of panel data. These findings are relevant for understanding resilience to food insecurity in Central Ethiopia, with *Enset* producers generally displaying greater resilience across a variety of measures than non-producers do.

One of the key differences is calorie intake, which is significantly greater for *Enset*-producing households across all rounds of data collection. In 2018/19, for example, producers had an average calorie intake of 3004.97 compared with 2061.06 for non-producers, with a highly significant difference (p<0.01p < 0.01p<0.01). This trend continues in subsequent years, indicating that *Enset* producers consistently consume more calories, a critical factor in food security. The literature supports this, emphasizing *Enset's* role as a key staple crop that sustains households during food shortages (Yemata, 2020). Additionally, food consumption per capita in monetary terms is significantly higher among the *Enset* producers. In 2023/24, *Enset* producers spent an average of 47,383.74 ETB per capita per year on food, compared with 28,670.56 ETB for non-producers (p<0.01p < 0.01p<0.01). This suggests that *Enset*-producing households not only consume more

food but also have more financial resources dedicated to food, further contributing to their resilience against food insecurity.

Concerning household characteristics, *Enset*-producing households tend to be larger, with an average household size of 5.52 compared with 4.52 for non-producers in 2023/24 ($p<0.05p < 0.05p<0.05$). Larger household sizes could be a mixed factor: while more family members could increase the need for food, larger families might also have more labor to contribute to farming activities, which is particularly important in *Enset* production. The multipurpose use of *Enset* as a food source, livestock feed, and material for household goods may help these larger households manage their food security better (Wambui, 2024). Furthermore, *Enset* producers benefit from better income and food access, with significantly higher total income and total consumption compared to non-producers across all rounds. In 2023/24, for example, producers had an average total income of 73,951.35 ETB, whereas non-producers earned 68,042.21 ETB ($p<0.05p < 0.05p<0.05$). The higher income levels among *Enset* producers likely enhance their ability to withstand food security shocks, as greater financial resources provide better access to food and other essential needs (Mulatu, 2021).

Access to basic services also differs between the two groups, with the *Enset* producers showing better access. The infrastructure index, which measures access to services such as toilets, electricity, and decent housing, is higher for producers across all rounds. In 2023/24, for example, *Enset* producers had an index score of 0.267 compared with -0.202 for non-producers ($p<0.05p < 0.05p<0.05$). Access to these basic services can be crucial for overall household well-being and resilience to food insecurity, as better infrastructure improves health outcomes and supports productive activities (Murendo et al., 2020). Another critical difference is seen in asset ownership. *Enset* producers have significantly more agricultural tools, a higher wealth index, and greater landholdings than non-producers. In 2023/24, the agricultural asset index was 0.551 for producers and 0.193 for non-producers ($p<0.05p < 0.05p<0.05$). These assets enhance households' ability to produce food and generate income, contributing to greater food security resilience. Owning more tools and wealth means that *Enset* producers are better positioned to recover from agricultural shocks, aligning with research that highlights the importance of assets in building household resilience (Sahle et al., 2018).

Another dimension of resilience is adaptive capacity, particularly through income diversification. *Enset* producers have a higher rate of income diversification than non-producers, with 76.56% of producers diversifying their income in 2023/24, whereas 59.5% of non-producers do ($p<0.01p < 0.01p<0.01$). Income diversification is a key strategy for coping with agricultural and market shocks, as it provides households with alternative income streams when one source is affected (Blomme et al., 2023b). This capacity to adapt helps *Enset* producers build resilience to food insecurity. Finally, the data show that *Enset* producers are less exposed to food security shocks than non-producers are. In 2023/24, only 1.74% of the *Enset* producers faced food security shocks, whereas 7.45% of the non-producers faced such shocks ($p<0.01p < 0.01p<0.01$). This reduced exposure to shocks highlights *Enset's* role as a buffer crop during periods of food scarcity. Other shocks, such as livestock loss or crop failure, show no significant differences between producers and non-producers. However, the data indicate that *Enset* producers are better insulated from food security threats, which aligns with studies on the drought-resistant properties of *Enset* that help stabilize food supplies during lean periods (Sirany et al., 2022).

Table 7.1: Summary statistics of variables over time

	2018/19		2021/22		2023/24		
Description of Continuous Variables	**Producer M (S. D.)**	**Non-Producer M (S. D.)**	**Producer M (S. D.)**	**Non-Producer M (S. D.)**	**Producer M (S. D.)**	**Non-Producer M (S. D.)**	**t test/X^2**
Calorie intake	3004.969 (2511.519)	2061.058 (2072.102)	2852.253 (2628.017)	1814.613 (1588.73)	2995.021 (2505.371)	1892.94 (1709.77)	-4.4720***
Food consumption per capita per household per year in ETB	46670.15 (38243.01)	28370.64 (32141.23)	49456.21 (46639.36)	29098.07 (26819.62)	47383.74 (37826.23)	28670.56 (27562.2)	-2.538***
Household characteristics							
Age of HH head	42.838(13.818)	42.85(15.91)	45.53(13.64)	45.21(15.22)	43.05(14.22)	43.12(16.23)	-0.083
Household size	5.11(2.32)	4.14(2.72)	5.52(2.35)	4.41(2.64)	5.52(2.35)	4.52 (2.82)	-2.320**
Adaptive Capacity (AC)							
Education level of HH head (year)	9.23(2.47)	7(5.72)	9.89(4.85)	8.44(8.39)	9.92(2.47)	9.81(5.72)	1.974
Income and Food Access (IFA)							
Total consumption (ETB)	62781.76 (51739.54)	43613.78 (4836.42)	75914.2 (8315.67)	44391 (11665.8)	78547.96 (5209.12)	43879.81 (48363.42)	-2.203**
Total income (ETB)	64466.13 (674.63)	45715 (843.71)	78648.65 (2525.37)	45577.3 (4210.83)	73951.35 (2674.03)	68042.21 (1843.71)	-2.212**
Access to Basic Services (ABS)							
Infrastructure Index (toilet, electricity, home condition)	0.213 (0.012)	-0.102 (0.23)	0.283 (0.231)	-0.182 (0.423)	0.267 (0.241)	-0.20 2(0.03)	0.256**
Distance to school (in km)	6.51 (5.56)	6.95 (5.56)	6.5 (5.56)	6.5 (5.96)	6.5 (5.56)	6.96 (5.906)	5.68
Distance to market (in km)	3.71(6.75)	3.45 (5.56)	3.71 (6.75)	6.5 (5.96)	3.71 (6.75)	6.96 (5.906)	5.68
Asset (AST)							
Agricultural asset index (agricultural tools)	0.26 (0.425)	0.012(0.23)	0.32 (0.83)	0.12(0.45)	0.551 (0.45)	0.193(0.522)	0.241**
Wealth index (home all tools)	0.592(0.984)	0.116 (0.95)	0.792(1.58)	0.252(2.19)	0.653(0.256)	0.184(0.971)	-2.527***
TLU (TLU unit)	3.36(2.12)	3.34(2.24)	3.06(0.22)	3.14(0.34)	0.31 (0.232	0.28 (0.257)	2.012**
Land size (ha)	0.998(0.349)	0.854(0.59)	0.932(0.459)	0.12(0.245)	0.923(0.47)	0.897(0.54)	0.231**
Description of dummy variables (in percentage)							
Household characteristics							
Sex of HH head (Male)	80.15	56.25	80.74	58.33	80.88	56.25	11.319**
Marital status (married)	77.45	63.83	81.89	65.96	81.89	65.96	13.967**
Social Safety Net (SSN)							
Receiving remittance (yes)	0.75	4.26	3.01	2.08	0.74	4.9	2.684
Access to Health Insurance (yes)	23.53	18.75	27.21	10.42	22.79	13	0.341
Adaptive Capacity (AC)							
Income diversification (yes)	75.56	55.6	76.42	58.3	76.56	59.5	24.23
Access to credit service (yes)	56.3	54.23	58.3	47.3	59.02	41.3	4.5
Access to mobile phone (yes)	62.3	64.3	63.6	62.5	69.7	59.3	4.51
Stability (S)							
Livestock loss (yes)	0.06	0.04	0.712	0.019	0.026	0.12	0.123
Crop loss (yes)	1.6	1.85	1.76	1.89	1.76	2.1	0.23
Exposed to food security shock (yes)	2.21	4.17	0.75	8.33	1.74	7.45	66.331***
Other shocks (yes)	11.5	13	22.5	34	15.25	38	4.22**

Standard deviation in parentheses, *** p<0.01, ** p<0.05, * p<0.01

7.4.2. Estimation of resilience

The MIMIC model results in Figure 7.3 and Appendix 7 (Table 7.7g) highlight crucial insights into the structural and measurement components influencing resilience to food insecurity among *Enset* producer and non-producer households in Central Ethiopia. The structural components (income and food access, assets, adaptive capacity, access to basic services, social safety nets, and stability) provide the foundation for understanding the factors that shape household resilience,

whereas the measurement components (reduced coping strategies index, food consumption score, food expenditure share, and calorie intake) serve as indicators to gauge the actual levels of resilience in these households.

For the *Enset* producers, assets (AST) and access to basic services (ABS) are highly significant, with strong positive coefficients (3.882 and 243.808, respectively), underscoring the importance of material wealth and access to infrastructure in building resilience. Adaptive capacity (AC) is another key structural factor with a significant positive coefficient (12.149), highlighting that households involved in *Enset* production have developed adaptive strategies such as diversified livelihoods and traditional knowledge, which enable them to withstand food security shocks better than non-producers (Borrell et al., 2020). This finding is consistent with the literature, which emphasizes that *Enset*, as a drought-resistant crop, strengthens food security during periods of scarcity (Morrow et al., 2023).

On the other hand, non-producer households have lower adaptive capacity (AC = 1.041) and lower access to basic services (ABS = 136.299), indicating that they may be more vulnerable to external shocks due to limited diversification and access to essential services. This lower resilience could stem from the dependence on market-based food sources or monocropping systems, which are more susceptible to climate variability and price fluctuations. The positive effect of assets (AST = 4.030) remains strong for non-producers, suggesting that wealth accumulation is still an important buffer, even for those not engaged in *Enset* production. Interestingly, the negative coefficient for social safety nets (SSNs) for *Enset* producers (-199.157) implies that households with stronger reliance on *Enset* production might be less dependent on external support systems. In contrast, non-producers (SSN = 116.94) may rely more heavily on external assistance, indicating their greater vulnerability to food insecurity shocks.

The measurement components offer evidence of how structural factors translate into resilience outcomes. The food consumption score (FCS) is significantly higher for *Enset* producers (0.864) than for non-producers (0.46), demonstrating that households cultivating *Enset* are better able to maintain consistent and diverse diets, which is a critical component of food security. This finding is in line with studies that emphasize the nutritional benefits of *Enset* as a staple crop, particularly in regions facing recurrent droughts (Morrow et al., 2023).

The reduced coping strategies index (rCSI) is constant for both groups and is set at 1, suggesting that households across the board employ similar coping strategies to address food insecurity. However, the higher FCS for *Enset* producers suggests that these households are less likely to resort to negative coping strategies such as reducing meal sizes or eating less preferred foods. The insignificant differences in the food expenditure share (FES) and calorie intake (CI) between the two groups reflect that both groups while experiencing food insecurity, face challenges in allocating household expenditures to food. The results from the MIMIC model suggest that compared with non-producers, *Enset* producers exhibit greater resilience to food insecurity. The significant positive impacts of assets, adaptive capacity, and access to basic services for producers highlight the advantages of *Enset* production in creating more resilient households. In contrast, non-producers are more dependent on external safety nets and display weaker adaptive capacity, making them more vulnerable to food insecurity shocks. These findings align with the literature, which advocates promoting *Enset* cultivation as a strategy to increase resilience in regions prone to climatic and market fluctuations (Bonso et al., 2022).

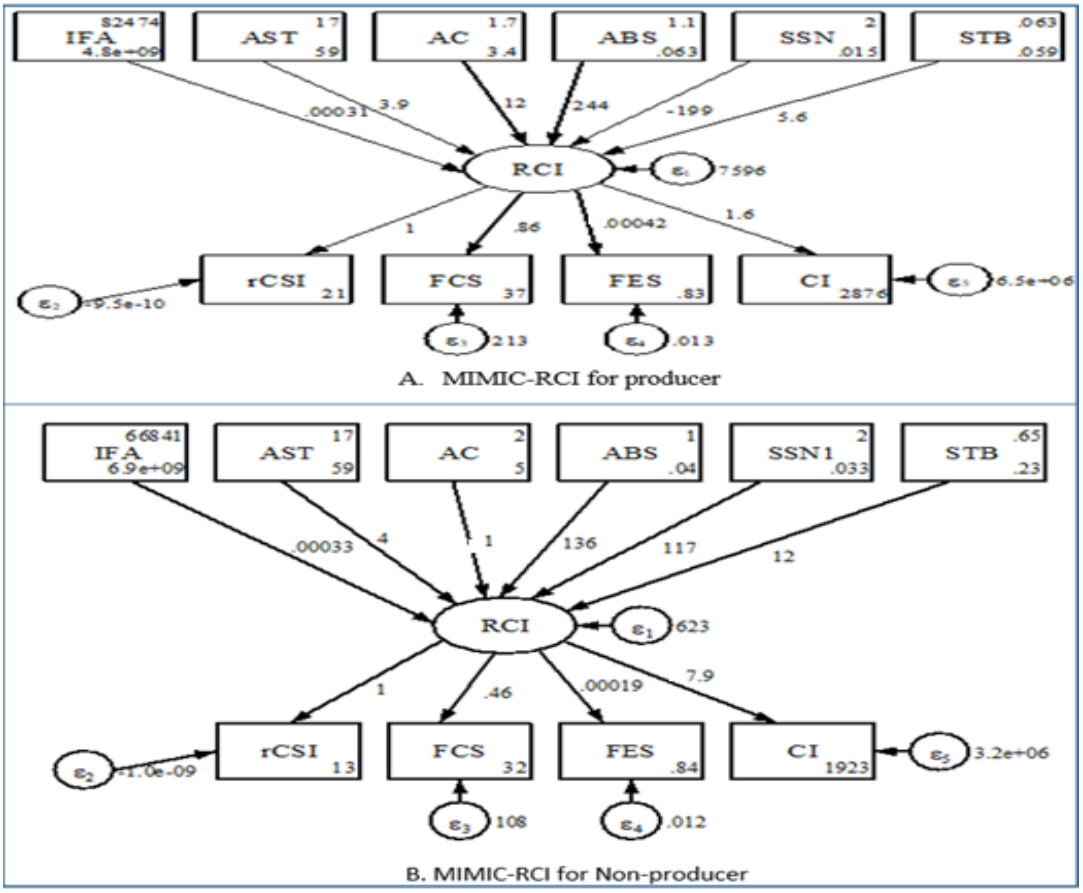

Figure 7.3: Multiple indicator multiple causes (MIMIC) model result

7.4.3. Bridging resilience and food security over time

Table 7.2 presents dynamic patterns of food insecurity among *Enset*-producer and non-producer households, measured via four key indicators: the Reduced Coping Strategies Index (rCSI), the Food Consumption Score (FCS), the Food Expenditure Share (FES), and Calorie Intake (CI). These indicators capture changes in household food security over time, comparing the resilience of *Enset* producers and non-producers from time *t* to time *t+2*. In terms of the rCSI, 12.23% of the *Enset*-producing households experienced increased coping strategies between *t* and *t+1*, indicating worsening food security. In contrast, 46.3% of non-producers faced this challenge. This suggests that non-producer households were significantly more likely to struggle and adopt coping mechanisms, reflecting greater food insecurity. In terms of recovery, 75.3% of the *Enset* producers managed to recover from increased coping strategies between *t+1* and *t+2*, whereas only 49.6% of the non-producers recovered. This higher recovery rate highlights the greater resilience of *Enset* producers than non-producers, who remained more vulnerable.

The FCS results further underline these trends. Approximately 25.36% of the *Enset* producers suffered a decline in their food consumption scores between t and t+1, whereas 52.56% of the non-producers did. Non-producers, therefore, face more significant challenges in maintaining food diversity and quality. Concerning recovery, 66.3% of the *Enset* producers managed to bounce back from food consumption losses, whereas only 42.45% of the non-producers did. This finding indicates that *Enset* producers experienced fewer declines in food consumption and had a greater ability to restore their food intake, suggesting more stability in their diets. The FES data reveal that 17.5% of the *Enset* producers experienced a decline in their food expenditure share, whereas 35.89% of the non-producers did. A decline in the food expenditure share suggests that non-producers were more likely to face worsening economic conditions or higher vulnerability, whereas *Enset* producers maintained more consistent food spending. For recovery, 56.3% of the *Enset* producers regained their food expenditure levels between *t+1* and *t+2*, whereas only 42.78% of the non-producers did, again underscoring the stronger economic resilience of the *Enset* producers.

Finally, in terms of calorie intake, 21.45% of the *Enset* producers experienced a decline between *t* and *t+1*, whereas 39.45% of the non-producers experienced a decline. This finding indicates that non-producers are more likely to experience food shortages or economic difficulties, leading to reduced calorie consumption. Moreover, the results suggest that 21.45% of *Enset*-producing households experienced a decline in calorie intake between time *t* and *t+1*, while 45.85% of them recovered their calorie intake between time *t+1* and *t+2*. In comparison, a larger proportion (39.45%) of non-producer households faced a calorie intake decline, with only 35.25% recovering by time *t+2*. These findings suggest that *Enset*-producing households demonstrate greater resilience in recovering their calorie intake after initial declines, highlighting the stabilizing role of *Enset* production in household food security.

Research has also indicated that the economic viability of the *Enset* food system is crucial for food security in Ethiopia, as it serves as a staple for approximately 20 million people (Sirany et al., 2022). The cultivation and consumption patterns associated with *Enset* contribute positively to both nutritional status and economic stability. Furthermore, mapping supply and demand dynamics for *Enset* products such as *kocho*—a staple derived from *Enset*—demonstrates that improving production can effectively address food security gaps in specific regions (Sahle et al., 2018). This

finding supports the notion that enhancing agricultural practices surrounding *Enset* can bolster household resilience. Recent studies have emphasized the importance of integrating indigenous crops such as *Enset* into broader agricultural strategies to combat food insecurity, particularly under changing climatic conditions (Morrow et al., 2023). This finding reinforces the need for policies that support sustainable farming practices around resilient crops. In conclusion, the comparative analysis of food security indicators between *Enset*-producing and non-producing households illustrates a clear advantage for those engaged in *Enset* cultivation. These findings are corroborated by existing studies that emphasize the vital role of crops in enhancing resilience and improving food security outcomes in Ethiopia. Future policies should focus on promoting *Enset* cultivation and integrating it into broader agricultural frameworks to ensure sustained improvements in food security across vulnerable populations.

Table 7.2: Dynamics of food insecurity patterns among households in percentages

Change in food insecurity status	**Producer (N=202)**	**Non-Producer (N=68)**
reduced the Coping Strategies Index (rCSI)		
Households suffering increased rCSI between time *t* and *t + 1*	12.23	46.3
Households recovering the increased rCSI between time *t + 1* and *t + 2*	75.3	49.6
Food Consumption Score (FCS)		
Households suffering a loss FCS between time *t* and *t + 1*	25.36	52.56
Households recovering the loss FCS between time *t + 1* and *t + 2*	66.3	42.45
Food Expenditure Share (FES)		
Households suffering Reduction occurring from time t to time t + 1	17.5	35.89
Household recovering FES the decline between time *t + 1* and *t + 2*	56.3	42.78
Calorie Intake (CI)		
Households suffering CI reduction between time *t* and *t + 1*	21.45	39.45
Household recovering CI the reduction between time *t + 1* and *t + 2*	45.85	35.25

Note: In the study, only significant changes in household food security status were considered, with a minimum threshold of 5% established to identify fluctuations in food security (MoFED, 2018). Consequently, a decline in food consumption and dietary diversity between time point's *t* and *t+1* is classified as such only if the food security indicator at time *t+1* is less than the value at time *t*, which is a reduction of 5%. Similarly, we determined that a household had recovered from losses incurred between time t and *t+1* if its food security indicator at time *t+2* was equal to or greater than its value at time *t*, minus 5%.

Table 7.3 presents the results from a probit regression model analyzing the possibility of facing adversity a calorie intake (CI) loss between time *t* and *t+1* (columns 1 and 2) and recovering from this loss between *t+1* & *t+2* (column 3). Separate results are presented for *Enset*-producing and non-producing households. The chi-square statistic is highly significant ($p < 0.001$) in all the

models, indicating that the model fits the data well. The Akaike information criterion (AIC) shows that the models for producers have lower values, indicating a better fit than the non-producer models. The dependent variable is binary: experiencing a CI loss or not (columns 1 and 2) and recovering from that loss or not (column 3).

Sex (female-headed): Female-headed households among producers have a positive but not statistically significant effect on CI loss in column 1, while they are negatively related to the likelihood of recovery. For non-producers, being a female-headed household is associated with lower levels of recovery, showing significant negative coefficients in columns 2 and 3. This suggests that female-headed households are less likely to recover from calorie intake losses, especially among non-producers.

Age of household head: Older household heads in producer households are less likely to experience CI loss, as indicated by the significant negative coefficients in column 1, whereas, among non-producers, age has a significant positive effect on recovery, particularly in columns 2 and 3.

Household size and squared household size: A larger household size increases the likelihood of suffering CI loss in both groups (positive coefficients in column 1), but as household size increases (when squared), it has a nonlinear effect, reducing CI loss significantly in columns 2 and 3 for both groups. This nonlinear pattern suggests that very large households might have coping mechanisms to manage calorie intake better.

Rural residence: For producers, rural households are less likely to experience CI loss, as shown by the significant negative coefficient in column 1. However, rural residence is a strong determinant of recovery for non-producers, especially in column 3.

Household category (producer): The household category variable indicates that being a producer household significantly reduces the likelihood of suffering CI loss, as shown by the negative coefficient in column 1 for producers. This protective effect is also visible in the recovery from CI loss in column 3, indicating that producer households have a resilience advantage.

Resilience capacity index (RCI): A higher RCI in producers and non-producers reduces the likelihood of CI loss (columns 1 and 2). For non-producers, it also significantly increases the chances of recovery, as shown in column 3. This implies that more resilient households are better equipped to cope with calorie intake fluctuations.

CI and CI < 2100: A higher initial calorie intake (CI variable) leads to a greater likelihood of suffering CI loss in columns 1 and 2 for both groups. This reflects that households with higher initial calorie intake have more room to reduce consumption without becoming food insecure. The interaction term (RCI * CI < 2100) suggests that resilience capacity mitigates the impact of extreme calorie deprivation (< 2100 calories) on future calorie losses.

The results of this analysis align with previous research that highlights the critical role of resilience capacity in determining households' ability to withstand food shocks. Studies on resilience in East Africa have consistently shown that households with greater resilience—often measured through economic, social, and asset-based buffers—are better able to mitigate the effects of adverse conditions such as droughts, price fluctuations, and other environmental shocks. For example, (Béné et al., 2014) reported that households with greater resilience are less likely to suffer significant declines in calorie intake during periods of food insecurity, as they have more resources to draw upon in times of need. Similarly, the work of (Brück et al., 2019) emphasized the importance of resilience in enabling households to maintain food security in the face of environmental shocks, noting that social networks and diversified livelihoods are critical components of household resilience.

The nonlinear relationship between household size and food security observed in this study also echoes findings from previous research. Larger households, while having higher calorie demands, are often more resilient due to the diversification of income sources and labor availability. Studies such as those by (Jones et al., 2013) suggest that larger households can better cope with food insecurity due to economies of scale, shared resources, and increased labor capacity, which provide more opportunities to buffer against food shortages. The inclusion of squared household size in this model captures this nonlinearity, indicating that after a certain point, larger households may have enough resources to mitigate food insecurity risk.

The significant difference between *Enset*-producing and non-producing households further suggests that *Enset* production has a stabilizing effect on food security. *Enset*, often referred to as the "tree against hunger," is well-documented for its drought resilience and ability to provide food security in the Ethiopian highlands (Brandt, 1997). Studies have demonstrated that *Enset*-producing households are more resilient to climatic shocks, as the perennial nature and resistance

of crops to drought enable farmers to maintain food supplies even during times of water scarcity (Mellisse et al., 2018). This supports the finding that producer households are better able to avoid calorie intake loss and recover more effectively from food shocks than non-producer households are.

Table 7.3: Probit regression of suffering in calorie intake (CI) loss between *t* and *t+1* and recovering from loss between *t+1* and *t+2*.

	Producer			**Non-producer**		
	1	**2**	**3**	**1**	**2**	**3**
Sex (female-headed)	0.367**	0.047	-0.308	-0.085	-0.018***	-0.028
	(0.373)	(0.879)	(0.313)	(0.067)	(0.003)	(0.041)
Age of household head	-0.557***	-0.308*	0.042	-0.028***	-0.047	0.039
	(0.258)	(0.313)	(0.168)	(0.008)	(0.041)	(0.049)
Marital status (married)	-0.0602	-0.429	0.441**	-0.150***	-0.053	0.016***
	(0.094)	(0.168)	(0.082)	(0.040)	(0.048)	(0.006)
Household size	0.27***	0.141***	-0.637**	0.005***	-0.016***	0.075**
	(0.128)	(0.082)	(0.692)	(0.001)	(0.004)	(0.029)
Squared household size	-0.22***	-0.637***	0.321	-0.482***	-0.102***	-0.002
	(0.371)	(0.692)	(0.920)	(0.185)	(0.023)	(0.001)
Rural	-0.065***	-0.321	0.187**	0.147***	0.003***	0.352**
	(0.0825)	(0.920)	(0.169)	(0.040)	(0.001)	(0.135)
Household category (Producer)	-0.737**	-0.187**	0.874***	0.729	0.348	-0.086**
	(0.0601)	(.969)	(0.489)	(1.824)	(0.111)	(0.029)
RCI	-0.280**	-	0.407***	-0.325***	-0.553***	0.033**
	(0.32)	546.874***	(0.489)	(0.824)	(0.210)	(0.342)
		(0.489)				
CI	0.464***	0.407***	-0.147	0.047***	0.025***	-0.413***
	(0.304)	(0.489)	(0.129)	(0.040)	(0.345)	(0.356)
CI<2100	-0.464***	-	-0.147	0.147***	0.756***	1.718***
	(0.304)	656.407***	(0.129)	(0.040)	(0.334)	(0.321)
		(157.489)				
RCI*CI<2100	-0.207		0.012***	0.729	0.718***	0.658***
	(0.156)		(0.029)	(0.824)	(0.231)	(0.352)
Constant	-2.235***	-1.560***	1.408***	-1.215***	-1.318***	1.718***
	(0.452)	(0.546)	(0.569)	(0.824)	(0.430)	(0.331)
Mean dependent var	0.219	0.321	0.253	0.2239	0.429	0.156
Prob > chi2	0.000	0.000	0.000	0.001	0.012	0.000
SD dependent var	0.414	0.014	0.321	0.142	0.254	0.432
Chi-square	61.992	60.97	51.52	53.721	48.456	49.75
Akaike crit. (AIC)	404.352	314.012	202.235	209.42	104.352	110.452

Note: 1=CI decline btw *t* & *t+1*; 2=CI decline btw *t* & *t+2*; 3=Recover from CI declines btw *t+1* & *t+2*. We assume a value of 1 for the decline in columns 1 & 2. Assuming value 1 for recovery in column 3

7.4.4. Determinants of household resilience to food insecurity

The overall significance of the model is supported by the Wald chi-square statistics, which indicate strong relevance to both producer and non-producer households. The Wald χ^2 values of 2943.08 for producer households and 2753.08 for non-producers, both with p values of 0.000, demonstrate

that the included variables are significant predictors of household resilience to food insecurity. Moreover, the log-likelihood ratio tests (Prob > chi^2 = 0.000) further confirm the high significance of the models, rejecting the null hypothesis that the coefficients are jointly zero. Thus, the model's overall fit is statistically sound for both groups, indicating that the selected predictors explain a substantial part of the variance in resilience to food insecurity (Table 7.4).

For producer households, several key variables emerge as significant determinants of resilience to food insecurity. Education level is one of the strongest predictors, with a coefficient of 0.806 and an odds ratio of 2.233 ($p<0.01$), indicating that higher educational attainment is positively associated with resilience. Households with more educated members are more than twice as likely to be more resilient, reflecting the role of education in improving knowledge, resource management, and access to opportunities that can mitigate food insecurity. Similarly, the asset index is positively associated with resilience, with a coefficient of 0.212 and an odds ratio of 1.243 ($p<0.01$). This suggests that households with more assets have a greater capacity to withstand food insecurity, likely because they can liquidate or leverage assets in times of need.

Conversely, exposure to shocks negatively affects resilience (Coeff = -0.237; odds ratio = 0.789; $p<0.01$), highlighting the vulnerability of households to external disruptions such as droughts or price shocks. Households exposed to shocks have 21% lower odds of being resilient. Total income also plays a significant role, with a coefficient of 0.202 and an odds ratio of 1.224 ($p<0.05$), indicating that higher-income households are better able to maintain food security. Surprisingly, land size is negatively associated with resilience (Coeff = -0.263; odds ratio = 0.768; $p<0.05$), which may reflect inefficiencies in land use or increased resource demands for managing larger plots, reducing household resilience.

For non-producer households, education level again proves to be a critical factor, with a coefficient of 0.592 and an odds ratio of 1.967 ($p<0.01$), indicating that better-educated households are nearly twice as likely to be more resilient. This finding reinforces the idea that education improves households' ability to cope with food insecurity, regardless of their reliance on agricultural production. In addition, health insurance is a significant predictor (Coeff = 0.744; odds ratio = 2.095; $p<0.05$), showing that access to formal safety nets enhances resilience by providing a buffer against health-related shocks that could otherwise deplete household resources.

Like producer households, exposure to shocks decreases resilience in non-producer households (Coeff = -0.128; odds ratio = 0.879; $p<0.01$), although the effect is slightly weaker than that in producers. Total income has a substantial positive effect on resilience, with a coefficient of 0.605 and an odds ratio of 1.833 ($p<0.01$), suggesting that non-producers rely more heavily on income to secure food. Additionally, calorie intake is a significant predictor of resilience (Coeff = 0.157; odds ratio = 1.147; $p<0.05$), indicating that higher food consumption directly contributes to a household's ability to avoid food insecurity.

Moreover, recent studies corroborate the findings that education, asset ownership, exposure to shocks, and income significantly influence this resilience. For example, a study highlighted that education is a robust predictor of resilience, with higher educational attainment correlating with increased odds of being resilient among both producer and non-producer households (Dereje et al., 2024). This aligns with the notion that education enhances knowledge and resource management capabilities, which are essential in mitigating food insecurity.

Moreover, the asset index is positively correlated with resilience, suggesting that households with more assets can better navigate periods of food insecurity by leveraging these resources (T. Melketo et al., 2021). Conversely, exposure to shocks—such as droughts or economic fluctuations—negatively impacts resilience, indicating that households facing frequent disruptions are less likely to maintain food security (Mossie et al., 2024). The relationship between total income and resilience is also significant; higher income levels enable households to secure food more effectively, as evidenced by various studies demonstrating that income diversification can enhance resilience against food insecurity (Beyene & Senapathy, 2023). Interestingly, land size presents a paradoxical finding, while larger land holdings are typically associated with greater agricultural output, they may also impose higher resource demands and inefficiencies that reduce resilience in some contexts16. For non-producer households, access to health insurance has emerged as a crucial factor, underscoring the importance of formal safety nets in enhancing resilience against health-related shocks that could deplete household resources (Dereje et al., 2024).

Table 7.4: Determinants of household resilience to food insecurity-random effects OLR

Resilience category	Producer		Non-Producer		Total as a pool	
	Coef.	**Odds Ratio**	**Coef.**	**Odds Ratio**	**Coef.**	**Odds Ratio**
Sex of household (female-headed)	-0.512 (0.601)	0.599 (0.24)	-0.160 (0.841)	0.852 (0.756)	-0.424 (0.669)	0.654 (0.437)
Age of household head	-0.175 (0.0142)	0.839 (0.16)	0.001 (0.0183)	1.001 (0.023)	-0.131 (0.0153)	0.877 (0.0134)
Marital status (married)	-0.0472 (0.162)	0.954 (0.839)	-0.0814 (0.226)	0.922 (1.89)	-0.056 (0.180)	0.946 (0.170)
Education level	0.806*** (0.0976)	2.238*** (1.001)	0.529*** (0.0984)	1.967*** (0.106)	0.737 (0.098)	2.09 ** (0.204)
Asset index	0.218*** (0.026)	1.243*** (1.003)	-0.126*** (0.0286)	0.882*** (0.027)	0.132 (0.0254)	1.141 ** (0.029)
Health insurance (yes)	0.16*** (1.381)	1.173*** (1.23)	0.744*** (0.281)	2.09*** (2.56)	0.31 (0.197)	1.363 (0.269)
Exposure to shock (yes)	-0.237*** (1.602)	0.789*** (0.3)	-0.128*** (0.948)	0.879*** (2.8630)	-0.21 (1.613)	0.811*** (1.308)
Household size	-0.131 (0.106)	0.877 (0.648)	0.114 (0.127)	1.12 (0.256)	-0.07 (0.112)	0.932*** (0.104)
Total income	0.202*** (0.105)	1.224 (1.002)	0.605** (0.105)	1.83*** (1.91)	0.302 (0.118)	1.353** (0.160)
Total annual consumption	Omitted	Omitted	Omitted	Omitted	Omitted	
Land size	-0.263** (0.113)	0.768 (0.86)	-0.102 (0.190)	0.903 (0.508)	-0.223 (0.136)	0.81*** (0.109)
Access to mobile phone	0.432 (0.412)	1.540 (0.875)	0.032 (0.111)	1.032 (0.578)	0.352 (0.361)	1.422** (0.514)
Access to credit	0.80*** (0.877)	2.225 (0.43)	0.533*** (0.446)	1.704 (0.326)	0.739 (0.792)	2.095 (1.659)
Food consumption	0.169*** (0.545)	1.184 1.02)	0.194** (1.605)	0.00347*** (2.795)	0.175 (0.929)	1.192 (1.107)
Calorie intake	0.212*** (0.756)	1.236 (0.987)	0.137 (0.028)	1.147*** (1.025)	0.193 (0.656)	1.213** (0.795)
Cut 1	33.13*** (9.696)	7527.859***	18.08*** (5.161)	407.338***	407.338*** (5.161)	
Cut 2	39.09*** (9.888)	8178.291*** (44.252)	22.02*** (5.440)	785.413***	785.713*** (5.440)	
Cut 3	45.88*** (10.13)	8804.284*** (88.890)	25.16*** (5.648)	1251.600*** *	4551.4*** (0.25)	
Sigma	0.056(0.365)		00.036(0.145)		0.36(0.185)	
Wald Chi2 (15)	2943.08		2753.08		2854.01	
Prob > chi2	0.000***		0.000***		0.000***	
Observations	603		207		810	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Note: resilience category (RCI < 10% = vulnerable, if 10% < RCI < 25% = moderately resilient, if 25% < = RCI < = 50% = resilient, if the RCI is above 50% = highly resilient)

7.5. Conclusion and policy implications

The study reveals that, compared with non-producer households, *Enset*-producing households demonstrate significantly greater resilience to food insecurity over time. This resilience is reflected in greater calorie intake, improved food consumption scores, and reduced exposure to food security shocks. *Enset* producers benefit from stronger financial stability, characterized by higher total income, agricultural assets, and wealth indices, which empower them to cope with food security challenges. Additionally, their adaptive capacity is enhanced through greater income diversification, enabling them to withstand agricultural and market shocks. Access to basic services further contributes to resilience for both producers and non-producers, with a pronounced positive effect observed among *Enset* producers. However, reliance on social safety nets negatively impacts the resilience of *Enset* producers, indicating that dependence on external aid may hinder long-term self-sufficiency. Moreover, *Enset* producers maintain more consistent food expenditures and recover more swiftly from food security declines, underscoring the broader economic benefits of *Enset* cultivation.

Specific determinants of resilience include household characteristics, such as size and composition. Larger households initially face greater risks of calorie intake loss but can leverage shared resources to improve their ability to cope over time. Female-headed households, especially non-producers, are particularly vulnerable and struggle to recover from calorie intake losses. In contrast, older household heads in producer households benefit from greater protection against such losses, highlighting the varying resilience capacities based on household demographics. Education plays a crucial role, as higher educational attainment enhances resilience for both *Enset* producers and non-producers by improving their resource management and coping abilities. However, exposure to external shocks, such as droughts and price fluctuations, significantly undermines household resilience.

To address these findings, policymakers should prioritize the promotion of *Enset* cultivation as a key strategy for enhancing resilience, particularly in regions vulnerable to food insecurity. Investments should focus on improving infrastructure and access to basic services, especially for non-producing households, to bolster their overall well-being and reduce food insecurity risks. Expanding programs that support income diversification will provide households with alternative financial sources during shocks.

CHAPTER 8: EXPLORING THE MAGNITUDE OF THE NEXUS BETWEEN WELFARE, FOOD SECURITY, AND RESILIENCE: A COMPARATIVE STUDY OF *ENSET (Ensete ventricosum)* PRODUCING AND NON-PRODUCING HOUSEHOLDS IN CENTRAL ETHIOPIA.

Abstract

Food security, welfare, and resilience are critical dimensions of sustainable development, particularly in agrarian economies such as Ethiopia. This study examines the interplay of these dimensions, comparing Enset growers and non-growers in the Central Ethiopian region, using panel data and robust analytical methods to address gaps in previous research. A mixed-methods approach was employed, combining quantitative analysis with qualitative insights from focus group discussions and key informant interviews. Descriptive statistics, principal component analysis (PCA), and three-stage least squares (3SLS) regression were used to examine these relationships and address endogeneity. The results show that resilience factors explained 58.5% of the variance for the Enset producers and 56.1% for the Non-producers. Enset producers were more reliant on social safety nets (loading = 0.630) and adaptive capacity (0.540), whereas non-producers were more reliant on income and food access (0.647). Welfare analysis in the expenditure approach accounted for 34.4% of the variance for producers and 34.2% for non-producers, with asset value being more critical for producers (loading = 0.656) and education for non-producers (0.741). Food security outcomes indicated that the Enset producers had significantly greater calorie intake ($p < 0.01$) and a larger proportion of food-secure households (60.78% vs. 23.61%). The 3SLS analysis confirmed significant linkages between food security, resilience, and welfare, with stronger effects for producers ($\beta = 0.009$, $p < 0.05$; $\beta = 0.856$, $p < 0.05$). The study concluded that Enset-producing households experience stronger interconnections between food security, resilience, and welfare, with calorie intake and resilience playing critical roles in enhancing well-being.

***Keywords**: Food security, Resilience, Welfare, 3SLS, Central region of Ethiopia*

8.1.Introduction

Food security[8], welfare[9], and resilience[10] are critical dimensions of sustainable development, as highlighted by the United Nations Sustainable Development Goals (SDGs), particularly SDG 1

[8] Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 2008).

[9] Welfare refers to the state of well-being of individuals or populations, encompassing physical, mental, and social dimensions. It includes access to essential resources, services, and conditions that enable individuals to lead healthy and fulfilling lives (Sen, 1999).

[10] Resilience is the capacity of a system, community, or individual to anticipate, absorb, adapt, and recover from shocks, stressors, or changes while maintaining essential functions and structures (Holling, 1973; Walker et al., 2004).

(No Poverty) and SDG 2 (Zero Hunger). Despite significant progress in reducing poverty and improving food security worldwide, challenges persist, especially in regions highly vulnerable to climate change, population growth, and resource constraints (IFAD, 2017). Sub-Saharan Africa remains one of the most food-insecure regions, with approximately 282 million people facing hunger in 2022, exacerbated by economic shocks, conflicts, and extreme weather events (WFP & UNICEF, 2023).

The global nexus of welfare, food security, and resilience is complex and multifaceted. Globally, food security is threatened by climate change, economic instability, and conflict (UNICEF, 2024). According to the World Food Programme (WFP), social protection programs are crucial in building resilience and ensuring food security (Sabates-Wheeler & Devereux, 2018). The United Nations has highlighted the importance of addressing these issues through integrated approaches (Sharma & Kumar, 2020). In addition, the Food and Agriculture Organization (FAO) emphasized the need for sustainable agricultural practices and policies to enhance food security and nutrition.

Regionally, in sub-Saharan Africa, the Intergovernmental Authority on Development (IGAD) has developed a Food and Nutrition Security Strategy (2025--2034) to address food security challenges in East Africa. This strategy focuses on improving the availability and accessibility of nutritious food, promoting sustainable agricultural practices, and increasing resilience to climate change (Canton, 2021).

Ethiopia, one of the most agrarian countries in Africa, faces persistent challenges in terms of food security and poverty reduction, compounded by recurrent droughts, land degradation, and rapid population growth (Deressa et al., 2009). The southern and central parts of the country's agricultural systems are diverse, with *Enset (Ensete ventricosum*) playing a vital role in the livelihoods of millions of households in central and southern Ethiopia. Known as the "tree against hunger," *Enset* is a perennial crop that enhances food security and resilience due to its drought tolerance characteristics and multiple uses (Yemata, 2020). However, there is a stark contrast between *Enset*-producing and nonproducing households regarding welfare and coping capacities, yet comparative studies examining these differences remain scarce.

Enset (*Enset*e ventricosum), sometimes called "false banana", is one of the staples in building up food security with respect to all four aspects- availability, accessibility, utilization, and stability at

different times of year. Its remarkable drought tolerance allows it to survive in areas where most other crops have perished and has year-round yields and provision as a "field bank" during food shortages. That property historically saved many populations from famine when such crises occurred, making it one of the very important sources of food availability in Ethiopia (Yemata, 2020). Moreover, *Enset* is produced nearly exclusively on a local scale, wherein communities are endowed with rich indigenous knowledge regarding its processing and use. Because of this local cultivation, both the *Enset* and its derived products are near potential users within growing regions, thus increasing accessibility for rural farmers. Greater demand for *Enset* has also provided small-scale farmers with new market opportunities, thus enlarging access to the crop (Senbeta et al., 2022). Nutritionally, *Enset* is rich in carbohydrates and essential nutrients that support dietary needs. Its various forms—such as kocho, amcho, and bulla—are staples in the diets of millions, and the long shelf life of *Enset* products allows for extended use without spoilage, making it an excellent source of food that can be stored and consumed over time (Wambui, 2024). Furthermore, the stability of *Enset* production is bolstered by its resilience to climate change and environmental stresses; its extensive root system helps prevent soil erosion while contributing to soil fertility. The integration of *Enset* farming with other crops promotes biodiversity, enhancing the overall stability of food systems in these regions (Borrell et al., 2020).

The nexus between welfare, food security, and resilience is a critical area of inquiry in addressing household well-being and sustainable development, particularly in agricultural economies such as Central Ethiopia. Understanding how these dimensions interact is vital for designing effective policies to combat poverty, food insecurity, and vulnerability. Ethiopia's development plans and food system pathways aim to build a more resilient and sustainable food system (EFD, 2019). The government has implemented various programs, such as the Green Legacy Initiative and the Wheat Initiative, to enhance food security and promote sustainable agricultural practices. Additionally, Ethiopia has been actively working on building climate resilience through measures such as promoting conservation agriculture and investing in irrigation infrastructure (Koo et al., 2019).

Previous studies have focused predominantly on the relationships between only two variables, such as welfare and food security (Sibhatu & Qaim, 2018) or welfare and resilience (Béné et al., 2012), neglecting the complex interplay among all three dimensions. This limitation restricts

understanding of the factors that shape household well-being, especially in rural agricultural communities.

Moreover, most prior research has relied on cross-sectional data (Béné et al., 2012; Deressa et al., 2009; Sibhatu & Qaim, 2018), which fail to capture the temporal dynamics and interdependencies of welfare, food security, and resilience. The exclusive use of quantitative methods in earlier studies (Frelat et al., 2016) further limits the depth of insights into household decision-making processes and coping mechanisms. Analytical methods such as two-stage least squares (2SLS) employed in previous studies (Alene & Manyong, 2006) have inadequately addressed the potential endogeneity and simultaneity of the nexus, leading to biased estimates.

This study addresses these gaps by adopting a novel approach. Conceptually, it simultaneously examines the magnitude of the nexus among welfare, food security, and resilience, offering a perspective that previous studies lack. This research uses panel data to capture intertemporal dynamics and variations, providing insights into how these variables evolve. Applying a mixed research design integrates quantitative and qualitative methods, enabling a more nuanced understanding of household behaviors and challenges. Additionally, using a robust three-stage least squares (3SLS) model ensures more accurate estimation by accounting for endogeneity and the interconnectedness of the variables. Focusing on *Enset*-producing and nonproducing households in Central Ethiopia, this study also addresses the contextual gap in the literature, as *Enset*—a staple crop in the region—is known for its resilience-enhancing properties but remains understudied for resilience, welfare, and food security. Specifically, the objectives of this study are (1) to evaluate and compare the levels of welfare, food security, and resilience among *Enset*-producing and nonproducing households in Central Ethiopia and (2) to identify and quantify the interrelationships between welfare, food security, and resilience within *Enset*-producing and nonproducing households. By bridging these gaps, this research contributes to the growing body of literature on sustainable livelihoods and offers actionable insights for policy and practice.

8.2.Conceptual framework

The conceptual framework presented in Figure 8.1 illustrates the interconnectedness of welfare, food security, and resilience among households, focusing on *Enset*-producing and nonproducing households in central Ethiopia. This study specifically examines these elements as the outcome

components of the Sustainable Livelihood Framework (SLF), which comprises five components: vulnerability, assets, processes and transformation, strategies, and outcomes. By concentrating on food security, resilience, and welfare, the framework provides a structured approach to understanding how these outcomes interact and shape household well-being and coping strategies.

Welfare is represented through indicators such as education, assets, health services, exposure to shocks, total expenditure, and total income. These factors contribute to the overall living standards and economic stability of households. Welfare directly influences food security, as higher income and greater asset ownership enhance food availability and access through increased purchasing power. Improved education and health services are crucial for sustainable welfare outcomes, which can lead to improved food security and increased household resilience. Recent studies support this connection, highlighting that higher welfare levels improve food access and utilization, thereby bolstering food security (Durao et al., 2020; Stifel & Minten, 2019).

Food security in the framework is captured by calorie intake, which serves as an indicator of whether households meet their nutritional needs. Food security is influenced by a household's welfare status, as adequate income and resources enable access to diverse and sufficient food. Studies have shown that crop diversification, such as *Enset* production, acts as a buffer against seasonal food shortages and can contribute significantly to food security (Sisay, 2024).

Resilience is defined by factors such as income and food access, assets, adaptive capacity, access to basic services, social safety nets, and stability. These elements are vital for a household's ability to respond to and recover from adverse events. Resilience moderates the effects of welfare on food security and vice versa. Households with high resilience are better equipped to maintain stable food security during economic or environmental challenges. Recent research has emphasized that households with strong adaptive capacities and access to social safety nets are more capable of sustaining food security under stress (RESILIENCE, 2019; Sam et al., 2019)

The interconnections depicted in the framework show that welfare improvements lead to better food security outcomes. For example, higher income levels empower households to purchase a more varied and nutritious diet. Additionally, aspects of welfare, such as education and asset ownership, contribute to building household resilience (French et al., 2019). The framework also

illustrates that resilience positively influences food security, as adaptive strategies, including diversified food sources and social support mechanisms, can sustain households during shocks.

The role of *Enset* production is particularly significant in this context. Studies highlight that, owing to the drought-resistant nature and nutritional benefits of crops, *Enset* productive households tend to be more food secure (Wambui, 2024). On the other hand, nonproducing households may depend on other crops or income-generating activities, influencing their resilience and food security differently (Taye et al., 2024). Overall, this framework underscores the complex and dynamic relationships among welfare, food security, and resilience. This suggests that policies aimed at enhancing education, asset-building, and social safety nets are critical for strengthening household resilience and achieving sustained food security over time. Understanding these relationships is vital for designing effective interventions that reduce vulnerability and promote sustainable development in regions such as central Ethiopia.

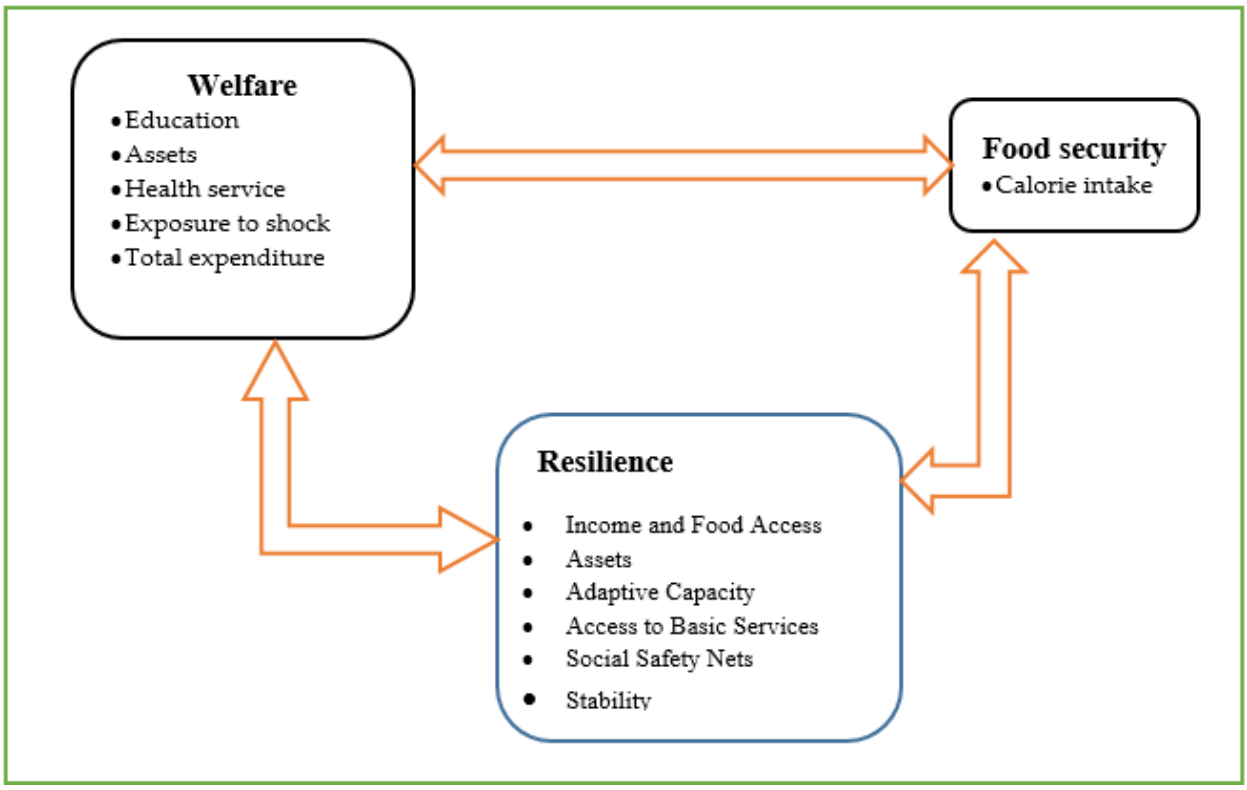

Figure 8.1: A conceptual framework for the nexus between welfare, food security, and resilience

8.3.Research Methodology

8.3.1. Research Approach and Design

This study utilized a methodological framework that blends qualitative insights with quantitative analysis within a longitudinal panel study framework. Employing panel data provides several distinct advantages. The mixed methods approach enhances validity through triangulation, enabling findings from one method to corroborate those from another, thus yielding richer, more nuanced conclusions than either method alone (Malina et al., 2011). One major advantage of using panel data is the ability to conduct dynamic analysis. Tracking the same households over time allows researchers to capture changes in the problem and gain deeper insights into how these issues evolve in response to external influences or interventions (Caruana et al., 2015). This approach helps identify long-term trends and patterns in food insecurity, which can be instrumental for policy-making and resource allocation (Fitzmaurice et al., 2012). While establishing causality can be challenging, longitudinal designs help mitigate biases often associated with cross-sectional studies by controlling for individual differences that remain constant over time (Baumgartner, 2020).

Philosophically, the study adopts a pragmatic research approach, combining both positivist and constructivist knowledge claims. Pragmatism, as a research philosophy, offers significant flexibility in methodology, allowing researchers to select the most suitable methods to address specific research questions, which can include both qualitative and quantitative approaches (Kaushik & Walsh, 2019). This adaptability not only enhances the research findings but also ensures that the study remains relevant and responsive to real-world complexities and issues.

8.3.2. Data Sources and Types

This study used household quantitative data from the Living Standards Measurement Study (LSMS) sourced from the 2018/19 and 2021/22 waves of the Ethiopian Socioeconomic Survey (ESS), which was conducted by Ethiopia's Central Statistics Agency and the World Bank. The researchers collected additional quantitative and qualitative data in 2024 via the same methodology and procedures as the ESS. For panel data analysis, these three datasets, with two-year intervals, are significant because they reduce missing data and make it easier to control for unobserved heterogeneity (World Bank, 2022a). To ensure consistency and robustness in the sampling

strategies, the researcher aligns the sampling strategies with the LSMS framework, drawing sampling design from multiple years of the ESS conducted by the World Bank. The decision to align the sampling strategy with the LSMS framework and to utilize data from multiple years of the ESS, conducted by the World Bank, is grounded in several key considerations. First, the LSMS framework employs rigorous and well-established sampling techniques that ensure representativeness at national and sub-national levels, providing a robust foundation for the study. the ESS offers a wide coverage of diverse households, including rural and urban populations, which is essential for assessing food security, resilience and welfare variables among both *Enset*-producing and non-producing households. Additionally, the involvement of the World Bank guarantees high standards of data quality and reliability, lending credibility to the study's findings and aligning the research with globally recognized practices in socioeconomic data collection. Moreover, utilizing pre-existing ESS data is both efficient and cost-effective, reducing the need for extensive primary data collection while maintaining methodological rigor.

Therefore, the households in the sample were chosen from the preselected group in the LSMS survey conducted by ESS and the World Bank. The study tracked 319 rural households in 2018/19, 307 in 2021/22, and 290 in 2023/24. Despite an annual attrition rate of less than 1%, the final analysis included 270 households surveyed across all waves. The sample comprised 75% of *Enset*-producing households and 25% of non-producer households, proportionally distributed within the overall sample size. The sampling strategy employed ensures that the sample adequately captures variations in practices, perspectives, and socio-economic impacts associated with *Enset* production. Proportionally distributing these groups within the overall sample size enhances the representativeness and validity of the findings, allowing for robust comparative analyses. This approach aligns with recommendations in the literature such as Creswell & Creswell (2017), who emphasize stratified sampling to ensure critical subgroups are represented in sufficient numbers for meaningful analysis. Additionally, it reflects the importance of addressing heterogeneity within the population, as highlighted by Etikan & Bala (2017), who stress the need to balance inclusivity and specificity when studying diverse communities. By maintaining proportionality, this strategy minimizes sampling bias and supports understanding of the research topic.

In addition, the researcher organized three focus group discussions (from Gurage Zone, Hadiya Zone, and Yem Zone), each comprising at least six participants with extensive knowledge and

expertise related to the study topics. The participants were carefully selected on their active involvement and strong interest in the issues under investigation, aiming to capture a variety of perspectives and insights. Furthermore, key informant interviews were conducted with a total of 22 participants, including 7 women, 10 men, and 5 government administrators. These key informants were chosen for their substantial expertise and engagement in areas pertinent to the study, ensuring that their contributions would be both relevant and valuable.

8.3.3. Methods of Data Analysis

In the data analysis section, we employed a variety of statistical techniques to interpret the data effectively. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize the data. Additionally, we utilized indices and conducted principal component analysis (PCA) and factor analysis to explore the underlying patterns. Inferential statistics, such as chi-square tests and t-tests, were applied to assess relationships between variables, whereas an econometric model using three-stage least squares regression was implemented to analyze complex interactions within the data.

8.3.3.1.Principal component analysis

To estimate the welfare and resilience indices, PCA and FA were used. Principal component analysis (PCA) and factor analysis (FA) are powerful statistical techniques for dimensionality reduction, each serving distinct purposes. PCA aims to reduce the number of variables in a dataset while preserving as much variance as possible. It transforms the original variables into a new set of uncorrelated principal components. The model operates on a data matrix, calculating the covariance matrix to extract eigenvalues and eigenvectors that indicate the directions of maximum variance. One of the key advantages of PCA is its ability to simplify complex datasets, making it easier to visualize and interpret high-dimensional data. Additionally, by reducing dimensionality, PCA can enhance the performance of machine learning algorithms by mitigating issues related to overfitting. Mathematically, for a data matrix X with n observations and p variables, PCA involves calculating the covariance matrix and then determining its eigenvalues and eigenvectors. The principal components are formed via these eigenvectors, where each component can be expressed as a linear combination of the original variables, represented by the following equation:

$$\boldsymbol{PC_i} = \sum_{j=1}^{p} \omega_{ij} X_j \tag{8.1}$$

Here, *wij* represents the weights (or loadings) corresponding to the i^{th} principal component, and *Xj* represents the original variables. This transformation effectively reduces dimensionality while retaining the essential structure of the data.

On the other hand, factor analysis (FA) seeks to uncover underlying relationships between observed variables by modeling them as linear combinations of latent factors. This technique is particularly useful in the social sciences for identifying constructs that explain patterns in data. The model specifies that observed variables are influenced by common factors and unique errors, allowing researchers to better understand the structure of their data. One significant advantage of FA is its capacity to reveal hidden patterns and theoretical constructs, facilitating deeper insights into complex phenomena. By identifying these latent factors, researchers can develop more targeted interventions or hypotheses, ultimately enriching their understanding of the subject matter at hand. The mathematical representation of this relationship can be expressed as:

$$X = \Lambda F + E \tag{8.2}$$

In this equation, X represents the matrix of observed variables, Λ denotes the matrix of factor loadings (which indicate the strength and direction of the relationship between each observed variable and the latent factors), F represents the matrix of latent factors, and E represents the unique error terms associated with each observed variable. Each observed variable is thus modeled as a combination of common factors plus an error term, allowing researchers to identify and quantify the underlying constructs that explain the correlations among observed data.

8.3.3.2.Estimation of the nexus between welfare, food security, and resilience

To estimate the nexus between welfare, food security, and resilience, a simultaneous regression model (three-stage least squares) is appropriate. The use of three-stage least squares (3SLS) to estimate the nexus between welfare, food security, and resilience is justified because of the interdependent nature of these variables. In this context, welfare can influence food security, which in turn affects resilience, creating a system of simultaneous equations. The 3SLS method allows for the simultaneous estimation of these interrelated equations while accounting for potential

endogeneity among the variables. This approach improves the efficiency of the estimates and provides a more accurate representation of the relationships among welfare, food security, and resilience. By capturing the reciprocal influences between these constructs, researchers can derive insights that are crucial for developing effective interventions aimed at enhancing household well-being and food security.

Several studies have employed similar models to explore these relationships. For example, Capaldo et al., (2010) utilized two-stage least squares regression in their analysis of vulnerability to food insecurity, highlighting the importance of understanding how different dimensions of food security interact with welfare outcomes. The FAO's resilience index measurement and analysis (RIMA) framework has also been applied in various contexts to assess household resilience concerning food security and nutrition, often incorporating multiple equations suitable for analysis via 3SLS Sibrian et al., (2021). Additionally, a review by Ansah et al., (2019) discusses empirical evidence linking resilience and food security, suggesting that higher resilience is correlated with better welfare outcomes.

Model specification of the simultaneous regression model (three stages of least squares)

Let W be the welfare indicator, F be the food security indicator, R be the resilience to food insecurity indicator, E be the dummy variable for *Enset* producer (1) or non-producer (0), and Z be the vector of other exogenous variables that affect the three endogenous variables. The system of equations can be written as (Drèze & Richard, 1983)

$$W = \alpha 1 + \beta 1F + \beta 2R + \beta 3E + \beta 4Z + u1 \quad (8.3)$$

$$F = \alpha 2 + \gamma 1W + \gamma 2R + \gamma 3E + \gamma 4Z + u2 \quad (8.4)$$

$$R = \alpha 3 + \delta 1W + \delta 2F + \delta 3E + \delta 4Z + u3 \quad (8.5)$$

where u1, u2, and u3 are the error terms that may be correlated across equations. To estimate this system via three stages of least squares, we can follow these steps:

Step 1. Construct instrumented counterparts for all variables identified as endogenous. These instrumented values can simply be considered the predicted values resulting from a regression of each endogenous variable on all exogenous variables in the system. This stage is identical to the first step in 2SLS and is critical for the consistency of the parameter estimates.

To obtain the instrumented value for W, we can regress W on E, Z, and the predicted values of F and R from the reduced-form equations:

$$W = \pi 1 + \pi 2E + \pi 3Z + \pi 4F* + \pi 5R* + v1 \quad (8.6)$$

where F* and R* are the predicted values of F and R from the reduced-form equations:

$$F = \rho 1 + \rho 2E + \rho 3Z + v2 \quad (8.7)$$

$$R = \psi 1 + \psi 2E + \psi 3Z + v3 \quad (8.8)$$

The instrumented value for W is then W* = π1 + π2E + π3Z + π4F* + π5R*. Similarly, we can obtain the instrumented values for F and R by regressing them on E, Z, and the predicted values of W and R and W and F, respectively.

Step 2. A reliable estimation of the covariance matrix associated with the equation error terms. These estimates are based on the residuals from a 2SLS estimation of each structural equation.

For example, to estimate the first equation via 2SLS, we can regress W on E, Z, and the instrumented values of F and R:

$$W = \alpha 1 + \beta 1F* + \beta 2R* + \beta 3E + \beta 4Z + u1 \quad (8.9)$$

The residual from this regression is u1, which is an estimate of the error term in the first equation. Similarly, we can obtain the residuals u2 and u3 from the 2SLS estimation of the second and third equations, respectively.

The covariance matrix of the equation disturbances can then be estimated as:

$$\Sigma = (u'u) / T \quad (8.10)$$

Where u is the vector of residuals from all equations and T is the number of observations.

Step 3. A generalized least squares (GLS)-type estimation is performed via the covariance matrix estimated in the second stage, with the instrumented values in place of the right-hand-side endogenous variables.

The GLS-type estimator for the system of equations is:

$$\beta = (Z'\Sigma - 1Z) - 1Z'\Sigma - 1y \quad (8.11)$$

Where β is the vector of all the parameters in the system, Z is the matrix of all the exogenous and instrumented variables in the system, Σ is the estimated covariance matrix of the equation disturbances, and y is the vector of all the endogenous variables in the system.

8.3.3.3.Measurement of food security

Food security was measured with kilocalorie intake acting as a proxy for evaluating household food security. Similar metrics have been employed in previous research, either individually or in

combination with other indicators (Khonje et al., 2015; Mmbando et al., 2015; Toyiba shafi, Jema Haji, Lemma Zemedu, 2023). This study implemented a seven-day recall method, as it typically yields more accurate data than the household expenditure approach (EHNRI (Ethiopian Health and Nutrition Research Institute), 1997). The consumption data gathered via the fourteen-day recall method was converted into kilocalories via a food composition table from the Ethiopian Health and Nutrition Research Institute. To calculate the household's daily caloric intake, the total caloric consumption over the fourteen days was divided by seven. The daily caloric intake per adult equivalent was determined by dividing the daily caloric intake by the adjusted family size.

Calorie intake is an effective measure of household food security when analyzing the nexus between welfare, food security, and resilience, as it directly reflects a household's ability to meet its nutritional needs, a core aspect of food security (Huang et al., 2015). Serving as an outcome-based indicator, it captures the ultimate impact of food availability, accessibility, and affordability on household welfare and resilience, providing an objective and quantifiable basis for analysis that minimizes biases associated with subjective or qualitative measures. Additionally, calorie intake serves as a practical approximation and reflection of the combined effects of food availability, accessibility, and affordability (Goshu et al., 2013).

8.4.Results and discussion

8.4.1. Household characteristics

Table 8.1 reveals notable trends in the differences in resilience, welfare, and food security between *Enset* producers and non-producers. The age of household heads has remained stable for both groups, with producers ranging from an average of 42.84 years in 2018/19 to 45.53 in 2021/22 and then slightly declining to 43.05 in 2023/24. This stability suggests that consistent household leadership can influence long-term decision-making and adaptive strategies, which are crucial for resilience and welfare. Household size has increased among both groups but more significantly for producers, growing from 5.11-5.52, compared with non-producers, who experienced a modest increase from 4.14-4.52. This larger household size in producer groups could mean greater labor availability, enhancing agricultural productivity and contributing to resilience and food security, which is consistent with the literature indicating that household size impacts production and consumption dynamics (Alp & Seven, 2019).

The education level of household heads shows an upward trend, particularly for producers who progressed from an average of 9.23 years in 2018/19 to 9.92 years in 2023/24. Non-producers also saw improvements, although at a slower rate, moving from 7.0 to 9.81 years. Improved education levels are associated with better welfare outcomes, as they support the adoption of innovative practices and income diversification. This aligns with studies that highlight education as a catalyst for enhancing household welfare and resilience. Consumption and income levels are consistently higher for producers than for non-producers across all years, with significant differences observed ($p<0.05$). For example, total consumption for producers increased from ETB 62,781.76 in 2018/19 to ETB 78,547.96 in 2023/24, whereas non-producers experienced only marginal changes. This suggests that *Enset* production supports greater economic resilience and overall welfare.

The infrastructure and agricultural asset indices also favor producers, with higher values throughout the years. This reflects better access to basic services and agricultural resources, contributing to stronger welfare and resilience capacities. The wealth index, which is significantly greater among producers ($p<0.01$), further underscores the economic gap between the two groups, highlighting the importance of asset accumulation in building long-term resilience. Additionally, while both groups experienced a decrease in livestock units, producers maintained a slight edge, and they consistently had more land, which supported income generation and food security. Notably, non-producers reported greater exposure to food security shocks, especially by 2023/24, with 7.45% compared with only 1.74% among producers. This discrepancy indicates that producers' diversified agricultural strategies, including *Enset* cultivation, buffer them against such shocks.

These findings are supported by recent studies that emphasize the value of diversified farming systems like *Enset* production in promoting resilience and food security (Were et al., 2022). *Enset*, a drought-tolerant crop, has been shown to stabilize food supplies and provide income during periods of climatic and economic stress. The upward trends in wealth and consumption among producers corroborate studies that suggest that agricultural diversification and asset building are vital for sustainable welfare and resilience. The observed improvement in education levels among producers also supports research pointing to education as a critical factor for equipping households with the knowledge and skills needed to adapt and thrive. Overall, the trends indicate that compared with non-producers, *Enset*-producing households are better positioned in terms of

resilience, welfare, and food security, suggesting that policies promoting agricultural diversification and infrastructure development could enhance community-wide welfare and resilience (Swarnam et al., 2018). Furthermore, exposure to food security shocks is notably greater among non-producers (7.45%) than among producers (1.74%), suggesting that producers have more robust coping mechanisms or diversified income streams that buffer against food insecurity. The comparison of these two groups highlights that producers enjoy significantly better economic conditions, which likely contribute to their enhanced resilience against food insecurity.

Overall, the results indicate a clear correlation between being a producer and improved welfare outcomes related to food security and resilience capabilities. Recent studies support these findings by emphasizing the role of agricultural production in enhancing household welfare through increased income and food availability (Were et al., 2022). Households engaged in production tend to have better access to critical resources and services during crises. The significant difference in exposure to food security shocks underscores the vulnerability of nonproducing households; reliance on market purchases without production capacity can lead to increased food insecurity during economic downturns or supply chain disruptions (Krieger, 1991). The ability of producers to mitigate these risks through diversification and self-sufficiency is a critical aspect of building resilience. Consequently, these findings suggest that enhancing agricultural productivity improves overall household welfare and food security in vulnerable populations, as supported by recent studies focused on rural development strategies.

Table 8.1: Summary statistics of variables over time

	2018/19		2021/22		2023/24		
Description of continuous Variables	Producer M (S. D.)	Non-Producer M (S. D.)	Producer M (S. D.)	Non-Producer M (S. D.)	Producer M (S. D.)	Non-Producer M (S. D.)	t- test/X^2
Age of HH head	42.838 (13.818)	42.85 (15.91)	45.53 (13.64)	45.21 (15.22)	43.05 (14.22)	43.12 (16.23)	-0.083
Household size	5.11(2.32)	4.14(2.72)	5.52(2.35)	4.41(2.64)	5.52(2.35)	4.52 (2.82)	-2.320**
Education level of HH head (year)	9.23(2.47)	7(5.72)	9.89(4.85)	8.44(8.39)	9.92(2.47)	9.81(5.72)	1.974
Total consumption (ETB)	62781.76 (51739.54)	43613.78 (4836.42)	75914.2 (8315.67)	44391 (11665.8)	78547.96 (5209.12)	43879.81 (48363.42)	-2.203**
Total income (ETB)	64466.13 (674.63)	45715 (843.71)	78648.65 (2525.37)	45577.3 (4210.83)	73951.35 (2674.03)	68042.21 (1843.71)	-2.212**
Infrastructure Index (toilet, electricity, home condition, piped water, car, motors cycle access)	0.213(0.012)	-0.102(0.23)	0.283(0.231)	-0.182(0.423)	0.267(0.241)	-0.202(0.03)	0.256**
Distance to school (in km)	6.51(5.56)	6.95(5.56)	6.5(5.56)	6.5(5.96)	6.5(5.56)	6.96(5.906)	5.68
Distance to market (in km)	3.71(6.75)	3.45 (5.56)	3.71(6.75)	6.5(5.96)	3.71(6.75)	6.96(5.906)	5.68
Agricultural asset index (agricultural tools, access to irrigation)	0.26 (0.425)	0.012(0.23)	0.32 (0.83)	0.12(0.45)	0.551 (0.45)	0.193(0.522)	0.241**
Wealth index (home all tools)	0.592(0.984)	0.116 (0.95)	0.792(1.58)	0.252(2.19)	0.653(0.256)	0.184(0.971)	-2.527***
Livestock (TLU unit)	3.36(2.12)	3.34(2.24)	3.06(0.22)	3.14(0.34)	0.31 (0.232	0.28 (0.257)	2.012**
Land size (ha)	0.998(0.349)	0.854(0.59)	0.932(0.459)	0.12(0.245)	0.923(0.47)	0.897(0.54)	0.231**
Description of dummy variables (in percentage)							
Sex of HH head (Male)	80.15	56.25	80.74	58.33	80.88	56.25	11.319**
Marital status (married)	77.45	63.83	81.89	65.96	81.89	65.96	13.967**
Receiving remittance (yes)	0.75	4.26	3.01	2.08	0.74	4.9	2.684
Health service (yes)	23.53	18.75	27.21	10.42	22.79	13	0.341
Income diversification (yes)	75.56	55.6	76.42	58.3	76.56	59.5	24.23
Access to credit service (yes)	56.3	54.23	58.3	47.3	59.02	41.3	4.5
Access to mobile phone (yes)	62.3	64.3	63.6	62.5	69.7	59.3	4.51
Livestock loss (yes)	0.06	0.04	0.712	0.019	0.026	0.12	0.123
Crop loss (yes)	1.6	1.85	1.76	1.89	1.76	2.1	0.23
Exposed to food security shock (yes)	2.21	4.17	0.75	8.33	1.74	7.45	66.331***
Other shocks (yes)	11.5	13	22.5	34	15.25	38	4.22**

Standard deviation in parentheses, *** p<0.01, ** p<0.05, * p<0.01

Note: ETB-Ethiopian birr; HH-household; M-mean; SD-Standard Deviation; TLU-Total livestock Unit

8.4.2. Resilience status

The initial three components (Comp1, Comp2, and Comp3) account for 58.5% of the total variance in producer households and 56.1% in non-producer households. In the first step, factor analysis was conducted on each variable (see Appendix 7 Table 7.1a - 7.6f). These findings indicate that

these three components effectively represent a substantial portion of household resilience characteristics (Tables 8.2 & 8.3).

Principal component analysis (PCA) of the resilience factors for producer and non-producer households reveals distinct resilience structures. Producer households show a significant reliance on social safety nets and adaptive capacity, with social safety nets strongly loading on the first component (0.630) and adaptive capacity on the third component (0.540). This suggests that producers rely heavily on social and adaptive resources, possibly because of the agricultural uncertainties they face. Non-producers, on the other hand, display high loadings for income and food access (0.647 on Comp1) and access to basic services (0.520 on Comp1), indicating that stability in income and access to services are more crucial to their resilience. These differences reflect the diverse resilience needs of the groups, where producers may require more social support and adaptive mechanisms, whereas non-producers focus on economic stability and external services.

The literature supports these findings, suggesting that different livelihood types foster unique resilience requirements. For example, (Bogale, 2014) noted that assets and access to income are critical in building resilience for those without agricultural buffers, aligning with non-producers' reliance on stable income and services. (Bernier & Meinzen-Dick, 2014) emphasize social capital's role in resilience, which aligns with producer households' high reliance on social safety nets. Similarly, (Chepkoech et al., 2020) highlight adaptive capacity as essential in agrarian contexts, a factor highly relevant to producers in this analysis. These insights imply that resilience-building policies should consider these differences, tailoring support mechanisms to address each group's unique vulnerabilities and strengths.

Table 8.2: Resilience index for producers

Principal components/correlation — Number of obs = 606; Number of comp. = 6; Trace = 6; Rho = 1.0000

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.348	0.222	0.225	0.225
Comp2	1.126	0.088	0.188	0.412
Comp3	1.038	0.063	0.173	0.585
Comp4	0.975	0.134	0.163	0.748
Comp5	0.841	0.169	0.140	0.888
Comp6	0.672	.	0.112	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
Income and Food Access	0.346	-0.402	-0.513	0.360	0.474	0.318	0
Assets	-0.395	-0.308	0.531	-0.209	0.611	0.225	0
Adaptive capacity	0.131	-0.280	0.540	0.739	-0.228	-0.122	0
Access to basic services	0.504	0.498	0.343	-0.037	0.041	0.614	0
Social safety net	0.630	-0.072	0.201	-0.287	0.323	-0.609	0
stability	-0.236	0.642	-0.074	0.444	0.495	-0.291	0

Table 8.3: Resilience index for non-producers

Principal components/correlation — Number of obs = 204; Number of comp. = 6; Trace = 6; Rho = 1.0000

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.237	0.111	0.206	0.206
Comp2	1.126	0.125	0.188	0.394
Comp3	1.001	0.055	0.167	0.561
Comp4	0.946	0.072	0.158	0.718
Comp5	0.874	0.058	0.146	0.864
Comp6	0.816	.	0.136	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
Income and Food Access	0.647	-0.075	0.172	-0.049	0.002	-0.737	0
Assets (AST)	0.137	0.607	-0.370	0.361	0.586	-0.050	0
Adaptive capacity (AC)	0.274	-0.557	0.296	0.472	0.437	0.336	0
Access to basic services	0.520	-0.021	-0.250	-0.659	0.187	0.445	0
Social safety net	-0.175	0.350	0.776	-0.328	0.371	0.015	0
Stability	0.432	0.440	0.286	0.321	-0.541	0.378	0

8.4.3. Welfare status

Outcomes of the PCA procedure for welfare indices among *Enset-producing* households (Table 8.4) and non-producing households (Table 8.5) highlight both similarities and differences in the factors influencing welfare within these groups. Initially, factor analysis was conducted for each

component (see Appendix 8 Table 8.1a – Table 8.7g). In both groups, the first two components account for a large portion of the variance, with the *Enset* producers' first component explaining 34.4% of the variance and the non-producers' first component explaining 34.2%. Combined with the second component, these two components explain approximately 53% of the welfare variance for both groups. This indicates a similar concentration of welfare determinants across the initial components, a pattern often observed in welfare studies focusing on multidimensional well-being.

The loadings for each component provide insight into the welfare dynamics of each group. Among the *Enset* producers, Component 1 has high loadings for total expenditure and total income (both at 0.687), emphasizing the critical role of economic factors in determining welfare. This finding is consistent with prior studies showing income and expenditure as central welfare indicators, particularly in agricultural households (Wondimu & Kebede, 2022). In Component 2 for producers, assets (0.656) and education (-0.539) are prominent, indicating that asset ownership and educational attainment are also significant welfare dimensions. The negative loading for education could reflect educational access or investment disparities, which may vary by household circumstances. Health services are essential in Component 3 for producers, showing that access to healthcare is a distinct and essential factor in welfare for these households.

Nonproducing households also show total expenditure and income as dominant factors in Component 1, reinforcing the importance of financial metrics in welfare. However, in Component 2, education (with a high positive loading of 0.741) plays a more substantial role than in producer households do, whereas assets have a weaker impact (negative loading of -0.143). This suggests that for non-producers, education may serve as a pathway to diversify income sources beyond agriculture, potentially enhancing welfare through nonfarm employment opportunities (PHAY, 2014). Health services are similarly influential in Component 3 for non-producers, yet exposure to shocks is particularly significant in Component 4, hinting at potentially greater vulnerability among non-producers owing to a greater dependence on markets for food security.

In comparing these groups, both economic and social factors emerge as primary welfare determinants, but with distinct nuances. For both groups, income and expenditure are crucial, aligning with the literature on income as a universal measure of welfare (Ravallion, 2016). However, *Enset* producers benefit from the stability that agricultural assets provide, which may

help buffer against economic shocks. Moreover, non-producers rely more strongly on education, likely because of their dependence on nonfarm income sources. Assets play a more significant role in producer households, which is consistent with findings on agricultural resilience, where land and livestock ownership are key to rural welfare security (Gwaka & Dubihlela, 2020).

Health service access remains critical for both groups, although varying loadings suggest potential disparities in healthcare utilization, which can affect long-term welfare and resilience (Northridge et al., 2020). Ultimately, these results suggest that while *Enset* producers and non-producers share some common welfare determinants, there are meaningful differences in how factors such as assets and education impact each group. Asset-based interventions are more beneficial for *Enset* producers, whereas educational support is especially impactful for non-producers, reflecting broader research on rural welfare and household production types.

Table 8.4: Welfare indices for producers

Principal components/correlations — Number of obs = 606; Number of comp. = 5; Trace = 5; Rho = 1.000

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.062	0.941	0.344	0.344
Comp2	1.121	0.121	0.187	0.530
Comp3	1.000	0.052	0.167	0.697
Comp4	0.948	0.079	0.158	0.855
Comp5	0.869	0.869	0.145	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
Education	0.125	-0.539	0.326	0.566	0.517	0
Assets	0.025	0.656	0.387	-0.174	0.624	0
Health service	0.154	-0.157	0.832	-0.268	-0.433	0
Exposure to shock/stability	0.133	0.504	0.107	0.750	-0.394	0
Total expenditure	0.687	0.006	-0.140	-0.091	0.029	0

Table 8.5: Welfare Index for Non-producers

Principal components/correlations					Number of obs = 204
					Number of comp. = 5
					Trace = 5
Rotation: (unrotated = principal)					Rho = 1.000
Component	Eigenvalue	Difference	Proportion	Cumulative	
Comp1	2.052	0.898	0.342	0.342	
Comp2	1.154	0.106	0.192	0.534	
Comp3	1.048	0.091	0.175	0.709	
Comp4	0.956	0.167	0.159	0.868	
Comp5	0.789	0.789	0.132	1.000	

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
Education	0.072	0.741	-0.111	0.056	-0.656	0
Assets	-0.095	0.143	-0.718	0.592	0.323	0
Health service	-0.137	0.651	0.339	-0.124	0.653	0
Exposure to shock/stability	-0.108	-0.064	0.596	0.785	-0.119	0
Total expenditure	0.691	0.031	0.036	0.087	0.112	0

8.4.4. Food security status

Table 8.6 reveals differences in calorie intake and food security status between *Enset* producers and non-producers over multiple years (2018/19, 2021/22, and 2023/24) in central Ethiopia. We have used the EHNRI food composition table to estimate each commodity's calorie composition (see Appendix Table 6.2b). In each year, the average calorie intake of the *Enset-producing* households is greater than that of the nonproducing households, with significant differences at the 1% and 5% levels. The observed differences suggest that *Enset* production may contribute positively to household food security by providing a stable source of nutrition, particularly as *Enset* is a drought-resistant crop well suited to Ethiopia's agroecological conditions. These findings align with studies indicating that diversification into resilient crops, such as *Enset*, can increase household food security and buffer against environmental and economic shocks (Senbeta et al., 2022; Tesafa et al., 2023).

Additionally, the table shows a greater proportion of food-secure households among *Enset* producers (60.78%) than among non-producers (23.61%) over the study period. This suggests that households producing *Enset* are better able to meet the FAO and WFP food security thresholds of 2100 kcal per day. The resilience of *Enset-producing* households to food insecurity may stem from *Enset's* role in providing consistent food sources and its adaptability to climate variability, which

is increasingly crucial in the context of climate change. Recent studies support this finding, emphasizing the importance of traditional crops in building resilience among rural households (Blomme et al., 2023b). These findings underscore the potential role of *Enset* production in food security policies aimed at improving dietary stability and resilience for rural Ethiopian communities.

As a result of focus group discussions and confirmation from household surveys, it is evident that there are significant differences between *Enset*-producing and non-producing households regarding food security. Non-producing households face challenges in several dimensions, including availability, access, utilization, and stability. These households often experience inconsistent food availability due to their reliance on purchased food and less resilient crops, leading to seasonal shortages. Economic constraints further limit their access to food; lower income levels and dependence on external markets make it difficult for them to purchase food during lean periods. Nutritionally, these households tend to have inadequate diets that lack diversity, which particularly affects vulnerable groups such as children and pregnant women. Stability is compromised by their heightened vulnerability to external shocks like droughts and economic downturns, disrupting both production and access to food. Additionally, non-producers generally demonstrate lower resilience due to their reliance on external markets and limited asset bases, which negatively impacts overall welfare by restricting opportunities for education and health care. In contrast, *Enset*-producing households benefit from enhanced food security and income generation, contributing to greater community resilience and improved welfare outcomes in rural Ethiopia.

Moreover, the focus group discussion emphasized the profound impact of external shocks, such as climate variability (in rainfall and temperature) and market disruptions, on the four key dimensions of food security: availability, access, utilization, and stability. *Enset* producers specifically pointed out that climate variability worsens food insecurity by reducing *Enset* yields. In contrast, non-producers faced market inflation caused by food shortages. Participants highlighted that government policies, NGOs, and political stability are crucial in mitigating these effects. They promote adaptive strategies like climate-resilient agriculture, social safety nets, and market stabilization measures. Collaborative efforts among stakeholders were recognized as vital for building resilience and safeguarding welfare in the face of these challenges.

Table 8.6: Calorie intake (food security status) among *Enset* producers and non-producers over time

		Non-producer N=202	Producer N=68	Diff.	St Err	t value
Calorie intake (in kilo)	2023/24	1892.945	2995.021	-1102.076	390.528	-2.8***
	2021/22	1814.613	2852.253	-1037.64	403.446	-2.55**
	2018/19	2061.058	3004.969	-943.911	403.894	-2.35**
Average		1922.872	2950.748	-1027876		
Food security status (in %)	Food secure	23.61	60.78			
	Food insecure	76.39	39.22			

Note: The calorie intake cutoff point is established by the FAO & WFP, indicating that a consumption level greater than 2100 kcal per day is considered food secure.

8.4.5. Nexus between welfare index, resilience index, and caloric intake

The researcher employed panel data as pooled data. The rationale for this choice in the context of a three-stage least squares (3SLS) model lies in its capacity to estimate parameters effectively across simultaneous equations, especially when handling endogenous variables. Pooled data strengthen the analysis by integrating observations from various entities or periods, thereby expanding the dataset and enhancing the precision of parameter estimates. This approach is particularly advantageous in 3SLS because it accounts for correlations between error terms across different equations, which, if neglected, can result in biased estimates. By estimating all equations in the system simultaneously, 3SLS harnesses the full scope of the data, offering improved efficiency over single-equation methods such as two-stage least squares (2SLS), which do not address such correlations. This integrated estimation is vital for accurately capturing complex and interdependent variable relationships, making pooled data indispensable for robust econometric modeling involving multiple equations (Hadjiantoni & Kontoghiorghes, 2018; Rezapour & Ferraro, 2022).

Exogenous variables (sex, year, and marital status) are incorporated to help achieve consistent and unbiased parameter estimates in the simultaneous equation system by acting as instruments and controlling for external influences.

The 3SLS model effectively captures the interconnections between welfare, resilience, and calorie intake for both the *Enset-producer* and the Non-producer households. The high R-squared values for the welfare and calorie intake equations, particularly for producers (0.998 and 0.727, respectively), indicate that the model explains a significant portion of the variance in these

outcomes (Table 8.7). However, the R-squared value for the resilience equation is lower (0.204 for producers and 0.762 for non-producers), suggesting that other factors that are not included in the model may influence resilience. Calorie intake has a significant positive effect on welfare for both groups, with a greater effect for producer households (β=0.009,<0.05) than for non-producer households (β=0.002,p<0.05). Resilience significantly boosts welfare in producer households (β= 0.856, $p < 0.05$), highlighting its critical role in sustaining well-being, whereas for non-producers, although resilience positively affects welfare ($\beta = 0.36$), it is not statistically significant. Welfare significantly enhances resilience among non-producers ($\beta = 0.231$, $p < 0.05$), indicating that better welfare levels lead to increased resilience, but this effect is not significant for producers (β=0.069). Additionally, calorie intake has a positive and significant effect on resilience for both groups, with producers showing a stronger effect ($\beta = 0.009$, $p < 0.01$) than non-producers do ($\beta = 0.006$, $p <$ 0.05).

When comparing the two groups, the welfare of producer households depends more heavily on both calorie intake and resilience, underscoring the crucial role that resilience plays for these households. For non-producers, the significant link between welfare and resilience points to welfare being a key determinant of resilience. The stronger coefficient of calorie intake in the resilience equation for producers suggests that food security, represented by calorie intake, is more impactful in enhancing resilience among producer households.

Focus group discussions (FGDs) and key informant interviews (KIIs) revealed important insights into the relationships among welfare, food security, and resilience among households in central Ethiopia. The participants in the FGDs emphasized that welfare is closely tied to their overall economic and social well-being and influences their ability to access adequate food and essential resources. Food security was described as the stability of food availability and access, often impacted by external factors such as droughts and market disruptions. Resilience, on the other hand, was identified as the capacity of households to withstand and adapt to these shocks, ensuring continuity in their food supply. The participants highlighted that improvements in welfare strengthen food security and foster resilience, allowing households to manage adverse conditions more effectively.

Key informants underscored the interdependence of welfare, food security, and resilience. They noted that strong welfare systems equip households with the means to sustain food security and build resilience during difficult periods. This resilience is essential for preventing prolonged food insecurity, as it supports quick recovery following economic or environmental challenges.

These results align with those of prior studies. For example, (Shilomboleni et al., 2024) highlighted the importance of resilience in supporting household welfare, especially in agricultural communities, which mirrors the significant effect observed for producers in this study. The positive impact of calorie intake on both welfare and resilience is supported by (Smith & Haddad, 2015), who emphasized that adequate food consumption is essential for improving welfare and building resilience. The differences between producer and non-producer households can be linked to the unique nature of *Enset* cultivation, which contributes to food security and buffers against food shortages, as noted by (Morrow et al., 2023).

Recent empirical studies further corroborate the critical nexus between welfare, food security, and resilience, particularly in agrarian economies like Ethiopia. For instance, Blomme (2023) and Tesafa et al. (2023) highlighted the diversity and drought-resistant nature of *Enset* production systems in Ethiopia, emphasizing their significant role in mitigating food insecurity and enhancing resilience to climate variability. These findings align with the present study, particularly in demonstrating the superior food security outcomes of *Enset*-producing households. However, this study extends the literature by offering a comparative perspective between *Enset*-producing and non-producing households, which remains underexplored. On a broader scale, Smith & Haddad (2015) and Shilomboleni et al. (2024) established the role of calorie intake and agricultural resilience in improving welfare, resonating with this study's findings that higher calorie intake significantly enhances welfare and resilience among *Enset* producers. Additionally, Morrow et al. (2023) emphasized crop diversification's role in building resilience across East Africa, further reinforcing the importance of *Enset* as a staple crop.

While similarities with previous studies are evident, this research also identifies important distinctions. For example, resilience mechanisms in this study reveal a nuanced differentiation based on agricultural engagement: *Enset* producers rely more on social safety nets and adaptive capacity, whereas non-producers depend more on income stability and access to basic services.

Such findings go beyond earlier works by Bogale (2014) and Bernier & Meinzen-Dick (2014), which broadly discussed resilience factors without addressing specific agricultural contexts. Furthermore, while income and expenditure remain universally critical welfare determinants, as established by Ravallion (2016), this study underscores the unique role of asset ownership for *Enset* producers and education for non-producers highlighting distinct pathways for welfare enhancement. Finally, the direct impact of drought-resistant crops like *Enset* on stabilizing food security and resilience has been less emphasized in prior studies, making this research an important contribution to the literature on sustainable rural livelihoods.

Table 8.7: Three-stage least squares (3SLS) regression results for the producers and non-producers

	Equation (1) Welfare		Equation (2) Resilience		Equation (3) Calorie intake	
VARIABLES	Producer	Non-producer	Producer	Non-producer	Producer	Non-producer
Calorie intake	0.009**	0.002**	0.009***	0.006**		
	(0.001)	(0.007)	(0.003)	(0.002)		
Resilience	0.856**	0.36**			539.15***	89***
	(0.645)	(0.184)			(938)	(704)
Time (year)	-0.659**	-0.555**	-0.0648**	-0.213	640.115**	27
	(0.111)	(0.981)	(0.015)	(0.112)	(0.287)	(217)
Welfare			0.231**	0.069**	696.507**	366
			(0.916)	(0.332)	(1227)	(738)
Marital status (married)	-0.035	-0.047	0.266	0.00570	0.024	-0.055
	(0.029)	(0.060)	(0.556)	(0.193)	(0.016)	(0.043)
Sex (female-headed)	-0.09	-0.021	-0.052	-0.03	-684.799	-721
	(0.12)	(0.216)	(0.21)	(0.16)	(3182)	(616)
Constant	0.6***	0.68**	0.160**	0.991***	8.69***	-15***
	(0.501)	(0.318)	(1.000)	(0.874)	(521)	(510)
Observations	609	201	609	201	609	201
R-squared	0.998	0.247	0.204	0.762	0.727	0.485

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

8.4.5.1. Post-estimation test

Post-estimation tests, as shown in Table 8.8, indicate that the model assumptions are adequately met for both groups. There were no significant issues with autocorrelation, heteroscedasticity, or normality. The single and overall autocorrelation tests (Harvey LM, Durbin Watson, and Guilkey LM) were non-significant, confirming that there were no problems with autocorrelation. Similarly, heteroscedasticity tests (Breusch–Pagan LM, likelihood ratio, and Wald tests) showed non-significant results, supporting homoscedasticity. The Jarque–Bera test results also indicated normality in the equations, reinforcing the reliability of the results.

Table 8.8: Results of the post-estimation test

		Producer			Non-producer		
		Eq. 1 (Welfare)	Eq. 2 (Resilience)	Eq. 3 (calorie intake)	Eq. 1 (Welfare)	Eq. 2 (Resilience)	Eq. 3 (calorie intake)
Single autocorrelation	Harvey LM test	3.79	3.486	7.658	0.39	3.948	0.62
	Durbin Watson Dw	1.712	1.721	1.649	1.65	1.45	1.53
Overall autocorrelation	Harvey LM Test		2.933			1.958	
	Guilkey LM Test		3.423			1.413	
Overall Heteroscedasticity	Breusch–Pagan LM		9.708			1.013	
	Likelihood Ratio LR		4.995			4.33	
	Wald Test		4.99			2.2	
Normality	Jarque-Bera LM	1.89	1.65	1.541	1.263	2.06	3.37

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

8.5.Conclusion and recommendation

This comparative study underscores the differences in welfare, food security, and resilience between *Enset* growers and non-growers residing in Central Ethiopia. *Enset-producing* households demonstrate greater resilience due to social support systems and adaptive strategies that mitigate agricultural risk. In contrast, non-producing households, though bolstered by consistent income and basic services, face heightened vulnerability to economic fluctuations due to less diverse coping strategies. The welfare analysis indicates that income and expenditure are pivotal for both groups, but *Enset* producers lean more on assets such as land and livestock as safeguards, whereas non-producers depend on education for diversified income pathways. Access to healthcare remains essential for all households, with usage disparities persisting across both groups.

Furthermore, the findings concluded that, for *Enset* producers, calorie intake significantly enhances both welfare and resilience, underscoring the critical role of food security. Resilience also has a substantial positive effect on welfare, emphasizing its importance in sustaining well-being. Conversely, for non-producers, calorie intake positively impacts welfare and resilience, but resilience does not significantly affect welfare. Welfare was a key determinant of resilience for non-producers, reflecting a feedback loop between well-being and resilience. These quantitative results affirm that compared with non-producers, *Enset-producing* households benefit more from the interplay between food security and resilience.

Stakeholders at zonal, regional, and national levels should collaborate to enhance resilience and food security through targeted policies and programs. Policymakers must prioritize the promotion of *Enset* cultivation, particularly in drought-prone areas, by implementing agricultural policies, providing extension services, and incentivizing sustainable practices. Asset-building initiatives, such as securing land tenure and improving livestock ownership for *Enset* producers, alongside educational and vocational training for non-producers, are essential to diversify income sources and strengthen household resilience. Integrated, household-specific programs combining agricultural support, and healthcare access are vital for improving long-term welfare outcomes. Incorporating resilient crops like *Enset* into broader food security and climate adaptation strategies will stabilize food access and nutritional intake for rural communities. Additionally, investments in value chains and market development can enhance *Enset's* economic viability. Future research should focus on comparative research across regions to better understand the socioeconomic factors influencing *Enset* production and its role in building community resilience.

CHAPTER 9: SYNTHESIS: RECAPITULATION, FINDINGS, POLICY IMPLICATIONS, AND CAVEATS AND FUTURE RESEARCH

9.1.Recapitulation

The persistent challenges of welfare inequality, food insecurity, and resilience remain central concerns in rural Ethiopia. While efforts have been made to address these issues through policy interventions and agricultural development strategies, disparities persist between *Enset*-producing and non-*Enset*-producing households. This study critically examines the multidimensional nature of these challenges, drawing on longitudinal panel data and diverse analytical methods to offer understanding of the dynamics at play.

Chapter 3 investigates welfare inequalities between *Enset*-producing and non-producing households in Central Ethiopia during 2018/19-2023/24, using panel data from 270 households. Welfare in Asset and expenditure outcome) Inequalities are examined using the Atkinson index and quantile regression models. Results show that both groups differ substantially from each other, with a higher welfare inequality for non-producers compared to producers. Various socioeconomic drivers such as education, income, access to credit, and exposure to shocks cause inequality. The study identifies the stabilizing role of *Enset* production in household welfare and suggests policies to address these inequalities.

Chapter 4 expands on these findings by examining intertemporal dynamics of welfare inequality among *Enset*-producing and non-producing households, using multi-dimensions. The study applied Fixed-effects modeling, a multidimensional inequality index, and t-tests for the analysis of welfare inequality over time. In this study, *Enset* cultivation is shown to reduce welfare inequality and build resilience, while non-producing households remain more vulnerable to shocks and state more unequal.

Chapter 5 explores the heterogeneity of food insecurity and coping strategies in *Enset*-producing and non-producing households in central Ethiopia. Taking a mixed-methods approach with both quantitative and qualitative data, the study applies a cross-sectional household survey of 270 participants supplemented by focus group discussions and key informant interviews. The study uses the Consolidated Approach to Reporting Food Security Indicators (CARI) framework and

applies statistical methods such as t-tests, chi-square tests, and an ordered logit model to establish food security determinants. The findings reveal that *Enset*-producing households are more food secure, have a more diverse diet, and adopt fewer extreme coping strategies compared to non-producers. These results highlight the critical role of *Enset* cultivation in improving household food security and economic coping capacity in the region.

Chapter 6 assesses the impact of *Enset* (*Ensete ventricosum*) production on food security using panel data from the Ethiopian Socioeconomic Survey (ESS) and supplementary data collected in 2023/24. Based on the estimation using the Endogenous Switching Regression (ESR) model, the study offers a causal and dynamic estimation, adjusting for observable and non-observable influences on *Enset* cultivation and food security conditions. Unlike previous studies that relied on cross-sectional data, the present study offers a more nuanced explanation of the relationship between *Enset* production and food protection across time. The research tries to fill knowledge gaps by examining how *Enset* cultivation enhances food resilience, particularly for Ethiopian smallholder farmers.

Chapter 7 investigates resilience to food insecurity among *Enset*-producing and non-producing households. Drawing on panel data from 270 sampled households, the study applies the Resilience Index Measurement and Analysis (RIMA) approach to estimate household resilience. The study employs the Multiple Indicators Multiple Causes (MIMIC) model and random effects ordered logistic regression in the analysis of the key drivers of resilience. The results provide a comparative perspective on the contribution of *Enset* production towards enhanced food security and household resilience to food insecurity.

Chapter 8 integrates these themes by analyzing the complex interaction between welfare, food security, and resilience in inner Ethiopia are investigated in this research by contrasting non-producing and *Enset*-producing households. By adopting a mixed-method approach, the analysis blends panel data analysis with a three-stage least squares (3SLS) regression model to determine interdependencies among the variables. It is revealed that *Enset*-producing households consistently possess better levels of food security, resilience, and welfare compared to their non-producing counterparts. By integrating both qualitative and quantitative results, the study presents an overall picture of *Enset*'s contribution towards household welfare in agrarian communities.

9.2.The major findings

Welfare Inequality and Resilience have been among the most debated areas for welfare and development in recent years. Investigating intertemporal Dynamics and Determinants of Welfare Inequality and Resilience to Food Insecurity has been an essential theme of this dissertation. Therefore, we applied statistical tools, econometric models, inferential statistics, and descriptive statistics to analyze the stated objectives in six self-contained but closely related chapters.

Intertemporal dynamics and determinants of welfare inequality: insights from expenditure and asset value

The findings indicate that asset inequality is consistently higher among non-producers, with the Atkinson index rising from 0.356 in 2019 to 0.781 in 2024, compared to an increase from 0.262 to 0.582 among *Enset* producers. Similarly, expenditure inequality has steadily worsened for non-producers, whereas producers exhibit fluctuations but maintain relative stability over time. Various socioeconomic factors shape these inequalities, including education, gender, household size, age, credit access, income, and exposure to shocks. Notably, education, remittances, land size, and financial resources play a significant role in reducing welfare inequality, particularly among *Enset*-producing households.

Intertemporal dynamics and determinants of welfare inequality: a multidimensional approach

A substantial welfare inequality gap existed between the non-producers and the *Enset* producers. *Enset* producers had consistently low levels of welfare disparity(an index of 0.109) due to the impact of shock resilience, sustained income increase (ETB 17,303), and balanced level of educational attainment (1.43 additional years). In the case of non-producers, on the other hand, the household demonstrated a higher level of inequality that was also more volatile (0.405 indexes), slower income growth (ETB 12,270), and minimal education gain (0.27 additional years). Welfare inequality causes for the two groups also differed: remittances, landholdings, mobile phone ownership, and were determinants in the case of *Enset* producers, while employment, household size, and lack of access to technology were binding factors for the second group.

Food insecurity and coping strategies of *Enset*-producer and non-producer households using CARI

The research's main findings lay out dramatic differences in food intake, coping mechanisms, and food security status between *Enset* producers and non-producers. *Enset*-producing households consume starchy staples, pulses, and fats more frequently compared to non-producers, showing the central role of *Enset* in their food basket. The study further finds that non-*Enset*-producing families are more inclined to adopt severe coping strategies such as reducing meal sizes, borrowing food, or selling property when their economy is strained. Further, analysis of food spending finds that food producers spend more per annum (96,157.46 ETB) on food than non-producers (89,098.07 ETB), which reflects that they have better food access. According to the CARI index, 3.52% of the *Enset* producers are food secure, whereas none of the non-producers are. Ordered logit regression analysis identifies the determinants of food security that are significant, and it is seen that education, remittances, and shock exposure have a strong impact on food security among the *Enset* producers. In contrast, non-producers rely more on household size, age, and institutional support like health insurance to reduce food insecurity.

The impact of *Enset* (*Ensete ventricosum*) Production on household food security

The study finds that *Enset* production significantly enhances food security, and producing households consume an average of 1,100 kilocalories per day more than non-producers. Whereas *Enset* producers consistently fall above the food security level of 2,100 kcal per day, non-producers frequently fall below this line, making them more susceptible to food insecurity and malnutrition. A few socioeconomic attributes, including male household heads, better education levels, and greater asset ownership, were found to positively influence the likelihood of *Enset* production. Moreover, according to counterfactual analysis, *Enset* producers have 35.2% higher calorie intake if they produce *Enset* than when they do not produce *Enset*, whereas non-producers would have 55.7% higher calorie intake if they produce *Enset*. The research also brings forth that *Enset* serves as a critical economic and environmental shock buffer, whereby affected households are likely to engage in *Enset* cultivation as a measure to achieve food security.

Dynamics of resilience to food insecurity among *Enset (Ensete ventricosum)*

The results show that *Enset*-producing households are 25% more resilient to food insecurity than their non-producing households. Households that grow *Enset* consume more food (0.864 compared to 0.46 for non-producers) and have a more stable calorie consumption, further confirming the role of the *Enset* crop in food security. *Enset* producer household also have a higher recovery rate, with 75.3% recovering from food insecurity between t+1 and t+2, compared to only 49.6% of non-producers. Key drivers of resilience include asset ownership, income diversification, access to basic services, and adaptive capacity, all of which are the assets that enable a household to absorb and recover from food shocks. Non-producers, however, are less resilient since they lack access to means and are highly dependent on social protection nets, which negatively impact their long-term autonomy.

The magnitude of the nexus between welfare, food security, and resilience

The study highlights contrasting differences between *Enset*-producing and non-producing households along different aspects. *Enset* producers enjoy more food security, with a higher percentage of food-secure households (60.78%) compared to non-producers (23.61%), along with significantly higher calorie intake. Resilience analysis shows that producers rely more on adaptive capacity and social protection nets, but non-producers rely more on income and access to food. Welfare tests also show that producers care more about asset ownership, while education as a determinant performs better for non-producers. Additionally, the 3SLS regression model also confirms such strong relationships between welfare, resilience, and food security, and yet stronger effects on *Enset* producers. Surprisingly, non-producers are more exposed to food insecurity shocks (7.45%) than producers (1.74%), highlighting the stabilizing effect of *Enset* cultivation.

9.3. Concluding remarks

The study concludes that *Enset* production contributes positively to economic stability and reduces welfare inequality. Since inequalities exist, the non-producers are disadvantaged since they lack access to financial and agricultural resources. The study emphasizes the role of intervention in bridging the gaps. *Enset*-producing households have a better welfare status, including higher consumption, income, and asset ownership compared to non-producing households. The outcome demonstrates the importance of *Enset* as a drought-resistant crop that plays a role in food

availability and economic resilience. On the other hand, non-producing households were subjected to economic and environmental shocks, leading to greater and more variable welfare inequality.

The study concludes that *Enset* farming raises food security through a reliable source of food and reduces vulnerability to economic and environmental shocks. *Enset*-farming households have greater resilience, consume a more diversified diet, and rely less on distress coping strategies compared to non-producing households. However, factors such as climatic conditions, labor-intensive processing, and limited market access still affect food security outcomes. Even though *Enset* is a very resilient crop, its cultivation is still affected by agroecological limitations that restrict its expansion to drier regions.

The study confirms that *Enset* production is a critical food security strategy among rural Ethiopian households. *Enset*-cultivating households not only enjoy higher calorie consumption but also enjoy higher resilience to food insecurity shocks. Based on these results, increased *Enset* production would be a key factor in achieving Ethiopia's Growth and Transformation Plan (GTP) and the United Nations' Sustainable Development Goal 2 (Zero Hunger). The study highlights the need for policies that favor *Enset* cultivation as a long-term solution to food insecurity, particularly in areas where climatic and environmental constraints could hinder the existence of traditional staple crops.

The study finds that *Enset* production significantly enhances household resilience via improved food security, financial resilience, and recovery capacity. The ability of *Enset* to provide a consistent supply of food, particularly in drought-prone areas, underscores its potential as a resilience-building crop. However, the study also identifies the risks involved in depending too heavily on outside assistance, which is likely to erode long-term adaptive capacity. Overall, the study emphasizes the need for policies that support *Enset* cultivation and resilience strategies to ensure food security in rural Ethiopia.

The study discovers that *Enset* cultivation is a key asset in enhancing food security, resilience, and well-being for farm households. The unique attributes of *Enset*, including drought tolerance and the ability to produce a dependable food item, create better well-being for producers. Households that cultivate *Enset* realize higher interdependence between food security and resilience, which in turn increases overall welfare. Non-producing households, however, are more vulnerable since

they are reliant on market-based access to food and reduced livelihood diversification. These observations highlight the importance of promoting resilient agriculture as a development nexus to food security and rural development.

9.4. Policy implications

The findings of this study suggest targeted policy interventions are essential to address the differing needs of Enset-producing and non-producing households in rural Ethiopia. For Enset-producing households, policies should focus on strengthening Enset value chains through investments in processing technologies, pest control, and market infrastructure to increase productivity and economic returns. Enhancing land tenure security and improving access to arable land are also critical to encourage sustained investment in Enset cultivation. Additionally, agricultural extension services must be expanded to provide technical training and promote crop diversification. Empowering women smallholder farmers through access to finance and capacity-building programs will further boost household resilience. Moreover, improving rural infrastructure, including roads and mobile connectivity, can enhance market access and facilitate better financial inclusion for these producers.

For non-producing households, policy efforts should prioritize expanding access to Enset farming in agro-ecologically suitable areas, especially through the scale-up of initiatives like the National Enset Flagship Development Program (NEtFDP). Since these households face greater food insecurity and limited livelihood options, alternative income-generating opportunities such as vocational training, job creation programs, and support for small enterprises should be promoted. Improving access to affordable credit and mobile banking technologies can facilitate productive investments and smooth consumption in times of economic stress. Furthermore, strengthening food security interventions, including nutrition assistance and safety nets, is crucial to protect non-producing households from environmental and economic shocks. Investments in education and family planning services are also needed to enhance household well-being and long-term resilience.

Cross-cutting measures that benefit both groups include adopting a multidimensional approach to welfare that integrates education, health, and social capital with agricultural and financial development. Climate-smart agricultural policies should be promoted to increase adaptive capacity

in the face of environmental change. Together, these interventions will help reduce welfare disparities, improve rural livelihoods, and support Ethiopia's broader development objectives, including the Growth and Transformation Plan (GTP) and Sustainable Development Goal 2 (Zero Hunger).

9.5. Future research

This study has certain limitations that should be acknowledged. First, its focus on rural households in Central Ethiopia means that the findings may not be fully generalizable to urban areas or other agroecological settings. Additionally, while panel data provides valuable insights into long-term trends, it may introduce biases due to time-dependent changes such as migration, natural calamities, and economic shifts.

Further studies should explore the scalability and sustainability of *Enset* production, particularly in light of its dependence on specific climatic and soil conditions. Research on labor-saving processing technologies and market-oriented solutions could enhance its economic viability. Additionally, examining *Enset's* role in broader agricultural and economic systems alongside other staple crops can offer alternative strategies for food security improvement.

Furthermore, future research should also assess the long-term climate resilience of *Enset* production and its potential integration into market systems for sustainable economic development. Moreover, gendered dimensions of welfare and resilience warrant further investigation to inform more targeted policy interventions. Expanding the geographic scope and sample size of studies would help validate and extend these findings, providing understanding of *Enset's* contribution to food security and household welfare.

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APPENDICES

Appendix 1

Table 1.1a: Estimation of sampling weight

Zone code	Pw_2018/19 (base weight)				Pw_2021/22				Pw_2023/24			
	A	B	C	D	A	B	C	D	A	B	C	D
01	6784	2261.33	1130.7	565.33	6538.31	2179.4	1089.7	544.8	7723.29	2573.41	1287.5	644.21
02	6486	2162	1081	540.5	5190	1730	865	432.5	6133.82	2045.48	1022.74	511.37
03	7226	2408.67	1204.33	602.16	6940	2313.3	1156.67	578.33	8189.77	2729.27	1364.63	682.32
12	6974	2324.67	1162.33	581.17	8447.02	2815.67	1407.82	703.92	9981.46	2731.18	1365.59	682.79
20	7839.49	2613.33	1306.66	653.33	5309	1769.7	884.8	442.42	9371.89	3320.15	1660.08	830.04
21	7061.9	2353.97	1176.98	588.49	6484.9	2161.6	1080.81	540.4	7666.27	2554.78	1277.39	638.7
Final used sample probability weighting(Pw)				588.5				540.40				664.905

Note:

A= Total Pw_2018/19, Pw_2021/22 and Pw_2023/24
B= Pw_2018/19, Pw_2021/22, and Pw_2023/24 for the region (A divided by 3)
C = Pw_2018/19, Pw_2021/22, and Pw_2023/24 for urban or rural (B /2)
D = Pw_2018/19, Pw_2021/22 and Pw_2023/24 for *Enset* producer and non-producer (C/2)

Appendix 4

Table 4.1a. Hausman test result

H_0: Random effects are appropriate; H_A: Fixed effects are appropriate.
Chi-squared statistic: 18.45 p-value: 0.0003
Decision: Reject H_0. A fixed effects model is appropriate.

Table 4.2b. Test for Heteroskedasticity

H_0: Homoskedasticity (constant variance).
Chi-squared statistic: 1.23 p-value: 0.268
Decision: Fail to reject H_0. Model is homoskedastic.

Table 4.3c. Test for Autocorrelation

H_0: No first-order autocorrelation.
F-statistic: 0.87 p-value: 0.387
Decision: Fail to reject H_0. No autocorrelation was detected.

Appendix 5

Table 5.1a: VIF for continuous variables

	VIF	1/VIF
Education level	1.182	.846
HH size	1.126	.888
Age	1.087	.92
Total Expenditure	1.047	.955
Asset	1.021	.98
Land size	1.001	.999
Mean VIF	1.077	.

Table 5.2b: Contingency coefficient for dummy variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) sex	1.000						
(2) Marital status	0.434	1.000					
(3) Receiving remittance	-0.121	-0.098	1.000				
(4) Access to credit	-0.041	-0.131	0.081	1.000			
(5) Access to health insurance	0.022	0.109	0.068	-0.079	1.000		
(6) Employed in GO	0.099	0.067	-0.022	0.139	0.008	1.000	
(7) Exposure to shock	0.274	0.138	-0.143	0.036	-0.049	0.087	1.000

Appendix 6

Table 6.1a. Hausman (1978) specification test

	Coef.
Chi-square test value	0.000
P-value	0.002

Table 6.2b: Food composition table for use in Ethiopia by EHNRI

Items	**Calorie per 100 G**
Maize	378
Teff	358
Wheat	351
Gebs	351
Rice	335
Lentils	370
Ater	352
Bakela	354
Shimbra	341
Sweet Potato	136
Chicken	140
Oil	896
Dabo	22
Coffee	110
Salt	0
Cabbage	20
Tomato	31
Onion	71

Halako	75
Banana	88
Berbere	360
Metmita	93
Macaroni & Pasta	352
Orange	47
Papaya	45
Mangoe	65
Enset	211
Cassava	160
Yam	118
Butter (Kibe)	736
Milk	73
Meat	187
Potato	100
Sugar	387
Egg	152
Taro	58

Appendix 7

Table 7.1a. Factor analysis results for access to basic services (ABSs) by the *Enset* producers and non-producers.

	Producer			Non-producer		
	Factor 1	Factor 2	uniqueness	Factor 1	Factor 2	Uniqueness
Infrastructural index	0.576	-0.032	0.732	0.445	0.221	0.643
Distance to school	0.536	0.012	0.731	0.412	-0.012	0.639
Distance to market	0.023	0.083	0.992	0.014	0.06	0.912

One factor was used to estimate the ABS for producers; it explains 95% of the variable variance. One factor was used to estimate the ABS for non-producers; it explains 96% of the variable variance.

Table 7.2b. Factor analysis results for assets (AST) by the *Enset* producers and non-producers

	Enset producer				Non-producer		
	Factor 1	Factor 2	Factor 3	uniqueness	Factor 1	Factor 2	Uniqueness
Agricultural asset index	0.796	0.212	0.032	0.324	0.542	0.121	0.123
Wealth index	-0.382	0.521	-0.023	0.756	0.412	0.022	0.856
TLU	0.653	0.423	0.013	0.523	0.494	0.11	0.070
Land	0.453	0.23	0.175	0.854	0.395	0.031	0.823

Two factors estimate AST for producers, jointly explaining 93% of the variable variance. Two factors were used to estimate AST for non-producers, jointly explaining 94% of the variable variance.

Table 7.3c. Factor analysis results for adaptive capacity (AC) by the *Enset* producers and non-producers.

	Producer			Non-producer		
	Factor 1	Factor 2	uniqueness	Factor 1	Factor 2	Uniqueness
Income diversification	-0.323	0.356	0.732	0.445	0.221	0.712
Education level	0.756	0.253	0.731	0.412	-0.012	0.756
Access to extension and credit	0.635	0.296	0.992	0.014	0.06	0.763

Two factors estimate AC for producers, jointly explaining 99% of the variable variance. One factor was used to estimate AC for non-producers, jointly explaining 97% of the variable variance.

Table 7.4d. Factor analysis results for income and food access (IFA) by the *Enset* producers and the non-producer.

	Producer		Non-producer	
	Factor 1	uniqueness	Factor 1	Uniqueness
Total income	0.775	0.832	0.565	0.982
Total expenditure	0.637	0.752	0.522	0.832

One factor estimates IFA for producers, explaining 100% of the variable variance. One factor was used to estimate IFA for non-producers, explaining 98% of the variable variance.

Table 7.5e. Factor analysis results for the social safety net (SSN) by the *Enset* producers and the non-producers.

	Producer			Non-producer		
	Factor 1	Factor 2	uniqueness	Factor 1	Factor 2	Uniqueness
Food aid from GO or NGOs	0.675	-0.042	0.754	0.546	0.321	0.892
Remittance	0.435	0.013	0.667	0.313	-0.112	0.789
Cash-for-work	0.122	0.073	0.577	0.113	0.16	0.652

One factor estimates SSN for producers, explaining 98% of the variable variance. One factor was used to estimate the SSN for non-producers, explaining 96% of the variable variance.

Table 7.6f. Factor analysis results for stability (S) by the *Enset* producer and non-producers.

	Enset producer			Non-producer		
	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
Livestock loss	0.375	0.132	0.842	0.745	0.0421	0.961
Crop loss	0.237	-0.32	0.811	0.612	-0.312	0.865
Other shocks	0.124	0.093	0.652	0.514	0.16	0.756

One factor estimates S for producers, explaining 98% of the variable variance. One factor was used to estimate S for non-producers, explaining 96% of the variable variance.

Table 7.7g. Multiple indicator multiple causes (MIMIC) model of the resilience capacity index (RCI) of *the settlement* producer and non-producer: coefficients of structural and measurement components

	Producer	**Non-Producer**
Structural Components	Coef. (Std Err.)	
Income and Food Access (IFA)	0.0031 (0.001)***	0.00032 (0.002)***
Assets (AST)	3.882 (0.569)***	4.030 (0.524)***
Adaptive Capacity (AC)	12.149 (2.382)***	1.041 (1.653)**
Access to Basic Services (ABS)	243.808 (21.380)***	136.299 (16.61)**
Social Safety Nets (SSN)	-199.157 (10.950)***	116.94
Stability (STB)	5.591 (22.436)	12.14
Measurement components		
reduced the Coping Strategies Index (rCSI)	1 (0)	1 (0)
Food Consumption Score (FCS)	0.864(0.122)***	0.46 (0.108)
Food Expenditure Share (FES)	0.004(0.002)	0.0002 (0.001)
Calorie Intake (CI)	1.602 (10.885)	0.94 (15.298)
Goodness-of-fit statistics		
X^2	345.522	253.522
P value	0.000	0.001
observation	608	202

*Standard error in parentheses: ** p< 0.05 & ***p< 0.01*

Appendix 8

Table 8.1a. Factor analysis of the welfare index

Principal components/correlation — Number of obs = 810; Number of comp. = 5; Trace = 5; Rho = 1.0000

Rotation: (unrotated = principal)

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.817	0.452	0.363	0.363
Comp2	1.366	0.456	0.273	0.637
Comp3	0.910	0.259	0.182	0.819
Comp4	0.651	0.396	0.130	0.949
Comp5	0.255	.	0.051	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Unexplained
Total expenditure	0.033	0.745	0.315	0.397	0.433	0
Education level	0.552	0.441	-0.281	0.056	-0.647	0
Health Service	0.472	0.013	0.597	-0.641	0.096	0
Asset value	0.586	-0.182	-0.510	0.042	0.601	0
Exposure to shock	0.358	-0.466	0.452	0.653	-0.153	0

Two factors estimate household welfare jointly, explaining 63.6% of the variable variance.

Table 8.2b. Factor analysis results for assets (AST) by the *Enset* producers and non-producers

	Enset producer		Non-producer	
	Factor 1	uniqueness	Factor 1	Uniqueness
Agricultural asset index	0.796	0.366	0.642	0.588
Other Household asset index	0.682	0.536	0.612	0.625

One factor was used to estimate AST for producers, accounting for 93% of the variance in the variable. Similarly, a single factor was utilized to estimate AST for non-producers, explaining 94% of the variance in that variable.

Table 8.3c: Factor analysis results for Agricultural assets by the *Enset* producers and non-producers

	Enset producer				Non-producer		
Variables	Factor 1	Factor 2	Factor 3	uniqueness	Factor 1	Factor 2	Uniqueness
Agricultural tools	0.796	0.212	0.032	0.32	0.742	0.121	0.435
Access to irrigation	0.682	0.521	-0.023	0.263	0.612	0.022	0.625
Access to credit	0.053	0.623	0.013	0.609	0.494	0.612	0.381
Land	0.453	0.23	0.675	0.286	0.695	0.031	0.516

Three factors estimate agricultural assets for producers, jointly explaining 83% of the variable variance. Two factors were used to estimate AST for non-producers, jointly explaining 94% of the variable variance.

Table 8.4d: Factor (F) analysis results for other Household assets by the *Enset* producers

Variable	Factor1	Factor2	Factor3	Uniqueness
Television ownership	0.742	0.017	-0.040	0.447
Radio ownership	0.671	0.013	0.262	0.481
Mobile phone ownership	0.633	0.047	-0.216	0.55
Car or motorcycle ownership	0.261	0.685	0.024	0.462
Types of flooring	0.078	0.623	0.031	0.605
Access to electricity	0.235	-0.215	0.687	0.427
Access to piped water	0.006	0.295	0.605	0.547

Three factors estimate other household assets for producers, jointly explaining 86% of the variable variance.

Table 8.5e: Factor (F) analysis results for other household assets of non-producers

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
Television ownership	0.775	-0.198	0.031	-0.105	0.348
Radio ownership	0.639	0.127	0.240	0.054	0.515
Mobile phone ownership	0.661	-0.155	0.063	0.183	0.501
Car or motorcycle ownership	0.395	0.256	-0.054	0.768	0.186
Types of flooring	0.419	0.653	0.097	0.003	0.389
Access to electricity	-0.114	0.165	0.719	0.049	0.44
Access to piped water	0.037	0.379	0.607	-0.066	0.482

Four factors estimate other household assets for non-producers, jointly explaining 89% of the variable variance.

Table 8.6f: Factor analysis results for the health indices of the *Enset* producer and non-producer groups.

	Enset producer				Non-producer		
	Factor 1	Factor 2	Factor 3	Uniqueness	Factor 1	Factor 2	Uniqueness
Health care access	0.825	0.132	0.352	0.178	0.725	0.401	0.313
Health insurance	0.696	0.32	0.452	0.209	0.658	0.512	0.304
Sanitation and hygiene	0.344	0.625	0.243	0.432	0.425	0.723	0.297
Prevalence of chronic disease	0.251	0.617	0.523	0.283	0.356	0.687	0.402
Calorie intake	0.125	0.332	0.721	0.178	0.423	0.653	0.393

The education index for producers was estimated via three factors, which explained 88% of the variance in the variables. For non-producers, two factors were used, accounting for 86% of the variance.

Table 8.7g. Factor analysis results for the education indices of the *Enset* producers and non-producers.

Variables	*Enset* producer				Non-producer			
	Factor 1	Factor 2	Factor 3	Uniqueness	Factor 1	Factor 2	Factor 3	Uniqueness
Year of schooling	0.736	0.362	0.154	0.303	0.685	0.401	0.241	0.313
Gender balance in education	0.6426	0.259	0.423	0.342	0.238	0.712	0.324	0.331
Expenditure on education	0.234	0.153	0.725	0.397	0.125	0.023	0.682	0.520

The education index for producers was estimated via three factors, which together explained 79% of the variance in the variables. The index was also calculated with three factors for non-producers, accounting for 76% of the variance.