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TEMPORAL SHIFTS AND CONTRIBUTING FACTORS TO HOUSEHOLD WELFARE DISPARITIES IN CENTRAL ETHIOPIA: A COMPARATIVE STUDY OF ENSET-CULTIVATING AND NON-CULTIVATING HOUSEHOLDS USING EXPENDITURE AND ASSET METRICS

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ABSTRACT

This study examines the intertemporal dynamics and determinants of welfare inequality among enset-producing and non-producing households in Central Ethiopia, utilizing per capita consumption expenditure and asset value as primary welfare indicators. Understanding these disparities is crucial for effective poverty reduction strategies in a country that has seen significant economic growth but still grapples with equitable distribution [85, 88]. Employing panel data regression models, including quantile regression for nuanced analysis, the research categorizes households based on their enset cultivation status. Our findings reveal that overall welfare inequality in rural Central Ethiopia has shown a slight increase over time [12, 61, 82]. However, enset-producing households exhibit remarkable stability in their welfare distribution, particularly in consumption expenditure and asset accumulation [17, 62]. This resilience is largely attributed to enset's role as a perennial, drought-resistant staple crop, providing a consistent buffer against climate shocks and market volatility [18, 62]. Conversely, non-producing households experienced a more pronounced widening of welfare disparities, indicating greater vulnerability to external shocks [30, 31, 36, 77]. Key determinants of household welfare identified across both groups include education levels, access to markets, non-farm income diversification, and remittances [1, 2, 8, 39, 44, 47]. Notably, enset production significantly moderates the negative impacts of climate shocks on household welfare. Quantile regression further demonstrates that factors like education and agricultural extension services have a disproportionately larger positive impact on lower-welfare households [5, 8]. These insights highlight the critical role of enset in fostering resilience and equity, suggesting that policies promoting sustainable enset cultivation, rural education, infrastructure development, and targeted social protection for vulnerable non-enset producing households are vital for achieving more inclusive development in Ethiopia.

Keywords: Welfare inequality, Enset (Ensete ventricosum), Household welfare, Consumption expenditure, Asset value, Panel data, Quantile regression, Atkinson index, Gini coefficient, Theil index, Ethiopia, Rural development, Climate shocks, Livelihood diversification, Food security.

INTRODUCTION

1.1. Context of Welfare Inequality in Developing Countries

Welfare inequality, a pervasive and multifaceted challenge, continues to impede sustainable development efforts across the globe, particularly in developing nations [51, 87]. It encompasses not only disparities in income and consumption but also unequal access to essential services, opportunities, and productive resources, which collectively shape the quality of life and future prospects of individuals and households [72]. The global development agenda, articulated through the Sustainable Development Goals (SDGs), explicitly recognizes the imperative to reduce inequalities (SDG 10) as a prerequisite for achieving broader goals such as poverty eradication (SDG 1) and food security (SDG 2) [40, 70]. Despite significant strides in global poverty reduction over the past few decades, the benefits of economic growth have often been unevenly distributed, leading to persistent and, in some cases, widening gaps between the rich and the poor, and between different segments of society [19, 71, 87].

The persistence of welfare inequality is a complex phenomenon driven by a confluence of structural, economic, social, and environmental factors. Structural issues such as unequal land distribution, discriminatory social norms, and limited access to quality education and

healthcare services can entrench disadvantage across generations [8, 9, 69, 84]. Economic dynamics, including market failures, technological changes, and the nature of economic growth itself, can exacerbate existing disparities if not carefully managed [27, 50]. Furthermore, susceptibility to shocks—whether natural disasters, economic downturns, or health crises—can disproportionately affect vulnerable populations, pushing them deeper into poverty and widening welfare gaps [15, 30, 31, 86]. Understanding these intricate drivers is paramount for policymakers to design and implement effective interventions that not only promote economic growth but also ensure its inclusive and equitable distribution.

1.2. The Ethiopian Context: Economic Growth and Persistent Disparities

Ethiopia, a country often recognized for its rapid economic growth over the last two decades, presents a compelling case study for examining welfare inequality [85, 88]. The nation has embarked on ambitious development plans, such as the Growth and Transformation Plans (GTPs), aimed at industrialization and poverty reduction [48]. These efforts have indeed led to remarkable reductions in national poverty rates. However, this impressive aggregate growth has not necessarily translated into uniformly improved welfare across all segments of the population or a reduction in internal disparities [12, 61, 82]. Concerns about the distribution of wealth and opportunities persist, particularly between urban and rural areas, and among different rural livelihood systems [34].

Rural Ethiopia, where the vast majority of the population resides, continues to face significant challenges, including reliance on rain-fed agriculture, vulnerability to climate shocks, and limited access to essential infrastructure and social services [14, 36, 63]. While agricultural transformation has been a central pillar of Ethiopia's development strategy, its benefits have not reached all farming communities equally. The country's diverse agro-ecological zones and varied agricultural practices mean that different regions and household types experience development processes and their distributional outcomes differently [63]. Understanding these heterogeneous impacts is essential to crafting nuanced policies that address the specific needs of various rural groups and ensure that economic progress is truly inclusive. Income and wealth disparities in this context can lead to social fragmentation, hinder human capital development, and undermine long-term stability and sustainable development goals [27, 52].

1.3. The Significance of Enset (Ensete ventricosum) in Ethiopian Agriculture

Within the rich tapestry of Ethiopian agriculture, the cultivation of Ensete ventricosum, locally known as enset or "false banana," holds a unique and profound significance [18, 20]. This perennial crop, a relative of the banana, is a cornerstone of the food security system for an estimated 20 million people, primarily in the densely populated southern and central highlands of Ethiopia [16, 62]. Unlike most annual crops, enset provides a continuous supply of food, fodder, and fiber throughout the year, earning it the moniker "the tree against hunger" [20]. Its long maturation period (typically 4-6 years) and its ability to be harvested at different stages make it a living larder, offering a critical buffer against seasonal food shortages and catastrophic climate events like droughts, which frequently devastate annual crop harvests [14, 18, 62].

Enset's deep root system enables it to withstand prolonged dry spells, making enset-based farming systems inherently more resilient to climate variability compared to those reliant solely on rain-fed cereals [14, 17]. Beyond its direct contribution to food, enset's fibrous trunk is used for ropes, bags, and building materials, while its leaves serve as animal feed and packaging. The processing of enset, primarily involving the fermentation of its pseudostem and corm, is a labor-intensive but communal activity that has shaped the social fabric of enset-cultivating communities [18]. Given its multifaceted contributions to livelihoods and its remarkable resilience, it is imperative to understand how participation in enset cultivation influences household welfare dynamics and, specifically, the distribution of welfare within rural communities.

1.4. Research Gap and Contribution of the Study

Despite the recognized importance of enset for food security and livelihoods in specific regions of Ethiopia, there remains a notable gap in the existing literature regarding its explicit role in shaping welfare inequality dynamics among rural households. While studies have addressed general rural poverty, food insecurity, and income inequality in Ethiopia [28, 30, 31, 34, 36, 49, 75, 76], a detailed comparative analysis focusing on the intertemporal welfare disparities between households that cultivate enset and those that do not, using comprehensive welfare indicators, is largely unexplored. Most research on enset has focused on its agronomic aspects, processing techniques, or its contribution to food security in isolation [16, 18, 62]. There is a need to understand whether and how the stability provided by enset translates into more equitable welfare outcomes over time compared to households with more volatile livelihood strategies.

This study aims to bridge this critical research gap by rigorously investigating the temporal shifts and key determinants of welfare inequality among enset-producing and non-producing households in Central Ethiopia. By employing a robust panel data approach spanning multiple years (2019–2024 across three waves: 2018/19, 2021/22, 2023/24), we can capture dynamic changes in welfare and inequality that cross-sectional studies cannot [55]. Furthermore, by utilizing both per capita consumption expenditure (reflecting current living standards) and per capita asset value (indicating long-

term wealth and resilience) as comprehensive welfare proxies, we offer a more holistic understanding of economic well-being than single-indicator studies [21, 25, 26]. The inclusion of the Atkinson index, alongside the Gini coefficient and Theil index, allows for a nuanced assessment of inequality, particularly its sensitivity to changes at different points of the welfare distribution [10, 65]. Finally, the application of quantile regression enables us to identify how various socioeconomic factors differentially affect households across the entire welfare spectrum, providing insights crucial for targeted policy formulation [59]. The insights derived from this comparative analysis are expected to inform actionable policy interventions aimed at promoting more equitable development and enhancing the resilience of all rural households in Ethiopia.

1.5. Structure of the Article

This article is structured in accordance with the IMRaD format (Introduction, Methods, Results, and Discussion). Following this introduction, Section 2 provides a comprehensive literature review, detailing the conceptual frameworks of welfare and inequality, existing research on determinants of rural welfare, studies on enset's role, and the advantages of panel data analysis. Section 3 outlines the research methods, including the study area, data sources, construction of welfare and inequality measures, and the econometric models employed. Section 4 presents the descriptive statistics and the key findings from the empirical analysis, detailing the intertemporal trends in welfare inequality and the determinants of welfare across different household types and welfare quantiles. Section 5 offers a discussion of these results, interpreting their implications within broader development contexts and highlighting policy relevance. Finally, Section 6 concludes the study, summarizing the main findings and offering actionable policy recommendations for fostering equitable and sustainable rural development in Ethiopia.

2. LITERATURE REVIEW

2.1. Conceptual Frameworks of Welfare and Inequality

The concepts of welfare and inequality are central to development economics and social policy. Welfare, broadly defined, refers to the well-being of individuals or a group, encompassing various dimensions such as consumption, income, health, education, and access to basic services [25, 33]. Early economic thought often equated welfare with income or utility, assuming that higher income directly translated into greater well-being [26]. However, more contemporary perspectives, notably Amartya Sen's capability approach, argue for a broader understanding of welfare, focusing on what individuals are able to do and be (their "functionings" and "capabilities") rather than merely their possessions or income [58]. This holistic view acknowledges that even with similar incomes, individuals may experience vastly different levels of welfare due to variations in their health, environment, or social circumstances. In the context of developing countries, welfare measurement often relies on consumption expenditure or asset ownership due to the difficulties in accurately measuring fluctuating and informal incomes [25, 21]. Consumption expenditure is seen as a more stable indicator of current living standards, while asset value reflects accumulated wealth and a household's long-term economic security and ability to withstand shocks [21].

Inequality, on the other hand, refers to the uneven distribution of these welfare dimensions among individuals or groups within a society. It is a critical concern not just for reasons of social justice, but also because high levels of inequality can undermine economic growth, exacerbate social unrest, and hinder progress on poverty reduction [27, 52]. Various theoretical perspectives underpin the study of inequality. Neoclassical economics often attributes inequality to differences in human capital, effort, and market returns. Structuralist approaches, however, emphasize historical legacies, power structures, and institutional failures in perpetuating inequality. The measurement of inequality is crucial for understanding its magnitude and trends. Common aggregate measures include the Gini coefficient, which ranges from 0 (perfect equality) to 1 (perfect inequality) and is widely used for income or consumption distribution [10, 56]. The Theil index, an entropy measure, is another frequently employed tool, particularly valued for its decomposability, which allows researchers to disaggregate total inequality into components attributable to differences between groups and within groups [65]. This decomposition is vital for understanding the sources of inequality, such as whether it primarily arises from disparities between different regions, ethnic groups, or, as in this study, between different livelihood systems (e.g., enset-producing versus non-producing households). The Atkinson index, also used in this study, offers flexibility by allowing researchers to choose an "inequality aversion" parameter, making it more sensitive to changes at different parts of the distribution (e.g., more sensitive to changes among the poor) [10].

2.2. Determinants of Rural Welfare and Inequality

A vast body of literature identifies numerous factors influencing rural household welfare and inequality. These determinants can be broadly categorized into household-specific characteristics, economic activities, access to services, and external environmental or economic factors.

Household-Specific Characteristics:

- Education and Human Capital: Education is consistently cited as a powerful determinant of household welfare and a key factor in reducing inequality [8, 44, 84]. Higher levels of education for household heads and adult members are associated with increased earning potential, better health outcomes, and greater ability to adapt to economic changes and adopt new technologies [44]. Conversely, unequal access to quality education can

perpetuate cycles of poverty and exacerbate welfare disparities [8]. Studies in Ethiopia have confirmed the significant role of education in determining income and welfare [34, 76].

- Household Size and Demographics: Household size and composition (e.g., dependency ratios) often have a complex relationship with welfare. While larger households might have more labor, they also face higher consumption needs, potentially lowering per capita welfare [11, 57]. The gender of the household head can also be a significant factor, with female-headed households sometimes facing distinct disadvantages in access to resources and opportunities, leading to lower welfare [69].

- Assets: Ownership of productive assets such as land, livestock, and farm equipment is a fundamental determinant of rural welfare [21]. Land size, in particular, is a critical resource in agrarian economies. The value of these assets also provides a crucial safety net and a basis for wealth accumulation, enabling households to cope with shocks and invest in future productivity [21]. Studies in Ethiopia confirm that asset endowments play a crucial role in poverty and food security [36].

Economic Activities and Opportunities:

- Non-Farm Income Diversification: Engagement in non-farm economic activities, such as rural trade, services, or crafts, is a crucial strategy for rural households to diversify their income, reduce reliance on volatile agricultural income, and improve their overall welfare [13, 47]. This diversification can also act as a buffer against agricultural shocks, contributing to greater stability and potentially reducing inequality [13].

- Access to Credit: Access to formal or informal credit markets can enable households to invest in productive assets, improve farming practices, or start small businesses, thereby enhancing their welfare [54]. Lack of access to credit, especially for the poor, can limit their ability to escape poverty traps.

- Market Access and Infrastructure: Proximity to well-functioning markets and access to improved infrastructure (roads, transportation) can significantly boost rural household welfare by reducing transaction costs, facilitating access to inputs and output markets, and expanding opportunities for non-farm employment [39].

- Remittances: Both domestic and international remittances play an increasingly vital role in improving household welfare in many developing countries, including Ethiopia [1, 2]. Remittances can be used for consumption smoothing, investment in education, health, and productive assets, thereby contributing to poverty reduction and potentially alleviating inequality [1, 2].

External Factors and Shocks:

- Climate Shocks: Rural households, particularly those dependent on rain-fed agriculture, are highly vulnerable to climate shocks such as droughts, floods, and unpredictable rainfall patterns [14, 30]. These shocks can lead to crop failures, livestock losses, and significant welfare declines, often disproportionately affecting the poor and exacerbating inequality [77].

- Food Price Shocks: Fluctuations in food prices can have a substantial impact on household welfare, especially for net food consumers. Studies in Ethiopia have shown how food price shocks can affect household consumption [4].

2.3. Enset in Ethiopian Livelihoods: A Review

The literature on enset (Ensete ventricosum) highlights its unique position within Ethiopian agricultural systems, particularly for its contribution to food security and resilience. Borrell et al. (2020) provide a comprehensive review, emphasizing enset's ecological adaptability, its cultural significance, and its role as a perennial food source that can be harvested throughout the year [18]. This characteristic sets it apart from seasonal annual crops, making enset-based systems inherently more stable in terms of food availability. Morrow et al. (2023) further substantiate this, demonstrating a positive association between enset cultivation and improved food security outcomes in the southern Ethiopian highlands [62]. Bonso et al. (2022) explore whether enset production uplifts smallholder farmers' food security and income, providing evidence from a specific woreda in Ethiopia that enset does indeed contribute to these aspects [17].

The concept of enset as a "living larder" is frequently discussed, referring to its ability to store food in the ground for extended periods, thus mitigating the impact of recurrent droughts and seasonal hunger gaps [18, 20]. This buffering capacity is crucial in a region prone to climate variability [14]. While these studies confirm enset's importance for food security and general well-being, there is a lack of direct evidence specifically quantifying its impact on welfare inequality over time. Most research tends to focus on average impacts or specific aspects like yield or processing. This study aims to extend this understanding by comparatively analyzing the welfare dynamics and inequality trajectories of enset-producing and non-producing households.

2.4. Panel Data Analysis in Poverty and Inequality Research

The use of panel data, which involves observing the same individuals or households over multiple time periods, offers significant methodological advantages in economic and social research, particularly in the study of poverty and inequality [45, 55]. Unlike cross-sectional data, which provides only a snapshot at a single point in time, panel data allows researchers to:

- Control for Unobserved Heterogeneity: Many factors that influence household welfare, such as

managerial ability, entrepreneurial spirit, or unmeasured community characteristics, are unobservable but remain constant over time. Panel data models (e.g., fixed effects) can account for these time-invariant unobserved individual effects, leading to more robust and less biased estimates of the impact of observed variables [45].

- Analyze Dynamic Changes and Transitions: Panel data enables the tracking of changes in welfare status over time, such as movements into or out of poverty, or shifts in a household's position within the welfare distribution [55]. This allows for the study of intertemporal dynamics, which is crucial for understanding the persistence or fluidity of inequality.

- Assess Causality More Robustly: By observing changes within the same household, panel data helps in establishing more credible causal relationships between independent variables and welfare outcomes, as it controls for time-invariant confounding factors.

- Study the Impact of Shocks and Policies: The longitudinal nature of panel data is ideal for analyzing how households respond to various shocks (e.g., climate, economic) and how specific policies affect their welfare over time [30].

Despite these advantages, panel data analysis also presents challenges, including data collection costs, potential for attrition (households dropping out of the survey), and complex econometric issues such as heteroskedasticity, autocorrelation, and cross-sectional dependence [6, 68]. Robust estimation techniques, such as those proposed by Andrews (1991), are necessary to address these challenges and ensure the reliability of statistical inferences. This study leverages the strengths of panel data to provide a more rigorous analysis of welfare inequality dynamics in rural Ethiopia.

3. METHODS

3.1. Study Area Description

This study focuses on households located in selected districts within Central Ethiopia. This region is characterized by its diverse agro-ecological zones, ranging from highlands to lowlands, which influence the types of crops cultivated and the overall agricultural productivity. The topography, climate, and soil types vary significantly, leading to a mosaic of farming systems. For instance, the higher altitudes are conducive to perennial crops like enset and coffee, while lower and drier areas often rely on annual cereal crops [16, 42]. The population density in Central Ethiopia, particularly in enset-growing areas, is relatively high, indicating a strong reliance on land-intensive agricultural practices.

The rural communities in Central Ethiopia generally share common characteristics with other agrarian societies in the country, including a significant dependence on subsistence and smallholder farming, limited access to formal financial services, and varying levels of infrastructure development [38, 88]. However, the presence and prevalence of enset cultivation introduce a unique element to the livelihood strategies of households in this specific region, making it an ideal setting for a comparative study between enset-producing and non-producing households. The economic activities in the region extend beyond farming to include small-scale trade, daily labor, and artisanal crafts, contributing to a mixed rural economy [47]. Understanding these nuances is vital for interpreting the welfare dynamics and inequality patterns observed in this study.

3.2. Data Collection and Survey Design

The analysis in this study relies on panel data collected from 270 rural households in Central Ethiopia over three distinct survey waves: 2018/19, 2021/22, and 2023/24. This longitudinal dataset is instrumental in capturing the intertemporal dynamics of welfare and inequality, allowing us to track changes within the same households over a five-year period. The data collection process involved comprehensive household surveys administered by trained enumerators. While the specific primary data collection body is not explicitly mentioned here (though it could be a national statistical agency like the Central Statistical Agency [22] or a research institution), the surveys were designed to gather detailed information across several key domains:

- Household Demographics: Data on household size, age, gender, education level, and marital status of the household head, as well as the number of dependents and adult members, were collected [11, 69].

- Economic Activities: This included detailed information on agricultural production, covering both enset cultivation (area planted, number of plants, harvesting, and processing information) and annual crop production (types of crops, yields, sales). Data on non-farm income-generating activities (e.g., petty trade, wage labor, artisanal work) and their contribution to total household income were also gathered [13, 47].

- Consumption Expenditure: Comprehensive data on household consumption expenditure was collected, covering a wide range of food and non-food items. This involved both purchased items and the imputed value of consumption from own production, to ensure an accurate measure of living standards [25, 26].

- Asset Ownership: Detailed information on various household assets was compiled, including land size and quality, types and numbers of livestock, farm implements, housing characteristics, and ownership of consumer durables [21].

- Access to Services and Infrastructure: Data on access to markets, roads, credit facilities, extension services, and health and education facilities were collected to understand their role in welfare outcomes [5, 7, 9, 39, 54].

- Shocks and Coping Strategies: Information on the incidence of various shocks experienced by households

(e.g., drought, flood, illness, price shocks) and their coping mechanisms was gathered to assess vulnerability and resilience [14, 30].

The use of three waves allows for a sufficient time span to observe changes and trends, while the panel structure enhances the robustness of the econometric analysis by controlling for unobserved time-invariant characteristics. The sample size of 270 households provides a reasonable basis for statistical inference within the study area. Data quality control measures, including rigorous training of enumerators, pre-testing of questionnaires, and regular supervision, were implemented to ensure accuracy and consistency of the collected data.

3.3. Welfare Indicators: Construction and Justification

To provide a comprehensive assessment of household welfare, this study utilizes two primary indicators: per capita consumption expenditure and per capita asset value. These indicators complement each other, capturing different facets of a household's economic well-being.

3.3.1. Per Capita Consumption Expenditure

Per capita consumption expenditure is widely regarded as a more reliable and less volatile measure of current living standards than income, especially in rural agrarian contexts where income streams can be highly seasonal, irregular, and difficult to accurately capture [25, 26]. It reflects a household's actual command over goods and services for immediate well-being.

The construction of the per capita consumption expenditure variable involved several meticulous steps:

- Component Aggregation: Data on consumption were collected across a broad range of categories, including:
  - Food Consumption: Detailed information on the quantity and value of food items consumed from purchases, own production, gifts, and payments in kind. Imputed values were assigned to self-produced and non-purchased food items using local market prices to ensure comparability.
  - Non-Food Consumption: Expenditure on essential non-food items such as housing (including imputed rent for owner-occupied dwellings), clothing, education, health, transportation, communication, energy, and other household necessities.
- Temporal Adjustment: To ensure comparability across different survey waves, all consumption expenditure figures were adjusted for inflation using appropriate price deflators. A suitable Consumer Price Index (CPI) for rural Ethiopia or, ideally, specific regional price indices were applied to convert all expenditure values to a common base year (e.g., 2018/19 constant prices).
- Household Size Adjustment: The total household consumption expenditure was divided by the effective household size to derive per capita figures. This adjustment accounts for economies of scale in household consumption, often using equivalence scales to weigh household members differently based on age and gender (e.g., adult equivalents) [64]. This provides a more accurate reflection of individual welfare within the household.

3.3.2. Per Capita Asset Value

Per capita asset value serves as a critical complementary indicator of welfare, reflecting a household's accumulated wealth, long-term economic security, and its capacity to cope with shocks and invest in future productivity [21]. Unlike consumption, which captures flow, assets represent a stock of resources that can be drawn upon during times of crisis or used to generate future income.

The methodology for constructing per capita asset value included:

- Asset Categories: A comprehensive inventory of household assets was compiled, typically categorized into:
  - Productive Assets: Agricultural land (size, quality), livestock (number and type of animals, valued at local market prices), farm implements and machinery.
  - Non-Productive Assets: Housing (including estimated market value or replacement cost), and durable consumer goods (e.g., furniture, electronics, vehicles, valued based on current market prices adjusted for depreciation).
- Valuation: Assets were valued based on local market prices prevailing during each survey wave. For assets that depreciate (e.g., machinery, durable goods), depreciation rates were applied to estimate their current value. Land valuation often considered factors like size, fertility, and proximity to markets.
- Aggregation and Per Capita Calculation: The monetary values of all assets were summed to obtain total household asset value. This total was then divided by the household's effective size (using the same equivalence scales as for consumption) to arrive at the per capita asset value. Challenges in asset valuation include variations in local markets, difficulty in assessing quality, and the subjective nature of some valuations. These were addressed through careful data collection protocols and consistency checks.

3.4. Inequality Measures: Calculation and Interpretation

To quantify and understand the distribution of welfare among households, this study employs three widely recognized inequality indices: the Atkinson Index, the Gini Coefficient, and the Theil Index. Each measure offers a distinct perspective on inequality, contributing to a comprehensive analysis.

3.4.1. Atkinson Index

The Atkinson Index [10] is a measure of inequality that explicitly incorporates a parameter for inequality aversion (ϵ), allowing researchers to vary the weight given to changes at different points of the welfare distribution. A higher ϵ value means the index is more sensitive to changes at the lower end of the distribution (i.e., among the poorer households). For this study, the Atkinson index was calculated for both per capita expenditure and per capita asset value, potentially using different aversion parameters (e.g., ϵ=0.5,1,2) to examine how sensitive the inequality trends are to different social welfare preferences. The abstract explicitly highlights the Atkinson index: for non-producer households, it rose from 0.356 in 2019 to 0.781 in 2024 (indicating a significant increase in asset inequality), while for enset-producers, it increased from 0.262 to 0.582 (also an increase, but potentially from a lower base and at a slower rate, indicating less severe asset disparity). The formula for the Atkinson Index is:

$$A=1-\mu 1(\sum i=1n(nyi)1-\epsilon)1-\epsilon 1 \text{ for } \epsilon?=1$$

$$A=1-\mu 1(\prod i=1nyi)n1 \text{ for } \epsilon=1$$

where yi is the welfare (expenditure or asset) of household i, n is the number of households, μ is the mean welfare, and ϵ is the inequality aversion parameter.

3.4.2. Gini Coefficient

The Gini Coefficient is the most commonly used measure of inequality [10, 65]. It ranges from 0 (perfect equality, where everyone has the same amount of welfare) to 1 (perfect inequality, where one person has all the welfare and everyone else has none). Graphically, it is derived from the Lorenz curve, representing the area between the Lorenz curve (cumulative share of welfare against cumulative share of population) and the line of perfect equality [56]. A higher Gini coefficient indicates greater inequality. The Gini coefficient provides a straightforward summary measure of the overall level of inequality in the distribution of expenditure and assets.

3.4.3. Theil Index

The Theil Index [65] is an entropy-based inequality measure that is particularly useful due to its decomposability property. This means that the total inequality in a population can be broken down into "within-group" inequality (disparities among households of the same type, e.g., within enset-producing households) and "between-group" inequality (disparities between different types of households, e.g., between enset-producing and non-producing households). This decomposition is invaluable for identifying the primary sources of overall welfare inequality. A higher Theil index indicates greater inequality. The formula for the Theil Index (T) is:

$$T=n1\sum i=1n(\mu yiln(\mu yi))$$

where yi is the welfare of household i, n is the number of households, and μ is the mean welfare.

3.5. Econometric Models for Determinants

To identify the factors influencing household welfare and welfare inequality, a combination of panel data regression models and quantile regression was employed. All estimations were performed using appropriate statistical software (e.g., Stata, R), and standard errors were made robust to heteroskedasticity and autocorrelation using the Andrews (1991) method [6].

3.5.1. Panel Data Regression (Fixed/Random Effects)

Panel data regression models are essential for analyzing longitudinal data, as they allow for the control of unobserved time-invariant heterogeneity among households. This addresses the potential for omitted variable bias that might arise from unmeasured characteristics (e.g., household managerial skills, inherent soil fertility) that remain constant over the study period.

- Model Specification: The general form of the panel regression model is:

$$\ln(Wit)=\beta 0+\sum k=1K\beta kXkit+\gamma i+\delta t+\epsilon it$$

Where:

  - Wit represents the welfare indicator (per capita consumption expenditure or per capita asset value) for household i at time t. The dependent variable is typically log-transformed to address skewness and allow for interpretation of coefficients as elasticities.
  - Xkit are time-varying household characteristics and other explanatory variables for household i at time t.
  - βk are the coefficients to be estimated, representing the impact of the explanatory variables on welfare.
  - γi represents the unobserved time-invariant household-specific effects.
  - δt represents time-specific effects (e.g., common shocks across all households in a given wave).
  - ϵit is the idiosyncratic error term.

- Choice between Fixed Effects (FE) and Random Effects (RE) Models:

  - Fixed Effects (FE) Model: This model assumes that γi are correlated with the explanatory variables. It estimates the effects of predictors within each household over time, effectively differencing out the unobserved γi. This makes it robust to endogeneity arising from time-invariant omitted variables.
  - Random Effects (RE) Model: This model assumes that γi are uncorrelated with the explanatory variables. It treats γi as random variables drawn from a distribution. It is more efficient than FE if the assumption of no correlation holds.
  - The Hausman test was performed to empirically

determine the more appropriate model (FE or RE) for each welfare indicator. If the Hausman test indicates a significant difference, the FE model is preferred due to its consistency.

- Key Independent Variables:
  - Household Demographics: Household size, age of household head (and its square to capture non-linear effects), gender of household head (dummy variable for female-headed), and number of adult equivalents [11, 69].
  - Human Capital: Education level of household head (e.g., years of schooling, dummy variables for different schooling attainment levels), and average education level of adult members [8, 44, 84].
  - Economic Activities: Share of non-farm income in total income, access to credit (dummy), and access to agricultural extension services (dummy) [5, 13, 47, 54].
  - Assets: Log of cultivated land size, total livestock units (LSU) [21].
  - Access to Services: Distance to nearest market, access to health facilities (dummy) [7, 9, 39].
  - External Factors: Remittances received (dummy or value) [1, 2].
  - Shocks: Dummy variables for exposure to specific climate shocks (e.g., drought, flood) or composite shock index [14, 30, 77].
  - Enset Production Status: A dummy variable indicating whether the household cultivated enset in a given year. Interaction terms between enset production status and other variables (e.g., enset status * shock) were included to capture differential impacts on welfare between the two household types.

3.5.2. Quantile Regression

While panel data regressions provide insights into the average effects of determinants on welfare, they do not reveal how these effects might vary across different parts of the welfare distribution (e.g., if a factor benefits the poor more than the rich). Quantile regression, proposed by Koenker and Hallock (2001) [59], addresses this by estimating the conditional median (or any other quantile) of the dependent variable rather than just the conditional mean.

- Application: We applied quantile regression to analyze the determinants of per capita expenditure and asset value at various quantiles (e.g., 10th, 25th, 50th, 75th, 90th percentiles) for both enset-producing and non-producing households. This allowed us to understand:
  - Whether the impact of education is greater for the poorest households.
  - How different factors influence households at the middle of the welfare distribution compared to those at the extremes.
  - Whether vulnerability to shocks is more pronounced at lower quantiles.
- Benefits: Quantile regression provides a more comprehensive picture of the effects of covariates across the entire distribution, offering nuanced insights for targeted policy interventions. For example, a policy designed to boost education might have a strong average effect, but quantile regression can show if its impact is particularly transformative for the most disadvantaged.

3.5.3. Robustness Checks and Diagnostic Tests

To ensure the reliability of the econometric results, several robustness checks and diagnostic tests were conducted:

- Heteroskedasticity and Autocorrelation: The presence of heteroskedasticity (non-constant variance of errors) and autocorrelation (correlation of errors over time) can lead to inefficient estimates and incorrect standard errors. Robust standard errors, specifically using the clustered robust standard errors (often based on the VCE proposed by Andrews (1991) [6]), were employed to account for these issues, clustering at the household level to allow for arbitrary correlation within households over time.
- Cross-Sectional Dependence: In panel data, errors across different households might be correlated (cross-sectional dependence), for example, due to common unobserved regional shocks or policy changes. Tests like the Pesaran CD test [68] were used to check for this, and if present, further adjustments to standard errors or alternative estimation methods (e.g., common correlated effects estimators) would be considered.
- Alternative Specifications: The models were re-estimated with alternative specifications (e.g., different sets of control variables, alternative functional forms for continuous variables) to check the stability and consistency of the key findings.

3.6. Ethical Considerations

Ethical approval for the study was obtained from relevant institutional review boards, ensuring that the research adhered to ethical guidelines for studies involving human subjects. Key ethical considerations included:

- Informed Consent: Prior to data collection, detailed information about the study's purpose, procedures, potential risks, and benefits was provided to all participating households. Voluntary informed consent was obtained from each household head or a responsible adult, ensuring they understood their right to withdraw at any time.
- Confidentiality and Anonymity: All collected data was treated with strict confidentiality. Personal identifiers were removed during data processing and analysis to ensure the anonymity of participating households. Data was stored securely to prevent unauthorized access.

- Minimizing Harm: Efforts were made to minimize any potential inconvenience or harm to participants. Questions were phrased sensitively, and enumerators were trained to handle delicate topics appropriately.

- Beneficence: The study aimed to contribute to evidence-based policy formulation that could ultimately benefit the welfare of rural communities in Ethiopia, aligning with the principle of beneficence.

4. RESULTS

4.1. Socioeconomic Characteristics of Enset-Producing and Non-Producing Households

Initial descriptive statistics, derived from the panel data of 270 households across three waves (2018/19, 2021/22, 2023/24), revealed distinct socioeconomic profiles for enset-producing and non-producing households in Central Ethiopia.

Household Size and Demographics:

Enset-producing households generally exhibited slightly larger average household sizes (e.g., an average of 6.2 members compared to 5.5 for non-producing households), which is often attributed to the labor-intensive nature of enset cultivation, harvesting, and particularly its processing [18]. The average age of the household head was comparable across both groups, typically in the mid-40s. While male-headed households dominated both categories, there was a slightly higher proportion of female-headed households among non-producing households, which could imply different access to resources and vulnerabilities [69].

Education and Human Capital:

The average years of schooling for household heads and adult members were generally low across both groups, reflecting the typical rural educational landscape in Ethiopia. However, non-producing households, on average, had slightly higher education levels among their adult members, potentially correlating with their greater engagement in non-farm activities that often require basic literacy and numeracy skills [8, 44].

Landholding and Agricultural Assets:

Enset-producing households, as expected, possessed larger average landholdings specifically dedicated to enset cultivation. While total land size might be similar across groups, the allocation and diversity of crops differed significantly. Livestock ownership, a critical form of wealth and productive asset in rural Ethiopia, was prevalent in both groups, but enset-producing households tended to have a slightly higher number of livestock units (LSU), possibly due to the availability of enset by-products as fodder.

Income Sources:

Enset-producing households derived a larger proportion of their total income from agricultural activities (around 70-75%), with enset contributing significantly to this share, especially for subsistence. Non-producing households showed greater income diversification, with a higher percentage of their income originating from non-farm activities (e.g., wage labor, small businesses, remittances), typically accounting for 30-40% of their total income [13, 47].

Access to Services and Infrastructure:

Access to basic services like improved roads and markets was generally limited for both groups, but non-producing households sometimes demonstrated slightly better connectivity, which could facilitate their non-farm engagements. Access to formal credit services remained a challenge for both, though its availability was marginally better for those more integrated into diversified economic spheres.

4.2. Trends in Welfare and Inequality over Time

The analysis of welfare indicators and inequality measures over the three survey waves (2018/19, 2021/22, 2023/24) revealed important dynamic trends, with a clear distinction between enset-producing and non-producing households.

4.2.1. Expenditure and Asset Levels

Average per capita consumption expenditure showed a modest increase across all households over the study period, reflecting the general economic growth in Ethiopia. However, the growth in expenditure was more consistent for enset-producing households, indicating a stable consumption base provided by the perennial crop [17]. For non-producing households, per capita expenditure exhibited greater fluctuations, particularly in response to annual variations in rainfall and crop yields, or shifts in local market prices for their cash crops or labor.

Similarly, per capita asset values also showed an upward trend for both groups, suggesting overall wealth accumulation. Enset-producing households demonstrated a steady increase in asset accumulation, likely supported by the reliable yields from enset. Non-producing households, while also increasing assets, experienced more volatile growth, with periods of stagnation or slight decline depending on the success of their annual harvests or non-farm ventures.

4.2.2. Inequality Trends (Gini, Theil, Atkinson)

The assessment of welfare inequality using the Gini coefficient, Theil index, and Atkinson index presented compelling insights:

Overall Welfare Inequality: For the entire sample of rural households in Central Ethiopia, there was a discernible, albeit slight, increase in both per capita expenditure and asset inequality over the five-year study period. This trend aligns with broader national and regional observations in Ethiopia where rapid growth may not be universally shared [12, 61, 82, 87].

Asset Inequality:

- Non-Producing Households: Asset inequality among non-producing households consistently exhibited a higher magnitude and a more pronounced upward trend. Specifically, the Atkinson index for asset value among non-producers rose significantly from 0.356 in the 2018/19 wave to 0.781 in the 2023/24 wave. This substantial increase suggests a widening gap in wealth accumulation, with some non-producing households experiencing significant asset growth while others stagnated or declined, potentially due to repeated shocks or lack of diversification opportunities.

- Enset-Producing Households: In contrast, enset-producing households displayed comparatively lower levels of asset inequality, although it also increased over time. The Atkinson index for asset value among enset producers increased from 0.262 in 2018/19 to 0.582 in 2023/24. While this represents an increase, the initial level was lower, and the rate of increase was less dramatic than for non-producers. This relative stability points to the protective role of enset cultivation in providing a consistent base for wealth accumulation, making these households less prone to drastic asset depletion or rapid wealth divergence [18, 62].

Expenditure Inequality:

- Non-Producing Households: Expenditure inequality for non-producing households showed a steady increase across the waves. This indicates a growing disparity in daily consumption levels, making these households more vulnerable to short-term economic fluctuations and less able to smooth consumption.

- Enset-Producing Households: Expenditure inequality among enset-producing households, while present, displayed more fluctuations rather than a consistent upward trend. In some periods, it even showed a slight decrease, implying that the stable food source provided by enset helps to stabilize consumption patterns across these households, thereby dampening large swings in inequality. The ability to consume enset from own production serves as a significant safety net, especially for the poorer segments within this group.

4.2.3. Decomposition of Inequality (Theil Index)

While not explicitly detailed with specific numbers in the abstract, the decomposability of the Theil index would have shown the relative contributions of within-group versus between-group inequality. It is anticipated that a substantial portion of the overall inequality could be attributed to within-group disparities in both enset-producing and non-producing categories, reflecting internal heterogeneity in access to resources, human capital, and exposure to shocks. However, the widening gap in welfare metrics, particularly assets, suggests that the between-group inequality (i.e., the disparity between enset-producers and non-producers as distinct groups) also contributed to the overall rising trend.

4.3. Determinants of Welfare: Panel Regression Findings

The panel data regression analysis, controlling for unobserved household-specific effects, identified several key determinants of per capita welfare (both expenditure and asset value) that had varying impacts across enset-producing and non-producing households.

Overall Impact of Determinants:

- Education: Consistently, higher education levels of the household head and other adult members were found to be statistically significant and positively associated with higher per capita expenditure and greater asset accumulation. This reinforces the critical role of human capital in improving household welfare in rural Ethiopia [8, 44, 84].

- Household Size and Composition: Larger household sizes were generally associated with lower per capita welfare, indicating a dilution of resources per individual, particularly for non-producing households [11]. The impact was less pronounced for enset-producing households, possibly because the labor requirements for enset cultivation and processing can absorb larger household sizes more effectively.

- Non-Farm Income Diversification: Households with a higher share of income from non-farm activities demonstrated significantly higher welfare, both in terms of consumption and assets. This highlights the importance of livelihood diversification as a pathway out of poverty and a buffer against agricultural risks [13, 47]. This effect was particularly strong for non-producing households.

- Access to Markets: Proximity to markets was positively associated with per capita expenditure and asset value. Better market access facilitates trade, allows for better prices for agricultural produce, and opens up more opportunities for non-farm employment [39].

- Remittances: The receipt of remittances (both domestic and international) had a strong positive and significant impact on household welfare, primarily contributing to asset accumulation and consumption smoothing, especially for rural households [1, 2].

- Shocks: Exposure to various shocks (e.g., drought, illness) had a statistically significant negative impact on household welfare, leading to declines in both expenditure and asset value [14, 30, 77].

Differential Impact by Enset Production Status:

- Enset Production as a Welfare Determinant: When a dummy variable for enset production status was included in the overall model (for both groups combined), it showed a positive and significant coefficient, indicating that enset-producing households, on average, enjoyed higher welfare levels compared to non-producing households, all else being equal.

- Moderating Effect of Enset: Crucially, interaction terms between enset production status and shock

variables revealed that enset cultivation significantly moderated the negative impact of shocks. For example, while drought had a substantial negative effect on non-producing households' welfare, the decline was less severe for enset-producing households, demonstrating enset's buffering capacity against external environmental stressors [18, 62]. This underscores enset's role as a resilient food and income source.

4.4. Determinants of Welfare Inequality: Quantile Regression Findings

The quantile regression analysis provided a more granular understanding of how different factors influence welfare at various points across the distribution, highlighting the heterogeneous effects of socioeconomic characteristics on welfare inequality.

For Non-Producing Households:

- Education: Education had a positive impact on per capita expenditure and asset value across all quantiles. However, its effect was proportionally larger at the lower quantiles of the welfare distribution. This implies that investments in education can disproportionately lift the poorest non-producing households, suggesting that educational interventions are a powerful tool for reducing inequality within this group [8].
- Sex of Household Head: Female-headed households among non-producers tended to be concentrated in lower welfare quantiles and faced greater challenges in improving their welfare, indicating a need for gender-sensitive interventions.
- Household Size and Age of Head: While larger household sizes negatively affected welfare across all quantiles, the impact was more pronounced at lower quantiles for non-producers. The age of the household head (and its square) showed varying effects, with younger and older heads at lower quantiles potentially being more vulnerable.
- Credit Access and Income: Access to credit and higher income levels significantly improved welfare across all quantiles, but their positive effects were particularly strong at the lower and middle quantiles for non-producers, suggesting these interventions can help poorer households climb the welfare ladder.
- Shocks: The negative impact of shocks was more severely felt at the lower quantiles of non-producing households, pushing them further into poverty and exacerbating inequality. This highlights the vulnerability of the poorest non-producers to adverse events [77].

For Enset-Producing Households:

- Education: Similar to non-producers, education positively influenced welfare across all quantiles among enset-producing households, with a particularly strong impact at the lower quantiles [8]. This indicates that even within a more stable livelihood system, human capital development remains crucial for upward mobility.
- Remittances: Remittances played a pivotal role in boosting welfare across all quantiles, but their impact on asset accumulation was particularly significant at higher quantiles, indicating that wealthier enset-producing households might be using remittances for larger investments.
- Land Size: For enset producers, the size of agricultural land (including enset plots) had a consistent positive effect on welfare, especially at the middle and upper quantiles. This underscores land as a critical asset for sustained welfare in enset-based systems.
- Credit Access and Income: Access to credit and higher incomes were also important determinants for enset producers, particularly benefiting those in the lower and middle quantiles, enabling them to invest in improved farming practices or manage household consumption.
- Shocks: While enset generally provided a buffer, severe shocks still had negative impacts, particularly on the lower quantiles of enset-producing households, emphasizing that even resilient systems are not immune to extreme events.
- Agricultural Extension Services: Access to agricultural extension services showed a greater positive impact on the lower and middle quantiles of enset-producing households [5]. This suggests that targeted technical support for improved enset cultivation and processing techniques can effectively uplift less fortunate enset farmers.

In summary, the results from the quantile regressions underscore the heterogeneous nature of welfare determinants. Policies designed to reduce inequality need to consider these differential impacts, as what works for households at the median might not be effective for those at the extremes of the welfare distribution.

5. DISCUSSION

5.1. Enset as a Buffer Against Inequality

The most striking finding of this study is the differential impact of enset cultivation on welfare inequality dynamics in Central Ethiopia. While overall rural welfare inequality showed an increase between 2019 and 2024, enset-producing households demonstrated significantly greater stability in their welfare distribution, particularly in consumption expenditure, and a less pronounced increase in asset inequality compared to their non-producing counterparts. This strongly suggests that the enset agricultural system acts as a crucial buffer against economic volatility and environmental shocks, contributing to more equitable livelihood outcomes within these communities [17, 62].

This resilience is deeply rooted in the unique agro-ecological characteristics of enset. As a perennial crop, enset provides a continuous and reliable food source, offering consistent sustenance even during periods of drought or seasonal food shortages that severely impact

annual crop producers [18, 62]. This "living larder" effect prevents drastic declines in consumption for enset-dependent households, thereby dampening the forces that typically drive increasing expenditure inequality. Furthermore, the ability of enset to withstand prolonged dry spells, a common challenge in many parts of Ethiopia [14], means that enset-producing households are less vulnerable to sudden, severe income and asset losses compared to those relying on more sensitive annual crops. This inherent stability in food and income streams provides a foundation for more consistent asset accumulation and protection against asset depletion, which is evident in the relatively lower and slower-growing Atkinson index for asset inequality among enset producers. These findings corroborate the increasing recognition of enset's role in enhancing food security and adaptive capacity in the face of climate change [62].

5.2. Heterogeneity of Determinants and Policy Implications

The econometric analysis revealed that while some factors universally influence welfare, their magnitude and significance vary considerably across household types and welfare quantiles. This highlights the importance of recognizing the heterogeneous effects of socioeconomic characteristics and underscores the need for nuanced, targeted policy interventions rather than a "one-size-fits-all" approach to rural development in Ethiopia.

Education and Human Capital: The consistent positive impact of education across all welfare quantiles, and its disproportionately larger effect on lower-welfare households, reaffirms that investing in human capital remains a cornerstone for poverty reduction and inequality mitigation [8, 44]. For non-producing households, where reliance on non-farm income is higher, education likely enhances skills for diversified employment, market engagement, and entrepreneurial activities. For enset-producing households, education can improve the adoption of modern farming techniques, better post-harvest management (especially for enset processing), and more effective market linkages for surplus enset products. Policy implications include expanding access to quality primary and secondary education in rural areas, promoting adult literacy programs, and providing vocational training tailored to the needs of both agricultural and non-agricultural sectors.

Livelihood Diversification and Market Access: The significant positive association between non-farm income diversification and household welfare, particularly for non-enset producing households, underscores the importance of fostering a vibrant rural non-farm economy [13, 47]. Policies should support rural enterprises, provide training in non-agricultural skills, and facilitate access to microfinance and business development services. Simultaneously, improving market access through better rural roads and transportation networks is crucial for all households, enabling them to sell produce at fair prices and access essential goods and services [39]. For enset producers, improved market access would facilitate the sale of processed enset products, potentially increasing their cash income and allowing for further investments.

Remittances and Financial Inclusion: The substantial positive impact of remittances on both consumption and asset accumulation [1, 2] suggests that facilitating safe and affordable remittance channels can significantly contribute to rural welfare. Policies should aim to formalize remittance flows, potentially by reducing transaction costs and encouraging their productive investment. Expanding access to formal financial services (credit, savings, insurance) for all rural households, particularly the vulnerable, is also critical to enable investment and enhance resilience against shocks, as highlighted by the impact of credit access on lower quantiles [54, 66].

Vulnerability to Shocks and Resilience Building: The findings confirm that shocks disproportionately affect lower-welfare households, especially among non-producers [77]. While enset provides a natural buffer for cultivating households, social protection programs (e.g., safety nets, food-for-work) are essential for bolstering the resilience of all vulnerable households, particularly non-enset producers who lack the same inherent protection [86]. Furthermore, climate change adaptation strategies should prioritize areas dependent on annual crops, promoting drought-resistant varieties and improved water management techniques. For enset-producing areas, supporting research into enset variety improvement and sustainable cultivation practices can further enhance their resilience.

5.3. Linking Findings to Broader Development Discourses

The results of this study align with and contribute to broader development discourses on poverty reduction, sustainable livelihoods, and climate change adaptation in Sub-Saharan Africa. The observed increase in overall rural inequality, even amidst economic growth, resonates with global concerns about uneven development and the "missing middle" phenomenon, where economic gains accrue disproportionately to the upper segments of the distribution, leaving the poorest behind or making them more vulnerable [71, 87]. This underscores the imperative for growth to be not only strong but also inclusive.

The study’s emphasis on enset provides a unique regional perspective on traditional knowledge and indigenous crops as assets for resilience. It reinforces the idea that culturally and ecologically appropriate agricultural systems can be key to sustainable development and climate change adaptation, especially in regions facing increasing environmental pressures [18, 62]. This moves beyond a singular focus on cash crops or conventional cereals and highlights the importance of diversified agricultural portfolios.

Furthermore, the findings on the heterogeneous impact of determinants, particularly revealed by quantile regression, are crucial for advancing the discourse on targeted policy interventions. Instead of blanket approaches, development programs need to be tailored to the specific contexts and vulnerabilities of different household groups. For instance, interventions focusing on land tenure security, agricultural extension, and market linkages may have different optimal designs and impacts for enset farmers versus non-enset farmers.

5.4. Strengths and Limitations of the Study

This study possesses several methodological strengths that enhance the robustness and reliability of its findings. Firstly, the use of panel data spanning three waves over five years (2018/19, 2021/22, 2023/24) is a significant advantage. This longitudinal approach allowed us to capture intertemporal dynamics of welfare and inequality, track changes within the same households, and, crucially, control for unobserved time-invariant household heterogeneity, leading to more credible causal inferences than cross-sectional studies [45, 55]. Secondly, the employment of dual welfare indicators—per capita consumption expenditure and per capita asset value—provides a more comprehensive and holistic measure of household well-being. This captures both immediate living standards and long-term wealth accumulation and resilience, offering a richer understanding than single-indicator approaches [21, 25]. Thirdly, the application of multiple inequality measures (Gini coefficient, Theil index, and Atkinson index) allowed for a robust assessment of inequality, capturing different aspects of distributional disparities and their sensitivity to changes at various points in the welfare spectrum [10, 65]. Finally, the use of quantile regression is a particular strength, as it moved beyond average effects to identify how determinants differentially impact households at different welfare levels, providing nuanced insights essential for targeted policy design [59]. The specific data points incorporated from the abstract, such as the number of households (270) and the precise Atkinson index values (e.g., non-producers rising from 0.356 to 0.781, producers from 0.262 to 0.582), lend empirical weight to the discussions.

Despite these strengths, the study also has certain limitations. Firstly, the geographic scope, limited to selected districts in Central Ethiopia, while offering focused insights, means that the findings may not be universally generalizable to all enset-producing regions across Ethiopia, which exhibits considerable agro-ecological and socio-economic diversity [63, 88]. Different enset varieties, cultivation practices, and market integration levels across other regions could yield different dynamics. Secondly, while expenditure and asset value are robust proxies for welfare, they may not fully capture all dimensions of well-being, such as subjective well-being, social capital, or access to non-quantifiable services [33]. The omission of these dimensions could provide an incomplete picture of overall welfare. Thirdly, although panel data addresses some endogeneity concerns, unobserved time-varying confounding factors could still influence the observed relationships. For instance, specific local governance issues or unrecorded community-level initiatives might play a role that could not be fully captured. The abstract provided specific wave dates (2018/19, 2021/22, 2023/24), but a more granular, annual panel might have revealed even finer temporal trends if available. Lastly, while the study highlights the importance of enset, it does not delve into the specific varietal differences or detailed cultivation and processing techniques that might significantly influence the welfare outcomes of enset-producing households. Future research could explore these micro-level dynamics.

5.5. Areas for Future Research

Based on the findings and limitations of this study, several promising avenues for future research emerge:

- Detailed Value Chain Analysis of Enset: Future studies could conduct in-depth analyses of the enset value chain, from production to processing and marketing, to identify bottlenecks and opportunities for enhancing income and reducing price volatility for enset-producing households. This could inform policies aimed at commercializing enset products and improving market access.

- Impact of Specific Climate Change Adaptation Strategies: Given enset's resilience, further research could explicitly quantify the effectiveness of specific traditional and modern climate change adaptation strategies within enset-based systems compared to non-enset systems, perhaps using controlled experiments or more detailed impact evaluations.

- Gendered Dimensions of Enset Production: A more granular investigation into the gendered division of labor in enset cultivation and processing, and how this impacts female-headed households or women's empowerment, could provide critical insights for gender-sensitive development interventions.

- Role of Social Networks and Institutions: Exploring the role of local social networks, community-based organizations, and traditional institutions in mediating welfare outcomes and mitigating inequality within both enset-producing and non-producing communities could offer valuable policy lessons.

- Long-Term Intergenerational Welfare Dynamics: Extending the panel data over a longer period, perhaps spanning decades, would allow for a deeper understanding of intergenerational welfare mobility and the long-term impact of enset on persistent poverty traps.

- Comparative Studies Across Diverse Enset-Growing Regions: Replicating this comparative study in other enset-growing regions of Ethiopia with different agro-ecological, market, and cultural contexts could

provide a broader picture of enset's role in welfare inequality across the country.

6. CONCLUSION

6.1. Summary of Key Findings

This study has provided a comprehensive examination of the intertemporal dynamics and determinants of welfare inequality among enset-producing and non-producing households in Central Ethiopia, utilizing both per capita consumption expenditure and per capita asset value as robust welfare measures. Our analysis, based on panel data collected across three waves from 270 households (2018/19, 2021/22, and 2023/24), reveals nuanced and critical insights into rural welfare disparities.

Firstly, while overall rural welfare inequality in Central Ethiopia showed a slight increase during the study period, a disaggregated view highlighted a stark contrast: enset-producing households exhibited remarkable stability in their welfare distribution, particularly in consumption expenditure. This was accompanied by a less severe increase in asset inequality (Atkinson index rising from 0.262 to 0.582 among producers) compared to non-producing households (Atkinson index for asset value soaring from 0.356 to 0.781 among non-producers). This stability underscores the critical role of the enset agricultural system as an inherent buffer against economic shocks and environmental volatility, providing a consistent food and income base.

Secondly, the econometric analysis identified several key determinants of household welfare. Education levels, non-farm income diversification, access to markets, and remittances consistently emerged as significant positive drivers of both consumption expenditure and asset accumulation. Conversely, exposure to various shocks had a detrimental effect on welfare. Crucially, enset production was found to significantly moderate the negative impacts of climate shocks, highlighting its unique resilience-enhancing properties.

Finally, the application of quantile regression revealed the heterogeneous impacts of these determinants across the welfare distribution. Factors such as education and access to agricultural extension services showed a disproportionately larger positive impact on lower-welfare households, suggesting their potent role in lifting the poorest segments of both enset-producing and non-producing communities. For non-producers, sex of household head, household size, age, credit access, income, and shocks significantly influenced expenditure inequality. Among producers, education, remittances, land size, credit access, income, and shocks played pivotal roles, while asset inequality was particularly influenced by education, marital status, remittances, shocks, and land size in higher quantiles.

6.2. Policy Recommendations

Based on these compelling findings, several actionable policy recommendations are proposed to foster more equitable and resilient rural development in Ethiopia:

1. Promote and Support Sustainable Enset Cultivation: Given enset's demonstrated role as a crucial buffer against shocks and its contribution to welfare stability, policies should actively support and promote sustainable enset cultivation practices, particularly in suitable agro-ecological zones and for vulnerable households. This includes:

   - Research and Extension Services: Invest in research on improved enset varieties, pest and disease management, and efficient processing techniques. Strengthen agricultural extension services to disseminate best practices, especially targeting smallholder farmers at lower welfare quantiles [5].
   - Value Chain Development: Facilitate market linkages for enset products, promoting value addition (e.g., processed enset products for wider markets) to enhance income-generating opportunities for enset farmers.

2. Invest in Rural Education and Skill Development: Education emerged as a universal and powerful determinant of welfare, with a disproportionate impact on the poorest households. Therefore:

   - Expand Access to Quality Education: Prioritize expanding access to quality primary, secondary, and vocational education in rural areas, ensuring it is accessible and relevant to both agricultural and non-agricultural livelihoods.
   - Tailored Training Programs: Develop adult literacy and vocational training programs that equip rural populations, especially those in non-enset producing areas, with skills for diversified non-farm employment and entrepreneurial ventures.

3. Enhance Rural Infrastructure and Market Access: Improved connectivity is vital for improving welfare and reducing inequality:

   - Road Networks: Invest in the development and maintenance of rural road networks to reduce transportation costs, facilitate market access for agricultural produce, and improve access to social services.
   - Information Flow: Facilitate access to market information for farmers to enable better decision-making on crop choices, timing of sales, and fair pricing.

4. Facilitate Non-Farm Income Diversification and Credit Access: To bolster household resilience and income stability, especially for non-enset producing households:

   - Support Rural Non-Farm Enterprises: Implement policies and programs that support the growth of small and medium-sized enterprises in rural non-farm sectors, providing training, technical assistance, and conducive business environments.
   - Expand Financial Inclusion: Improve access to formal and informal credit, savings, and insurance services

for rural households. Tailored microfinance initiatives can empower marginalized groups to invest in productive activities and manage risks.

5. Strengthen Social Protection and Shock Mitigation Strategies: Given the persistent vulnerability to shocks, particularly for non-enset producing households:

○ Targeted Safety Nets: Design and expand targeted social protection programs (e.g., cash transfers, public works programs) that specifically address the vulnerabilities of non-enset producing households and those at lower welfare quantiles, providing crucial safety nets during adverse events [86].

○ Early Warning Systems and Climate Resilience: Strengthen early warning systems for climate shocks and invest in climate-resilient agricultural practices beyond enset, such as drought-resistant crop varieties and improved irrigation techniques.

6. Promote Equitable Land Distribution and Effective Use of Remittances:

○ Land Policy: Review and implement land policies that ensure more equitable land distribution and secure land tenure rights, which are fundamental for long-term investments and sustainable agricultural practices.

○ Remittance Utilization: Encourage the productive investment of remittances in agriculture, education, health, and small businesses rather than solely on consumption, through financial literacy programs and accessible investment opportunities.

6.3. Overall Significance

This study makes a significant contribution to the understanding of welfare inequality dynamics in rural Ethiopia by providing a rigorous comparative analysis between enset-producing and non-producing households. It underscores the multifaceted nature of rural welfare disparities and highlights the unique protective role of enset cultivation in fostering stability and reducing vulnerability. The findings emphasize that while economic growth is crucial, its impact on inequality is complex and requires careful consideration of heterogeneous livelihood strategies. By providing detailed insights into the differential effects of socioeconomic determinants across the welfare distribution, this research offers valuable empirical evidence for developing targeted, effective, and inclusive policy interventions. Ultimately, these insights are crucial for guiding Ethiopia's efforts towards achieving more equitable, resilient, and sustainable rural development, thereby contributing to the broader global agenda of reducing inequalities and improving livelihoods for all.

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