ADDIS ABEBA UNIVERSITY
COLLEGE OF VETERINARY MEDICINE and AGRICULTURE
CENTER FOR FOOD SECURITY STUDIES

INTERPLAY OF DROUGHT, RESILIENCE, AND FOOD SECURITY IN THE SOMALI REGIONAL STATE OF ETHIOPIA

By

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Declaration of the Candidate

The undersigned author declares that this MSc thesis is my original work. This study was not conducted in any other academic setting or university. All sources and materials used in this study are acknowledged in this manuscript.

Addis Ababa University, March, 2026

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Table of Contents

List of tables

List of figures

ACRONYMS and ABBREVATIONS

ABS Access to Basic Services
AC Adaptive Capacity
AST Assets
ESPS Ethiopian Socioeconomic Panel Survey
ESS Ethiopian Statistical Service
FAO United States Food and Agricultural Organization
FCS Food Consumption Score
FGDs Focus Group Discussions
FSIS Food Security Information Network Secretariat
GDM Global Drought Monitor
GNAFC Global Network Against Food Crises
GRFC Global Report on Food Crises
HDDS Household Dietary Diversity Score
Kcal Kilocalorie
KIIs Key Informant Interviews
LSMS-ISA World Bank Living Standards Measurement Study-Integrated Surveys of Agriculture
MIMIC Multiple Indicators Multiple Causes
NVDI Normalized Difference Vegetation Index
RIMA Resilience Index Measurement and Analysis
SPEI Standardized Precipitation Evapotranspiration Index
SPEI Standardized Precipitation Index
SPEI-24 Standardized Precipitation Evapotranspiration Index at 24 months
SPEI-6 Standardized Precipitation Evapotranspiration Index at 6 months
SSN Social Safety Nets
WFP World Food Program
WMO World Meteorological Organization

Abstract

The interaction between drought resilience and food security challenges the global community and influences agriculture-based food systems. This study aimed to investigate the effects of short- and long-term drought shocks on food security and identify specific resilience indicators that mitigate these impacts among rural households in Ethiopia's Somali Regional State. This study used mixed methods, combining qualitative data from focus group discussions and key informant interviews across three districts, along with self-reported shock data from the Ethiopian Socioeconomic Panel Survey (ESPS) waves 4 (2018/19) and 5 (2021/22), and quantitative analysis of panel household data from the ESPS's two waves and historic observations of climate data. The study examined how rural Somali households experienced drought through both subjective (qualitative data from FGDs and KIIs, along with self-reported shock data from the ESPS waves) and objective drought measures (specifically the Standardized Precipitation Evapotranspiration Index (SPEI) for 6- and 24-month droughts). A subsample of 313 rural households' socioeconomic datasets across both waves was quantitatively analyzed using the FAO's RIMA-II framework and household fixed-effects panel regression. RIMA identified potential observed resilience variables contributing to core resilience pillars. By modeling realized per capita daily kilocalorie consumption as a dependent variable and interaction terms between dummy drought indicators and the identified potential resilience variables in household fixed effects panel regressions, the study disclosed how much both short- and long-term droughts negatively affected the realized food security indicator and which specific resilience indicators moderated this relationship. Qualitative findings confirmed drought as a frequent and severe climate shock, undermining rural livelihoods, water access, and food security, while the drought analysis based on quantitative data confirmed an increase in the exposure and severity of both short- and long-term droughts in these communities by 2022. Short-term drought disrupts pastoral and agro-pastoral production, affecting food availability, whereas long-term drought causes chronic food insecurity through water stress. Assets, adaptive capacity, and access to basic services correlate with resilience, whereas social safety nets primarily smoothen consumption patterns. The regression results showed 5.2 % and 6.2% reductions in daily kilocalorie consumption from effects of short- and long-term droughts, respectively. Key resilience indicators for mitigating short-term droughts include income diversification, livestock holdings, cropland area, and access to protected water and health services. For long-term droughts, market access, income diversification, herd diversity, financial inclusion, and access to water and health services reduce adverse effects. The study recommends strengthening these interconnected resilience components and context-specific resilience pathways, emphasizing diversified livelihoods, market access, financial inclusion, improved water and health services access, enhanced productive assets, and reformed safety nets to sustain food security amid escalating drought effects in rural areas of the Somali Region.

Keywords: Drought, Ethiopia, Food Security, Resilience, Rural Households, Somali Region,

CHAPTER 1: INTRODUCTION

1.1. Background of the Study

The intricate interplay between drought, resilience, and food security is a major concern to the global community and influences agriculture-based food security systems. Despite decades of sustained policy efforts and international commitments, global hunger continues to increase. The Global Report on Food Crises (GRFC) shows that 258 million people across 58 countries faced acute food insecurity in 2022, the highest number in the GRFC's seven-year history (FSIN & GNAF, 2023). This alarming trend demonstrates the failure to achieve the second goal of sustainable development, namely, the eradication of hunger by 2030. The extreme weather events and conflict, particularly in developing countries, have exacerbated the global hunger.

Among climate-related shocks, drought stands out as the most recurrent and severe climate shock, not only because of its frequency but also because of its slow, cumulative, and often devasting effects. Unlike sudden shocks such as conflict, drought unfolds gradually, eroding rainfall-based livelihoods, weakening coping mechanisms, and reshaping entire socioeconomic systems. Droughts have affected over one billion people worldwide between 1994 and 2013, with Africa bearing the most effects (UNISDR, 2015). Its impacts are unevenly distributed in the continent and particularly severe in Sub-Saharan Africa, where drought exposure is high and adaptive capacity remains limited (Conway and Schipper, 2011; Andrew et al., 2013; Malhi et al., 2021; Filho et al., 2021). Over time, recurrent and severe droughts have moved from being episodic climate change to becoming structural features of socioeconomical vulnerability in many dryland regions in Africa, where livelihoods depend directly on natural resources.

Ethiopia exemplifies this challenge, where drought-induced food insecurity reached critical levels in 2022, affecting 23.6 million people, or 21 percent of the national population (Kogan et al., 2019; USAID, 2023; FSIN & GNAF, 2023). Ethiopia's vulnerability stems from its heavily reliance on rain-fed agriculture, combined with an increasing climate variability. Since the 1980s, both the frequency and intensity of drought shocks have increased, with recent episode, especially the prolonged 2020–2023 drought, surpassing earlier crises in scale and severity (Zeleke et al., 2017; UNHCR, 2023). The 2020-2023 drought has led to failed consecutive

agricultural cycles, millions of livestock death, affecting rural livelihoods and food insecurity in the country's pastoral regions, including the Somali Region (UNHCR, 2023; OHCA, 2023c; Destrijcker et al., 2023; REACH, 2024). Previously, the El Niño-induced drought events between 2015 and 2017 affected more than 10 million people and caused acute food insecurity in 2016 (Demissie et Galu, 2016; Demissie et al., 2021).

Within Ethiopia, the drought impacts are not evenly distributed and pastoral and agro-pastoral communities face a disproportionately burden compared to smallholder farmers (Kebede et al., 2016; Birhanu et al., 2017; Haile et al., 2022). Drought impacts, exacerbated by climate and anthropogenic shocks, interact with the intrinsic vulnerabilities of the country's pastoral regions, including the Somali Regional State. The pastoral regions have limited infrastructure, market isolation, inadequate services, and marginalization, which intensifies food insecurity (Destrijcker et al., 2023; Tofu et al., 2023; Wakeyo, 2024).

The Somali region of Ethiopia is recognized as one of the most drought-prone and food-insecure areas, primarily because of its arid and semi-arid climate, fragile ecosystems, and a strong dependence on livestock-based livelihoods (Birhan et al., 2017; Brück et al., 2019; Delgado, 2021; Liebig et al., 2022). The Somali region is mainly inhabited by pastoral and agro-pastoral communities, it has experienced significant increases in temperature and rainfall variability, prolonged dry spells, and recurrent droughts over the past few decades. Research indicates declining rainfall patterns, an increase in consecutive dry days, and intensified drought exposure in the region. These factors have led to rangeland degradation, depletion of water resources, livestock losses, worsening food insecurity, and extended recovery periods (Teku & Eshetu, 2024; Gebremeskel et al., 2025). During the recent long and severe drought from 2020 to 2023, millions (3.9 million people) required emergency food assistance, highlighting the regions chronic vulnerability to drought shocks (WFP, 2023; Destrijcker et al., 2023).

In response to such challenges, the concept of resilience has gained prominence (Errico & Di Giuseppe 2018). Rather than focusing solely on vulnerability, resilience concept emphasizes the capacity of households and communities to absorb, adapt, and recover from shocks and stressors, which is crucial to analytical and policy analysis and the focus for academic and policy research

(Barrett & Constas, 2014). Moreover, scholars have highlighted the significant welfare cost related to drought-induced food insecurity and prompted global policies and resilience-building responses. In pastoral settings, resilience is shaped by a complex mix of factors such as livelihood diversification, access to markets and basic services, productive asset ownership, and social networks, among others. However, the interplay between drought, resilience, and food security is far from straightforward. It is dynamic, context-specific, and shaped by both short-term and long-term interactions between shocks and socioeconomic conditions. Understanding how these elements interact, particularly in highly vulnerable arid and semi-arid pastoral regions like the Somali Region, is s essential for designing effective policy responses and actionable resilience-building interventions to moderate the drought adverse effects on rural household food security.

1.2. Problem Statement

Policies to reduce the adverse impacts of drought shocks aim to either mitigate household exposure to drought shocks or strengthen household resilience to cope with, recover from, and adapt to the impacts of drought. However, several studies have identified challenges, such as inadequate infrastructure and service provision and limited adaptive capacity, as obstacles to pastoral community and household resilience against the compounding impacts of climate shocks (Birihanu et al., 2017; Debela et al., 2019; Mekuyie and Mulu, 2021; Tofu et al., 2023). In this regard, numerous existing studies in Ethiopia's pastoral regions have highlighted that characterizes pastoral and agro-pastoral systems in Ethiopia as possessing inherently low resilience of pastoral and agro-pastoral households due to their dependence on climate-sensitive rural livelihoods and natural resources such as water and rangeland (Birhanu et al., 2017; Melketo et al., 2021; Tofu, Fana et al., 2023; Tofu, Mekuria et al., 2023). On average, pastoralists and female-headed households exhibit lower resilience (Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023).

Drought continues to undermine food security in ways that are both immediate and cumulative. Short-term droughts disrupt seasonal production and reduce food availability, while prolonged droughts degrade natural resources, weaken livelihoods, and entrench long-term food insecurity. Pastoral households, whose livelihoods depend heavily on climate-sensitive resources, are

particularly vulnerable to these layered effects. The Somali Region, characterized by arid and semi-arid climates, fragile ecosystems, and a strong dependence on livestock-based livelihoods, has become one of the country's most drought-prone and food-insecure areas (Brück et al., 2019; Liebig et al., 2022). Recurrent rainfall failures, rising temperatures, and prolonged dry spells have accelerated rangeland degradation, reduced water availability, and increased livestock mortality.

In response to recurrent and severe drought impacts, a growing body of research has extensively examined household resilience to drought-induced food insecurity in the Ethiopia pastoral areas. Many of these studies have explored household and community resilience using cross-sectional data, often indirectly modeling the shock(s) and conceptualizing resilience as a static capacity index (Mayian 2018; d'Errico & Pietrelli, 2017; Temesgen et al., 2016). Others have examined the impacts of climate shocks directly modelling climate shock such as drought and using self-reported data, which, while valuable, are susceptible to recall bias and measurement limitations (Birhanu et al. 2017; Mekuyie et al., 2018; Gebrekidan 2019; Hailay 2020). These approaches have generated useful insights such as the importance of diversified income sources, livestock assets, access to services, and social cohesion in enhancing the resilience of pastoral households in Ethiopia's drought-prone areas. These studies, however, often ignore the dynamic relationship between drought shocks and food security outcomes due to the lack of detailed information on the shock exposure and severity over various timescales and spaces. Moreover, they do not capture the dynamic nature and complex causality of food security outcomes nor resilience as a dynamic capacity of households and communities to withstand drought shock impacts. These and other few dynamic empirical studies in pastoral areas of the country examine the overall relationship between drought shocks and household food security and often assess the role of resilience compressively in this relationship. They also did not account for the diversity in households' specific resilience factors for short- and long-term resilience building efforts.

Despite the Somali Region's high vulnerability, the region remains underrepresented in climate-econometric research that integrated historical climate data with longitudinal household and community socioeconomic data, which uses the robust method to estimate the magnitude and non-liner impacts of short- and long-term droughts on household food security and identify

specific resilience indicators significantly mitigate these effects. Today, dynamic analyses of the relationships between drought, resilience, and food security outcomes in pastoral settings have been limited to only a few studies to date. For example, Frankenberger and Smith (2015) analyzed the PRIME project's interim monitoring survey in Ethiopian pastoral areas by applying the TANGO framework to assess absorptive, adaptive, and transformative capacities. Their findings indicate that absorptive capacity plays a more significant role in buffering drought impacts on food security than adaptive or transformative capacities do. Emerging high-frequency panel studies in pastoral regions of northern Kenya and southern Ethiopia integrate satellite-based NDVI as a proxy for forage conditions with weekly household surveys, revealing that a 10% increase in NDVI correlates with a roughly 12 percentage point reduction in food insecurity probability. This effect is largely mediated by improved livestock productivity and reduced food prices (Alulu et al., 2024). These limitations are especially evident not only in the Somali Region but also in other pastoral settings of the country because of the Ethiopian Socioeconomic Survey that included the first three rounds over five years, from 2011 – 2016, were not representative at each regional level of the pastoral regions of the country. This study make use of the 4^{th} and 5^{th} rounds of the Ethiopian Socioeconomic Panel Survey longitudinal datasets, which were representative for almost all regional states of the country, to examine the adverse impacts of both short- and long-term drought on realized household food security and access the contribution of specific resilience indicators in moderating these effects.

These contributions are timely because policymakers seek robust, context-specific evidence on how short- and long-term droughts affect household food security and which specific resilience indicators are most significant in mitigating these adverse effects of drought shocks in pastoral context of the country. This study's findings highlighted which resilience investments yield the greatest food security outcomes, informing specific resilience pathways for adverse effects of short- and long-term droughts in Ethiopia's pastoral regions such as Somali Region State.

This study addresses these gaps by examining the interplay between drought shocks, resilience, and household food security using a mixed-methods approach. By integrating objective drought measures with longitudinal socioeconomic data in household fixed-effects panel regression models, supplemented with qualitative insights, it provides a more nuanced estimations of the

magnitude and non-linear effects of both short- and long-term droughts on realized household food security outcome indicator while identifying specific resilience indicators that mediate these effects significantly over the study period. By studying this region, which shares contextual similarities with other Ethiopian pastoralist regions, this study provides insights into the specific resilience indicators that mitigate the adverse effects of short- and long-term drought on rural household food security in the pastoral settings in the country as a whole. Understanding the impact of drought on household food security and designing effective interventions to enhance resilience in pastoral communities are crucial for improving rural household food security (d'Errico; Di Giuseppe, 2018; Brück et al., 2019; Destrijcker et al., 2023).

1.3. Objectives of the Research

This study's overall objective was to examine the intricate interplay between drought, resilience, and food security among rural households in Ethiopia's Somali Regional State.

This study aimed to achieve the following objectives:

1. To describe drought shocks affecting rural communities in the Somali Regional State and their characteristics (prevalence, severity, and heterogeneity).
2. To evaluate the profiles and trends of rural household food security outcomes in the Somali Region over the study period.
3. To estimate the magnitude of short- and long-term drought shocks' impacts on realized household food security outcome indicator among rural Somali households.
4. To identify specific resilience indicators that significantly mitigate the effects of short- and long-term drought on realized rural Somali household food security outcome in the region.

1.4. Research Questions

To examine the interplay between drought resilience and food security among rural households in the Somali Regional State of Ethiopia, this study posed the following research questions:

1. Which types of drought shocks are most prevalent (frequent) and severe among rural households in the Somali Region, and how do these shocks vary across the region's zones and over time?
2. What are the profiles and trends of rural household food security outcomes in the region over the study period?
3. How much have short- and long-term drought shocks negatively affected rural household food security outcome?
4. Which specific resilience indicators at both the household and community levels effectively mitigate these effects of short- and long-term drought shocks on rural household food security in the Somali Region?

1.5. Significance of the Study

This study has several analytically, methodologically, and practically significances. From an academic perspective, it contributes to the growing literature on interplay between drought shocks, resilience, and food security by moving beyond static and perception-based analyses. By combining objective drought indicators (SPEI) with panel household data in climate-econometric analyses, the study estimates both the magnitude and non-linear drought impacts on realized household food security outcome over time. It also advances resilience research by identifying specific resilience indicators that mediate these effects significantly, rather than treating resilience as aggregated and static concept.

Methodologically, the study demonstrates the value of integrating longitudinal socioeconomic data with enumeration level high-resolution climate data, specifically the Standardized Precipitation Evapotranspiration Index (SPEI-6 and SPEI-24), offering a more robust framework for analyzing the intricate relationship between drought shocks, specific resilience factors, and food security. The inclusion of both short-term (SPEI-6) and long-term (SPEI-24) drought measures allows for a clearer distinction between immediate and cumulative effects of short-term (agricultural) and long-term drought (hydrological) droughts, an important and often recommended dimension in recent limited empirical evidence in rural Ethiopia and comparable African contexts (Dell et al., 2014; Demissie et al., 2021; Haile et al., 2022). Following similar

empirical techniques employed in relevant past studies (Dell et al., 2012; Deschênes and Greenstone, 2011; Demissie et al., 2021), this approach allows for a more accurate quantification of the drought effects that correspond to the seasonal and multi-year rainfall variability characteristics of the rural areas of the region. Such evidence is essential for designing effective human–development nexus interventions that address the immediate and cumulative impacts of drought in pastoral settings.

From a policy perspective, the findings provide actionable insights for policy response. By quantifying how much short- and long-term drought shocks reduce household food security and identifying which specific resilience indicators are most effective, the study offers evidence that can guide targeted interventions for short- and long-term resilience building efforts. In particular, it highlights the importance of livelihood diversification, financial inclusion, livestock diversification, and access to essential services in strengthening long-term resilience in the Somali Region where drought exposure and severity become repetitive and worst in history, specifically between 2020 and 2023.

Practically, the study provides specific information about the causal relationship between drought shocks and rural household food security and which specific resilience indicators significantly mitigate the adverse effects of both short- and long-term droughts in pastoral settings of Ethiopia. It recognizes that resilience is dynamic, multi-dimensional, and that effective strategies must be context-specific, addressing both short-term needs and long-term structural vulnerabilities. In doing so, it supports more sustainable and locally grounded specific resilience pathways to improving food security in Ethiopia's dryland regions.

1.6. Scope of the Study

This study investigated the interconnections between drought shocks, resilience, and food security outcomes among rural households in Ethiopia's Somali Region. Geographically, the analysis focuses on rural households' dependence on agricultural and nonagricultural activities, excluding urban areas. The spatial domain encompasses rural Somali households engaged in

pastoral and agro-pastoral activities over the long and severe 2020–2021 drought period. It integrates Ethiopian Socioeconomic Survey (ESS) data with geo-referenced climate data from the Global Drought Monitor (GDM) to assess the impact of droughts on household food security. The qualitative component, which examines households' perceptions of their drought exposure, its impacts, and coping mechanisms, covers three woredas within the Fafan, Sitti, and Liben Zones. Although these three districts are not represented for entire the Somali Region, the qualitative findings capture the experiences of all rural communities in these three districts of the region.

Moreover, this study analyzed drought severity using SPEI datasets from the Global Drought Monitor, combined with longitudinal socioeconomic datasets from the two rounds of the Ethiopian Socioeconomic Panel Survey (ESPS). It examined rural household specific resilience factors and food security across two waves (Wave 4 (2018/19) and Wave 5 (2021/22)). The specific resilience variables and food security outcome indicators constructed from the two waves of the ESPS datasets were merged with the Standardized Precipitation Evapotranspiration Index (SPEI) to determine the adverse effects of the prevalent types of drought shocks using 6- and 24-month values for short- and long-term droughts, respectively. SPEI values were extracted for the "Gu" and "Deyr" rainy seasons of 2017/18 and 2020/21, a year preceding the ESPS two waves' periods. This framework enables the analysis of the interplay between drought, specific resilience indicators, and food security outcome indicator.

Methodologically, this study employed mixed methods, integrating qualitative data from FGDs and KIIs with quantitative analysis of panel household data and climate indices. It constructs drought variables using SPEI indices, estimates the resilience capacity index and identifies potential resilience variables using the FAO's RIMA-II. Household fixed-effects regressions were used to assess the impact of both short- and long-term drought shocks on per-capita calorie consumption and identify moderating effects through the interaction terms between drought and resilience variables. These findings contribute to the climate resilience literature by providing insights into the impact of drought on household food security and evidence-based strategies for policy responses in Ethiopia's pastoral settings.

1.7. Limitations of the Study

Despite its methodological strengths and the use of longitudinal and objective datasets, this study has key limitations. First, the study did not incorporate extensive primary data on climate and non-climate shocks and the qualitative dimensions of resilience, which could have enriched the analysis by linking perceived risks to empirically measured drought patterns. To mitigate this gap, the researcher adopted a mixed-methods approach. However, this study has still limited qualitative coverage and future research should integrate broader qualitative datasets to better capture the social, institutional, and cultural aspects of resilience.

Second, the analysis relied on short-to medium-term panel data, limiting its ability to capture long-term resilience dynamics and thus, it two ESPS waves provide short-term econometric analysis. Longitudinal studies spanning multiple decades would allow for a deeper understanding of the structural changes in pastoral livelihoods, intergenerational resilience, and evolving adaptive capacities.

Third, although this study identified resilience indicators that moderate drought impacts, some may not be exogenous and may be influenced by household exposure to multiple shocks. Future research should consider methods that better address endogeneity concerns, such as instrumental variable approaches and natural experiments.

Finally, the geographic scope of this study, which focused on the Somali Region, limits the generalizability of the findings to other pastoral regions in Ethiopia. Expanding research to include Afar, Borana, and other dryland areas would improve our understanding of regional variations in resilience pathways and strengthen the evidence for national-level pastoral development and drought-resilient policies.

1.8. Organization of the thesis

This thesis comprises five chapters as follows. Chapter one introduces the study's background, problem statement, objectives, research questions, significance, scope, and limitations, emphasizing the urgency of addressing the impact of drought on food security in Ethiopia, particularly in pastoralist communities. The second chapter reviews the theoretical and empirical literature, focusing on conceptual frameworks and identifying research gaps. Chapter three

outlines the methodology, including the study area, design, approaches, sampling techniques, datasets, and analysis methods. The results and discussion are presented in chapters four. Chapter five summarizes the findings and offers conclusions and recommendations.

1.9. Operational Definition of Terms

Drought is a recurring climatic shock marked by extended periods of insufficient precipitation and heightened evaporative demand, leading to reduced soil moisture, lower agricultural productivity, exhausted water resources, and depressed agricultural economies.

Resilience: The capacity of households, communities, or systems to withstand, adapt to, and recover from shocks and stressors without compromising their long-term well-being outcomes, such as food security.

Food security: The condition under which everyone has access to sufficient, safe, and nutritious food at all times, which is deeply linked to drought and resilience.

Definitions of Dependent and Explanatory Variables: A set of prespecified variables used by this study to construct dependent and explanatory variables and/or indices to undertake its empirical analyses of the interplay between drought, resilience factors, and food security outcomes are described in the Methodology Chapter in Section 3.5.3 (pages 36 – 40). These variables were categorized into three main domains: drought shock measures (exposure and severity), realized food security outcome indicator, and household/community attributes related to rural Somali household resilience dimensions and potential observed resilience variables, following the FAO's RIMA-II methodology and household fixed-effects panel regression models. Moreover, the definitions of the two food security outcome variables (Food Consumption Score (FCS) and the Household Dietary Diversity Score (HDDS)), core four pillars, and observed resilience variables used in the RIMA-II MIMIC analyses, including their statistics, are presented in Appendix I (Table 4.9).

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter explores the foundational concepts and frameworks relevant to this study and provides insights into the theoretical and empirical evidence that support the hypotheses. It

begins with key concepts such as drought, food security, resilience, and the interplay between all three, mainly focusing on pastoralist contexts and establishing their role as research topics in the literature. Theoretical perspectives such as Vulnerability Theory, Resilience Theory, and Socio-Ecological Systems Framework were examined to understand the dynamics within pastoralist communities facing drought. Additionally, the chapter outlines the analytical framework guiding the conceptual framework and methodology of the study, enhancing our understanding of the interplay between drought shocks, resilience, and food security amid the challenges of climate change.

These frameworks provide a structure for research on the interplay between drought resilience and food security, ensuring rigorous inquiries rooted in existing scholarship. A critical review of empirical research on the impact of droughts on rural household food security and the role of resilience in the relationship between drought and food security revealed research gaps, particularly in pastoral communities, highlighting areas that require further exploration. Key research gaps concerning the complexities of drought resilience and food security in pastoralist contexts were identified, setting the stage for deeper investigation. This comprehensive review offers insights into the theoretical foundation and landscape of this topic, fostering an informed analysis and understanding of the findings.

2.2 Conceptual Review

2.2.1 Concept of Drought and Food Security

Drought is a recurring climatic shock marked by extended periods of insufficient precipitation and heightened evaporative demand, leading to reduced soil moisture, lower agricultural productivity, exhausted water resources and depressed agricultural economies. The literature differentiates between meteorological, agricultural, and hydrological droughts, each of which uniquely contributes to food insecurity (He et al. 2019). Recent literature suggests that droughts should be viewed as both meteorological events and socio-environmental processes. Differentiating between meteorological, agricultural, hydrological, and socioeconomic droughts clarifies how rainfall deficits affect household food security (Daryanto et al., 2015; He et al., 2019; Mohammed et al., 2022). Meteorological droughts are water shortages caused by insufficient precipitation and high evaporation demand. Precipitation is often employed in

meteorological drought analysis (Chang, 2024; Eltahir, 1992; Bogale and Erena, 2022). Agricultural drought refers to a soil moisture deficit resulting from meteorological droughts, climatic conditions such as warmer temperatures and lower humidity, and the effects of these factors on agricultural production and income. Soil moisture is the basis for evaluating agricultural drought factors. Hydrological drought refers to insufficient surface and subsurface water resources for an established water balance and its use in a specific shade management system. Streamflow data are commonly used in hydrological drought analyses (Dracup et al., 2002; Chang, 2024). Research indicates that meteorological drought can trigger agricultural and hydrological droughts, which in turn lead to socioeconomic drought, which is a collapse of livelihoods and markets that fail to sustain adequate food consumption (He et al. 2019).

Drought remains a pervasive threat to food security, particularly in developing regions where rural livelihoods are highly dependent on rain-fed agriculture and fragile ecosystems (Leng and Hall, 2019; Ngcamu and Chari, 2020; Qiao et al., 2024). Its impact on food security disrupts food availability, access, utilization, and stability, particularly in regions with limited resources and infrastructure in Africa and Asia (Daryanto et al., 2015; He et al., 2019; Mohammed et al., 2022). In low-income agrarian economies, such climatic shocks result in reduced dietary diversity, meal skipping, and increased undernutrition, especially affecting the rural poor, women and children (Ogutu et al., 2025; Akinkuolie et al., 2025; Farah et al., 2025).

Pastoral livelihoods in Ethiopia's lowlands, including the Somali Regional State, are susceptible to drought, rising temperatures, and rainfall variability, which compromise livestock production and the food security. Analyses of climate variability in the Siti Zone indicate declining rainfall, rising temperatures, and increased dry days with moisture stress, as evidenced by the Standardized Precipitation Index (SPI) and Standardized Evapotranspiration Index (SPEI), which compromise food availability by reducing pasture and livestock productivity and impairing food access through herd asset depletion and higher food prices (Gebremeskel et al., 2025). Pastoral communities report that droughts and reduced rainfall are the primary climate risks affecting their livelihoods, leading to food shortages, livestock loss, and rangeland degradation (Tofu et al., 2023). Evidence indicates that drought undermines food security by reducing crop and livestock production, lowering incomes, and exacerbating food insecurity and malnutrition in

Ethiopia's marginal pastoral regions (Ngcamu and Chari, 2020; Belay et al., 2025; Feleke et al., 2025). Studies in Afar, Borana, and other pastoral regions have also documented rising temperatures, decreasing rainfall, and frequent droughts as threats to food security, affecting pasture availability, livestock health, land quality, and rural livelihoods in arid lowlands, leading to low resilience among pastoralists (Ambelu et al., 2017; Melketo et al., 2021; Tofu et al., 2023; Feleke et al., 2025).

Given these challenges, there is an urgent need to develop a robust conceptual and theoretical framework to analyze the complex interplay between drought resilience and food security. Such frameworks are essential tools for understanding the underlying dynamics and causal relationships between interconnected variables (d'Errico & Di Giuseppe, 2018). Through a structured approach to the conceptualization and investigation of these phenomena, the theoretical framework enables researchers and policymakers to identify the main drivers, mechanisms, and interventions that can enhance resilience and mitigate the adverse effects of drought on food security (Brück et al., 2019). Moreover, the clarity of concepts and rigor of theories are essential to guide empirical research efforts and inform evidence-based policy interventions aimed at strengthening resilience and improving food security in drought-affected areas affected by drought (Demissie et al., 2021).

Recent research has shifted from merely documenting these impacts to exploring the concept of resilience—understood as the capacity of households and food systems to absorb, adapt, and transform in response to shocks—and its measurement, determinants, and mitigation roles (Ansah et al., 2021; Smith & Frankenberger, 2022; Sunday et al., 2023; Béné et al., 2023). Based on various theoretical frameworks, resilience is the ability to anticipate, absorb, adapt, and change in response to changing circumstances and challenges (Bene et al., 2012; Barrett et al., 2014). In pastoral communities, resilience can not only respond to drought-induced shocks but also maintain basic livelihood activities and social networks against challenges (Lokosang et al., 2014).

Food security is defined as the condition under which everyone has access to sufficient, safe, and nutritious food at all times, and is deeply linked to drought and resilience. Disruptions induced by drought in food production and access may undermine food security, leading to malnutrition,

hunger, and poverty in pastoral communities (Melketo et al., 2021). Therefore, improving drought resilience is essential for enhancing food security and livelihoods in these vulnerable populations. This conceptual framework clarifies the interaction between drought resilience and food security within pastoral communities, allowing for the analysis of complex dynamics and the development of targeted interventions to strengthen resilience and improve food security.

2.2.2 The Concept of Resilience and Its Measurement

Resilience has emerged as a central concept for understanding how households and communities manage food security systems during climate shocks such as droughts. In the development literature, it is widely defined as the capacity of households, communities, or systems to withstand, adapt to, and recover from shocks and stressors without compromising their long-term well-being (Hodbod & Eakin, 2015; Kaya et al., 2024; Nahid et al., 2021). The Resilience Measurement Technical Working Group (RMTWG), whose definition has become highly influential, describes resilience as "the capacity that ensures adverse stressors and shocks do not have long-lasting adverse development consequences" (Sunday et al., 2022). This definition explicitly links resilience to three interrelated capacities: absorptive, adaptive, and transformative, which correspond to persistence, incremental adjustment, and fundamental change, respectively, in response to shocks (Bene et al., 2012). Absorptive capacity refers to the ability to cope with and maintain function during a shock (e.g., savings, informal safety nets, and short-term coping strategies). Adaptive capacity refers to the ability to make incremental adjustments through livelihood diversification, technology adoption, and climate information use. Transformative capacity is the ability to enact deeper structural changes, including improved governance, infrastructure, markets and institutions (Kaya et al., 2024; Nahid et al., 2021; Hodbod & Eakin, 2015). These capacities are now considered core components of the conceptual and analytical frameworks of household and community resilience in food security analyses (Sunday et al. 2022).

Moreover, as highlighted by Constas et al. (2022), this definition implies four features that must be captured in the modeling and estimation of resilience: (i) resilience is an outcome-based concept in which the outcome is a measure of food security, as in this study, or any other indicator of well-being; (ii) resilience is analyzed with regard to exposure to specific shocks and

associated stressors; (iii) resilience emphasizes long-lasting effects on outcome variables, unlike similar concepts such as vulnerability-based analysis; and (iv) resilience requires the agency's capacity to absorb, adapt, and transform their livelihood strategies to offset the anticipated or realized (actual) negative consequences of shocks and stressors (d'Errico et al., 2018).

In empirical studies, resilience is measured in two distinct ways: resilience as capacity and normative approach. The resilience-as-capacity approach uses realized well-being outcome indicators to explain variations in well-being using resilience indicators. The Resilience Indicators for Measurement and Analysis (RIMA) by the FAO and the multidimensional index by TANGO International are widely adopted methods in the development and food security analysis context. In these empirical studies, resilience is usually treated as a latent (unobservable) construct inferred from multiple observable indicators of assets, access to services, social safety nets, and adaptive capacity (Alinovi et al., 2008; d' Errico et al., 2018; Smith & Frankenberger, 2018). In the RIMA-I methodology, Alinovi et al. (2008) pioneered the estimation of resilience as an unobservable variable via a two-stage factor analysis using observable indicators of social safety nets, access to public services, assets, income and food access, adaptive capacity and stability (d'Errico et al., 2018; Sunday et al., 2022; Hail et al., 2022). Building on this work, the FAO's resilience index measurement and analysis II (RIMA-II) framework operationalizes resilience through four core pillars—access to basic services, assets, social safety nets, and adaptive capacity—and estimates a Resilience Capacity Index (RCI) using two-stage factor analysis and structural equation model procedures (Sunday et al., 2022).

TANGO International developed a closely related but distinct capacity-based framework that groups indicators directly under absorptive, adaptive, and transformative capacities and uses two-step factor and regression analyses to construct capacity-specific indices and an overall resilience index (Sunday et al., 2022). TANGO avoids including food security outcomes in the index, allowing resilience to be used as an explanatory variable in food security-related regressions (Sunday et al., 2022).

On the other hand, resilience as a normative condition recognizes stochasticity in well-being realizations, with the Cissé and Barrett (C&B) measure being the most widely used method

derived from this approach based on Barrett and Constas's (2014) theory of development resilience. Based on this theory, resilience is defined as maintaining an acceptably high likelihood of staying above the poverty line despite shocks and stressors, and is directly applied by Cissé and Barrett (2018). This method, used in the Ethiopian context by a few academic researchers (Vaitla et al., 2020; Demissie et al., 2021; Upton et al., 2022), estimates the conditional mean of well-being for each household using a normal ordinary least squares (OLS) regression. This moment-based strategy requires panel data and modeling of outcome variable thresholds. Its advantage lies in its ability to combine separate resilience indicators for a more aggregated measure when the appropriate data are available. However, the comparative work of resilience measurement approaches by Upton et al. (2022) found that these three approaches tend to yield similar policy implications, even though they may diverge in out-of-sample household-level predictions, leading to false positives and negatives when classifying resilience status. Moreover, this comparative study noted the need to improve resilience measurements to better inform future interventions (Upton et al., 2022).

In Ethiopia, recent research has extensively adapted the FAO and TANGO International's multidimensional resilience frameworks within rural and pastoral contexts, identifying crucial household resilience determinants of food insecurity. Collectively, these studies underscore how multidimensional resilience factors, including social, economic, basic social services, infrastructural, and environmental assets, shape household resilience to shock-induced food insecurity in rural Ethiopia, including pastoral settings, consistent with the FAO and TANGO resilience approaches. In the pastoral context, resilience-focused studies indicate that households with better adaptive capacity, such as diverse income sources, substantial productive asset bases (especially livestock and cropland access), better basic service access, and robust social networks, have higher resilience scores and less severely reported impacts of recurrent drought on food and feed (Tofu et al., 2023; Demisse et al., 2024; Wassie et al., 2023).

2.3 Theoretical Framework

To understand the complex interactions between drought resilience and food security within pastoral communities, we need to examine the relevant theoretical perspectives that illuminate

their basic dynamics and interactions. The following section provides an overview of the theoretical framework for understanding these phenomena. One theoretical perspective is vulnerability theory, which argues that vulnerability to natural hazards such as droughts is influenced by exposure, sensitivity, and adaptive capacity (Adger, 2006).

In pastoral communities, vulnerability to drought stems from limited access to resources, dependence on rain-fed agriculture, and inadequate infrastructure to cope with environmental stressors (Dercon et al., 2005). By analyzing these vulnerabilities from the perspective of vulnerability theory, researchers can identify the key determinants of vulnerability and develop targeted interventions to increase adaptive capacity.

Resilience theory provides valuable insights into the resilience and recovery capabilities of pastoral communities in response to drought-induced shocks. Resilience is defined as the ability of social and ecological systems to absorb disturbances while maintaining their essential functions and structure (Folke et al., 2010). In the pastoral sector, resilience includes not only the ability to deal with the immediate impact of drought but also to adapt and change livelihood strategies in response to changes in environmental conditions (Béné et al., 2012). Research examining resilience through a theoretical lens can identify factors that improve or inhibit the resilience process and inform the design of sustainable, effective interventions. The Social-Ecological System Framework provides a comprehensive framework for analyzing the complex interactions between human societies and their environments (Berkes et al., 2003). In this context, drought shocks are viewed as disruptive to socio-ecological systems and trigger feedback cycles and adaptive reactions that affect food security (Hill and Porter, 2016). By integrating concepts from vulnerability theory, resilience theory, and social and ecological system frameworks, researchers can develop a holistic approach to understanding and responding to the links between drought resilience and food security in pastoral communities.

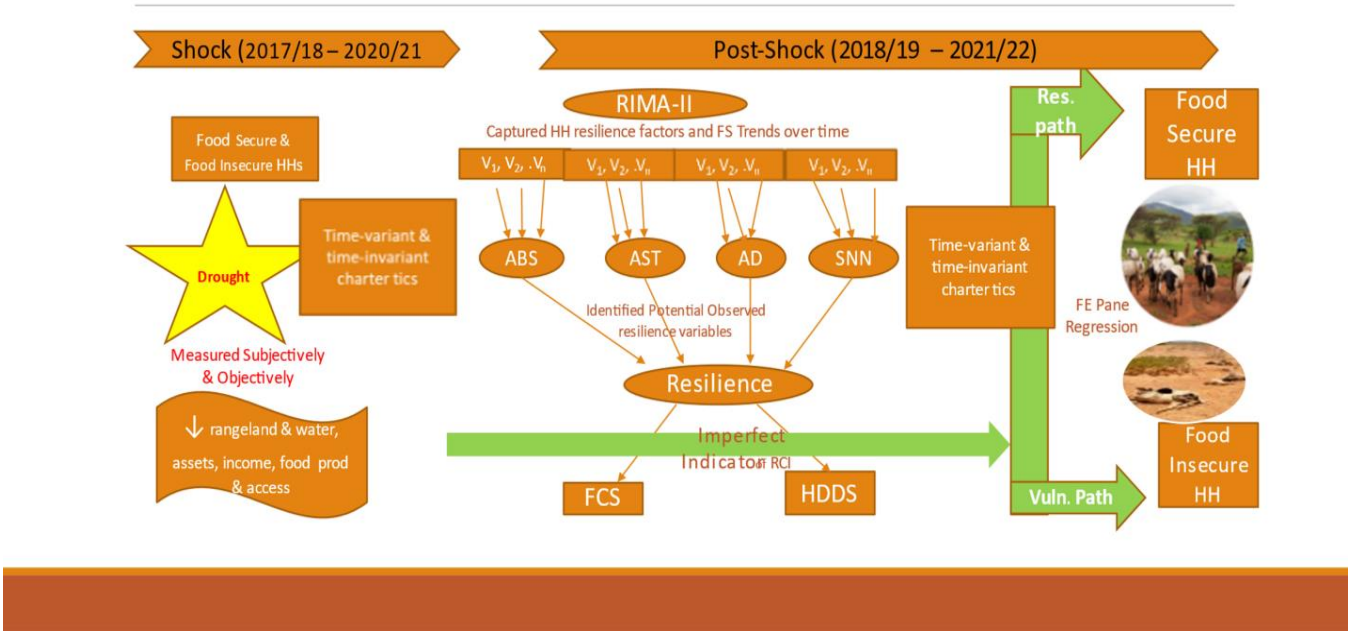
By examining these theoretical perspectives and frameworks, researchers can gain deeper insights into the underlying dynamics of shocks, stressors, and vulnerabilities in pastoralist communities. By integrating these perspectives, more nuanced analyses and interventions can be

developed to address the multifaceted challenges of building resilience and enhancing food security in the face of drought-induced stress.

2.4 Analytical Framework

Building on Demissie et al. (2021), Sunday et al. (2022), and the broader resilience literature in similar settings in Africa, this thesis conceptualizes the complex interplay of drought resilience and food security within an integrated analytical framework in which specific resilience pathways moderate the effects of drought on food security. More specifically, as shown in figure-1 below, the analytical framework for this study links drought exposure and severity, measured objectively, to food security outcomes. Figure 2.1 illustrates the analytical framework of this study.

Figure 2.1. The Study's Analytical Framework



First, droughts were treated as exogenous climatic shocks measured using objective indicators, as shown in figure 2.1. Objective measures (e.g., SPEI) provide spatially and temporally explicit information on rainfall and evapotranspiration anomalies in the study area. This approach reduces bias from recall and perception of subjective drought measures while capturing the intensity and duration of drought shocks over time.

Second, household resilience was operationalized as a latent, multidimensional construct comprising access to basic services, assets, adaptive capacity, and social safety nets. Following FAO's RIMA-II approach, observable indicators are organized under these capacities and combined via a two-step factor analysis to construct resilience pillar-specific indices and an overall Resilience Capacity Index. RIMA-II includes both direct (descriptive) and indirect (inferential) analytical components. Direct analysis was used to quantify the resilience capacity index (RCI) and resilience structure matrix (RSM) of the four pillars (ABS, AST, SSN, and AC) using factor analysis. The indirect analysis explored the potential determinants of food security, with the RCI as a key variable, using a multiple indicator multiple cause (MIMIC) model. In Ethiopia's pastoral settings, relevant indicators include livestock holdings and diversification, access to markets, health facilities, water, informal and formal safety nets, livelihood and income diversification, access to financial services, and herd diversification.

Third, food security is captured through consumption‐based indicators, notably per-capita daily kilocalorie consumption, in accordance with recent resilience study findings. Per capita food consumption is measured at constant prices, incorporating purchased, own-produced, and gifted food, and may lag relative to drought to reflect the delayed impacts. The frequency of meals reflects short-term consumption-smoothing responses.

The empirical specification places the realized food security indicator as the outcome of interest and includes drought, specific resilience indices, their interaction terms, and relevant household and location control variables as explanatory variables in the model. The interaction terms between drought and realized per capita daily kcal intake and between drought and each of the potential specific resilience indicators allow for the estimation of the extent to which drought impacts realized food security levels and which specific resilience indicators are most effective in buffering these shocks. Fixed-effects models are used because they control for all unobserved household-level characteristics that are constant over time. This helps isolate the effect of time-varying household-level characteristics, covariate shocks such as droughts and resilience variables. This reduces the omitted variable bias. As the ESPS is a panel dataset, the FE provides consistent estimates and eliminates confounding factors from the household heterogeneity.

This framework is particularly suited to pastoral Ethiopia, where heterogeneous access to resources, services, and institutions generates substantial variations in resilience and drought impact across households and locations in Ethiopia.

2.5 Empirical Review

Empirical studies in Ethiopia and comparable African contexts provide critical insights into the complex relationship between drought resilience and food security, although they vary significantly in terms of drought and food security measurements, resilience operationalization, and a focus on specific resilience pillars. These variations have important implications for understanding the impact of droughts and formulating effective policies in drought-prone rural Ethiopia, particularly in pastoral and agro-pastoral settings.

A substantial portion of Ethiopian research adopts vulnerability- or resilience-based frameworks that link these indices to food-security outcomes. Vulnerability-based studies typically assess household responses to climatic shocks, especially droughts, and their effects on food security, often inferring resilience indirectly through exposure, sensitivity, and coping or adaptation strategies, rather than explicitly modeling it. These studies predominantly rely on subjective drought measures, households' self-reported drought exposure, and perceived severity, which capture localized microclimates and the social dimensions of drought experiences that are critical for understanding long-term coping and adaptation decisions in the long run. Investigations into covariate shocks and household adaptation strategies have revealed persistent vulnerability among rural Ethiopian households owing to high climate exposure, dependence on rain-fed agriculture, and limited adaptive capacity. In smallholder farming contexts, strategies such as soil and water conservation, irrigation, climate-smart agriculture, and livelihood diversification are associated with enhanced climate resilience. However, their effectiveness is contingent on access to resources, infrastructure and supportive institutional frameworks.

Pastoral communities in Ethiopia face complex socioecological dynamics that affect their resilience to climate change. A systematic review applying a socio-ecological lens found that governance, policy, and institutional interventions are often lacking, hindering the adaptation

capacities of pastoral communities related to social capital and asset access, which are critical for coping with and adapting to climatic variability and food security challenges (Cho et al., 2024). Additionally, the vulnerability of pastoral areas is exacerbated by factors such as land investment-induced displacement and land degradation, which affect agricultural assets and access to grazing land and livestock. Pastoral households employ context-specific adaptation strategies tailored to the type, intensity, and duration of the drought shocks. The literature highlights herd mobility, livestock diversification, non-farm activities, and community-based social safety nets (Berhanu and Beyene, 2015; Berhe et al., 2017; Debela et al., 2019). However, the increasing frequency of droughts threatens safety net systems, highlighting the need for enhanced resilience-building interventions and context-specific policy support (Davies & Bennett, 2007; Debela et al., 2019).

Second, numerous empirical studies have extensively examined household resilience to climate shock-induced food insecurity in rural Ethiopia, including in pastoral areas. The RIMA-I methodology developed by the FAO dominates early empirical research. It treats resilience as a latent construct composed of pillars, such as income and food access, assets, social safety nets, and access to public services, with stability and adaptive capacity cutting across them (Alinovi et al., 2010; Ansah et al., 2019). RIMA-II refined this by treating resilience explicitly as a capacity separate from food security and shocks, and by recommending a Multiple Indicator Multiple Cause (MIMIC) model to link resilience as capacity modeling to food security outcomes (Ansah et al., 2019; FAO, 2016). Recent FAO-style applications in Ethiopia and other countries have used factor analysis and structural equation modeling to estimate the RCI and examine how access to basic services, assets, and adaptive capacity influence food security outcomes (Abebe, 2025; Tasnim et al., 2025). Other studies have adopted multidimensional approaches from TANGO International to assess the absorptive, adaptive, and transformative capacities of food insecurity.

In drought-affected highland areas, the FAO's RIMA application highlights perceptions of climate variability, agricultural assets, adaptive capacity, enabling institutions, and income and food access as central to resilience, although a significant proportion of households (50–57 %) remain non-resilient (Demissie et al., 2024; Wassie et al., 2023; Molla et al., 2023). The TANGO

approach, which is increasingly applied in rural highland Ethiopia than in pastoral lowlands, structures resilience indicators around absorptive, adaptive, and transformative capacities (Frankenberger, 2015; Smith and Frankenberger 2018). The TANGO approach's applications in areas such as the Mekiet District and the Dinki Watershed, using factor analysis to derive capacity-specific resilience indices, typically show strong positive contributions of absorptive and adaptive capacities to household resilience, while transformative capacity often loads weakly or negatively, where formal institutions and safety nets are underdeveloped (Asmamaw, 2019; Dessie & Demsie, 2024).

In pastoral and agro-pastoral contexts, resilience to climate shock-induced food insecurity is assessed using the RIMA and TANGO frameworks, identifying context-specific core resilience pillars essential for household resilience-building. However, these studies predominantly employ cross-sectional designs, treating resilience as a static attribute, and often focus on household-level resilience without incorporating explicit objective drought shock measures and food security outcome indicators into their analyses (e.g., Ambelu et al., 2017; Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023). Many rely on self-reported shock exposure and recall-based cross-sectional surveys, in which respondents identify recent droughts and their impacts on crops, livestock, and food security. This approach may limit the understanding of the dynamic role of resilience and its determinants in moderating the impact of drought and climate variability on food security (Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023; Demisse et al., 2024).

These studies consistently indicate low average resilience scores across Ethiopia's pastoral regions, revealing significant disparities between pastoral and agro-pastoral households and between female-headed and male-headed households. On average, pastoralists and female-headed households exhibit lower resilience (Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023). Their findings collectively underscore the importance of diversified income sources, livestock assets, access to services, and social cohesion in enhancing the resilience of pastoral households in Ethiopia's drought-prone areas. They advocate for context-specific, integrated resilience strategies that simultaneously improve livestock assets and productivity, natural resource management, access to basic services and infrastructure, gender-sensitive livelihood

diversification, and social protection mechanisms rather than relying on short-term emergency responses or single-sector interventions (Ambelu et al., 2017; Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023).

For instance, in Borana, resilience indices indicate that only approximately one-third of households are resilient, with pastoralists being less resilient than agro-pastoralists due to limited access to services and adaptive capacity (Tofu et al., 2023). Ambelu et al. (2017), employing principal component analysis and structural equation modeling in Borana's Arero and Dhas districts, highlighted the multidimensional nature of resilience to recurrent droughts, where household food insecurity is the ultimate consequence of inadequate resilience, influenced by infrastructure, social services, livestock, human capital, and psychosocial distress. This study emphasizes the need for interventions focusing on livestock systems and infrastructure to enhance resilience and reduce food insecurity. Livestock diversification is crucial for pastoralists in Southern Ethiopia. Households with various livestock, such as camels and cattle, enhance their resilience to climate variability by diversifying their risks and strategies (Megersa et al., 2014). Borana pastoralists employ strategies such as diversified livestock production and land-use agreements, reflecting indigenous knowledge and social structures to support resilience against environmental stress (Homann et al., 2008). Income diversification beyond livestock, such as crop farming and non-pastoral activities, is common among younger, educated individuals, enhancing risk management during droughts (Berhanu et al. 2007). A multi-region pastoral analysis reported resilience scores ranging from 0.32 to 0.90, identifying income, food access, public services, social safety nets, and asset diversity as key contributors, whereas drought periods influenced resilience outcomes (Wakeyo, 2024). In the Mille district of Afar, pastoral households exhibit limited resilience to food insecurity, with determinants such as family size, age, wealth, market proximity, irrigation, soil and water conservation, credit access, and livestock diversification (Melketo et al., 2021). Complementing these findings, Mekuyie et al. (2018) demonstrated that in Gewane and Amibara districts, enhanced livestock productivity, social safety nets, market and credit access, education, irrigation farming, and farm inputs collectively strengthen resilience to climate change, underscoring the need for integrated interventions prioritizing assets, services, and livestock production.

A recent but limited strand of empirical research emphasizes dynamic or movement-based approaches that conceptualize resilience as a moderator of drought impacts, focusing on which specific resilience capacities mitigate the effects of climate shock on food security outcomes. These studies, conducted in rural Ethiopia and comparable African contexts, employ resilience as capacity (through frameworks such as RIMA, TANGO), or normative resilience approaches with integrated climate shock and panel socioeconomic data to estimate resilience capacity at an initial time point (t_0) and assess its influence on food security outcomes at a later time (t_1), including changes in food security over time. This dynamic specification enables resilience to be interpreted as a forward-looking capacity that moderates the impact of subsequent climatic shocks on food security or other wellbeing outcome indicators. Moreover, these analyses incorporate climate shocks directly using historical climate indices and or self-reported shock data, recognizing the variability in shock impacts owing to differing household resilience levels by modeling resilience as a dynamic moderator and identifying key resilience dimensions in the casual relationship between climate shock and household food security.

Beyond Ethiopia, rigorous applications of capacity-based resilience frameworks linked to objectively measured drought and panel socioeconomic data have been exemplified in studies conducted in Tanzania and Uganda (d'Errico et al., 2018; Sunday et al., 2022). Using three-wave household panels, d'Errico et al. (2018) estimated the FAO's Resilience Capacity Index via factor analysis and structural equation modeling, subsequently applying probit models to evaluate whether resilience predicts future food security and recovery following shocks. Their findings highlight adaptive capacity as the primary contributor to household resilience, closely associated with education and the income-earner ratio, underscoring the critical role of human capital and labor structure in household resilience. A higher resilience capacity is significantly linked to improved future food security and enhanced shock absorption, which empirically validates the resilience metrics in food security analyses.

Similarly, Sunday et al. (2022) utilized five waves of panel data to develop resilience indices based on the TANGO framework and analyzed their interaction with subjective and objective drought measures in influencing food consumption and the frequency of meals (Kaya et al., 2024). While self-reported shocks were statistically insignificant, drought measured using the

Standardized Precipitation Evapotranspiration Index (SPEI) significantly reduced per capita food consumption and meal frequency. This study revealed that resilience capacities are generally low and relatively static, drought substantially diminishes food security, and higher resilience attenuates the adverse effects. Specific resilience pillars, such as informal safety nets, financial services, information access, linking social capital, infrastructure, markets, and communal resources, have emerged as effective buffers against drought. The methodological and analytical frameworks provided in this study offer valuable guidance for the development of Ethiopian pastoral and agro-pastoral production systems.

Within Ethiopia, Haile et al. (2022) constructed a resilience capacity index using panel data from the Ethiopian Socioeconomic Survey that multidimensional resilience analysis and structural equation modeling, linking resilience to various food and nutrition security indicators, including kilocalorie intake, food poverty, dietary diversity, and multi-dimensional food security. The core resilience components identified included assets, access to social services, and adaptive capacity, with a higher resilience capacity correlating with improved food security. However, this study relied on subjective shock measures, which may have introduced recall bias and masked variations in shock severity (Delbiso et al., 2017). At the national rural level, Demissie et al. (2021) advanced this research by defining resilience as both a capacity and normative condition, modeling realized consumption, and the probability of consumption exceeding a threshold as a function of resilience indicators and drought shocks. Employing climate-econometric techniques that integrate objective climate data with panel socioeconomic surveys, they demonstrated that drought caused a 7% reduction in adult consumption between 2011 and 2016, with wealth, transfers, income, livestock diversification, and agricultural assets serving as protective objectives or movement-based perspectives that more accurately capture the temporal dynamics of resilience and are especially pertinent to recurrently drought-affected pastoral systems.

Pastoral Ethiopia is notably underrepresented in the dynamic resilience analyses. This gap limits the contextual validity of prevalent climate econometric techniques and hinders our understanding of how resilience evolves to mitigate drought-induced food insecurity in these critical pastoral areas, thereby impeding the development of effective and tailored interventions. Few studies on Ethiopia's pastoral remodeling have comprehensively examined the dynamic

interplay between drought, resilience, and food security. For example, Frankenberger and Smith (2015) analyzed the PRIME project's interim monitoring survey in Ethiopian pastoral areas by applying the TANGO framework to assess absorptive, adaptive, and transformative capacities. Their findings indicate that absorptive capacity plays a more significant role in buffering drought impacts on food security than adaptive or transformative capacities do. Although this study incorporated both subjective and objective drought measures, such as the Standardized Precipitation Index (SPI), Soil Moisture Index, and Normalized Difference Vegetation Index (NDVI), it did not directly correlate resilience indices with objective drought data. Emerging high-frequency panel studies in pastoral regions of northern Kenya and southern Ethiopia integrate satellite-based NDVI as a proxy for forage conditions with weekly household surveys, revealing that a 10% increase in NDVI correlates with a roughly 12 percentage point reduction in food insecurity probability. This effect is largely mediated by improved livestock productivity and reduced food prices (Alulu et al., 2024). These dynamic and objective indicators are invaluable for early warning systems and anticipatory interventions in remote pastoral regions.

Finally, and most critically, there is a pronounced gap in rural Ethiopian research explicitly modeling the interaction between specific resilience indicators and objective drought measures within climate-economic frameworks, especially in pastoral and agro-pastoral settings. Most extant studies have assessed resilience without integrating shock variables or relying solely on self-reported shock exposure. Although several cross-sectional household-level resilience analyses have shown that higher resilience correlates with improved food security, this empirical evidence underscores the importance of integrated and context-specific resilience strategies for improving food security. These strategies should concurrently strengthen livestock assets and productivity, natural resource management, access to basic services and infrastructure, gender-sensitive livelihood diversification, and social protection mechanisms, moving beyond short-term emergency or single-sector responses (Frankenberger & Smith, 2015; Ambelu et al., 2017; Mekuyie et al., 2018; Tofu et al., 2023). However, the dynamic interactions among drought shocks, evolving resilience factors, and subsequent food security outcomes in pastoral regions remain poorly understood.

To address these critical gaps, this study integrated objective drought metrics with multidimensional capacity-based resilience indices tailored to pastoral settings in the Somali region. It explicitly models how both short- and long-term drought episodes reduce realized food security outcomes, measured by per-capita kilocalorie consumption, and identifies the specific resilience components that effectively mitigate these adverse impacts on rural Somali households over time.

2.6 Research Gaps

While the literature on the interplay between drought shocks, resilience, and food security in pastoral Ethiopia has advanced significantly, it reveals several critical research gaps that this study aims to address in the paper while building upon and extending relevant previous studies' scope, research context, methodological approaches, and key findings. Notably, few studies have integrated objective drought metrics with multidimensional resilience indices within a unified analytical framework; the majority rely on subjective, self-reported shock data or treat resilience independently without explicitly modeling the interaction between shocks and resilience capacities. Panel-based evidence examining resilience as both a capacity and a normative condition remains limited in pastoral settings, where drought exposure is recurrent and severe. Moreover, existing research seldom disaggregates resilience into its absorptive, adaptive, and transformative components or models specific resilience indicators, such as informal safety nets, climate information access, infrastructure, mobility, markets, and communal resources, as moderators of drought impacts using interaction terms. This gap contrasts with more developed analyses in contexts such as Uganda, where dynamic moderation effects have been quantified.

Methodologically, widely used resilience indices, such as RIMA and TANGO, have been applied uniformly across heterogeneous agro-ecological zones and livelihood systems, raising concerns regarding their contextual validity and predictive performance in pastoral settings. Empirical findings suggest that these indices correlate only modestly with observed food security or other well-being outcome trajectories in such settings, underscoring the need for improved context-specific resilience metrics that capture the unique socioecological dynamic model of pastoral or agro-pastoral livelihoods in the study region. Conceptually, the distinction between resilience as a latent capacity and as a normative condition remains underexplored in pastoral

Ethiopia, limiting nuanced modeling designs that address both household-level capacities and systemic vulnerabilities.

This study fills these gaps by focusing explicitly on Ethiopia's Somali Regional State and integrating objective drought measures with multidimensional capacity-based resilience indicators derived from socioeconomic panel datasets. It models how resilience moderates both the magnitude and nonlinear effects of drought shocks on realized food security outcomes, measured by per-capita kilocalorie consumption. By identifying which specific resilience indicators most effectively mitigate drought impacts and distinguishing between short- and long-term adaptive capacities, this study provides a refined and contextually grounded understanding of specific resilience pathways. This approach advances empirical rigor and policy relevance by capturing the dynamic interplay among drought severity, evolving resilience factors, and food security outcomes in pastoral contexts, thereby informing integrated targeted interventions to enhance household and community resilience.

CHAPTER 3: METHODOLOGY

3.1.Introduction

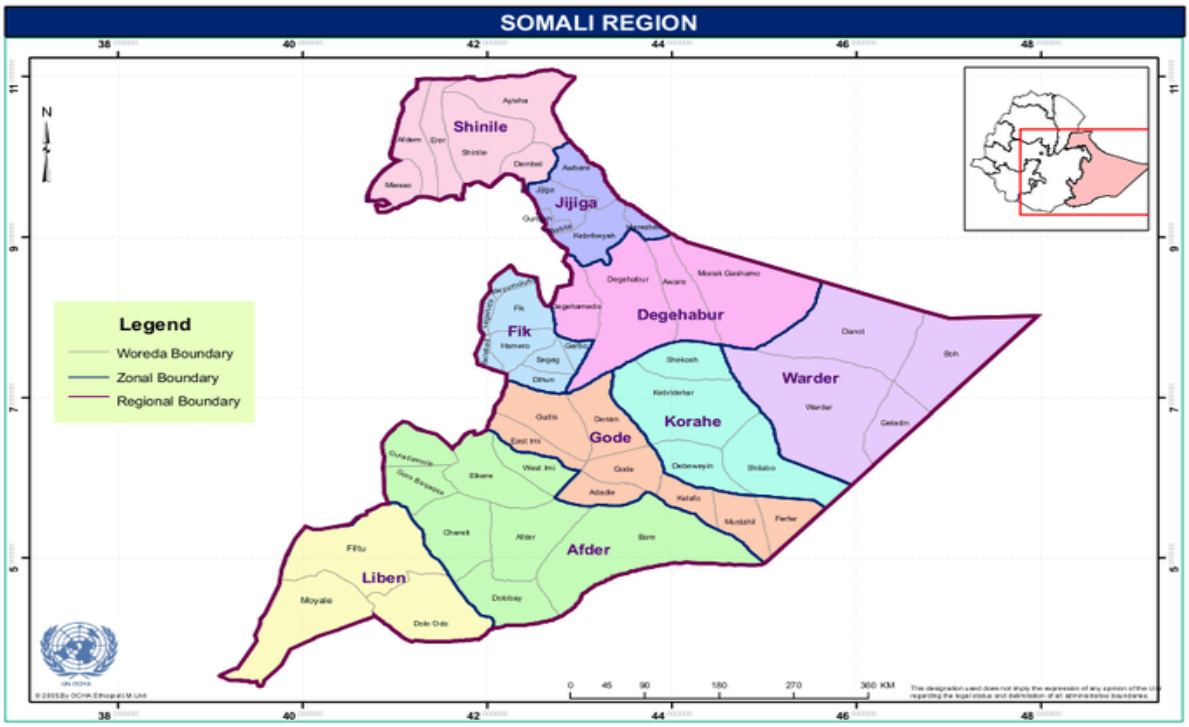
This chapter describes the methodology used to study the impact of drought shocks on household food security and identify specific resistance indicators in rural areas of Ethiopia's Somali Region. This chapter begins with a description of the research area, including the research design and methods, sampling techniques, sample size, data types, sources, cleaning and analysis tools. This section elaborates on the construction of food security indicators, resilience indicators, objective household drought shock measures, and empirical strategies used for the analysis.

3.2. Description of the Study Areas

The study area was the Somali Regional State of Ethiopia. It is located in the east and southeast of the country (4–11° N, 40–48° E), and the region is administratively divided into nine zones, 68 districts, and 786 kebeles. The zones are Fafan (formerly Jigjiga), Siti (formerly Shinile), Liban, Afder, Shabelle (formerly Gode), Korahe, Dolo (formerly Warder), Jarar (formerly Degehabur), and Nogob (formerly Fik) (OCHA 2005). The region shares borders with the Republic of Somalia to the east, Kenya to the south, Djibouti to the north, and the Ethiopian regions of Afar and Oromia to the west of the country.

It has an estimated population of 6.2 million, 54.5% of whom are men and 45.5% are women (CSA, 2025). It is considered one of Ethiopia's most ethnically homogeneous regions, with between 95 and 97% of the population identified as Somalis and more than 98 percent identified as Muslims (SRHB, 2012, as cited in Destrijcker et al., 2023). Somali society is organized into clans and subgroups, which are central to the effective management of natural resources, conflict resolution, and provision of social safety nets in the region. The clan system is the foundation of societal survival in this region. Clan and sub-clan structures, managed and led by clan elders, are important informal institutions that provide an institutional framework for supporting intra-clans and solving conflicts within and beyond the clan. It is an informal institution that serves the interests of the clan and sub-clan members of the region. Even in times of crisis, humanitarian organizations are the first to respond to the needs of poor people.

Figure 3.1. Map of the Study Area, Somali Reginal State of Ethiopia



Source: *OCHA, 2005*

The Somalia region has a dry and semi-dry climate characterized by irregular rainfall and high temperatures, with average temperatures between 18 and 45 °C and an annual average rainfall between 150 mm in the lowlands and 660 mm in the high-altitude regions (EEPA, 2024). The livelihoods of the region are classified into three categories: agriculture, agro-agriculture and cropping. The differences between the regions are mainly due to the relative availability and quality of pastures and waterways, geographical factors, and market isolation (Livelihoods Integration Unit, 2016).

With respect to the seasonal calendar, the region primarily follows a local pastoral bimodal system with two rainy seasons. The "Ganna'' (Long Rains) are the long rains, typically occurring from March to May, providing a crucial period for pasture growth and water for pastoral communities, mainly in the southern areas of the region. "Hagaya'' (short rain) refers to Short Rains occurring from October to December. ''Diraac/Jiilaal (Dry Season) is a dry period, which can be seen as the dry season which followed after the ''Deyr''/''Hagaya'' rains. The Southern areas consist of seven administrative zones namely, Jarar, Korahe, Shabelle, Afder, Liban,

Oogob and Dollow, and these areas receive the “Gu” rain as the principal rainy season which normally occurred from April to June followed by “Deyr” rains from October to February. The Northern areas are the Fafan and Siti administrative zones, which have climatic patterns similar to those of the rest of the country’s northern pastoral areas. As most of these areas are covered by pastoral livelihood zones, the majority of the population is engaged in pastoralism, agro-pastoralism, farming, and trade as their primary livelihoods. The livestock includes camels, cattle, goats, sheep, and donkeys (Devereux 2006). Croplands are limited to areas located towards the interior borders of the Somali Region. The economic value of rain-fed crop production in the Somali Region is extremely low, with the most productive areas concentrated in the Jijiga Subregion. While the two rainy seasons in a year are instrumental in improving pasture and water availability for livestock and crop production, their failure has grave consequences for the livelihoods and food security of rural communities in the region.

The Somali region is highly exposed to drought and is particularly vulnerable to food and water shortages (HRD-2012; Winthrop et al. 2018; World Bank 2019). An important recent example is the record-breaking severe and multi-year 2020 – 2023 drought (1), which has caused acute food insecurity, water scarcity, and consequential impacts on the livelihoods of pastoral communities in East Africa (REACH, ET). Following this historical drought, the Somali Region’s Disaster and Risk Management Bureau reported that over 3 million people were affected by the drought, especially in the Afder, Liben, and Dawa zones, in early 2023, and more than 4.5 million livestock died in late 2021, leaving millions at risk (Addis Standard, 2023, as cited in Destrijcker et al., 2023).

The data obtained from Kurt (2003) and USAID (2016) show that the Ethiopian lowlands account for approximately 61% of the country's land area. These are mostly arid and semi-arid areas inhabited primarily by pastoralists and agro-pastoralists. Unlike sedentary crop farmers found in the highlands, these communities rely heavily on livestock for their livelihoods and for food security. These regions play an essential role in supporting over 12 million Ethiopians, whose livelihoods depend mainly on livestock exploitation supplemented by local crop production (FAO, 2018). Despite their economic importance, pastoral communities face significant challenges, including natural vulnerability, political pressure, and the historical

marginalization of resource allocation (Ambelu et al., 2017). These challenges include frequent droughts that require resilience as a strategic policy response to climate change impacts. In recent years, the northern and southern pastoral areas have been the subject of a long drought, with the worst effects on millions of people and livestock (World Bank Group and the UK International Development Agency, 2019; GRFC Regional Focus on IGAD Member States, 2023; Global Food Crisis Report, 2023; USAID, 2023).

Understanding the challenges and nuances of this region is paramount for devising context-specific targeted interventions aimed at enhancing resilience and sustaining food security systems, with a focus on addressing drought resilience and food security concerns within rural households in the region.

3.3. Research Design and Approach

The research design and approach of this study was structured in combination with a mixed-method design, including both qualitative and quantitative approaches, to investigate the complex relationship between drought resilience and food security among rural households in the Somali Region. The reason for adopting a mixed-methods approach was adopted to capture a holistic understanding of the research topic by combining deeper contextual insights with empirical evidence, thus allowing a comprehensive and nuanced understanding of household vulnerability and adaptive capability.

The research began in the qualitative phase using rapid evaluation techniques, including key informant interviews (KIIs) and focus group discussions (FGDs) with different community members, including community leaders, community members, agricultural researchers, and local experts. These engagements clarified the perception of local drought risks, the underlying factors of vulnerability, existing adaptation and adaptation abilities, and strategies for resilience to drought-related impacts on rural households' food security. Field observations enriched this phase by capturing the lived experiences of drought-affected communities.

Based on the qualitatively identified themes, secondary panel data were analyzed in the subsequent quantitative phase to validate and generalize these findings. Two main data sources

were used: (1) the latest two rounds of the rural sample of the Ethiopian Socioeconomic Panel Survey (ESPS), ESPS Wave 4 (2018–2019) and Wave 5 (2021–2022), which provide longitudinal information on household food security and socioeconomic factors; and (2) the Global Drought Monitor's area-level climatic data, which are linked to the ESPS through geospatial coordinates. The merged datasets facilitate rigorous research into exposure to drought shocks and their differential impacts on food security, as well as the role of mediation in household resilience.

This sequential and integrated design is consistent with established mixed-methods frameworks (Miles and Huberman 1994, Creswell, 2005, Tashakkori and Creswell, 2007), thus improving the validity and applicability of our findings. The combined use of qualitative and quantitative evidence not only highlights the contextual relevance of the analysis but also provides a solid empirical basis for informing household and community resilience-building interventions specific to climate-sensitive pastoral settings in northern Kenya.

3.4. Data Collection Methods – Qualitative Phase

To capture the complex social and cultural dynamics and contextual realities related to drought risk, resilience, and food security, the qualitative phase of the study was conducted through interviews with key informants and focus groups with various stakeholders, such as government officials, informal community leaders, senior leaders, agricultural expansion agents, and rural households affected by the drought. Participants were systematically selected from a *woreda* in the Fafan, Sitti, and Liben regions (one *woreda* per region) to ensure that the Somali region's diverse livelihood, socio-cultural, and ecological contexts were represented. The FGDs were carried out in six kebeles (the smallest administrative unit in Ethiopia), that is, two kebeles (a pastoral and an agro-pastoral kebele) from each district (''woreda''). These Kebeles were selected to ensure the representation of various livelihood groups and the extent of vulnerability of the competition area to repeated droughts. Three FGDs (one each for men, women, and non-official community leaders) and one KII (one each for government officials and technical experts/agents) were conducted for each kebele.

Eighteen FGDs and three KIIs were conducted to identify local perceptions of drought shocks, household-level vulnerability, and existing capacity among different community members, including community leaders, community members, agricultural researchers, and local experts. Interviews and discussions were guided by a semi-structured protocol designed to produce detailed stories of historical experiences of drought, strategies for adaptation, institutional responses, and perceptions of interventions for building resilience. This approach has enabled the exploration of often-neglected areas in quantitative studies, such as social capital, informal support networks, and indigenous knowledge systems. Qualitative data show how cultural norms, gender roles, and household dynamics affect food security and adaptive behaviors. These insights are crucial for contextualizing the statistical trends observed in the quantitative phase and for identifying gaps in formal policy interventions.

The qualitative phase data were systematically translated, encoded, and analyzed using grounded theory. This inductive process allowed for the emergence of cross-disciplinary themes and patterns related to the study's objectives. The alignment of the views of multiple participants improved the credibility and depth of our results. Finally, the qualitative analysis provided a nuanced understanding of rural household experiences during droughts and informed the subsequent quantitative analysis by identifying the key variables and mechanisms influencing household resilience and food security among rural households in the Somali region of Ethiopia.

3.5. Data Collection – Quantitative Phase

3.5.1 Sampling Techniques and Sample Size

This study used and analyzed panel data from Waves 4 (2018-2019) and 5 (2021-2022) of the Ethiopian Socioeconomic Panel Survey (ESPS), collected by the Ethiopian Statistical Services (ESS) in collaboration with the World Bank Living Standards Measurement Study-Integrated Surveys of Agriculture (LSMS-ISA). The ESPS is a regionally and nationally representative panel survey of households in nine Ethiopian regions and two administrative cities (Addis Ababa and Dire Dawa), including the Somali Regional State. This study examined rural household food security across two waves (Waves 4 (2018/19) and 5 (2021/22)). For this purpose, a sample of 313 rural households from the Somali region, tracked across both survey waves, was extracted to

analyze longitudinal patterns in drought exposure, resilience, and food security status and trends over the study period (2018 – 2022). By selecting the same rural households across each round/wave of the ESPS, this study aimed to mitigate potential attrition bias and ensure the representativeness of the panel data used in the study. Moreover, this targeted subsample ensures both temporal and spatial comparability within the study region, and the ability to follow the same households over time makes the ESPS a powerful tool for studying the role of resilience in household food security outcomes over time in the face of the persistent challenges of drought shocks faced by rural Somali communities in the study area.

The ESPS uses a stratified two-stage probability sampling design. Enumeration areas (EAs) in rural areas were drawn from the EAS of the Agricultural Sample Survey (AgSS) using simple random sampling (SRS). Within each EA, systematic random sampling was employed to select ten agricultural and two non-agricultural households, although there were fewer than two or no non-agricultural households in some of the sampled EAs. These households were surveyed using multi-topic questionnaires at the individual, household, and community levels, encompassing demographics, education, health, labor, expenditure, food security, assets, income sources, a wide range of socioeconomic variables, and various types of shocks experienced by the surveyed households.

In this study, the panel structure of the ESPS supports dynamic analyses of the complex interplay between drought resilience and food security over time among rural households of the Somali Region of Ethiopia. To complement the survey data, this study integrated high-resolution climate data from the Global Drought Monitor, specifically the Standardized Precipitation Evapotranspiration Index (SPEI), at various temporal scales (6- and 24-month). Spatial matching of ESPS EAs via latitude and altitude coordinates allowed for the objective measurement of both short-term agricultural and long-term hydrological drought conditions in the region. The merged dataset provides a robust empirical basis for assessing the temporal and spatial effects of drought exposure on household food security outcomes and the mediating role of context-specific resilience factors in rural households in the Somali Region over time.

3.5.2 Data Types, Sources, and Management Tools

This study employed methodically selected data types, sources, and management tools to ensure comprehensive and reliable data analysis to understand and examine the complex interplay between drought shocks, household resilience capacities and food security outcomes. First, the study used rural samples from the Ethiopian Socioeconomic Panel Survey (ESPS) Waves 4 (2018–2019) and 5 (2021–2022) datasets from the Somali Region. These regionally representative datasets capture extensive information at the individual, household and community levels. At the household level, the questionnaire collects information on expenditure, labor market participation, socio-demographic characteristics, asset ownership, family wealth, private transfers, and different types of shocks experienced by the households. Regarding self-reported shocks, households were asked whether they had been affected by any of the 17 shocks that led to an adverse loss of assets, caused their household income to fall substantially, or resulted in a significant reduction in consumption in the 12 months preceding the survey. Shocks affecting all households in the village are covariates, whereas those limited to the household level are idiosyncratic (9). Furthermore, an additional module that collected detailed agricultural information was administered to the agricultural households.

At the community level, the questionnaire included the socio-economic characteristics of the community as well as the infrastructure of the place where the respondent lived, such as the distance to health, markets, and schools. Although the ESPS data do not include pre-constructed indicators, they contain all the variables required to derive key food security indicators at specific periods, such as the food consumption score, household dietary diversity score, and per capita daily caloric intake. Agricultural households also completed a detailed agricultural module, enabling robust longitudinal and cross-sectional analyses specific to rural settings over time in the Somali Region. Therefore, the two datasets from Waves 4 (2018/19) and 5 (2021/22) are representative at each regional level and at rural and urban area levels and offer a unique opportunity to study and compare household drought exposure, analyze resilience factors, and examine food security trends over time and across diverse contexts within the study region.

Second, this study employed an enumeration area-level climatic index from the Global Drought Monitor, specifically the Standardized Precipitation Evapotranspiration Index (SPEI), to

objectively measure drought shock exposure and severity. These objective measures of drought shocks were geo-matched to the ESPS datasets using the GPS coordinates of each EA, enabling a precise assessment of both short- and long-term drought exposure and its effects on food security dynamics in the study area.

The raw datasets were cleaned and pre-processed in Microsoft Excel, following the FAO (2023) Shiny RIMA Guidelines. The process included harmonizing variable names and codes, resolving inconsistencies, imputing or excluding missing values, and identifying and managing the outliers. The final dataset was validated to ensure full compatibility, completeness, and reliability with the Shiny RIMA platform, enabling an accurate estimation of the Resilience Capacity Index (RCI) and a robust empirical analysis of the interplay between drought shocks, resilience factors, and food security outcome indicators.

3.5.3 Description of Variables

This study employed a prespecified set of variables to construct dependent and explanatory variables and/or indices to undertake empirical analyses of the interplay between drought exposure, household resilience factors, and food security outcomes during the study period. These variables were categorized into three main domains: objective measures of drought shock exposure and severity, realized food security outcome indicators, and household/community attributes potentially related to resilience dimensions, following the FAO's RIMA-II methodology and household fixed-effects panel regression models.

i. Food Security Outcome Indicators

Three well-established indicators were used to represent the multidimensionality of food security: per capita daily kilocalorie consumption, food consumption score (FCS), and household dietary diversity score (HDDS).

Daily Per Capita Kilocalorie Consumption was calculated by converting household food consumption over a 7-day recall period into weekly kilocalories using the Ethiopian Food Composition Table (EHNRI, 1997). The total weekly kilocalorie (kcal) intake was averaged per day and adjusted for household size using adult-equivalent conversion factors (Hoddinott, 2022).

Households meeting the minimum threshold of 2,200 kcal per adult equivalent were categorized as food energy secure and deficient/insecure.

The Food Consumption Score (FCS) measures dietary adequacy by combining consumption frequency, diversity, and nutritional value across eight standard food groups over a 7-day recall period. Each food group was assigned a weight based on its nutritional importance, and the scores were summed to generate the FCS. Following the World Food Program (WFP) vulnerability analysis and mapping guidelines (37), FCS scores were classified into three categories: poor (<28), borderline (28.5–42), and acceptable (>42), adjusted for the local dietary profile in the Somali region, which is characterized by high oil and sugar diet types, as revealed by the study's qualitative findings. The table-1 details the key steps of FCS estimation, including food groups, recall period, scoring procedures, total FCS calculation, and interpretation of dietary quality levels.

Table 3.1 Construction of Food Consumption Score (FCS) – based of WFP VAM

Component	Details
Data upload	Relevant raw data on food consumption frequency over a standard 7 days recall period were uploaded from the publicly available repositories, ESPS_w4 and ESPS_w5 micro datasets of the household data files named sect6a_hh-w4, sect6b_hh_w4, sect6a_hh-w5, and sect6b_hh_w5.
Data Cleaning	All relevant food dataset uploaded and merged with appropriate household demographic datasets are imported in Microsoft Excel for data cleaning and management
Food Groups	Using the standard 7-day food frequency data, all the food items were grouped into specific foods groups (cereals and tubers, pulses, vegetables, fruits, meat, dairy, oils, and sugar)
Summing	Sum the consumption frequencies of the food items in the same group, record the value of each group above 7 as 7
Weighted Score	The value of each group was multiplied by its weight, yielding new weighted good-group scores.
Total FCS	The sum of all weighted scores provides the total FCS, which reflects dietary diversity and nutritional adequacy of the diet.
Interpretation	FCS was categorized into categorical variables: poor (FCS < 28), borderline (FCS 28.5-42), and acceptable (FCS > 42).

The Household Dietary Diversity Score (HDDS) quantifies food access quality using seven food groups consumed over a 7-day or flexible recall period. This study adopted the IFPRI's flexible reference approach, and the HDDS measures the extent to which food consumption

patterns create disparities in nutrient intake over time. This reflects both the quantity and quality of food access [34]. Scores were generated using a simple count of seven food groups (cereals, tubers, vegetables, fruits, meat, eggs, fish, pulses, milk, and oil) consumed over a flexible recall period. The score ranges from 0 to 7, inversely signifying the nutrient intake and diversification of diets and mediating the pathway from agriculture to improved nutritional intake [35]. The HDDS takes the form of ordered terciles: low (HDDS < 4.5, indicative of FSC 0− 28), medium (HDDS 4.5 – 6; indicative of FCS 28 < FCS ≤42), and high (HDDS > 6; indicative of FCS >42) [IFPRI]. Owing to data constraints in the first-panel wave (Wave 4 (2018/19)), this study used the flexible period approach validated by the IFPRI, instead of the FAO-recommended 24-hour measure model. The table-2 details the key elements of the HDDS construction.

Table 3.2: Construction of Household Dietary Diversity Score – as per IFPRI

Component	Details
Data upload	Relevant raw data on food consumption frequency over a standard 7 days recall period were uploaded from the publicly available repositories, ESPS_w4 and ESPS_w5 micro datasets of the household data files named sect6a_hh-w4, sect6b_hh_w4, sect6a_hh-w5, and sect6b_hh_w5.
Data Cleaning	All relevant food dataset uploaded and merged with appropriate household demographic datasets are imported in Microsoft Excel for data cleaning and management
Regroup	The 16 food groups used for the FCS were regrouped into seven food groups (1. cereals, roots, and tubers, 2. Pulses and legumes, 3. Vegetables, 4. Fruits, 5. Meat, Fish, and Eggs, 6. Dairy products and 7. Oils and fats were validated by the IFPRI for a flexible recall period.
Binominal variable	For each food group, a new binomial variable was created that had two possible values: 1-yes if the household had consumed that specific food group, otherwise 0- no;
Creating HDDS	The sum of all binomial variables was used to create an HDDS for each household, the HDDS will have a value ranging from 0 to a maximum of 7.
Interpretation	HDDS was categorized into categorical variables: Low (HDDS < 4.5), Medium (HDDS 4.5–6), and Good (HDDS > 6) as per the IFPRI proposals for flexible periods other than the 24-hour recall period.

ii. Drought Exposure Indicators

The Somali Regional State of Ethiopia is facing severe droughts that are affecting rural livelihoods, water resources and food security. This study examines drought shock types and their effects on household food security using self-reported data and climate indicators,

analyzing drought exposure from 2018 to 2022 across all 11 zones in the country. This assessment is based on an analysis of self-reported (idiosyncratic) shock data collected from two rounds of the ESPS: ESPS Wave 4 (2018/19) and ESPS Wave-5 (2021/22). In these two panel surveys, households were asked whether they had been affected by any of the 19 shocks (both natural and man-made) that led to an adverse loss of assets, caused their household income to fall substantially, or resulted in a significant reduction in their food security status in the 12 months before the

The periods of the self-reported incidence of drought shock data from the two panel surveys were also analyzed using objective measures of drought from a global climate database. In line with recent empirical studies (Demissie et al., 2021; Sunday et al., 2022; Upton et al., 2022), this study used the Standardized Precipitation Evapotranspiration Index (SPEI) as an objective measure of drought exposure and severity. The SPEI data were downloaded from the Global Drought Monitor (http://sac.csic.es/spei/map/maps.html). The SPEI, which integrates both precipitation and potential evapotranspiration, was calculated at multiple temporal scales (1, 3, 6, 12, and 24-month) to capture drought frequency and duration. For example, a 3-month SPEI obtained at the end of December compares the precipitation and temperature totals of the October, February, and December periods with the same 3-month period over the historical records (i.e., from 1950, onwards). Shorter timescales (e.g., 3- and 6-month SPEI) reflect more frequent droughts with short-term agricultural impacts, whereas longer timescales (e.g., 12- and 24-month SPEI) indicate less frequent but longer-lasting droughts associated with prolonged water resource stress.

Given that the survey period during which panel data for the study key variables were collected was 2019 (ESPS Wave 4) and 2022 (ESPS Wave 5), the SPEI values were calculated for 2018 and 2020/2021, representing the shock years (the year before each survey). Therefore, this study utilized the 6-month and 24-month SPEI values for the main “Gu” rainy seasons of 2018 and 2020/2021 to identify short- and long-term drought exposures and impacts across the 11 zones of the Somali Region. These SPEI values, extracted from the Global Drought Monitor (http://sac.csic.es/spei/map/maps.html) at a 0.5-degree spatial and monthly resolution, were categorized into drought severity levels ranging from no drought (SPEI>0), mild drought

(−1<SPEI<0), moderate drought (−1.5<SPEI<-1), severe drought (-2<SPEI<-1.5), and extreme drought (SPEI<−2).

For the empirical analysis to identify the effect of drought shocks on household food security outcomes, two specific dummy variables were generated using a threshold value of -1 to identify significant negative anomalies in rainfall, focusing on realized shocks rather than potential ex-ante risk exposures. A dummy short-term drought exposure indicator variable is defined as 1 if the standard deviation of the rainfall prior to the survey is less than the threshold SPEI (6-month SPEI= -1) and 0 otherwise. The same threshold (24-month SPEI = -1) was used to define the dummy variables for long-term drought exposure. This methodology enables robust spatial and temporal analyses of drought exposure and intensity, which is critical for assessing the adverse consequences of drought shocks on the lives, livelihoods, natural resources, and food security of rural households in the region.

iii. Household and Community Attributes - Observed Resilience Variables

Drawing on FAO's RIMA-II methodology (FAO 2016 b) and operationalized through the Shiny RIMA tool (2022), the study constructed observed variables from the two panel datasets of the ESPS to estimate each of the four pillars of the RIMA framework that contribute to household resilience. The four resilience pillars analyzed were **Access to Basic Services (ABS)**, **assets (AST)**, **Adaptive Capacity (AC)**, and **Social Safety Nets (SSN)**. The observed variables used to estimate the pillars are summarized as follows.

- **Demographics:** household size, head's age, sex, and education level.
- **Access to Basic Services (ABS):** proximity to protected water sources, improved sanitation, markets, health facilities, and electricity
- **Assets (AST):** Cropland size, livestock holdings (in Tropical Livestock Units), and wealth indices (agricultural and durable assets using PCA).
- **Adaptive Capacity (AC)** to diversified sources of income/livelihood diversification, access to savings and credit, and herd diversity.
- **Social Safety Nets (SSN):** Participation in formal and informal assistance schemes, including the Productive Safety Net Program (PSNP).

All observed variables were extracted and constructed from the two datasets of the ESPS, cleaned, and standardized for consistency across the two panel surveys to ensure compatibility with the Shiny RIMA tool and accurate estimation of the Resilience Capacity Index (RCI) in accordance with the FAO (2022) Shiny RIMA guidelines (Rome. https://doi.org/10.4060/cc3353en).

3.5. Resilience Measure and Identification of Potential Resilience Indicators

Resilience capacity plays a critical role in determining how households and communities absorb, adapt to, and recover from the adverse effects of recurrent droughts. Resilience in development and food security is the ability to prevent shocks from affecting long-term health (Barrett and Constas, 2014). It is a multidimensional construct that predicts household food security in adverse conditions (Alinovi et al., 2009). Two key perspectives are resilience as a capacity and as a normative condition (Barrett and Constas, 2014; Cissé & Barrett, 2018). This study adopts the resilience-as-capacity approach using the FAO Resilience Index Measurement and Analysis (RIMA-II) framework (FAO, 2016b), which is recognized for quantitative household resilience assessment and is supported by various studies, including those by d'Errico et al. (2018), Ansah et al. (2019), Haile et al. (2022), and Upton et al. (2022).

The shiny RIMA tool is a web-based application in the R environment that performs resilience analyses and measures household resilience using a resilience capacity index (RCI). The RIMA-II methodology (FAO, 2022) focuses on four pillars: Access to Basic Services, Assets, Social Safety Nets, and Adaptive Capacity. A two-stage process combines factor analysis and a MIMIC model to estimate sustainability pillars. In the first stage, Factor Analysis identified attributes that contribute to household resilience using observed variables from the ESPS panel datasets, which were cleaned, standardized, and harmonized to ensure compatibility with the Shiny RIMA tool. In the second stage, the MIMIC model links the four pillars to the resilience capacity index (RCI), while simultaneously associating the RCI with food security outcomes. The structural equation model (SEM) estimates the contribution of each pillar to the RCI as follows:

$$RCI = [\beta 1, \beta 2, \beta 3, \beta 4] \; X \; [ABS, AST, AC, SSN] + 3 \quad \text{--------- Equation 1}$$

The measurement component relates the RCI to the two food security indicators used according to the RIM II requirements, that is, the Food Consumption Score (FCS) and the Household Dietary Diversity Score (HDDS), as follows:

$$FCS, HDDS = [1, 2] \times [RCI] + [1, 2] \quad \text{.....Equation 2}$$

Methodological caution is warranted when interpreting the latent variable model as a causal inference framework because the RCI may be jointly determined with food security outcomes, and endogeneity may bias estimates. Although the MIMIC model does not fully eliminate this risk, Hausman-Vu tests indicate the mitigation of endogeneity concerns (D'Errico et al., 2018; Haile et al., 2022). According to FAO guidance, the RIMA II model was used here as a descriptive analytical tool to explore the relationships among resilience dimensions, while causal inference was made about the interplay between drought resilience and food security in the subsequent climate-econometric analyses, specifically the household-fixed effects panel regression models.

Latent RCI does not include scale measurement. To establish a reference scale, the FCS loading (Λ_1) was set at one, which means that a one-standard deviation increase in the RCI corresponds to a one-standard-deviation increase in the FCS. Additionally, this establishes the unit of measurement for the variance of the two food security indicators as well as the other food security indicator, that is, the household dietary diversity score (HDDS) ($\Lambda 2$), as specified in the following equations:

$$FCS = \Lambda 1 RCI + \varepsilon 1 \quad \text{- Equation 3}$$

$$HDDS = \Lambda 2 RCI + \varepsilon 2 \quad \text{- Equation 4}$$

This study employs a multiple-indicator multiple-cause model (MIMIC) for the measurement analysis of food security determinants, focusing on resilience-related indicator variables. The resilience capacity index (RCI) is a key latent variable that correlates two food security indicators as measures of resilience. A quantitative analysis following the RIMA-II methodology identified significant resilience indicators that affected the impact of drought shocks. Causal inference was then examined through econometric analysis using the standardized RCI, observed resilience indicators, relevant statistics from the Shiny RIMA tool, and food security outcomes in

the panel regression models. These empirical strategies were used to estimate the impact of drought shocks on household food security and identify specific resilience indicators that mitigate the effects of drought. The RCI was standardized through minimum-maximum transformation, and its final outputs, including the RCI values, correlation coefficients, and resilience indicators, were combined with geo-referenced drought exposure data to create the RCI. This integrated approach highlights context-specific resilience indicators that improve adaptive capacity and alleviate adverse drought effects in the Somali Region, ultimately supporting improved food security (Dell et al. 2014; d'Errico et al. 2018; Demissie et al. 2021; Haile et al. 2022).

3.6. Empirical Strategies

3.6.1. Estimation of Drought Impact

To empirically assess how drought shocks and household resilience jointly influence food security outcomes, this study used a household fixed-effects panel regression model that appropriately accounts for unobserved time-invariant household characteristics and the longitudinal structure of the ESPS data (Dell et al., 2014; Demissie et al., 2021; Haile et al., 2022). The fixed effects specification isolates the variation within the household across the two survey waves (2018/19 and 2021/22), thus aiming to assess the effects of drought shocks, represented by short-term (SPEI-6) and long-term (SPEI-24) drought dummy variables on household food security outcome indicators. The econometric model is expressed as:

$$\ln(FS_{it}) = \alpha + \beta C_{it} + \gamma Z_{it} + \mu_i + \theta_{rt} + \varepsilon_{it} \qquad \text{Equation (5)}$$

FSi is the per capita daily Kilocalorie (Kcal) consumption of household i in year t; Cit is a vector of dummy climate shock variables: short-term drought variable (SPEI-6) and long-term drought (SPEI-24) variable in year t; Zit contains household characteristic that is likely to vary over time: household size, age of household head in years, sex of household head i in year t; θrt is time indicator; μi are the household fixed effect. The effects of drought shocks on daily per-capita Kcal consumption are represented by β.

Using established climate shock panel methods, such as those employed by Dell et al. (2014) and cited by Demessie et al. (2021), this study provides information on the magnitude and location of drought effects on household per-capita daily kcal consumption. Furthermore, this study explored the potential non-linear effects of droughts on per capita daily Kcal consumption by interacting the drought dummy variables with a polynomial in the magnitude of location-normalized shock measures ($W2it$), following similar methodologies (Equation 6 below) employed in relevant past studies (Dell et al., 2012; Demissie et al., 2021).

$$\ln(FS_{it}) = \alpha + \beta C_{it} + W^2_{it} \times C_{it} + \gamma Z_{it} + \mu_i + \theta_{rt} + \varepsilon_{it} \qquad \text{Equation (6)}$$

The key parameters of interest are $W2it \times Cit$ and the implied variables give estimates of the nonlinear impacts of drought shocks on per capita Kcal intakes without mixing variation around the norm with variation in the distribution tail.

3.6.2. Identification of Specific Resilience Factors

Drawing on a household fixed-effects model, this study investigated the mitigating influence of resilience indicators on drought shocks using interaction terms for drought shocks and potential resilience indicators.

$$\ln(FS_{it}) = \alpha + \beta C_{it} + R_{it} \text{ X } C_{it} + \gamma Z_{it} + \mu_i + \theta_{rt} + \varepsilon_{it} \qquad \text{Equation (7)}$$

FSit is realized food security of household i in year t as used in equation (1); Cit is a vector of dummy climate shock variables: short-term drought variable (SPEI-6) and long-term drought (SPEI-24) variables in year t; Rit is the vector of dummy resilience indicator variables of household i in year t.

The inclusion of these interaction terms enabled us to test whether households with specific resilience indicators identified through the RIMA analysis, such as diversified income sources, improved savings and credit services, larger productive asset holdings, and proximity to social service access, demonstrated greater resilience to drought-induced food insecurity. To operationalize the potential resilience indicators, continuous indices related to the variables showing the highest absolute correlations or relevance within each of the four RIMA-II pillars were transformed into categorical and binary variables, following Filmer and Pritchett (2001).

These indicators included proximity to protected water sources, health facilities, and markets (km, one way), wealth and agricultural asset indices, cropland area (hectares), livestock holdings (Tropical Livestock Units [TLU]), number of distinct sources of income, livestock diversity, and savings and credit access.

Households were classified by each indicator and grouped according to percentile thresholds: the bottom 40% were classified as low, the middle 40% as medium, and the top 20% as high-income households. A binary variable was then created for each indicator, taking a value of 1 for households in the medium or high group (better-off) and 0 for those in the low group (least resilient). Regarding the social safety net dimension, resilience was measured directly using two dummy variables that captured whether the household received monetary or in-kind transfers from formal or informal sources in the past 12 months. This classification enabled a systematic examination of the heterogeneity of drought responses among households with varying resilience factors to drought. This provides an analytical foundation for identifying specific resilience indicators within and across the four RIMA II pillars that statistically and substantively mitigate the adverse effects of both short- and long-term drought shocks on realized household food security among rural households in the Somali Region.

3.7. Ethical Considerations

This study adhered to the ethical principles of research involving human participants. Before data collection, informed consent was obtained from all participants to ensure voluntary participation, confidentiality, and anonymity. Participants received clear information about the purpose, procedures, risks, and benefits of the study and had the right to withdraw at any time, without penalty. Data handling and storage complied with data protection regulations to ensure participant confidentiality. Ethical approval was obtained from the relevant institutional review board or ethics committee to ensure that the study met the established ethical standards and guidelines.

CHAPTER 4: FINDINGS AND DISCUSSIONS.

4.1. Introduction

This chapter examines the findings and discusses the interplay between drought shocks, resilience, and food security among rural households in Ethiopia's Somali Region. Using a mixed-methods approach, this study integrates qualitative and quantitative evidence, combining qualitative insights and objective drought shock measures with panel socioeconomic datasets from the Ethiopian Socioeconomic Panel Survey (ESPS Waves 4 and 5, 2018/19 and 2021/22). Qualitative insights came from interviews and discussions with community members and officials in three districts from the Fafan, Sitti, and Liben zones, supplemented by analyses of self-reported shock data from the ESPS Waves 4 and 5, 2018/19 and 2021/22. The quantitative component used rural household panel socioeconomic datasets from the ESPS Waves 4 and 5, 2018/19, and 2021/22, integrated with climate data from the Global Drought Monitor. The ESPS's longitudinal design facilitated tracking of the same households over time, providing robust evidence of how drought exposure influences food security outcomes and resilience-building trajectories over time.

This chapter is organized according to the study's five specific objectives. Section 4.2 summarizes the descriptive statistics for the study's empirical findings: (a) describe prevalent drought shock types using self-reported shocks and climate-based indicators such as the Standardized Precipitation Evapotranspiration Index (SPEI); (b) evaluate household food security profiles and trends; (c) quantify the effects of short- and long-term droughts on realized food security; and (d) identify specific resilience indicators significantly mitigating the droughts'

impacts, applying the FAO's RIMA-II methodology and household-fixed effects panel regression models.. Section 4.3 describes the prevalent drought shock types, their severity, and spatial heterogeneity. Section 4.4 presents and discusses the evaluation of rural household food security status and trends over time using different indicators. Section 4.5 assesses household resilience levels and identifies key resilience pillars and potential resilience variables contributing to household resilience using the RIMA-II approach. Section 4.6 investigates the causal relationship between drought shocks and realized per-capita Kcal consumption using household fixed-effects panel regression methods. Finally, Section 4.7 identifies specific resilience indicators that mitigate the negative effects of both short- and long-term droughts on realized food security indicators.

4.2. Summary of Descriptive Statistics

Table 4.1 presents the summary statistics of the main outcome and other key variables used for the empirical analyses to assess how drought shocks and specific resilience indicators jointly influence rural household food security outcomes in each wave (ESPS Waves 4 (2018/19) and 5 (2021/22)) of the ESPS surveys. The outcome variable used in the panel regression model was per capita daily kilocalorie (kcal) consumption, along with key explanatory drought exposure variables (dummy variables of 6- and 24-month SPEI values) and a range of observed resilience indicator variables identified as potential resilience indicators from the FAO RIMA analyses. The details of the two food security outcome variables (Food Consumption Score (FCS) and the Household Dietary Diversity Score (HDDS)), pillars, and observed resilience variables of the MIMIC analyses, including their statistics, are presented in Appendix I (Table 4.9). Overall, the statistics in Table 4.1 indicate the variation in per capita daily kcal consumption, exposure to drought shocks, and resilience indicators among the sampled rural households in the study.

Table 4.1: Descriptive Statistics of Major Variables, 2019 - 2022

Variable	Mean	
	2019	2022
Per Capita Kcal Consumption	2596.012	2414.19
Log of Per Capita Kcal Consumption	7.85	7.76
Food Energy Insecure (1 if Per Capita Kcal intake <2,200 Kcal; otherwise, 0)	0.32	0.46
Household Size	6.73	7.10
Female-headed HH	0.24	0.20

Age of household head in years	46.68	46.97
Exposed to short-term drought (1 if score of SPEI-6 <-0.5; otherwise, 0)	0.21	0.74
Exposed to long-term drought (1 if score of SPEI-24 <-0.5; otherwise, 0)	0.87	0.88
Access to Protected Water Sources	0.45	0.46
Closeness to Market (Km – one way)	0.51	0.02
Closeness to Hospital/Health Facility (Km – one way)	0.32	0.35
Wealth Index	0.48	0.38
Agricultural Asset Index	0.33	0.16
Cropland Area (hectare)	0.6	0.05
Tropical Livestock Unit (TLU)	13.87	7.31
Number of Income Sources	2.47	2.09
Herd Diversity	0.83	1.38
Access to Savings and Credit	0.26	0.4
Access to Informal Transfers (whether the household received money and or in-kind transfers from informal sources (1=yes; 0=no)	0.38	0.63
Access to Formal Transfers (whether the household received money and or in-kind transfers from informal sources (1=yes; 0=no)	0.42	0.48
Observations (n)	313	313

Sources: Computation using climate data from the Global Drought Monitor and two ESPS panel datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22)).

4.3. Description of Drought Shocks: Prevalence, Severity, and Heterogeneity

Objective 1: Describe the types of drought shocks in rural communities of the Somali Region and their characteristics (prevalence, severity, and dynamics)

This study analyzed drought exposure and severity among rural Somali households using both subjective and objective measures. The subjective findings of this study, drawn from qualitative inquiry and analysis of self-reported shock data from the ESPS, clearly show that drought is the most recurrent and severe climate shock affecting rural households in the Somali Regional State.

In April 2024, three key informant interviews (KIIs) with government officials and 18 focus group discussions (FGDs) with community members (men, women, and community leaders) gathered local experiences on major natural hazards, underlying factors of vulnerability, and existing local capacities/resilience strategies against drought-induced food insecurity in three purposively selected districts from the Fafan, Sitti, and Liben zones. These FGDs and KIIs were conducted in six kebeles, two in each woreda, ensuring the representation of pastoral and agro-

pastoral livelihoods. The districts and kebeles include (kebeles in parenthesis): Jigjiga (Hadew and Shebele), Mieso (Hunde-misoma and Oda Roba), and Filtu (Hayadmitu & Osobey) from Fafan, Sitti, and Liben zones, respectively. Although it is not possible to generalize the findings for the entire region, the qualitative insights from FGDs and KIIs reveal drought as an increasingly frequent and severe phenomenon.

Rural community participants unanimously perceived drought shocks as the most frequent and severe climate hazard affecting rural livelihoods, followed by floods, human and livestock diseases, and crop pests. Community members attributed drought primarily to frequent erratic, delayed, or failed main rainy seasons, the long rains (‘‘Gu’’/ “Ganna’’), and the short rains (“Deyr’’/’’Hagaya’’), which are critical for pasture regeneration, local crop production, and water availability. Dryness in rural communities is a key factor contributing to drought, driven by erratic rains, water scarcity, and rangeland degradation. Drought adversely affects agriculture, leading to significant losses in crop yields and pasture lands, which worsens food security for Somali communities that rely on rain-fed agriculture. Participants noted signs of impending drought, such as extreme morning cold, cloudy dusty winds, drying water sources, and unusual animal behaviors, highlighting the critical need for awareness and preparation for these environmental challenges. Local community knowledge suggests that the frequency of drought events has increased substantially, shifting from historically occurring every six–ten years to nearly annual occurrences in recent years for prolonged years. Most community participants cited the recent historically severe and long drought from 2020 to 2023, which resulted in extended food insecurity, water scarcity, and huge livestock deaths, along with significantly detrimental impacts on rural livelihoods in the region.

Drought-induced livestock deaths have negatively impacted crop yields, prompting some former pastoral and agro-pastoral households to migrate to urban areas for alternative livelihoods. Participants highlighted various community-level consequences, including water and pasture shortages, unsafe migration, increased vulnerability to diseases, conflicts over resources, and rising food prices, all of which exacerbated their food security challenges. Participants noted that while droughts can occur independently, they often worsen with other hazards, such as diseases and conflict, compounding the difficulties faced by communities.

The community participants attributed their vulnerability to drought to environmental fragility, limited livelihood options, and weak social services and infrastructure. They noted the arid and semi-arid climate, erratic rainfall, and degraded rangeland and water resources that cause their frequent vulnerability to droughts. Vulnerable human groups include children, pregnant women, the elderly, disabled persons, female-headed households, poor pastoralists, and ex-pastoralists. Livestock, particularly cattle and sheep, are vulnerable because of their reliance on pastures, whereas camels and goats are less affected because they can consume dry shrubs. Drought also impacts social service institutions and infrastructure, such as schools, health posts, local markets, and water facilities, which often become non-functional during prolonged and severe droughts. The narratives emphasized that vulnerability is not only environmentally but also socioeconomically differentiated, with more arid areas and marginalized groups facing greater challenges in coping with and recovering from droughts.

Qualitative inquiries reveal that despite numerous vulnerability factors, rural Somali households have several capacities to withstand and recover from drought impacts. Wealth is a dominant physical capacity, with livestock holdings, cultivable land, durable assets such as houses and carts, and agricultural assets being key factors. Respondents highlighted livestock as essential for their livelihoods and coping strategies during droughts. They stressed the need for effective livestock management, increased productivity, herd size control, diversification, and the introduction of drought-resistant forage. Moreover, access to drinking water, animal health services, and proper grazing land management are crucial for enhancing livestock capacity and adapting to recurrent drought challenges in rural communities. Adaptive capacities include alternative income sources and/or livelihood diversification, herd diversity, and informal access to financial services (access to savings and credit) and non-financial assets (e.g., rental houses). Natural resource-based capacities, such as access to rangelands and water sources, are vital but are increasingly constrained by overuse and conflict. Social safety nets and institutional capacities, such as traditional social security and mutual community support systems, play crucial roles in ensuring peace and livestock redistribution during droughts. However, the community participants noted that these traditional social mechanisms have weakened as government and NGO aid interventions have dominated the indigenous mechanisms.

Key government officials have identified droughts as a significant threat to rural livelihoods, water resources, and food security, particularly affecting livestock and local crop production. In addition to emphasizing the negative effects of drought on local crop and livestock yields, all of which weakened household food consumption and market supply, the participants also pointed out that the lack of water and pasture significantly limited livestock production and productivity, which directly impacted the pastoral livelihoods that make up the majority of the Somali rural communities. In addition to agriculture, drought exacerbates water scarcity for domestic and agricultural purposes, making households even more vulnerable to food insecurity.

Both community and government respondents highlighted the 2020–2023 drought as one of the most severe climatic shocks experienced in recent decades, resulting in widespread livestock deaths, acute water shortages, and declining crop production. These impacts triggered cascading rural livelihood disruptions, including pasture scarcity, increased migration in search of water and grazing resources, rising food prices, and intensified competition for natural resources. Drought also exacerbates other compounding shocks, including conflict over scarce natural (grazing and water) resources and the spread of disease.

Although the qualitative findings are geographically limited and not representative of the entire region, they provide important contextual evidence supporting the quantitative drought analysis' results below by illustrating the lived experiences and socio-economic consequences of drought shocks within rural communities of the region. To address the geographical limitations of the qualitative analysis, this study conducted a thorough examination of the spatial and temporal extent of drought exposure and its severity in rural communities across all 11 zones of the Somali region over the period between 2018 and 2021, utilizing the self-reported (idiosyncratic) shocks' data from the two rounds of the ESPS (ESPS Wave 4 (2018/19) and ESPS Wave-5 (2021/22)). In these two panel surveys, households were asked whether they had been affected by any of the 19 shocks (both natural and man-made) that led to an adverse loss of assets, caused their household income to fall substantially, or resulted in a significant reduction in food security status over the 12 months preceding the respective survey period.

The self-reported shock data analysis from the two rounds of the ESPS revealed a significant increase in drought exposure among rural households in the Somali Region. Drought was the most frequent and severe shock, followed by livestock loss, food and input price hikes, crop damage, and human illness. During the ESPS 2018/19 survey, 43% of the 313 panel households across the 11 zones reported experiencing drought in the past 12 months, whereas this proportion increased to 89% in the 2021/22 survey, indicating the intensification of drought shocks in both their frequency and severity.

Table 4.2: Self-Reported Incidence of Major Shocks among Rural Households in the Somali Region (2018 – 2021)

Types of Shock	Number (%) Of Households Affected (2018)	Number (%) Of Households Affected (2021)	Change number (%)
Drought	134 (43%)	280 (89%)	146 (47%)
Livestock loss/disease	50 (16%)	178 (57%)	128 (41%)
Food and input price increase	51 (17%)	79 (25%)	28 (8%)
Crop damage	1 (0%)	38 (12%)	37 (12%)
Human illness	29 (9%)	28 (9%)	-1 (0%)
Conflict/insecurity	5 (2%)	9 (3%)	4 (1%)
Multiple concurrent shocks (≥2)	75 (24%)	217 (69%)	142 (45%)

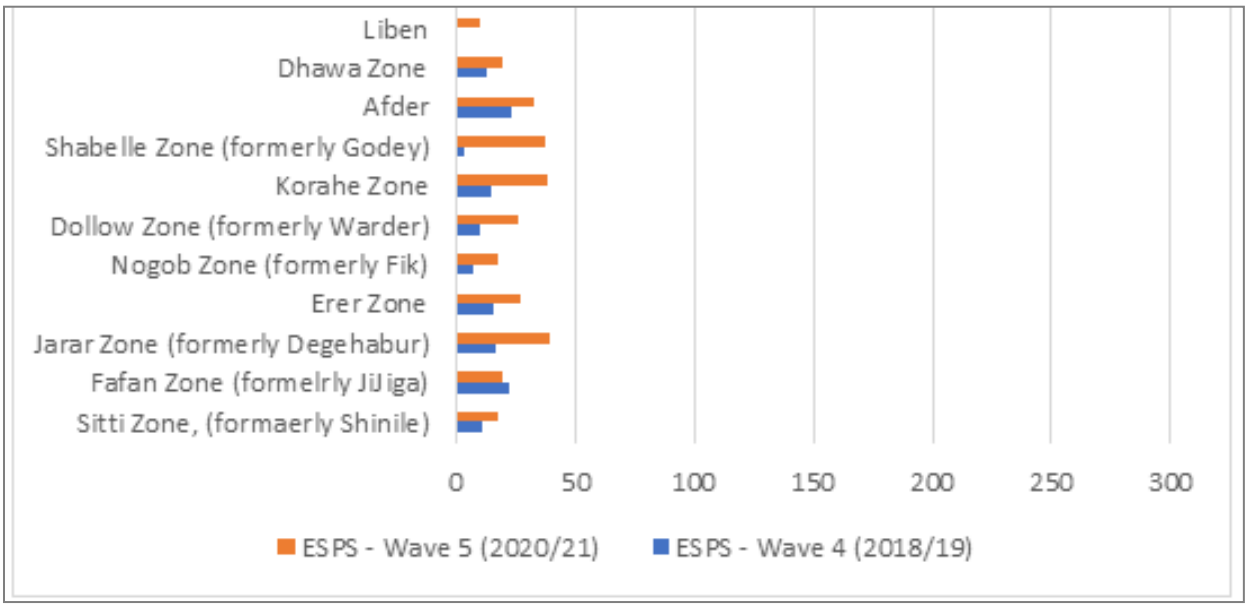
Sources: Authors' computation using ESPS two-panel datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22).

The increasing prevalence of drought is also accompanied by a marked rise in the incidence of multiple concurrent shocks. The share of households reporting exposure to at least two simultaneous shocks increased from 24% in 2018 to 69% in 2021, reflecting a 45 percentage-point increase. This pattern suggests that both short- and long-term droughts rarely occur in isolation but interact with other climatic and socioeconomic shocks. In particular, drought shock coincided with massive livestock loss or death (16% to 57%), increases in food and agricultural input price shocks (17% to 25%) and crop damage (1% to 12%). These overlapping shocks compound rural livelihoods by simultaneously reducing household income sources while increasing the cost of food production and agricultural inputs, thereby constraining households' coping and recovery capacities.

Livestock loss is a critical mechanism through which drought affects pastoral and agro-pastoral livelihoods in the Somali Region. The proportion of households reporting significant livestock mortality rose from 16% in 2018 to 57% in 2021, reflecting a deterioration in herd productivity and survival rates under prolonged drought conditions by 2021/22. Given that livestock constitute the primary store of wealth, source of income, and key productive asset for pastoral households, prolonged and severe drought-induced herd losses erode household productive asset bases and undermine long-term recovery. Consequently, drought exposure is associated with declines in income, local food production, food stocks, and market purchasing power, all of which directly threatened rural Somali household food security over the study period.

The self-reported shock data analysis further revealed considerable heterogeneity in drought exposure across zones. In the year prior to the 2021/22 survey, the highest proportions of drought-affected households were recorded in Jarar (14%), Korahe (14%), Shabelle (13%), Afder (11%), and Erer (10%). In contrast, in the year prior to the 2018/19 survey, drought exposure was most pronounced in Afder (17%), Fafan (16%), Jarar (12%), Erer (11%), and Korahe (10%).

Figure 4.1: Drought Shock reportedly experienced by rural households by number of households across all eleven zones of the Somali region in 2018 and 2021.



Sources: Authors' computation using ESPS two-panel datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22)).

The persistence of drought exposure in zones such as Jarar, Korahe, and Erer in the years prior to both survey waves suggests that certain zones experience recurrent drought shocks owing to their geological characteristics and strong dependence on rain-fed pastoral production systems. These findings indicate that drought exposure is highly prevalent and spatially uneven, reflecting local climatic variability and differences in rural livelihood systems.

Both the quantitative and qualitative evidence indicates that drought shocks have become increasingly frequent, severe, and the dominant climate hazard across the rural communities of the Somali Region over the study period. The ESPS's self-reported data analyses quantify the scale of exposure, while the qualitative findings illuminate the mechanisms through which drought affects local livelihoods, resource access, and food security outcomes.

To complement the subjective drought shock data, this study incorporated objective drought indicators derived from the Standardized Precipitation–Evapotranspiration Index (SPEI) at 6-month (short-term) and 24-month (long-term) timescales. The SPEI analysis provides an independent climatic assessment of drought conditions and identifies the prevalent drought types across the Somali Region prior to the two waves of the ESPS. Understanding prevalent drought types is crucial for evaluating their differential effects on rural livelihoods and household food security. The SPEI analysis includes results for the two main rainy seasons (Gu "and Deyr ") across 11 zones, as detailed in Table 4.3.

Table 4.3: Objective Drought Measures (SPEI-6 and -24 Month Averages) and Severity Trends by Zone in Somali Region

Zone	SPEI-6 (2017/18)	Severity Trend	SPEI-24 (2017/18/)	Severity Trend	SPEI-6 (2020/21)	Severity Trend	SPEI-24 (2020/21)	Severity Trend
Sitti	-1.027	Moderate	-1.71	Severe	-1.33	Moderate	-1.86	Severe
Fafan	-2.099	Extreme	-3.48	Extreme	-3.22	Extreme	-5.00	Extreme
Jarar	-0.168	Mild	-1.61	Severe	-2.26	Extreme	-2.54	Extreme

Erer	0.601	No drought	-0.65	Mild	-0.50	Mild	-0.54	Mild
Nogob	0.000	No drought	-0.88	Mild	-2.64	Extreme	-1.91	Severe
Dollow	0.318	No drought	-0.54	Mild	-1.71	Severe	-1.44	Moderate
Korahe	0.320	No drought	-0.65	Mild	-2.12	Extreme	-1.90	Severe
Shabelle	0.839	No drought	-0.76	Mild	-0.96	Moderate	-1.01	Moderate
Afder	1.070	No drought	-0.98	Mild	-0.36	Mild	-0.80	Mild
Dhawa	0.494	No drought	-0.52	Mild	-1.32	Moderate	-0.98	Mild
Liben	0.881	No drought	-1.20	Moderate	-0.43	Mild	-0.42	Mild
Region level	0.061	No drought	-1.249	Moderate	-1.641	Severe	-1.869	Severe

Source: Author's Computation from the Global Drought Monitor (SEPI) Datasets 2017/18 – 2020/21

The results for the year preceding the 2018/19 survey show that short-term drought conditions were relatively limited in spatial extent in the region. Most zones recorded near-normal rainfall conditions, with SPEI-6 values close to zero. However, localized short-term drought conditions were observed in Sitti (moderate drought) and Jarar (mild drought), whereas Fafan experienced extreme short-term drought conditions (SPEI ≈ -2.10). These localized short-term drought signals indicate that rainfall deficits were unevenly distributed across the region during this period.

In contrast, the 24-month SPEI results for the same period reveal a more widespread pattern of long-term (hydrological) drought. Nine of the eleven zones experienced moderate to extreme long-term drought conditions, with SPEI-24 values ranging between approximately -1.14 and -3.48. The most severe conditions were recorded in Fafan, indicating prolonged water deficit and sustained hydrological stress. Such long-term drought conditions likely reduced groundwater recharge, depleted surface water sources, and degraded rangelands, thereby undermining the ecological foundations of pastoral and agro-pastoral livelihoods in the region.

The drought situation deteriorated further in the year preceding the 2021/22 survey period. The 6-month SPEI analysis indicates that short-term drought conditions became considerably more

widespread, with most zones recording negative SPEI values. Severe to extreme short-term drought conditions were observed in Sitti, Jarar, and Fafan, reflecting a significant seasonal rainfall failure. Short-term droughts of this nature directly affect pasture regeneration and local crop growth during critical agricultural seasons, thereby increasing the vulnerability of pastoral and agro-pastoral households.

Long-term drought conditions also intensified during this period. The regional average SPEI-24 value declined to approximately −1.87, indicating severe long-term drought conditions at the regional scale. At the zonal level, Fafan experienced catastrophic hydrological drought (SPEI ≈ −5.0), while Jarar, Korahe, and Nogob also experienced severe to extreme long-term drought conditions. These results highlight the persistence of multi-year drought cycles, which progressively deplete water resources and degrade natural ecosystems.

The SPEI findings provide an important climatic explanation for the patterns observed in household survey data. The sharp increase in the proportion of households reporting drought between 2018 and 2021 coincided with objectively measured intensification of both short- and long-term drought shocks by 2021. This convergence suggests that the observed rise in drought exposure is not solely a matter of perception but reflects genuine climatic deterioration, characterized by repeated rainfall deficits (short-term, agricultural, drought) and prolonged hydrological stress (long-term, hydrological, drought).

Synthesizing the three types of evidence from qualitative inquiry, self-reported shock data from the ESPS, and objective climatic indicators reveals the chronic exposure of the Somali Region's rural communities to both short- and long-term drought shocks, threatening rural livelihoods (pastoral and agro-pastoral production systems), natural resources (water and rangeland), and rural household food security. Qualitative evidence identified drought as the primary and most severe climate shock affecting rural communities in the Somali region. Erratic rainfall and rangeland degradation contribute to recurrent drought events, leading to water and pasture scarcity, livestock deaths, reduced crop yields, and significant food shortages, impacting rural livelihoods almost every year for up to three years. Analysis of self-reported shock data from the two waves of the ESPS shows a significant increase in rural households reporting drought shock,

from 43% in 2019 to 89% in 2022, making drought the most frequent and severe climate shock across all 11 zones of the Somali region by 2022. Analysis using 6- and 24-month SPEI values revealed a shift from mild or localized short-term drought in 2018 to widespread severe short-term and long-term drought shocks by 2021. This objective analysis showed an intensification of both types of drought severity and spatial exposure in most rural communities by 2021. While short-term droughts disrupt seasonal agricultural activities, long-term droughts indicate sustained hydrological stress, limiting water availability and degrading natural resources. Zone-level variations highlight heterogeneous drought exposure and severity, emphasizing the need for context-specific, integrated, and multidimensional resilience-building interventions.

Meanwhile, the SPEI analysis offers objective climatic confirmation that both short- and long-term drought conditions intensified between 2018 and 2021. The observed intensification in both short- and long-term drought indicators closely corresponded with the increase in self-reported drought exposure among households. This triangulation of self-reported data in the two rounds of the ESPS, qualitative evidence, and climatic indicators strengthens the reliability of this study's findings and demonstrates that the rising incidence of drought reported by households reflects a broader pattern of climatic variability and both short- and long-term drought shocks affecting the rural communities of the region.

Overall, the integrated results indicate the chronic exposure of the Somali Region to both short- and long-term drought shocks, characterized by increasing frequency, spatial heterogeneity, and prolonged duration, which threaten rural livelihoods (pastoral and agro-pastoral production systems), natural resources (water and rangeland), and rural household food security. These dynamics pose significant challenges to rural livelihoods and food security, particularly in rural communities that depend heavily on seasonal rainfall and fragile rangeland ecosystems.

The findings of this study are consistent with a growing body of literature documenting increasing drought frequency and severity across Ethiopia's Somali Region and the broader Horn of Africa. Previous studies (e.g., Birhanu et al., 2017; Mekuyie et al., 2018; Alemu & Mengistu, 2019, Melketo et al., 2021) similarly report that pastoral and agro-pastoral communities in Ethiopia are highly vulnerable to climate variability because of their dependence on rain-fed

livestock production systems for their livelihoods. The observed shift toward more frequent and prolonged drought shocks between 2018 and 2020/21 in this study aligns with recent reports indicating that the 2020–2023 drought was among the most severe and multi-year drought shocks in the past several decades (Global Report on Food Crises, 2023; UNHCR, 2023; USAID - Fact Sheet #11, 2023; Amha et al., 2023).

A key contribution of this study is its emphasis on the compounded nature of drought shocks. The significant increase in rural households experiencing multiple shocks, with nearly 70% of households reporting at least two simultaneous shocks in 2020/21, highlights that drought interacts with economic and social shocks and/or stressors, such as massive livestock deaths, rising food and input prices, and conflict. This finding supports earlier research suggesting that climate shocks often trigger cascading effects that amplify vulnerability and constrain the recovery of productive assets (livestock, cropland, water, and rangeland resources) (Bogale & Mulu, 2021; Demissie et al., 2021; Mekuyie & Erena, 2022; Muhummed et al., 2024). Unlike studies that examine drought in isolation, this study demonstrates how overlapping shocks can erode households' coping and recovery capacities more rapidly.

The strong link between drought and livestock loss observed in this study also reinforces the findings from pastoral systems in other parts of Ethiopia, where repeated drought events have led to significant asset depletion (Tadesse et al., 2021). However, the magnitude and rapid increase in livestock loss reported in this study suggest that the recent severe and prolonged drought of 2020–2023 may have had a more severe impact on rural livelihoods in the Somali region.

The objective drought measures reveal that drought exposure increased dramatically, with severe short- and long-term droughts across most zones of the Somali region by 2020/21, a year prior to the ESPS Wave- 5 (2021/22). The spatial and temporal heterogeneity of short- and long-term droughts identified in this study further contributes to the literature by highlighting that drought impacts are not uniform across the 11 zones of the region. The Somali region, which is mainly pastoral, is particularly exposed to drought shocks due to its dependence on rain-fed systems and fragile rangelands. Although some zones consistently experience high levels of drought exposure, others are relatively less affected. This suggests that local environmental and

socioeconomic conditions play a critical role in shaping vulnerability, supporting arguments for context-specific resilience strategies (UNDP, 2022; WFP, 2023; World Bank, 2023). Objective indices, such as the Standardized Precipitation Evapotranspiration Index (SPEI), Standardized Precipitation Index (SPI), and Normalized Difference Vegetation Index (NDVI), have been used to document increasing drought intensity, particularly since 2015, with severe impacts on pastoralist livelihoods, livestock, and food production in the Somali region's zones, such as Korahey, Fafan, and Jarar (Lelamo et al., 2022; Bogale & Erena, 2022; Alasow et al., 2024; Kourouma et al., 2022). These findings align with the findings of this study regarding the escalating exposure and severity of both short- and long-term drought shocks and the need for spatially targeted interventions.

From a methodological perspective, the integration of qualitative evidence, self-reported shock data from the ESPS, and objective climate indicators strengthens the validity of the findings. Many previous studies relied on a single data source, which may limit their ability to capture the full complexity of drought dynamics. By triangulating multiple sources, this study provides a more comprehensive understanding of the prevalent types of drought shocks, their severity, and their differential impacts.

Nevertheless, some limitations of this study should be noted. Qualitative data were collected from three districts in the Fafan, Sitti, and Liben zones and may not fully represent the diversity of experiences across the entire region. This was complemented by the analysis of self-reported shock data from the two waves of the ESPS. Moreover, the two ESPS waves provided short-term econometric analyses with limited qualitative longitudinal coverage. However, these limitations do not undermine the validity of the study but indicate opportunities for future research.

Overall, the results demonstrate that droughts in the Somali Region are widespread and increasingly severe, prolonged, and unevenly distributed across space. The findings suggest that drought should be understood not merely as a climatic event but as a complex and dynamic challenge that affects multiple aspects of rural livelihoods. Therefore, police responses should move beyond short-term relief measures and focus on long-term resilience-building.

4.4. Household Food Security Profiles and Trends

Objective 2: Evaluate rural household food security profiles and trends

This study used three food security indicators: per capita daily kilocalorie (Kcal) consumption, Food Consumption Score (FCS), and Household Dietary Diversity Score (HDDS), to assess food security profiles and trends among rural households in the Somali Region between 2019 (ESPS Wave 4) and 2022 (ESPS Wave 5). The study calculated per capita daily kilocalorie (kcal) consumption, FCS, and HDDS from food consumption data collected over seven days of recall periods during ESPS Waves 4 (2019) and 5 (2022), following the procedures outlined in Chapter 3 (Methodology). The study also assessed household food energy in/security by comparing each rural household's per-capita daily kilocalorie intake with the minimum energy requirement of 2,200 kcal per adult equivalent. Households that met or exceeded this threshold were classified as food-energy secure, whereas those that fell below this threshold were classified as food-energy insecure. Table 4.4 presents the findings of food security profiles and trends among rural households in the Somali region over time between 2019 and 2022.

Table 4.4: Food security profile and trends among rural households in the Somali Region

Profiles and Changes in Food Security Status	ESPS Wave4 (2019)	ESPS Wave 5 (2022)
Per capita daily Kcal consumption		
Mean per capital daily Kcal consumption	2596.016	2414.193
Food energy insecure households (%)	32%	46%
Households suffering a loss between 2019 & 2022		45%
Food Consumption Score (FCS)		
Mean FCS (standard deviation)	44.89 (13.2)	40.48 (15.09)
Households suffering a loss between 2019 and 2022		49%
Household Dietary Diversity Score (HDDS)		
Mean HDDS (standard deviation)	4.22 (0.92)	4.48 (1.09)
Households suffering a loss between 2019 and 2022		49%
Total households	313	313

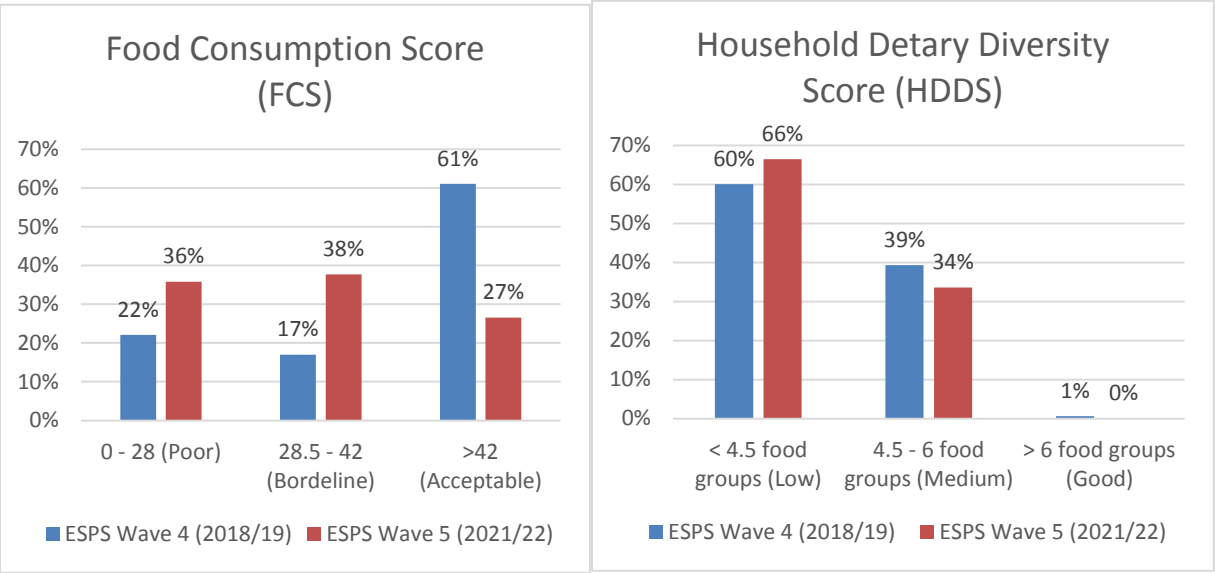
Sources: Authors' computation using ESPS two-panel datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22).

The study showed a clear deterioration in rural household food security between 2019 and 2022. The average per capita daily caloric consumption, which gauges dietary diversity and food energy sufficiency among households, declined from 2,596 Kcal in 2019 to 2,414 Kcal in 2022, a 182 Kcal decrease. The proportion of food energy-insecure households increased from 32% in 2019 to 46% in 2022. In addition, 45% of households experienced decreased caloric intake, indicating increased vulnerability to undernourishment, with an average caloric intake below the minimum dietary energy requirement.

Similarly, the Food Consumption Score (FCS) showed a decline in both the mean value and household-level score. The average FCS fell from 44.89 in 2019 to 40.48 in 2022, with nearly half (49%) of rural households reporting a drop in their scores over the study period. This deterioration reflects reduced dietary quality and consumption frequency, which is exacerbated by drought-associated livelihood disruptions, market access constraints and rising food prices. FCS trajectory analysis further indicates a sharp 34% downward mobility among rural households that were initially in the acceptable consumption category in 2019, with only modest upward mobility from the poor and borderline categories, signaling worsening consumption-related food insecurity of the Somali rural households in 2022.

In contrast, the Household Dietary Diversity Score (HDDS) exhibited a marginal increase in the mean score, rising from 4.22 to 4.48, suggesting some improvement in average dietary diversity at the regional level. However, this improvement is misleading and masks significant disparities in the HDDS at the household level. Nearly half (49%) of the rural households experienced a decline in dietary diversity, and the proportion of those consuming more than six food groups fell from 1% in 2019 to 0% in 2022. Additionally, the share of households with poor or medium HDDS increased, underscoring that the overall increase in HDDS at the regional level was driven by a small number of households, while many others faced worsening access to nutritionally diverse diets. Figure 4.2 shows the results of the categorization and trajectories of the FCS and HDDS of rural households in the Somali region over the survey period (2019 – 2022).

Figure- 4.2: FCS and HDDS dynamics between 2019 and 2022



Sources: Authors' computation using ESPS two-panel datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22).

This study's results indicate a worsening food security status and trends among rural households in the Somali Region between 2019 and 2022, with observable impacts on both food availability and access dimensions. These findings align with studies reporting increased food insecurity, reduced dietary quality, and heightened vulnerability to under-nutrition in the region, especially following the 2020–2023 drought (Smith et al., 2022; Bogale et al., 2022; Mezgebe et al., 2024). As Bogale et al. (2022) noted, prolonged droughts not only reduce food availability but also erode dietary quality through reduced market access and declining purchasing power. The worsening inequality in dietary diversity in this study is particularly concerning, suggesting that vulnerable households are disproportionately affected by drought.

The increase in food energy insecurity observed in this study reflects a broader trend of worsening food insecurity in drought-prone regions of Ethiopia. Similar findings have been reported by Mezgebe et al. (2024), who document declining caloric intake and increased vulnerability to undernutrition following recent drought episodes. The decline in the FCS further underscores the deterioration of food consumption patterns. This finding aligns with previous studies suggesting that households often cope with food shortages by reducing their meal frequency and shifting to less diverse diet (Smith et al., 2022). However, the results of this study

provide stronger evidence by showing that such changes are widespread and persistent. The mixed results observed for the HDDS highlight the importance of examining food security at both aggregate and disaggregate levels. While the average HDDS increased slightly, the decline experienced by a large proportion of households suggests growing inequality in dietary access. This finding adds nuance to the existing literature by demonstrating that aggregate indicators may obscure underlying disparities.

This result provides significant insights into the causal relationship between drought shocks and multidimensional food insecurity. The simultaneous 2022, 49% in per capita daily kilocalorie intake, Food Consumption Score (FCS), and Household Dietary Diversity Score (HDDS) among many households indicates that drought affects both the quantity and nutritional quality of food. This finding supports the perspective that food security is a multidimensional construct encompassing availability, access, and utilization. The adverse effects of the prolonged and severe 2020-2022 drought on food security outcomes can largely be attributed to the limited resilience capacities of Somali rural households. These capacities have evolved to cope with and recover from drought effects, related food access constraints, reduced agricultural yields, and declining purchasing power due to market price shocks. These impacts are particularly severe among pastoral households, where massive livestock loss, reduced local crop production, and depletion of productive assets are 49 % consequences (Lelamo et al., 2022; Bogale and Erena, 2022; Petros et al., 2017). These patterns reflect the study's findings of worsening food security and persistent multidimensional food insecurity in rural Somali regions between 2019 and 2022. These results underscore the necessity of a deeper examination of the differential effects of drought shocks on realized household food security outcomes and the role of context-specific resilience factors in mitigating these adverse impacts. The following sections investigate the effects of short- and long-term drought shocks on household food security outcomes and explore specific resilience capacity factors that mediate the adverse effects of drought on the food security outcomes of rural Somali households over the study period.

4.6. Estimating Household Resilience and Potentially Resilience Indicators

Objective 4: Household resilience measurement and analysis of Potential Resilience Indicators

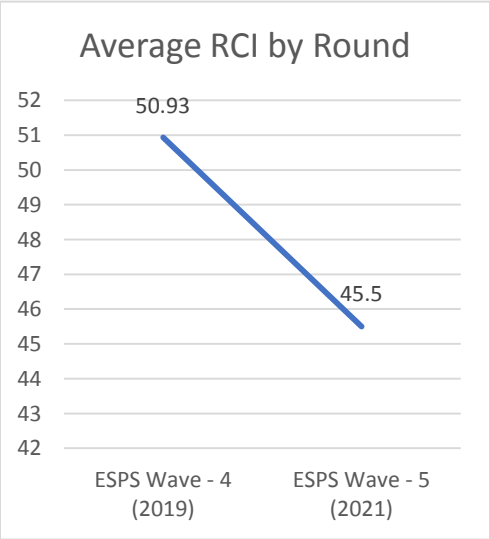
This section presents and discusses the findings from a household resilience analysis using the FAO's RIMA-II methodology, based on rural household panel data from the Ethiopian Socioeconomic Panel Surveys (ESPS Wave 4, 2018/19 and Wave 5, 2021/22). The study employed the Shiny RIMA tool, which operationalizes the RIMA-II methodology and integrates descriptive and inferential methods within the R environment, to analyze resilience capacity and its relationship with two food security indicators, per RIMA-II requirements. The tool's outputs included the Resilience Capacity Index (RCI), Resilience Structure Matrix (RSM), and Measurement Equation Model (MEM) of the Multiple Indicators Multiple Causes (MIMIC) model, supplemented by visual profiles such as spider diagrams, radar plots, and path diagrams. These outputs provide insights into household resilience levels, the significance of each pillar, relevant observed resilience variables in each core pillar, and variations across households, groups, and locations over time.

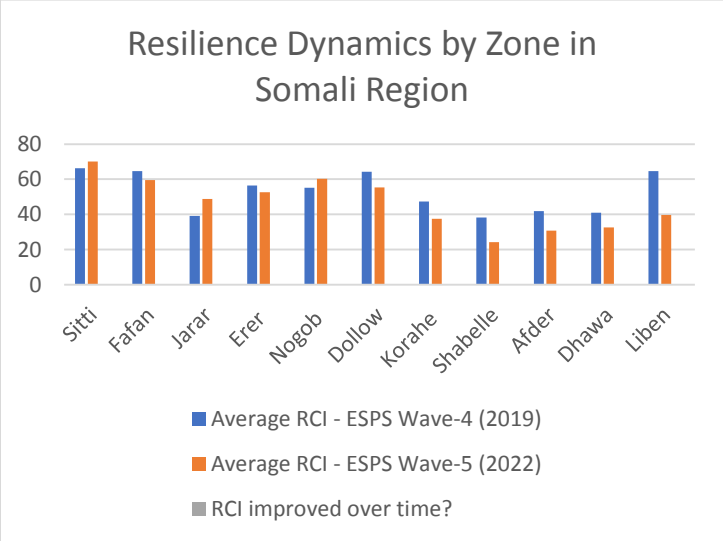
The RIMA analysis focused on four resilience pillars: Access to Basic Services (ABS), assets (AST), Social Safety Nets (SSN), and Adaptive Capacity (AC), along with two food security indicators: Food Consumption Score (FCS) and Household Dietary Diversity Score (HDDS). According to the FAO's RIMA-II guidance, the RIMA II model was used here as a descriptive analytical tool to explore the relationships among resilience pillars with the RCI, specific observed resilience variables with each pillar, and the RCI with the two food security indicators. Thus, this study used the FAO RIMA-II methodology to identify the core resilience pillars and specific observed resilience variables in each core pillar that could potentially moderate the adverse impacts of drought shock on the realized household food security indicator (per capita kilocalorie consumption). These findings establish an empirical basis for subsequent studies on the interaction between drought shocks, specific resilience indicators, and realized food security outcomes, which can be further interpreted in the context of the existing literature and research objectives. Thus, causal inferences regarding the relationship between drought, specific resilience indicators, and food security outcome indicators were drawn in subsequent climatic-

econometric analyses. This inference is examined through climate-econometric analysis, employing specific resilience variables identified in the RIMA analysis, alongside objective drought variables, household food security outcome indicators, and relevant statistics from the shiny RIMA tool in household fixed-effects regression panel models, as detailed in the methodology chapter.

The analysis of household resilience in the Somali Regional State highlights low and uneven resilience among rural households, with significant temporal and spatial variations across different zones and study periods. Using the FAO's Resilience Index Measurement and Analysis (RIMA-II) framework, resilience is defined as a multidimensional capacity reflecting households' ability to absorb, adapt to, and recover from shocks such as droughts. The measurement of household resilience through FAO's RIMA-II methodology specifically indicated a decline in the average RCI among rural households in the Somali Region, from 50.93 in 2019 to 45.5 in 2022 (Figure 4.3). This reduction is attributed to weakened asset and adaptive capacity pillars, particularly the decline in livestock (TLU), cropland (hectare), and herd diversity during the period of–2020-2022 drought. Appendix I (Table 4.9) contains information on the pillars, observed variables, and the two food security indicators (FCS and HDDS) used in the RIMA analysis. Spatial analysis revealed that only 26% of households in the Sitti, Jarar, and Nogob zones experienced RCI improvements, while zones like Shabelle, Jarar, and Dhawa showed stagnation. The bar graph in Figure 4.3 presents the RCI estimates for rural Somali households (N=313) by zones and waves of the ESPS (ESPS Waves 4 (2019) and 5 (2022)).

Figure 4.3: Average RCI by rounds (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/2011)) (left) and a Bar Graph (right) showing the average RCI by zones and rounds.





Sources: Author's computation for Somali rural households using two panel ESPS datasets (ESPS Wave 4 (2018/19) and ESPS Wave 5 (2021/22).

In both 2019 and 2022, male-headed households exhibited a higher RCI, with scores of 52.04% and 46.35%, respectively, compared with female-headed households, which had scores of 47.41% in 2019 and 42.13% in 2022. Neither group demonstrated any improvement in resilience during the study period.

Table -4.5: Household Resilience Analysis by Gender

Household-head gender	Average RCI (Wave-4)	Average RCI (Wave-5)	RCI improved over time?	N (Wave-4)	N (Wave-5)	Total N
Female	47.41	42.13	No	75	63	138
Male	52.04	46.35	No	238	250	488

As illustrated in Table -4.6, RIMA's MIMIC model demonstrates statistically significant correlation coefficients for the ABS, AST, and AC pillars ($p < 0.01$) across both waves of the ESPS. However, Social Safety Nets (SSN) do not show a significant correlation with RCI in ESPS Wave 5 (2021/2022).

Table-4.6: Multiple Indicators Multiple Causes (MIMIC) Model of Resilience Capacity Index: Coefficients of Structural and Measurement Components

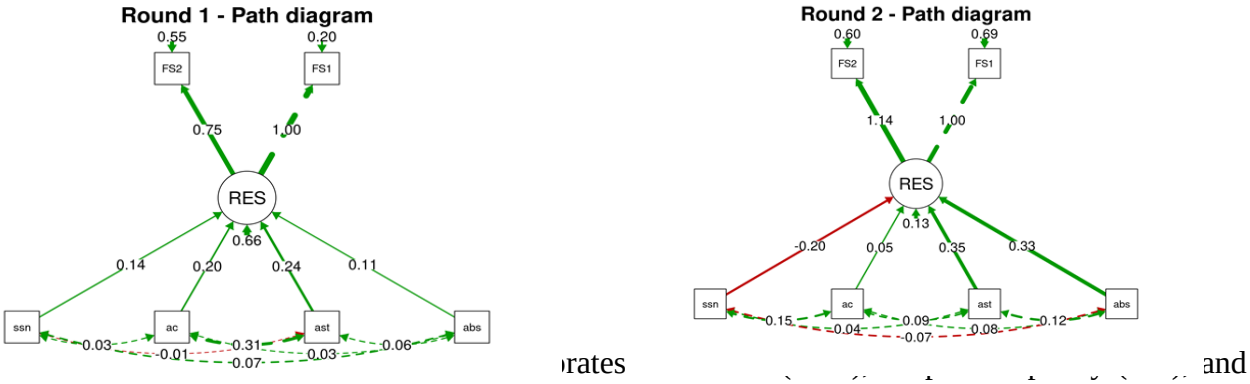
	ESPS Wave-4 (2019)	ESPS Wave-5 (2021)
Structural Component		
Access to Basic Services (ABS)	0.11	0.33
	(0.039)	(0.044)
Assets (AST)	0.24	0.35
	(0.063)	(0.036)
Adaptive Capacity (AC)	0.20	0.05
	(0.038)	(0.062)
Social Safety Nets (SSN)	0.14	-0.2
	(0.035)	(0.035)
Measurement Component		
Food Consumption Score (FCS)	1	1
	(0)	(0)
Household Dietary Diversity (HDDS)	0.75	1.14
	(0.052)	(0.062)
Goodness-of-fit statistics		
Tucker-Lewis Index (TLI)	0.969 (Good fit)	0.985 (Good fit)
Comparative Fit Index (CFI)	0.99 (Good fit)	0.995 (Good fit)
Root Mean Square Error of Approximation (RMSEA)	0.045 (Good fit)	0.027 (Good fit)

Observations (n)	313	313

Standard errors in parentheses. ***p<0.001

Figure 4.4 below presents the path diagram analysis of the MIMIC model, illustrating the standardized correlation coefficients of the structural and measurement components of the MIMIC model for each ESPS survey wave. The four pillars are hypothesized to positively influence resilience (RCI/RES), which is expected to correlate with the two food security indicators: the Food Consumption Score (FCS), and the Household Dietary Diversity Score (HDDS). To quantify resilience (RES), the FCS was assigned a fixed factor loading of 1.00, indicating that a one-standard deviation increase in resilience corresponds to a one-standard deviation increase in the FCS. This establishes the measurement scale for HDDS (Λ2) and the variance for both indicators, as detailed in the Methodology chapter. The upper section displays the measurement models linking RES to the two food security indicators, with coefficients indicating the expected changes per unit change in resilience. The central portion depicts the resilience structural matrix (RSM), illustrating the relationships between the pillars and resilience through green and red lines for positive and negative connections, respectively. The coefficients demonstrate the contributions of the pillars to household resilience, and visualize the relationships between the four pillars and resilience capacity.

Figure 4.4: Path diagram analysis for Wave 4 (top) and Wave 5 (bottom)



rates and access to basic services (ABS) were the most influential resilience pillars across both waves of the ESPS surveys. These key observed variables under each resilience pillar were identified based on their correlation coefficients in the MIMIC SRM component and factor analyses. Radar plot analyses, presented in Appendix III (Figures 6-9), illustrate the most relevant observed

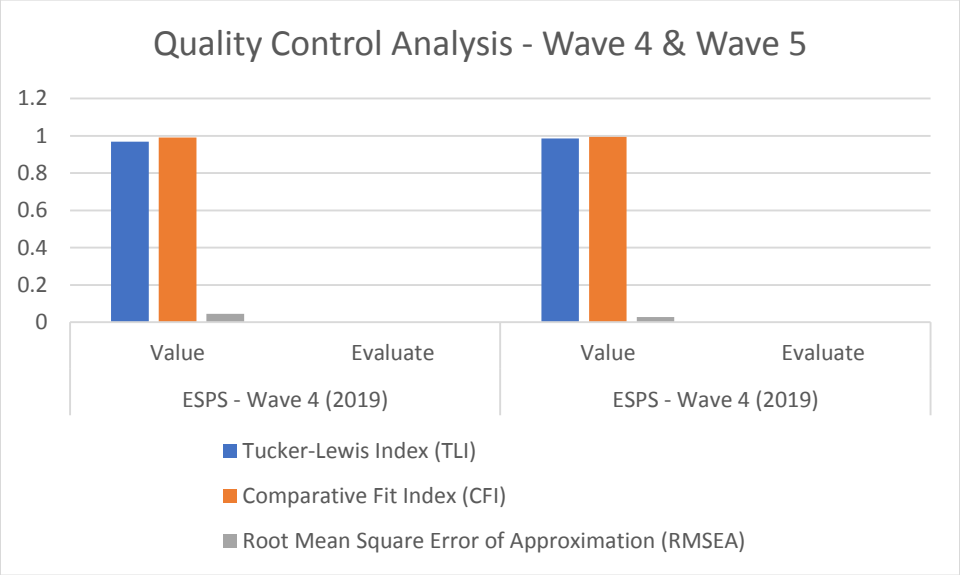
variables according to their correlations with their respective pillars across both waves of the ESPS surveys. Additionally, the results of the first-stage factor analysis of the MIMIC model are provided in Appendix II (Tables 10-13). In 2019, AST (0.24 coefficient) and AC (0.20 coefficient) exhibited a strong correlation with the RCI, whereas in 2022, ABS (0.33 correlation coefficient) and AST (0.35 correlation coefficient) demonstrated a dominant correlation, similar to the RSM in Table 4.6 above. The analysis further indicates that improvements in ABS are insufficient to fully counteract the negative impacts of asset depletion and declining adaptive capacity. Although initially significant in 2019, Social Safety Nets (SSN) displayed a statistically insignificant or even negative correlation with resilience in 2022, suggesting limitations in their design or implementation for fostering long-term household resilience. For assets, livestock holdings, cropland area, and wealth index were the most pertinent variables observed across both waves (2019 and 2022). The adaptive capacity pillar was strongly correlated with diversified income sources, livestock diversity, and access to savings and credits. The ABS was driven by proximity to markets, healthcare, and access to protected water sources, while SSN contributions primarily originated from formal and informal transfers, although the ABS pillar significantly declined and negatively correlated with resilience (the RCI) in 2022.

In summary, the study's MIMIC analyses identified three fundamental resilience pillars and key observed variables influencing rural Somali households' short- and long-term resilience. Consistent with recent findings, this study highlights the multidimensional and context-specific nature of resilience-building in addressing drought-induced food insecurity. The core resilience pillars are asset ownership, adaptive capacity, and access to basic social services, emphasizing the need to reinforce formal and informal social safety nets for sustainable resilience. Potential resilience indicators include diversified income sources, livestock diversity, and access to savings and credit from adaptive capacity; livestock holdings, cropland area, and household wealth from assets; and proximity to markets, healthcare access, and protected water sources from basic services. These variables were deemed most pertinent for the study's causal analysis in subsequent panel regression models, aiming to elucidate the interplay between drought shocks, specific resilience indicators, and the realized food security indicators. These observed resilience variables provide valuable insights for designing targeted policies and interventions that enhance household resilience and mitigate the adverse effects of recurrent droughts on food security in

rural Somali communities. However, the RIMA methodology carefully considers these observed resilience variables, their core pillars, and the resilience estimates identified using the MIMIC model, as they are descriptive and do not imply causal inference. Consequently, this study employs the potential observed variables identified in the RIMA analysis in its subsequent panel regression analysis to determine which specific resilience indicators significantly moderate the adverse effects of drought shocks on rural household food security, in line with recent empirical evidence from Birhan et al. (2021) and related literature.

Path analysis further substantiated a positive correlation between resilience and food security, particularly with respect to the Food Consumption Score (FCS) and Household Dietary Diversity Score (HDDS). Specifically, an increase of one standard deviation in resilience resulted in a 0.75 and 1.14 standard deviation increase in the HDDS during Waves 4 and 5, respectively. This association between resilience and the two food security indicators (FCS and HDDS) was mediated by key resilience drivers. These descriptive findings underscore the necessity of integrated resilience strategies that encompass asset building, livelihood diversification, enhanced access to services, and effective safety nets. The robustness of the MIMIC model corroborates these conclusions, and Figure 4.5 provides a summary of the reliability and fitness statistics for the RIMA-II framework employed in this study to evaluate rural resilience and inform targeted resilience-building interventions among rural households in the Somali Region.

Figure 4.5: A chart comparing the fit indices (RMSEA, CFI, TLI) for the ESPS Waves 4 and 5.



As illustrated in Figure 4.5, the performance statistics of the RIMA MIMIC model reveal a strong fit across Waves 4 and 5 of the ESPS data for rural households in the Somali Region. Both the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) surpassed 0.97 in each wave, indicating an excellent fit and demonstrating that the model aligned well with the observed data. A CFI value above 0.97 suggests that the model performs 97% better than a null model that assumes no relationships among the variables. The Root Mean Square Error of Approximation (RMSEA) values were 0.045 in Wave 4 and 0.027 in Wave 5, both below the 0.05 threshold, signifying a good fit for the data. These favorable fit indices confirm that the model effectively captures the underlying latent constructs and serves as a valid measure of resilience capacity among rural households in the region.

Overall, the findings of this study on the measurement and analysis of household resilience indicate a decline in the average Resilience Capacity Index (RCI) of rural households in the Somali region, decreasing from 50.93 in 2019 to 45.5 in 2022. This reduction is primarily attributed to diminished asset ownership and adaptive capacities resulting from decreased access to croplands, livestock holdings, and herd diversity. These changes are linked to increased exposure to and severity of both short- and long-term drought shocks in the years (2020/21) preceding the second round of the ESPS (ESPS Wave 5 (2021/22)). Male-headed households demonstrated higher RCI scores than female-headed households; however, neither group exhibited improved resilience over the study period. These findings are consistent with the existing literature that characterizes pastoral and agro-pastoral systems in Ethiopia as possessing inherently low resilience due to their dependence on climate-sensitive pastoral and agro-pastoral livelihoods and natural resources (Birhanu et al., 2017; Melketo et al., 2021; Tofu, Fana et al., 2023; Tofu, Mekuria et al., 2023). Tadess et al. (2021) identified key factors such as access to irrigation, water and soil conservation practices, availability of savings and credit, and the livestock diversification index as crucial for explaining variations in household resilience. Tofu et al. (2023) found that resilience in Eastern Ethiopia is underdeveloped, with scores falling below acceptable thresholds. They recommended integrated strategies for enhancing resilience, including sustainable natural resource management, livestock protection and enhancement, livelihood diversification, and access to social services and infrastructure improvements.

Although these studies did not explore the complex relationship between climate shocks, resilience, and food security outcomes, they emphasized that adaptive capacity, including diversified income sources, market access, sustainable water and rangeland resource management, and livestock diversity, is vital for resilience against climate extremes. Furthermore, several studies have identified challenges, such as inadequate service provision and limited adaptive capacity, as obstacles to pastoral community and household resilience against the compounding impacts of climate shocks (Birihanu et al., 2017; Debela et al., 2019; Mekuyie and Mulu, 2021; Tofu et al., 2023).

In this study, the analysis of MIMIC's RSM component highlights three pillars—AST, AC, and ABS—showing that investments in asset building, adaptive capacity, and basic social services are crucial for enhancing rural Somali households' resilience against drought impacts on food security. The decline in the RCI over the study period indicates the 2020-2022 drought eroded productive asset bases and adaptive capacities, while ABS improvements were insufficient to counter these effects in 2022. The RSM analysis found that the SSN pillar was not statistically significant and negatively correlated with resilience in 2022, suggesting deficiencies in design and/or implementation. This highlights the need for adaptive SSN mechanisms through integration with asset building, livelihood diversification, and increased investment in social services and infrastructure to ensure long-term resilience. These findings align with studies identifying AST, AC, and ABS as core elements of rural resilience (d'Errico et al. 2018; Brooks et al. 2019; Adger et al. 2020; Haile et al. 2022). Recent research emphasizes the importance of multidimensional resilience capacities in mitigating the impacts of drought on food security. Key resilience components include adaptive capacity (e.g., income diversification and herd heterogeneity), asset holdings (e.g., livestock and cropland), access to essential services (e.g., health, markets, and water), and social safety nets, notably the PSNP (Smith & Frankenberger, 2022; Knippenberg & Hoddinott, 2019; Wakeyo, 2024; Demisse et al., 2024; Birhanu et al., 2017). Previous studies (e.g., FAO, 2016; d'Errico et al., 2018) similarly suggest that resilience is significantly influenced by asset ownership, adaptive capacity, and access to basic services, serving as buffers against shocks. The impact of asset ownership, particularly livestock, on resilience is consistent with prior research emphasizing the role of productive assets in sustaining livelihoods and recovery (Tadesse et al., 2021). However, the

findings reveal a vulnerability: while livestock contributes positively to resilience under normal conditions, it becomes highly susceptible during droughts. This dual role underscores the need for diversification beyond primarily livestock-based production systems. The limited adaptive capacity observed reflects the structural constraints faced by rural households in the Somali Region. A heavy reliance on a narrow range of livelihood activities reduces households' ability to respond flexibly to environmental changes. This finding corroborates earlier studies that identified livelihood diversification as a key path to enhancing resilience (Mekuyie & Mulu, 2021). The SSN finding aligns with broader evidence and theoretical discussions in the resilience literature (FAO, 2016), cautioning that households receiving public and private transfers from formal and informal sources generally exhibit lower resilience scores, underscoring the need for adaptive social protection mechanisms (d'Errico et al., 2018; Haile et al., 2022).

The findings of this study, which are consistent with those of relevant past research, have several important implications for improving resilience in Ethiopia's pastoral regions. A multifaceted and integrated multidimensional approach is required, which includes enhancing productive asset bases (such as livestock and cropland holdings), promoting adaptive capacity (through diversified income sources, savings and credit access, and herd diversity), investing in basic social services and infrastructure (including access to health, market, and water resources), and leveraging both informal and formal transfers to develop effective social protection mechanisms for sustaining rural livelihoods amidst increasing drought risks (Birihanu et al., 2017; Debela et al., 2019; Zeratsion et al., 2023). By addressing these factors at the policy and targeted intervention levels, significant progress can be made toward ensuring resilient pastoral and agro-pastoral livelihoods in the Somali Region and other pastoral areas of Ethiopia, amid ongoing concurrent climate and economic challenges. While the FAO's RIMA analysis over the study period has provided insights into these potentially relevant resilience variables, the causal inference of these observed variables remains limited in understanding their moderating roles in the relationship between drought shocks and food security among rural Somali households, as these findings are primarily descriptive in nature. The following sections of this study aim to identify which specific resilience indicators significantly moderate the adverse effects of drought shocks on rural household food security by utilizing household fixed-terms panel regression models.

4.7. Empirical Findings

4.7.1 Interplay between Drought Shocks, Resilience and Food Security Outcome

Objective 3: Investigate the relationship between drought shocks and food security outcomes

This study's objective drought analysis based on historic observations of climate data confirmed an increase in the exposure and severity of both short- and long-term droughts in rural communities of the Somali Region in a year prior to the ESPS's second (ESPS Wave 5 2021/022). In this context, this study conducts an in-depth analysis of the effects of both types of prevalent drought shocks on realized rural household food security and examines specific resilience indicators that significantly mediate the adverse effects of these droughts on food security in the rural Somali region of Ethiopia. This was achieved using regionally representative socioeconomic panel datasets from the recent two waves of the ESPS integrated with climate data from the Global Drought Monitor and a range of climate-econometric methods. To examine the adverse effects of both short- and long-term drought shocks on the realized food security indicator, this study employed household fixed-effects panel regression models, as described specifically in Equations (5) and (6) in the Methodology chapter. The outcome variable used in the analysis was the natural logarithm of per capita daily kilocalorie (Kcal) consumption, which served as a proxy for food energy intake. The key explanatory variables are dummy variables of short-term drought (SPEI-6) and long-term drought (SPEI-24), capturing drought exposure and severity at different temporal scales, time-variant household characteristics, and household fixed effects. The findings will provide strong empirical evidence of a causal link between drought shocks and food insecurity, offering valuable insights for policymakers to effectively address food security challenges in the region.

Table 4.7 presents the results of Equations (5) and (6), respectively. Column 1 shows the results of the estimates of Equation (5), with the dependent variable being the log of daily per capita kcal consumption, drought shock variables (dummy 6-month and 24-month SPEI drought indicators), household characteristics at variable times, and fixed effects of the household.

Column (2) presents the results of the estimates of Equation (6), with the same dependent variable on a vector interaction term between the dummy drought indicators (SPEI-6 and SPEI-24) and a polynomial of the magnitude of location-normalized drought measures (W2it).

Table 4.7: Effect of short- and long-term droughts on per capita daily Kcal consumption realized

	Realized consumption			
	(1)	(2)	(3)	(4)
SPEI-6_drought	-0.052*	-0.071**		
	(0.023)	(0.023)		
SPEI-6_drought x SPEI-6		-0.056 *		
		(0.027)		
SPEI-24_drought			-0.062**	-0.109**
			(0.027)	(0.045)
SPEI-24_drought x SPEI-24				-0.110*
				(0.045)
N	626	626	626	626
R-squared	0.141	0.214	0.21	0.241

Note: All specifications use SPEI-6 and SPEI-24 climate data from the Global Drought Monitor and the ESPS Waves 4 (2019) and 5 (2022) panel datasets and include household control variables and fixed effects. The robust standard errors are indicated in parentheses. A short-term drought dummy variable is defined as 1 if the 6-month SPEI is < -0.1) and 0, otherwise. The same threshold (24-month SPEI < -0.1) was used to define a dummy variable for long-term drought shock $p < 0.01$, $p < 0.05$.

This study found negative and statistically significant effects of short- and long-term droughts on daily per-capita kilocalorie consumption among rural households in the Somali Region. However, the magnitude of the effect differed across the two types of drought shocks. Households affected by negative rainfall anomalies of short-term drought during the main rainy season experienced a 5.2% decline in their daily calorie consumption. This decline increased slightly to 6.2% when drought exposure was measured over consecutive rainy seasons on a 24-month SPEI timescale (i.e., long-term drought). Short-term drought disrupts pastoral and agro-pastoral production, reflecting immediate disruptions in food availability and access, leading to temporary reductions in food consumption. In contrast, long-term droughts cause chronic food insecurity through sustained reductions in household productive assets, such as livestock, limited diversified income sources, and water stress. Short-term drought (SPEI-6) was associated with a moderate decline in per capita kilocalorie (Kcal) intake, reflecting immediate disruptions to food access and availability. These short-term shocks primarily affect seasonal production and market supply, leading to temporary reductions in consumption levels. The results show that long-term

drought (SPEI-24) has a substantially larger and more cumulative negative effect on rural household food security outcome.

The inclusion of household fixed effects ensures that these estimates capture within-household changes over time, controlling for unobserved heterogeneity, such as time-invariant household characteristics. This strengthens the causal interpretation of the regression results, reflecting that the observed declines in food consumption are directly attributable to drought exposure, which is dynamic over time and space, rather than pre-existing differences between households.

Overall, the findings indicate that both short- and long-term droughts significantly reduced per capita daily Kcal consumption in 2022, by 5.2 % and 6.2% reductions in daily Kcal consumption from adverse effects of short- and long-term droughts, respectively. while Long-term drought had a more severe, prolonged, and widespread adverse effect on rural household food security outcomes across most zones of the Somali Region in 2022. These findings provide strong empirical evidence of a causal link between both types of drought shocks and food insecurity, reinforcing the argument that climate variability is a key driver of food insecurity in vulnerable regions (Demeke et al., 2011; Knippenberg et al., 2017; Lelamo et al., 2022). The negative and statistically significant effects of drought on caloric intake are consistent with previous studies (e.g., Asfaw et al., 2018; Kumar et al., 2021), which documented similar impacts in drought-prone areas.

The study results, therefore, reveal a significant association between short- and long-term droughts and a decline in per capita daily caloric intake, and hence, food insecurity. These results add to the limited body of empirical research that examines how climate shocks affect food security (Wineman et al., 2017), health (Cooper et al., 2019; Delbiso et al., 2017), and agricultural productivity (e.g., Lobell et al., 2011; Schlenker & Roberts, 2006). However, many of these studies offer preliminary evidence of the relationship between drought exposure and different well-being outcomes. In addition to demonstrating the association between and the effect of drought on various wellbeing outcomes, these studies imply that the drought impacts on wellbeing outcomes differ systematically among households because of variations in their capacities to deal with shocks.

Expanding upon these limited studies and aligning the panel polynomial regression models employed by Demissie et al. (2021), this study investigates the effects of drought on realized household food security for policy uptake in drought-prone pastoral areas of Ethiopia. Unlike most past empirical studies that focused on drought exposure, this study estimates the magnitude and possible nonlinear effects of drought shocks on per capita Kcal consumption to obtain a full picture of its effects on household food security. This is one of the primary reasons why most prior empirical studies have been unable to thoroughly investigate the impact of drought on household wellbeing outcomes. Such robust drought impact analyses might provide valuable insights into effective strategies for mitigating the adverse impacts of droughts on food security among the country's pastoral communities.

Furthermore, droughts are complex climate shocks that can occur over a wide range of timescales, from a month-long moisture stress to decades of water scarcity (Vicente-Serrano et al., 2012 as quoted in Birihanu et al., 2021). By incorporating both short-term (SPEI-6) and long-term (SPEI-24) drought objective indicators in the specification in Equations (5 and 6), which capture distinct agricultural and hydrological droughts, respectively, this study provides a robust quantitative analysis to understand how these different types of droughts' affect rural household food security in a different way (Bayissa et al., 2018; Birihanu et. al., 2021). A key finding of this study is the differential impact of short-versus long-term droughts on household food security outcomes. Short-term (agricultural) droughts reduce crop yields and livestock outputs, leading to immediate food shortages and income losses. Long-term (hydrological) droughts impose sustained water stress, impair natural resources and rural livelihoods over extended periods, and lead to chronic food insecurity. Understanding these differential impacts can inform targeted policy responses and actionable context-specific resilience-building interventions to address both immediate and chronic food security challenges in drought-prone regions (Upton et al., 2017; Demissie et al., 2021; Upton et al., 2022; UNDP, 2022; WFP, 2023). Short-term (agricultural) droughts reduce crop yields and livestock outputs, leading to immediate food shortages and income loss. Long-term (hydrological) droughts impose sustained water stress, impairing natural resources and rural livelihoods over extended periods and exacerbating chronic food insecurity. Understanding these differential impacts can inform targeted policy response

and actionable context-specific resilience-building interventions to address both immediate and chronic food security challenges in drought-prone regions (Birihanu, et al., 2017; Demissie et al., 2021; Upton et al., 2022; UNDP, 2022; WFP, 2023). The subsequent section presents and discusses the study's findings on testing and identification of the specific resilience indicators that mitigate significantly the adverse effects of short- and long-term drought shocks on realized per-capita Kcal consumption, using the interaction terms between drought exposure (dummy 6-month and 24-month SPEI variables) and key potential specific resilience variables identified in this study's RIMA analyses in the household fixed-effects panel models.

4.7.2. Mitigating Specific Resilience Factors

Objective 4: Identify specific resilience indicators

Building on the potential resilience variables identified through the RIMA analysis, this study identified specific resilience indicators that significantly mitigate the adverse effects of drought shocks on realized per capita daily kcal consumption, a core food security outcome indicator in resilience as a capacity approach. Table 4.8 (column1 and 2) reports the results for Equation (7) estimates using the interaction terms between potential resilience indicators and drought indicators (short-term, SPEI-6 month, and long-term, SPEI-24 month) with household fixed effects. The results revealed that the specific resilience indicators that significantly mitigated the adverse effects of both types (short- and long-term) of droughts were more or less in similar sets of indicators, but with mixed results based on the core roles of their respective resilience pillars in overall resilience and food security outcome indicators.

Table 4.8: Specific resilience indicators associated with attenuating the adverse effects of short- and long-term drought shocks on realized per capita Kcal consumption

	Realized consumption	
	Short term (6-months)	Long term (24-months)
Drought	-0.071***	-0.11***
	(0.019)	(0.017)
Diversified income sources	0.082***	0.180***
	(0.037)	(0.021)
Herd diversity	0.066*	0.110***
	(0.038)	(0.033)

savings and credit access	0.065**	0.072***
	(0.045)	(0.04)
Wealth index	0.044**	-0.027**
	(0.038)	(0.034)
Agricultural asset index	0.027**	-0.001
	(0.042)	(0.039)
Cropland area	0.072**	0.081**
	(0.048)	(0.012)
Livestock holdings (TLU)	0.079**	0.011**
	(0.037)	(0.032)
Protected water sources	0.071**	0.081**
	(0.043)	(0.013)
Market access	0.043*	0.182***
	(0.05)	(0.063)
Hospital/health facility access	0.074**	0.081***
	(0.052)	(0.064)
Informal transfer	-0.032	-0.014
	(0.036)	(0.029)
Formal transfer	-0.060	-0.013
	(0.039)	(0.039)
N	626	626
R-squared	0.34	0.42

Note: All specifications use SPEI-6 and SPEI-24 climate data from the Global Drought Monitor and the ESPS Waves 4 (2019) and 5 (2022) panel datasets and include household control variables and fixed effects. Robust standard errors are presented in parentheses. The variables (labeled "Income diversification × SPEI-6_drought," etc.) refer to the interaction terms between the drought variable and the resilience indicators. All resilience indicator variables were binary ($p < 0.01$, $p < 0.05$, $p < 0.1$).

For short-term droughts, key specific resilience indicators that significantly mitigated rural households from immediate food insecurity included income diversification ($\beta = 0.082$, $p < 0.05$), livestock holdings (TLU, $\beta = 0.079$, $p < 0.05$), cropland ownership ($\beta = 0.072$, $p < 0.05$), improved access to protected water sources ($\beta = 0.070$, $p < 0.05$), and health facilities ($\beta = 0.074$, $p < 0.05$). These results suggest that diversified income sources, productive asset bases, and access to essential services play vital roles in cushioning the immediate welfare effects of climate change shocks.

For long-term droughts, resilience capacity was strengthened more by income diversification ($\beta = 0.18$, $p < 0.01$), financial inclusion through savings access ($\beta = 0.072$, $p < 0.01$), livestock diversity ($\beta = 0.11$, $p < 0.05$), cropland ownership ($\beta = 0.081$, $p < 0.05$), market access ($\beta = 0.182$, $p < 0.01$), and improved water ($\beta = 0.081$, $p < 0.05$), and health service accessibility ($\beta = 0.081$, $p < 0.05$). The correlation coefficient for income diversification increased from 0.082 under short-term drought to 0.18 under long-term drought, underscoring the growing importance of non-farm livelihood activities, such as trade, wage labor, and microenterprises, in enhancing adaptive capacity and reducing dependence on climate-sensitive agriculture. Similarly, financial inclusion (savings and credit access), cropland area, and livestock diversification, as well as proximity to markets, protected water sources, and health facilities, contributed to long-term resilience by promoting climate-resilient investments against the long-term drought impacts on realized food security.

However, the results reveal that the formal and informal transfers from the social safety nets (SSN) pillar were not statistically significant and correlated negatively with realized per capita daily kcal intake for both short- and long-term droughts. These findings align with the results of the RIMA MIMIC analysis, which suggested potential flaws in their design and/or implementation and the need for adaptive SSN mechanisms through their integration with asset-building, livelihood diversification, and greater investment in social services and infrastructure development strategies to ensure long-term household resilience.

These findings align with empirical evidence highlighting context-specific moderating resilience indicators in Ethiopia's pastoral systems, including livelihood diversification, climate-resilient agricultural practices, enhanced productive asset bases, financial inclusion, and access to water and health services (Birhanu et al., 2017; Debela et al., 2019; Upton et al., 2022; Satish et al., 2024). Previous studies similarly emphasize that expanding income sources beyond rain-fed agriculture, through trade, wage labor, and credit access, reduces vulnerability to drought and enhances adaptive capacity (Tadesse et al., 2021; Demissie et al., 2021; Haile, 2022). Given the arid conditions of the Somali region, efficient water management and rangeland rehabilitation are indispensable for drought resilience (Peng et al. 2021; Bogale 2025). Improved livestock management, animal health services, and social networks also enhance rural livelihoods and food

security (Birhanu et al., 2017; Bogale & Erena, 2022; Lewis, 2017). Climate-smart strategies, such as crop and livestock diversification, adoption of drought-tolerant varieties, and soil and water conservation, further strengthen resilience (Feleke et al., 2025). However, the limited effectiveness of social safety nets without integration into broader rural livelihoods, asset-building, and human development strategies remains a key challenge (Bahru & Zeller, 2021; Abay et al., 2022; Daba et al., 2025).

In conclusion, this chapter shows that both short- and long-term droughts significantly reduce food security among rural Somali Regional State household. These effects were significantly moderated by household-specific resilience indicators. By quantifying the magnitude and nonlinear effects of these droughts on rural household food security and identifying specific resilience indicators, this study provides insights into resilience pathways that can mitigate the effects of droughts and enhance food security. The findings emphasize the importance of multidimensional, integrated, context-specific resilience-building pathways linking livelihood diversification, productive asset accumulation, financial inclusion, and improved access to markets, water, and health services. These specific resilience indicators are central to moderating drought-induced food insecurity. Strengthening these interconnected core resilience capacities and specific resilience indicators, alongside adaptive social protection systems, is essential for sustaining household food security in drought-prone areas of the Somali Region. This study also addresses the limited empirical evidence linking objective drought exposure, dynamic resilience factors, and food security outcomes in pastoral settings. Previous studies in Ethiopian pastoral areas and the Horn of Africa often used cross-sectional designs, treating resilience as static, and focusing on household-level resilience without integrating explicit objective drought measures and food security outcomes. Many studies have relied on self-reported shock exposure and recall-based surveys, limiting our understanding of the dynamic role of resilience in moderating the impacts of drought and climate variability on food security (Mekuyie et al., 2018; Melketo et al., 2021; Tofu et al., 2023; Demisse et al., 2024).

CHAPTER 5: CONCLUSION, LIMITATIONS, AND RECOMMENDATION

5.1. Summary

Policies to reduce the adverse impacts of drought shocks aim to either mitigate household exposure to drought shocks or strengthen household resilience to cope with, recover from, and adapt to the impacts of drought. Following the resilience-as-capacity approach, this study aimed to identify key context-specific resilience factors that mitigate the impacts of drought shocks on rural household food security outcomes over time in the Somali Regional State of Ethiopia, focusing on the complex relationship between drought resilience and food security. Specifically, this study first identifies and describes prevalent drought shocks and evaluates rural household food security profiles and trends from 2019 to 2022. Subsequently, the relationship between drought shocks and food security outcomes was investigated, and specific resilience indicators that effectively mitigated the adverse impacts of both short- and long-term droughts on realized food security outcome indicators (s) were identified. This study employed a mixed-methods research design that integrated qualitative and quantitative approaches to investigate the complex interplay between drought resilience and food security. The study commenced with a qualitative study using a grounded theory approach to understand local perspectives and insights into drought risks, drivers of vulnerability, coping strategies, and resilience factors against the impact of drought on rural household food security in the study area. These qualitative insights shed light on the underlying drivers of drought, vulnerability, and resilience factors, which are quite local and context-specific, while providing contextual framing for the study's quantitative analysis performed using the two panel datasets (ESPS Wave 4 (2018/2019) and ESPS Wave 5 (2021/2022)) from the ESPS, along with climate data derived from the Global Drought Monitor.

This study highlighted that both short- and long-term droughts in the Somali Region are becoming more frequent and severe, causing significant adverse effects on rural household food security. The results indicate a worsening rural household food insecurity situation between 2019 and 2022 owing to the adverse impacts of the severe and prolonged 2020 – 2022 drought in the region. The average household resilience capacity also declined from 50.93 in 2019 to 45.5 in 2022. This study indicates that the low resilience of rural households may explain the adverse impacts of drought, although specific resilience pillars, such as assets, adaptive capacity, and

access to basic social services, emerged as the most influential resilience capacities and helped mitigate drought impacts. The study also identified different resilience factors that are effective in mediating the impacts of short-and long-term droughts. These specific resilience indicators include diversified income sources, savings and credit access, livestock diversity, and access to essential services such as markets, protected water sources, and health facilities to mitigate the adverse impacts of long-term droughts.

Income diversification is the most effective resilience factor for enhancing resilience to the impacts of both short- and long-term droughts on rural household food security. By reducing reliance on climate-sensitive agriculture, diversified income sources strengthen household adaptive capacity. Access to savings, credit, and livestock diversity is crucial for fostering resilience. However, these adaptive factors must be strengthened through further investment in formal financial services and market access in rural communities in the Somali Region. Furthermore, enhancing access to vital social services and infrastructure, such as health facilities, improved water sources for domestic and agricultural use, and road access, is essential for sustaining rural household food security in the face of drought. The results also underscore the role of social safety nets, particularly when combined with sustainable diversified livelihoods and asset-building strategies, because their current design and implementation are limited to the impact of long-term droughts. These findings align with the literature on climate shocks and resilience in pastoral systems in the Horn of Africa, highlighting the need for context-specific approaches.

The findings of this study provide valuable insights into the intricate interplay between drought shocks, specific resilience factors, and realized food security outcomes among rural households in the Somali Regional State. The Somali Region illustrates the inadequacies of current food security policies in the face of recurrent and severe droughts in Ethiopia. By emphasizing the role of livelihood diversification, enhancement, and protection of productive assets, specifically enhanced livestock production and productivity, increasing financial inclusion, improving access to basic social services, and adaptive social safety nets, policymakers can foster environments that build rural household resilience and sustainable food security against the effects of droughts. Integrating these context-specific findings into policy frameworks and actionable programs is

crucial for enhancing resilience, promoting sustainable rural livelihoods, and ensuring food security in Ethiopia's drought-prone pastoral regions.

5.2. Conclusion

This study revealed that droughts in the Somali Region are becoming more frequent and severe, impacting rural households in different ways. It uses subjective shock data from its qualitative inquiry and self-reported shock data from two recent waves (Waves 4 (2018/19) and 5 (2021/22) of Ethiopian Socioeconomic Panel Surveys (ESPS), as well as objective drought measures from the Global Drought Monitor's high-resolution SPEI datasets, to study the adverse effects of drought on realized rural household food security in Ethiopia's Somali region. This study provides evidence of the complex relationship between drought, resilience, and household food security, while determining the magnitude and nonlinear effects of short- and long-term drought shocks on realized household food security outcome indicator and identifying specific resilience indicators that significantly mediate these effects of droughts in fragile rural contexts in Ethiopia's Somali region. This study contributes to the literature by providing specific information about how much drought reduces rural Somali household food security and which specific resilience indicators significantly mitigate these effects. It fills major evidence gaps in climate-economics literature for pastoral communities in Ethiopia, using panel socioeconomic datasets integrated with objective drought measures over time in the study period (2018 and 2022). By focusing on the Somali Region, the study aims to inform policy and sustainable food security through locally contextualized specific resilience-building pathways.

This study revealed a decline in rural household food insecurity between 2019 and 2022, along with a decline in resilience. This was mainly due to the adverse effects of drought shock. Short-term droughts cause immediate food shortages, whereas long-term droughts exacerbate chronic food insecurity by causing water stress, degrading natural resources, and undermining rural livelihoods over extended periods.

Specific resilience indicators, such as diversified income sources, savings and credit access, livestock diversity, and access to essential services such as markets, protected water sources, and

health facilities, mitigate the adverse impacts of both short- and long-term droughts. These findings suggest that pastoral systems require multidimensional and targeted context-specific resilience strategies to address the differential effects of short- and long-term droughts on the immediate and chronic food insecurity outcomes.

To improve resilience, policies should focus on improving the bases of productive assets, promoting livelihood diversification, expanding financial inclusion, and improving connectivity with essential social services and infrastructure. This would allow governments, NGOs, and donors to enhance resilience in Ethiopia's pastoral regions.

5.3. Addressing the Study's Limitations

To address broader aspects, a broader spectrum of socioeconomic and environmental variables should be incorporated to provide a more comprehensive and nuanced understanding of the intricate relationships involved. Factors such as income levels, access to education and roads, land tenure systems, rangeland and water resource access dynamics, and biodiversity should be considered along with climate data to provide a more complete picture of the challenges faced by rural communities in the Somali Regional State of Ethiopia.

In addition, there is a pressing need for interdisciplinary approaches that seamlessly integrate insights from climate science, social science, anthropology, economics, and local knowledge systems. This holistic approach enables researchers to develop more effective, culturally sensitive, and context-specific resilience-building strategies for children. By combining scientific data with traditional ecological knowledge, researchers can discover innovative solutions that are both scientifically valid and locally applicable to the region.

Furthermore, longitudinal studies spanning several years or even decades would be invaluable for tracking the long-term trends and efficacy of different interventions. These studies can help identify successful resilience-building strategies that have emerged organically within communities and households while assessing the long-term effects of external interventions.

Another crucial aspect is the role of technology in enhancing its resilience. Studies should explore how mobile technologies, remote sensing, and early warning systems can be effectively integrated into pastoral livelihoods to improve decision-making and risk management. Moreover, research should investigate into the gender dimensions of climate change impact and adaptation strategies in pastoral communities in the future. Understanding how climate change affects men and women differently can lead to more equitable and effective gender-differential resilience-building measures.

Such comprehensive research efforts could inform evidence-based policies and actionable program interventions that address the multifaceted challenges faced by pastoral communities regarding climate change and food insecurity. By providing policymakers with a more holistic understanding of the issues at hand, these studies can contribute to the development of more targeted and effective resilience-building strategies, ranging from improved access to climate information services to the implementation of sustainable natural resource management practices and livelihood diversification.

Ultimately, this expanded research agenda aims to bridge the gap between scientific knowledge and practical applications, ensuring that pastoral communities are equipped with the tools and strategies needed to navigate the complex landscapes of climate change and food security in the 21st century.

5.4. Policy Recommendations

The implications of this study extend beyond academia, advocating for actionable policy and practice interventions that strengthen rural household resilience against the adverse consequences of drought shocks on household food security outcomes in drought-prone regions, such as the Somali Regional State. The study underscores that protecting and enhancing productive assets (primarily livestock), diversifying rural livelihoods, and ensuring market access and financial inclusion serve as the most effective resilience factors that mitigate the adverse effects of both short- and long-term drought shocks among rural communities in the Somali Region. By identifying specific resilience indicators tailored to pastoral contexts, this study provides a

foundation for targeted policy responses and actionable programs aimed at enhancing household resilience and mitigating food insecurity in the face of frequent and severe droughts. At the core of policy recommendations, governments and government partners should reframe their policy strategies towards multidimensional and context-specific targeted resilience-building policy responses that directly address the complex relationship between drought, resilience, and food crises in the nation's pastoral areas.

5.4.1. Reorient Food Security Policy towards Structural Change

The results of this study emphasize that the Somali Region of Ethiopia is experiencing increasingly severe and recurrent short- and long-term droughts, which significantly compromise food security in rural households. Current national food security policies are based on a tripartite framework: (i) humanitarian aid for acute food insecurity, (ii) development initiatives aimed at chronic food insecurity and poverty, and (iii) safety nets for vulnerable populations. Although these measures are crucial, they often function in isolation and fail to address the underlying causes of vulnerability and context-specific resilience factors of the affected population. The findings of this study indicate that recurring severe droughts deplete assets, diminish adaptive capacity, and highlight the limitations of segmented strategies.

Policymakers must transition to integrated, transformative, and multidimensional strategies that explicitly connect humanitarian assistance with long-term livelihood enhancement and food security outcomes. This necessitates:

- Incorporating resilience as a primary goal in national food security policies, rather than treating it as an ancillary component of humanitarian and/or developmental efforts.
- Creating adaptive social protection frameworks that are responsive to shocks, scalable, and capable of enhancing households' productive assets and access to essential social services and infrastructure, instead of merely addressing immediate needs, is essential.
- Connecting humanitarian and developmental funding sources to prevent cycles of emergency assistance followed by disjointed recovery and development initiatives is recommended for future research.

5.4.2. Strengthen Productive Asset Bases and Livelihood Diversification

The study indicates that asset depletion, especially massive livestock loss, damage and/or limited access to farming cropland areas, and the associated market access are the primary factors contributing to diminishing resilience. The findings highlight that protecting and enhancing productive assets (primarily livestock), diversifying rural livelihoods, and ensuring market access and financial inclusion serve as the most effective resilience factors that mitigate the adverse effects of both short- and long-term drought shocks among rural communities in the Somali region.

Consequently, it is imperative for governments, non-governmental organizations, and funding bodies to

- Resources should be allocated towards primary productive asset protection, recovery, and enhancement initiatives (such as market-based livestock production, improved livestock husbandry and health services, livestock insurance, restocking programs, rangeland, and water resource restoration).
- Encourage the development of sustainable non-pastoral and non-agricultural income-generating activities, including trade, wage employment, small business ventures, and integration into the value chains of livestock and crop products.
- Broaden access to financial inclusion strategies, encompassing access to markets, microfinance, savings cooperatives, and formal financial systems, to facilitate investments in climate-smart, diversified livelihood options.

These strategies not only assist rural families in coping with the adversities of drought shocks but also mitigate the systemic reliance on rain-dependent pastoral practices, which are becoming increasingly untenable in light of recurrent drought shocks in the pastoral areas of the country.

5.4.3. Enhance Provision of Basic Social Services and Infrastructure

Access to markets, healthcare, water, and electricity is essential for building resilience. However, pastoral communities in the Somali Region continue to experience chronic under-investment in infrastructure and services, increasing their vulnerability to drought.

The priority actions include:

- Investing in rural infrastructure, particularly feeder roads, water harvesting and storage systems, and decentralized renewable energy, to enhance market access and essential social service delivery.
- Improving water management systems, such as irrigation schemes, rainwater harvesting, and groundwater recharge, to mitigate chronic hydrological stress, is essential.
- Expanding healthcare and veterinary services to minimize human and livestock losses during crises is essential in this regard.

These investments necessitate long-term commitment but offer transformative returns by alleviating the structural marginalization of pastoral communities.

5.4.4. Redesign Social Protection for Pastoral Contexts

This study revealed that existing social safety nets have minimal or detrimental impacts on long-term resilience. This reflects their emphasis on short-term solutions, insufficient alignment with productive asset building, and long-term sustainable rural livelihood strategies.
Policymakers and donors should:

- Redesign social protection systems to be tailored to specific contexts, integrating cash or food transfers with livelihood assistance (e.g., skills training, productive household and community asset creation, or subsidized insurance schemes).
- Scalable safety nets that can rapidly expand during drought periods and contracts in normal years should be established to minimize reliance on improvised emergency relief efforts.
- A gender-sensitive approach should be adopted to recognize the reduced resilience capacity of female-headed households and their restricted access to assets and services in the region.

This approach positions social protection as a tool for fostering resilience, rather than as a temporary fix for crises.

1.5. Actionable Program Practice Recommendations

5.5.1. Promote Knowledge Integration and Climate Adaptation

The results indicate that rural households are diversifying their income sources. This indicates that rural households are increasingly engaging in non-farm income-generating activities, such as trade, wage labor, and small businesses. This shift reduced dependence on climate-sensitive agriculture and strengthened household adaptive capacity. However, their adaptive capacities are hindered by insufficient climate-smart agricultural practices (crop and livestock production). Enhancing resilience requires integrating indigenous knowledge and local practices with scientific advancements and policy frameworks.

Key actions include:

- Investing in climate-smart crop and livestock methodologies, such as drought-resistant crops, enhanced livestock diversity, sustainable natural resources, and agroforestry practices is essential.
- Supporting community-driven natural resource management and bolstering collective efforts in rangeland and water governance.
- Facilitating participatory planning processes and ensuring that the perspectives of pastoral communities shape the development of resilience strategies and policies that honor mobile lifestyles.

These initiatives align with Ethiopia's Climate-Resilient Green Economy Strategy but require increased localization and contextual adaptation.

5.5.2. Reform Donor and NGO Programming Approaches

Donor and NGO interventions frequently perpetuate short-term relief cycles without addressing the underlying structural causes of food crises. The findings of this study advocate for a comprehensive re-evaluation of the current guidelines.

- Transition from project-to system-oriented strategies, integrating humanitarian, development, and resilience objectives within unified programming frameworks.

- Implementation of multi-year, adaptable funding models that facilitate the responsive management of changing drought conditions.
- Emphasize resilience indicators such as asset protection and enhancement, livelihood diversification, and access to services alongside conventional food security measures when formulating and assessing programs.

This shift necessitates moving away from the "structural reproduction" of outdated programming frameworks and promoting authentic structural transformation in food security policies and practices.

5.6. Future Research Directions

Considering the limitations of this study, its findings recommend future research directions as follows:

- Long-term longitudinal or panel data and advanced estimation methods should be used in future studies to monitor changes in food security outcomes and resilience attributes over an extended period to enhance our understanding of the complex relationship between drought shocks, specific resilience factors, and household food security outcomes.

- Investigate the gender dimensions of drought impact, resilience factors, and food security outcomes to ensure inclusive and gender-responsive interventions.

- Assess the scalability and reliability of successful resilience strategies across different contexts in pastoral regions.

In conclusion, this thesis contributes to advancing knowledge on climate resilience and food security by elucidating the complex interactions among drought shocks, specific resilience factors, and realized food security outcomes among rural households in the Somali Regional State. By addressing the identified gaps and leveraging insights from the existing literature, this study provides a foundation for informed decision-making and practical actions to enhance resilience and promote sustainable food security in drought-prone regions of the country. Implementing the proposed recommendations and pursuing future research directions will be crucial for building rural household resilience and maintaining food security amid frequent and severe impacts of drought shocks.

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Appendices: Additional Tables and Figures

Appendix I: Dimensions and Observed Variables used to estimate resilience (RIMA-II)

Table 4.9: Dimensions and Observed Variables used to estimate resilience (RIMA-II)

Observed Variables	Definition	Wave 4 Mean	Wave 4 SD	Wave 5 Mean	Wave 5 SD
Food Security Indicators					
Food Consumption Score (FCS)	measures dietary adequacy by combining consumption frequency, diversity, and nutritional value across eight standard food groups over a 7-day recall period	44.89	13.2	40.48	15.09
Household Dietary Diversity Score (HDDS)	a scoring system that quantifies food access quality based on the consumption of seven food groups over a flexible recall period, utilizing IFPRI's flexible reference approach;	4.22	0.92	4.48	1.09
Access to Basic Services (ABS)	Essential social services provided by the public play a key role in determining households' risk exposure.				
Access to Water	A dummy variable that takes the value 1 if the household has access to a protected water source and 0 otherwise.	0.45	0.5	0.46	0.5
Access to Sanitation	A dummy variable, taking the value 1 if the household has access to improved toilet facilities and 0 otherwise.	0.29	0.45	0.35	0.48
Access to Electricity	A dummy variable, taking the value 1 if the household has access to electricity and 0 otherwise.	0.47	0.5	0.47	0.5
Closeness to Market	The walking distance (one way) of the household dwelling from the functional market (in Km)	0.51	0.48	0.02	0.04
Closeness to Hospital/Health Facility	The walking distance (one way) of the household dwelling from the functional health facility (in Km)	0.32	0.43	0.35	0.44
Assets (AST)	Household wealth is an important risk-coping mechanism.				
Wealth Index	Index combining a number of durable assets (car, bicycle, electric/gas cooker, and mobile phone) owned by a household member.	0.48	0.25	0.38	0.26
Agricultural Asset Index	Index combining a number of agricultural assets (tractor, ox-plow, and machete) owned by a	0.33	0.26	0.16	0.22

	household.				
Crop Area	Hectares of owned cropland area	0.6	1.04	0.05	0.12
Tropical Livestock Unit (TLU)	Number of livestock (cattle, camels, sheep, goats, and poultry) owned in TLU	13.87	8.71	7.31	7.66
Adaptive Capacity	Household capacity to cope with and adapt to certain shocks.				
Number of Income Sources	Number of income sources a household has	2.47	0.85	2.09	0.64
Household's members literate	Number of a household members who are literate	1.79	1.68	2.63	2.26
Herd Diversity	The indicator represents the livestock herd composition of a household, assigning a value of 1 for each distinct type of livestock (e.g., cattle, sheep, goats, and camels) that the household keeps.	0.83	0.75	1.38	0.93
Access to Savings and Credit	A dummy variable, taking the value 1 if the household has access to savings and credit (formal and/or informal), and 0 otherwise.	0.26	0.44	0.4	0.49
Social Safety Nets (SSN)	Formal and informal access to public and private transfers to households from different sources that make up a substantial portion of poor households' annual income				
Access to Informal Safety Nets	A dummy variable, taking the value 1 if the household received informal transfers/gifts from friends, relatives, and community members in the last 12 months, and 0, otherwise.	0.38	0.49	0.63	0.48
Access to Formal Safety Nets	A dummy variable, taking the value 1 if the household received cash and/or in-kind transfers from formal sources in the last 12 months and 0 otherwise.	0.42	0.49	0.48	0.5
Value of Formal Safety Nets	The total amount of formal in-kind transfers received in the last 12 months by household members (in Birr); and	0.24	0.36	0.22	0.33
Access to Productive Safety Net Program	A dummy variable, taking the value 1 if the household participated in the ((PSNP) in the last 12 months, and 0 otherwise.	0.25	0.44	0.26	0.44
HH Control Variables					
Household Size	Numeric	6.73		7.1	
Female-headed HH	Dummy=1, if yes	0.24		0.2	
Age of HH head	Numeric	46.68		46.97	

Observations (n)	313	313	313	313

Appendix II: Factor Analysis Results for Access to Basic Services (ABS), Assets (ABS), Adaptive Capacity (AC) and Social Safety Nets (SSN) by Round – Table 4.10 – Table 4.13

Table 4.10: Factor Analysis Results for ABS by Round

	ESPS Wave 4 (2018/19)			ESPS Wave 5 (2021/22)		
ABS	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
abs_water	0.707	-0.489	0.261	0.627	0.363	0.475
abs_sanitation	0.312	-0.702	0.409	0.165	0.729	0.442
abs_electricity	0.581	0.058	0.659	0.71	0.216	0.449
abs_closeness_market	0.314	0.71	0.397	0.537	-0.532	0.428
abs_closeness_hospital/health facility	0.701	0.439	0.315	0.485	-0.444	0.567

Two factors were used to estimate the ABS as 2 in Wave 4. Together, they explained 59% of the variance. Two factors were used to estimate ABS in Wave 5. Together, they explained 53% of the variance.

Table 4.11: Factor Analysis Results for Assets (AST) by Round

	ESPS Wave 4 (2018/19)			ESPS Wave 5 (2021/22)		
AST	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
ast_wealth_index	0.242	0.777	0.338	0.501	0.716	0.236
ast_agasset_index	0.658	-0.41	0.338	-0.264	-0.023	0.93
ast_croparea	0.702	-0.289	0.338	-0.494	0.732	0.22
ast_tlu	0.554	0.515	0.338	0.822	-0.004	0.324

Two factors were used to estimate AST = 2 in Wave 4. They jointly explained 56% of the variance in the variables. Two factors were used to estimate the AST in Wave 5. Together, they explained 61% of the variance.

Table 4.12: Factor Analysis Results for Adaptive Capacity (AC) by Round

	ESPS Wave 4 (2018/19)			ESPS Wave 5 (2021/22)		
AC	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
ac_income_sources	0.709	0.273	0.423	0.806	-0.123	0.335
ac_members_literate	0.75	0.167	0.41	0.335	0.605	0.522
ac_herd_diversity	-0.28	0.692	0.443	0.646	-0.567	0.26
ac_saving & credit	-0.182	0.69	0.491	0.443	0.596	0.449

Two factors were used to estimate the AC in Wave 4. They jointly explain 56% of the variance in the variables. Two factors were used to estimate the AC in Wave 5. Together, they explained 61% of the variance.

Table 4.13: Factor Analysis Results for Social Safety Nets (SSN) by Round

	ESPS Wave 4 (2018/19)			ESPS Wave 5 (2021/22)		
SSN	Factor 1	Factor 2	Uniqueness	Factor 1	Factor 2	Uniqueness
ssn_informal	0.011	0.939	0.119	-0.076	0.788	0.373
ssn_formal	0.942	-0.099	0.103	0.892	-0.119	0.19
ssn_formal value	0.918	-0.035	0.157	0.919	-0.041	0.153
ssn_psnp	-0.329	-0.35	0.769	0.301	0.676	0.453

Two factors were used to estimate the SSN in Waves 4 and 5. They jointly explain 71% of the variance in each wave.

Appendix III: Pillars' Radar Plots – Figure 6 – 9

Figure 6: Pillar Radar Plots - Sub Variables Correlations with ABS Pillar during Waves 4 (in the left) and Wave 5 (in the right)

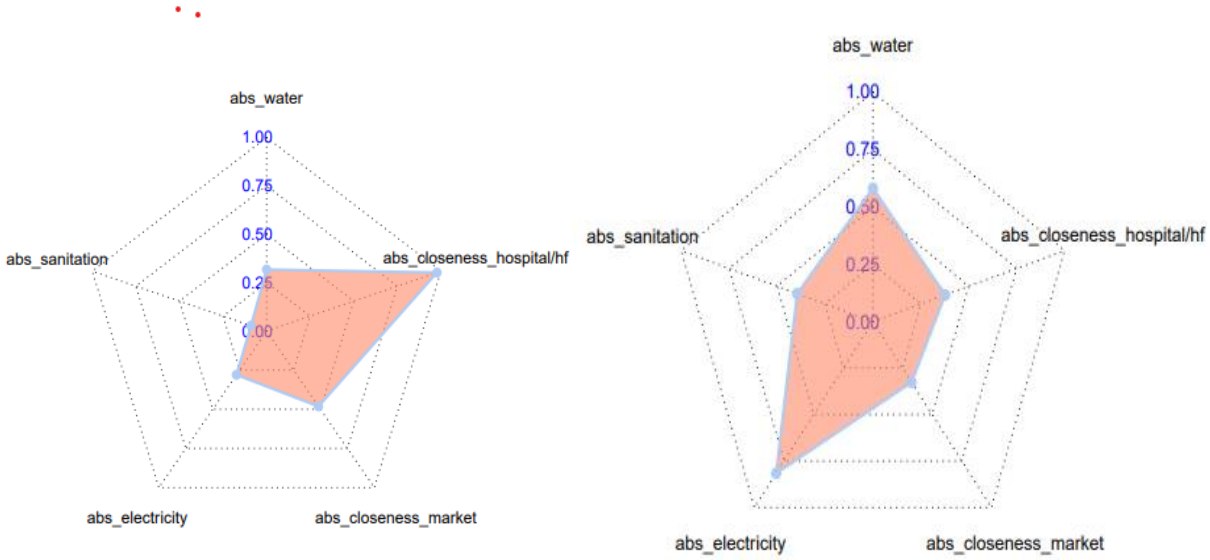

Figure 7: Radar Plots - Sub Variables Correlations with AST Pillar - Waves – 4 (in the left) and Wave 5 (in the right)

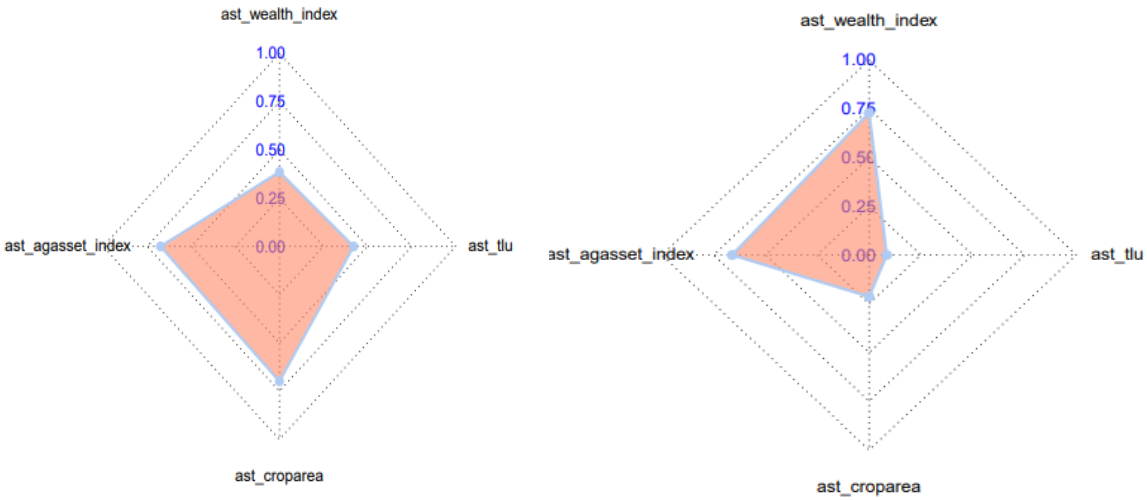

Figure 8: Radar Plots - Sub Variables Correlations with AC Pillar - Waves – 4 (on the left) and Wave 5 (on the right)

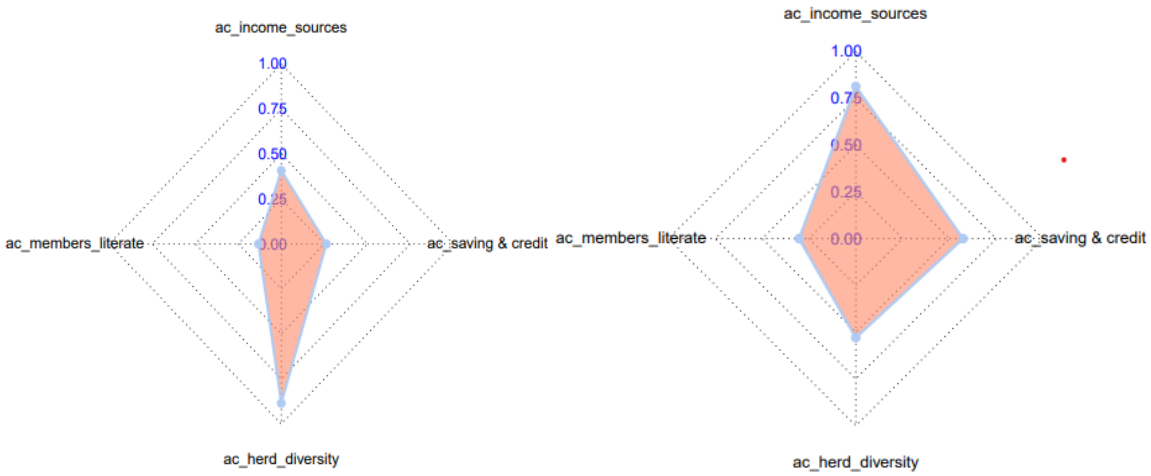

Figure 9: Radar Plots - Sub Variables Correlations with SSN Pillar - Waves – 4 (in the left) and Wave 5 (in the right)