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The Influence of the Food Environment on Dietary Quality and Nutrient Adequacy in Ethiopia

A Thesis Submitted to the Department of Food Business and Development

National University of Ireland, Cork

In Fulfillment of the Requirements for the Degree of Doctor of Philosophy

June 2026

By

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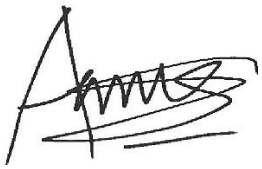
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Declaration

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism.

Andinet Abera Hailu



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June 2026

Dedication

This PhD thesis is lovingly dedicated to:

My late mother, Bektu Tesso Tura, whose love, resilience, and quiet strength continue to guide my life. Her sacrifices laid the foundation for every achievement I have made.

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Abbreviations

ASF	Animal Source Foods
CAPI	Computer-Assisted Personal Interviewing
CDDS	Child Diet Diversity Score
CotD	Cost of the Diet
COVID-19	2019 Novel Coronavirus
CPI	Consumer Price Index
CSA	Central Statistical Agency
DDS	Dietary Diversity Score
DQQ	Diet Quality Questionnaire
DQQ	Diet Quality Questionnaire
EA	Enumeration Areas
EDHS	Ethiopia Demographic and Health Survey
EPHI	Ethiopian Public Health Institute
ESS	Ethiopia Socioeconomic Survey
ETB	Ethiopian Birr
FANTA	Food and Nutrition Technical Assistance Project
FAO	Food and Agriculture Organization
FBDGs	Food-Based Dietary Guidelines
FDRE	Federal Democratic Republic of Ethiopia
FEWS NET	Famine Early Warning Systems Network
FFQ	Food Frequency Questionnaire
FFQs	Food Frequency Questionnaires
FGDs	Focus Group Discussions
FHI	FHI 360
FVS	Fruit and Vegetable Score
g	Gram
GDP	Gross Domestic Product
GDQS	Global Diet Quality Score
GDR	Global Diet Recommendations
GIS	Geographic Information Systems
GTP	Growth and Transformation Plan
HCES	Household Consumption and Expenditure Survey
HDDS	Household Dietary Diversity Score
HLPE	High-Level Panel of Experts on Food Security and Nutrition
Horti-LIFE	Horticultural Livelihoods, Innovation, and Food Safety in Ethiopia
ICF	ICF International
KII	Key Informant Interviews

LMICs	Low and Middle-Income Countries
MAD	Minimum Acceptable Diet
MAHFP	Months of Adequate Household Food Provisioning
MAR	Mean Adequacy Ratio
MDD	Minimum Dietary Diversity
MDD-W	Minimum Dietary Diversity for Women
NAR	Nutrient Adequacy Ratio
NCDs	Non-Communicable Diseases
NNP	National Nutrition Programme
OLS	Ordinary Least Squares
PhD	Doctor of Philosophy
PLW	Pregnant and lactating women
PSNP	Productive Safety Net Program
RDA	Recommended Dietary Allowance
SBCC	Social and Behaviour Change Communication
SD	Standard Deviation
SNNP	Southern Nations, Nationalities, And Peoples
USD	United States Dollar
WFP	United Nations World Food Programme
WHO	World Health Organization

Abstract

Improving dietary quality and micronutrient adequacy remains a critical public health challenge in Ethiopia, where food insecurity, seasonal shortages, and limited market access constrain nutritional outcomes. This thesis examines how the food environment (FE) shapes dietary quality and micronutrient adequacy, with a particular focus on women and children.

Using a mixed-methods approach, the study integrates household survey data, qualitative insights from focus groups and key informant interviews, and Cost of the Diet modeling to provide a comprehensive understanding of how the food environment influences dietary quality. A novel composite food environment score was developed to capture the various dimensions of the FE, including availability, market diversity, affordability, and infrastructure, and was strongly and consistently associated with all analyzed dietary quality measures.

This study shows that households with more favourable food environments achieve higher dietary diversity and micronutrient adequacy, although pronounced spatial and socioeconomic disparities persist across the study regions. Production diversity and seasonality further enhance micronutrient intake and buffer households against seasonal food shortages. For example, greater on-farm crop diversity—such as the cultivation of cereals, legumes, fruits, and vegetables—was associated with improved dietary diversity and micronutrient intake. Households producing a wider range of food groups (high production diversity) had significantly higher Women's Dietary Diversity Scores (WDDS) and Food Variety Scores (FVS). In addition, the study highlights the role of policies and programs, including agricultural extension services, nutrition-sensitive agriculture initiatives, and market access interventions, in enhancing the availability and accessibility of diverse, nutrient-rich foods. These findings underscore the importance of integrating crop diversification strategies with supportive food and nutrition policies to improve dietary outcomes.

However, economic pressures and market incentives often limit the translation of diverse production into actual consumption. Cost of the Diet analyses indicate that nutrient-adequate diets cost three to six times more than calorie-only diets, and only a minority of households can afford

them. Interventions such as agricultural diversification, food fortification, and low-cost nutrient-dense substitutes can lower diet costs, but persistent infrastructure and governance constraints continue to limit access to nutritious foods. Qualitative findings show that sociocultural norms, including religious fasting, gendered power dynamics, and perceptions of affordability, shape food choices, underscoring that improving physical or economic access alone is insufficient.

This thesis shows that Ethiopia's poor dietary quality and nutrient gaps are driven by concrete barriers in the food environment, including unreliable markets, high prices for nutritious foods, limited on-farm diversity, and gendered constraints that shape household food choices. Addressing these gaps requires integrated solutions that expand diverse production, lower the cost of nutritious foods, improve market access, and support women's decision-making. By synthesizing quantitative and qualitative evidence, this work provides clear, actionable guidance for designing more effective nutrition policies and programs.

Key Words: Food environment, dietary quality, micronutrient adequacy, Ethiopia.

1. Chapter One: Introduction

1.1. Background

Malnutrition remains a significant public health issue in low- and middle-income countries (LMICs), where chronic undernutrition, micronutrient deficiencies, and rising obesity rates coexist, creating a complex and diverse nutrition landscape (Global Nutrition Report, 2022; FAO et al., 2025). Ethiopia, a country with a mainly agrarian based economy, faces significant obstacles in achieving food and nutrition security, driven by a combination of socioeconomic, environmental, political, institutional, and technological factors (Abebe and Amare, 2025; Korir et al., 2024). In particular, religious practices such as fasting periods and dietary restrictions can influence food consumption patterns and nutrient intake. Addressing these interconnected challenges requires a comprehensive and systemic approach that targets both immediate nutritional needs and the long-term transformation of the food system to ensure sustainable food and nutrition security (Haas et al., 2025; Pittore et al., 2025).

In recent decades, Ethiopia has made significant progress in reducing hunger and undernutrition, as reflected by declines in child stunting from 51% in 2005 to 44% in 2011 and 37% in 2019 (CSA and ICF, 2012, 2005; EPHI and ICF, 2019). However, more recent evidence from the 2021 national food and nutrition survey, reported in 2023, indicates that this progress has slowed, with a slight increase in stunting rates in recent years. This stagnation may be linked to the combined effects of political instability, conflict, recurrent droughts, religious practices that influence dietary patterns (such as fasting periods), and other socioeconomic challenges that have disrupted livelihoods and food systems.

Malnutrition remains a serious public health issue, especially among vulnerable groups such as women and children. According to the recent national nutrition survey, 39% of children under five are stunted, 21% are underweight, and 11% are wasted (EPHI, 2023). Among women of reproductive age, 19% are underweight, with rural women being disproportionately affected. Dietary quality

remains a significant concern: only 8% of children aged 6–23 months consume five or more food groups daily, and just 7% of women meet the Minimum Dietary Diversity for Women (MDD-W) threshold of consuming at least five out of ten food groups per day, as recommended by the Food and Agriculture Organization (FAO) (2016). This highlights limited dietary variety and widespread micronutrient deficiencies across the population. These statistics emphasize the urgent need to improve diet quality and nutrient intake in Ethiopia to enhance health outcomes and achieve Sustainable Development Goal 2 (Zero Hunger).

The Ethiopian government has demonstrated a strong commitment to combating malnutrition through a range of strategic policy initiatives. These include the National Nutrition Program (NNP), launched in 2008 and updated in 2013 and 2016; the National Food and Nutrition Policy, introduced in 2018; and the Seqota Declaration, initiated in 2016 (FDRE, 2016; FDRE, 2018; EPHI, 2021). These policies work together to address the root causes of food insecurity and malnutrition by promoting a sustainable food systems approach. This involves efforts to improve the food environment, increase both physical and economic access to a variety of nutrient-rich foods, reduce micronutrient deficiencies, and respond to the rising burden of non-communicable diseases (NCDs).

Policy responses to persistent nutrition and food security challenges have increasingly adopted a food systems approach, recognizing that nutrition and food security outcomes are shaped by interconnected processes across the entire food supply chain, from agricultural production and processing to distribution, consumption, and waste management (Tendall et al., 2015; HLPE, 2017; FAO et al., 2020). This holistic strategy provides a structured basis for identifying critical points for consideration across the food system, while also highlighting key leverage points through which targeted interventions can enhance impacts on population health, social equity, and environmental sustainability. In this way, it plays a central role in supporting progress toward global development objectives such as the Sustainable Development Goals (Nguyen, 2018; Bhunnoo, 2019).

Within the broader food systems view, the concept of the food environment has emerged as an important lens for understanding the factors that influence dietary patterns and nutritional

outcomes. The food environment is often defined as the consumer interface with the food system and encompasses the availability, accessibility, affordability, and appeal of food, as well as the social, economic, and cultural factors that shape food choices (Herforth and Ahmed, 2015; Turner et al., 2020, 2018). In LMICs, this framework should not rely solely on market sources but also include cultivated and even wild foods (Downs et al., 2020). For instance, rural households often depend on subsistence farming, which is heavily affected by seasonality and agricultural diversity, but they also rely on local markets to supplement food needs, particularly for foods not produced on-farm or during periods of shortage (Sibhatu and Qaim, 2018). Meanwhile, urban populations rely more heavily on markets, where food availability and prices can fluctuate frequently. These dynamics directly affect how individuals and households access food, leading to disparities in diet quality across sociodemographic and economic groups.

Dietary quality is defined as the consumption of a diverse and balanced diet that meets nutritional requirements, and is a key determinant of nutrient adequacy (Arimond et al., 2010). Poor diet quality, characterized by low dietary diversity and reliance on staples, is a major contributor to micronutrient deficiencies in Ethiopia (Hirvonen et al., 2016; Hirvonen, 2019a, 2019b; Mohamed and Weldesilassie, 2021). Women and children are particularly vulnerable due to their higher nutritional needs and limited decision-making power over food choices (Smith et al., 2003; Visser and Wangu, 2021). Social gradients, including wealth status, education level, age, and sex, further exacerbate disparities in dietary outcomes, as they influence access to resources, knowledge, and opportunities to make healthier food choices (Black et al., 2013; Harris-Fry et al., 2015).

Agricultural production diversity plays a crucial role in shaping Ethiopia's food environment, where more than 80% of the population relies on smallholder farming for their livelihoods (CSA, 2019). A diverse agricultural system can significantly enhance household access to various nutrient-rich foods, including fruits, vegetables, legumes, and animal-source products—essential for addressing widespread micronutrient deficiencies (Jones et al., 2014).

However, the potential benefits of production diversity are often influenced by broader external factors, including food importation patterns, global food price fluctuations, and the effects of conflicts and wars, which can disrupt both international and domestic food supply chains. These global and regional dynamics interact with local production systems, shaping the availability, affordability, and stability of foods within Ethiopia's food environment. Consequently, the contribution of production diversity must be understood within this wider global food system context, where both local and external forces jointly determine dietary outcomes.

At the local level, seasonal fluctuations in agricultural output, limited access to functioning markets, and other economic barriers also hinder rural households from converting on-farm diversity into improved dietary outcomes (Sibhatu and Qaim, 2017). These challenges are particularly severe in remote areas with weak infrastructure and limited food storage and preservation options. Conversely, urban populations, who depend more on purchased foods, are affected by the diversity, quality, and affordability of foods available in local markets. In these settings, market factors such as food prices, supply chain efficiency, and vendor practices significantly influence dietary choices and nutritional status (Headey et al., 2018).

Understanding the relationship between market-based metrics, agricultural production, and socio-economic factors is crucial for creating effective, tailored interventions. A comprehensive strategy to enhance nutrition in Ethiopia must therefore address both production and consumption in the food system, ensuring that agricultural policies align with nutrition objectives and that market conditions promote fair access to a variety of affordable, nutritious foods.

Besides structural and economic factors, sociocultural norms, family dynamics, and gender roles greatly influence how food is allocated and consumed within households (Kimani-Murage et al., 2011; Harris-Fry et al., 2017). These social constructs often determine who eats what, when, and how much, often to the disadvantage of women and children, who may receive smaller or less nutritious portions. Economic challenges, such as low household income and rising food prices, further restrict access to nutrient-rich foods, particularly among vulnerable groups (FAO, 2021). Simultaneously,

behavioural factors such as individual food preferences, cultural dietary habits, and usual consumption patterns play a significant role in shaping how available foods are selected and consumed (Drewnowski and Specter, 2004).

Understanding these complex and interconnected influences requires more than quantitative data alone. Qualitative research is also vital for revealing the lived experiences, perceptions, and decision-making processes of individuals and communities dealing with food environments characterized by scarcity, inequality, and cultural differences (Aitaoto et al., 2015). Such insights are crucial for developing nutrition-sensitive interventions that are not only evidence-based but also socially and culturally suitable.

1.2. Statement of the research problem

Diets in Ethiopia remain consistently low in diversity, revealing deep structural issues within the national food system (EPHI, 2023). Many households still depend on subsistence farming, which limits the year-round availability and accessibility of nutrient-rich foods and reduces opportunities for dietary variety (Ruel and Alderman, 2013; Headey et al., 2019). These production challenges are compounded by broader weaknesses in the food system, including inadequate market infrastructure, poor transportation and market integration, limited cold storage and food processing facilities, price volatility, weak institutional support, and limited access to agricultural inputs and extension services, all of which shape local food environments where food variety, affordability, and access often fall short of supporting healthy, diverse diets (FAO et al., 2019). Traditionally, food security frameworks—particularly those aligned with the FAO approach—have emphasized sufficient energy supply, often prioritizing staple crop production. While this has contributed to improvements in calorie availability, it has not necessarily translated into access to diverse and nutrient-rich foods. As global and regional forces increasingly affect markets, supply chains, and agricultural practices, Ethiopian households remain vulnerable to limited market access, seasonal fluctuations in food supplies, and a heavy reliance on staples. These conditions hinder the adoption of nutritionally adequate diets and

contribute to long-standing micronutrient deficiencies across the population. Understanding how these interconnected food systems and the food environment factors affect dietary quality in Ethiopia is crucial for creating effective policies and interventions to improve nutrition outcomes and build more resilient livelihoods.

Despite growing recognition of the importance of a well-performing food environment in improving dietary quality among populations, significant gaps remain in the literature, particularly in low- and middle-income countries such as Ethiopia. Although several studies have examined dietary patterns across different population groups, including at the household level (Workicho et al., 2016; Ahmed Ali, 2020; Wolle et al., 2020; Mengesha, 2021; Kumma and Loha, 2023), among women (Hidru et al., 2020; Bitew et al., 2021; Geremew et al., 2024), and children (Moges et al., 2024), none have explored how the multidimensional food environment, which includes food availability, physical and economic access, home-production diversity and seasonality, and supportive infrastructure, shapes dietary outcomes. As a result, evidence on the pathways through which food environment characteristics affect diet quality in Ethiopia remains limited.

Building on the analysis of how different food environment factors, such as market food availability and food prices, affect access, it is important to examine the role of markets in supplying diverse foods and how this, along with their nutrient content, influences households' ability to afford the least-cost, nutrient-adequate diet across regions. A significant research gap remains in determining the minimum cost of a nutritious diet that accounts for local market diversity, as well as in assessing the affordability gap for vulnerable groups. Addressing this issue is essential, as it not only reveals the market's potential to achieve nutrient adequacy but also highlights disparities caused by regional, seasonal, and demographic variations, including differences across age groups. By estimating the minimum cost of a nutritious diet in each Ethiopian region and evaluating the affordability gap, this study aims to provide data to support targeted interventions and inform policy decisions to improve food security and reduce malnutrition among the most vulnerable populations.

Although the role of agricultural production diversity in improving dietary diversity has been explored widely in the literature, the interplay between production diversity, seasonality, and nutrient intake within the broader food environment remains understudied (Sibhatu et al., 2015; Sibhatu and Qaim, 2017; Sibhatu and Qaim, 2018). Many studies focus on either household-level production or market access in isolation, without considering how these factors interact to shape diet quality. Furthermore, the perceived social, economic, and behavioral factors influencing food choices in Ethiopia are often studied quantitatively, with limited qualitative research exploring individuals' perceptions and lived experiences within their food environments (Harris-Fry et al., 2017).

This research aims to fill these gaps by examining how the food environment affects diet quality and nutrient adequacy in Ethiopia, with a focus on households, women, and children. This study aims to provide a comprehensive understanding of the complex interrelationships between the food environment, agricultural systems, market access, and individual behaviors, ultimately supporting evidence-based strategies to enhance nutrition in Ethiopia.

This research hypothesizes that different areas within the overall food environment—covering both personal aspects (such as affordability, accessibility, convenience, and desirability) and external factors (including food availability, price, diversity of agricultural production, seasonality, and existing infrastructure)—affect nutrient intake and dietary patterns among individuals and households in different ways. Specifically, it suggests that changes in the performance and quality of the food environment lead to significant differences in dietary diversity and nutrient adequacy among study subjects. The study also expects that the interaction between personal and external food environment factors, along with supporting infrastructural factors, accounts for a significant portion of the observed disparities in nutritional outcomes across social factors such as wealth, education, and geography.

1.3. Research aim, objectives, and questions

1.3.1. General aim

This research goal to analyze the influence of the food environment on dietary quality and nutrient adequacy in Ethiopia.

1.3.2. Specific objectives

To accomplish this overall aim, the research aimed to achieve the following specific objectives:

1. To assess dietary patterns and nutrient adequacy at household and individual levels, and analyze disparities by wealth, education, and age.
2. To assess the availability and accessibility (physical and economic) of diverse foods at market levels
3. To examine how the comprehensive food environment and supporting infrastructure influence consumption patterns and dietary quality.
4. To examine the effects of agricultural production diversity and seasonality on nutrient intake within the broader food environment.
5. To estimate the minimum cost of a nutritious diet in the study regions and assess its affordability among different population groups, taking into account food diversity and market prices.
6. To explore community perceptions of the food environment and examine the socioeconomic and cultural factors that influence food access and dietary decision-making through qualitative inquiry.

1.3.3. Research questions

Based on the objectives above, the research questions (RQ) guiding this PhD research are:

RQ1. How do the composite and individual dimensions of the food environment influence dietary quality and nutrient adequacy?

RQ2. How do agricultural production diversity and seasonal fluctuations in food availability affect nutrient intake and the adequacy of consumption patterns among women and children when compared with recommended dietary guidelines?

RQ3: How do community perceptions mediate the relationship between the external food environment and actual food choice and consumption behaviours?

RQ4. How does the cost and affordability of nutrient-adequate diets vary across regions and seasons in Ethiopia, and what structural, market, and policy factors shape households' ability to achieve recommended nutrient requirements?

1.4. Contribution of the PhD thesis

Although there is growing scholarly and policy attention on the multiple aspects of malnutrition in Ethiopia, significant knowledge gaps remain in understanding how the food environment affects dietary quality, nutrient intake, and nutritional inequalities among vulnerable groups—especially women of reproductive age and young children. Current research often examines dietary intake in isolation or narrowly focuses on specific parts of the food system, such as market access or agricultural diversity, without considering the broader contextual factors that influence consumption. Additionally, there is limited empirical evidence on how local food availability and variety translate into actual nutrient intake, particularly for populations facing socioeconomic, geographic, and behavioral barriers to healthy eating. This thesis helps to bridge these gaps by applying a comprehensive food environment framework to explore the complex interactions between food system features and individual dietary outcomes. Hence, this study significantly advances the literature by providing a novel integrated analysis of how various aspects of the food environment interact to affect dietary outcomes in Ethiopia.

The study also situates agricultural diversity within the food environment, arguing that a significant portion of household food consumption in the country depends on home-grown supplies, which significantly shape the options available. By emphasizing the importance of local farming practices and seasonal variations, the research highlights how sustainable agriculture can help build a resilient food system that addresses the varied needs of Ethiopian households. Situating agricultural production diversity within the broader food environment and explicitly considering seasonal

fluctuations in dietary diversity and nutrient intake, this research highlights the dynamic interactions among agricultural cycles, market integration, and physical access. These factors collectively influence the availability and consumption of diverse, nutrient-rich diets. The study's findings offer policy-relevant insights for local food system planning, underscoring the need for seasonally responsive, geographically tailored strategies to improve dietary adequacy and resilience.

Building on the structural, agricultural, and behavioral factors that influence diet quality, this research introduces an essential economic perspective by quantifying the costs households face to meet nutrient needs. The analysis employs the Minimum Cost of a Nutritious Diet (CotD) model to estimate the lowest possible cost of achieving nutrient adequacy with locally available foods, accounting for food diversity, nutrient content, seasonal availability, and current market prices. By examining affordability gaps across socioeconomic groups and regions, the study highlights significant inequalities in economic access to nutritious diets, even when food supply or awareness are not constraints. By modeling practical, nutritionally adequate household diets, this analysis provides valuable insights into the financial barriers households face and potential solutions. In doing so, it complements the overall goal and offers policy-relevant insights to develop integrated, equitable nutrition programs and strengthen the broader food system.

This research demonstrates the potential of a comprehensive food-environment approach to enhance diet quality and nutrient intake, providing strong evidence for more targeted and equitable policy actions. Specifically, it should assist policymakers in allocating resources more effectively and in implementing market-based and agricultural interventions within a holistic food-environment framework, moving beyond fragmented, single-focus interventions. These insights are particularly timely and relevant to the execution of Ethiopia's recently endorsed Food and Nutrition Policy, National Nutrition Strategy, and the Seqota Declaration, all of which aim to reach nutritionally vulnerable groups through coordinated, multisectoral efforts.

Methodologically, the study empirically tests a comprehensive framework for understanding the food environment by combining household survey data with assessments of the market food

environment. This holistic approach to evaluating the overall food environment offers a model for future research in LMIC settings, enabling replication and adaptation in other regions facing similar nutritional and food system challenges. Therefore, this research advances the use of the comprehensive food environment framework in a complex, low-income context, contributing to the ongoing discussion about the link between food systems and nutrition. Additionally, it provides contextual data on factors affecting dietary diversity and nutrient adequacy among Ethiopia's most vulnerable populations; data that has previously been limited.

In summary, this research challenges fragmented efforts to improve nutrition that focus on single entry points, such as increasing agricultural diversity, expanding market food availability, or promoting behavior change in isolation. Instead, the evidence shows that meaningful and sustained progress toward nutrition equity requires integrated, multisectoral strategies that address market dynamics, production systems, sociocultural influences, and individual behaviors together, recognizing their interdependence within the broader food environment.

1.5. Thesis layout

This thesis presents a systematic investigation into the impact of the food environment on dietary quality and nutrient adequacy in Ethiopia, centred around the four research questions.

Chapter one introduces the study by outlining the contextual background, articulating the research problem, and presenting the aims, objectives, research questions, and the broader significance of the inquiry.

Chapter two establishes the scholarly foundation through a comprehensive literature review that critically examines existing research on food systems, dietary diversity, and nutrition outcomes, with a particular emphasis on Ethiopia and comparable low- and middle-income country contexts.

Building on this foundation, Chapter three presents the conceptual framework, delineating the theoretical perspectives and key constructs that underpin the research design. It also maps the

hypothesized relationships between food environment dimensions and dietary outcomes, thereby guiding the empirical analysis in subsequent chapters.

The following four chapters present the empirical findings derived from the methodologies and analyses employed to address the research questions. Each chapter is structured as an individual academic paper, two of which had been published at the time of writing. Accordingly, there is no separate methodology chapter; instead, methodological approaches are integrated within each empirical paper. This structure enables a clear and context-specific presentation of methods and results, ensuring that each study is self-contained while collectively contributing to the overall research objectives.

Chapter four presents the main analytical findings focused on the first research question, examining how the dimensions and combined effects of the food environment influence dietary quality and adequacy. The analysis highlights the varied impacts across population groups and geographic areas, providing detailed insights into the structural factors that shape diet quality.

Chapter five examines how the diversity and seasonality of agricultural production affect nutrient intake and food choices by analyzing the impact of farming cycles and crop variety within the larger food environment. In low-income countries like Ethiopia, where a large part of the population relies on subsistence farming, farm production is a crucial component of the food environment. Unlike in high-income regions, where food access is often shaped by markets, rural households in Ethiopia frequently depend on what they grow or gather, making agricultural diversity and seasonal availability vital to diet quality. This chapter emphasizes the need to include on-farm food sources in food environment frameworks to better reflect the realities of food access and nutrition in these settings.

Chapter six offers a qualitative perspective on how individuals and communities perceive and interact with their food environment, highlighting the socioeconomic and cultural factors that influence food access and dietary choices. In low-income areas such as Ethiopia, where food systems are highly local and shaped by both formal and informal structures, understanding lived experiences is essential to capturing the complexity of food environments. This chapter uses in-depth interviews

and focus group discussions to demonstrate how factors such as income, gender roles, cultural norms, and social networks impact food-related behaviors. By emphasizing community voices, this chapter complements the quantitative data and stresses the importance of context-specific, people-centred approaches to improving food access and nutrition policy.

Chapter seven expands the analysis by introducing a modeling-based approach to examine the affordability and accessibility of nutritious diets within local food environments. It starts by assessing the potential of regional markets to support nutrient-adequate diets, using a cost of the diet model that integrates information on locally available foods, market prices, nutrient content, and household purchasing power. This modeling framework offers region- and season-specific insights into how economic access and food availability influence dietary adequacy. By measuring the cost of a nutrient-adequate diet and identifying affordability gaps among low-income households, the chapter provides evidence to inform policy actions to improve the affordability of healthy diets and strengthen food systems in Ethiopia.

Chapter eight presents an integrated synthesis of findings from earlier chapters to address the PhD thesis's overall research objectives. It draws on both quantitative and qualitative analyses to show how components of the food environment interact to influence diet quality and nutrition outcomes. This foundation supports exploration of the research's broader theoretical, policy, and methodological implications, highlighting its significant contributions to the literature on food systems and nutrition, particularly in low-income country contexts. The chapter also presents a general conclusion based on the thesis's key findings and their importance for improving food and nutrition security. It provides evidence-based recommendations for policy and practice, highlights key areas for intervention, and offers directions for future research.

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2. Chapter Two: Food Environments, Diet Quality and Nutrient Adequacy - A Comprehensive Review of the Literature

2.1. Introduction

The link between food environments, dietary quality, nutrient adequacy, and broader determinants of nutrition and health is a subject of growing scholarly and policy interest on a global scale (Shafiq, 2017; Ahmed et al., 2018; Caspi et al., 2012; Downs et al., 2020; Turner et al., 2020). Food environments are defined as the physical, economic, policy, and socio-cultural contexts in which individuals engage with the food system to procure or consume food and are widely recognized as critical determinants of what people eat and their subsequent health outcomes (Swinburn et al., 2013). In low- and middle-income countries (LMICs), including Ethiopia, these interactions are deeply rooted in market dynamics, smallholder agricultural outputs, and, at times, fragile contexts shaped by diverse structural, economic, and cultural factors.

Although undernutrition and micronutrient deficiencies have long been recognized, there is growing awareness that issues with diet quality have become a more complex public health challenge. The rise of overweight, obesity, and diet-related non-communicable diseases (NCDs), alongside ongoing undernutrition, constitutes the "triple burden of malnutrition"—a phenomenon increasingly seen in low- and middle-income countries, including Ethiopia (Chilot et al., 2023; Hawkes et al., 2015; Tarekegn et al., 2022). This shift highlights the importance of considering not only food availability but also the broader factors that influence how individuals and households choose to acquire and consume food. In Ethiopia, these issues are exacerbated by rapid urbanization, changes in food systems, shifts in agricultural production, recurrent food insecurity, and significant seasonal fluctuations in food access, climate change and conflict (Abebe, 2024; Hirvonen et al., 2016; Worku et al., 2017). These structural factors interact with deep-seated social and cultural norms, gender roles, and varying levels of nutritional knowledge, creating a complex environment that directly and

indirectly impacts dietary habits and nutritional outcomes (Jayasinghe et al., 2025; Ranilović and Barić, 2013; Trübswasser et al., 2020).

Research on food environments has expanded over the past decade, exploring how factors like market access, food affordability, and the variety of the food supply influence healthy eating habits (Herforth and Ahmed, 2015; Turner et al., 2018). Researchers are increasingly aiming to move beyond individual and household factors to examine how the broader food system affects or supports dietary choices and nutrient intake. In Ethiopia, efforts to improve dietary quality must address both the need to increase food production and the challenge of ensuring that greater food availability results in better nutritional outcomes (Workicho et al., 2016).

This chapter offers a critical overview of local and global evidence on key trends, patterns, and factors that influence dietary quality and nutrient adequacy, with a focus on how food environments affect these outcomes. Building on the introduction, the review explores how structural, economic, agricultural, and socio-cultural aspects of food environments shape what people can access, afford, and eat. By examining evidence from previous studies, the chapter demonstrates how food availability, affordability, market access, production systems, and social norms interact to affect dietary choices and nutritional health.

2.2. Dietary quality and nutrient adequacy

2.2.1. Defining dietary quality

Dietary quality is a complex concept that assesses how well an individual's or a population's diet aligns with established nutritional standards and health-promoting dietary guidelines. It encompasses both the adequacy and balance of nutrient intake and the diversity and moderation of eating habits (Kant, 1996; Alkerwi, 2014). Evaluating dietary quality involves comparing macro- and micronutrient levels, food variety, and adherence to dietary recommendations to prevent nutrient deficiencies and chronic diseases (Ruel, 2003). The concept originated in nutritional epidemiology, which has evolved to identify diet-related risk factors for non-communicable diseases (NCDs) and to

inform public health nutrition strategies (Fry and Anderson, 2024). Kant (1996) was among the first to define dietary quality in terms of nutrient density, dietary variety, and moderation, emphasizing that a high-quality diet should provide essential nutrients without excessive energy intake or harmful components. Despite its increasing significance, defining and measuring dietary quality remains challenging due to its complex, multidimensional nature and the variation in diets across different populations (Alkerwi, 2014).

Global guidelines, such as those from FAO and WHO, provide recommended intakes for macro- and micronutrients, but these standards vary by age, sex, and physiological status, making them difficult to apply across diverse settings (Joint FAO/WHO Expert Consultation, 2004). Estimating nutrient adequacy is further complicated by reliance on food composition tables, which often lack complete or region-specific data and are influenced by variability in nutrient content due to crop variety, soil quality, and post-harvest handling (Charrondiere, 2021). Cooking methods also affect nutrient availability, especially for water-soluble vitamins such as vitamin C and the B vitamins, which are particularly vulnerable to losses during boiling or prolonged heating (Kwan, 2024). These limitations underscore the importance of using context-specific approaches to evaluate dietary quality and nutrient adequacy, especially in low-resource settings.

2.2.2. Dietary diversity and healthy eating indices

Dietary diversity is commonly used as an indicator of dietary quality and nutrition security. It reflects the number of different food groups consumed over a specific period, indicating nutritional adequacy and food access (Hoddinott and Yohannes, 2002). For example, the Minimum Dietary Diversity (MDD) indicator measures intake of ten specified food groups and has been recognized as a proxy marker of micronutrient adequacy among women (Arimond et al., 2010; FAO, 2016). Its straightforwardness and relevance in resource-constrained environments make it especially useful in Ethiopia and similar countries, where detailed dietary intake data are limited. However, it is important to recognize the absence of quantitative information: an individual or household may have a diverse

diet but consume it in very small amounts and still be highly food insecure, even when their dietary diversity score suggests otherwise.

Developed mainly in high-income countries, composite indices such as the Healthy Eating Index (HEI), Mediterranean Diet Score, and Diet Quality Index assess adherence to dietary guidelines based on food group servings, nutrient recommendations, and limits on unhealthy components (Guenther et al., 2013; Murphy et al., 2006). These indices provide comprehensive evaluations but often require detailed dietary intake data and may not fully consider local dietary habits or food availability in LMICs.

Quantitative assessments also include calculating Nutrient Adequacy Ratios (NAR) and Mean Adequacy Ratios (MAR), which compare individual nutrient intakes to recommended dietary allowances (RDAs) (Foote et al., 2004). These ratios enable precise evaluation of micronutrient sufficiency but rely on accurate dietary intake data and food composition tables, which can be difficult to obtain in low-resource settings.

Complementing nutrient-based indicators, the Food-Based Dietary Guidelines (FBDGs) contextualize dietary quality within culturally relevant dietary advice, promoting foods that improve nutrient adequacy while respecting local food habits and preferences (Herforth et al., 2019). Ethiopia has developed national dietary guidelines, which can help tailor dietary quality assessment and interventions (EPHI, 2022). Notably, the Ethiopian FBDGs provide detailed quantitative recommendations for daily intake of major food groups across different age groups and fasting practices, offering a practical framework for evaluating diet quality in diverse settings (Table 2.1).

Dietary quality is a key factor influencing both undernutrition—manifested as stunting, wasting, and micronutrient deficiencies—and the increasing prevalence of overweight, obesity, and diet-related non-communicable diseases (NCDs) (Popkin et al., 2020; Miller et al., 2020). In low- and middle-income countries (LMICs), including Ethiopia, poor dietary quality plays a significant role in widespread micronutrient deficiencies (such as iron, vitamin A, and zinc) and the rising trend of overweight in urban areas (Getacher et al., 2023; Gowele et al., 2021). Improving dietary quality is

therefore crucial to enhancing nutrient adequacy and promoting long-term health outcomes. Nutrient-rich diets that include a diverse range of minimally processed foods from multiple food groups support immune function and cognitive development in children and reduce the risk of chronic illnesses (Black et al., 2013).

Table 2.1. Ethiopian food-based dietary guidelines recommended daily intake of food groups by population segments (g/day)

Food Group	General Population (≥2 yrs)	2–5 yrs	6–18 yrs and 65+ yrs	19–64 yrs (non-fasting)	19–64 yrs (Intermittent Fasting)	19–64 yrs (Continuous Fasting)
Grains, roots and tubers	570	490	600	650	600	600
Pulses	90	90	115	90	100	200
Nuts and seeds	15	15	10	15	15	50
Milk and dairy foods	250	200	200	250	250	0
Meat and eggs	30	30	50	45	40	0
Fruits	150	100	150	150	150	200
Vegetables	130	75	95	120	130	135
Fats and oils	15	15	15	15	15	15
Added sugar and SSBs	15	15	15	15	15	15
Salt	<5	<5	<5	<5	<5	<5
Alcohol	50	0	0	50	50	50

Source: Ethiopian Public Health Institute (2022). Food-Based Dietary Guidelines

In LMICs, dietary quality is influenced not only by individual choices but also by complex food environments marked by availability, affordability, cultural preferences, and socio-economic status. Moreover, seasonal fluctuations in food supply and reliance on subsistence farming significantly affect dietary diversity and quality in rural areas (Herforth and Ballard, 2016). Urbanization and market transitions further increase access to processed and ultra-processed foods, which can sometimes reduce traditional dietary quality but also create new opportunities for more diverse diets (Popkin et al., 2020). At the same time, there is emerging evidence of increasing exposure to ultra-processed

foods (UPFs) in Ethiopia, particularly in urban areas and among wealthier households. Although UPFs still contribute a relatively small share of total dietary energy, their consumption is rising, with commonly consumed items including biscuits, soft drinks, and other packaged foods, especially among children (Gebremedhin and Gashu, 2025)

2.3. Global patterns of diet quality and micronutrient deficiency

Micronutrient deficiencies remain a significant global public health problem, especially in low- and middle-income countries (LMICs) across sub-Saharan Africa, South Asia, and Latin America (FAO et al., 2025). Although progress has been made in reducing some forms of undernutrition, deficiencies in vitamin A, iron, iodine, calcium, and zinc, in particular, still pose health and productivity risks worldwide (Liu et al., 2022; Stevens et al., 2015). Diet quality, which encompasses adequacy, diversity, and balance, is crucial for preventing these deficiencies, and recent global assessments reveal significant disparities in access to nutritious, nutrient-dense foods.

Figure 2.1 shows regional variation in the achievement of key diet quality indicators, highlighting disparities in dietary patterns across five global regions: the Americas, Asia Pacific, Europe and Central Asia, the Middle East and North Africa, and Sub-Saharan Africa. The figure presents four diet quality indicators. These include meeting all five core Global Diet Quality Score (GDQS) measures (All-5), defined as consuming at least one serving of vegetables, fruits, legumes, nuts or seeds, and whole grains. The other indicators are consuming at least one serving of animal-source foods, consuming at least one serving of vegetables, and meeting the Minimum Dietary Diversity for Women (MDD-W). The data show substantial regional differences in the proportion of the population meeting these diet quality indicators, with average levels from 2021 to 2024.

Evidence shows that Sub-Saharan Africa consistently exhibits poorer dietary quality than other regions across all four measures, and Ethiopia's situation is even worse. In Sub-Saharan Africa, only about one-quarter of the population meets the "All-5" indicator, reflecting limited achievement of minimum dietary diversity compared with other regions. While a relatively high share of the

population consumes at least one meal of vegetables (around three-quarters) a day, this remains lower than in Europe and Central Asia and the Middle East and North Africa, indicating challenges in both access and regular consumption.

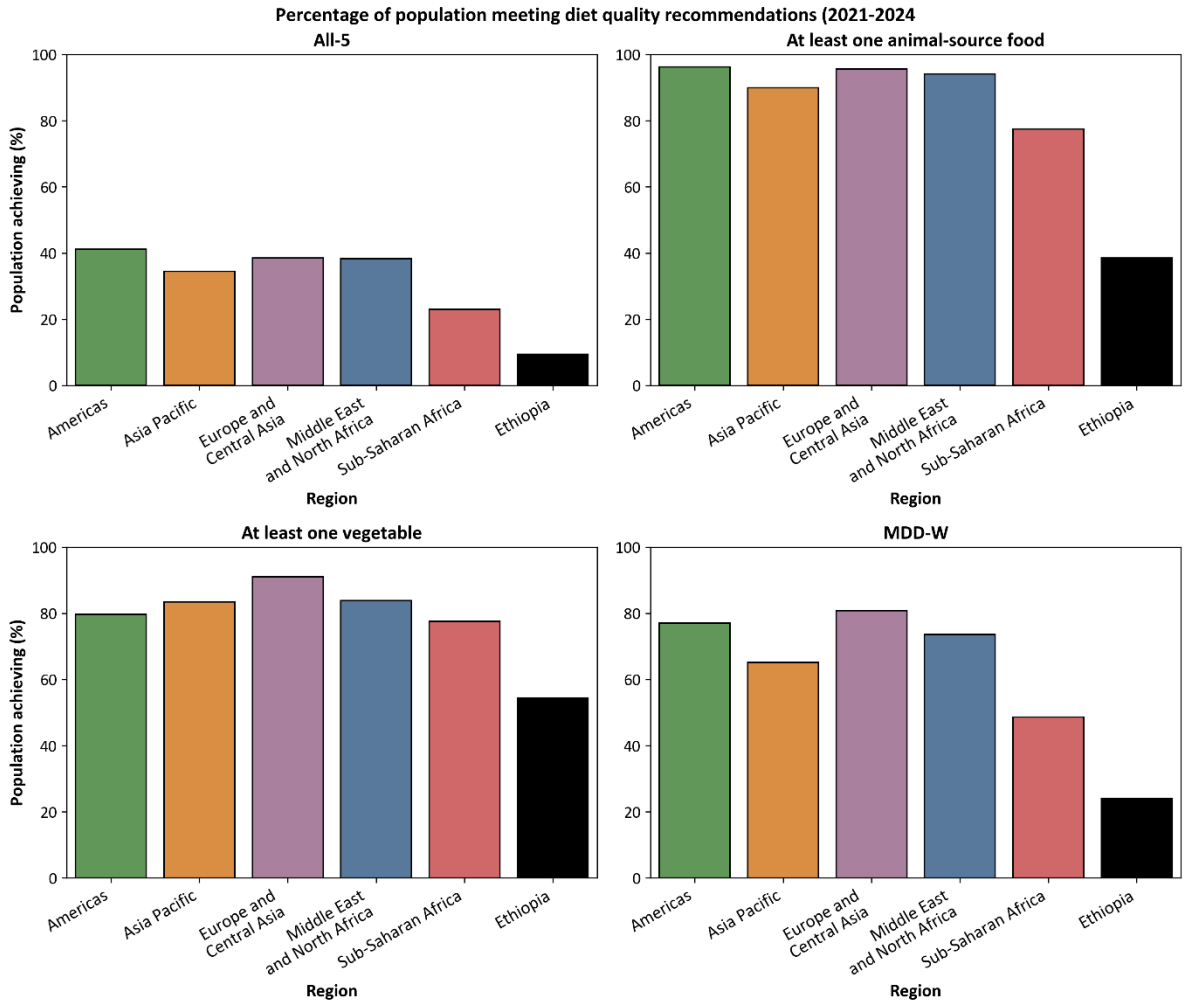


Figure 2.1. Global patterns of diet quality indicators (2021–2024)

(Source: Author's calculations using Global Diet Quality Project (GDQP) 2021–2024 data, available at https://www.dietquality.org/)

Notably, although most of the population in Sub-Saharan Africa consumes at least one meal of animal-source food a day, this proportion is significantly lower than in other regions, highlighting persistent barriers related to affordability and access. These issues are further reflected in the MDD-W indicator, where Sub-Saharan Africa has the lowest prevalence, with fewer than half of women meeting the minimum dietary diversity threshold. The figure emphasizes that diets in Sub-Saharan

Africa are characterized by limited dietary diversity, especially in nutrient-rich foods, underscoring the need for policies that address structural challenges in food systems, affordability, and access to diverse, nutritious foods.

The mean scores of four diet quality indicators—Dietary Diversity Score (DDS), Global Diet Recommendations (GDR) score, NCD-Protect, and NCD-Risk—across global regions are shown in Figure 2.2. The DDS indicates the variety of food groups consumed, while the GDR score assesses how closely diets follow global dietary guidelines. NCD-Protect measures the intake of foods that help prevent non-communicable diseases, such as fruits, vegetables, and whole grains, whereas NCD-Risk reflects the consumption of foods linked to higher NCD risk, including processed meats and sugary drinks. Europe and Central Asia, along with the Middle East and North Africa, generally have higher DDS and GDR scores, indicating more diverse and balanced diets. In contrast, Sub-Saharan Africa as a region and Ethiopia specifically show the lowest DDS and NCD-Protect scores, suggesting limited access to protective foods. Meanwhile, NCD-Risk scores are higher in the Americas, Europe, and Central Asia, indicating a greater prevalence of risk-related foods in these regions. Overall, the findings highlight regional differences in diet quality: low- and middle-income regions face challenges in adopting protective dietary patterns, while higher-income regions face risks from unhealthy food choices. These regional differences and Ethiopia's status offer a useful comparative backdrop for understanding dietary challenges in Ethiopia.

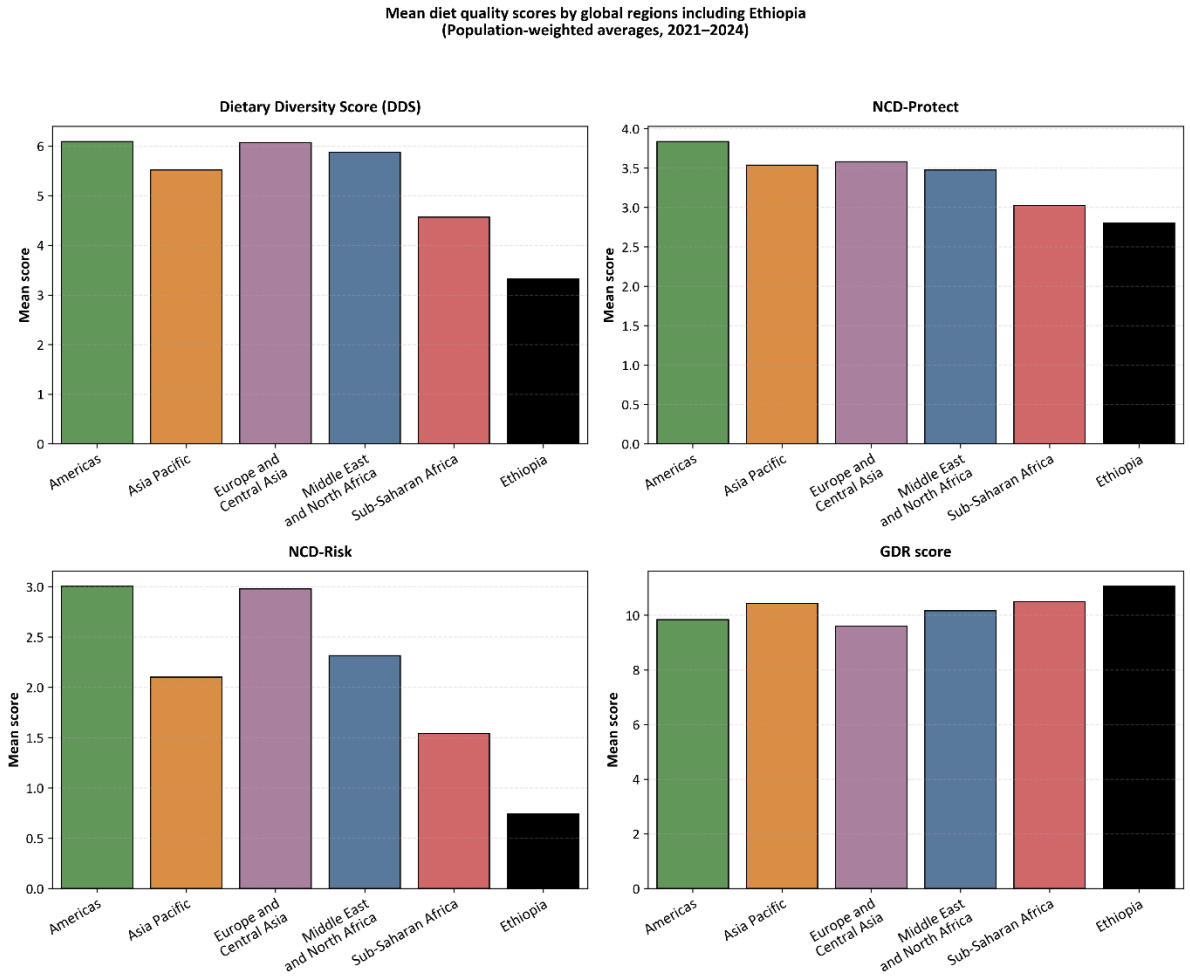


Figure 2.2. Mean scores of dietary quality indicators (DDS, GDR, NCD-Protect, and NCD-Risk) across global regions

(Source: Author's calculations using Global Diet Quality Project (GDQP) 2021–2024 data, available at https://doi.org/10.7910/DVN/KY3W8A)

Micronutrient deficiencies follow a similar regional pattern. LMICs account for over 80% of global disability-adjusted life years (DALYs) due to nutritional deficiencies (Liu et al., 2022). Iron-deficiency anaemia remains widespread in sub-Saharan Africa and South Asia, affecting up to 40% of children in some countries. Vitamin A and zinc deficiencies are also very common among young children and women of reproductive age, increasing risks of infection, impaired growth, and death (FAO et al., 2025; Stevens et al., 2015). These patterns are illustrated in Figure 2.3, which presents

recent global estimates of micronutrient deficiencies by region, highlighting high levels of nutrient deficiencies, particularly in sub-Saharan Africa.

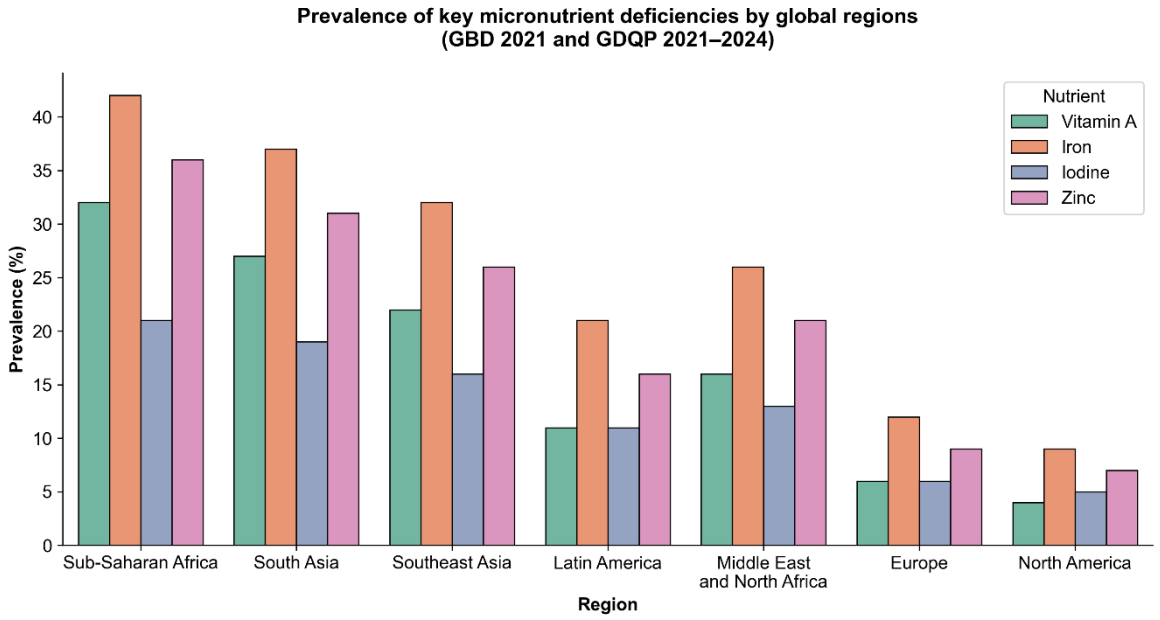


Figure 2.3. Prevalence of key micronutrient deficiencies by global regions

(Source: Author's calculations using Global Diet Quality Project (GDQP) 2021–2024 data). The figure shows the prevalence of deficiencies in vitamin A, iron, iodine, and zinc across major world regions. Micronutrient deficiency data are based on the Global Burden of Disease (GBD) 2021 estimates, which cover all age groups and sexes across 204 countries, and are accessed from https://ourworldindata.org/micronutrient-deficiency.

Dietary diversity is a strong predictor of micronutrient adequacy across LMICs. Large-scale studies consistently show that low dietary diversity is associated with stunting, anaemia, and other micronutrient deficiencies among women and children (Arimond et al., 2010; Stevens et al., 2022). Regions with lower dietary diversity scores—especially sub-Saharan Africa—also have the highest rates of child undernutrition and anaemia. These links highlight the importance of diet quality, rather than just calorie intake, in determining nutritional outcomes worldwide.

Persistent structural challenges continue to hinder improvements in global diet quality. The high cost of nutrient-dense foods, weak market systems, rural isolation, and seasonal fluctuations in food availability remain significant barriers in many LMICs (Herforth and Ahmed, 2015). Urbanization

and evolving food systems have created a double burden of malnutrition, with increasing consumption of ultra-processed foods even as micronutrient deficiencies persist (Popkin et al., 2020).

In summary, both global and regional evidence indicate consistently low diet quality and high micronutrient deficiency burdens in LMICs, especially in sub-Saharan Africa and South Asia. This regional context is particularly relevant for Ethiopia, where similar dietary patterns, affordability issues, and food-environment challenges lead to widespread micronutrient deficiencies. Understanding these regional trends helps place Ethiopia's dietary problems within broader global patterns while also highlighting opportunities for targeted, food-environment–focused interventions.

2.4. Dietary diversity and micronutrient deficiency in Ethiopia

Ethiopia continues to face significant challenges in achieving adequate dietary diversity and micronutrient intake, particularly in rural areas where diets are predominantly cereal-based and lack fruits, vegetables, and animal-source foods (ASFs) (EPHI; 2013, 2023). These patterns are shaped by a combination of structural, economic, and socio-cultural factors. Limited agricultural diversification and heavy reliance on staple crop production constrain the availability of diverse foods at the household level, while low incomes and high food prices limit access to nutrient-rich foods through markets. In addition, knowledge of optimal dietary practices remains limited in some communities. Cultural and religious practices, especially fasting periods that restrict ASF consumption, further reinforce plant-based dietary patterns. Practical constraints—including limited time for food preparation, inadequate cooking facilities, and insufficient storage and food processing technologies—also reduce the variety of foods consumed. As a result, diets remain heavily dependent on staples such as cereals, maize, teff, and sorghum, which provide energy but lack essential micronutrients. Consequently, the intake of nutrient-dense foods such as legumes, fruits, vegetables, dairy products, eggs, and meat remains insufficient to meet protein, fat, and micronutrient requirements.

This limited dietary diversity is reflected in national indicators. Household Dietary Diversity Score (HDDS) assessments show that nearly 90% of rural households fall into low- or medium-diversity categories, typically consuming fewer than five of the ten food groups (Jateno et al., 2023). Similar trends are observed among children aged 6–23 months, of whom only 35–48% meet the WHO minimum dietary diversity threshold (Mulatu et al., 2024; Sisay et al., 2022). Animal-source foods are among the least consumed food groups, particularly in poorer and rural households (Fentahun et al., 2025). Beyond economic constraints, religious fasting practices—especially those observed by the Ethiopian Orthodox Church—further limit ASF intake for extended periods of the year (Haileselassie et al., 2022; Workicho et al., 2016). During these periods, diets shift toward plant-based foods such as cereals, pulses, and oilseeds (Seleshe et al., 2014; Tadesse et al., 2020). While these foods contribute to energy intake, they are often low in bioavailable micronutrients such as iron, zinc, vitamin B12, and high-quality protein, leading to seasonal declines in dietary adequacy, particularly among women and young children (Arimond et al., 2010; Harika et al., 2017a).

These dietary limitations contribute to a substantial burden of micronutrient deficiencies and undernutrition. Stunting affects approximately 37% of children under five, placing Ethiopia among the countries with the highest rates of chronic malnutrition globally (EPHI, 2023; Wiemers et al., 2024). Iron-deficiency anaemia remains a major public health concern, affecting 20–30% of women and children, largely due to inadequate dietary intake, food insecurity, and infections (EPHI, 2016; Berhe et al., 2022). In addition, deficiencies in vitamin A and zinc further increase susceptibility to infections and impair growth and development (Harika et al., 2017b).

Significant disparities in dietary diversity persist between urban and rural areas and across Ethiopia's regions. Urban residents generally consume more diverse diets, reflecting better market access, higher income opportunities, and greater availability of both fresh and processed nutrient-rich foods (Hirvonen, 2016). In contrast, rural households rely primarily on subsistence production and are more vulnerable to seasonal food insecurity, which limits year-round access to a wide range of foods (Hirvonen and Hoddinott, 2017).

Marked geographic variations are also evident across Ethiopia. Households in Harari and surrounding Dire Dawa report higher dietary diversity, mainly attributable to improved market integration and income opportunities, whereas households in Tigray, Amhara, and Oromia exhibit more constrained dietary profiles (Jateno et al., 2023). Collectively, these studies indicate that regional differences in dietary diversity are shaped by agroecological conditions, market availability, cultural food preferences, and socioeconomic contexts, as well as by limitations in the scope and coordination of nutrition-sensitive interventions (Hirvonen, 2016; Hirvonen and Hoddinott, 2017; Jateno et al., 2023).

Multiple factors influence dietary diversity and micronutrient intake in Ethiopia. Poverty remains a significant barrier, limiting the ability to purchase or produce a diverse range of foods (Harris-Fry et al., 2015). Household wealth status is strongly linked to dietary diversity, with wealthier families more likely to consume multiple food groups, including animal-source foods (Hailu et al., 2025a). Parental education, especially maternal education, also plays a significant role by enhancing nutrition knowledge, caregiving practices, and food resource allocation (Mulatu et al., 2024). Female-headed households sometimes have better dietary diversity, reflecting different priorities in food choices and distribution (Jateno et al., 2023). Access to livestock is associated with increased consumption of animal-source foods, thereby improving micronutrient intake (Fite et al., 2022). Moreover, household decision-making dynamics influence food distribution and dietary diversity, as power imbalances and social norms can restrict fair access to nutrient-rich foods for women and children (Malapit and Quisumbing, 2015; Padmaja et al., 2019).

2.5. Policy context on nutrition interventions and dietary quality in Ethiopia

The Government of Ethiopia has prioritized improving nutrition through implementing a comprehensive set of high-impact policies and interventions in recent years. Key among these are the Ethiopian National Nutrition Strategy and the overarching Ethiopian Food and Nutrition Policy, both of which are designed to provide integrated, multisectoral legal and institutional frameworks to

enhance food and nutrition security nationwide (FDRE, 2018, 2021). The Ethiopian Food and Nutrition Policy aims to mainstream nutrition objectives across all sectors, establish effective coordination and monitoring bodies, ensure legal reforms for food quality and safety, and align with international food and nutrition standards. Complementing these efforts, the Seqota Declaration (FDRE, 2016) and the *Yelemat Tirufat* government initiatives (Dessie et al., 2023) continue to target stunting, micronutrient deficiencies, and dietary inadequacies at scale, while the Productive Safety Net Program (PSNP) offers cash or food transfers to food-insecure households to improve food security and dietary diversity (Welteji et al., 2017). Together, these policies demonstrate Ethiopia's commitment to cross-sectoral action, ambitious nutrition targets, and the establishment of a strong national food and nutrition system.

Despite these broad efforts, the impact on dietary diversity remains mixed. Evidence shows that while the PSNP improves basic food security and energy intake for vulnerable families, it does not always translate into a more diverse or nutrient-rich diet, particularly in the absence of nutrition education or improvements in market access (Bahru et al., 2020; Feyisa, 2021; Gebrehiwot, 2017). In some contexts, PSNP participants even had lower dietary diversity scores compared to non-participants, often because transfers primarily covered caloric needs but failed to address barriers to nutrient-dense foods (Berhane, 2014). This suggests that context-specific and multisectoral interventions—which go beyond food availability to address underlying constraints such as poverty, education, cultural dietary practices, and food system limitations—are essential for significant, sustained progress (Bahru et al., 2020; Berhane, 2014b).

Nutrition education is widely recognized as a key strategy. Programs focusing on dietary diversification, especially those encouraging the inclusion of animal-source foods and vitamin-rich fruits and vegetables, have been shown to produce significant improvements among various Ethiopian populations (Adugna et al., 2024; Bidira et al., 2022). These interventions are most effective when paired with community engagement and tailored messaging that address local preferences and knowledge gaps (Bidira et al., 2022). Consistent with these findings, Bidira et al. (2022) reported that

mothers and caregivers who received targeted nutrition education had higher household dietary diversity scores and more frequent consumption of fruits, vegetables, and animal-source foods.

Additionally, agricultural diversification strategies remain a promising means of improving micronutrient intake and overall diet quality. Promoting the production and access to nutrient-rich foods—including fruits, vegetables, pulses, and animal-source products—can increase both household food availability and dietary variety (Ruel et al., 2018; Tesfaye, 2021). However, scaling up these strategies requires support through investment in rural infrastructure, improved market access for smallholders, and coordinated efforts between agricultural extension and nutrition sectors (Pingali and Sunder, 2017). Behavioral change communication is also essential, as simply producing nutrient-rich foods does not ensure their consumption unless paired with efforts to influence dietary preferences and norms (Herforth and Ballard, 2016).

In the Ethiopian context, translating these strategies into impact requires stronger integration and contextual adaptation across sectors. Specifically, linking social protection programmes such as the PSNP with targeted nutrition education and behaviour change communication can enhance their impact beyond calorie provision. Strengthening rural market infrastructure and improving connectivity between producers and markets would increase the availability and affordability of diverse foods, particularly during lean seasons. In addition, promoting context-specific agricultural diversification—aligned with local agroecological conditions and cultural practices—can improve both production and consumption of nutrient-dense foods. Greater coordination between health, agriculture, and social protection systems, alongside community-based approaches that consider religious practices, gender roles, and local food preferences, will be critical to ensure that these interventions effectively improve dietary quality and micronutrient adequacy in Ethiopia.

In summary, Ethiopia's nutrition policy framework and the coverage of related interventions have expanded substantially over the past few decades, contributing to measurable reductions in chronic undernutrition through integrated, multisectoral strategies (FDRE, 2021). Despite these positive trends, a significant proportion of the population continues to experience malnutrition,

underscoring the need for sustained, comprehensive efforts. To achieve sustainable nutrition for all Ethiopians, strategies must go beyond income support and address persistent barriers related to access, knowledge, cultural practices, and systemic transformation within the food system. Importantly, Ethiopia has recently adopted food-systems–based approaches within its national food and nutrition policy, prioritising the creation of healthier food environments by enhancing the availability, affordability, and accessibility of nutritious foods (FDRE, 2018). However, a substantial evidence gap persists regarding which specific components of the food systems framework should be prioritised to achieve the greatest nutritional gains, underscoring a key area for future research and policy innovation.

2.6. Challenges in dietary measurement

Accurate measurement of diet quality and nutrient adequacy is fundamental to understanding nutritional status and designing effective interventions. However, comparing diet quality across different settings, especially in low- and middle-income countries (LMICs) such as Ethiopia, poses considerable methodological challenges. Variability in dietary assessment methods, recall periods, food group classifications, and inherent context-specific consumption patterns complicate data collection, analysis, and interpretation (Herforth et al., 2020).

Dietary intake assessment uses several complementary methods, each with unique advantages and limitations. The 24-Hour Dietary Recall (24HR) involves a detailed record of all foods and beverages consumed by an individual in the previous 24 hours and is widely used for individual-level dietary assessment (Gibson, 2008; Thompson and Subar, 2017). While 24HR can provide quantitative data, its accuracy depends on participants' memory and interviewers' skill, as it relies on respondents' ability to recall foods and portion sizes accurately and is subject to misreporting and recall bias (Gibson et al., 2017). Single 24HRs only capture short-term intake and may not be representative of habitual diet, so multiple recalls are required to estimate usual dietary patterns, increasing both complexity and resource requirements (Gibson, 2005).

Among the dietary quality indicators, Dietary Diversity Scores (DDS) and Minimum Dietary Diversity (MDD) qualitatively assess the consumption of specific food groups over reference periods, typically the previous 24 hours, serving as practical proxies for diet quality due to their ease of use and adaptability across contexts (Arimond and Ruel, 2004; The INDDEX Project, 2023). These indicators capture the number of distinct food groups consumed but do not account for food quantities, which limits their ability to fully reflect nutrient intake (FAO, 2016; Hanley-Cook et al., 2020). Food Frequency Questionnaires (FFQs) estimate habitual dietary patterns over longer periods by asking respondents how frequently they consume specific foods or food groups. While less resource-intensive than detailed recalls, FFQs often have lower accuracy due to reliance on fixed food lists and respondent recall bias; this challenge is amplified in diverse cultural contexts like Ethiopia, where diets vary seasonally and regionally (Ruel, 2003).

Weighed Food Records, regarded as the gold standard for dietary assessment, involve weighing and recording all foods consumed by an individual, providing detailed quantitative intake data (Thompson and Subar, 2017). However, their use in large-scale surveys in Ethiopia is limited by high logistical demands and costs, making them impractical for nationwide dietary surveillance (Gibson, 2005).

To overcome limitations of self-reported dietary data, biomarker validation is increasingly being integrated into dietary quality assessment. Biomarkers such as serum retinol for vitamin A status, serum ferritin for iron, and urinary iodine concentration help triangulate dietary intake data and provide objective measures of micronutrient status (Bingham, 1997; Dragsted et al., 2018; Xu et al., 2023). In Ethiopia, biomarker use in nationally representative surveys is growing, although coverage remains limited due to high costs, technical expertise requirements, and logistical challenges (EPHI, 2016). Biomarkers also have inherent limitations, including their susceptibility to infection or inflammation, which complicates interpretation and necessitates concurrent assessment of inflammatory markers (Erhardt et al., 2004).

Resource limitations in Ethiopia constrain the implementation of methodological gold standards. The use of repeated 24-hour food records, weighed food records, or large biomarker panels requires substantial financial, human, and institutional capacities, often unavailable in rural or hard to reach areas (Gibson et al., 2017). This often results in trade-offs between feasibility and the granularity or accuracy of dietary data collected. Recognizing these challenges, global initiatives advocate harmonization of dietary assessment protocols and indicators to improve comparability and reliability. The Food and Agriculture Organization (FAO) and the Food and Nutrition Technical Assistance Project (FANTA) have developed standardized guidelines for calculating Minimum Dietary Diversity for women and children, promoting consistent use in LMICs (FAO, 2016). More recently, the Diet Quality Questionnaire (DQQ), a low-burden, standardized survey tool, has been developed and adapted for use in over 90 countries, including Ethiopia. The DQQ captures consumption of 29 distinct food groups over the previous day, enabling population-level monitoring of diet quality indicators, such as Minimum Dietary Diversity, and diet-related risk factors for non-communicable diseases. Its feasibility, low cost, and adaptability make it well-suited for large-scale surveys in resource-limited settings and can enhance harmonized dietary quality data collection (Herforth et al., 2024).

In addition to conventional approaches, several emerging methods are being developed to improve the accuracy, scalability, and efficiency of dietary assessment in LMICs. Technology-assisted tools, such as mobile-based 24-hour recalls, tablet-assisted surveys, and image-based dietary assessment (e.g., using photographs of meals), are increasingly used to reduce recall bias and improve portion size estimation (Illner et al., 2012; Boushey et al., 2017). Advances in machine learning and artificial intelligence are also enabling automated food recognition and portion estimation from digital images, offering promising opportunities for real-time dietary monitoring. Furthermore, metabolomics and other omics-based approaches are expanding the use of objective dietary biomarkers by identifying dietary intake patterns through biological samples, although their application in LMICs remains limited due to cost and technical requirements (Brennan, 2017). In Ethiopia and similar contexts, the integration of such innovations with existing low-burden tools—such

as the Diet Quality Questionnaire (DQQ)—could enhance dietary assessment by improving data accuracy while maintaining feasibility in resource-constrained settings.

In conclusion, evaluating diet quality and nutrient adequacy in Ethiopia and similar LMIC settings is complicated by diverse dietary assessment methods, inconsistent food groupings, varying recall periods, and culturally specific eating habits. Although newer methods, including repeated 24-hour recalls and biomarker validation, improve assessment accuracy, resource requirements and capacity constraints remain significant challenges. Efforts to standardize methods and build local expertise will be crucial for generating reliable, comparable data to inform nutrition policies and programs tailored to Ethiopia's unique context.

2.7. Food systems transformation in Ethiopia

Ethiopia's food system is undergoing significant change due to rapid urbanization and population growth, along with improvements in infrastructure such as roads, logistics, and retail space (Minten et al., 2012). Traditionally reliant on open-air markets and subsistence farming, Ethiopia's urban and peri-urban regions have seen a notable increase in supermarkets, minimarkets, and modern retail outlets. This transition has increased the availability of processed and convenience foods, altering food sourcing habits, dietary patterns, and overall nutrition outcomes — with both beneficial and adverse effects on food availability, food security, and public health, especially in cities (Reardon et al., 2021).

However, while there is an urgent need to rethink food systems in Ethiopia's rapidly growing urbanization, where population expansion, widening economic disparities, and persistent nutrition challenges intersect, it is equally, critical to re-envision rural food systems, where most food-insecure households live and where underdeveloped markets, limited storage for perishables, and low food diversity further constrain access to nutritious diets (Baye et al., 2021). Fragmented governance, weak infrastructure, and uneven access to vegetable-rich diets underscore the importance of policymakers adopting a more integrated, multisectoral approach that addresses both supply and demand factors

(International Food Policy Research Institute (IFPRI), 2024; Global Alliance for Improved Nutrition (GAIN), 2025). Coordinated actions at national and local levels — such as strengthening local governance, enhancing market infrastructure, and empowering communities — are crucial for creating a sustainable, inclusive, and resilient urban food system. As Ethiopia continues its rapid urbanisation, policymakers must strengthen alignment between national and local food strategies and remove barriers that limit access to nutritious foods—particularly fruits, vegetables, pulses, and animal-source foods. The Ethiopian Food and Nutrition Strategy 2021–2030 emphasises improving the availability, affordability, and accessibility of diverse, nutrient-dense foods as a core national priority, underscoring the need for nutrition-sensitive policies to support the country's broader development agenda (FDRE, 2021).

The transformation of food retail is also linked to Ethiopia's greater integration into regional and global value chains, which increases both opportunities and vulnerabilities. While diverse food imports and processed items can improve food availability and help buffer local supply shocks, reliance on such commodities makes markets vulnerable to international price swings (Bachewe et al., 2017; Minten et al., 2016). Recent evidence shows that price spikes in global cereals and edible oils quickly spread to urban Ethiopian markets, affecting food affordability and purchasing habits, disproportionately impacting poorer households (Abebe, 2024; Assefa et al., 2016).

Policymakers face tough trade-offs in managing market transformation. On the one hand, improving market infrastructure, supporting private-sector growth, and enhancing food logistics can boost economic development and urban food security. On the other hand, regulatory efforts are necessary to reduce the marketing and consumption of unhealthy foods, protect smallholder and local market actors, and ensure fair access to affordable, nutritious foods in both urban and rural areas (Gebru et al., 2018).

2.7.1. The role of markets in dietary outcomes

Access to markets is widely recognized as a crucial factor influencing household dietary diversity, providing families with opportunities to enhance their food variety through purchases from

different food groups (Abay and Hirvonen, 2017; Koppmair et al., 2017; Nandi et al., 2021; Usman and Callo-Concha, 2021). Dietary diversity, defined as the number of distinct food groups consumed over a given period, is associated with better nutritional outcomes, particularly in areas where smallholder farming is prevalent (Gómez et al., 2020; Ruel et al., 2008). A systematic review by Nandi et al. (2021) found that most empirical studies report a strong, positive association between market access and dietary diversity, though context matters. Markets not only serve as places for direct purchase but also facilitate income generation through agricultural sales, enabling households to buy more diverse and nutrient-rich foods (Milner et al., 2022).

Markets expand the dietary options available to rural households beyond what they can produce themselves. Most rural households primarily grow staple cereals such as teff, maize, and sorghum, leaving little land for other crops. As a result, homestead food production, such as small vegetable gardens or backyard plots, tends to be practiced on very small areas and often contributes only modestly to overall dietary diversity (Usman and Haile, 2022). In such contexts, markets play a vital role in providing micronutrient-rich foods, including fruits, vegetables, and animal-source foods, helping to address nutritional gaps that home production alone cannot fill (Usman and Haile, 2022). Evidence also indicates that dietary diversity is higher among households with better road connectivity, suggesting that the quality of market infrastructure, including sheltered market facilities, refrigerated storage and other systems that support the handling and preservation of perishable foods, can be just as important as physical distance (Kunaka et al., 2025). Other features of local food environments—such as the frequency of market days and the variety of foods available—also influence household food access (Milner et al., 2022). However, the link between market access and dietary diversity is not always simple. Household income, purchasing power, production diversity, and seasonal changes often determine how much markets can improve diets (Usman and Haile, 2022). Additionally, even when markets are physically accessible, limited food variety or income barriers may still restrict households' ability to consume a diverse diet (Balcha et al., 2025).

With a predominantly rural population, limited connectivity, and unevenly developed market systems, Ethiopia provides a compelling setting for analysing the interactions between market access, food availability, and dietary diversity (Headey et al., 2019; Hirvonen, 2019a). Research shows that remote smallholder households face dual challenges, including limited production variety and restricted market access, often caused by long distances or impassable roads during the rainy season (Stifel and Minten, 2017). Data from Tigray (Northern Ethiopia) indicate that both farm production diversity and the frequency of market visits are strongly linked to higher household dietary diversity, and that frequent market visits improve the positive effects of production diversity (Hirvonen et al., 2020a). Therefore, policies should address both agricultural and market barriers (Gebru et al., 2018). Households near market centres enjoy more diverse diets, spend more on food, and experience less food insecurity than those in remote areas (Stifel et al., 2015). A study conducted in southwestern Ethiopia also shows that proximity to markets leads to higher dietary diversity, not only because of increased income but also because of direct access to a variety of foods (Usman and Callo-Concha, 2021).

Seasonality further complicates access: during the post-harvest period, both home production and market supplies increase, but in lean months, dietary diversity drops sharply, especially for remote villages where markets are already hard to reach (Minten et al., 2016; Mezgebe et al., 2024). Upgrades to infrastructure, particularly all-weather roads, are repeatedly highlighted as policy priorities to improve year-round access and enhance nutrition outcomes (Minten et al., 2018). Thus, the evidence from Ethiopia suggests that markets play a central role in enhancing dietary diversity, but highlights that these benefits are contingent upon infrastructural, economic, and seasonal contexts (Hirvonen et al., 2016; Abay and Hirvonen, 2017). Integrated policies that address both farm- and market-side barriers, tailored to local and seasonal contexts, are likely to yield the most sustainable progress.

2.7.2. Economic access to nutritious foods

Food affordability refers to households' economic ability to access enough, diverse, and nutritious foods at current market prices. It is a key aspect of food security in Ethiopia, closely tied to

income levels, price fluctuations, and the effectiveness of social protection programs. Ongoing rural poverty, frequent shocks, and rising food prices highlight the fragility of nutritional well-being, especially among vulnerable groups (Arimond et al., 2010; Turner et al., 2018).

Economic access, or households' ability to buy nutritious food with their income, forms the core of the “affordability” aspect of food and nutrition security (FAO et al., 2023). While physical availability through markets and production is essential, even in food-rich environments, undernourishment among the poor cannot be prevented without sufficient purchasing power.

Ethiopia’s economy, particularly in rural areas, remains heavily reliant on subsistence farming, characterized by low and unpredictable cash incomes (World Bank, 2022). Income constraints are worsened by irregular and often significant price increases for both staple foods and micronutrient-rich foods such as fruits, vegetables, pulses, dairy, and animal-sourced products (FAO et al., 2023). According to Bachewe et al. (2017), even during high-production periods, many households in Ethiopia still struggle to maintain sufficiently diverse diets—mainly due to cost. Their analysis of market prices and household consumption patterns demonstrates that the affordability of nutritious foods remains a key barrier to diet diversity for poorer households, despite improvements in agricultural output and seasonal availability (Ameye et al., 2021; Bachewe et al., 2017).

Household expenditure surveys consistently show that Ethiopian families, especially the poorest, spend a large portion—often 60% or more—of their total expenses on food, with staples comprising most of it (Bachewe et al., 2017; EPHI and WFP, 2020). Micronutrient-rich foods, including animal-source foods, remain a luxury item, and their consumption is strongly linked to income, education, and urban living (Workicho et al., 2016). During lean seasons and after disasters, as food prices rise, the economic gap in access widens—forcing families to sacrifice dietary quality for sufficient calories.

Beyond price-income dynamics, structural constraints, such as inadequate rural roads, fragmented markets, and the absence or weakness of centralized procurement, worsen affordability issues (Minten et al., 2016). Additionally, limited social safety nets and inconsistent implementation

of price buffering mechanisms leave the most vulnerable exposed to nutritional shocks (Hoddinott et al., 2012).

The reach of social protection programs like the Productive Safety Net Programme (PSNP) has expanded over the past decade, but many food-insecure households remain outside its coverage, and benefits are often insufficient to ensure access to healthy diets, according to Gebrehiwot (2017) and Hailu and Amare (2022). These authors underscore that maintaining diet quality amid rising prices remains a significant challenge, underscoring the vulnerability of economic access to nutritious foods in rural and informal urban areas.

2.7.3. Ethiopian policy approaches to improving nutrition

Ethiopia's food and nutrition policy framework places strong emphasis on improving food availability, accessibility, and affordability through investments in rural infrastructure, agricultural productivity, and market stabilization mechanisms (FDRE, 2018). These efforts are intended to enhance households' ability to access a diverse range of nutritious foods. However, their long-term effectiveness has often been constrained by limited public budgets, persistent inflationary pressure, and recurrent climate and economic shocks—including drought, conflict, global commodity price fluctuations, and the COVID-19 pandemic—which continue to undermine both food production and market stability (Hirvonen et al., 2021, 2020b).

Within this policy landscape, the Productive Safety Net Programme (PSNP) also remains an important social protection intervention, reaching more than eight million chronically food-insecure people through a combination of cash or food transfers, public works, and direct support for labour-constrained households (Hoddinott et al., 2012). Empirical evidence shows that PSNP participation helps reduce reliance on negative coping strategies and supports the maintenance of household dietary diversity during periods of acute stress (Berhane, 2014). Yet, despite these contributions, the broader policy objective of enabling affordable, healthy diets for all remains largely unmet (EPHI, 2021).

Persistent affordability barriers reflect deeper structural limitations. Macroeconomic pressures, including currency devaluation, rising import dependency, and global food price volatility, fall broadly outside the influence of national food and nutrition policies, yet can rapidly erode gains in diet affordability and food environment quality (Choudhury et al., 2025). Collectively, these challenges highlight the need for more comprehensive, multisectoral policy approaches that address both structural weaknesses in the food system and emerging risks affecting household access to diverse, nutritious diets.

2.8. Agricultural and nutrition linkages

2.8.1. Production diversity and household nutrition

A growing body of international evidence emphasizes the importance of agricultural production diversity as a key factor in enhancing dietary diversity and improving nutrient intake at the household level (Koppmair et al., 2017; Sibhatu et al., 2015; Sibhatu and Qaim, 2018). Production diversity generally refers to the range of crops, livestock species and other food groups that farming households grow or raise. On-farm production diversity often directly leads to the consumption of a wider variety of nutrient-rich foods, especially in rural areas with limited market access.

Meta-analyses and cross-country studies consistently find positive correlations between farm production diversity and dietary diversity, as well as between farm production diversity and micronutrient adequacy, in sub-Saharan Africa and South Asia. For example, Sibhatu et al. (2018) conducted a meta-analysis across 15 countries, showing that households with more diverse agricultural portfolios consumed a wider variety of food groups, including animal-source foods, fruits, and vegetables, which are essential for micronutrient sufficiency. Similarly, Koppmair et al. (2017) found that production diversity improves dietary outcomes, but the strength of this relationship varies by context and market orientation. Nonetheless, this relationship is complex and not uniformly strong in all contexts. Several studies have noted that market access can either attenuate or amplify this association. In areas with functioning markets, households may rely less on home production diversity

and instead purchase nutrient-rich foods, while in more remote locations, production diversity plays a critical role in ensuring access to a varied diet (Jones et al., 2014).

2.8.2. Empirical insight into the role of agriculture on nutrition in Ethiopia

In Ethiopia, where agriculture remains the backbone of rural livelihoods, studies confirm that increasing agricultural production diversity—covering cereals, pulses, vegetables, fruits, and livestock—is linked to improved household and individual dietary quality (Bakhtsiyarava and Grace, 2021; Hirvonen and Hoddinott, 2017; Moges et al., 2021; Taye et al., 2024). Evidence from household surveys found that the number of crop species grown and the presence of livestock were positively linked to higher Household Dietary Diversity Scores (HDDS)(Balcha et al., 2025a; Kabeta et al., 2023), better consumption of animal-source foods (Fite et al., 2022), and improved nutrient intake among women and children (Bakhtsiyarava and Grace, 2021; Moges et al., 2022). Similarly, Hirvonen and Hoddinott (2017) demonstrated that children in rural Ethiopian households with access to diverse production had better dietary diversity and a lower risk of nutrient deficiencies.

Including nutrient-dense foods such as legumes, vegetables, and fruits in production systems is essential for enhancing micronutrient intake in Ethiopia, where staple cereals often dominate diets. Legumes help fill protein and micronutrient gaps, while fruits and vegetables provide vital vitamins and minerals, such as vitamin A, vitamin C and folate, which support overall health and help address common deficiencies (Arimond and Ruel, 2004). Livestock ownership further improves diet quality by providing animal-source foods such as milk, eggs, and meat, which are rich in highly bioavailable micronutrients, including iron, zinc, and vitamin B12. These nutrients are especially important for child growth and cognitive development, as animal-source foods provide higher-quality protein and denser micronutrient content than plant-source foods. Studies in Ethiopia show that livestock ownership is positively associated with increased child consumption of animal-source foods and better nutritional outcomes, including improved haemoglobin levels and growth (Fite et al., 2022).

2.8.2.1. Mediating factors influencing the production-diet relationship

Despite the generally positive correlation, several contextual factors influence how production diversity impacts dietary outcomes in Ethiopia. Access to markets affects households' reliance on their own production versus purchased foods. Households with better road connectivity and market infrastructure may focus on high-value cash crops and buy a variety of foods instead of growing many crops themselves (Stifel and Minten, 2017). Conversely, limited market access increases the importance of own production diversity for diet quality (Turner et al., 2018).

Cultural food habits strongly influence dietary practices in Ethiopia, shaping what foods are consumed versus sold. Some nutritious crops or animal products are often sold for economic reasons rather than eaten within the household, reflecting social preferences and livelihood strategies (Seleshe et al., 2014b). For example, fruits, vegetables, dairy products and eggs are often sold by rural households to generate income, while staple grains like teff or maize tend to be retained for household consumption to ensure food security (Ahmed and Tesfaye, 2024; FAO, 2019; Seleshe et al., 2014). Such practices are embedded in local culture and economic necessity, balancing cash needs with subsistence requirements.

Households growing cash crops usually dedicate less land and labour to food crops, which may limit their own food diversity, even though it boosts income and purchasing power (Minten et al., 2016). The overall impact on diet quality depends on whether cash income is spent on nutrient-rich foods.

Gender dynamics play a key role in the production-consumption relationship. Women's control over agricultural assets and decision-making is connected to greater dietary diversity and better child nutrition (Malapit and Quisumbing, 2015). In Ethiopian rural households, when women influence production choices and food distribution, the diversity and nutritional quality of diets generally improve (Sraboni et al., 2014).

2.8.2.2. Land tenure, farm size and irrigation access

Access to irrigation significantly expands opportunities for diversified production and a year-round food supply. Households with irrigation can cultivate fruits, vegetables, and legumes year-round, thereby smoothing seasonal food shortages and improving diet quality (Domènech, 2015). Evidence from national and regional studies in Ethiopia shows that households with access to irrigation achieve substantially higher dietary diversity. Nationally representative data indicate that irrigation improves diet quality by increasing the production of micronutrient-rich crops and enabling households to adopt productivity-enhancing technologies (Ahmed, 2022).

Similarly, empirical research from Northwest Ethiopia finds that irrigating households consume two to three additional food groups per week compared with non-irrigating households, and that average dietary diversity scores among irrigation users rise from 4.25 to 6.33, a significant improvement (Biru et al., 2025). These findings complement earlier cross-country work showing that small-scale irrigation improves dietary diversity primarily through the income pathway, particularly in Ethiopia, where gains in production diversity and higher production value translate into better diets (Passarelli et al., 2018).

Moreover, irrigated production of fruits, vegetables, and legumes has consistently been linked to higher micronutrient intake (Domènech, 2015; Ruel et al., 2018). Ethiopia-based studies confirm this link, with irrigation supporting the cultivation of nutrient-dense foods, enhancing household food security, and increasing income available to purchase additional nutritious foods (Alemu Tolla et al., 2021). Together, these findings underscore the importance of strengthening secure land tenure systems and expanding equitable access to irrigation as central pillars of Ethiopia's nutrition-sensitive agricultural transformation.

2.8.2.3. The impact of seasonality on production in Ethiopia

Agriculture in Ethiopia heavily relies on seasonal rainfall, which governs cropping cycles and productivity, ultimately affecting food availability, local food prices, and dietary patterns. The country's agroecology features diverse but distinct rainy seasons, mainly the *Belg* (short rains from

February to May) and *Kiremt* (main rains from June to September), with notable geographic and timing differences in when rainfall starts, how long it lasts, and its intensity (Markos et al., 2023). This bimodal rainfall pattern supports the dominant rainfed farming systems used by more than 90% of Ethiopian smallholder farmers (Wakjira et al., 2021). Rainfall variability, both in volume and timing, leads to marked fluctuations in agricultural output. The Kiremt season contributes the largest share of national crop production, dominated by staple cereals such as teff, maize, sorghum, and barley (Wakjira et al., 2021). In contrast, the Belg season is shorter and less reliable, primarily supporting early-season cropping and making a comparatively minor contribution to overall agricultural production (Gebremichael et al., 2014). Certain regions, especially in southern and eastern Ethiopia, have more bimodal or even unimodal rainfall patterns, adding to the complexity (Habte et al., 2023; Hailu et al., 2024).

Highly variable rainfall—both seasonally and inter-annually—can disrupt planting schedules, shorten growing periods, and reduce yields, which are exacerbated by erratic onset and early cessation of rains (Gebremichael et al., 2014; Hailu et al., 2024). The coefficient of variation (CV) of rainfall can exceed 30% in several areas, marking high vulnerability to drought and crop failure (Gebremichael et al., 2014). For example, dry spells during crucial early growth periods have been linked to crop establishment failure and lower yields (Gebremichael et al., 2014).

The pronounced lean seasons, usually occurring just before the main harvest (often in May-June), are associated with declining food stocks, rising food prices, and reduced dietary diversity (Hirvonen et al., 2016; Mezgebe et al., 2024). During lean periods, households experience greater food insecurity and become increasingly dependent on less diverse, often less nutritious foods, leading to dietary monotony and nutritional stress (Stevens et al., 2017). Seasonal shortages of nutritious foods, such as fruits, vegetables, and animal-source foods, worsen micronutrient deficiencies, increasing the risk of chronic undernutrition (Mezgebe et al., 2024; Roba et al., 2019). Moreover, seasonal food price inflation, particularly for nutrient-rich foods, limits affordability at critical times (EPHI and WFP, 2020).

The seasonality of food access is thus a significant driver of intra-annual fluctuations in dietary quality and nutrient adequacy, precipitating cyclical vulnerabilities across rural populations.

Seasonal rainfall patterns directly affect the diversity of household food production and the availability of market food, influencing dietary habits in rural and urban communities across Ethiopia. After harvests, food availability and diversity reach their peak, allowing for better dietary quality and nutrient intake (Hirvonen and Hoddinott, 2017). In contrast, as food stocks run low during lean seasons, dietary diversity drops, leading to less consumption of perishable, nutrient-rich foods (vegetables, legumes, animal-source foods) and increased dependence on staple cereals (Bai et al., 2020). Seasonality also affects market operations, with some rural markets experiencing limited supply and higher prices during lean periods, further constraining dietary access (Hoddinott et al., 2015) (Hoddinott et al., 2015). Urban populations similarly face seasonal food price volatility, influencing purchasing behaviors and diet quality (Ygnatios et al., 2023).

Addressing the adverse effects of seasonality on agricultural output and diets requires a diverse range of strategies. Expanding irrigation infrastructure to decrease dependence on rainfed farming has been identified as a vital approach to stabilize production throughout seasons (Minten et al., 2018). Irrigation enables multiple cropping cycles and the production of nutrient-rich foods, even during dry periods, helping to buffer lean-season shocks. Improved post-harvest storage and processing technologies can also moderate food availability fluctuations, reducing spoilage and allowing for extended consumption of perishable foods (Gebremichael et al., 2014). Crop diversification with drought-tolerant varieties and climate-smart agricultural practices also provides resilience pathways. Social protection programs such as Ethiopia's Productive Safety Net Program (PSNP) offer seasonal aid during difficult times, aiming to help households avoid food insecurity and nutritional issues (Gebrehiwot, 2017).

In summary, Ethiopia's agricultural system, which relies heavily on seasonal rainfall, results in significant fluctuations in food production, availability, local prices, and dietary quality. The lean season preceding main harvests is a critical period of nutritional vulnerability, characterized by limited

food diversity, heightened food insecurity, and increased risks of malnutrition. Understanding these seasonal patterns is crucial for developing agricultural, market, and nutrition programs that ensure consistent food access year-round and improve dietary outcomes across Ethiopia's diverse agroecologies by fostering a sustainable food environment.

2.8.3. Structural and policy issues on agriculture

Ethiopia's agricultural sector is a vital component of the economy and rural livelihoods, and it has been a central focus of national policies aimed at enhancing food security, nutrition, and economic growth. Despite efforts to expand and diversify by promoting the integration of horticulture, livestock, and staple crop production to enhance dietary diversity and nutrient intake, persistent structural and systemic barriers prevent these initiatives from reaching their full potential (Minten et al., 2020).

One of the main challenges to agricultural diversification and productivity in Ethiopia is the prevalence of very small-scale farms. The average farm size is estimated at less than one hectare per household, having declined over the last decade, with some recent figures indicating an average as low as 0.78 hectares (Headey et al., 2014). Land fragmentation, often resulting from inheritance and customary practices, further reduces farm sizes and makes efficient land use more difficult (Deininger et al., 2008). Small plots are often spatially separated, ranging from 0.15 to 0.5 hectares, thereby increasing inefficiency and complicating management. Such fragmentation is recognized as a barrier to mechanization and productivity (Dzever et al., 2023). Small landholdings limit both the amount and diversity of food produced, negatively impacting household dietary diversity and nutritional health, as households with more limited, fragmented land tend to grow fewer types of crops, thus narrowing dietary options (Hailu et al., 2025).

Enhancing agricultural productivity and diversification requires access to key inputs, including improved seeds, fertilizers, pesticides, livestock feed, and irrigation infrastructure. However, these inputs are often prohibitively expensive for smallholder farmers, and access is further constrained by limited credit, weak supply chains, and inadequate infrastructure (Minten et al., 2016). As a result,

many farmers are unable to adopt productivity-enhancing technologies or diversify into higher-value, nutrient-dense activities such as fruit and vegetable production or livestock rearing.

Market access is essential for encouraging diversification; farmers need confidence in both sellers and buyers for higher-value, perishable foods. However, inadequate rural infrastructure—such as roads, market facilities, storage, and cold chains—limits dependable market participation, increasing the risk of post-harvest losses and price swings (Stifel and Minten, 2017). Transport costs and thin markets reduce profits, discouraging farmers from diversifying beyond staples (Haile, 2023). These challenges are especially acute for horticultural and livestock products that require quick sale and handling.

The Ethiopian government has recognized the vital linkages between agriculture, nutrition, and development, embedding diversification and diet quality objectives in key policy frameworks such as the National Nutrition Program (NNP II), the Growth and Transformation Plan (GTP II), and the Livestock Development Master Plan and Food and Nutrition Policy (FDRE, 2018). These policies promote scaling up integrated crop-livestock systems, irrigation investments, improved seed distribution, and value chain development for nutrient-rich foods.

Access to credit is crucial for farmers to invest in diversified production, including inputs for horticulture and livestock, as well as irrigation equipment. However, many rural households face significant barriers to getting formal credit due to a lack of collateral, high interest rates, and underdeveloped rural financial systems (Minten et al., 2016). Limited financial capital restricts both initial diversification efforts and the expansion of diversified farms. Furthermore, technological innovations, including improved seed varieties, irrigation technologies, feed improvements, and post-harvest handling equipment, have varying levels of adoption. Barriers include insufficient extension support, risk aversion, lack of awareness and incompatibility with local agroecologies or farmer knowledge systems (Birhanu and Jensen, 2023; Kebebe, 2015).

Female farmers, who play key roles in diversified production such as vegetables and small livestock, often face additional challenges in accessing technologies and inputs (Abdisa et al., 2024;

Tsige et al., 2020). Gender roles and norms determine access to productive resources and decision-making power related to agriculture and food use. Women often have limited rights to land, credit, and control over income, which hampers their ability to engage in diverse production that could enhance household diets (Malapit and Quisumbing, 2015). Policies and programs that fail to systematically address gender disparities may miss opportunities to improve nutrition through diversification.

Research shows that the successful implementation of integrated horticultural and livestock diversification can boost household food availability and diet quality, especially for vulnerable groups like women and children (Shanmugam et al., 2024). Households practicing diverse crop-livestock systems generally have higher dietary diversity scores and greater intake of bioavailable micronutrients (Sekaran et al., 2021). Targeted improvements, such as improved agricultural extension services, promotion of small-scale irrigation schemes, and adoption of better animal feeding and crop-livestock management practices, can significantly increase the production of fruits, vegetables, pulses, and livestock products. These efforts expand household access to a variety of foods, providing essential vitamins, minerals, and high-quality protein that complement staple cereals and help reduce the risks of chronic malnutrition and micronutrient deficiencies (Agitew et al., 2024). Several studies highlight that the connection between production diversity and market participation can further improve nutritional benefits, suggesting that policies supporting on-farm diversity and strong market links are essential (Koppmair et al., 2017; Sibhatu et al., 2015; Sibhatu and Qaim, 2018).

Overall, Ethiopia's progress in agricultural diversification to improve dietary quality is hindered by persistent structural challenges, including small landholdings, high input costs, gaps in extension services, inadequate market infrastructure and credit limitations. National policies and programs promote integrated crop-livestock systems and nutrition-sensitive agriculture but face practical barriers to widespread adoption. Addressing gender inequalities and improving access to credit, technology, and markets are essential to unlock the full nutritional potential of agricultural diversification. Multi-sectoral, context-specific strategies that simultaneously address these structural

constraints offer the greatest potential to transform Ethiopia's agricultural systems toward improved diet quality and nutrition outcomes.

2.9. Socio-cultural influences on dietary practices

Dietary behaviour is influenced not only by economic and physical factors but also by deeply rooted socio-cultural influences. In Ethiopia, where diverse ethnic groups, religions, and traditions intersect with food systems, understanding how food taboos, gender roles, and social norms influence diets is crucial for effectively improving nutritional outcomes.

2.9.1. Food taboos, preferences, and cultural influence

Food taboos and cultural food preferences powerfully shape dietary patterns in Ethiopia, often determining what is consumed, by whom, and when (Workicho et al., 2016). These dietary guidelines, influenced by religious beliefs, ethnic identity, and historical subsistence practices, are essential to meal composition and nutrient intake.

One of the most influential socio-cultural practices that affects diet is religious fasting, especially within the Ethiopian Orthodox Christian community, which comprises 45% of the population (Armdie et al., 2022; Michael and Baye, 2023). Orthodox Christians often fast on Wednesdays and Fridays, as well as during extended periods like Lent and Advent, which can total up to 150 days each year (Haileselassie et al., 2022). During these times, abstaining from all animal-source foods, including meat, dairy, and eggs, is required, significantly altering the usual dietary composition. Evidence shows that during fasting seasons, the consumption of animal-sourced foods decreases significantly, resulting in lower intake of essential micronutrients, such as vitamin B12, iron and high-quality protein (Workicho et al., 2016). While fasting can offer spiritual and communal benefits, it may also increase seasonal nutritional vulnerabilities, especially among women and children who are already at risk of deficiencies.

Aside from religion, ethnic identity plays a significant role in shaping culinary traditions and food choices among Ethiopia's diverse groups. For example, many groups typically eat injera

(fermented teff flatbread) with various stews, while others focus on specific local cereals, starchy tubers, roots, or wild foods (Tadesse et al., 2020). These preferences impact dietary diversity and nutrient content, with some diets naturally being plant-based and low in animal foods (Workicho et al., 2016).

2.9.2. Gender and intra-household dynamics

Gender roles and relations fundamentally shape food access, allocation, and nutritional outcomes within Ethiopian households, reflecting broader social and economic power dynamics.

Women in Ethiopia are often responsible for food preparation, child feeding, and household nutrition, but their control over resources, including agricultural production and income, is limited by socio-cultural norms (Armdie et al., 2022). Studies show that when women have greater decision-making power and control over productive assets or earnings, family dietary diversity and quality improve (Fikadu et al., 2024). For instance, women's ownership of small livestock or participation in income-generating activities correlates positively with household food security (Jemaneh and Shibeshi, 2023) and linked with a low likelihood of childhood stunting (Wassie et al., 2024). Women's empowerment and gender equity can thus be direct pathways to enhancing household nutrition.

2.10. Synthesis and summary

The body of literature reviewed shows that dietary quality and nutritional adequacy in Ethiopia are influenced by a complex, evolving network of factors. These include food environments, agricultural production, market access, seasonality, economic affordability, and socio-cultural determinants. Each aspect contributes in a unique yet interconnected way to the opportunities and challenges that households face in accessing a variety of nutrient-rich diets.

Market access and food availability serve as essential gateways, enabling the movement of various foods beyond household production, particularly in rural areas where subsistence farming is prevalent (Headey et al., 2019). Proximity to well-functioning markets, reliable infrastructure, and fewer seasonal obstacles are consistently associated with greater dietary diversity and food security

(Stifel and Minten, 2017; Minten et al., 2020). However, distance from markets, poor road conditions, and seasonal lean periods reduce these benefits and exacerbate nutritional risks.

The seasonality of diet and food security highlights significant intra-annual variations in both food availability and consumption patterns, particularly for micronutrient-rich foods like fruits, vegetables, and animal-source products (Hirvonen et al., 2016). Lean seasons limit diet quality and increase child undernutrition, leading to coping strategies that often sacrifice nutrient adequacy and resilience (Workicho et al., 2016). It is crucial to incorporate seasonal variation into the analysis to understand the temporal dynamics of food insecurity.

Food affordability and economic access remain key barriers to improving diet quality. High and unstable food prices, low rural incomes, and limited social safety nets restrict many Ethiopian households from purchasing adequate, diverse diets (Ameye et al., 2021; EPHI and WFP, 2020). Even with better infrastructure and increased production, the cost of a nutritious diet often stays too high, especially for vulnerable groups during lean seasons. This highlights the need for targeted strategies to improve affordability and income support programs.

At the same time, socio-cultural factors significantly influence dietary habits and nutritional outcomes. Food taboos, religious fasting—such as the extensive Orthodox Christian abstinence from animal products—and gendered intra-household food distribution directly affect what is eaten, by whom, and when (Harris-Fry et al., 2015; Michael and Baye, 2023). Women's empowerment and control over resources are linked to better dietary diversity; however, deep-rooted social norms restrict market participation and agency, particularly limiting rural women's roles in improving nutrition.

Alongside these substantive thematic insights, the methodological landscape for studying food environments and diets in Ethiopia shows notable gaps. Studies mainly rely on cross-sectional surveys, offering valuable descriptive snapshots but falling short in comprehensively capturing dynamic, seasonal, and spatial variability. Comprehensive measurement of food environment, longitudinal data,

and mixed methods that integrate objective market audits with consumer perceptions remain limited but are essential for understanding relationships and developing effective interventions.

Furthermore, the adoption of global food-environment measurement frameworks remains limited in Ethiopia due to the dominance of informal and fragmented markets, resource limitations, and sociocultural complexities (Turner et al., 2018). This hampers the thorough mapping and monitoring of food environments, market diversity, and pricing trends, which are crucial for policymaking.

In summary, although extensive research documents the various drivers of nutrition problems in Ethiopia, significant gaps remain in understanding how the food environment influences dietary quality and nutrient adequacy. To this author's knowledge, no study systematically explores how market structures, food prices, agricultural production, seasonality, and socio-cultural norms interact within the food environment to shape individual dietary choices. Additionally, there is a significant lack of integrated research linking these food-environment factors to nutrition outcomes in both urban and rural informal settings. Limited geographic coverage and methodological challenges further impede comprehensive analysis. Addressing these gaps with context-specific, methodologically sound studies of the food environment is vital for generating practical insights. Such evidence will guide policies and interventions aimed at improving market efficiency, reducing seasonal vulnerabilities, increasing economic access, and overcoming socio-cultural barriers—ultimately helping to promote sustainable improvements in dietary quality and nutrition health across Ethiopia. This key gap in linking food environments to diet quality forms the basis for the next section, which presents a conceptual framework that highlights the food environment as a crucial determinant of nutritional outcomes.

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3. Chapter Three: The Food Environment Conceptual Framework

3.1. Introduction

The concept of the "food environment" has emerged as a crucial framework for understanding the complex factors that shape dietary behaviours and influence nutritional health (Choudhury et al., 2025; Downs et al., 2020; Herforth and Ahmed, 2015). As eating habits change due to economic growth, globalization, and urban development, comprehensive theoretical models are needed to explain how the wider environments influence food choices and, ultimately, health and nutrition (Story et al., 2008; Swinburn et al., 2019, 2013). This section examines the key theories and models that inform the global discourse on food environments, highlighting their relevance and limitations, particularly within the contexts of low- and middle-income countries (LMICs).

3.2. Defining the food environment

Food environments encompass the physical, economic, policy and sociocultural contexts in which individuals, households and communities interact with the broader food system to obtain food for consumption (HLPE, 2017; Swinburn et al., 2013; Turner et al., 2018). Figure 3.1 illustrates a conceptual framework that depicts the dynamic interactions within food systems, emphasizing the relationships among food supply chains, food environments, and consumer behavior. Swinburn et al. (2013) describe food environments as "the collective physical, economic, policy, and sociocultural surroundings, opportunities, and conditions that influence people's food and beverage choices and nutritional status." This multidimensional view emphasizes both place-based elements, such as grocery stores, markets, and food service outlets, and systemic factors, including food pricing, marketing strategies, and regulatory policies (Glanz et al., 2005).

In addition to broader external factors, the household food environment is crucial in shaping dietary intake. This refers to conditions within the home that influence food acquisition, preparation, and consumption. Key elements include food availability and storage practices, which determine the types and quality of foods accessible at any given time. The availability of cooking facilities, utensils,

and energy sources (such as electricity, gas, or biomass fuels) further impacts the ability to prepare diverse and nutritious meals (Yalew, Tessema and Lahiff, 2025). Household composition and size also affect intra-household food distribution, dietary variety, and nutritional adequacy, especially for vulnerable members like women and children. Additionally, time constraints, gender roles, and household decision-making processes can influence food preparation and consumption patterns. Collectively, these factors demonstrate that the household is a central environment where food choices ultimately translate into dietary intake, closely interacting with the broader food environment. Understanding these environments is essential for recognizing how structural and contextual factors influence dietary behaviors and health outcomes across diverse populations.

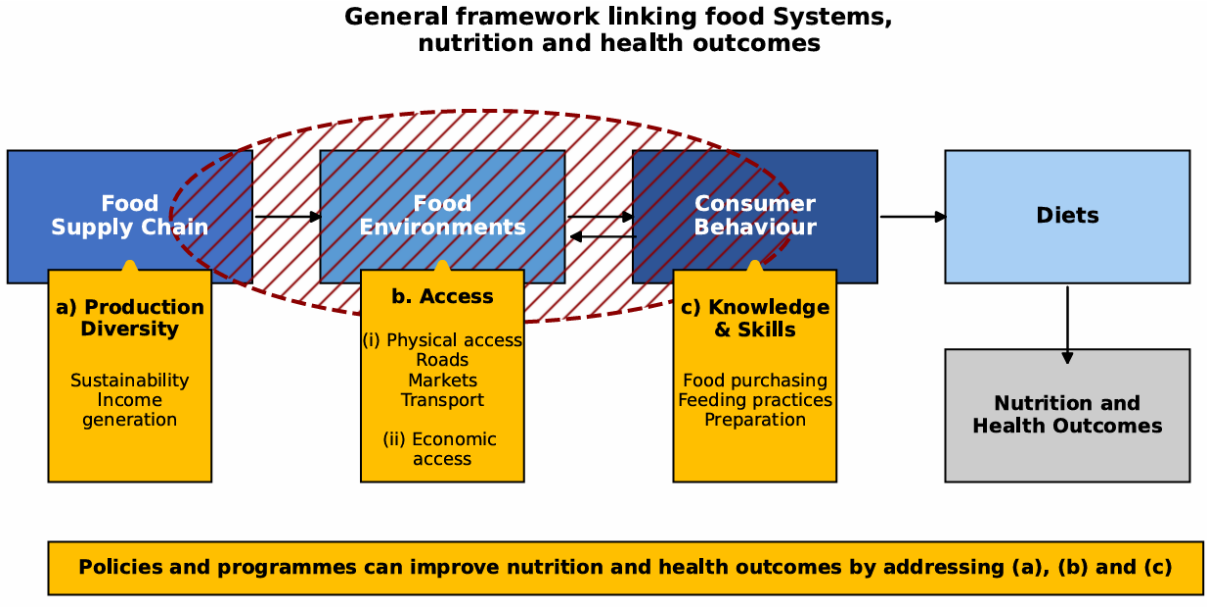


Figure 3.1. The food systems conceptual framework (Adapted from HLPE, 2017).

3.3. Ecological and systems-theoretical approaches

The ecological systems theory, introduced by Bronfenbrenner (1977) and adapted by public health scholars, underpins much of contemporary thinking about food environments. This framework views individual dietary choices as part of interconnected systems: microsystems (e.g., households, social networks), mesosystems (e.g., community food settings, institutions), exosystems (e.g., urban or food policy, market networks), and macrosystems (e.g., cultural attitudes, economic trends) (Story

et al., 2008). This ecological approach emphasizes that dietary behaviours are not simply personal decisions but are shaped by overlapping contexts that can promote or hinder healthy eating habits.

Building on this ecological model, researchers such as Glanz et al. (2005) have proposed differentiating between the community food environment (the types and locations of food outlets within a neighbourhood or region) and the consumer food environment (the factors within food outlets, such as availability, price, promotion, and placement of foods). These distinctions have enabled more nuanced syntheses of how environments vary within and between countries, and how they influence the dietary options available to different populations.

3.4. The food environment within the concept of food systems

A well-cited classification of the food environment (FE) was introduced by Turner et al. (2018) who divided it into two interconnected domains: the “external” and the “personal.” The external domain encompasses objectively measurable aspects of the food environment, including food availability, prices, vendor characteristics, product quality, food safety and promotional activities. This domain mainly reflects the broader structural and market context in which consumers make their food choices, whereas the personal domain centres on individual experiences and perceptions, including physical accessibility (distance and convenience), affordability (linked to income and resources), personal preferences, cultural acceptability, habitual behaviours, and knowledge of available food options. While some food choices may be predetermined (e.g., through home-prepared shopping lists), these behaviors are more directly related to consumer decision-making processes than to the classification of the food environment itself.

The food environment framework has been adapted to explicitly incorporate sustainability considerations and the essential role of both cultivated and wild foods, particularly in food environment research in low- and middle-income countries (Downs et al., 2020). Specifically, Downs et al. (2020) argue for a broader conceptualization of food environments that recognizes the contribution of wild, foraged, and non-cultivated foods, including fruits, vegetables, edible leaves,

tubers, mushrooms and insects, to household diets and dietary diversity. The authors emphasize that accounting for wild foods more accurately reflects the lived food-acquisition practices of many rural populations in LMICs, where such foods remain an important component of daily diets. Moreover, Downs et al. (2020) highlight the sustainability benefits of integrating wild foods into food environment research, noting their role in supporting agrobiodiversity, enhancing climate resilience and exerting lower environmental pressures than many intensively produced or ultra-processed foods.

By integrating food environments into the broader food systems framework and explicitly acknowledging both external (structural) and personal (subjective/experiential) domains, along with the sustainability advantages of wild and foraged foods, researchers and policymakers can develop a more comprehensive and context-aware understanding of how food environments impact dietary patterns, nutritional health, and the resilience of food systems over time (Downs et al., 2020; HLPE, 2017; Turner et al., 2020). Figure 3.2 illustrates an adapted conceptual framework from Turner et al. (2018) that situates food environments within broader food systems.

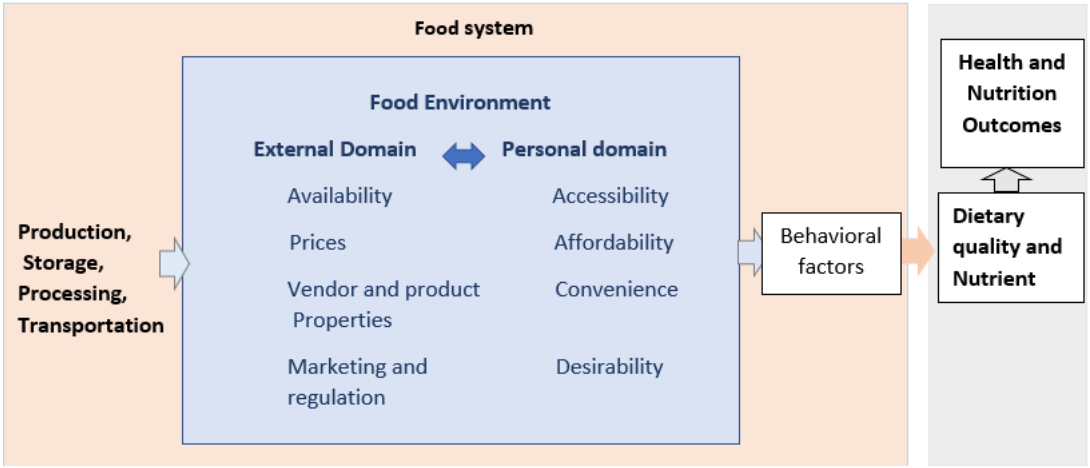


Figure 3.2. The conceptual framework depicts the food environment as the interface within the food system (Adapted from Turner et al., 2018).

The figure presents the conceptual framework underpinning this study's analysis, illustrating how components of the food environment and behavioral factors influence dietary quality and nutritional outcomes. In the Ethiopian context, the framework is particularly relevant given

constraints related to market access, food affordability, and seasonal variability in food availability. Specifically, this study applies the framework by examining how dimensions of the food environment—such as accessibility and affordability—together with behavioural factors, shape dietary quality indicators, including WDDS, FVS, GDQS, and HDDS. While the broader food system encompasses production, storage, and distribution, these elements are not explicitly included in this framework, though they are acknowledged as underlying factors shaping the food environment. The framework, therefore, guides the empirical analysis by focusing on how proximate determinants within the food environment and consumer behaviour affect nutrition outcomes in Ethiopia.

3.5. The need to contextualize the food environment

A substantial body of theory has developed around the nutrition transition. The shift from traditional diets rich in cereal grains and fibre to diets high in fats, sugars, and animal-source foods, often linked to increased urbanization, rising incomes and globalization (Popkin et al., 2020). Alongside this transition, many LMICs face a double burden of malnutrition, where undernutrition coexists with overweight, obesity, and related NCDs (Pinstrup-Andersen, 2013). Theories of nutrition transition highlight the rapid changes in food environments—such as the spread of supermarkets, expansion of processed food industries and evolving marketing practices—as key drivers of these changes (Hawkes, 2006). Global food environment theories argue that these environmental drivers are rarely uniform or linear; instead, their effects are influenced by specific variables such as social stratification, gender, urbanization rate and local food cultures (Hawkes et al., 2020). Theories, therefore, increasingly advocate for models that are sensitive to context and can account for both structural and cultural diversity in food environments, especially in the Global South.

Alongside these structural perspectives, behavioral theories offer complementary insights into how food environments translate into dietary behavior at the individual and household levels. Frameworks such as Social Cognitive Theory and the Theory of Planned Behavior highlight the roles of environmental cues, social norms, and perceived behavioral control in shaping food choices, in

interaction with individual knowledge, attitudes, and intentions (Bandura, 1986; Ajzen, 1991). These theories underscore that even when nutritious foods are physically available, dietary behavior may remain constrained by social expectations, time pressures, gendered roles, and perceived affordability, reinforcing the need to consider behavioral pathways alongside structural features of the food environment.

3.6. Food environment frameworks in LMICs

Food environments in low- and middle-income countries (LMICs), especially in sub-Saharan Africa, differ significantly from those in high-income countries because of unique socioeconomic, structural and environmental factors (Turner et al., 2020). Understanding food environments in these settings requires frameworks that account for informal market activities, subsistence farming, infrastructure challenges and high climatic variability (Herforth and Ahmed, 2015). These factors interact with rapid urban growth, market integration and changing dietary habits. This section critically reviews the development and use of food environment frameworks in LMICs, with a particular focus on Ethiopia.

3.6.1. Informal markets and subsistence agriculture

Unlike the relatively formal retail sectors common in many high-income countries, food environments in sub-Saharan African LMICs are mainly characterized by informal markets and a high level of subsistence production, or self-provisioning. Informal markets, including street vendors, open-air markets, and small kiosks, dominate the supply chain for fresh and minimally processed foods and are the primary source of food for most households (Herforth and Ahmed, 2015; Workicho et al., 2016). These markets are embedded within socioeconomic, cultural, and infrastructure networks as well as social capital, contributing not only to food access but also to livelihoods and community resilience (Skinner, 2016; Battersby, 2019).

Subsistence or near-subsistence agriculture remains a crucial factor in food availability, especially in rural areas. Smallholder farmers typically produce most of their household food, making

the food environment closely tied to agricultural production cycles and seasonality (Hirvonen et al., 2016; Hirvonen and Hoddinott, 2017). This dual dependence on self-production and informal market sources complicates the application of traditional food environment frameworks, which were primarily developed for formal retail settings (Stuckler and Nestle, 2012). This evidence highlights that understanding the food environments in Ethiopia's rural areas requires recognizing these interconnected agricultural and market factors.

3.6.2. Urban versus rural differences in food environment

Food environment frameworks in LMICs often emphasize significant urban-rural differences. Urban areas in sub-Saharan Africa increasingly exhibit characteristics typical of middle- and high-income countries, such as the growth of supermarkets and fast-food outlets, and the rising availability of processed and ultra-processed foods (Laar et al., 2022; Osei-Kwasi et al., 2021; Ygnatios et al., 2023). This change influences both availability and affordability, sometimes enhancing access to a variety of foods but also exposing urban populations to obesogenic diets associated with the nutrition transition (Westbury et al., 2021).

In contrast, rural food environments continue to depend more on traditional markets, own-production, and seasonal food availability. Rural diets tend to be less diverse and are heavily impacted by climatic shocks such as droughts or floods, which intermittently limit supply and worsen food insecurity (Hirvonen, 2016; Minten et al., 2018). Challenges in market access, weak infrastructure, and fluctuating prices further restrict rural consumers, creating compounded vulnerabilities that standard food environment models do not adequately capture (Hailu et al., 2025).

Evidence from Ethiopia illustrates these differences, showing that urban households often obtain a large share of their calories from purchased foods, while rural households rely mainly on staple grains from both household farms and local markets (Hirvonen, 2016; Worku et al., 2017). However, both environments share concerns about affordability and nutrient adequacy (EPHI and WFP, 2020). Understanding these contrasting yet connected food environments is crucial for creating effective nutrition programs and food system policies.

3.6.3. Market liberalization, migration, and dietary change

Frameworks applied in LMICs increasingly recognize the dynamic processes that reshape food environments, including economic liberalization and demographic shifts. Ethiopia's experience illustrates how structural reforms and market integration have transformed food systems over recent decades (Jayne et al., 1998; Stifel and Minten, 2017). The liberalization of agricultural markets and increased participation of private sector actors have expanded food availability, but also introduced new challenges related to price volatility, quality control, and equity in access (Bachewe et al., 2017; Dorosh and Minten, 2020; Minten et al., 2020).

Migration, whether rural-to-urban or international, further reshapes food environments by influencing household structures, income sources, and food choices (Lindstrom et al., 2023). Remittances can boost purchasing power and expand diets, while migrants may adopt urban dietary patterns characterized by increased consumption of processed foods and drinks (Holdsworth and Landais, 2019). These dynamic interactions among market forces, migration, and dietary habits complicate the modelling of food environments and the forecasting of nutrition outcomes.

Studies in Ethiopia show that market liberalization has not consistently improved dietary quality. While some households benefit from greater market access, others face rising costs and more competition for natural resources (Stifel and Minten, 2017). These complexities highlight the need for food environment frameworks in LMICs to account for multidirectional causality and temporal change, rather than relying on static snapshots.

3.7. Evidence gaps and challenges in the food environment measurement

A persistent challenge in applying food environment frameworks in LMICs, including Ethiopia, is the lack of high-quality, detailed empirical data linking specific food environment features to dietary outcomes (Sacks et al., 2019; Turner et al., 2018). Most existing tools and surveys have been designed for or tested in high-income countries with formal retail structures, making their direct use problematic without modification. For example, the concepts of food deserts and food swamps, which

have been extensively studied in high-income settings, do not readily translate to areas where informal markets dominate, and food access is influenced by seasonality and home production (Herforth and Ahmed, 2015). Furthermore, data on food prices, availability, marketing practices, and consumer behaviours are often incomplete or inconsistent in LMICs, limiting the ability to perform longitudinal or causal analyses (Turner et al., 2020).

3.7.1. Critiques and evolving models

The growing field of food environment research has greatly improved our understanding of how food systems influence diets and nutrition (Choudhury et al., 2025; Westbury et al., 2021). However, scholars are increasingly criticizing traditional frameworks for being too abstract and theoretical and less practical in settings with informal markets and rural livelihoods, such as Ethiopia and many other low- and middle-income countries (Gupta et al., 2023; Turner et al., 2020). This section highlights the main critiques of current food environment models and proposes approaches that focus on context-specific and systems-based perspectives suitable for LMIC settings (Goh et al., 2024; Karapici and Cummins, 2024; Kumar et al., 2023; Turner et al., 2018).

Despite the expansion of conceptual frameworks, significant challenges remain in translating theory into practical interventions, especially in low- and middle-income countries (LMICs). Global models like INFORMAS provide functional categories for monitoring food environments, but their application often assumes formal retail systems and regulations typical of high-income countries (Swinburn et al., 2013; Turner et al., 2018; Turner et al., 2020). In LMIC settings, food environments are very diverse, shaped by informal markets, street vendors, and mixed livelihood strategies, which these frameworks often fail to recognize (Downs et al., 2020; Gupta et al., 2023).

Empirical evidence from Ethiopia illustrates this disconnect. Informal food markets dominate both urban and rural food systems, yet they operate outside formal regulatory frameworks and differ significantly from assumptions in global models (Herforth and Ahmed, 2015).

Food markets in LMICs are shaped by dynamic pricing, pronounced seasonality, reliance on subsistence production, and sociocultural influences on food choice—features often insufficiently

captured by analytical frameworks used in the built environment (Laar et al., 2022; Turner et al., 2020; Warrender, 2025). As a result, critics caution that interventions based on frameworks that are not customized based on contexts may fail to reflect local realities, thereby limiting their effectiveness in improving diet quality and nutrition outcomes (Goh et al., 2024; Kumar et al., 2023).

3.7.2. Traditional food environment frameworks in LMICs contexts

Battersby and Watson (2018) have pointed out that traditional food environment frameworks inadequately capture the realities of informal urban food systems standard in African cities. For example, the prevalence of informal vendors and open-air markets challenges assumptions about stable, measurable points of food access. Similarly, in rural Ethiopia, seasonal availability due to rain-fed agriculture and reliance on own-production further complicate static conceptualizations of access and availability (Hirvonen et al., 2016; Hirvonen and Hoddinott, 2017).

Furthermore, the cultural and social meanings of food are often overlooked in standard models that focus on economic and physical access factors (Turner et al., 2018). In Ethiopia, food choices are deeply rooted in sociocultural norms, religious practices, and household power dynamics, which shape dietary patterns beyond just availability or price considerations (D'Haene et al., 2019; Haileselassie et al., 2022b).

Another critique concerns the dominance of cross-sectional or snapshot studies that fail to capture the highly dynamic nature of food environments in LMICs affected by seasonal fluctuations (Ramírez-Toscano et al., 2023). Static frameworks, therefore, risk oversimplifying complex feedback loops and temporal variations in dietary access and quality. Ramírez-Toscano et al. (2023) highlight the importance of longitudinal research designs that can track how food environments change over time, especially in areas affected by seasonal shifts and economic shocks. Using longitudinal data would enhance the understanding of how temporary shortages, price fluctuations, and cultural events impact dietary adequacy and nutritional health.

Furthermore, there is increasing recognition that food environment research needs to adopt more participatory and mixed methods approaches to combine quantitative measures with qualitative

insights. These approaches can reveal the lived experiences of households managing multiple, sometimes conflicting, food-acquisition strategies, including own production, market purchases, gift exchanges and migration-related remittances (Turner et al., 2018).

3.7.3. Methodological gaps in food environment measurements

The study of food environments, defined as the settings in which people access, purchase, and consume food, has expanded rapidly in recent years, reflecting growing recognition of their influence on dietary choices and public health outcomes (Turner et al., 2020). Researchers employ various methods to investigate different aspects of food environments, including surveys, direct observation, Geographic Information Systems (GIS), policy analysis, and participatory mapping (Caspi et al., 2012). Traditional survey methods often rely on standardized questionnaires to document household purchasing habits, access to food outlets, and the nutritional quality of available foods (Moore et al., 2008). Additionally, techniques such as store audits, market inventories, and street assessments are commonly used to analyze product placement, pricing, promotional strategies, and the variety or number of food outlets (Gustafson et al., 2012). Emerging technological tools, such as GPS tracking and mobile data collection, are becoming cost-effective and scalable additions to these observational techniques (Kerr et al., 2011; Widener and Shannon, 2014).

Spatial methods using GIS have proven especially useful for analyzing the geographic distribution of food access. These approaches measure the proximity of different types of food outlets—ranging from supermarkets and restaurants to informal street vendors—and examine how physical access influences dietary behaviour (Downs et al., 2024). GIS-based spatial modeling can also identify patterns of clustering, such as “food deserts” and “food swamps,” allowing researchers to investigate spatial inequalities in access to healthy versus unhealthy food sources. At the same time, participatory mapping and other mixed-method approaches are becoming more popular, especially in low- and middle-income countries (LMIC) settings, where informal markets and seasonal variations significantly impact food availability. These methods involve community members and stakeholders in mapping both formal and informal food sources, ensuring that the local context is reflected in data

collection and analysis (Downs et al., 2024). Additionally, systematic and scoping reviews have helped by consolidating existing tools and indicators for measuring food environments, outlining classification systems and identifying gaps in standardization (Azevedo et al., 2024).

Despite notable progress in methodology, significant limitations and research gaps still exist. One of the most persistent issues is the lack of standardized frameworks for measuring food environments globally. This absence of universal indicators has led to considerable variation in study designs, hindering comparability across settings and limiting the development of global benchmarks (Blanchard et al., 2024; Kumar et al., 2023). Data quality and access also pose challenges; discrepancies often arise between policy objectives and local conditions, making it difficult to evaluate interventions accurately (Blanchard et al., 2024). Another gap is the insufficient recognition of contextual and cultural factors—especially the role of informal food systems, seasonal changes, and local norms—that can significantly influence food access and dietary outcomes (Downs et al., 2024; Kumar et al., 2023b). While new digital data collection methods, such as crowdsourcing or online surveys, can quickly expand data collection efforts, concerns remain about data completeness, validity, and how well these data fit into existing health and policy monitoring systems (Odoms-Young et al., 2024). Additionally, much of the current research has mainly described or documented food environments, with fewer studies evaluating the effectiveness of specific regulations, market strategies, or environmental policies, and even fewer investigating the long-term sustainability of these interventions (Blanchard et al., 2024; Kumar et al., 2023).

Food environment measurement in LMIC settings presents extra challenges (Turner et al., 2020). In many of these settings, food systems feature hybrid retail structures that include formal supermarkets, small shops, open-air markets and mobile vendors. Recent studies emphasize the need to modify food environment measurement tools to capture the wide range of these diverse and evolving market channels, as well as cultivated and wild foods (Downs et al., 2020, 2024; Kumar et al., 2023). Participatory and community-based mapping methods have proven especially valuable in LMICs for capturing informal and seasonal food access patterns that standard tools often overlook.

Researchers also recommend using an interdisciplinary approach that considers economic, cultural, gender and institutional factors when evaluating food environments in developing settings. These comprehensive methods can provide a more comprehensive understanding of the influences on consumer choices and the barriers to healthy eating (Kumar et al., 2023). Field tests of market-based food environment assessment tools across multiple LMICs show that these methods can be tailored to different cultural and infrastructural contexts, though they also reveal notable differences in ease of implementation, data accuracy, and long-term scalability (Downs et al., 2024). Overall, the literature suggests that while progress in food environment measurement is rapid, more effort is needed to address key knowledge gaps, especially in developing standardized yet adaptable tools suitable for resource-limited environments.

3.8. Towards systems-oriented and multi-dimensional frameworks

Emerging models view food environments as part of broader food systems, highlighting connections among production, distribution, retail, consumption, and governance (HLPE, 2017; Turner et al., 2018). This holistic perspective is especially relevant to Ethiopia, where food environments are closely tied to smallholder agriculture, differences in market networks and functionality, and policy changes that influence food price and affordability (Baye et al., 2021; Stifel and Minten, 2017). New frameworks aim to incorporate various access dimensions—including physical, economic, and social—as well as qualitative aspects like food desirability, cultural acceptability, and perceived safety (Turner et al., 2018). This indicates a move from simple cause-and-effect models to more complex, multi-dimensional approaches that account for feedback, power relations, and local differences. Research by Battersby and Watson (2018) and others emphasizes the importance of informal markets not just for food access but also as venues for social interaction, risk-sharing, and cultural expression. Therefore, emerging models advocate for better representation of social and cultural roles to more accurately capture food environments in LMIC urban and rural settings.

The critiques and evolving models emphasize that interventions to improve dietary quality and nutrition in Ethiopia through changes to the food environment require customized, context-specific strategies. Policy frameworks should go beyond infrastructure and affordability by addressing informal market regulation, supporting smallholder diversity, implementing social protection measures, and providing culturally sensitive nutrition education (Battersby and Watson, 2018; Baye et al., 2021). Moreover, systematic monitoring and evaluation require developing appropriate metrics and tools to reflect the complex and evolving nature of food environments in LMICs. Initiatives like INFORMAS provide valuable starting points, but they must adapt their tools to account for informal-sector activities and seasonal variations to remain relevant in Ethiopia (Swinburn et al., 2013; Turner et al., 2020).

In summary, while traditional food environment frameworks have established important foundations, critiques highlight their limited relevance to rural, informal, and culturally diverse settings typical of Ethiopia. Increasingly, researchers favor longitudinal, context-specific, participatory, and systems-based models that better capture the dynamic, multifaceted, and socially embedded nature of food environments in LMICs. These emerging frameworks show promise for more effectively linking food environment features to dietary and nutrition outcomes, ultimately guiding more effective policies and interventions.

3.9. Study conceptual framework

The conceptual framework in Figure 3.3 was developed to capture the multiple and interacting pathways through which the food environment shapes dietary quality and nutrient adequacy in Ethiopia. Drawing on food systems and food environment theories, the framework integrates market-based factors (market availability and diversity, accessibility, affordability, and infrastructure), household-level production characteristics (diversity and seasonality), and sociocultural and behavioral influences that mediate food acquisition and consumption decisions. Rather than treating these elements in isolation, the framework conceptualizes dietary quality as the outcome of

overlapping structural, economic, and social processes operating at the household and individual levels.

This framework underpins the thesis's empirical structure and informs the design of four interconnected studies presented in Chapters 4–7. As each chapter contains its own methodology, there is no separate overall methodology chapter. Together, these chapters examine complementary dimensions of the food environment and their implications for the key dietary outcomes analyzed.

Chapter 4 presents the core quantitative analysis. It develops and operationalizes a novel composite food environment score tailored to the Ethiopian context, incorporating market food diversity, physical access, affordability, and supporting infrastructure. Using household survey data, the chapter examines associations between variation in the food environment performance and dietary outcomes, including Women's Dietary Diversity (MDD-W), the Global Diet Quality Score (GDQS), the Fruit and Vegetable Score (FVS), and the Household Dietary Diversity Score (HDDS).

Recognising that own production remains a dominant source of food in Ethiopia and accounts for a large share of caloric intake, Chapter 5 extends the framework to explicitly incorporate the home production dimension of the food environment. This chapter focuses on nutritionally relevant aspects of farm production, namely cultivated food group diversity and seasonal stability, and assesses their associations with dietary diversity and micronutrient intake among women and children. By linking these production characteristics to dietary diversity and micronutrient intake, this chapter quantifies the contribution of home-grown food diversity and seasonal stability, while accounting for other key food-environment dimensions, such as market proximity and food prices.

While Chapters 4 and 5 provide quantitative evidence on which aspects of the food environment are associated with dietary quality and nutrient adequacy, Chapter 6 adopts a qualitative approach to explore why and how specific features of the food environment act as barriers or enablers of nutritious diets. Drawing on focus group discussions and key informant interviews, chapter 6 examines the roles of cultural and religious norms, perceived affordability and availability, nutrition knowledge, gendered decision-making, and food purchasing practices. These insights illuminate the

socioeconomic and behavioural mechanisms that quantitative models do not fully capture, thereby providing essential context for interpreting the econometric findings from the preceding chapters.

Chapter 7 complements this analysis by applying Cost of the Diet linear programming models to estimate the minimum cost of locally available, nutritionally adequate diets and to assess the share of households unable to afford them. By linking affordability estimates to the same geographic areas and socioeconomic groups examined in earlier chapters, this chapter translates food environment constraints into concrete monetary terms and evaluates the potential impact of selected policy-relevant interventions to improve nutrient intake at the lowest possible cost.

Together, these chapters demonstrate how dietary quality in Ethiopia is shaped by the interaction of market conditions, production systems, affordability constraints, and sociocultural factors, reinforcing the need for integrated, food-environment-based policy responses.

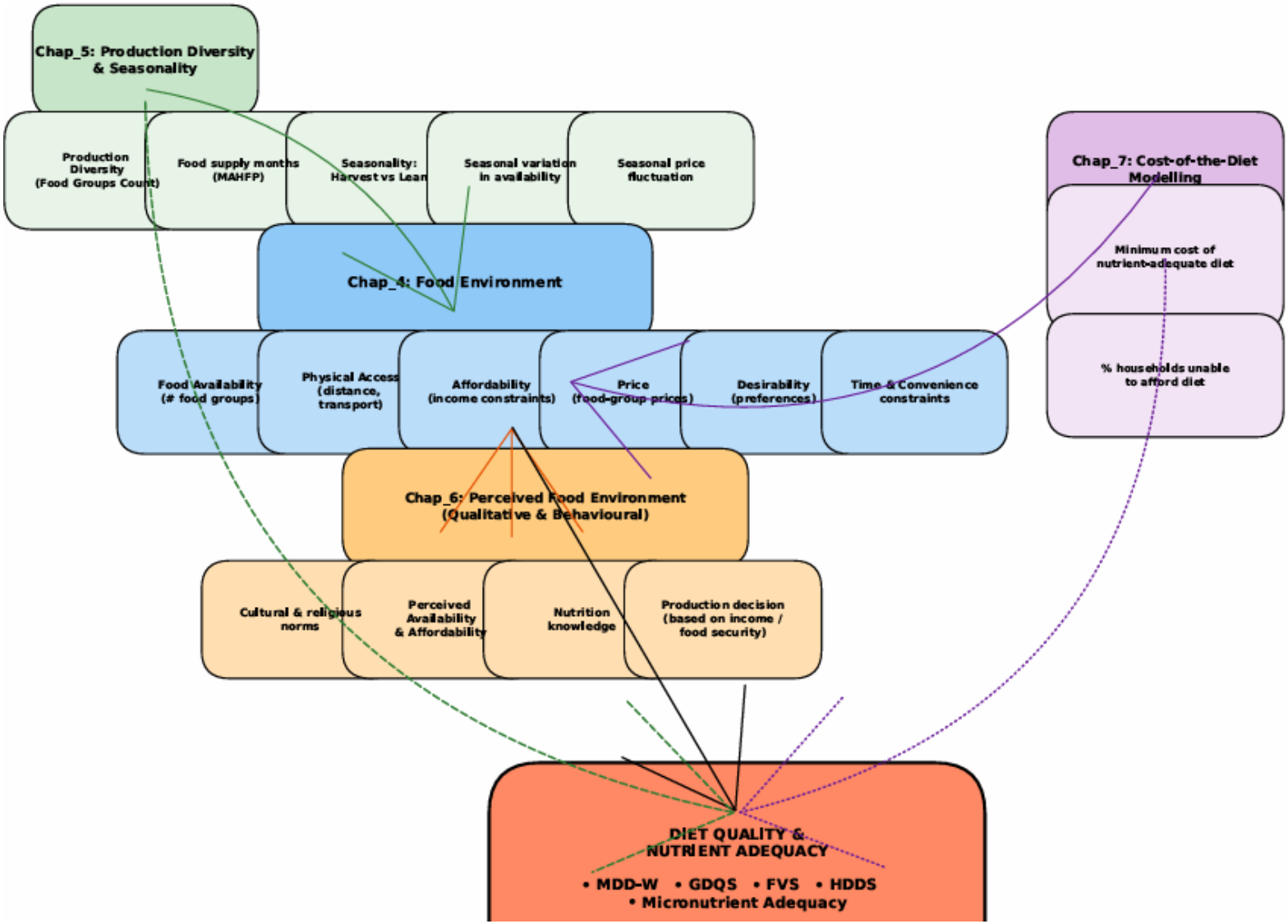


Figure 3.3. The study's conceptual framework.

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4. Chapter Four: The Influence of Food Environment on Diet Quality Among Ethiopian Women and Households [1]

This chapter examines how the comprehensive food environment shapes dietary quality among Ethiopian women of reproductive age and their households. Drawing on household survey data, it provides the quantitative basis for the analyses that follow. The subsequent chapters build on this foundation by examining related dimensions of the food environment, including agricultural production diversity, community perceptions of food availability and access, and the affordability of nutritious diets.

Abstract

Undernutrition is a significant challenge in Ethiopia, where limited dietary diversity and widespread micronutrient deficiencies affect millions of people, especially women of reproductive age. Although much research has explored dietary gaps and practices, the impact of the food environment (FE) on diet quality remains understudied. This study examines how FE factors influence dietary quality, using a food systems approach to inform sustainable nutrition policies.

A cross-sectional survey of 1,828 households was utilized to assess women's dietary quality using Poisson regression, with food environment (FE) components and socioeconomic variables predicting four indicators: women's diet diversity score (WDDS), fruit and vegetable score (FVS), global dietary quality score (GDQS), and household diet diversity score (HDDS).

Dietary diversity was low, with fewer than 20% of women meeting the minimum recommendation; however, improvement was observed in higher-quality food environments (FEs). Starchy staples dominated consumption across all FE, while pulses and dark green leafy vegetables

[1] A version of this chapter has been published in BMC Nutrition, 2025, As Hailu, A.A. et al. 2025. The influence of the food environment on diet quality: Insights from an extensive household survey in Ethiopia, focusing on women of reproductive age. BMC Nutrition. Available at: https://doi.org/10.1186/s40795-025-01097-z

increased in households with medium and high FE. Low household dietary diversity (average 6.23) and a GDQS of 20.7 (far below the maximum of 49) indicate widespread deficiency. Poisson regression (adjusted for socioeconomic covariates) showed that a high FE score was associated with significantly better dietary outcomes compared to a low FE score: 27% higher WDDS (exp(β) = 1.27, 95% CI: 1.22–1.32, $p < 0.001$), 43% higher FVS (exp(β) = 1.43, 95% CI: 1.33–1.54, $p < 0.001$), and 48% higher HDDS (exp(β) = 1.48, 95% CI: 1.43–1.54, $p < 0.001$). The OLS model for GDQS showed a more modest but still statistically significant improvement (β = 0.05, 95% CI: 0.02–0.08, $p < 0.001$) for women in households with high FE-score compared with those in households with low FE-score. The results demonstrate consistent and significant associations between higher food environment (FE) scores and improved diet quality across all four dietary metrics.

To enhance dietary quality and health outcomes, policymakers should prioritize interventions that expand diverse food markets, strengthen rural infrastructure (roads, transportation), and improve affordability through targeted economic support and price stabilization, ensuring equitable access to nutritious foods.

4.1. Introduction

The burden of malnutrition, including stunting, wasting, and micronutrient deficiencies, remains a persistent public health issue in Ethiopia, worsened by limited dietary diversity and insufficient intake of essential micronutrients (CSA and ICF, 2005; EPHI, 2016; Moursi et al., 2008). Several studies have shown that an inadequate diet is often associated with limited access to diverse foods due to a range of factors, such as poverty, lack of education, climate and weather variability, conflict, and other sociocultural barriers (Egal, 2006; Moore et al., 2008). These dietary inadequacies often involve complex, interacting factors, including limited access to diverse and affordable foods, suboptimal food environments, and socioeconomic disparities (Baye and Hirvonen, 2020; Black et al., 2013; Headey, 2017; Herforth and Ahmed, 2015; Workicho et al., 2016).

The food environment (FE), a crucial component of the broader food system, is defined by the intricate interplay of physical, economic, and sociocultural factors that ultimately shape dietary patterns at the household level (Bezerra et al., 2024; Fanzo et al., 2020). These encompass not only the physical availability and accessibility of diverse food but also the affordability of various food options, the prevailing cultural norms and traditions surrounding food consumption, and the market functioning and access that influence people's diet and nutrition (Downs et al., 2020; Turner et al., 2020). Consequently, there is growing research interest in understanding how these multifaceted aspects of the food environment impact dietary quality. For instance, several studies emphasize that FE mediates dietary outcomes through both external factors (e.g., market access) and individual factors (e.g., purchasing power), providing a framework for analyzing these dynamics in low-income settings (Turner et al., 2018, 2020; Downs et al., 2022).

A growing body of evidence highlights the critical role of the FE in shaping dietary quality, which is linked in complex ways to socioeconomic factors at both the individual and household levels (Pitt et al., 2017; Downs et al., 2022; Choudhury et al., 2025). Individuals with higher socioeconomic status (SES) often reside in areas with better access to diverse food options, supported by higher disposable incomes that enable them to purchase a variety of foods from markets or, in rural settings, to cultivate diverse crops (Darmon and Drewnowski, 2008; Hawkes et al., 2017). Evidence from low- and middle-income countries (LMICs) shows that higher SES is associated with improved market access, better infrastructure, and the capacity to invest in agricultural inputs, all of which contribute to enhanced dietary diversity (Hirvonen et al., 2015; Sibhatu et al., 2015). In contrast, those with lower SES may be constrained to producing or purchasing less diverse and less nutritious foods, often relying on staple crops with limited nutritional value. This disparity in access and affordability results in significant differences in dietary quality, exacerbating the double burden of malnutrition prevalent in many LMICs, including Ethiopia (FAO, IFAD, UNICEF, WFP and WHO, 2020).

The relationship between the food environment (FE) and dietary quality remains poorly understood, particularly in resource-constrained settings (Turner et al., 2018). Research on individual

dimensions of the FE dimension, such as the availability of healthy foods, correlates with increased consumption of fruits and vegetables and improved overall diets (Bryant and Stevens, 2006). However, dietary behaviors, cultural preferences, and perceptions also substantially shape dietary outcomes (Alamirew et al., 2023). Similarly, Herforth and Ahmed (2015) suggest that interventions targeting the FE could improve dietary intake by enhancing access to nutrient-rich foods, especially among vulnerable groups such as women of reproductive age. However, challenges such as limited market access, limited food diversity in markets, limited availability of supporting infrastructure, fluctuating food prices, dependence on subsistence agriculture, and other key aspects of the FE elements intensify socioeconomic disparities, particularly among low-income households in Ethiopia (Hirvonen et al., 2015). Despite these insights, a comprehensive study of the food environment remains a notable research gap, particularly in Ethiopia.

Inadequate dietary diversity (Borku et al., 2024; Handiso et al., 2020; Sisay et al., 2022) and insufficient nutrient intake (Belay et al., 2022; Moges et al., 2021) are prevalent in Ethiopia, particularly among women, with the prevalence varying across regions and socioeconomic groups. Diet-related risks, such as low fruit and vegetable consumption, are among the country's leading contributors to disease and mortality, particularly for vulnerable populations (Misganaw et al., 2022). While extensive research has examined dietary practices and nutrient deficiencies (Alamirew et al., 2023; Borku et al., 2024; Handiso et al., 2020; Sisay et al., 2022), no study, to the authors' knowledge, has comprehensively examined the role of the food environment in shaping dietary patterns among Ethiopian women and households. Evidence remains limited on how specific or combined dimensions of the food environment, such as physical and economic access to diverse foods, affect dietary quality in this context. The High Level Panel of Experts (HLPE) highlights that food environments in low-income countries like Ethiopia are often constrained by poor infrastructure and market inefficiencies, underscoring the need for targeted research (HLPE, 2017).

This study addressed critical gaps in the literature by examining the multifaceted dimensions of the food environment and their impact on dietary quality among women of reproductive age in

Ethiopia, a group often underrepresented in nutritional research. To explore these dynamics, we investigated key aspects of the food environment, including availability, physical accessibility, price, affordability, and the infrastructure supporting these elements, as well as their relationships with dietary quality indicators, focusing on women of reproductive age. Household food consumption patterns and women's dietary quality were first assessed. A comprehensive food environment framework was then applied to evaluate performance across the studied settings, providing insights into the factors shaping food access. Finally, associations between food environment characteristics and dietary quality measures were analyzed to identify pathways influencing women's nutrition. This study generated actionable evidence to guide targeted interventions and policies that enhance dietary quality and improve nutritional outcomes in Ethiopia.

4.2. Methods

4.2.1. Study design and setting

The study employed a sequential mixed-methods design, beginning with a repeated cross-sectional quantitative household survey conducted in two rounds to assess seasonal changes in agricultural production and dietary outcomes (Creswell and Creswell, 2018; Creswell and Plano Clark, 2018). The first round household survey was conducted from August 25 to September 30, 2022, using a structured questionnaire with multiple modules across five regions and one city administration in Ethiopia—Amhara, Oromia, Somali, Southern Nations, Nationalities, and Peoples (SNNPR + Sidama), and Addis Ababa (Figure 4.1). Sampling locations were purposively selected to capture a wide range of food environment characteristics, ensuring diversity in dietary habits and representation of both urban and rural settings. While the relevant food environment data were collected comprehensively during this initial round, the repeated-survey design captured temporal variation, particularly in agricultural conditions (addressed in Chapter 5) and individual dietary outcomes.

Regions experiencing active or residual conflict from the two-year war in the northern part of the country, including Tigray and Afar, were excluded from the study due to persistent security

concerns, access restrictions, and risks to fieldwork. The study areas were deliberately selected to reflect the country's demographic, agroecological, and livelihood diversity, including crop–livestock systems, primarily pastoralist communities, and both rural and urban settings. This variety of contexts enables a thorough evaluation of how differences in food system structures and food environment characteristics influence dietary outcomes (FAO, 2016; Herforth and Ahmed, 2015; Sibhatu and Qaim, 2018).

Amhara and Oromia are mainly highland regions characterized by mixed crop–livestock farming systems and better market integration. SNNPR and Sidama are more densely populated areas with diverse agricultural systems, including enset-based and cash-crop systems. The Somali region is mostly arid and dominated by pastoral and agro-pastoral livelihoods, facing greater challenges in market access and food availability. Addis Ababa, the capital city, has an urban food environment with better market access but relies more on purchased foods.

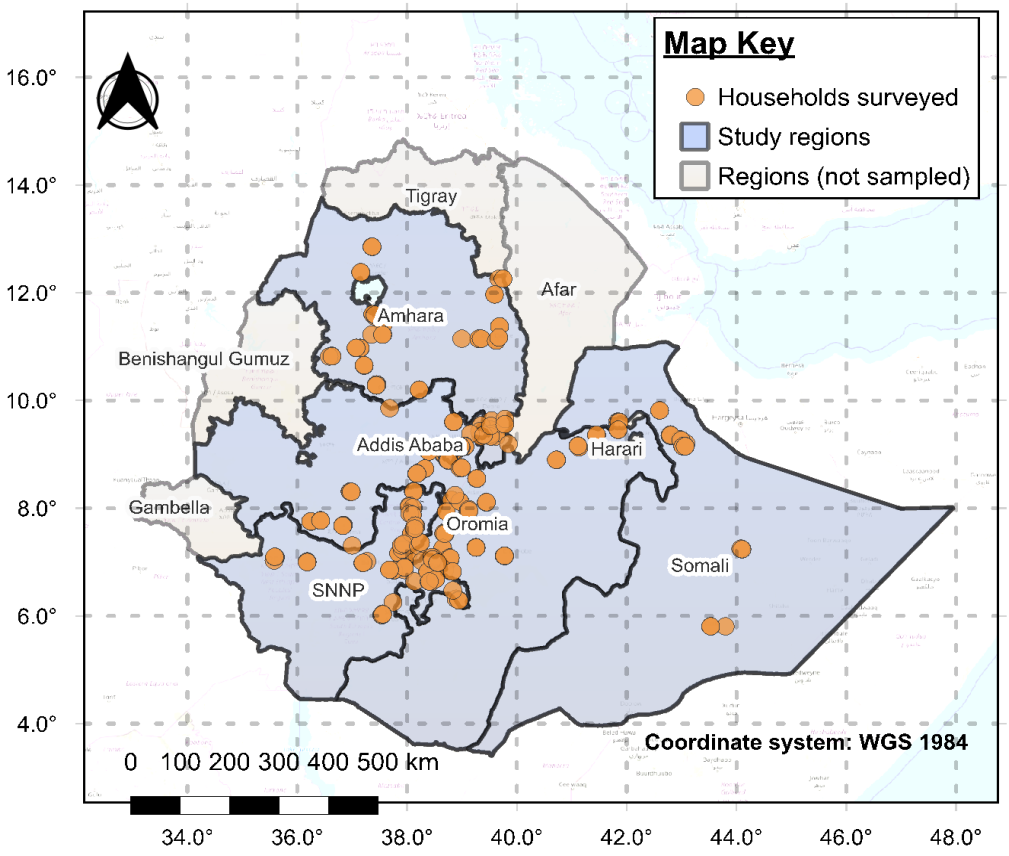


Figure 4.1. Geographic distribution of sample households across Ethiopia.

4.2.2. Study population

The study population included key household members and demographic groups important for understanding dietary quality, nutrition, and exposure to the food environment. The following groups were included:

- Household heads (male or female): Selected as primary respondents for questions related to land access, agricultural production, livelihoods, and household-level food environment exposures.
- Women of reproductive age (15–49 years): Prioritized because of their increased nutritional needs and susceptibility to diet-related deficiencies in Ethiopia.

4.2.3. Data sources

4.2.3.1. Household survey

i) Sample size determination

Sample sizes for the target populations were calculated at the household level using a single population proportion formula based on key dietary indicators (e.g., Minimum Dietary Diversity for Women (MDD-W), child MDD, and vitamin A intake prevalence). A 95% confidence level, a relative standard error of 0.05, and a design effect of 1.5 were applied. Households were selected first, and all eligible women aged 15–49 years and children aged 6–23 months within sampled households were included in the survey. Adjustments were made for household size, target population proportions, and anticipated response rates at both the household (95%) and individual (95%) levels.

The required household sample size was determined using estimates from the 2016 Ethiopia Demographic and Health Survey (EDHS), the average household size, and a 5% household non-response rate (CSA and ICF, 2016). The women's sample size was then derived from this household-level sampling framework, based on the expected presence of women of reproductive age and national prevalence estimates of the Minimum Dietary Diversity for Women (MDD-W). Households were sampled first, and all eligible women aged 15–49 years within selected households were included in the survey. Under these assumptions, approximately 1,950 households with women of reproductive

age needed to be sampled to achieve regional representativeness. The resulting household and regional sample allocation is presented in Table 4.1.

The sample size was computed using the following formula.

$$n = \frac{Z\frac{2}{\frac{\alpha}{2}}\ P\,(1-P)}{d^2} * Deff * \frac{100}{RRHH} * \frac{100}{IRR} * \frac{1}{HH\ size} * \frac{1}{\%\ of\ Target\ PP}$$

Where:

n = Required sample size

Zα/2 = Z-score for 95% confidence (1.96)

P = Prevalence of the key indicator (region-specific)

D = Margin of error (0.05)

Deff = Design effect (1.5)

HH size = Average household size in each region

% of Target Pop = Proportion of the target population from each region

HHRR = Household response rate (95%)

IRR = Individual response rate (95%)

Table 4.1. Regional distribution of enumeration areas (EAs)

and household sample

Regions	Number of EAs	Household Sample
Addis Ababa	16	320
Amhara	22	430
Oromia	26	520
SNNP and Sidama	27	540
Somali	7	140
Total		1950

The present analysis draws on this original sample and focuses specifically on women of reproductive age included in the survey. However, the analytical sample for this chapter was restricted to women with complete data on key variables relevant to the study objectives. After excluding

observations with missing or incomplete information, 1,828 households with women were retained for analysis. This sample size remained sufficient to maintain regional representation and statistical precision for the outcomes examined in this chapter.

ii) Sampling procedure and allocation

A multistage sampling procedure was used to select households for the study (Figure 4.2), drawing on the framework of the Ethiopian Household Income and Expenditure Survey (Ethiopian Statistical Service (ESS) and World Bank, 2023).

Stage 1: Selection of Primary Sampling Units (PSUs)

The sampling process began with purposive selection of administrative zones and woredas within each region (stratum) to ensure representation of Ethiopia's diverse agroecological zones, farming systems, and socio-economic contexts (Ahmed, 2024). This included variation in livelihood systems (e.g., crop-based, agro-pastoral, and pastoral), market access, levels of urbanization, and resource endowments. Primary Sampling Units (PSUs) were then selected based on predetermined food system characteristics. Sample sizes for each target group were allocated proportionally across regions according to population distribution and place of residence (urban and rural), with approximately 30% of kebeles drawn from urban areas and 70% from rural areas to reflect national population patterns.

Stage 2: Selection of kebeles and villages

Within selected PSUs, kebeles and villages were randomly selected. A household listing was conducted in each selected Enumeration Area (EA), locally known as 'Gotes', with the support of village leaders to identify eligible households. Households were considered eligible if they included at least one member from the target study groups.

Stage 3: From each EA, 20 households were selected using systematic random sampling (Ahmed, 2024; Maduekwe and De Vries, 2019). In each selected household, interviews were conducted with the head of household and one woman aged 15–49 years.

During data collection, every effort was made to interview all selected households. If household members were absent, up to two callback visits were made. No replacements were made for non-responding households.

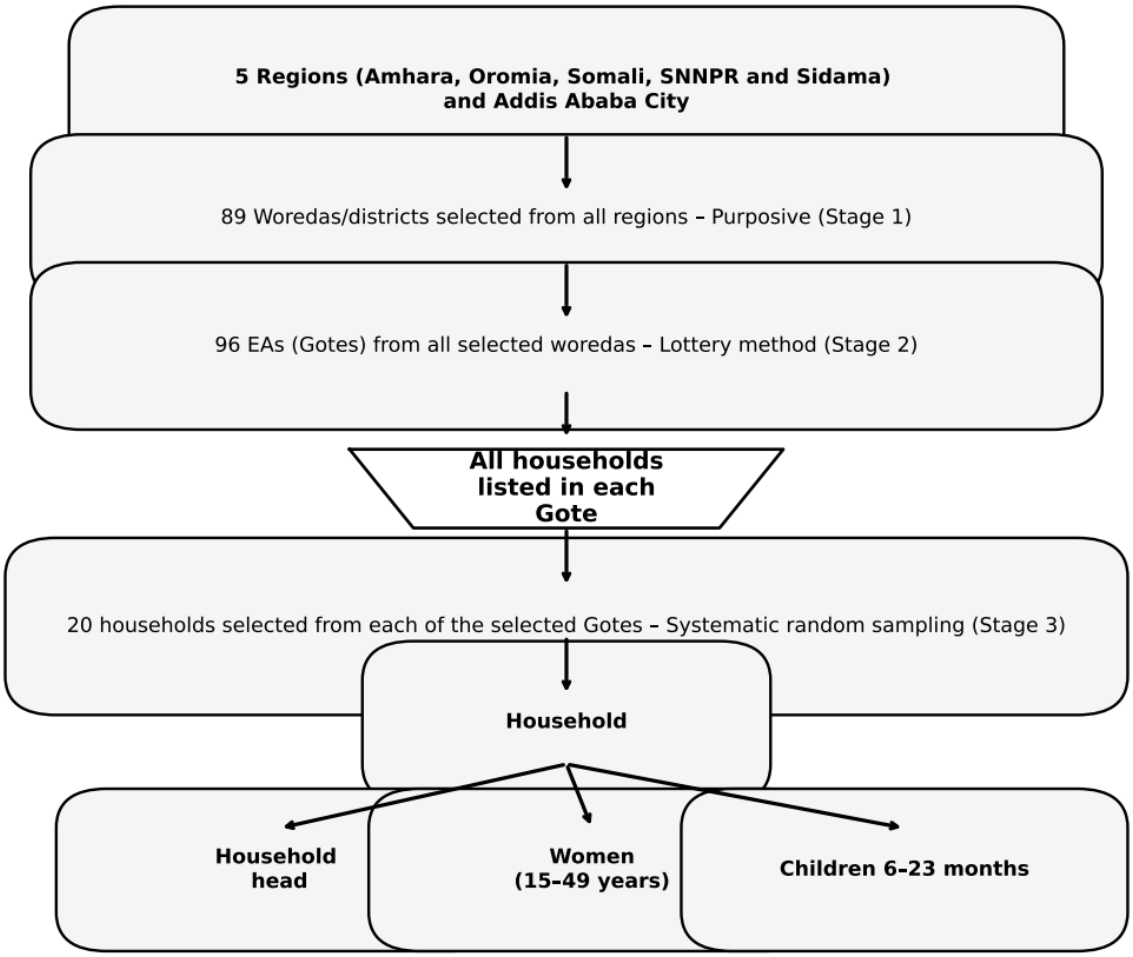


Figure 4.2. Sampling procedure flowchart.

iii) Household questionnaire

The household survey was a key part of the study's methodology and the primary source of quantitative data, designed to systematically gather data on several topics relevant to the study objectives (see Appendix, Table A4.1). The instrument was organized into several topics, each addressing a distinct domain pertinent to the food environment and overall food systems.

a. Household identification and socio-demographic characteristics

This section recorded geographic identifiers (region, zone, woreda, kebele, and enumeration area) along with GPS coordinates. A complete household roster was documented, including age, sex, relationship to the head of the household, marital status, literacy, religion, and highest level of education.

b. Individual and economic factors

Collected data on employment status, occupation, employer type, income sources, and time dedicated to domestic, agricultural, and market activities. Asset ownership information covered household goods, livestock breeds, and farming tools. The section also assessed behavioral indicators, such as food preferences, household access to preferred foods, and the frequency of consuming desired foods.

c. Food availability

Assessed the availability of foods within the local environment. For major food groups, respondents reported availability within a 60-minute radius. Food consumption over the previous seven days and 24 hours was recorded along with expenditure on purchased items. Exposure to food-based dietary guidelines (FBDG) messages through health workers or mass media was also documented.

d. Food supply

This module examined data on household participation in agricultural production and post-harvest activities. It covered information on landholding features, cropping systems, input use (fertilizers, irrigation, labor), soil types, and conservation methods. It recorded storage methods, post-harvest losses, crop sales, livestock production, and the use of livestock by-products. It also evaluated challenges related to marketing, processing, packaging, and access to agricultural markets.

e. Access to supporting infrastructure

This section of the questionnaire was designed to collect data on household access to financial and social services in the area, including the distances to the nearest commercial bank, microfinance institution, savings and credit cooperatives (SACCO), insurance branch, and health post, both in kilometres and in estimated travel time. The household distance to the nearest market and town was also collected to provide context on service availability, market access, and their impact on household economic decisions, food access, and well-being.

f. Dietary quality and nutrient adequacy

The Diet Quality Questionnaire (DQQ) was administered to adult women, who reported both their own dietary intake and the dietary intake of children aged 6–23 months, to assess diet quality based on food group consumption, in line with global dietary guidelines adapted to local contexts (Herforth et al., 2020). The DQQ records food items consumed over the last 24 hours, enabling evaluation of dietary diversity.

The Food Frequency Questionnaire (FFQ) was used to track typical eating habits over a long period (Khamis et al., 2021). This tool provided insights into how often and consistently they ate key food groups, complementing the short-term dietary data from the DQQ.

The multi-module questionnaire was initially developed in English and later translated into the local languages of Amharic and Afaan Oromo. It was then programmed using CSPro and uploaded to smartphones prepared for data collection. The researcher pretested both the paper and electronic versions at a location outside the study area. The field survey was carried out using tablet devices equipped with CSPro software, and quality assurance checks were incorporated into the electronic questionnaire to ensure data consistency and accuracy (Brahme et al., 2018).

Household heads mainly answered questions about land use, agriculture, assets, and economic activities, while women and caregivers were primary respondents for household, women, and children's dietary questions. Respondents with cognitive impairments that could affect their participation or response accuracy were excluded from the study.

iv) Data collection

A team of 34 enumerators and eight field supervisors completed 10 days of training and practice sessions with survey tools before deployment across all regions for fieldwork. The training covered important topics, including questionnaire modules, fieldwork logistics and operations, interview techniques, data quality assurance, using CSPro for electronic data entry, administering the questionnaire, obtaining informed consent, household listing, identifying eligible households, planning household revisits, and other essential fieldwork preparations.

Supervisors reviewed data daily and sent it to the Ethiopian Public Health Institute (EPHI) central server before data collectors left the enumeration areas. This process aimed to reduce the risk of data loss and enable the central data manager to give feedback to data collectors, helping them correct any errors.

4.2.3.2. Consumer price index

To complement household-level data, food price data were sourced from the Ethiopian Central Statistical Service's monthly Consumer Price Index (CPI), covering five months from July to November 2022 (Ethiopian Statistics Service, 2023). This dataset included prices for 119 food commodities—spanning staples (e.g., grains, roots), nutrient-rich foods (e.g., fruits, vegetables, dairy, eggs), and other groups (e.g., pulses, meat)—which enabled calculation of average food-group costs across study zones. These temporal price data were matched to the survey period to assess the impact of food prices and affordability on dietary outcomes. Additionally, household food expenditure data at the regional level were extracted from the Ethiopian Socioeconomic Survey (ESS) (CSA and ICF, 2018) and integrated with the study dataset. The ESS provided aggregated food expenditure estimates, offering a broader economic context for interpreting a household's affordability of a nutritious diet (Deptford et al., 2017).

Data were managed and analyzed in STATA version 16 (StataCorp, 2019) after thorough cleaning and data quality verification. Incomplete observations were excluded rather than imputed to maintain model robustness, as imputation risked introducing bias given the dataset's complex interrelationships (Wooldridge, 2010).

4.2.4. Diet quality

Women's diets were assessed using the Diet Quality Questionnaire (DQQ), adapted for Ethiopia (Herforth et al., 2020; Herforth, 2023). The DQQ tool comprises 29 food items or specific categories consumed over the previous 24 hours. In this research, we used four diet quality indicators: the Women's Dietary Diversity Score (WDDS), a simple Fruit and Vegetable Score (FVS) derived from DQQ, the Global Diet Quality Score (GDQS), and the Household Dietary Diversity Score (HDDS). These indicators were selected based on suitability for the cross-sectional survey and established correlation with nutrient adequacy (FAO, 2021).

The Women's Dietary Diversity Score (WDDS), following the FAO's MDD-W protocol (FAO, 2021), measures 24-hour dietary diversity across 10 food groups, with scores ranging from 0 to 10. A WDDS of five or more food groups suggests better micronutrient adequacy (Gómez et al., 2024, 2020; Tavakoli et al., 2016). The FVS, with scores from 0 to 6, assesses fruit and vegetable food groups and has also been shown to correlate with micronutrient adequacy (Pastori et al., 2023). The GDQS, a 25-food-group metric (scored 0-49), evaluates nutrient adequacy and NCD risk using a food frequency approach (Bromage et al., 2020). The details of GDQS scoring and mean intake by food group among women of reproductive age are provided in the Appendix (Table A4.2 and Table A4.3). The HDDS, based on 16 FAO-defined food groups, measures household food variety and access (Kennedy et al., 2011).

These indicators were all assessed based on a 24-hour recall period. Despite the potential for recall bias, particularly with infrequent items (Thompson and Subar, 2017), these indicators were selected for their feasibility in the cross-sectional study and adherence to DQQ standards (FAO, 2018). While repeated measures could more effectively capture habitual intake (Willett and Gunnar, 2014), employing multiple indicators could help reduce bias and improve the evaluation of how food environment predictors influence dietary quality (Maxwell et al., 2014; Waijers et al., 2007).

4.2.5. Analytical Approaches

4.2.5.1. The food environment framework and composite score

A conceptual framework was adapted and applied in low- and middle-income settings, as well as in the broader food systems framework, to evaluate comprehensive food environment performance (HLPE, 2017; Turner et al., 2018). This framework classifies the food environment into two main domains: external and personal, making it suitable for low- and middle-income countries (Turner et al., 2018). The external domain encompasses food availability, prices, vendor and product characteristics, marketing, and regulation. The personal domain includes individual-level factors such as food accessibility, affordability, convenience, and desirability. This distinction highlights how broader market dynamics and personal circumstances influence diets. Figure 4.3 illustrates the conceptual framework guiding the study's investigation of the relationships among components of the food environment (FE) and dietary outcomes. The framework facilitated the creation of a composite score for food availability, affordability, accessibility, price, convenience, and desirability by integrating individual scores. Due to data limitations, certain aspects of the theoretical framework (e.g., vendor/product characteristics, marketing/regulation) remain unaddressed (Figure 4.33).

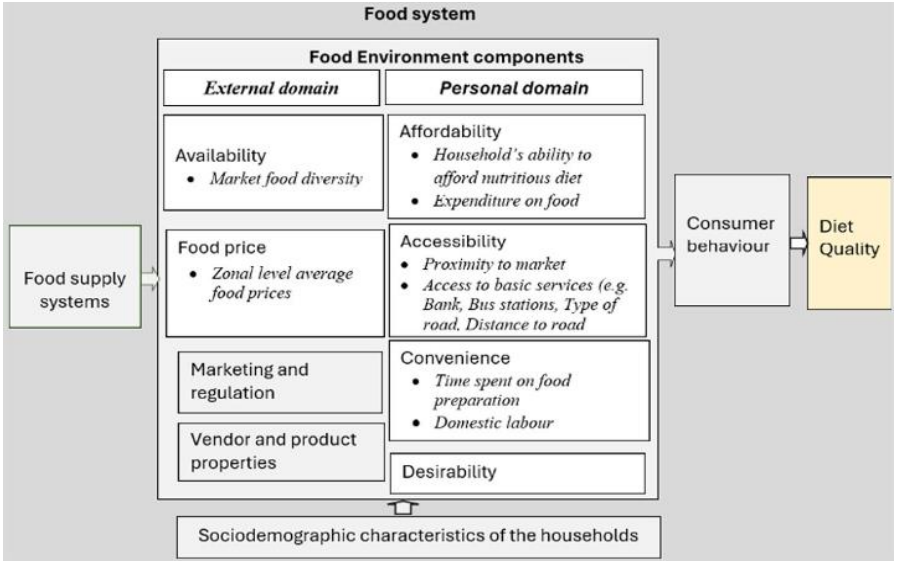


Figure 4.3. A conceptual framework illustrating the dimensions of the food environment.

(Adapted from Turner et al. (2018))

Food availability*:* Participants reported the presence of food items from a list of 58 within a 60-minute walk from their residences (Bryant and Stevens, 2006). This list was then categorized into ten groups according to the FAO's WDDS guidelines (FAO, 2021). A score reflecting the number of available food groups was classified as low (≤4 groups), medium (5-7 groups), or high (8-10 groups).

Price, Expenditure, and Affordability: Food prices were analyzed over five months, centred on the interviews. Prices for each food group were averaged by study zone and categorized into tertiles (low, medium, high) based on the overall distribution. A final food price score (1 to 3) was derived for each zone by averaging the scores across food groups (Shepperdley et al., 2024). Affordability was defined as a household's capacity to obtain a nutrient-adequate diet using locally available foods (Deptford et al., 2017). Non-affordability was evaluated by comparing the household's average monthly food expenditure with the cost of a nutritious diet for that zone and classifying the zone as low, medium, or high.

Physical accessibility: refers to the ease with which individuals can acquire food (Turner et al., 2018). In this analysis, the variables related to "physical access" included the reported walking distance to the nearest market, distance to roads, distance to transportation facilities, distance to banking services, and road type. These variables were used to determine whether households had a reasonable opportunity to access the resources needed to obtain the food necessary for a healthy diet.

Convenience: This study defines convenience as the ease and speed with which individuals can acquire and prepare food, acknowledging its potential to enhance or impair food choices and diet quality (Caspi et al., 2012). To operationalize convenience, two key factors were evaluated in the household context: the time allocated to food preparation (measured in minutes per meal, as reported by respondents) and the availability of domestic labour dedicated to food preparation.

Desirability: Participants ranked their top three food preferences (1 = most preferred, 2 = second, 3 = third) under no financial or health constraints. They then reported how often they consumed these foods over the previous 24 hours. A desirability score was calculated by weighting preferences (3, 2, and 1 points for first, second, and third choices) and multiplying each by consumption

frequency, with higher scores indicating greater alignment between diet and preferences (Drewnowski and Darmon, 2005; Story et al., 2008).

Food environment composite score: A composite score for the food environment for each household was developed by integrating scores for food availability, affordability, price, access, convenience, and desirability (Figure 4.4). This composite score was then categorized into three levels of food environments: low, medium, and high, corresponding to scores of 1, 2, and 3, respectively.

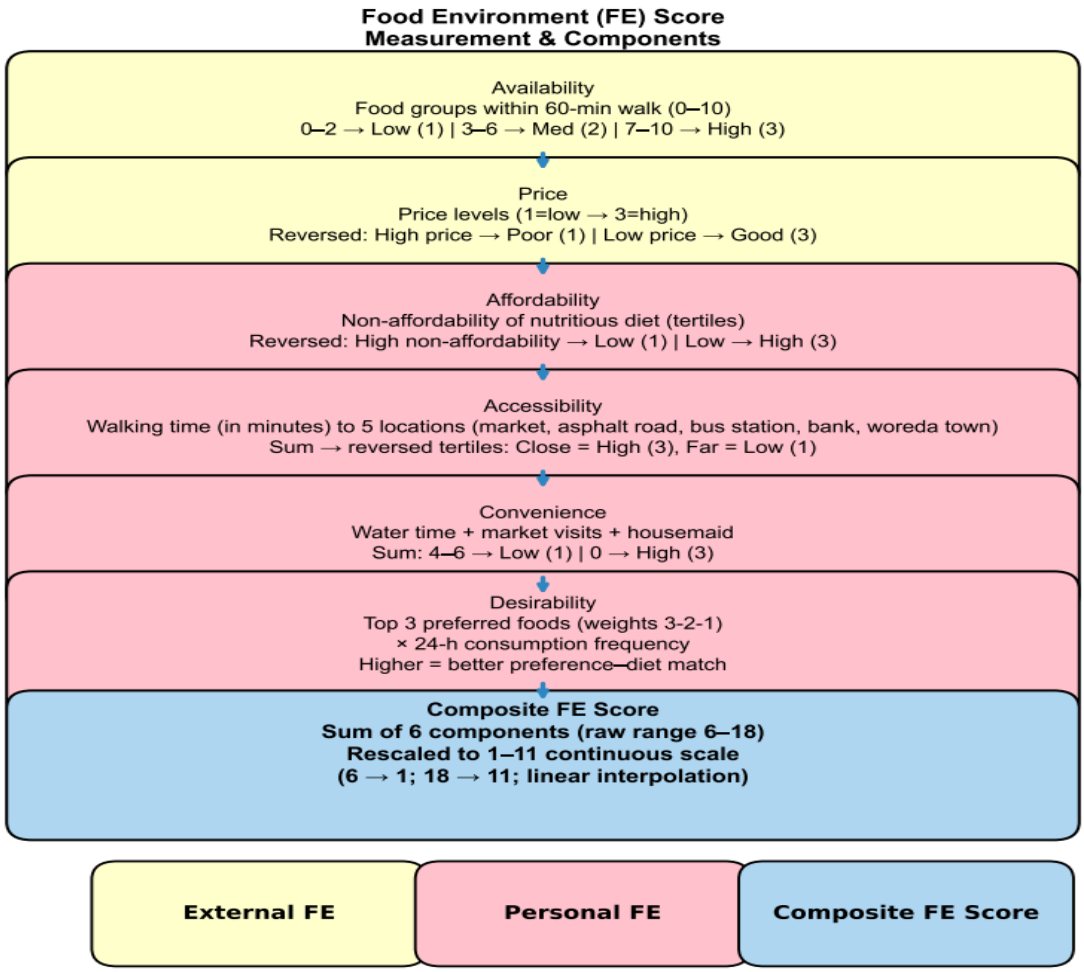


Figure 4.4. Development of the Food Environment Score.

4.2.5.2. Econometric approach

The wealth index was constructed using principal component analysis (PCA) of household asset ownership (including livestock), following methods explained elsewhere (Rutstein and Johnson, 2004; Vyas and Kumaranayake, 2006).

To investigate the relationship between dietary quality indicators—Women's Dietary Diversity Score (WDDS), Fruit and Vegetable Score (FVS), Global Diet Quality Score (GDQS), and Household Diet Diversity Score (HDDS)—and the food environment, the author employed a series of Poisson regression models, a method widely used for count outcomes in nutritional studies (Hardin and Hilbe, 2014). First, a baseline model (Model 1) was estimated using sociodemographic characteristics, including residence (urban/rural), gender, age, education level, region, livelihood type, and wealth index, to establish baseline associations, consistent with standard practice in dietary research as outlined by Kennedy et al. (2011). Then, in Model 2, the food environment dimensions were assessed, capturing external factors (e.g., the number of food groups available in nearby markets and average prices) and personal factors (e.g., household expenditure, non-affordability, and access to infrastructure such as markets and roads), consistent with frameworks for food environment analysis (Turner et al., 2018). Model 3 combined all predictors to assess their joint influence on dietary outcomes, while Model 4 used a composite food environment score alongside sociodemographic covariates as an alternative approach, a method applied in similar studies to simplify complex food environment effects (Shepperdley et al., 2024).

For each diet quality indicator Yk (where k denotes WDDS, FVS, GDQS, and HDDS), we modeled the log of the expected count using a Poisson regression model. The fully adjusted model (Model 3) is specified as:

$$\log(\mathrm{E}[Y_k]) = \alpha k + \beta_{k1}X_1 + \beta_{k2}\,X_2 \ldots + \beta_{km}X_m + \gamma_{k1}\,Z_1 + \gamma_{k2}\,Z_2 + \cdots + \gamma_{kn}\,Z_n \quad \text{(Eq. 1)}$$

Where: X_1, X_2,…, X_m are sociodemographic variables, Z_1, Z_2,…, Z_n are food environment variables (external and personal), and α_k, β_{kj}, γ_{kj} are the intercept and coefficient specific to outcome k (Hardin and Hilbe, 2014). Equivalently, the expected count can be specified as:

$$E[Y_k] = \exp\left[\alpha k + \beta_{k1}X_1 + \beta_{k2}\,X_2 \ldots + \beta_{km}X_m + \gamma_{k1}\,Z_1 + \gamma_{k2}\,Z_2 + \cdots + \gamma_{kn}\,Z_n\right) \ldots \text{(Eq. 1a)}$$

Model 4 simplifies the food environment dimensions into a composite score, specified as:

$$\log(\mathrm{E}[Y_k]) = \alpha k + \beta_{k1}X_1 + \beta_{k2}\,X_2 + \cdots + \beta_{km}X_m + \delta_k\,W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(Eq. 2)}$$

W is the composite food environment score, and δ_k is its coefficient. Coefficients (exp (β_{kj}), exp (γ_{kj}), exp(δ_k)) represent the multiplicative effect on the expected count of indicator k per unit increase in the respective predictor (Hardin and Hilbe, 2014). Estimated coefficients were deemed significant at $p<0.05$, with additional thresholds at $p<0.01$ and $p<0.001$ for robustness.

This model was selected for its suitability for count response variables and its ability to manage both continuous and categorical predictors within the food environment framework (Vyas and Kumaranayake, 2006). Model assumptions were evaluated: goodness-of-fit was confirmed through the deviance statistics, and overdispersion was assessed using the ratio of residual deviance to degrees of freedom. No significant overdispersion was identified ($p > 0.05$), supporting the Poisson model over a negative binomial alternative (Vyas and Kumaranayake, 2006). Multicollinearity was evaluated using variance inflation factors (VIFs), all of which were below 10, indicating no significant multicollinearity (Mekonnen et al., 2020).

4.3. Results

4.3.1. Description of household characteristics

Table 4.2 outlines descriptive statistics of the demographic and dietary characteristics of the households and women included in the study. Overall, 63.6% of respondents resided in rural areas and 38.4% in urban areas. The average age of the household heads was 42 years, and 18% were female. On average, households consisted of five members. In urban areas, about 50% of household heads have completed high school or higher, while only 20% in rural areas have achieved this level of education.

Table 4.2. Household sociodemographic characteristics by residential status

Characteristic	Total (N=1,828)	Rural (n=1,126)	Urban (n = 702)
Regions, %			
Amhara	20.3	25.4	12.1
Oromia	27.6	32.5	19.8
Somali	7.2	8.5	5.3
SNNP	20.9	26.7	11.7

Sidama	7.3	7.0	7.7
Addis Ababa	16.7	0.0	43.4
Household head Gender, %			
Female	18.3	13.1	26.8
Male	81.7	86.9	73.2
Household head age, mean (SD)	41.6 (12.2)	40.5 (11.4)	43.4 (13.2)
Family size, mean (SD)	4.7 (1.8)	4.9 (1.8)	4.6 (1.8)
Household head education attained, %			
Primary (1-8 years)	66.8	77.1	50.1
Completed high School	18.1	11.9	28.1
High school + certificate	4.7	3.2	7.0
Bachelor and above	7.7	4.8	12.4
Other informal	2.7	2.9	2.4
Wealth tertiles, %			
Poorest	33.4	39.1	24.1
Middle	33.7	24.6	48.3
Richest	32.9	36.2	27.6
Dietary scores, mean (SD)			
WDDS	3.4 (1.5)	3.3 (1.4)	3.4 (1.6)
HDDS	6.2 (0.05)	5.8 (0.1)	6.7 (0.1)
FVS	1.3 (1.3)	1.3 (1.2)	1.3 (1.4)
GDQS	20.7 (0.12)	20.5 (0.17)	21.0 (0.18)
MDD-W, %	19.8	19.1	20.9
Food environment (FE), %			
Low FE	37.6	48.5	20.1
Medium FE	40.0	35.7	47.0
High FE	22.4	15.8	32.9

Data are presented as % for categorical variables and mean (SD) for continuous variables—abbreviations: SD, standard deviation; NA, not applicable.

4.3.2. Women's diet quality and the food environment

Figure 4.5 illustrates women's consumption of food groups across food environment (FE) categories. Grains, white roots, and tubers were consumed by nearly all women (approximately 99%) across all FE categories, followed by pulses (40% in low FE, 70% in medium FE, and 75% in high FE). Other vegetables and dark green leafy vegetables were consumed by 45-47.2% and 23.5-50% of women, respectively, with slight increases from low to high FE. Dairy consumption was higher in low

FE (51%) than in medium (23.3%) or high FE (19%), while meat, poultry, fish, and eggs showed lower consumption, with consumption increasing slightly with higher FE. Vitamin A-rich fruits and vegetables, other fruits, nuts, and seeds had the lowest consumption (1% to 24%) with modest increases across FE categories. The graph also shows an improvement in the percentage of women achieving minimum dietary diversity as FE increases from low to high.

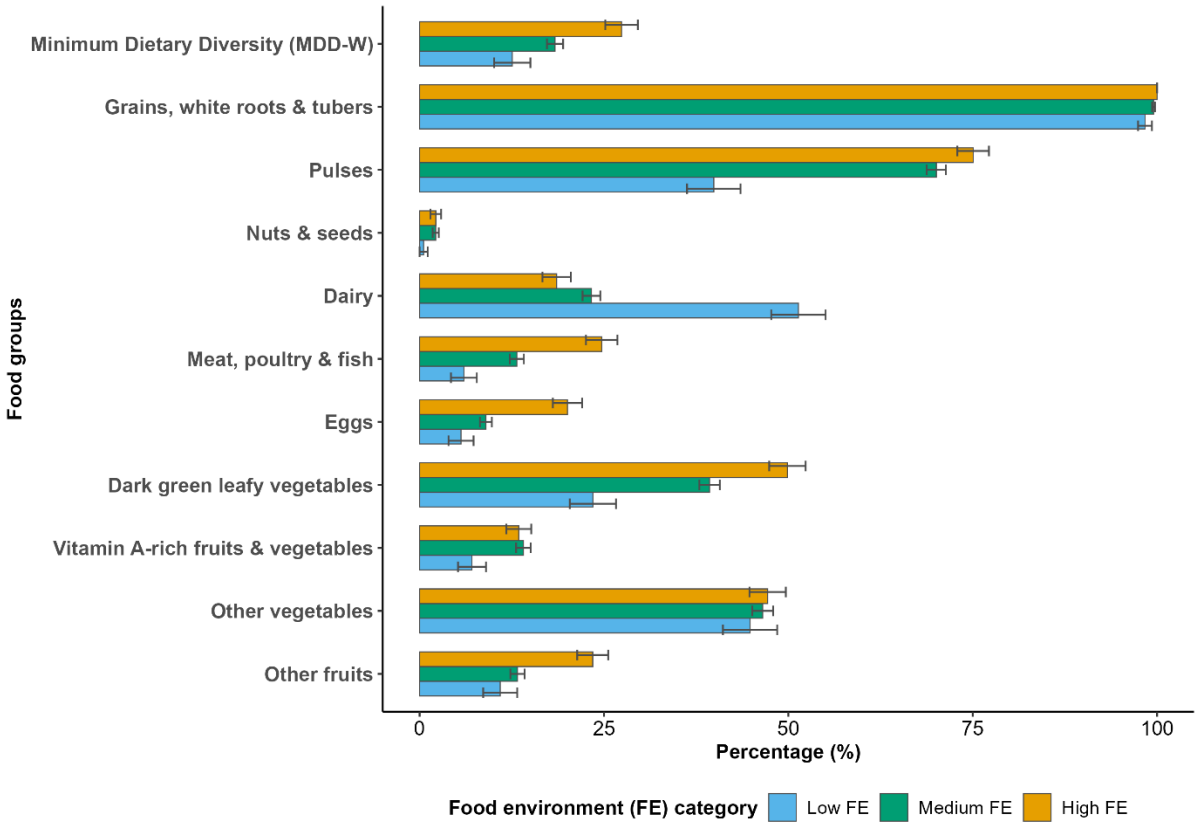


Figure 4.5. Women's consumption of food groups by food environment (FE) category.

The bars in the figure show the proportions of women consuming each food group, categorized by Food Environment (FE) level: Low, Medium, and High. Error bars indicate standard errors of the proportions.

Figure 4.6 displays the mean global diet quality score (GDQS) across food environment (FE) categories for 1,828 participants. The total GDQS increased from low to high FE (Figure 4.6a); however, the observed means were notably lower than the maximum possible score of 49, suggesting significant dietary inadequacies. An increasing trend in the GDQS was observed with higher FE, and this pattern was more pronounced for the GDQS+ (healthy food groups; maximum score = 32; Figure 4.6b). Further

analysis of GDQS intake, categorized as low, middle, and high based on established daily intake cutoffs (in grams), and the distribution of women across these categories is detailed in Tables A5.2 and A5.3.

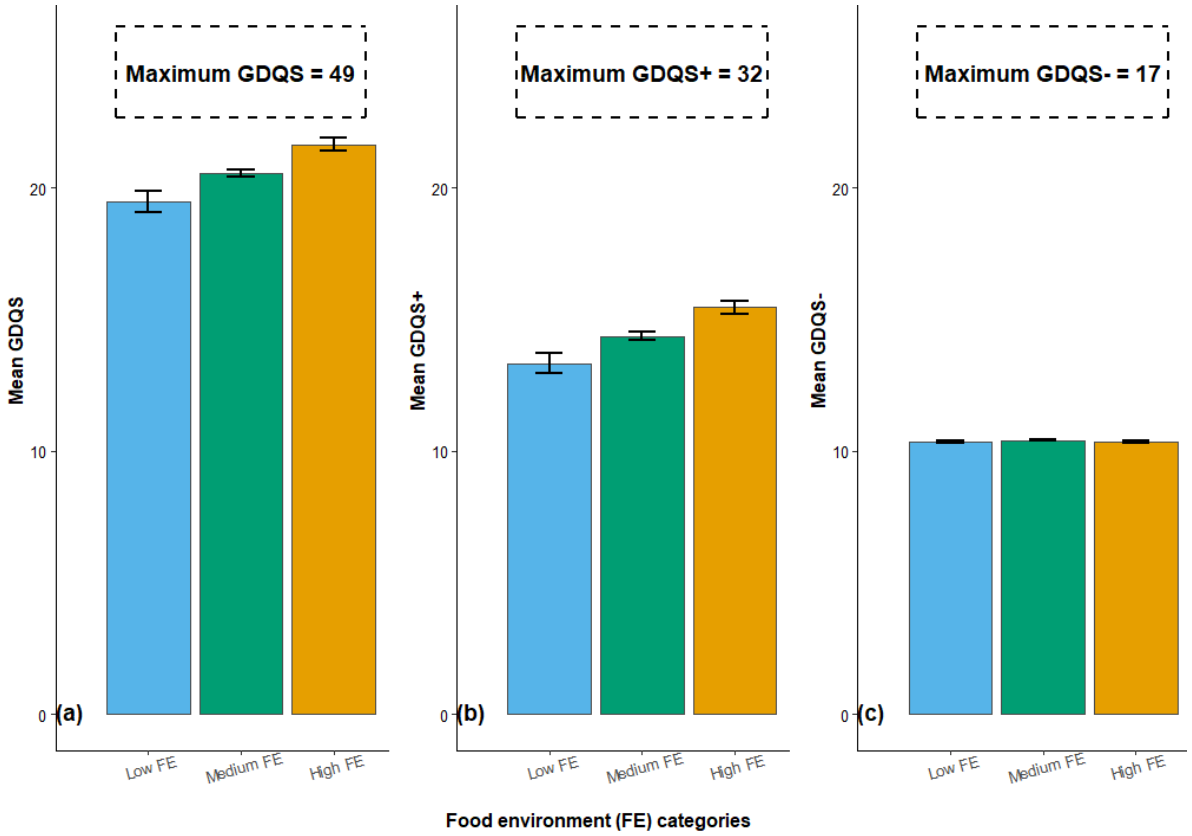


Figure 4.6. Women's mean GDQS and subcomponents (GDQS + and GDQS-) by food environment.

(Panels: a total GDQS (max score = 49); b GDQS + (healthy food groups, max score =32); c GDQS- (unhealthy food groups, max score = 17))

Dietary diversity and intake scores were analyzed by Food Environment (FE) and wealth status (Figure 4.7). The average Women's Dietary Diversity Score (WDDS) increased across FE categories, with the wealthiest group demonstrating the highest scores (Figure 4.7a). Similar trends were noted for the mean Household Dietary Diversity Score (HDDS) (Figure 4.7b) and the average Global Diet Quality Score (GDQS) (Figure 4.7c). The findings indicate that the wealthiest group had the highest average scores across all indicators in each FE category.

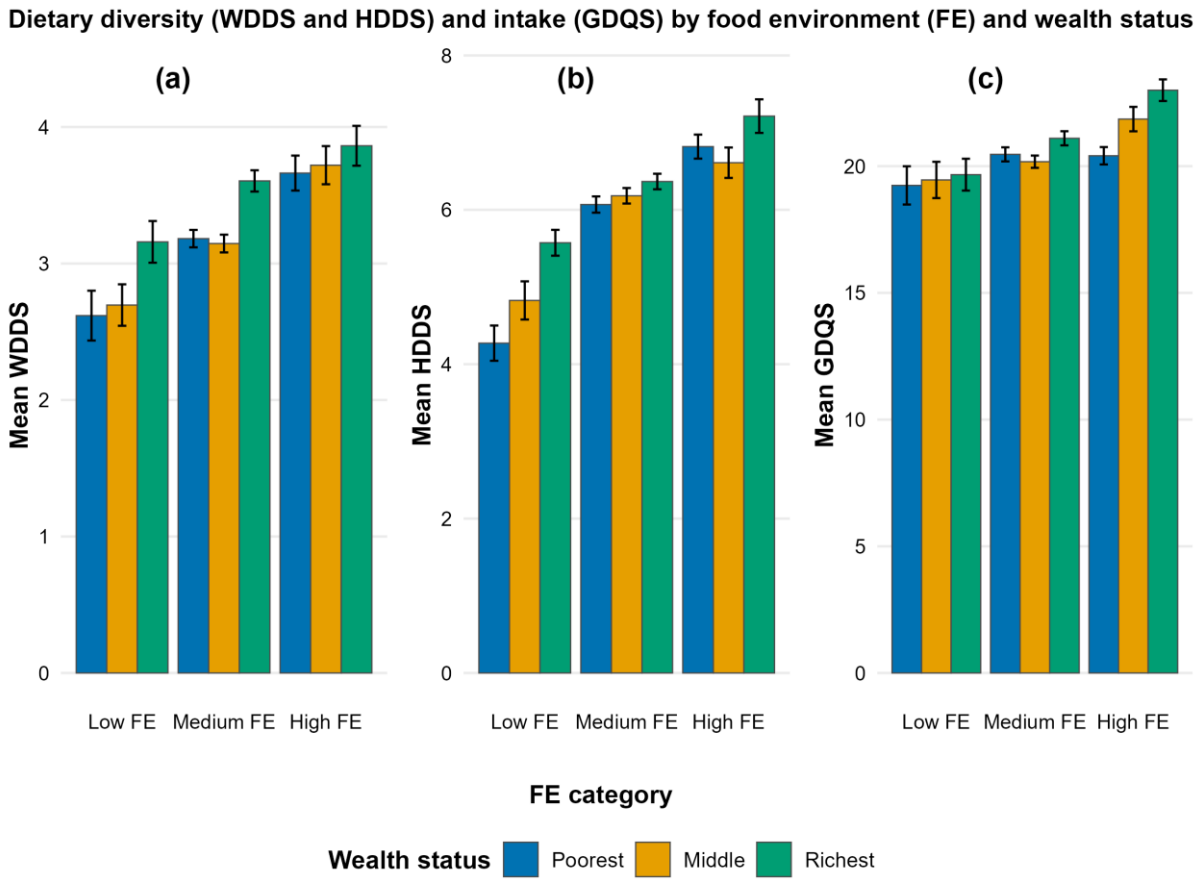


Figure 4.7. Dietary diversity (WDDS and HDDS) and intake (GDQS) based on the food environment and wealth status.

Panels show (a) Mean women's dietary diversity score (WDDS), b mean household dietary diversity score (HDDS), and (c) mean global diet quality score (GDQS). Bars represent scores for the poorest, middle, and richest wealth categories within each FE group.

4.3.3. Sociodemographic and dimensions of the food environment

Table 4.3 presents the results of Poisson regression analyses that examine the associations between dietary quality indicators—Women's Dietary Diversity Score (WDDS), Fruit and Vegetable Score (FVS), Global Diet Quality Score (GDQS), and Household Dietary Diversity Score (HDDS)—and a range of socioeconomic and food environment factors from a sample of 1,828 households and women. This section summarizes key findings on the socioeconomic and food-environment predictors of these multiple diet-quality indicators, based on fully adjusted Poisson regression results. The model fit for WDDS, FVS, GDQS, and HDDS improved across specifications, with Model 3 (complete model)

demonstrating the strongest explanatory power. Model fit statistics are presented in the Appendix as Tables A4.4-A4.6.

4.3.3.1. Sociodemographic predictors

The regression analysis highlights significant regional variations in dietary diversity across Ethiopia, as detailed in Table 5.2. Compared with the reference region (Oromia), Amhara and Somali regions exhibit significantly lower dietary diversity scores. In Amhara, the WDDS is reduced by 8% ($\exp(\beta) = 0.92$, $p < 0.05$), the FVS decreases by 47% ($\exp(\beta) = 0.53$, $p < 0.01$), and the HDDS is lower by 17% ($\exp(\beta) = 0.83$, $p < 0.001$). These findings highlight substantial disparities in dietary quality across regions. Similarly, in Somali, the WDDS is 20% lower ($\exp(\beta) = 0.80$, $p < 0.01$), indicating a significant challenge in achieving diverse diets. Other regions, such as SNNP and Sidama, show mixed outcomes: SNNP exhibits a relatively stable WDDS and a higher FVS ($\exp(\beta) = 1.20$, $p < 0.05$) compared to the reference. In contrast, Sidama demonstrates a lower FVS ($\exp(\beta) = 0.64$, $p < 0.05$) along with a slightly reduced GDQS ($\beta = 2.25$, $p < 0.05$).

Table 4.3. Results from the Poisson and OLS regression analysis on the associations between dietary quality, socioeconomic factors, and components of the FE in Ethiopia

Variables (N=1828)			(1) WDDS - Poisson	(2) FVS - Poisson	(3) GDQS - OLS	(4) HDDS - Poisson
			(exp(β) [95% CI]	(exp(β) [95% CI]	β [95% CI]	(exp(β) [95% CI]
Residence [Rural = Ref]			1.07 [1.02,1.13] *	1.28 [1.14,1.44] ***	0.109 [-0.58–0.80]	1.01 [0.97,1.06]
Gender [Female = Ref]			0.99 [0.94–1.04]	.99 [0.88–1.14]	0.120 [-0.50–0.73]	0.99 [0.96–1.03]
Education years attended			1.01 [1.00–1.01] *	1.01 [1.00–1.01] *	0.059 [0.01–0.11] *	1.01 [1.00–1.01] **
Region						
Amhara			0.92 [0.86–1.00] *	0.67 [0.54–0.82] ***	0.043 [-0.93–1.02]	0.83 [0.78–0.88] ***
Oromia			1	1	1	1
Somali			0.80 [0.67–0.95] **	0.53 [0.38–0.73] **	.957 [0.22–2.13]	0.88 [0.71–1.08]
SNNP			0.95 [0.87–1.03]	1.20 [1.00–1.43] *	1.06 [0.21–1.904] *	0.82 [0.74–0.84] ***
Sidama			0.94 [0.81–1.10]	0.64 [0.44–0.94] *	-2.25 [-4.10–-0.38] *	0.93 [0.82–1.06]
Addis Ababa			1 .04 [0.98–1.10]	1.09 [0.96–1.24]	0.21 [-0.35–0.77]	1.03 [0.98–1.08]
		Poorest	0.88 [0.85–0.93] ***	0.86 [0.77–0.96] **	-0.61 [-1.19–-0.03] *	0.93 [0.90–0.96] ***
Wealth status		Middle	0.92 [0.89–0.98] ***	0.91 [0.82–1.01]	-0.44 [-1.01–0.12]	0.95 [0.92–0.98]5**
		Richest	1	1	1	1
HH income decile (ETB)			1.01 [1.00–1.02] **	1.02 [1.00–1.04] *	0.31 [0.21–0.40] ***	1.01 [1.00–1.01] *
	Low (<4 FGs)		1	1	1	1
Food availability	Medium (5–7 FGs)		1.07 [1.00–1.15]	1.22 [1.01–1.46] *	1.33 [1.09–1.64] *	1.22 [1.15–1.30] ***
	High (8– 10 FGs)		1.08 [1.02–1.15] **	1.18 [0.99–1.41]	1.77 [1.45–2.75] ***	1.42 [1.35–1.50] ***
	Grain, root, and tubers		1.09 [1.05–1.13] ***	1.28 [1.17–1.39] ***	1.02 [0.49–1.55] ***	0.98 [0.96–1.02]
Average food group price	Vegetables		0.89 [0.84–0.94] ***	0.79 [0.70–0.89] ***	-1.19 [-1.86–-0.52] ***	.98 [0.96–1.04]
	Fruits		.99 [0.96–1.01]	1.02 [0.96–1.09]	-0.64 [-1.00–-0.271] **	1.03 [1.01–1.05] *
	Meats		1.01 [1.01–1.02] ***	1.04 [1.03–1.06] ***	0.21 [0.15–0.27] ***	1.00 [1.00–1.01]

	Milk	1.01 [1.00–1.01] *	1.00 [0.99–1.00]	0.01 [-0.03–0.04]	1.00 [1.00–1.00]
	Pulses, nuts, and seeds	0.93 [0.92–1.01] *	0.98 [0.85–1.13]	0.51 [-0.04–1.06]	0.99 [0.95–1.03]
	Eggs	1.02 [1.00–1.03] *	1.02 [0.99–1.06]	-0.14 [-0.33–0.04]	1.00 [0.99–1.02]
Expenditure decile (ETB)		1.01 [1.00–1.02] **	1.00 [0.98–1.02]	0.12 [0.011–0.224] *	1.02 [1.01–1.03] ***
Non-affordability (NA)	High NA	1	1	1	1
	Medium NA	1.03 [0.97–1.10]	1.17 [1.01–1.35] *	0.03 [-0.70–0.76]	0.97 [0.92–1.02]
	Low NA	1.01 [0.92–1.11]	1.33 [1.08–1.65] **	0.49 [-0.62–1.60]	0.86 [0.85–1.03] ***
Distance to market–km		.99 [0.99–1.00] *	0.99 [0.98–1.00] *	-0.07 [-0.11–-0.03] ***	1.00 [1.00–1.00]
Distance to the road–km		1.00 [1.00–1.00]	0.99 [0.99–1.00] **	-0.02 [-0.04–-0.01] ***	0.95 [0.94–1.00] ***
Distance to bus station–km		1.01 [0.98–1.00] **	1.00 [0.99–1.00]	-0.004 [-0.04–0.03]	1.00 [1.00–1.00]
Distance to a bank–km		1.00 [1.00–1.01]	1.01 [1.00–1.02]	0.02 [-0.03–0.07]	1.00 [1.00–1.00]
Type of road access	No road within 1 hour	1	1	1	1
	Gravel/all-weather	1.12 [1.07–1.18] ***	1.20 [1.08–1.34] ***	0.12 [-0.56–0.79]	1.03 [0.99–1.07]
	Dry weather road	1.05 [0.99–1.10]	1.06 [0.95–1.19]	0.911 [-2.08–3.90]	1.02 [0.98–1.05]
Convenience score		1.06 [1.00–1.11] *	1.18 [1.06–1.32] **	0.42 [-0.305–1.138]	1.11 [1.06–1.15] ***
Desirability score		1.14 [1.10–1.19] ***	1.31 [1.19–1.45] ***	2.01 [1.46–2.56] ***	1.03 [1.00–1.07]
Model P-value		<0.001	<0.001	<0.001	<0.001
N		1818	1816	1818	1818

Model 3 includes sociodemographic covariates, external food environment (FE), and personal FE components. Results are expressed as incidence rate ratios (exp(β)), with 95% confidence intervals in brackets. GDQS coefficients represent linear effects (β). *Significance levels are indicated: *p < 0.05, **p < 0.01, ***p < 0.001. Sample sizes vary due to missing data. Abbreviations: NA: Non-affordability; ETB: Ethiopian Birr.*

In addition to regional differences, wealth status and household income also influence dietary quality. Compared to the wealthiest category (reference), the poorest households exhibit reduced dietary diversity, with a 11% lower WDDS ($\exp(\beta) = 0.89$, $p < 0.001$), a 14% lower FVS ($\exp(\beta) = 0.86$, $p < 0.01$), and a 7% lower HDDS ($\exp(\beta) = 0.93$, $p < 0.001$), along with a slight decrease in GDQS ($\beta = -0.61$, $p < 0.05$). Middle-wealth households also experience lower scores, with an 8% reduction in WDDS ($\exp(\beta) = 0.92$, $p < 0.001$) and a 5% reduction in HDDS ($\exp(\beta) = 0.95$, $p < 0.01$), while FVS and GDQS show no significant changes. Household income, measured in deciles of monthly income in Ethiopian Birr (ETB), positively correlates with dietary diversity, with a 1% increase in WDDS ($\exp(\beta) = 1.01$, $p < 0.01$), a 2% increase in FVS ($\exp(\beta) = 1.02$, $p < 0.05$), a 0.3 unit increase in GDQS ($\beta = 0.31$, $p < 0.001$), and a 1% increase in HDDS ($\exp(\beta) = 1.01$, $p < 0.05$) per decile, highlighting the role of economic resources in improving dietary quality.

Other socioeconomic and demographic predictors, including residential status (rural as reference), show significant differences for WDDS and FVS but negligible effects on HDDS and GDQS. Gender also plays a minor role, with no substantial differences between males and females across all scores. Education, measured by years attended, demonstrates a minimal positive association, with a slight increase in dietary quality scores across indicators, though the effect is not pronounced. These findings underscore the dominant influence of regional context and economic status.

4.3.3.2. Food environment dimensions and diet quality scores

a. External food environment

Dietary outcomes are significantly influenced by factors in the external food environment, primarily food availability and food prices. Compared with households with low food availability (<4 food groups), households with medium (5-7 food groups) and high availability (8-10 food groups) are associated with increases of 7% and 8% in WDDS, respectively. Similarly, the regression results show a 42% higher HDDS ($\exp(\beta) = 1.42$, $p < 0.001$) with high food availability than with low food availability, suggesting that greater local food diversity enhances women's and household dietary diversity. While high availability shows a trend toward an increased FVS, this association was not statistically significant.

Medium availability (5-7 food groups) also demonstrates positive associations, with an increased FVS ($\exp(\beta) = 1.22$, $p < 0.05$) and HDDS ($\exp(\beta) = 1.22$, $p < 0.001$). Higher food availability is also associated with increased GDQS (Table 5.2).

In addition to food availability, food prices significantly influence dietary outcomes. Higher vegetable prices are associated with notable decreases in WDDS (11%, $p < 0.001$), FVS (21%, $p < 0.001$), and GDQS ($\beta=-1.2$, $p < 0.001$). Higher fruit prices slightly reduce GDQS ($\beta=-0.64$, $p < 0.01$), while increased prices for pulses, nuts, and seeds are linked to a 7% decrease in WDDS ($p < 0.05$). Conversely, higher prices for grains, roots, and tubers are associated with increases in WDDS (9%, $p < 0.001$), FVS (28%, $p < 0.001$), and GDQS ($\beta=1.02$, $p < 0.001$). Similarly, higher meat prices lead to small but significant increases in WDDS (1%, $p < 0.001$), FVS (4%, $p < 0.001$), and GDQS ($\beta = .21$, $p < 0.001$), and fruit prices also increase HDDS (3%, $p < 0.01$). These findings indicate that while greater availability enhances diversity, higher relative prices for vegetables, fruits, and pulses hinder dietary quality.

b. Personal food environment

Factors reflecting household and individual access and preferences also play a crucial role. Improved convenience in food preparation is positively associated with higher scores in WDDS ($\exp(\beta)=1.06$, $p<0.05$), FVS ($\exp(\beta)=1.18$, $p<0.01$), and HDDS ($\exp(\beta)=1.11$, $p<0.001$), indicating that ease of food preparation promotes a more diverse diet. The desirability score, which captures the frequency of consuming preferred foods, shows even stronger effects. Higher desirability scores correlate with increased WDDS ($\exp(\beta)=1.14$, $p<0.001$), FVS ($\exp(\beta)=1.31$, $p<0.001$), and GDQS ($\beta=2.01$, $p<0.001$), particularly pronounced for FVS. This suggests that diets more closely aligned with food preferences have higher quality, especially regarding fruit and vegetable consumption. Household non-affordability (i.e., lower affordability) is linked to a lower FVS ($\exp(\beta)=1.33$, $p<0.01$), indicating that the ability to afford food boosts women's fruit and vegetable intake. However, non-affordability is not significantly associated with HDDS ($\exp(\beta)=1.01$, $p<0.01$).

c. Supporting Infrastructure

Access to supporting infrastructure, such as market proximity and road access, demonstrates modest yet significant associations with dietary outcomes. A higher distance to market is linked to lower dietary diversity, as indicated by a 1% decrease in WDDS ($\exp(\beta) = .99$, $p < 0.05$) and FVS ($\exp(\beta) = 0.99$, $p < 0.05$) for every additional one kilometer. Similarly, increased distance to roads correlates with lower FVS and HDDS. The type of road access also matters, as access to dry-weather roads (compared to no road within one hour) positively associates with WDDS ($\exp(\beta) = 1.12$, $p < 0.001$) and FVS ($\exp(\beta) = 1.20$, $p < 0.001$), highlighting the advantages of even basic infrastructure. While gravel or all-weather roads show a positive but somewhat weaker correlation with dietary diversity (FVS), the impact is not as conclusive. In contrast, proximity to bus stations and banks has a limited effect, with significant associations identified only for women's dietary diversity score.

4.3.3.3. The food environment composite score and dietary quality

The composite food environment score is positively and significantly associated with all measured dietary outcomes after adjusting for socio-demographic covariates (Model 4) (Figure 5.7). As food environment performance improves, predicted dietary scores increase in a precise pattern. Women's Dietary Diversity Score (WDDS) rises almost linearly from approximately 3.0 in the poorest food environments to around 4.0 food groups on average in the most favorable ones, while the Fruit and Vegetable Score (FVS) shows a flatter but still positive trend, increasing from about 1.15 to 1.55. The Global Diet Quality Score (GDQS) shows a steady upward trend, increasing slightly from roughly 20 to nearly 22 across the full range of food environment scores. The strongest association is observed for the Household Dietary Diversity Score (HDDS), which rises sharply from around 5.5 in the lowest-quality food environments to approximately 8.5–9 in the highest-quality food environments. Taken together, these consistent positive gradients demonstrate that more favorable food environments are robustly associated with greater dietary diversity and improved diet quality at both the individual and household levels.

The overall food environment (FE) significantly influences dietary outcomes, with predicted dietary scores increasing across higher FE categories after adjusting for socioeconomic covariates (Figure 4.8). Specifically, the Women's Dietary Diversity Score (WDDS) and Fruit and Vegetable Score (FVS) are lowest in the Low FE category, with scores rising progressively as the FE score increases (Figure 4.8a, Figure 4.8b), indicating that a more favorable food environment enhances women's dietary diversity and fruit and vegetable intake. Similarly, the Global Diet Quality Score (GDQS) and Household Dietary Diversity Score (HDDS) exhibit a clear upward trend across FE categories, with the highest scores observed in the High FE category (Figure 4.8c, Figure 4.8d), underscoring the positive impact of improved food environments on overall dietary quality and household diversity. Detailed results for predicted dietary quality outcomes by food environment score, adjusted for socioeconomic covariates, are available in the Appendix (Figure A4.1-Figure A4.4).

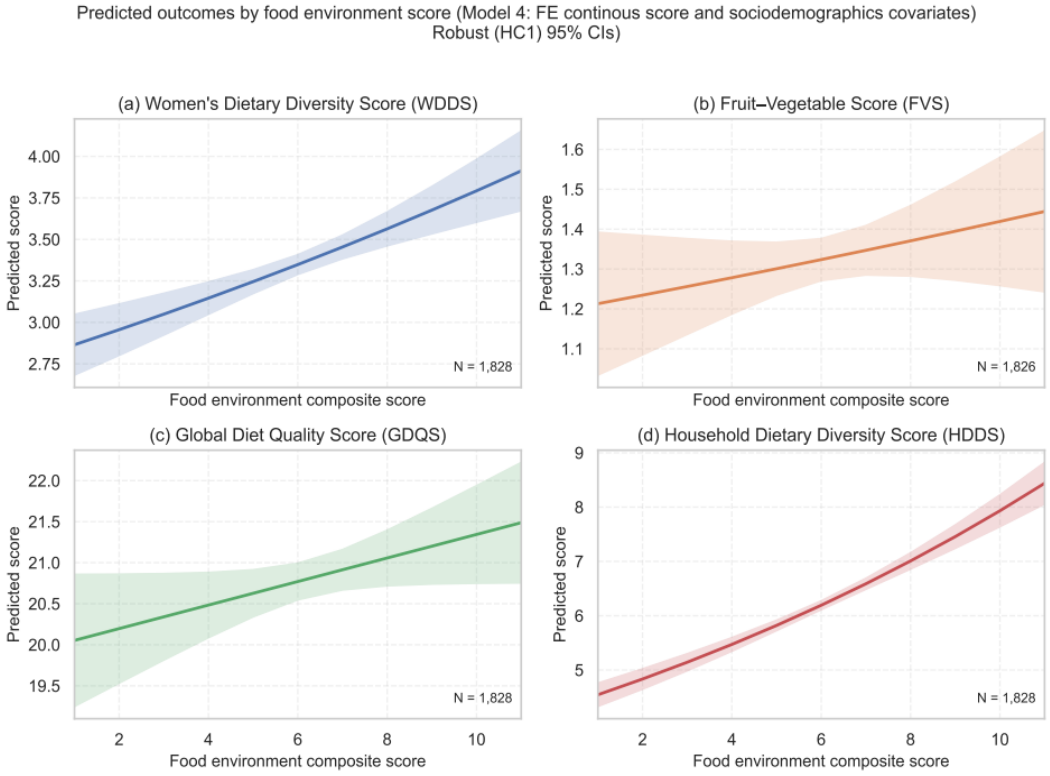


Figure 4.8. Associations between food environment composite score and dietary outcomes.

(Adjusted Predictions). Shaded areas represent robust 95% confidence intervals using heteroskedasticity-consistent (HC1) standard errors.

The food environment composite score exhibits a strong, positive, and nearly linear association with the Months of Adequate Household Food Provisioning (MAHFP) after adjustment for socio-demographic covariates (Model 4; Figure 4.9). Predicted MAHFP rises from approximately 8.6 months in households located in the least favorable food environments (FE score ≈ 0–2) to nearly 11.7 months in those with the highest overall food environment performance (FE score ≈ 10). This represents an increase of more than three additional months of adequate food provisioning across the full range of the food environment continuum. The actual regression analysis also shows a highly significant association ($p < 0.001$).

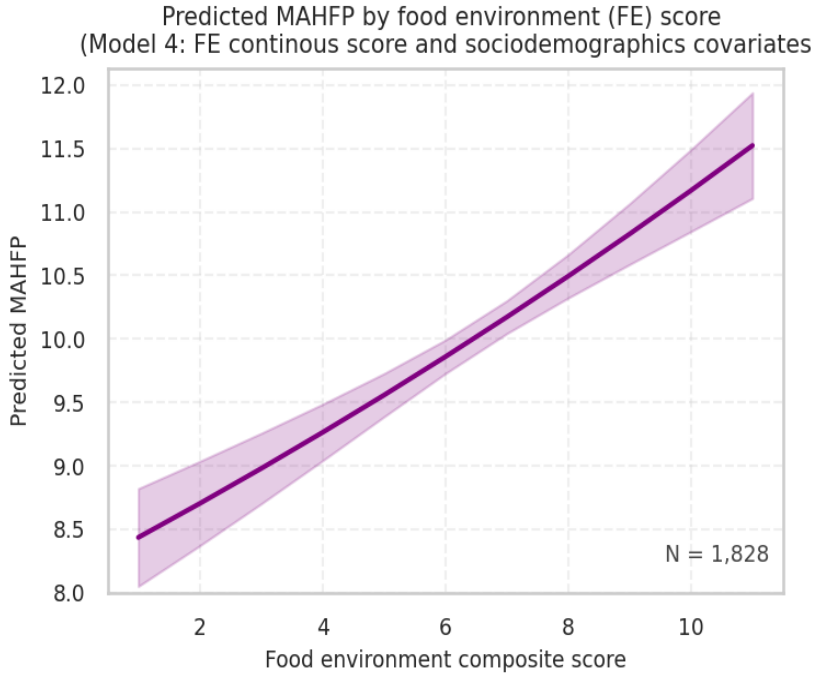


Figure 4.9. Association between food environment composite score and Months of Adequate Household Food Provisioning (MAHFP).

Multivariable Poisson regression models with robust standard errors confirmed strong positive associations between the continuous FE score and key nutrition outcomes (Table 4.4). The regression results for the categorized FE score are also provided in Table 4.5. A one-unit increase in the FE score was associated with a 3% higher expected WDDS (IRR 1.03, 95% CI 1.02–1.04, $p<0.001$), a 6% higher HDDS (IRR 1.06, 95% CI 1.05–1.07, $p<0.001$), and a 3% increase in months of adequate household food provisioning (MAHFP; IRR 1.03, 95% CI 1.02–1.04, $p<0.001$). The FE score showed a

positive but non-significant association with the Fruit-Vegetable Score (IRR 1.02, 95% CI 0.99–1.05) and a suggestive linear association with GDQS (β=0.143, 95% CI -0.004–0.291).

Table 4.4. Associations between continuous FE composite score and dietary and food security outcomes using multivariable Poisson and linear regression (N ≈ 1,828)

Predictor	WDDS	FVS	GDQS	HDDS	MAHFP
	AIRR	AIRR	β (SE)	AIRR	AIRR
FE continuous score	1.03 [1.02,1.04] ***	1.02 [0.99,1.05]	0.143 [-.004,0.291]	1.06 [1.05,1.07] ***	1.03 [1.02,1.04] ***

Notes:
Exponentiated coefficients shown. 95% confidence intervals in brackets. IRR = exp(β). Robust standard errors used. GDQS coefficients represent linear β effects. Poisson regression covariates omitted here (details provided in the Appendix). p < 0.05, ** p < 0.01, *** p < 0.001.

Table 4.5. Associations between categorical FE composite score and dietary outcomes

Predictor Food Environment Category	WDDS AIRR	FVS AIRR	GDQS β (SE)	HDDS AIRR
Low FE Score	1	1	1	1
Medium FE Score	1.15 (0.04) ***	1.35 (0.12) ***	1.04 (0.026) ***	1.32 (0.033) ***
High FE Score	1.27 (0.08) ***	1.44 (0.15) ***	1.05 (0.028) ***	1.47 (0.045) ***
Observations	1,828	1,828	1,828	1,828

Notes: AIRR = Adjusted Incidence Rate Ratio. Robust standard errors are used for Poisson regression (DDS, FVS, HDDS). GDQS coefficients (β) are from ordinary least squares (OLS) regression, with standard errors in parentheses. p < 0.05, ** p < 0.01, *** p < 0.001.

In summary, higher food environment scores were consistently linked to improved women's dietary diversity, household dietary diversity, and household food security in Ethiopia, with the most robust effects observed for HDDS, underscoring the potential of food environment interventions to enhance multiple dimensions of household nutrition and food access.

4.4. Discussion

This study examined the influence of the food environment (FE) on multiple dietary quality outcomes among Ethiopian women and households, highlighting how FE dimensions—availability, accessibility, affordability, and infrastructure—influence dietary patterns and nutritional wellbeing (Turner et al., 2018, 2020).

Our findings reveal distinct dietary consumption patterns among Ethiopian women across food environment (FE) categories, highlighting challenges in achieving diverse diets. The mean Household Dietary Diversity Score (HDDS) across 16 food groups is 6.24, indicating moderate diversity. Limited consumption of nutrient-dense foods, including fruits, vegetables, and animal-source foods, was observed among women, which likely contributes to insufficient micronutrient intake (Daniels, 2009; Gómez et al., 2020; Mekonnen et al., 2020). However, grains, white roots, and tubers were almost universally consumed, reflecting their role as dietary staples in Ethiopia (Wolle et al., 2020; EPHI, 2013). Intake of nutrient-rich food groups, such as pulses, fruits, and vegetables, modestly increased from low to high FE categories. In contrast, dairy consumption was notably higher in households with low food-environment scores than in those with medium or high scores. This pattern likely reflects structural constraints rather than preference alone. As noted by Minten et al. (2018), limited market access and weak infrastructure in Ethiopia constrain opportunities to commercialize perishable products such as milk, leading to greater on-farm consumption. Although agropastoral households constitute a relatively small share of the sample, Sibhatu and Qaim (2017) argue that poor market integration can lead households in low-food-environment settings to rely more heavily on self-consumption, even where overall food diversity and affordability remain limited. Headey (2017) similarly emphasizes that the high perishability of dairy products, combined with inadequate storage and transport options, often shifts milk use from market sale to household consumption. These patterns underscore the influence of the food environment on dietary diversity, with factors such as availability, access, affordability, and cultural preferences likely shaping intake, as we explore further in the following sections, using socioeconomic and food-environment predictors.

The findings confirm the significant role of socioeconomic factors in predicting diet quality among women and households. Higher household income was associated with improved dietary outcomes, with each income decile increase leading to a small but significant rise in dietary scores, such as a 1% increase in Women Diet Diversity Score (WDDS) (exp(β)=1.01, p<0.05) and a 2% increase in Fruits and Vegetables Score (FVS) (exp(β)=1.02, p<0.1). This suggests that even modest financial improvements can enhance access to more diverse and nutritious diets (Ruel et al., 2013). Wealth disparities were particularly pronounced, with women in the poorest tertile experiencing significantly lower dietary diversity and quality across all indicators. For example, WDDS was 12% lower (exp(β)=0.88, p<0.01), and FVS was 14% lower (exp(β)=0.86, p <0.05) compared to the richest category. Similarly, the Global Diet Quality Score (GDQS) and HDDS scores declined significantly, reflecting the impact of economic constraints on dietary patterns. These findings align with prior evidence that financial constraints restrict access to diverse and healthy food choices (Darmon and Drewnowski, 2015), thereby limiting the ability to achieve an adequate diet in resource-poor settings (Headey and Alderman, 2019). The middle tertile showed intermediate effects, with significantly lower WDDS and HDDS than their richest counterparts, though some dietary indicators did not reach statistical significance (Table 4.33). In contrast, women in the richest tertile consistently achieved higher dietary scores, reinforcing the advantages of economic stability in securing a higher diet quality (Usman and Callo-Concha, 2021). These socioeconomic gradients underscore the need to address financial barriers to improving dietary diversity in Ethiopia, particularly among the most disadvantaged households. Policies that enhance income opportunities and strengthen social safety nets could help mitigate the observed dietary inequalities.

The education level of the household head had a statistically significant but practically small effect on diet quality, with each additional year of education associated with a 0-1% increase in the expected GDQS and HDDS. Although the impact of education on dietary outcomes in this study is modest, prior research links education to greater nutritional awareness and improved food choices (Alamirew et al., 2023; Rippin et al., 2020), but several factors may limit its impact in our sample. First,

the average educational attainment of household heads in our sample was very low, with a mean of 6.1 years (SD = 0.12). This limited education may not translate into practical knowledge to improve dietary practices or unlock other benefits tied to education, such as higher income, which could ultimately enhance diets (Alderman and Headey, 2017). Second, the food environment in Ethiopia, characterized by limited market access (e.g., mean distance to weekly markets = 6.7 km) and high non-affordability of diverse foods (74% of households reported non-affordability), may override the influence of education on diet quality (Turner et al., 2018). Third, cultural influences, such as reliance on staple grains like teff and limited consumption of fruits and vegetables, may further diminish the role of education in diversifying diets (Wolle et al., 2020). Enhancing overall educational attainment may be advantageous, as evidence indicates that education can moderate the relationship between the food environment and dietary outcomes by improving the ability to overcome food access barriers (Vogel et al., 2017).

Regional variations reveal how geography and socioeconomic conditions affect diet quality in Ethiopia. Compared to Oromia (the reference region), Amhara households exhibited notably lower average dietary scores: WDDS lower by 7% ($\exp(\beta) = 0.93$, $p<0.05$) and FVS lower by 33% ($\exp(\beta) = 0.67$, $p<0.001$). Somali households also showed a substantially smaller WDDS ($\exp(\beta) = 0.80$, $p<0.01$). However, urban versus rural residence showed no meaningful difference, suggesting that regional factors outweigh urban-rural distinctions in this study. These results diverge from prior studies linking urban Ethiopia to greater dietary diversity (Hirvonen, 2016), yet they resonate with evidence that region-specific food availability and income disparities drive nutritional outcomes (Hirvonen, 2019b, 2019a; Moges et al., 2021). The lower dietary scores in Amhara and Somali may reflect limited food diversity, economic constraints, or cultural factors, underscoring the need to identify and address region-specific challenges to improve diet quality.

Food availability, as assessed by market food diversity, significantly influences diet quality among Ethiopian women and households. Compared to low availability (<4 groups), medium availability (5-7 groups) boosts women's dietary diversity by 7% and household diversity by 22%, while

high availability (8-10 groups) further improves WDDS and HDDS. This highlights how market availability of diverse foods can improve access to and consumption of nutrient-rich options, particularly when economic barriers are reduced, a crucial factor in contexts where dependence on staple foods limits micronutrient intake (Hirvonen, 2019b, 2019a; Wolle et al., 2020). Previous studies have shown that markets help bridge nutritional gaps, enhancing dietary diversity within Ethiopia's uneven food production landscape (Ambikapathi et al., 2019; Usman, 2021). However, market food availability did not significantly correlate with GDQS, suggesting that while diet diversity improved, it did not necessarily translate into adequate nutrient intake. This could be due to low consumption frequency (Bromage et al., 2021), portion-size limitations (Daniels et al., 2009), or methodological constraints in dietary assessment (Hirvonen et al., 2021), as discussed in the study's limitations. Similarly, FVS exhibited a positive but non-significant trend with high market food availability, indicating that while market diversity may promote fruit and vegetable consumption, affordability and preference barriers may temper its impact (Headey and Alderman, 2019).

The findings of this study reveal that food prices are crucial in determining diet quality, with impacts varying across food groups. Higher vegetable prices significantly reduced dietary quality, lowering the expected WDDS count by a factor of 0.89 (95% CI: 0.84-0.94, $p<0.001$) and FVS by 0.79 (95% CI: 0.70-0.89, $p<0.001$), reflecting greater price sensitivity for nutrient-rich foods compared to staples. This aligns with evidence that economic barriers disproportionately limit access to fruits and vegetables in low-income settings like Ethiopia (Usman, 2021), a pattern echoed by Ali (2020), who found that fruits and vegetables in Southwest Ethiopia are price-elastic luxuries, with demand dropping sharply as prices rise. In contrast, rising grain prices led to slight increases in WDDS and FVS, possibly due to a substitution effect whereby expensive staples prompt shifts toward cheaper, more diverse alternatives, thereby enhancing dietary variety. Hirvonen (2021) similarly notes that households adjust consumption toward available substitutes in response to price changes. These divergent impacts underscore the complex interplay between prices and dietary choices, suggesting that stabilizing the

prices of nutritious foods such as fruits and vegetables could safeguard access to a diverse range of foods (Ambikapathi et al., 2019).

The study confirms that affordability is an important determinant of diet quality. Lower non-affordability (vs. high) increased FVS by a factor of 1.33 (95% CI: 1.08-1.65, $p<0.01$), suggesting reduced financial strain improves fruit and vegetable intake, yet its non-significant effect on other indicators like WDDS or GDQS implies affordability alone may not suffice without addressing factors such as availability of diverse and nutrient-rich food options in nearby markets (Abay and Hirvonen, 2017; Ambikapathi et al., 2019; Usman and Callo-Concha, 2021). While easing financial constraints improves access to nutrient-rich foods, it does not consistently improve overall diet quality in resource-poor settings, where consumption patterns reflect competing priorities such as cost and accessibility (Ahmed Ali, 2020; Turner et al., 2020). These findings underscore the need for targeted interventions beyond price stabilization, such as subsidies for fruits and vegetables or improved market access, to ensure that affordability translates into balanced, diverse diets for Ethiopian women and households (Abay and Hirvonen, 2017; Sawyer et al., 2021).

The personal dimensions of the food environment, particularly convenience and desirability, are significantly associated with diet quality. Higher convenience scores—reflecting time allocated for food preparation and domestic labor (often involving paid household workers for food-related tasks)—enhance dietary diversity, increasing FVS and HDDS. These findings also reflect underlying social dynamics, in which convenience-based food choices are shaped by intra-household roles, particularly women's time constraints, labor burden, and decision-making responsibilities. In many Ethiopian households, women are primarily responsible for food preparation, and limited time due to domestic and income-generating activities may lead to reliance on quicker, more convenient food options or simplified meals. This indicates that reduced preparation burdens could encourage the inclusion of a variety of foods in diets (Jabs and Devine, 2006). Similarly, desirability, which is linked to preferred food consumption, notably improves WDDS and FVS, underscoring the impact of personal dynamics on nutrition. In this study, desirability reflects the more frequent consumption of foods that households

or individuals wish to eat. It significantly enhances women's dietary diversity and fruit and vegetable intake, suggesting that nutritional gains occur when preferred foods are consumed more often (Drewnowski and Darmon, 2005). This aligns with the idea that desirability serves as a motivator, encouraging healthier choices when access allows, despite economic and availability barriers (Beydoun and Wang, 2008).

Access to essential services influences diet quality in distinct ways. Greater distance from bus stations slightly reduces women's dietary diversity, emphasizing the critical role of transportation, while the increased distance to markets modestly lowers fruit and vegetable consumption, reflecting market access challenges (Ambikapathi et al., 2019; Hirvonen, 2019a). Similarly, a greater distance to roads subtly hampers household dietary variety, underscoring the influence of infrastructure. Access to all-weather roads stands out, significantly boosting WDDS and FVS, as the regression results in Table 5.2 indicate. Prior studies confirm that enhanced road and market infrastructure improve access to nutritious foods. In contrast, the lack of road access within an hour's walk limits dietary outcomes, underscoring that functional infrastructure reduces costs and enhances access to diverse, nutrient-rich foods, thereby mitigating food insecurity in Ethiopia (Hirvonen, 2016; Wudad et al., 2021).

Across all dietary outcomes, model fit improved progressively with the sequential inclusion of covariates, as reflected by increases in pseudo R^2 for Poisson models and R^2 for OLS models. For WDDS and HDDS (Poisson), pseudo-R^2 increased modestly from the socioeconomic models (Model 1) to the full models (Model 3), indicating incremental gains in explanatory power with the addition of food-environment variables. Larger improvements were observed for FVS, suggesting a more substantial contribution of the food environment and contextual factors to fruit and vegetable intake. The GDQS, estimated using OLS, showed a significant increase in R^2 across model specifications, with the complete model explaining a markedly higher proportion of variation than the socioeconomic-only model. This pattern suggests that GDQS may be particularly responsive to broader food environment and socioeconomic conditions. Overall, the progression in (pseudo) R^2 across models, based on empirical statistical analysis, supports the added explanatory value of food environment factors while

underscoring that dietary outcomes remain influenced by multiple unobserved and contextual determinants.

The analysis shows the impact of individual dimensions (external and personal) of the food environment in the previous sections. An alternative approach that examines their combined influence via the food environment score shows an even more substantial effect across all indicators. For instance, households with a high FE score see women's dietary diversity increase by 27% compared to those with low scores, underscoring that a comprehensive food environment amplifies nutritional outcomes beyond isolated factors. These findings highlight the urgent need for integrated policies that address Ethiopia's uneven food environment to enhance diet quality equitably. The analysis of the composite food environment score reveals significant disparities in food environment performance across Ethiopia's regions (Figure 4.10). Although most households face a poor overall food environment score, the central highlands exhibit relatively better FE, reinforcing socioeconomic, geographic, and infrastructural disparities, whereas remote or lowland areas like Somali face substantial barriers, as observed on the spatial map.

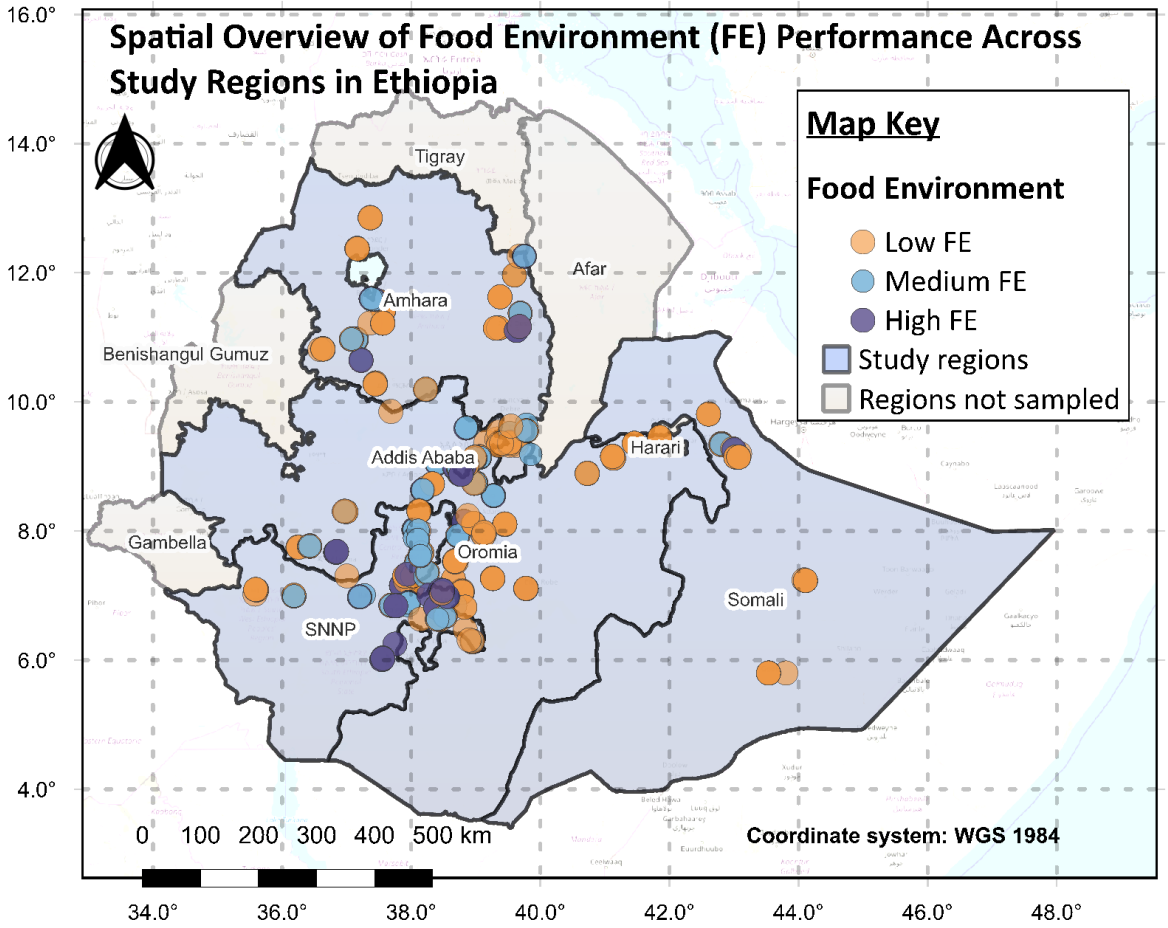


Figure 4.10. Mapped distribution of household FE across Ethiopian regions.

(Circle shapes represent households, with colours indicating food environment categories: Low, Medium, and High based on their FE score)

The strong positive association observed between the food environment composite score and Months of Adequate Household Food Provisioning (MAHFP) highlights the broader role of the food environment in shaping household food security. Households residing in more favourable food environments experienced substantially longer periods of adequate food provisioning, approaching year-round sufficiency. This suggests that improvements in food availability, affordability, and accessibility can translate not only into better dietary quality but also into more stable food access over time. These findings reinforce the importance of food environment–focused interventions as a pathway to enhancing multiple dimensions of food security in the Ethiopian context.

Overall, this study demonstrates the critical influence of food environments—encompassing market food diversity, physical access (e.g., food availability), economic access (e.g., affordability), and

supportive infrastructure (e.g., roads, transportation, financial services)—on improving dietary quality among Ethiopian women and household food security. High food prices, socioeconomic disparities, and regional variations limit access to nutrient-rich foods (e.g., fruits, vegetables, animal-sourced products), particularly for low-income households.

Limitation: This study used a large survey dataset to examine household and individual diets within the food system framework, providing valuable insights while also highlighting notable limitations. However, the cross-sectional design limits causal inference, and single-day dietary recall may not fully capture typical dietary patterns, necessitating context-specific validation of adapted food-environment frameworks. These constraints require cautious interpretation of the findings. Future research should employ longitudinal designs, multi-day dietary assessments, and mixed methods to validate food environment indicators and explore systemic factors, thereby informing effective interventions to improve nutrition outcomes, particularly for vulnerable groups such as women of reproductive age.

4.5. Conclusion

This study confirms the vital role of a comprehensive food environment (FE) in enhancing dietary quality among Ethiopian women and households. The FE includes physical access (e.g., availability of diverse foods), economic access (e.g., affordability and income), and supporting infrastructure (e.g., proximity to markets, transportation, roads, and financial services), all of which enable healthier dietary choices. However, ongoing challenges, such as limited dietary diversity and insufficient intake of nutrient-dense foods, are exacerbated by high food prices, which particularly restrict access to nutrient-dense foods. Women in low-income households exhibit markedly lower dietary scores, with socioeconomic disparities and regional differences (e.g., lower diversity in Amhara and Somali compared to Oromia) adding to these issues. Barriers such as limited market access and unaffordability further restrict access. To improve nutrition and food security, policymakers should focus on the key dimensions of the food environment identified in this study. Interventions should

prioritise improving physical access to markets, particularly in areas with limited access, and addressing affordability constraints by enhancing household purchasing power. In addition, efforts to increase the availability of diverse food groups in local markets and to support consumer-oriented factors such as convenience and food preferences may contribute to improved dietary quality. These targeted actions, aligned with the study's empirical findings, can help strengthen pathways linking the food environment to better nutrition outcomes.

4.6. Chapter summary

This chapter examined how the multidimensional food environment influences household-level dietary quality, with particular emphasis on women of reproductive age. The analysis found strong associations between food availability, market access, and affordability and women's dietary diversity and diet quality. The findings highlighted substantial socioeconomic and spatial disparities, underscoring the role of structural constraints within the food environment in shaping nutritional outcomes in Ethiopia.

Within the broader thesis, this chapter provides the core empirical foundation by addressing the first research question and establishing the significant role of the comprehensive food environment in determining diet quality in Ethiopia. By focusing on women of reproductive age, a nutritionally vulnerable group, the chapter situates individual dietary outcomes within household and market contexts. These insights inform subsequent chapters by showing that improvements in food environments are necessary but not sufficient on their own to achieve sustained improvements in diet quality.

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Appendices

Table A4.1. Household Questionnaire. (see https://static-content.springer.com/esm/art%3A10.1186%2Fs40795-025-01097-z/MediaObjects/40795_2025_1097_MOESM4_ESM.docx)

Table A4.2. The GDQS scoring and mean intake by food group among women in Ethiopia (N=1828)

Food Group	*GDQS Scoring Ranges (g/day)*	*Sub-scores*	*Mean Intake (g/day)*	*SD*
Healthy				
Citrus fruits	*<24/ 24–69/ >69*	*0 / 1 / 2*	*9.94*	*20.19*
Deep orange fruits	*<25/ 25–123 />123*	*0 / 1 / 2*	*39.94*	*72.83*
Other fruits	*<27/ 27–107/ >107*	*0 / 1 / 2*	*34.75*	*50.22*
Dark green leafy	*<13/ 13–37/ >37*	*0 / 2 / 4*	*17.59*	*29.79*
Cruciferous	*<13/ 13–36/ >36*	*0 / .25 /*	*0*	*0*
Deep orange	*<9/ 9–45/ >45*	*0 / .25 /*	*32.54*	*51.65*
Other vegetables	*<23/ 23–114/ >114*	*0 / 0.25 /*	*39.16*	*42.1*
Legumes	*<9/9–42/>42*	*0 / 2 / 4*	*111.46*	*13.88*
Nuts and seeds	*<7/7–13/>13*	*0 / 2 / 4*	*0.1*	*.01*
Deep orange tubers	*<12/ 12–63/ >63*	*0 / 0.25 /*	*32.54*	*51.65*
Whole grains	*<8/ 8–13/ >13*	*0 / 1 / 2*	*454.66*	*213.97*
Liquid oils	*<2/ 2–7.5/ >7.5*	*0 / 1 / 2*	*4.35*	*6.96*
Fish and shellfish	*<14/ 14–71/ >71*	*0 / 1 / 2*	*2.57*	*8.14*
Poultry	*<16/ 16–44 >44*	*0 / 1 / 2*	*8.22*	*19.16*
Low-fat dairy	*<33/ 33–132/ >132*	*0 / 1 / 2*	*63.53*	*85.23*
Eggs	*<6/ 6–32/ >32*	*0 / 1 / 2*	*10.89*	*15.52*

Unhealthy in excessive amount				
High-fat dairy	*<35/ 35–142/>142-734/*	*0 / 1 /*	*23.1*	*39.73*
Red meat	*<9/ 9–46/ >46*	*0 / 1 / 0*	*14.74*	*25.1*
Processed meat	*<9/9-30/>30*	*2/1/0*	*NA*	*NA*
Refined grains and	*<7/7-33/>33*	*2/1/0*	*6.5*	*0.6*
Sweets and ice	*<13/13-37/>37*	*2/1/0*	*NA*	*NA*
Sugar-sweetened	*<57/57−180/>180*	*2 / 1 / 0*	*.156*	*0.05*
Juice	*<36/36-144/>144*	*2/1/0*	*2.1*	*0.9*
White roots and	*<27/27−107/>107*	*2 / 1 / 0*	*26.49*	*59.27*
Purchased deep-fried	*<9/9-45/>45*	*2 / 1 / 0*	*2.4*	*0.6*

Notes: *GDQS scoring ranges separate low, medium, and high intake categories (e.g., <24 / 24–69 / >69). Sub-scores indicate points assigned to each category. NA: means no consumption was recorded or a very small amount*

Table A4.3. Distribution of women across GDQS intake categories by food group (N=1828)

Food Group	***% Women by GDQS Categories***
Healthy Components	
Citrus fruits	*84.0/8.4/7.6*
Deep orange fruits	*50.6/41.1/8.4*
Other fruits	*64.1/24.7/11.2*
Dark green leafy vegetables	*35.9/43.4/20.7*
Cruciferous vegetables	*100/-/-*
Deep orange vegetables	*45.2/33.9/20.1*
Other vegetables	*46.4/43.8/9.9*
Legumes	*10.7/27.6/61.7*
Nuts and seeds	*100/-/-*
Deep orange tubers	*45.2/33.9/20.9*
Whole grains	*0.2/0.1/99.7*
Liquid oils	*68.8/18.3/12.9*
Fish and shellfish	*91.2/7.0/1.8*
Poultry	*88.8/5.5/5.7*
Low-fat dairy	*58.4/ 19.9/ 21.7*
Eggs	*66.0/ 25.0/9.0*
Unhealthy in excessive amount	
High-fat dairy	*80.1/16.1/2.5/1.3*
Red meat	*30.9 / 64.0 / 5.1*
Processed meat	*100 / - / -*
Refined grains and baked goods	*100 / - / -*
Sweets and ice cream	*100 / - / -*
Sugar-sweetened beverages	*100 / - / -*
Juice	*100 / - / -*
White roots and tubers	*82.8 / 8.8 / 8.4*
Purchased deep-fried foods	*100 / - / -*

A dash (-) indicates no women in that category.

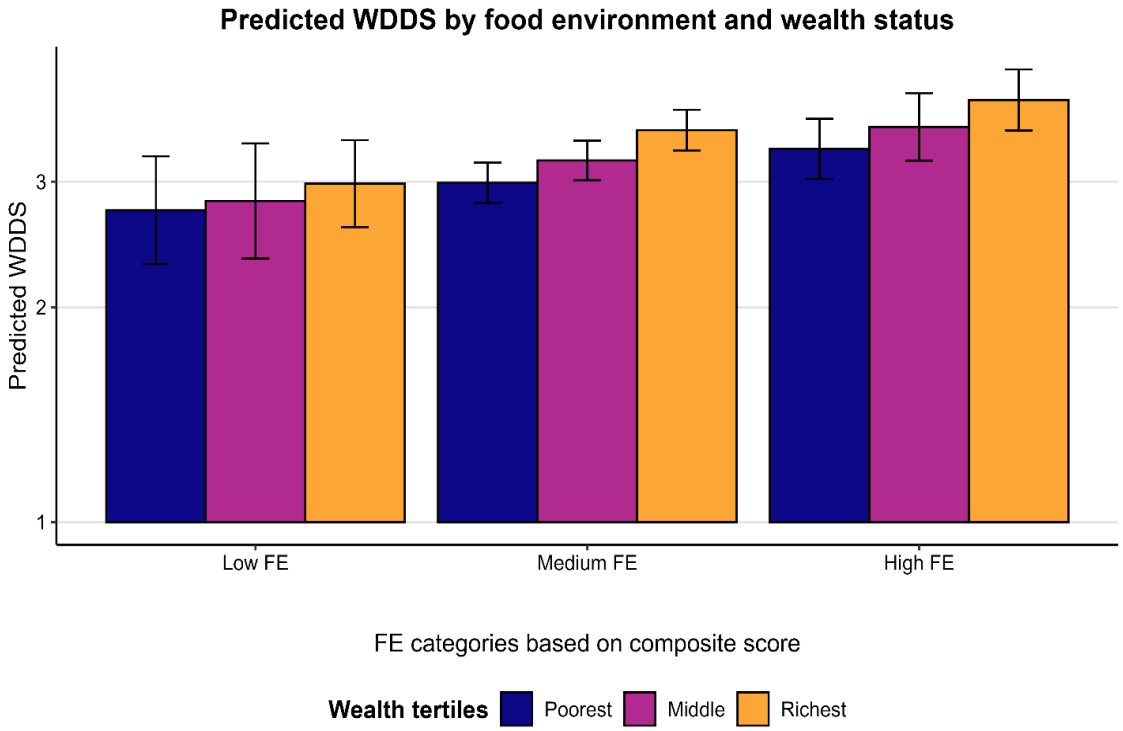


Figure A4.1. Predicted WDDS by FE Score and Wealth Tertile.

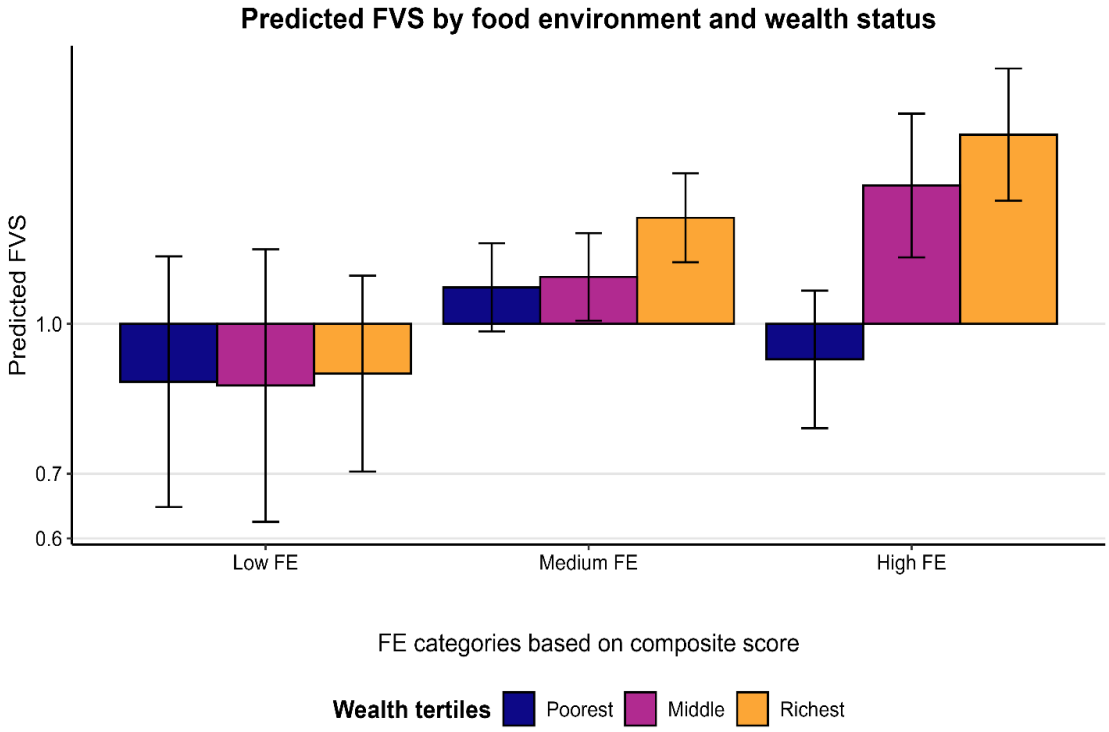


Figure A4.2. Predicted FVS by FE Score and Wealth Tertile.

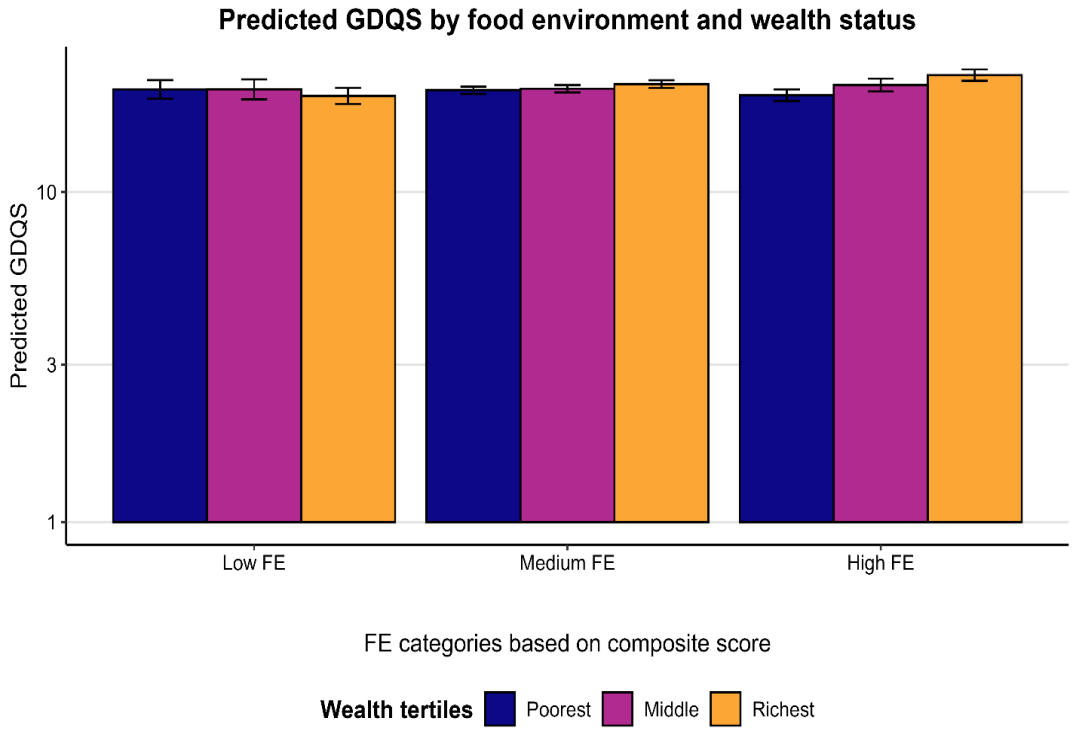


Figure A4.3. Predicted GDQS by FE Score and Wealth Tertile.

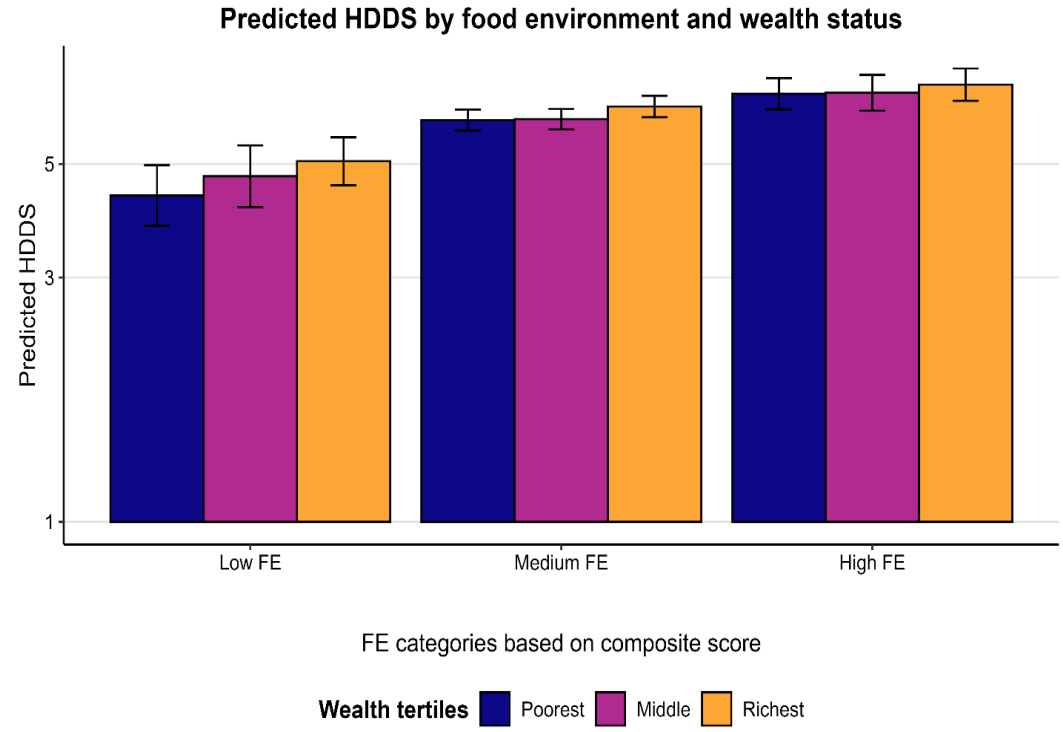


Figure A4.4. Predicted HDDS by FE Score and Wealth Tertile.

Table A4.4. Variance inflation factors for the multivariable regression results in the fully adjusted model (Model 3)

	WDDS		***FVS***		***GDQS***		***HDDS***	
Variable	*VIF*	*1/VIF*	*VIF*	*1/VIF*	*VIF*	*1/VIF*	*VIF*	*1/VIF*
Food environment (FE) levels [Low FE=1]								
Medium FE	*3.64*	*0.274405*	*3.64*	*0.274879*	*3.64*	*0.274405*	*3.25*	*0.307259*
High FE	*3.7*	*0.270489*	*3.7*	*0.270511*	*3.70*	*0.270489*	*3.38*	*0.295512*
Gender of HH head	*1.14*	*0.880729*	*1.14*	*0.880922*	*1.14*	*0.880729*	*1.14*	*0.880875*
Age of the HH head	*1.12*	*0.890122*	*1.12*	*0.891205*	*1.12*	*0.890122*	*1.12*	*0.891949*
Education of the HH head years	*1.42*	*0.702448*	*1.42*	*0.702816*	*1.42*	*0.702448*	*1.42*	*0.702897*
Administrative regions [Oromia=1]								
Amhara	*1.62*	*0.617471*	*1.62*	*0.617398*	*1.62*	*0.617471*	*1.63*	*0.614696*
Somali	*4.39*	*0.227996*	*4.51*	*0.221537*	*4.39*	*0.227996*	*4.25*	*0.23527*
SNNP	*2.2*	*0.454938*	*2.2*	*0.454979*	*2.20*	*0.454938*	*2.23*	*0.447891*
Sidama	*1.74*	*0.57476*	*1.74*	*0.574732*	*1.74*	*0.57476*	*1.75*	*0.572007*
Addis Ababa	*2.85*	*0.350851*	*2.85*	*0.350907*	*2.85*	*0.350851*	*2.86*	*0.34984*
Livelihood zone [Mixed=1]								
Agropastoral	*4.8*	*0.208294*	*4.96*	*0.201561*	*4.80*	*0.208294*	*4.75*	*0.210493*
Meher only cropping	*3.38*	*0.295897*	*3.38*	*0.296272*	*3.38*	*0.295897*	*3.36*	*0.297992*
Urban	*4.15*	*0.240816*	*4.15*	*0.240908*	*4.15*	*0.240816*	*4.14*	*0.241801*
Wealth tertiles [Richest=1]								
Poorest	*1.5*	*0.665681*	*1.5*	*0.66566*	*1.50*	*0.665681*	*1.51*	*0.662678*
Middle	*1.46*	*0.686011*	*1.46*	*0.685974*	*1.46*	*0.686011*	*1.46*	*0.686151*
Monthly HH income	*1.44*	*0.695797*	*1.44*	*0.696486*	*1.44*	*0.695797*	*1.45*	*0.69076*
Mean VIF	*2.53*		*2.5*		*2.53*		*2.48*	

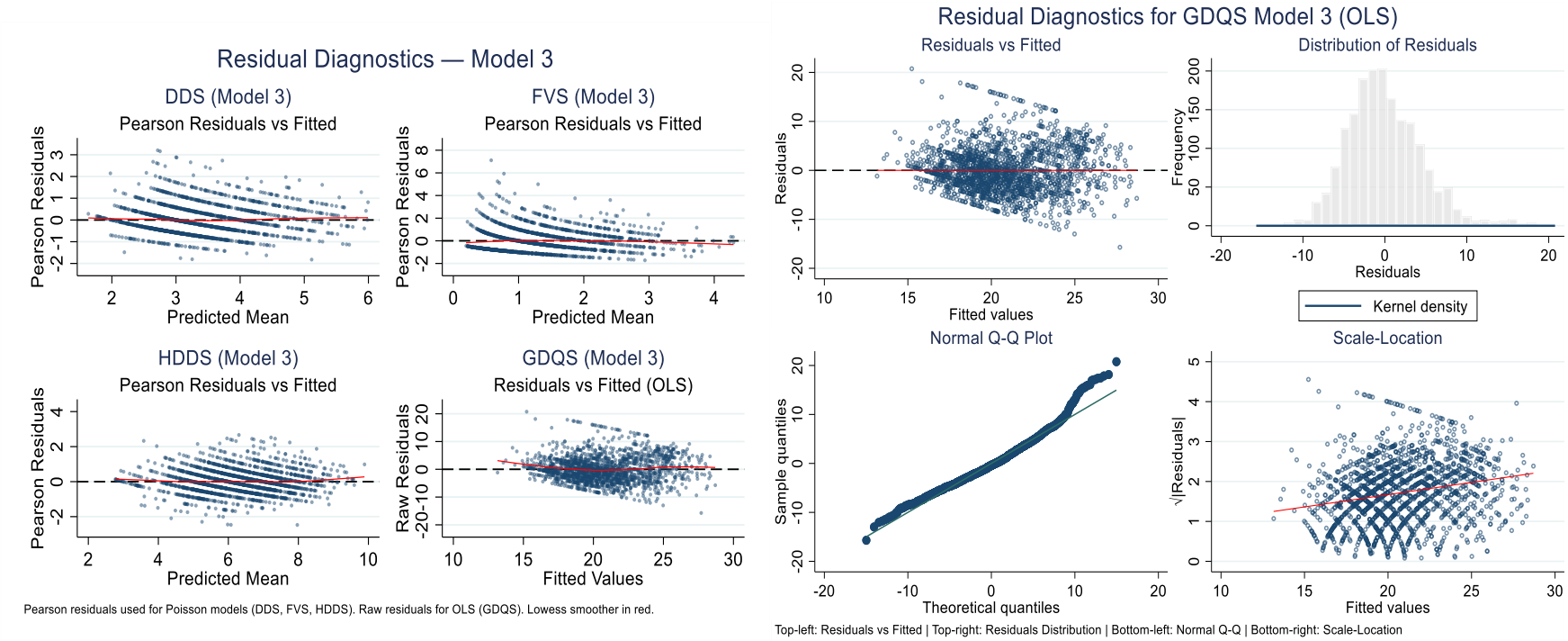


Figure A4.5. Residual plots after Poisson and OLS regression for dietary outcomes were analyzed.

Table A4.5. Overdispersion Test for Poisson Full Model (Model 3)

Variables	Dispersion
WDDS	1.0000
FVS	1.0000
HDDS	1.0000

Notes: Dispersion = Pearson chi2 / df. Values > 1 suggest overdispersion, supporting potential use of negative binomial regression. If ≈ 1, Poisson is adequate. WDDS: Women's Dietary Diversity Score; FVS: Fruits and Vegetables Score; GDQS: Global Diet Quality Score; HDDS: Household Dietary Diversity Score.

Table A4.6. Detailed Model Fit Statistics for Poisson Regression Models

Metric	WDDS (Model 3)	FVS (Model 3)	GDQS (Model 3)	HDDS (Model 3)	DDS (Model 4)	FVS (Model 4)	GDQS (Model 4)	HDDS (Model 4)
Log Pseudolikelihood	-3143.4	-2452.9	-5269.0	-3751.0	-3194.3	-2540.4	-5389.1	-3840.2
Wald Chi-Square	845.5	767.7	954.3	1157.6	511.5	526.9	497.2	644.5
P-Value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Degrees of Freedom	37	37	37	37	17	17	17	17
AIC	6362.9	4981.7	10614.0	7578.0	6424.6	5116.9	10814.2	7716.6
BIC	6572.4	5191.1	10823.4	7787.4	6523.8	5216.1	10913.4	7815.8

Notes: Model 3 includes sociodemographic covariates, external FE, and personal FE. Model 4 includes FE composite score and sociodemographic covariates. AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion. The Wald Chi-Square test assesses the overall significance of the model. P-values less than 0.001 are reported as <0.001. Sample sizes vary by model and outcome due to missing data.

5. Chapter Five: The Influence of Farm Production Diversity and Seasonality on Dietary Diversity and Nutrient Intake among Women and Children in Rural Ethiopia [2]

This Chapter presents the second set of empirical findings from this thesis and extends the household survey analysis by examining how farm-level production diversity and seasonal variation affect dietary diversity and nutrient intake among women of reproductive age and young children in rural Ethiopia. Using repeated cross-sectional data collected before and after harvest, the study provides evidence at the nutrient level on the role of agricultural systems and seasonality within the broader food environment, complementing the analysis presented in Chapter 4.

Abstract

Dietary diversity is a key indicator of diet quality and nutritional adequacy, especially for women of reproductive age and young children who are highly vulnerable to micronutrient deficiencies. In Ethiopia, diets rely mainly on energy-dense staples, with limited access to nutrient-rich foods. Many studies overlook seasonal variation, nutrient-level analysis, and the effects of agricultural systems within other food environment factors. This study aims to examine how production diversity and seasonality, along with key agricultural and market-related food environment factors, influence dietary diversity and nutrient intake among women and children.

A repeated cross-sectional study was conducted during two key agricultural periods: the pre-harvest season (August–September 2022) and the post-harvest season (March–April 2023). The sample included households with 520 women aged 15–49 years and 250 children aged 6–23 months. Data were collected using a structured household survey comprising a diet quality questionnaire to assess dietary diversity and a food frequency questionnaire (FFQ) to estimate nutrient intake. To

[2] A version of this chapter has been published in BMC Agriculture; as Hailu, A.A. et al. 2025. The Influence of Farm Production Diversity and Seasonality on Dietary Diversity and Nutrient Intake among Women and Children in Rural Ethiopia. BMC Agriculture.

examine factors influencing nutrient intake, ordinary least squares (OLS) regression was employed, while Poisson regression was used to identify determinants of dietary diversity.

Higher farm-level production diversity (mean = 2.31 food groups; 95% CI: 2.24–2.38) was strongly associated with improved nutrient intakes in both women and children. Diet diversity increases slightly during the post-harvest period for both groups. Among rural women, the proportion meeting the Minimum Dietary Diversity (MDD-W) rose from 16.8% pre to 25.0% post-harvest, while among children, the Minimum Dietary Diversity (MDD) increased from 11.8% to 23.3%, and the Minimum Acceptable Diet (MAD) rose from 7.6% to 16.5% after harvest. Despite improvements in production diversity and post-harvest gains, energy and micronutrient deficiencies remain common issues. Nutrient intake also varies significantly across cropping systems, with agropastoral and highland perennial systems supporting higher levels of calcium and vitamin A, while tuber-based systems consistently show lower levels, especially for zinc. Additionally, limited access to nearby markets and greater distance from roads are negatively associated with nutrient intake. Higher relative food prices further restrict access to nutrient-rich foods, highlighting the combined impacts of infrastructure and affordability on diet quality.

Farm-level production diversity significantly improves micronutrient intake for women and children in rural Ethiopia, while various cropping systems have distinct effects on specific nutrient outcomes. For example, iron intake is notably higher in cereal-pulse-based farming systems, and agropastoral areas have better calcium intake. Persistent energy and micronutrient shortages, along with challenges such as limited market access, poor road infrastructure, and high food costs, underscore that diversification alone is insufficient. Effective strategies should combine crop and livestock diversification with investments in infrastructure and markets, as well as targeted nutrition programs, to better address dietary gaps and improve overall nutrition for these vulnerable groups.

5.1. Introduction

Dietary diversity refers to the variety of different foods or food groups consumed over a specific period and is widely recognized as an important measure of diet quality and nutritional adequacy (Kennedy et al., 2011). Eating a diverse range of foods increases the chances of meeting micronutrient and macronutrient needs, playing a vital role in preventing deficiencies and supporting optimal health (Henjum et al., 2016; Gómez et al., 2020). Evidence suggests that dietary diversity is linked to adequate micronutrient intake, improved nutritional status, household food security, and a reduced risk of chronic diseases, including stunting, anaemia, and non-communicable conditions (Ruel, 2003; Kobayashi and Thielecke, 2024).

Women of reproductive age and children are disproportionately impacted by dietary deficiencies, especially micronutrient inadequacy, in low- and middle-income countries (Stevens et al., 2022; FAO, IFAD, UNICEF, WFP and WHO, 2024). Insufficient intake of iron, vitamin A, and zinc hinders growth, cognitive development, and maternal health, continuing cycles of intergenerational malnutrition (Beal et al., 2017; Wells et al., 2020). Recent studies show that dietary outcomes are shaped by complex interactions among individual, household, and food system factors, including agricultural diversity, market access, infrastructure, and seasonal variations (HLPE, 2020; Rasmussen et al., 2020).

Evidence in Ethiopia suggests that dietary patterns mainly rely on energy-dense staple grains (Pingali, 2015; Hirvonen and Hoddinott, 2017; Hirvonen, 2019b; Usman, 2021), which lack essential micronutrients (Stevens et al., 2022) due to systemic inefficiencies in the food system. These gaps include limited crop diversity (Sibhatu and Qaim, 2018), insufficient post-harvest storage infrastructure for perishable foods (Mikuličić et al., 2024), and volatile market prices that restrict access to nutrient-rich foods such as fruits, vegetables, and animal-source products (Bachewe and Minten, 2023).

Diversifying agricultural production is often associated with improved household dietary diversity (Jones et al., 2014; Hirvonen and Hoddinott, 2017; Sibhatu and Qaim, 2018). However,

barriers such as limited market access due to poor road networks, seasonal fluctuations in food availability, and economic constraints seriously undermine diet quality, especially among farming households in Ethiopia (Bachewe et al., 2018; Sibhatu and Qaim, 2018; Headey et al., 2019).

Although many studies have examined the link between agricultural production diversity and dietary diversity in Ethiopia, they often overlook nutrient level analysis, seasonal changes in micronutrient intake, and the direct connection with cropping system characteristics (Jones et al., 2014b; Sibhatu et al., 2015). This gap limits understanding of how the variety of food available at the household level affects overall dietary quality and micronutrient intake in rural farming communities (Shen et al., 2025). Additionally, the relationship between dietary quality and agricultural practices within the food environment, including market access and food prices, remains poorly understood (Balcha et al., 2025).

This study aims to examine how agricultural production diversity, market access, and seasonal changes collectively influence dietary diversity and nutrient adequacy among women and young children in rural Ethiopia. It addresses crucial gaps by moving beyond methods that focus only on agricultural or socioeconomic factors. Instead, it employs a comprehensive framework that combines elements of the agricultural and food environments—such as land use, production diversity, market access, and food price trends—to assess their combined effects on dietary diversity and nutrient intake (Baye et al., 2021). Additionally, by collecting data during both pre-harvest and post-harvest periods, the study captures seasonal shifts in dietary diversity and nutrient intake (Bosha et al., 2019). This seasonal approach provides valuable insights into how variations in food availability and access throughout the farming cycle influence consumption patterns and the nutritional health of populations in resource-limited areas (Mezgebe et al., 2024).

Guided by this goal, four key research questions shape the analysis. First, how do seasonal changes in agricultural production diversity affect dietary diversity and nutrient intake? This question addresses the absence of temporal trends in previous studies and emphasizes the dynamic nature of food availability across seasons and its impact on micronutrient consumption. Second, what

socioeconomic and demographic factors influence dietary diversity and nutrient adequacy among women and children? Third, how do agricultural factors—such as land use, cropping systems, and production diversity—impact consumption patterns and nutrient intake? Lastly, how do market-related food environment factors, including market access and food prices, influence dietary outcomes? These questions expand the analytical scope by considering structural barriers and facilitators within the food system, offering a more comprehensive understanding of the challenges faced by rural Ethiopian households.

5.2. Methods

5.2.1. Study design

This study employed a repeated cross-sectional household survey conducted in two rounds, designed to capture seasonal variation in agricultural production and dietary outcomes in Ethiopia (Figure 5.1). The timing of data collection was aligned with the country's bimodal rainfall pattern and dominant agricultural seasons, which strongly influence food availability due to the reliance on rain-fed farming. The first round was conducted during the pre-harvest period (August–September 2022), while the second took place in the post-harvest period (March–April 2023), corresponding to the Meher and Belg agricultural cycles, respectively (Hirvonen et al., 2016).

The study was conducted in five regions—Amhara, Oromia, Southern Nations, Nationalities, and Peoples (SNNP), Sidama, and Somali—selected to reflect Ethiopia's diverse agroecological and livelihood systems. These regions encompass variations in farming practices, market access, and environmental conditions. Other regions were excluded because of security constraints during the data collection period.

Data on agricultural production, including home production diversity, were collected through household surveys based on respondents' self-reports. Participants were asked to recall and list the different crop and livestock species produced on their farms during the reference period.

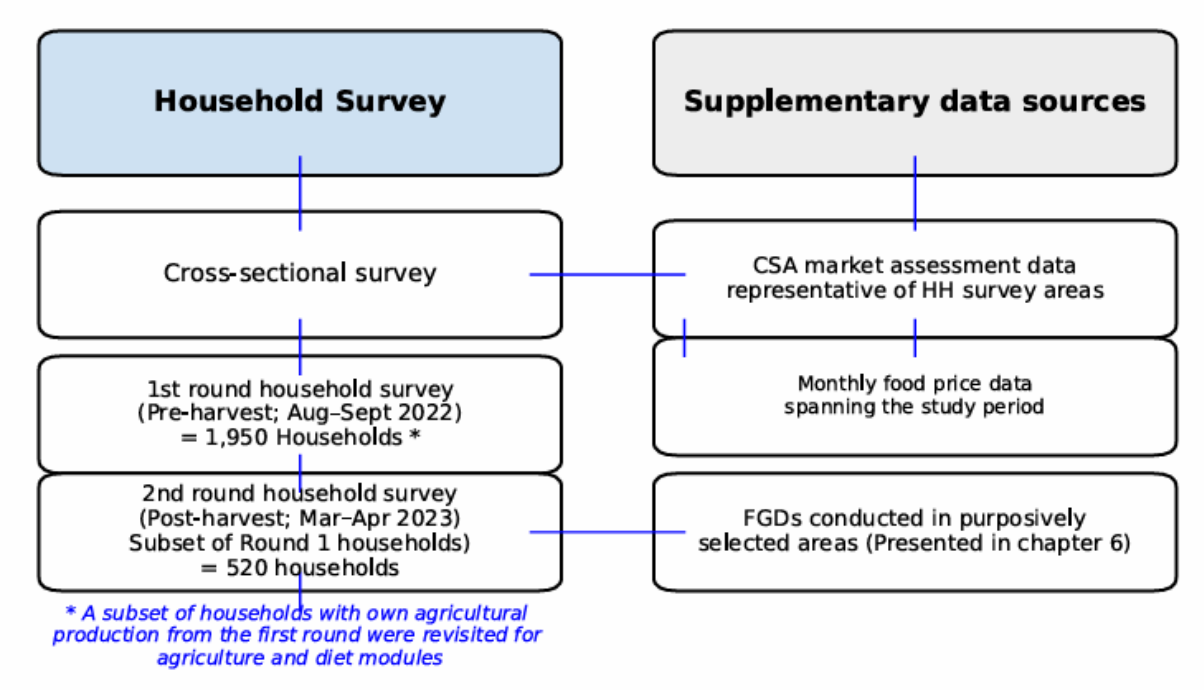


Figure 5.1. Data acquisition framework.

5.2.2. Study population and sampling

The study focused on women of reproductive age (15–49 years) and children aged 6–23 months. Women were interviewed using a structured household questionnaire covering their dietary practices, household characteristics, and agricultural activities, with husbands contributing information on agricultural production when necessary. Information on children's dietary intake was collected through the mother or primary caregiver, who reported on the child's feeding practices and food consumption. This approach enabled the assessment of dietary outcomes and the factors influencing them for both women and children.

The sample size was calculated using the single population proportion formula (Ahmed, 2024), with a 95% confidence level ($Z\alpha/2 = 1.96$), a 5% margin of error ($D = 0.05$), and a design effect of 1.5 to account for clustering (Milligan, 2004; Zhang and Hartmann, 2023). The information required for sample size calculation, such as regional household size, target population proportion, and a 95% household response rate, was derived from the Ethiopian Demographic and Health Survey data, and the following formula was used:

$$n = \frac{(Z^2 \alpha/_2 .P(1-P) .Deff)}{D^2} . HH\ Size. \%Target \frac{PP}{HHRR.IRR} \quad (1)$$

Where: n = Sample size; Zα/2 = 1.96; P = Regional prevalence of Minimum Dietary Diversity for Women (MDD-W); D = Margin of error; Deff = Design effect; HH Size = Average household size per region; % Target PP = Proportion of the target population per region; HHRR = Household response rate (95%); IRR = Individual response rate (%).

Households were selected using a multistage sampling approach from the 2020/2021 Ethiopian Household Income and Expenditure Survey Framework (CSA and ICF, 2018). Administrative zones and woredas were purposively chosen, followed by random sampling of kebeles and villages. Enumerators listed households in each selected village, systematically sampling 20 households per cluster (Milligan, 2004).

5.2.3. Data sources

Data were collected from households with 520 women of reproductive age (pooled across pre- and post-harvest seasons; 965 observations) and 250 children aged 6–23 months (pooled across pre- and post-harvest seasons; 450 observations) across two rounds using computer-assisted personal interviewing (CAPI) software on tablets, administered by trained enumerators. Sociodemographic data (age, gender, household composition, and education) and food environment factors (agricultural production, land use, market access, and infrastructure) were collected through structured interviews. The questionnaire employed in this study was previously published as supplementary material elsewhere (Hailu et al., 2025). Food prices were evaluated using the Ethiopian Central Statistical Service's Consumer Price Index (CPI)[3] data for 119 food commodities (July 2022–April 2023), aligned with household data collection, to calculate the average costs of food groups across the study zones.

3 The Ethiopian Statistical Service regularly collects monthly commodity prices, including food prices, nationwide

5.2.4. Dietary Measurements

The Diet Quality Questionnaire (DQQ), adapted for the Ethiopian context using locally relevant foods (e.g., incorporating staples like teff and enset), was used to calculate the Women's Dietary Diversity Score (WDDS) and the Minimum Dietary Diversity for Women (MDD-W), based on ten food groups, as per the FAO/FANTA MDD-W protocol (FAO, 2021; Herforth et al., 2024). The DQQ was administered via interviewer-assisted 24-hour dietary recall to women of reproductive age, capturing all foods and beverages consumed from the previous day and night. The DQQ was selected for its standardized, globally validated framework, which enables the rapid measurement of dietary diversity across key food groups, making it particularly suitable for large-scale surveys in low-resource settings, such as rural Ethiopia. It aligns well with validated indicators, such as the Minimum Dietary Diversity for Women (MDD-W) and the Minimum Acceptable Diet (MAD) for children.

Locally adapted food lists were used to classify items into the ten predefined food groups, ensuring cultural relevance (e.g., grouping indigenous Ethiopian foods, such as injera, under the grains category) (Herforth, 2023). Each reported food or beverage was classified into one of the ten MDD-W food groups (Table 5.1). Consumption of any item within a group counts as "yes" (1) for that group; multiple items within the same group do not add extra points.

Table 5.1. List of food groups used to construct the women's dietary diversity score (WDDS)

Food Groups	Food Group Name
1	Grains, white roots and tubers, and plantains (e.g., teff, maize, cassava, enset)
2	Pulses (beans, peas, and lentils) (e.g., fava beans, chickpeas)
3	Nuts and seeds
4	Dairy (e.g., milk, yogurt, cheese)
5	Meat, poultry, and fish (e.g., beef, chicken, tilapia)
6	Eggs
7	Dark green leafy vegetables (e.g., kale, spinach)
8	Other vitamin A-rich fruits and vegetables (e.g., carrots, mangoes, papaya)
9	Other vegetables (e.g., tomatoes, onions)
10	Other fruits (e.g., bananas, oranges)

The Women's Dietary Diversity Score (WDDS) is the total sum of the ten food groups consumed, ranging from 0 (no diversity) to 10 (maximum diversity), as shown in Eq. 2.

$$WDDS = \sum(Scoreforeachgroup) \quad (2)$$

The MDD-W is a binary indicator derived from the WDDS that shows whether the diet meets a minimum threshold for micronutrient adequacy (Gómez et al., 2020). Validated guidelines classify MDD-W as adequate (MDD-W = 1, indicating a WDDS of 5 or higher, which suggests a higher likelihood of micronutrient adequacy) or inadequate (MDD-W = 0, indicating a WDDS below five, implying a lower probability of adequacy) (FAO, 2021). The Children's Dietary Diversity Score (CDDS) was assessed based on mothers' or caregivers' reports of the foods their children consumed from eight specific food groups in the past 24 hours. These food groups, as recommended by the World Health Organization (WHO), include grains, roots, and tubers; legumes and nuts; dairy products such as milk, yogurt, and cheese; flesh foods like meat, fish, poultry, and organ meats; eggs; vitamin A-rich fruits and vegetables; other fruits and vegetables; and breast milk (Jones et al., 2014a).

The Child Dietary Diversity Score (CDDS) was calculated by summing the scores across all eight food groups, yielding a possible range of zero to eight. Children were considered to have achieved Minimum Dietary Diversity (MDD) if they consumed foods from at least five of the eight specified food groups on the previous day (Jones et al., 2014a). The total score for each child was computed using the following formula (Eq. 3):

$$CDDS = \sum(Score\ for\ each\ food\ group) \quad (3)$$

Minimum Acceptable Diet (MAD) is a comprehensive indicator that captures both dietary diversity and meal frequency to assess feeding adequacy among young children. A child is considered to meet the MAD standard if they achieve the Minimum Dietary Diversity (MDD) and receive the minimum recommended number of meals per day appropriate for their age and breastfeeding status. Specifically, breastfed children aged 6–8 months must receive at least two meals per day, while those aged 9–23 months must receive at least three meals per day. For non-breastfed children aged 6–23

months, the threshold is at least four meals per day, including milk feeds. This approach is consistent with the WHO guidelines for infant and young child feeding practices for evaluating the adequacy of complementary feeding in this age group (Jones et al., 2014a).

Nutrient intake was estimated using a food frequency questionnaire (FFQ), which was collected during pre-harvest and post-harvest seasons to capture seasonal variations (Ramírez-Silva et al., 2012; Sauvageot et al., 2013). Consumption frequency was categorized (daily, 3–6 times/week, 1–2 times/week, ≤twice/month), and standardized serving sizes from the 2021/2022 National Food Consumption Survey were used to estimate daily intakes via weighted averages (EPHI, 2013). The Nutrient Adequacy Ratio (NAR) was calculated by dividing daily nutrient intake by reference values from the Ethiopian Food-Based Dietary Guidelines for energy (EPHI, 2022) and the FAO and WHO references for micronutrients (Joint FAO/WHO Expert Consultation, 2004). The Mean Adequacy Ratio (MAR) was calculated using truncated NARs (capped at 1) for five nutrients, with an NAR ≥ 0.67 indicating adequate intake (Akter et al., 2021; Islam et al., 2023). Distribution of MAR by study samples is shown in Figure A5.1.

$$\text{NAR} = \frac{\text{Daily nutrient}}{\text{Reference intake}} \tag{4}$$

$$\text{MAR} = \frac{\sum \text{NAR (individual nutrient)}}{\text{Number of nutrients}} \tag{5}$$

The FFQ was used to capture detailed information on the frequency and quantity of food consumption over time, allowing for estimation of nutrient intake and identification of seasonal variations. Together with DQQ, these tools provide a robust and context-sensitive approach to understanding individual dietary patterns and nutrient adequacy.

5.2.5. Production diversity and cropping system classification

Household production diversity was quantified using a Production Diversity Index (PDI), adapted from the methodology used to calculate the Women's Dietary Diversity Score (WDDS). Following FAO guidelines (FAO, 2016a), crops produced by each household were grouped into

standardized food categories relevant to the Ethiopian context, including cereals, pulses, vegetables, fruits, roots and tubers, dairy products, and other locally important food groups.

The PDI captures the extent of agricultural diversification at the household level and is defined as:

$$\text{PDI}_i = \sum_{j=1}^{n} F_{ij} \ (1)$$

where

- PDI_i is the production diversity score for household i,
- F_{ij} is a binary variable indicating whether household i produces food group j (1 = yes, 0 = no), and
- n represents the total number of food groups considered.

Equation (1) provides the number of distinct food groups produced over the reference period and serves as a proxy for potential on-farm dietary diversity and nutrient availability. A higher PDI indicates greater production diversity, which has been associated with improved dietary quality and nutritional outcomes, particularly among women and young children (Jones et al., 2014b; Sibhatu, Krishna, and Qaim, 2015; Bakhtsiyarava and Grace, 2021; Aweke et al., 2022). In this study, the PDI served as a key predictor variable in subsequent analyses of dietary outcomes among women of reproductive age and young children.

To further characterize farming systems, cropping systems were identified through frequency analysis of the dominant crops produced by households, followed by hierarchical clustering based on crop composition. This approach classified households into four major systems: (1) cereal–pulse mixed farming, (2) cereal–pulse–tuber systems, (3) highland perennial crop systems, and (4) agropastoral systems. These systems reflect distinct agroecological contexts across the regions of Amhara, Oromia, SNNP, Sidama, and Somali, each with different cropping patterns. This classification was used to compare nutrient intake across farming systems and to link agricultural practices to household nutrition (Table 5.2).

Table 5.2. Cropping system classification

Predominant Crops identified	Cropping system	Rationale
Barley, Wheat, Pulses, Teff, Maize, Sorghum, Millet	Cereal-Pulse Mixed Farming	Predominantly characterized by a diverse array of cereals (barley, wheat, teff, maize, sorghum, millet) integrated with pulses, reflecting a balanced agroecological system common in Ethiopia's highland and midland regions, optimizing both grain and legume production.
Maize, Pulse, Potato, Enset	Cereal-Pulse-Tuber Mix	A versatile system combining cereals (maize), pulses, root crops (potatoes), and the culturally significant Enset (false banana), a staple in southern Ethiopia. This mix is widespread across highland and midland areas, supporting food security with diverse staple crops.
Maize, Coffee, Khat, Pepper, Spices	Perennial crops	Dominated by high-value perennial and cash crops, including coffee, khat (a stimulant crop), pepper, and spices. This system is tailored for economic returns and is prevalent in regions suitable for such specialty agriculture.
Animal rearing and agrarian mix	Agropastoral	Primarily focused on livestock rearing, supplemented by limited cereal production, representing a hybrid system that leverages pastoral traditions with minimal crop cultivation, typical in semi-arid or transitional agroecological zones.

Seasonality plays a critical role in shaping agricultural production and dietary outcomes. In Ethiopia, food availability typically improves during the post-harvest season, leading to higher household dietary diversity and better nutritional indicators. In contrast, the pre-harvest period is often marked by food shortages, reduced dietary diversity, and heightened vulnerability to undernutrition, particularly among women and children (Hirvonen et al., 2016). These seasonal

dynamics are reflected in household-level indicators (e.g., HDDS and MAHFP) and individual-level outcomes (e.g., MDD-W and nutrient intake).

To complement production data and better understand seasonal food access, monthly food price data from Ethiopia's Consumer Price Index (CPI), covering 119 food commodities, were incorporated. These data were used to compute average prices for major food groups over time. Although CPI data do not distinguish between locally produced and imported foods, they provide a reasonable approximation of market conditions faced by households. Given that most staple foods in Ethiopia are domestically produced, the price trends largely reflect local market dynamics. This enabled analysis of how seasonal price fluctuations interact with food availability to influence household food access and dietary outcomes.

Overall, this integrated approach captures the complex interactions among production diversity, cropping systems, seasonality, and market conditions, providing a robust framework for analyzing how agricultural systems affect food security and dietary quality. These insights are essential for informing seasonally responsive nutrition interventions and climate-smart agricultural policies aimed at improving the well-being of vulnerable populations, particularly women and young children.

5.2.6. Statistical approaches

Women's Dietary Diversity Score (WDDS) and Children's Dietary Diversity Score (CDDS) for women and children aged 6–23 months were analysed using Poisson regression models with robust standard errors, clustered at the household level (Hardin and Hilbe, 2014). Nutrient intakes (energy, calcium, iron, zinc, and vitamin A) were assessed using pooled ordinary least squares (OLS) regressions (Wooldridge, 2010). Both models included sociodemographic, socioeconomic, agricultural, market access, and seasonal factors as covariates. Analyses were conducted in STATA 16 (StataCorp, 2019), and data visualizations were produced in R (R Core Team, 2023).

5.2.7. Limitations

Although this analysis was grounded in established food systems and nutrition research frameworks, several limitations should be acknowledged. First, key variables—including dietary intake (based on 24-hour recall, FFQ, and DQQ) and production diversity—were self-reported, which may be subject to recall bias, misreporting, and social desirability bias, potentially affecting estimates of dietary quality and nutrient intake. Second, production diversity was measured using a binary food-group approach that indicates whether a food group was produced but does not account for quantity produced, seasonal availability, or post-harvest losses, which may limit its ability to reflect actual food access or consumption fully. Third, although the same households were revisited across two survey rounds to capture seasonal variation, the data still represent only two time points and may not fully capture the complexity of agricultural cycles, climate variability, and intra-seasonal fluctuations that influence both production and dietary outcomes.

5.3. Results

5.3.1. Household characteristics

Table 5.3 presents the socio-demographic and agricultural characteristics of study households across the two data collection periods, conducted during the main farming seasons and reflecting seasonal variations in food availability. Most households were male-headed (90.3%), while female-headed households accounted for 9.7% of the sample. A considerable difference in production diversity was observed between the previous and current main harvest seasons ($p < 0.01$). The religious affiliation of household heads was predominantly Orthodox Christian (44.5%), followed by Muslim (31.9%), Protestant (23.1%), and other religions (0.5%). These proportions remained relatively stable across seasons, with no statistically significant differences. Religious affiliation is particularly relevant in the Ethiopian context due to fasting practices—especially among Orthodox Christians—which involve periodic abstention from animal-source foods and can influence dietary diversity and nutrient intake.

The average family size was consistent across both seasons, with a mean of approximately five members (SD = 1.7), and showed no significant seasonal variation. Similarly, the average age of the women respondents was around 33 years (SD = 8.7), with no meaningful difference between the pre-harvest and post-harvest periods.

The average total landholding was 1.0 hectare, and irrigated land remained minimal across both seasons, with no statistically significant differences observed. Production diversity, estimated based on the number of distinct crop groups produced in the year preceding each data collection round, showed a statistically significant seasonal increase. Specifically, during the pre-harvest survey round, production diversity reflected crops cultivated and harvested up to that point (mean = 2.1, SD = 1.0). During the post-harvest survey round, production diversity captured the total number of crop groups produced during the primary production season preceding the data collection date (mean = 2.6, SD = 1.1). This increase from pre-harvest to post-harvest was statistically significant ($p < 0.001$), reflecting greater crop availability and diversity following the main harvest.

Table 5.3. Socio-demographic and agricultural characteristics by season among Ethiopian households

Variable (N = 965)	Total (N=965)	Pre-harvest (n=517)	Post-harvest (n=448)	P-value
	n (%)	n (%)	n (%)	
Region				0.021
Amhara	341 (35.3)	190 (36.8)	151 (33.7)	
Oromia	251 (26.0)	122 (23.6)	129 (28.8)	
Somali	23 (2.4)	19 (3.7)	4 (0.9)	
SNNP	250 (25.9)	136 (26.3)	114 (25.4)	
Sidama	100 (10.4)	50 (9.7)	50 (11.2)	
Household head gender				0.096
Female	94 (9.7)	58 (11.2)	36 (8.0)	
Male	871 (90.3)	459 (88.8)	412 (92.0)	
Household head education				0.463
Primary school (1-8)	786 (81.5)	432 (83.6)	354 (79.0)	
Attended high school	88 (9.1)	41 (7.9)	47 (10.5)	
Diploma/Certificate	31 (3.2)	15 (2.9)	16 (3.6)	
Bachelor's and above	12 (1.2)	5 (1.0)	7 (1.6)	
Other informal education	48 (5.0)	24 (4.6)	24 (5.4)	
Religion of the HH head				0.355
Orthodox	429 (44.5)	217 (42.0)	212 (47.3)	

Muslim	308 (31.9)	176 (34.0)	132 (29.5)	
Protestant	223 (23.1)	121 (23.4)	102 (22.8)	
Others	5 (0.5)	3 (0.6)	2 (0.4)	
Family size	5.0 (1.7)	5.1 (1.7)	5.0 (1.7)	0.382
Women's age	33.0 (8.7)	32.6 (8.1)	33.4 (9.2)	0.345
Months of Adequate Household Food Provisioning	10.2 (2.5)	10.3 (2.7)	10.0 (2.1)	<0.001
Total land (ha)	1.0 (2.5)	1.1 (3.2)	1.0 (1.2)	0.242
Irrigated land (ha)	0.0 (0.3)	0.0 (0.3)	0.0 (0.3)	0.866
Production diversity	2.3 (1.1)	2.1 (1.0)	2.6 (1.1)	<0.001

5.3.2. Dietary diversity and nutrient intake

5.3.2.1. Women's dietary diversity

The results in Figure 5.2 illustrate the proportion of women who consumed foods from the ten recommended food groups and met the criteria for Minimum Dietary Diversity for Women (MDD-W)—defined as consuming at least five of the ten recommended food groups—during both the pre-harvest and post-harvest seasons. Consumption of "staple grains and roots" remained high in both seasons, followed by "pulses," which saw significant post-harvest increases, suggesting improved availability. "Other vegetables" showed a substantial increase during post-harvest, while the "other fruits" and "vitamin A-rich fruits and vegetables" food groups exhibited modest increments during post-harvest compared to the pre-harvest season. In contrast, "nuts and seeds" and "eggs" consistently exhibited very low consumption. "Dairy" consumption showed improvement during post-harvest, while "meat, poultry and fish" remained low. Consequently, the proportion of women achieving MDD-W increased modestly from 16.8% before harvest to 25% after harvest, indicating limited overall dietary diversity. In summary, while the post-harvest season generally saw improved consumption across most food groups, particularly pulses and fruits, nutrient-dense foods such as nuts and seeds, eggs, and meat remained low year-round, highlighting persistent challenges in achieving a diverse diet.

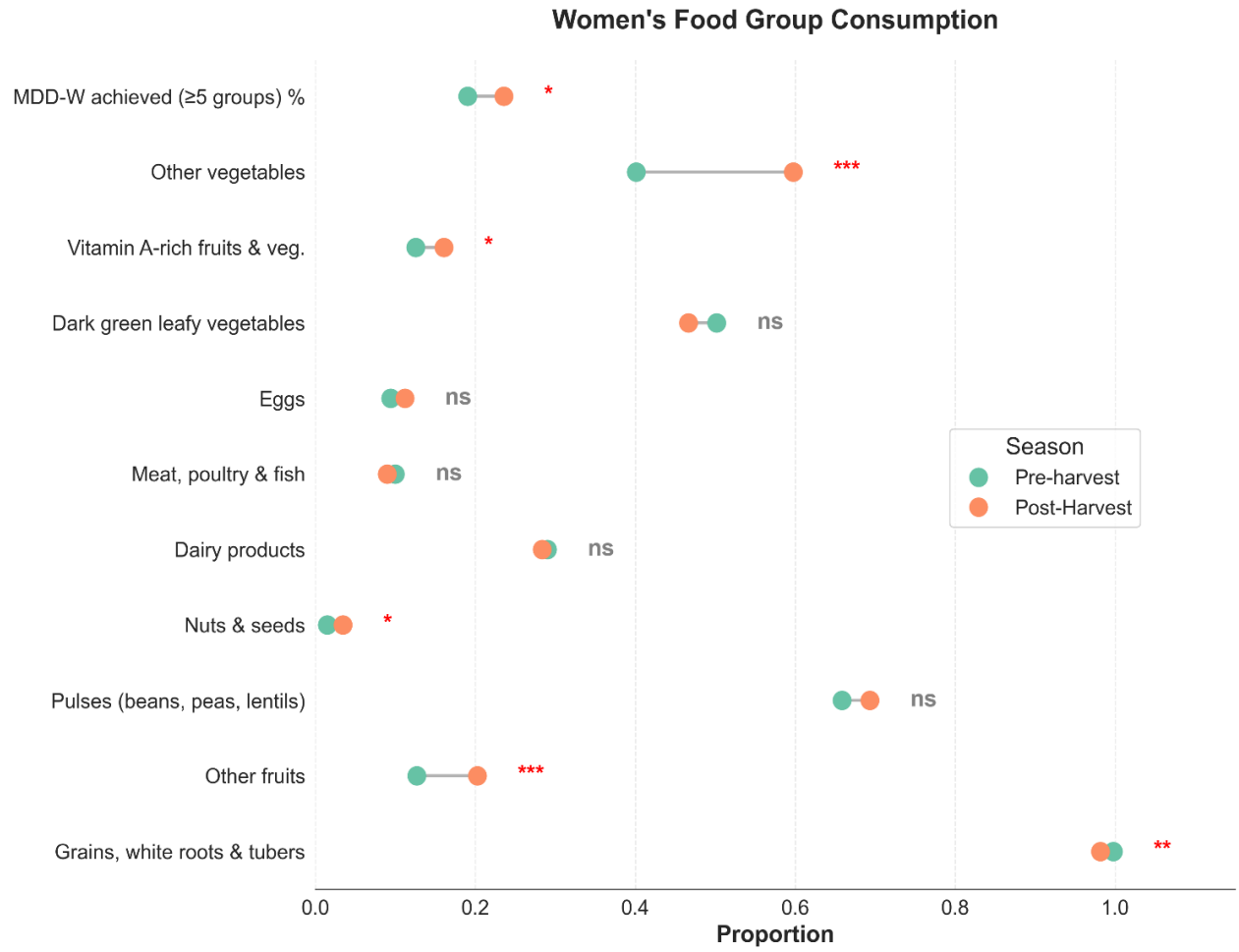


Figure 5.2. Proportion of women consuming each of the ten MDD-W food groups in the 24 hours preceding the survey.

(The plot compares pre-harvest (teal) and post-harvest (orange) seasons. Horizontal lines connect the paired seasonal estimates for each food group. Significance of seasonal differences assessed using McNemar's test: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ns = not significant)

5.3.2.2. Children's diet diversity

Figure 5.3 compares children's consumption of food groups over the previous 24 hours during the pre-harvest (lean) season to the post-harvest season. In a pattern similar to that of women, "grains, roots and tubers" are children's most consumed food group, increasing from 81.5% pre-harvest to 90.3% post-harvest, reflecting a heavy reliance on staples across both groups. Consumption of "other fruits and vegetables" among children nearly doubled, suggesting that post-harvest access to fruit benefits both groups. Children's consumption of pulses, nuts, and seeds remained stable, with a slight

increase from 42.9% to 43.7%. Consumption of Vitamin A-rich fruits and vegetables among children slightly improved post-harvest.

Children's consumption of animal-source foods, such as dairy products, increases from 21.8% before harvest to 26.2% after harvest, aligning with the trend among women, where dairy consumption rises from 24.4% to 28.1%. Consumption of "Flesh foods (meat, poultry, fish)" and "eggs" remains minimal in both groups, although there are significant post-harvest increases among children (1.7% to 6.8% for flesh foods, 10.9% to 15.5% for eggs), highlighting limited access to animal-source foods.

The proportion of children meeting the Minimum Dietary Diversity (MDD) increased from 11.8% to 23.3% post-harvest, while those achieving the Minimum Acceptable Diet (MAD) rose from 7.6% to 16.5%. Children demonstrate a greater relative improvement in MDD, suggesting that seasonal abundance may have a more substantial impact on their dietary diversity. In summary, the post-harvest season improves dietary outcomes for both groups, particularly in pulses, fruits, and vegetables, as well as overall dietary diversity. However, the persistently low consumption of animal-source foods underscores nutritional challenges.

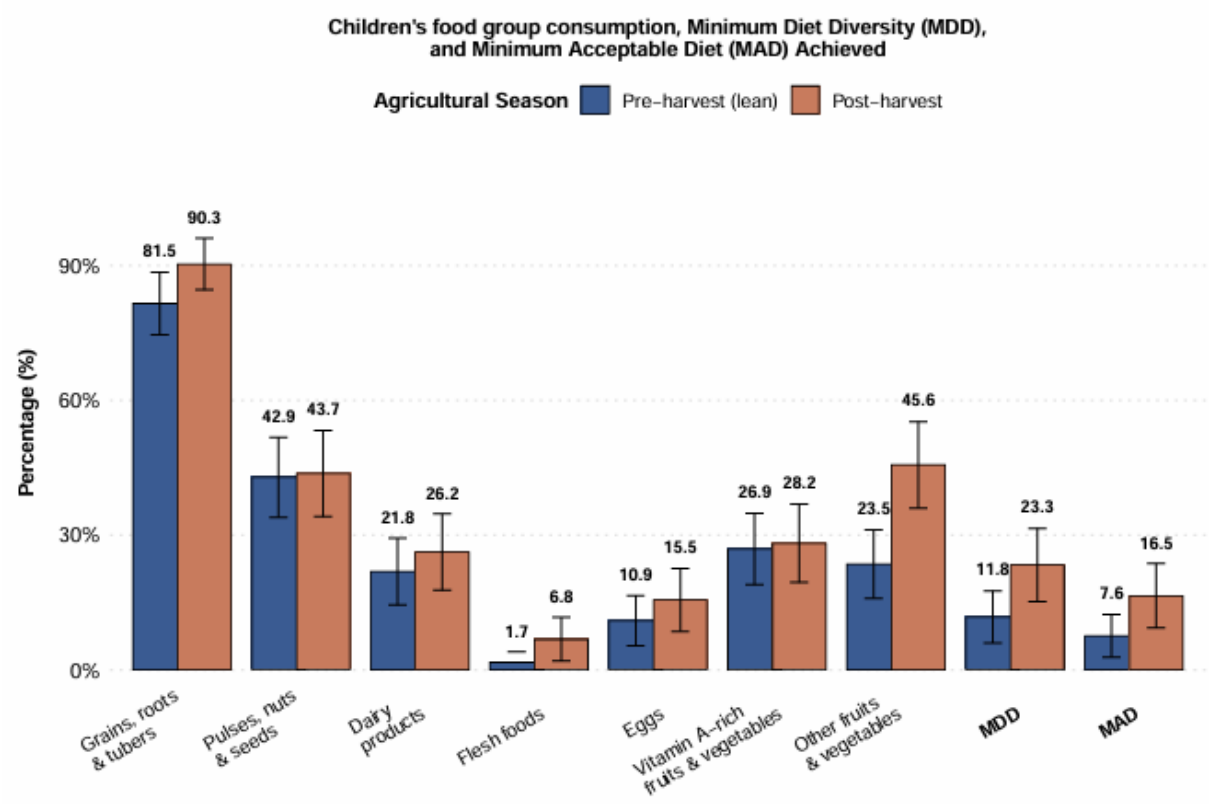


Figure 5.3. Children's Consumption of food groups, Minimum Dietary Diversity (MDD) and Minimum Acceptable Diet (MAD) by season.

The plot illustrates the proportion of children aged 6 to 23 months who consume seven food groups and achieve Minimum Dietary Diversity (MDD) and Minimum Acceptable Diet (MAD) across two seasons: pre-harvest (lean, dark gray) and post-harvest (light gray). The bars represent mean proportions with 95% confidence intervals.

5.3.3. Women's and children's intakes vs. recommended cutoffs

Seasonal variation in energy and micronutrient intakes is shown in Figure 5.4. Women's energy intake increased significantly after harvest, from an average of 1430.3 kcal/day to 1589.3 kcal/day, but remained below the Ethiopian FBDG recommendation of 2300 kcal/day, indicating ongoing energy deficiency. Calcium intake also improved after harvest but stayed below recommended levels. Vitamin A increased from an average of 394.1 to 482.1 µg RAE/day but remained below the 600 µg RAE/day RNI, suggesting a potential deficiency. Iron and zinc intakes rose after harvest, though they remained inadequate. Similarly, for children, energy intake increased significantly from 733.7 to 815.1 kcal/day but remained below the 1250 kcal/day guideline. Calcium rose from 220.7 to 273.4 mg/day but

remained well below the RNI of 1000 mg/day. Vitamin A intake neared adequacy, increasing from 282.5 to 394.6 µg RAE/day, while iron intake improved sufficiently after harvest (Figure 5.4).

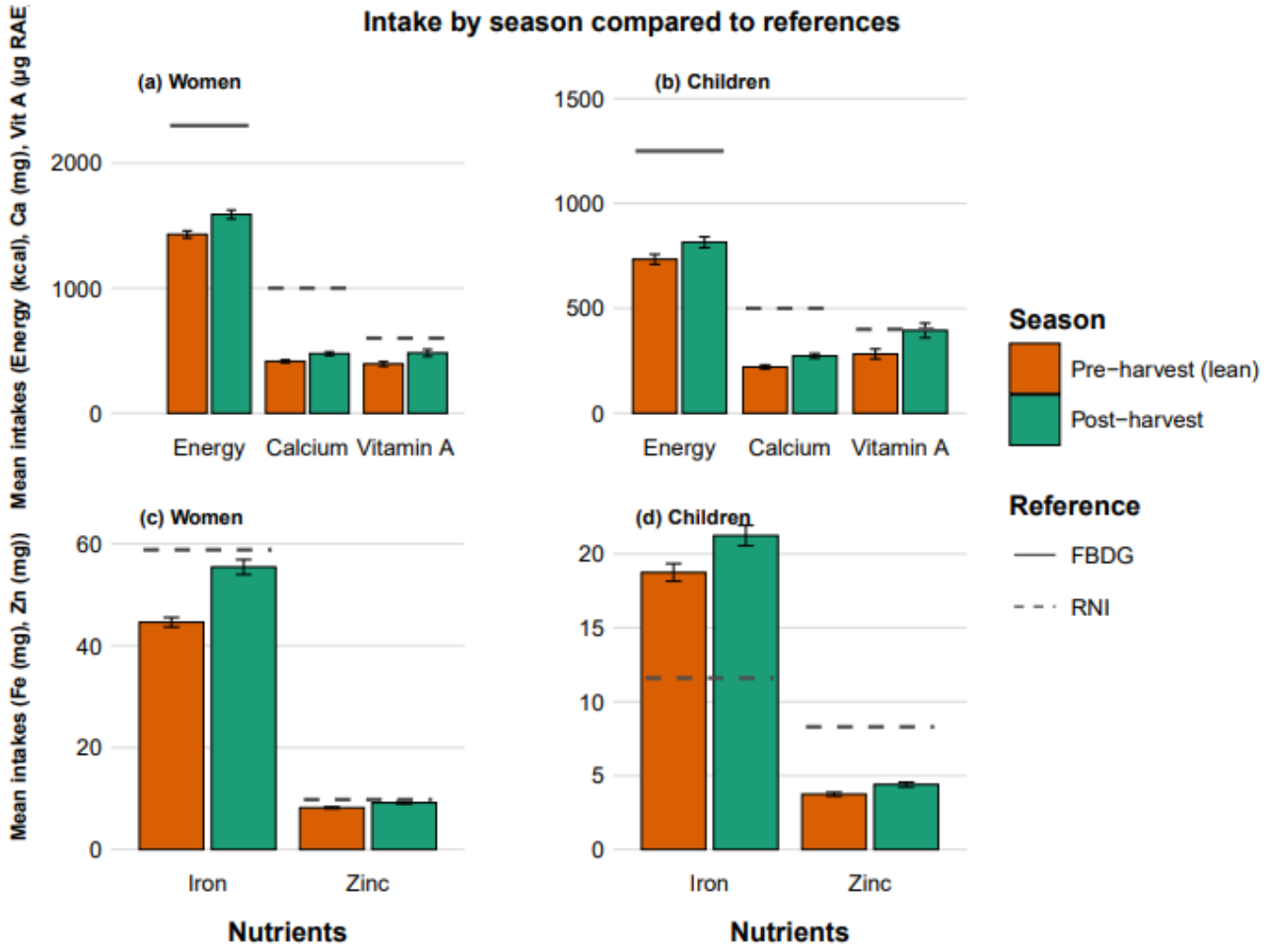


Figure 5.4. Nutrient intakes of women and children compared to reference values by seasons.

Panels (a) and (b) show average intakes of energy (kcal/day), calcium (mg/day), and vitamin A (µg RAE/day) for women and children, relative to the Ethiopian FBDG (solid line) for energy and the RNI (dashed line) for other nutrients. Panels (c) and (d) display the average intakes of iron (mg/day) and zinc (mg/day) for women and children, respectively, compared to the Recommended Nutritional Intake (RNI) (dashed line). Orange and teal bars represent the pre-harvest (lean) and post-harvest seasons, respectively, with error bars indicating standard deviation. FBDG: Food-Based Dietary Guidelines; RNI: Recommended Nutrient Intake; RAE: Retinol Activity Equivalent.

5.3.4. Nutrient adequacy among women and children

As shown in Figure 5.5, nutrient adequacy among women varied markedly across nutrients. Calcium exhibited the greatest inadequacy, with only 17.8% of women meeting adequacy requirements (82.2% inadequate). Vitamin A adequacy was also low at 34.7%, while energy adequacy remained modest at 38.1%. In contrast, relatively higher adequacy was observed for zinc

(63.8%) and iron (58.3%), indicating comparatively better intake levels for these nutrients. The Mean Adequacy Ratio (MAR) among women was 60.1%, suggesting that, on average, women achieved about 60% of the recommended nutrient intakes.

Among children, adequacy patterns differed somewhat. Iron intake showed the highest adequacy, with 92.5% of children meeting requirements, followed by energy (36.0%) and vitamin A (33.9%). However, adequacy was considerably lower for calcium (27.0%) and zinc (21.6%), highlighting these as key limiting nutrients in children's diets. The MAR for children was 60.4%, which is very similar to that observed among women.

Overall, calcium and zinc were the most limiting nutrients among children, whereas calcium and vitamin A represented the largest nutrient gaps among women. These findings highlight the need for targeted, nutrient-specific dietary interventions to improve micronutrient adequacy, particularly among women of reproductive age and young children.

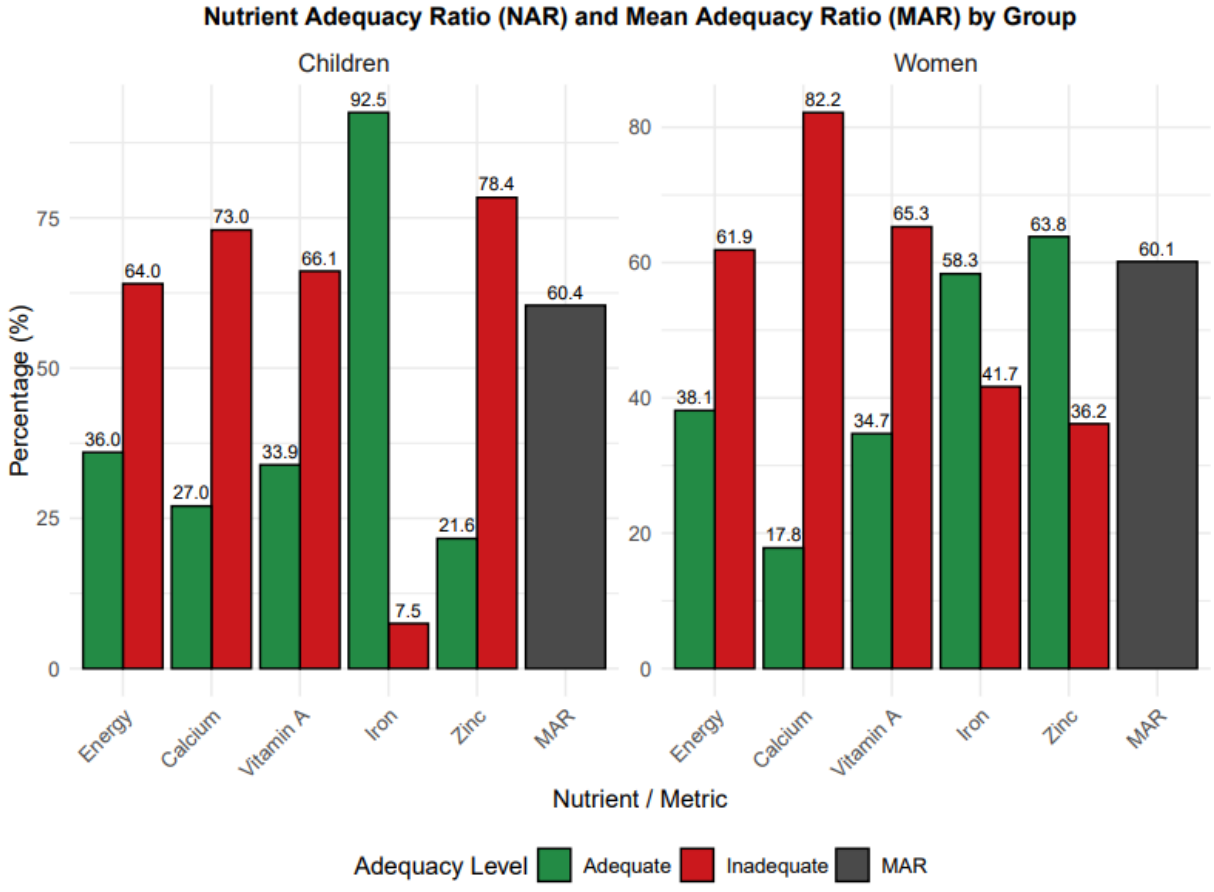


Figure 5.5. Nutrient adequacy ratio (NAR) and mean adequacy ratio (MAR) by group.

The plot bar graph depicts Nutrient Adequacy Ratio (NAR ≥ 0.67) for energy, calcium, vitamin A, iron, and zinc, alongside the Mean Adequacy Ratio (MAR). Adequacy is categorized as inadequate (NAR ≤ 0.66, red) or adequate (NAR > 0.66, green), with MAR shown as a percentage (gray). The data reflect dietary intake over 24 hours.

5.3.5. Seasonality and food access

Figure 5.6 shows seasonal changes in household food adequacy across two survey rounds aligned with key agricultural periods. A clear pattern appears. Food insecurity peaks during the lean season (June–September), especially in 2022/2023, with the highest levels in July and August. Post-harvest months (November–March) consistently show a lower occurrence of food inadequacy. The sharper increase in food insecurity in 2022/2023 suggests a potential decline in household resilience between the years.

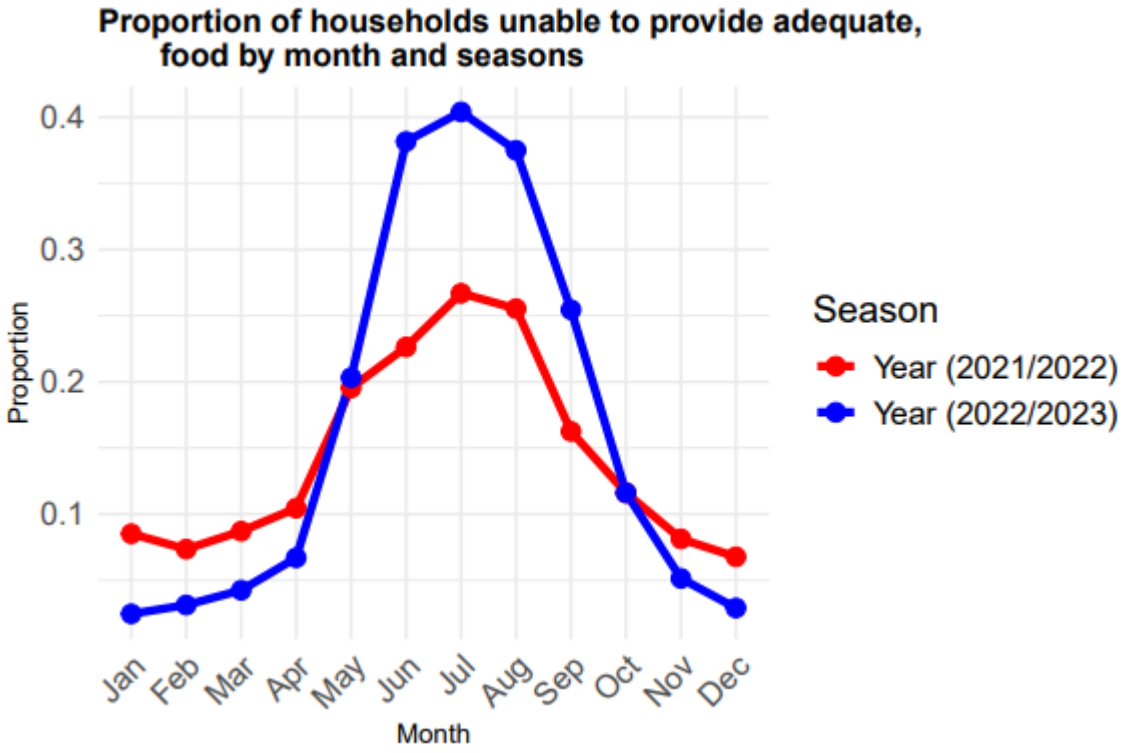


Figure 5.6. Monthly household food insecurity trends across two consecutive years.

The line graph depicts the monthly proportion of households experiencing food inadequacy over a year, comparing pre- and post-harvest seasons. The x-axis represents months (January-December), and the y-axis shows the percentage of households affected.

The chart in Figure 5.7 shows a link between the number of months with inadequate food supply and women's energy and micronutrient intake. Women in households with minimal food

shortages (0–2 months) consume the highest levels of energy, calcium, iron, zinc, and vitamin A. As shortages increase from 3 to 12 months, intakes steadily and significantly decrease—most notably for iron, zinc, and vitamin A. Many women in households that are constantly food-insecure fall well below recommended nutrient levels. These findings emphasize the direct nutritional impact of recurring seasonal food shortages.

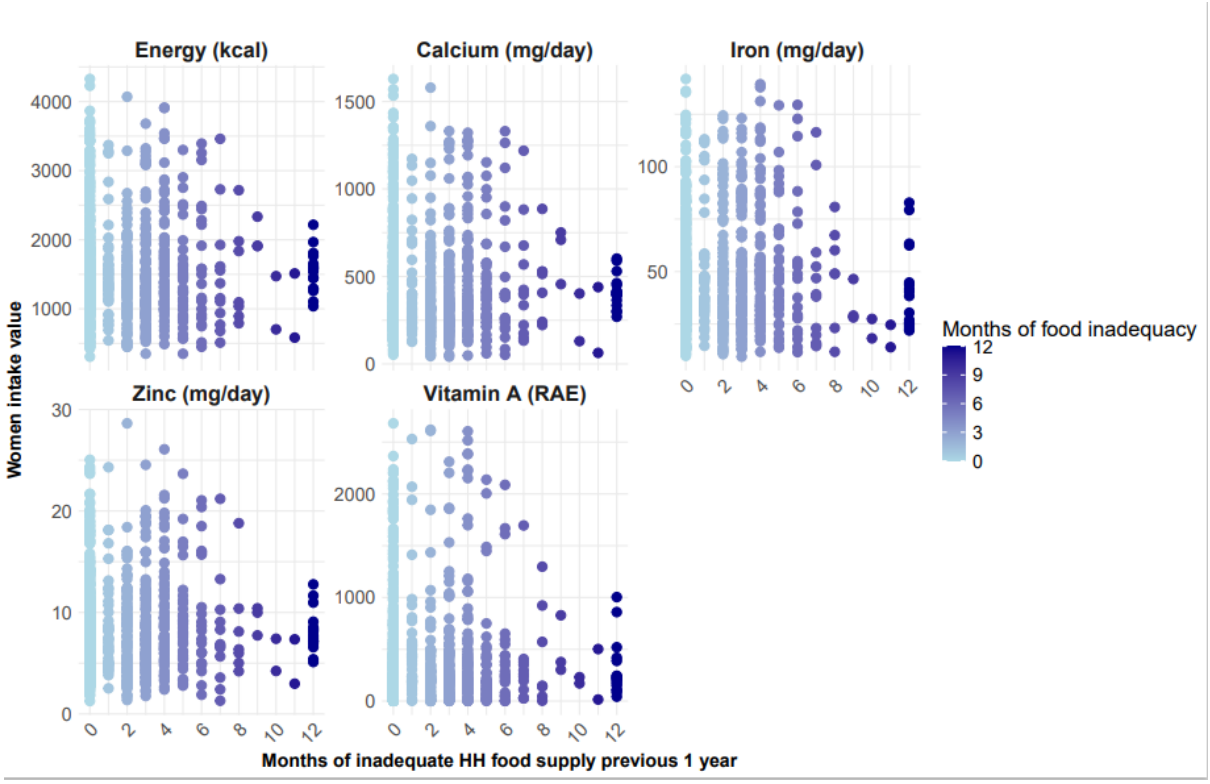


Figure 5.7. Women's energy and micronutrient intake by months of household food inadequacy.

5.3.6. Cropping systems, production diversity, and nutrient intake

In rural Ethiopia, agriculture is essential for livelihoods and food security. The types of cropping systems, farm-level production diversity, and seasonality significantly influence household diets and nutrient intake.

5.3.6.1. Main cropping systems

The distribution of households across four central cropping systems in the study area shows that Cereal–Pulse–Tuber systems account for the largest share, at 46.4%, followed by Cereal–Pulse

mixed systems at 39.1%. Highland perennial systems represent 11.3%, and agropastoral systems are the least common, at just 3.2%. This distribution emphasizes the dominance of cereal-based systems, especially those involving tubers, and the smaller share of perennial and agropastoral systems.

5.3.6.2. Land use and cropping patterns

Households in the study area manage small, rain-fed parcels, usually around 1 hectare, with little to no access to irrigation. Land uses are sharply divided within this limited space. Most of the land (87.1%) is used for crop farming, underscoring the need to make the most of each plot. Smaller portions are used for livestock grazing (5.5%), soil recovery through fallowing (2.3%), or to house homesteads (4.3%). Forest patches comprise only 0.8% of the land (Figure 6.7).

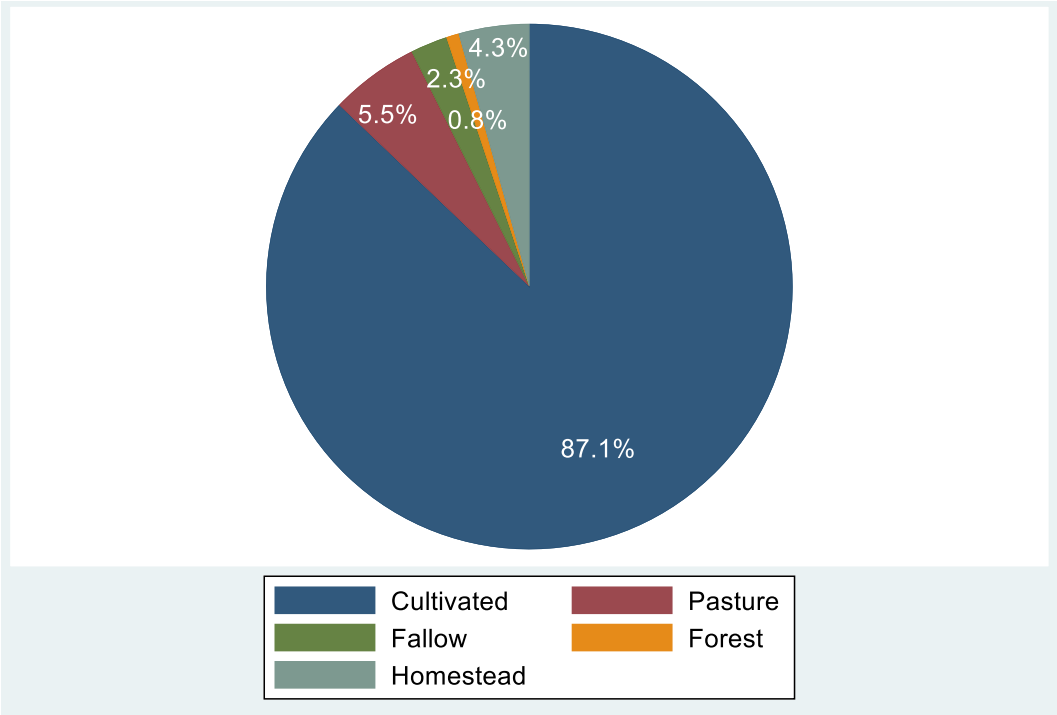


Figure 5.8. Average household's land use proportion during the previous production season (2022/2023).

Across different seasons, farming in the study area consistently centres on staple grains. Grains, mainly teff, maize, sorghum, and wheat, cover approximately two-thirds to 80% of cultivated land and dominate total output. Figure 5.9 illustrates both land allocation and production shares during the pre-harvest (2021/2022) and post-harvest (2022/2023) periods. While these two measures

are presented together, they are not directly comparable, as production shares also reflect differences in crop yields and productivity. Pulses rank as the second most important crop group, occupying 19–25% of cultivated land and contributing 13–19% of total production. Fruits and vegetables remain minor, covering only 4–9% of land and contributing less than 7% of total output, while other crops, such as oilseeds and root crops, are grown on a small scale.

The 2022/2023 production year shows an increased share of land allocated to grains (up to 80.2%), although their share in total production does not increase proportionally. This suggests differences in productivity across crop groups rather than a direct one-to-one relationship between land allocation and output shares. The already limited allocation to fruits and vegetables also declines slightly, highlighting their continued low priority within these smallholder farming systems.

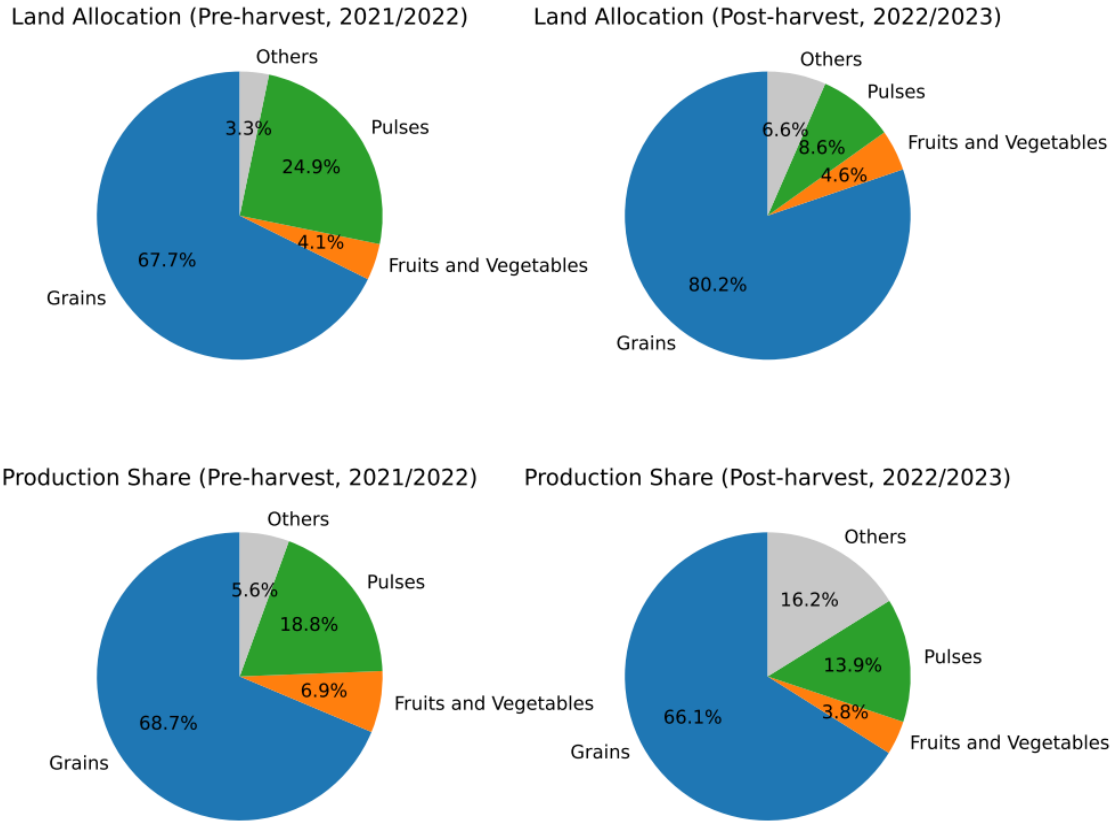


Figure 5.9. Household land allocation and production share by crop group across two production years.

These differences in farming systems are essential for understanding dietary patterns and variations in nutrient intake, as shown in Table 5.4. This table displays women's daily intake of calcium

(Ca), iron (Fe), zinc (Zn), and vitamin A (RAE) across four cropping systems: Cereal-Pulse Mixed (n = 377), Cereal-Pulse-Tuber (n = 448), Highland Perennial (n = 109), and Agropastoral (n = 31). Significant differences were observed for calcium, iron, and zinc (ANOVA: Ca $F(3,961) = 10.52$, $p < 0.001$; Fe $F(3,961) = 6.74$, $p < 0.001$; Zn $F(3,961) = 20.46$, $p < 0.001$), while vitamin A did not show a significant difference ($F(3,961) = 2.19$, $p = 0.088$).

Calcium intake was highest in Agropastoral (560.6 ± 47.9 mg/day) and Highland Perennial (538.6 ± 41.5 mg/day) systems, and lowest in Cereal-Pulse-Tuber households (393.2 ± 10.2 mg/day). Tukey tests confirmed that Cereal-Pulse-Tuber differed significantly from Cereal-Pulse-Mixed (466.9 ± 16.9 mg/day) and Highland Perennial, while Agropastoral did not differ from Highland Perennial.

Table 5.4. Mean (± SEM) daily nutrient intakes among women by dominant cropping system in rural Ethiopia (pooled across pre- and post-harvest seasons; N=965 observations from 520 women)

Farming system (N=965)	n	Calcium (mg/day)	Iron (mg/day)	Zinc (mg/day)	Vitamin A (µg RAE/day)
Agropastoral	31	560.6 ± 47.9[a]	34.4 ± 5.4[b]	9.4 ± 1.0[ab]	443.9 ± 96.0
Cereal-Pulse Mixed	377	467.0 ± 16.9[b]	53.1 ± 1.5[a]	9.7 ± 0.3[a]	433.4 ± 31.4
Cereal-Pulse-Tuber	448	393.2 ± 10.2[c]	47.3 ± 1.1[a]	7.4 ± 0.2[c]	408.1 ± 18.4
Highland perennial	109	538.6 ± 41.5[a]	51.4 ± 2.9[a]	9.8 ± 0.5[a]	548.1 ± 55.1
ANOVA F (3, df)		10.52	6.74	20.46	2.19
p-value		<0.001	<0.001	<0.001	0.088

Note. Values are means ± SEM. Values in the same column that do not share a superscript letter (e.g., a, b, c) are significantly different from each other based on post-hoc multiple comparison tests, Tukey HSD, $p < 0.05$.

Iron intake was highest in Cereal-Pulse Mixed (53.1 ± 1.5 mg/day) and Highland Perennial (51.4 ± 2.9 mg/day), and significantly lower in Agropastoral households (34.4 ± 5.4 mg/day). Cereal-Pulse-Tuber (47.3 ± 1.1 mg/day) was intermediate. Zinc intake showed the most significant differences: households in Cereal-Pulse-Tuber had significantly lower intake (7.4 ± 0.2 mg/day) than in all other systems, while Highland Perennial (9.8 ± 0.5 mg/day) and Cereal-Pulse Mixed (9.7 ± 0.3 mg/day) had the highest intake. Agropastoral households (9.4 ± 1.0 mg/day) did not differ significantly from either group. Vitamin A intake was highest in Highland Perennial (548.1 ± 55.1 µg RAE/day), but this

difference was not statistically significant (p = 0.088). Overall, diversity in cropping systems significantly influenced the adequacy of calcium, iron, and zinc, whereas vitamin A intake was less affected by system type.

5.3.6.3. Farm size, irrigation, and children's nutrient intake

Figure 5.10 explores how total landholding, cultivated area, and access to irrigation relate to children's daily energy and micronutrient intake. Larger farms show only slight nutritional benefits: even among households with 2–3 hectares, energy and micronutrient intakes (calcium, iron, zinc, vitamin A) remain low, and positive trends are weak. Simply expanding rain-fed cereal cultivation does not lead to improved diets.

However, irrigated plots are typically small—often less than 0.2 hectares—and households with irrigation consistently have higher intakes of iron, zinc, and vitamin A, along with modest increases in energy and calcium. These improvements are significant for micronutrients that are often missing in Ethiopian diets. Irrigation allows for continuous or off-season production of vegetables, fruits, and other nutrient-rich crops—resources that rain-fed systems cannot reliably provide.

These findings show that farm size alone offers limited nutritional benefits in a cereal-based, rain-fed system. In contrast, even small areas of irrigated land are positively linked to better dietary quality.

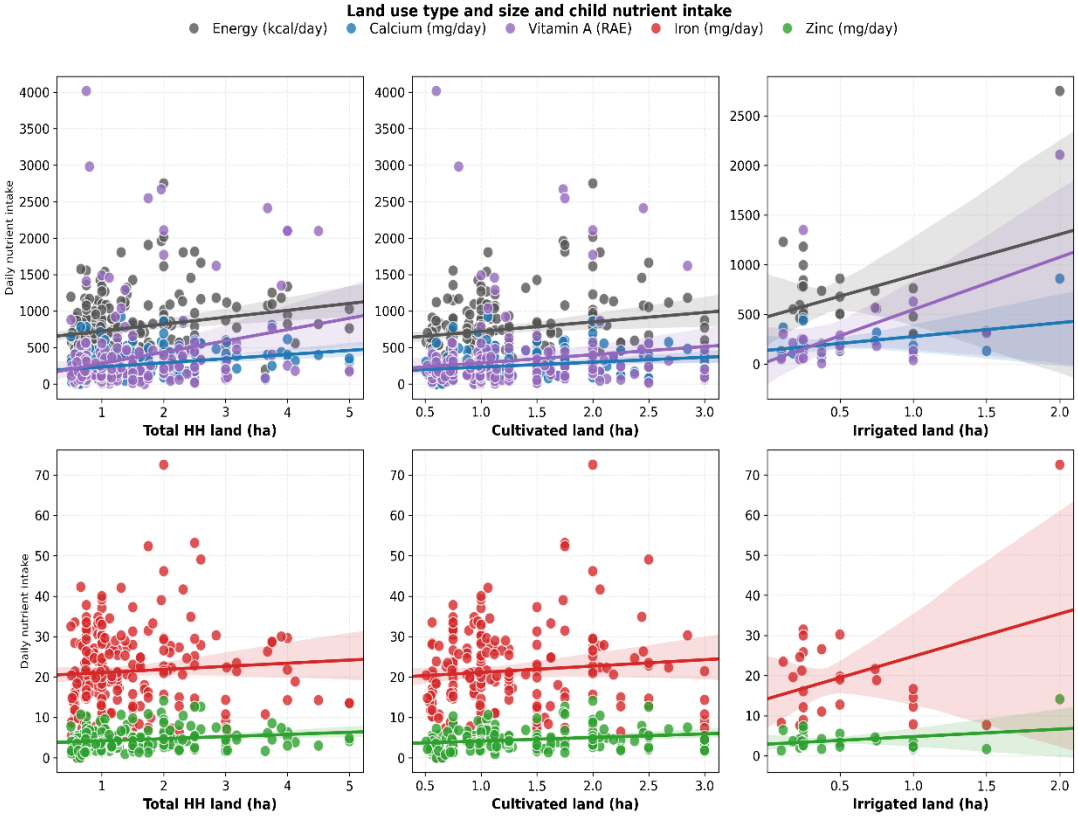


Figure 5.10. Associations between farm size, irrigated land, and children's daily nutrient intake.

Moving from cropping systems to farm-level production diversity. Figure 5.11 illustrates mean daily intakes of calcium, vitamin A, iron, and zinc for women and children, stratified by farm production diversity and season. Women in households with higher production diversity (≥4 groups) consistently demonstrated higher intakes across all nutrients. This effect was particularly pronounced for vitamin A, which nearly doubled (from 385.16 to 721.28 µg RAE/day), thereby improving calcium intake. Similar patterns were observed in children. Children in households with higher production diversity (four or more food groups) consumed significantly more vitamin A (384.49 vs. 318.52 µg RAE/day, $p < 0.01$), zinc (4.77 vs. 3.97 mg/day, $p < 0.05$), and iron (22.24 vs. 20.70 mg/day, $p < 0.1$), with calcium levels also markedly higher (322.96 vs. 236.56 mg/day, $p < 0.01$) compared to children whose households were engaged in less production diversity.

Seasonal variation further reinforces the influence of the differences in cropping systems and farm production diversity. Across both groups and nutrients, while post-harvest intakes were slightly higher than pre-harvest, the dominant pattern was the strong positive impact of farm diversity on micronutrient consumption, highlighting its potential to reduce deficiencies in vulnerable populations. Mean differences, 95% confidence intervals, and exact p-values for nutrient intake by production-diversity category (≤3 vs ≥4 food groups produced) are presented in Table A5.1.

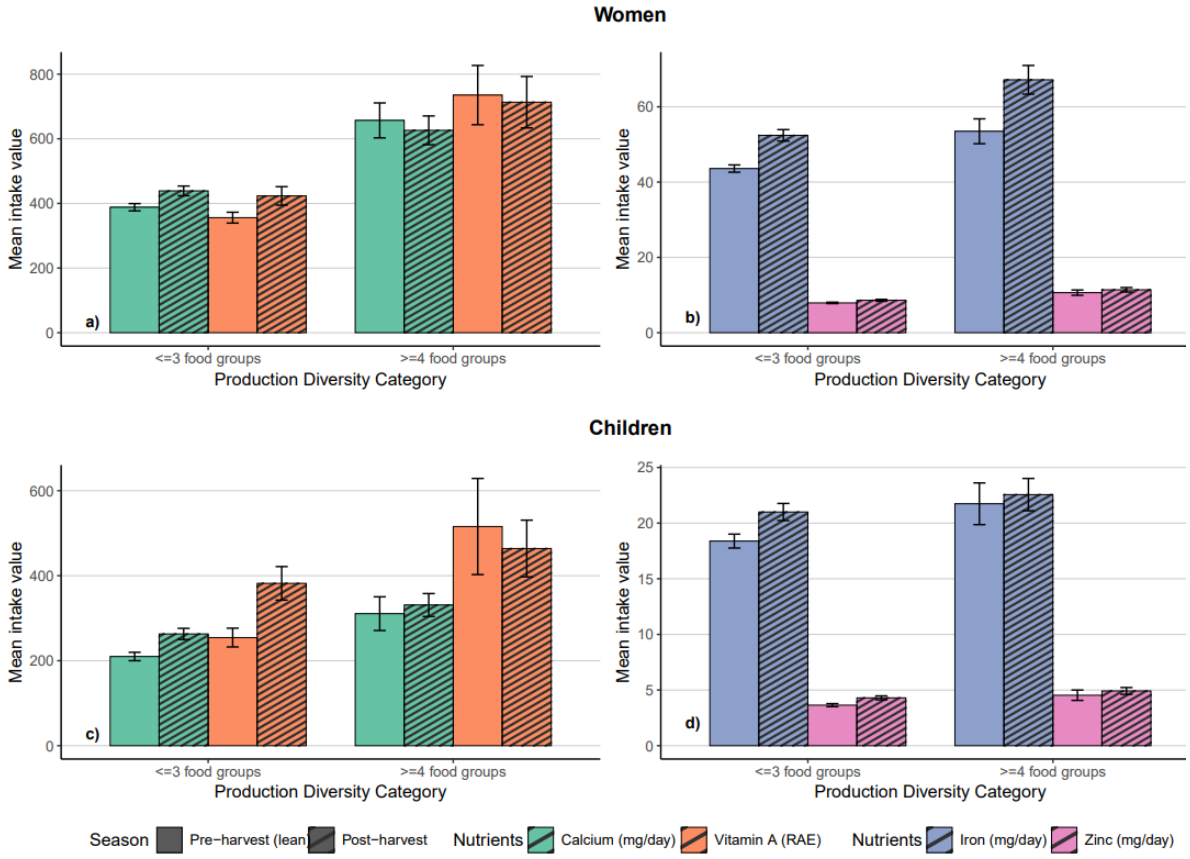


Figure 5.11. Mean nutrient intake by production diversity and season in women and children, Ethiopia.

Panels show: (a) Women's calcium (teal) and vitamin A (orange); (b) Women's iron (blue) and zinc (pink); (c) Children's calcium (teal) and vitamin A (orange); (d) Children's iron (blue) and zinc (pink). Bars indicate means with standard errors. RAE: Retinol Activity Equivalent.

The pooled OLS regression results for nutrient intakes among women and children are presented in Tables 6.5 and 6.6, respectively. All models indicate a significant overall fit ($p < 0.01$), with adjusted R^2 values ranging from 0.169 to 0.275 for women across nutrients (Table 5.5) and from 0.227

to 0.327 for children (Table 5.6). Greater farm production diversity is strongly associated with improved dietary quality among women and children. For women, each additional food group produced corresponds to significant daily increases of 103.8 kcal in energy, 66.9 mg in calcium, 101.4 µg RAE in vitamin A, 3.75 mg in iron, and 0.70 mg in zinc (all $p < 0.01$). For children, production diversity is linked to gains of 21.99 mg calcium ($p < 0.01$), 63.4 µg RAE vitamin A ($p < 0.01$), 1.05 mg iron ($p < 0.05$), and 0.30 mg zinc ($p < 0.05$), while the effect on energy intake (23.4 kcal) was not statistically significant. These results demonstrate that farm diversification plays a critical role in enhancing micronutrient intake and improving nutrition outcomes for vulnerable groups.

Marked regional differences were observed in both women's and children's nutrient intakes. Among women, those residing in Oromia had significantly higher intakes of energy, calcium, zinc, and vitamin A compared to those in Amhara. In contrast, women in SNNP and Sidama had substantially lower intakes of iron and zinc but higher intakes of vitamin A. No consistent differences were observed among women in Somali, although coefficients were generally positive and imprecisely estimated (Table 5.5). Among children, Oromia had higher calcium intake but lower iron intake than Amhara (Table 5.6). Children in SNNP and Sidama had markedly lower intakes of iron and zinc, but substantially higher intakes of vitamin A, while those in Somali had higher calcium intakes but no apparent differences in other nutrients. Overall, these findings highlight pronounced heterogeneity in dietary adequacy across regions, with Oromia showing advantages for several nutrients among women, while SNNP and Sidama showed both nutrient deficits (iron, zinc) and surpluses (vitamin A) among children.

Food security, as measured by monthly adequate household food provisioning (MAHFP), was positively associated with diet quality among women and children. Higher MAHFP scores were consistently linked to greater energy and micronutrient intakes, particularly calcium, iron, and zinc. The effect was most pronounced among women, with increases in MAHFP resulting in significant improvements in dietary adequacy. Among children, the associations were smaller in magnitude but remained substantial for key micronutrients. These results highlight the pivotal role of household food security in determining nutrient availability and intake.

Land resources were strongly associated with dietary adequacy in both women and children. Larger cultivated land size was positively linked with all key nutrients: each additional hectare of cultivated land corresponded to an increase of 2.07 kcal/day in energy intake (SE = 0.53, $p < 0.001$), 0.74 mg/day of calcium (SE = 0.16, $p < 0.001$), 0.022 mg/day of iron (SE = 0.01, $p < 0.01$), 0.01 mg/day of zinc (SE = 0.002, $p < 0.001$), and 0.65 µg/day of vitamin A (SE = 0.19, $p < 0.001$) (see Table 6.5). Homestead land size showed even stronger associations, with an additional hectare associated with markedly higher intakes of energy (+80.42 kcal/day, SE = 14.97, $p < 0.001$), calcium (+43.01 mg/day, SE = 6.30, $p < 0.001$), iron (+1.84 mg/day, SE = 0.56, $p < 0.001$), zinc (+0.52 mg/day, SE = 0.10, $p < 0.001$), and vitamin A (+102.9 µg/day, SE = 17.54, $p < 0.001$). By contrast, irrigated land size was positively but not significantly associated with nutrient intake: coefficients were positive for all nutrients, including energy (+80.48 kcal/day), calcium (+32.67 mg/day), iron (+1.03 mg/day), zinc (+0.47 mg/day), and vitamin A (+54.23 µg/day), but none reached statistical significance.

Among children, cultivated land was also beneficial, with each additional hectare associated with higher energy (+0.83 kcal/day, SE = 0.42, $p < 0.05$), iron (+0.01 mg/day, SE = 0.005, $p < 0.05$), and zinc (+0.003 mg/day, SE = 0.002, $p < 0.05$), while homestead land showed strong positive associations, especially for energy (+540.9 kcal/day, SE = 271.5, $p < 0.05$) and iron (+12.5 mg/day, SE = 7.3, $p < 0.10$) (Table 6.6). These results suggest that although the magnitudes of the effects differed, land resources consistently supported nutrient adequacy for both women and children, with homestead land playing a central role in dietary diversification.

Access to markets was an important determinant of dietary intake. Compared with households with access to a nearby village market, those located more than 1 hour from a market had significantly lower intakes of key nutrients in both groups. The negative associations were most consistent for energy and calcium, indicating that proximity to local village markets supports better dietary adequacy, while greater distance acts as a barrier to accessing nutrient-rich foods.

Food prices were inversely related to nutrient consumption, with particularly strong effects for eggs and vegetables. Among women, higher egg prices were consistently associated with

significant declines across all nutrients per 1 unit (Ethiopian Birr) increase in price, including −62.5 kcal/day in energy intake (SE = 12.3, $p < 0.001$), −23.9 mg/day in calcium (SE = 5.4, $p < 0.001$), −2.38 mg/day in iron (SE = 0.47, $p < 0.001$), and −39.5 µg/day in vitamin A (SE = 8.9, $p < 0.001$). Similarly, higher fruit and vegetable prices were strongly associated with lower vitamin A intake (−57.0 µg/day; SE = 13.9; $p < 0.001$). For children, egg prices were negatively associated with iron intake (−1.24 mg/day, SE = 0.44, $p < 0.001$), while higher fruit and vegetable prices were linked to reduced vitamin A intake (−241 µg/day, SE = 124.6, $p < 0.10$). By contrast, meat and milk prices showed mixed associations, with children's vitamin A intake increasing with rising meat prices (+10.7 µg/day, SE = 3.2, $p < 0.001$), while women's vitamin A intake decreased (−6.25 µg/day, SE = 3.2, $p < 0.05$). Taken together, these findings highlight the high sensitivity of diet quality to price fluctuations, particularly for nutrient-dense foods such as eggs, fruits, and vegetables, which are less affordable for vulnerable households.

Table 5.5. Pooled OLS regression estimates of the association between farm production diversity, other food environment factors, and women's nutrient intake

Variables (n=946)	Energy (kcal/day)		Calcium (mg/day)		Iron (mg/day)		Zinc (mg/day)		Vitamin A (RAE/day)	
	β	se	β	se	β	se	β	se	β	se
Production diversity	103.8***	22.04	66.91***	11.77	3.75***	0.829	0.694***	0.141	101.4***	19.02
Region										
Amhara	1		1		1		1		1	
Oromia	431.67***	70.85	221.57***	32.07	2.914	2.59	1.97***	0.45	513.20***	50.58
SNNP	-56.963	68.50	-53.69*	29.71	-17.19***	2.68	-2.94***	0.410	427.38***	47.16
Sidama	-72.02	82.78	-44.54	34.56	-17.98***	3.36	-3.17***	0.49	339.26***	55.94
Somali	212.11	327.04	172.7	119.59	-17.32	12.25	-1.97	2.17	97.45	227.63
HH head is male (female=ref)	3.849	73.61	2.84	32.74	1.31	2.91	-0.10	0.47	-28.39	58.77
HH head education (years)	4.38	4.25	0.03	1.84	0.01	0.17	0.03	0.028	1.43	2.79
Wealth quintile (1-5)	21.65	18.92	2.85	7.82	1.81**	0.74	0.188	0.119	23.97*	12.77
MAHFP	6.09	10.19	5.37	3.77	-0.28	0.34	0.02	0.06	11.54 *	6.58
Total land cultivated	2.07***	0.53	0.74***	0.16	0.022 **	0.01	0.01 ***	0.002	0.65 ***	0.190
Homestead land (ha)	80.42***	14.97	43.01***	6.30	1.835***	0.56	0.52***	0.103	102.9***	17.54
Irrigated land (ha)	80.48	77.07	32.67	30.73	1.03	2.86	0.47	0.454	54.23	34.92
Average food group price										
Fruit and vegetable	35.27	21.87	21.384**	8.978	0.871	0.893	0.095	0.132	57.04***	13.88
Meat	-5.95	5.24	-4.96**	2.05	0.215	0.176	-0.022	0.029	-6.25**	3.17
Milk	-0.250	1.11	0.36	0.47	0.047	0.044	-0.005	0.007	-1.125*	0.61
Pulses/Legumes	14.17	16.02	-5.64	6.98	0.149	0.601	0.070	0.102	20.97*	11.15
Eggs	-62.46***	12.33	-23.86***	5.36	-2.38***	0.47	-0.34***	0.074	-39.493***	8.85
No market within 1 hour [Nearby village=ref)	-80.80	49.16	-49.03**	21.51	-2.31	1.73	-0.40	0.307	-51.39	34.92
Distance to road (km)	-9.74***	3.06	-3.21***	1.11	-0.31**	0.12	-0.064***	0.021	-1.88	2.03
Post-harvest	196.82***	52.37	87.12***	20.94	11.21***	1.96	1.06***	0.326	75.25**	32.60
Pre-harvest	1		1		1		1		1	
Adjusted R^2	0.169		0.240		0.251		0.274		0.275	

Notes: Standard errors are shown in parentheses. * p<0.1; ** p<0.05; *** p<0.01. Differences were significant at the 1% and 5% levels. MAHFP: Monthly Adequate Household Food Provisioning; ha = hectare; ref = reference. Pooled across pre- and post-harvest seasons; N=965 observations from 520 women.

Table 5.6. Pooled OLS regression estimates of the association between farm production diversity, other food environment factors, and child nutrient intake

Variables (n=427)	Energy (kcal/day)		Calcium (mg/day)		Iron (mg/day)		Zinc (mg/day)		Vit A (RAE/day)	
	β	se	β	se	β	se	β	se	β	se
Production diversity	23.44	18.93	21.99***	8.25	1.053**	0.431	0.229**	0.097	63.44***	18.255
Region										
Amhara	1		1		1		1		1	
Oromia	19.30	79.98	66.13*	34.21	-5.55***	2.06	-0.045	0.429	120.03	90.29
SNNP	192.12*	99.83	45.05	40.93	-4.88*	2.52	-0.50	0.552	457.86***	82.95
Sidama	150.72	151.85	17.16	60.02	-4.44	3.85	-0.98	0.86	390.82***	113.20
Somali	420.49	258.54	175.42*	99.26	4.59	6.04	1.211	1.50	349.85	264.01
HH head is male (female=ref)	115.79**	57.84	36.25	26.54	4.37***	1.51	0.69**	0.33	73.31**	36.38
HH head education (years)	7.83*	4.21	1.58	1.79	0.24**	0.11	0.04*	0.02	7.63	5.11
Wealth quintile (1-5)	47.17**	20.06	24.83***	8.08	0.82*	0.48	0.28**	0.11	12.64	17.96
MAHFP	14.28*	7.27	4.43	3.25	0.04	0.17	0.06	0.04	-14.49*	8.07
Total land cultivated	0.83**	0.42	0.024	0.114	0.010 **	0.005	0.003 **	0.002	0.307	0.27
Homestead land (ha)	540.92**	271.54	227.44	161.01	12.49*	7.32	2.91	1.82	763.72	512.37
Average food group price										
Fruit and vegetable	-15.83	124.18	1.24	50.65	3.91	2.69	-0.174	0.651	-241.23*	124.57
Meat	2.45	6.08	1.37	1.07	0.042	0.06	0.012	0.013	10.72***	3.24
Milk	3.73	2.38	-0.92	1.07	-0.08	0.06	-0.003	0.01	-8.193***	2.92
Pulses/Legumes	-27.92	39.21	-15.67	15.73	0.54	0.95	-0.056	0.222	-64.40**	26.69
Eggs	-23.95	17.30	-4.26	7.97	-1.24***	0.443	-0.134	0.096	-29.92	26.77
No market within 1 hour [Nearby village=ref)	-48.90	39.47	-34.23**	17.17	-0.58	0.911	-0.238	0.217	-90.027**	35.21
Distance to road (km)	-1.59	2.32	-0.42	0.76	-0.03	0.043	-0.01	0.013	1.48	2.90
Post-harvest	-16.98	16.77	4.96	7.27	-0.498	0.415	-0.016	0.090	-33.23	21.07
Pre-harvest	1		1		1		1		1	
Adjusted R^2	0.227		0.312		0.327		0.296		0.290	

Notes: Standard errors are shown in parentheses. * p<0.1; ** p<0.05; *** p<0.01. Differences were significant at the 1% and 5% levels. MAHFP: Monthly Adequate Household Food Provisioning; ha = hectare; km = kilometer; ref = reference. Pooled across pre- and post-harvest seasons; N=427 observations from 250 children

The marginal effects from multivariable regression models examining the relationship between household production diversity (measured as the number of food groups produced, ranging from 1 to 5) and women's predicted nutrient intakes and Women's Dietary Diversity Score (WDDS) are presented in Figure 5.12**.** Overall, the models reveal a positive association between production diversity and both dietary diversity and nutrient intakes, with increasing diversity corresponding to higher predicted values across all outcomes. The predicted values are shown with 95% confidence intervals, indicating generally narrow intervals and consistent trends, though the regression slopes vary by outcome.

The analysis revealed a consistent and positive association between household production diversity and dietary outcomes. As the number of food groups produced increased from 1 to 5, predicted values for the Women's Dietary Diversity Score (WDDS) rose steadily, indicating that greater agricultural diversity is associated with more varied diets among women (Figure 6.12a). Nutrient intake followed similar trends across all measured indicators. Predicted vitamin A intake increased markedly with production diversity, rising from approximately 500 µg RAE/day to over 1000 µg RAE/day. Calcium intake also showed a strong upward trajectory, nearly doubling from around 450 mg/day to 900 mg/day. Iron and zinc intakes increased more modestly, with iron rising from 44 to 66 mg/day and zinc from 8.5 to 12 mg/day. Energy intake demonstrated a clear positive gradient, increasing from roughly 1550 kcal/day to 1800 kcal/day as production diversity expanded. These findings highlight the nutritional benefits of diversified food production, indicating that households cultivating a wider range of food groups are better equipped to meet their dietary requirements and enhance overall nutrient adequacy.

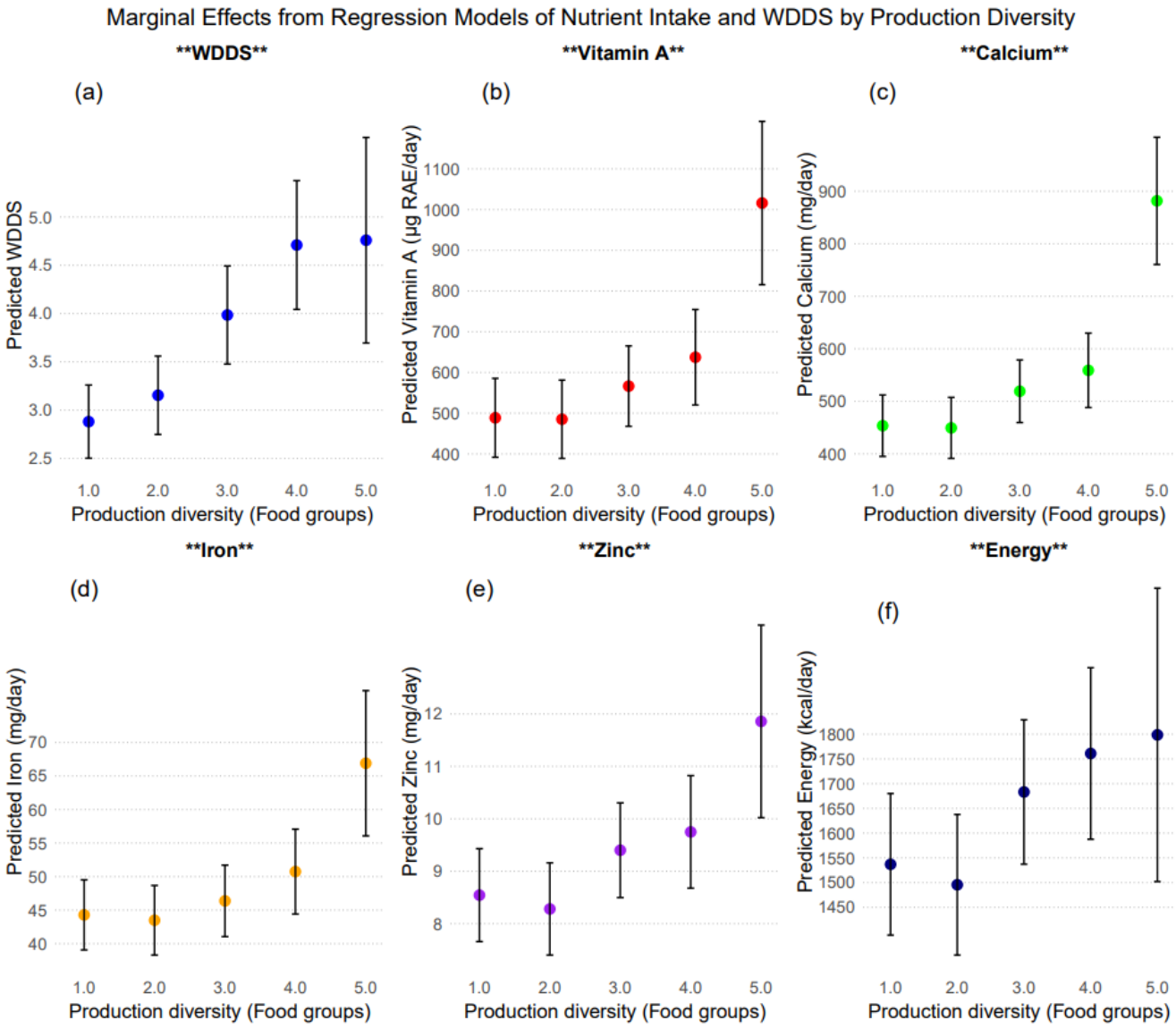


Figure 5.12. Marginal effects from regression models of women's dietary diversity score (WDDS), energy, and micronutrient intake by production diversity.

The plot shows predicted values from regression models, illustrating the marginal effects of production diversity on women's dietary diversity score (WDDS) and nutrient intakes: vitamin A (µg RAE/day), calcium (mg/day), iron (mg/day), zinc (mg/day), and energy (kcal/day). The circles represent predicted outcomes with 95% CI. Pooled across pre- and post-harvest seasons; N=965 observations from 520 women.

The association between home production diversity and children's dietary diversity score (CDDS) and nutrient intakes is displayed in Figure 5.13. The marginal effects from the regression models confirm a strong positive association between household production diversity and children's dietary outcomes. As the number of food groups produced increased from one to five, the predicted

Child Dietary Diversity Score (CDDS) increased from approximately 3.0 to 4.5, indicating that children in more diverse agricultural households consume a wider variety of foods. Nutrient intake also improved in a manner consistent with production diversity. Predicted vitamin A intake increased from around 250 µg RAE/day to 450 µg RAE/day, while calcium intake rose from approximately 200 mg/day to over 310 mg/day. Iron intake increased gradually from 16.5 mg/day to 22 mg/day, and zinc intake rose from 3.5 mg/day to 4.2 mg/day. Energy intake followed a similar trend, increasing from roughly 700 kcal/day to 850 kcal/day. These findings reinforce the nutritional advantages of diversified household food production, highlighting its role in enhancing both dietary diversity and micronutrient adequacy among children.

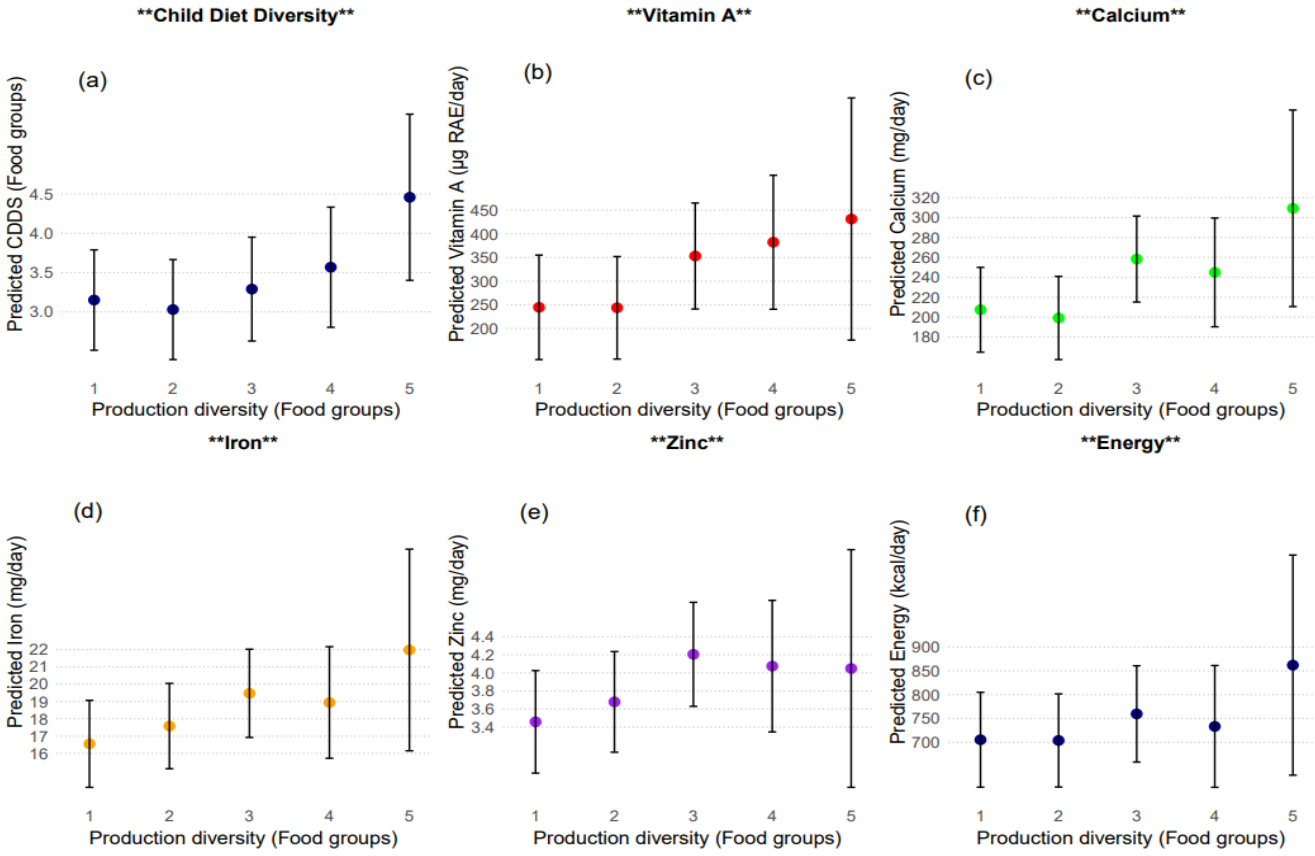


Figure 5.13. Marginal effects from regression models of children's dietary diversity score (CDDS), energy, and micronutrient intake by production diversity.

The plot shows predicted values from regression models, illustrating the marginal effects of production diversity on children's dietary diversity and nutrient intakes: vitamin A (µg RAE/day), calcium (mg/day), iron (mg/day), zinc (mg/day), and energy (kcal/day). The circles indicate predicted outcomes with 95% CI. Pooled across pre- and post-harvest seasons; N=427 observations from 250 children.

5.4. Discussion

This study examines how dietary diversity, nutrient intake, and nutritional adequacy among women and children in rural Ethiopia are affected by agricultural factors—especially production diversity and seasonality—as well as other aspects of the food environment. By comparing food-group consumption and nutrient intake with national and global dietary standards, this analysis highlights key nutritional gaps and underscores the influence of agricultural conditions on diet quality.

Dietary adequacy among children remains low, particularly during the lean season, with only 12% meeting the minimum dietary diversity (MDD) and 8% achieving the minimum acceptable diet (MAD), although the situation improves modestly post-harvest. Among women, MDD-W improved from 17% in the lean season to 25% after harvest. Grains, roots, and tubers persistently dominate the dietary pattern, and the alarmingly low consumption of animal-source foods (ASF)—namely, meat, fish, eggs, and dairy—remains a key barrier to achieving nutrient-rich diets (Dror and Allen, 2011). The low intake of ASFs and vitamin A-rich fruits and vegetables further highlights ongoing barriers to accessing diverse diets, especially among resource-limited households (Faber et al., 2016). These barriers are multifaceted, encompassing socioeconomic constraints, seasonal food insecurity, limited agricultural diversity, cultural food taboos, and inadequate nutrition education, all of which restrict the availability, affordability, and acceptability of diverse and nutrient-rich foods in low-income settings (Faber et al., 2016; Kaur, 2023).

Consumption of dairy and dairy products increased modestly during the post-harvest season (women: 24% to 28%; children: 21.8% to 26.2%). This seasonal pattern likely results from the greater availability of animal feed after harvest, as feed resources such as crop residues and grazing aftermath become more abundant, supporting higher milk yields during and after the rainy season (Gebreyohanes et al., 2021). Consequently, milk production typically increases during the post-harvest period, resulting in a greater supply of dairy products for household consumption (Bedada et al., 2021; Gebreyohanes et al., 2021). Despite minor seasonal variation, dairy and overall animal-source food (ASF) consumption remain critically low in Ethiopia, even though the country has one of the largest

livestock populations in Africa. Previous studies have shown seasonal variation in dairy consumption in Ethiopia, with intake increasing after harvest periods (Bedada et al., 2021; Headey, 2017). Despite seasonal constraints, studies also show that households often prioritize livestock for income or savings rather than consumption (Abegaz et al., 2018; Negassa and Jabbar, 2008).

Cultural and religious practices, particularly Ethiopian Orthodox Christian fasting—which spans 140 to over 200 days annually—significantly reduce ASF intake, with Orthodox households consuming up to 30% less ASF during fasting periods (Potts et al., 2019). Potts et al. (2019) found that only 24% of children aged 6–23 months consumed any ASF during Lent, despite 80% of households owning livestock. Caregivers often avoided feeding ASF to children to prevent contamination of utensils or community disapproval. This low intake of nutrient-dense foods limits access to essential micronutrients, such as iron and zinc, underscoring the urgent need for interventions such as biofortification, supplementation, and culturally sensitive behaviour change strategies.

Seasonality emerged as an important determinant of dietary diversity and nutrient intakes in both women and children. Compared with the pre-harvest (lean) season, the post-harvest period was consistently associated with higher consumption of several food groups, greater achievement of minimum dietary diversity (MDD-W for women; MDD and MAD for children), and modestly higher intakes of calcium, iron, zinc, and vitamin A. These seasonal trends mirror the cyclical nature of food availability and household purchasing power, both of which typically peak post-harvest and decline during lean periods (Abay and Hirvonen, 2017; Hirvonen et al., 2016). The observed increases in consumption of grains, pulses, and vegetables after harvest indicate improved access to home-grown and market foods (Workicho et al., 2016). However, the persistent inadequacy, even in the post-harvest season, underscores the need for year-round strategies to stabilize food access and improve dietary quality. Seasonal food insecurity remains a significant challenge in rural Ethiopia, and interventions must be tailored to address these temporal fluctuations (Headey et al., 2019; Jones et al., 2014b; Maxwell et al., 2014). The observed seasonal variations in dietary outcomes are consistent

with evidence from sub-Saharan Africa, where agriculture plays a central role in shaping livelihoods (Abay and Hirvonen, 2017; Bai et al., 2020).

Although intakes of energy, calcium, vitamin A, iron, and zinc improved significantly post-harvest, they still failed to meet the reference values set by the Ethiopian Food-Based Dietary Guidelines (FBDG) (EPHI, 2022) and FAO/WHO micronutrient requirements (Joint FAO/WHO Expert Consultation, 2004). Calcium intake in Ethiopia remains critically low, with only 17.8% of women and 27.0% of children meeting adequacy requirements. This widespread deficiency is consistent with reliance on cereal-based diets that typically lack sufficient dairy and other calcium-rich foods (GAIN and UNICEF, 2021). In contrast, iron adequacy showed notable differences between groups. A high proportion of children (92.5%) met iron requirements, whereas adequacy among women was lower but still moderate at 58.3%. Vitamin A intake, however, remained inadequate in both groups, with only 34.7% of women and 33.9% of children achieving adequacy. These patterns may reflect limited dietary diversity, low consumption of micronutrient-dense foods, and constraints on bioavailability in predominantly plant-based diets (Gibson et al., 2006).

The Mean Adequacy Ratio (MAR) was approximately 60% for both women (60.1%) and children (60.4%), indicating persistent inadequacy across multiple micronutrients. Despite some variation by nutrient, these findings underscore the need for comprehensive, nutrient-specific interventions to improve overall diet quality.

The pooled ordinary least squares (OLS) regression analyses reveal a strong positive association between farm production diversity and micronutrient intakes among women of reproductive age in rural Ethiopian households, with significant coefficients for energy (β=103.8, $p<0.001$), calcium (β=66.91, $p<0.001$), iron (β=3.75, $p<0.001$), zinc (β=0.694, $p<0.001$), and vitamin A (β=101.39, $p<0.001$). These results are consistent with evidence that diversified agricultural production improves household dietary quality, particularly in subsistence-oriented settings where market access is constrained (Sibhatu et al., 2015). Greater crop and livestock variety likely facilitates access to nutrient-dense foods, thereby enhancing intakes of key micronutrients such as iron and zinc,

which are vital for preventing anemia and bolstering immune health among women (Moges et al., 2021).

For children, the associations are more varied, with production diversity positively linked to intakes of calcium ($\beta = 21.99$, $p < 0.001$), iron ($\beta = 1.053$, $p < 0.01$), zinc ($\beta = 0.229$, $p < 0.01$), and vitamin A ($\beta = 63.44$, $p < 0.001$). This indicates that diversified production supports micronutrient adequacy—potentially mitigating stunting and undernutrition when complemented by adequate complementary feeding practices (Dewey and Adu-Afarwuah, 2008). As women primarily prioritize children's needs in household intra-household food allocation, women's empowerment in agricultural decision-making further amplifies these effects, fostering production diversity and better nutritional outcomes for children (Argaw et al., 2021; Jemaneh and Shibeshi, 2023).

Cluster analysis of dominant cropping systems in rural Ethiopia reveals marked variation in women's micronutrient intake. Hierarchical clustering identified four main systems (Figure 6.7), with Cereal-Pulse-Tuber farming being the most prevalent (~46%), common in highland and mid-altitude zones. In contrast, mixed pastoral systems represent only ~3% of households. Other systems include Cereal-Pulse-Tuber (~40%) and Highland Perennial (~11%). These patterns reflect Ethiopia's agroecological diversity and its impact on dietary quality and access to micronutrients.

Nutrient intake by the dominant cropping system highlights systemic variations that underscore the importance of production diversity. Agropastoral systems display the highest calcium intakes, likely attributable to livestock rearing and dairy access, while cereal-pulse mixed and cereal-pulse-tuber systems excel in iron, owing to the nutrient profiles of grains such as teff, legumes, and tubers (Amede et al., 2004; Desalegn et al., 2024; Gebreyohanes et al., 2021). Vitamin A intake remains suboptimal across cropping systems (~400–450 μg RAE/day), falling below recommended levels for women and indicating limited access to vitamin A–rich fruits and vegetables. The Highland Perennial system shows comparatively better Vitamin A intake, likely due to the greater availability of perennial fruits rich in micronutrients, including Vitamin A. These findings are supported by studies showing that farming system diversity, particularly in highland perennial and mixed systems, is associated with

higher vitamin A intake than cereal-dominated systems (Amede et al., 2004; Moges et al., 2021). Cereal-pulse-tuber systems showed the lowest calcium and zinc intakes, indicating potential deficiencies in tuber-dominated diets.

Despite observed variation in micronutrient intake across cropping systems, significant adequacy gaps persist, indicating a widespread risk of deficiency regardless of agricultural pattern (Moges et al., 2021). The monotonous nature of cereal-based diets, limited access to animal-source foods, and soil micronutrient depletion all contribute to this nutritional gap (Abegaz et al., 2018; Ahmed Ali, 2020; Belay et al., 2022). These findings underscore the potential of nutrition-sensitive agriculture in low-resource contexts. Strategies such as intercropping and livestock diversification can effectively address micronutrient gaps among women and children (Sibhatu et al., 2015). Evidence suggests that nutrition-sensitive agricultural approaches—such as homestead food production, small-scale livestock programs, improved storage and food preservation techniques—should be integrated with behavior change communication to promote sustained consumption of nutrient-dense foods (Chikhungu and Madise, 2014; Olney et al., 2016). Additionally, biofortification of staple crops, such as maize and sweet potatoes (Bouis and Saltzman, 2017), dietary diversification using locally available foods (Koppmair et al., 2017; Lachat et al., 2018; Mekonnen et al., 2020; Wondafrash et al., 2016), and targeted supplementation for key micronutrients, including iron, vitamin A, and zinc, can further address critical nutrient deficiencies (Haider and Bhutta, 2017).

The results show that the size of cultivated and homestead land significantly increases energy and nutrient intake, as well as calcium and vitamin A intake. This suggests that land size enhances quantity and variety, possibly through increased yields of staple or nutrient-rich crops (Bakhtsiyarava and Grace, 2021). Irrigated land, however, shows no significant impact on women's nutrient intake, which contrasts with expectations of its role in diversifying diets (Ahmed, 2022). This may be due to limited irrigation infrastructure or a focus on staple crops rather than nutrient-rich crops, such as vegetables. For instance, maize is the most cultivated crop by irrigation in Ethiopia (Menber et al., 2024).

Socioeconomic and geographic differences were also observed in dietary outcomes. Energy, calcium, and vitamin A among women and children are higher in Oromia and SNNP, possibly driven by fertile lands and better market access in these regions (Hirvonen, 2019b). Conversely, Amhara's reliance on iron-rich teff boosts iron and zinc consumption, while SNNP and Sidama's starchy crop dominance limits nutrient diversity (Hirvonen, 2019a; Menber et al., 2024). These regional disparities align with prior studies demonstrating uneven dietary patterns across Ethiopia (Potts et al., 2019). In pastoralist regions like Somali, reliance on animal-source foods boosts specific nutrient intakes but restricts overall dietary diversity (Desalegn et al., 2024). These regional covariates highlight how agroecological and cultural factors interact with seasonal and production dynamics to influence nutrition. Moreover, the household head's education, a key socioeconomic covariate, modestly improves diet quality, with each additional year associated with higher energy, iron, and zinc intakes among children. This supports evidence that education enhances nutritional awareness and resource allocation, ultimately improving dietary outcomes (Alderman and Headey, 2017). These findings underscore the need for region-specific interventions that utilize socioeconomic and demographic covariates to maximize the benefits of diverse agricultural production and alleviate seasonal dietary constraints.

This research demonstrates that market accessibility and food prices significantly influence dietary diversity and nutrient intake among women and children in rural Ethiopia. Households relying on distant district markets, rather than local village markets, exhibited lower dietary quality, with negative associations observed for most nutrient intakes. Limited access to nearby markets was consistently associated with reduced nutrient intake. Additionally, increased distance to roads further constrained nutrient intake, particularly among women, highlighting the critical role of infrastructure in facilitating access to diverse and nutritious foods (Headey et al., 2019). These findings underscore the need for targeted investments in rural infrastructure—especially roads and transportation networks—to enhance market connectivity and support improved dietary outcomes (Nakamura et al., 2020).

This study employed two rounds of data collection to capture seasonal variability and assess nutrient intake across key agricultural periods. However, several limitations should be acknowledged. First, the use of Food Frequency Questionnaires (FFQs) may introduce recall bias and inaccuracies in portion-size estimation, despite efforts to minimize these biases through enumerator training and standardized protocols. Second, the models' modest explanatory power suggests that unmeasured influences, including dietary preferences, intra-household food allocation, and cultural practices, may also be important determinants of nutritional outcomes. Third, while the study captures seasonal contrasts, focusing on only two agricultural seasons may overlook intra-seasonal fluctuations in food availability and consumption. Future research should adopt longitudinal designs to better understand these dynamics and explore gender- and age-specific dietary patterns within households.

5.5. Conclusion

This study underscores the interplay between agricultural systems, market access, and nutritional outcomes in rural Ethiopia. Women's and children's diets remain nutritionally inadequate, with conditions worsening during the lean season, which is characterized by low dietary diversity and micronutrient intake. Increased farm-level production diversity was significantly associated with improved intake of key micronutrients across both groups, reinforcing the importance of diversified farming systems in addressing nutritional inadequacies. Moreover, variation in dominant cropping systems—such as agropastoral and highland perennial systems—was linked to higher intakes of calcium and vitamin A, while tuber-based systems showed consistent deficiencies, particularly in zinc. These findings underscore the need for nutrition-sensitive agricultural strategies that promote diverse crop combinations tailored to local agroecological conditions. In addition, improved market access and rural infrastructure, including road and irrigation systems, are crucial for enhancing the year-round availability and affordability of nutrient-rich foods. Ultimately, given the persistent gaps in micronutrient intake, complementary interventions such as food fortification, biofortification, and

targeted supplementation remain crucial to achieving significant improvements in dietary health among vulnerable populations.

5.6. Chapter summary

Building on the food environment analysis presented in Chapter 4, this chapter examined how farm production diversity and seasonal variation interact with broader food environment conditions to shape dietary quality and nutrient adequacy among women and children. By incorporating measures of nutrient intake and adequacy, the chapter extended the analysis beyond dietary diversity to assess the nutritional implications of agricultural production systems across seasons.

This chapter strengthens the thesis by showing that agricultural production diversity and seasonality are integral to the food environment in smallholder-dominated contexts, such as Ethiopia. The findings indicate that while diversified production can enhance dietary diversity and micronutrient intake, seasonal constraints and limited market integration often prevent the translation of production gains into consistent nutritional benefits. This chapter reinforces the thesis argument that food environment frameworks in low-income settings must explicitly incorporate production systems and seasonal dynamics to fully capture the determinants of diet quality and nutrient adequacy.

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Appendices

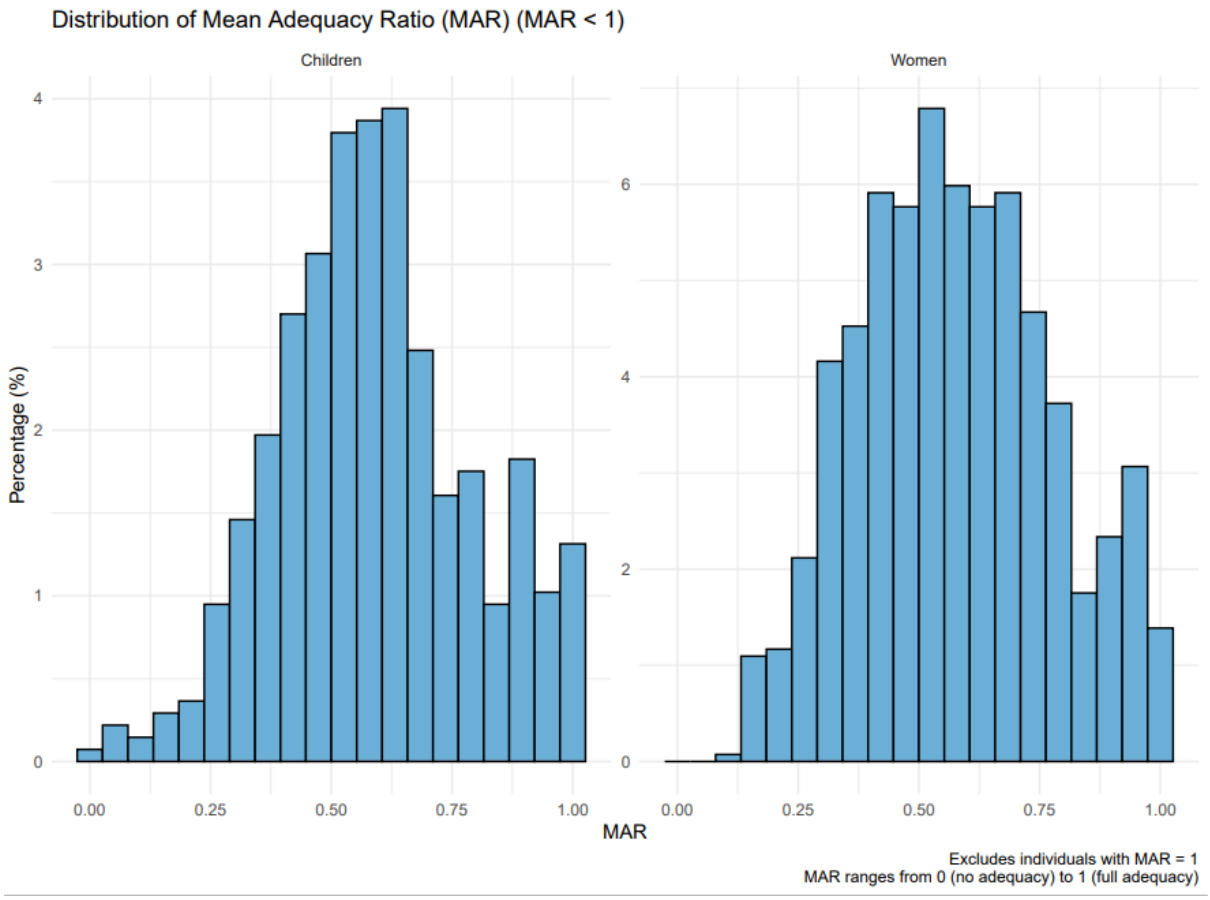


Figure A5.1. Distribution of mean adequacy ratio (MAR) among children and women (MAR < 1).

The histogram illustrates the percentage distribution of the Mean Adequacy Ratio (MAR) for children (left panel) and women (right panel), excluding individuals who achieved full nutrient adequacy (MAR = 1). The MAR represents the average nutrient adequacy ratio across key micronutrients, ranging from 0 (no adequacy) to 1 (full adequacy). Data are binned to show the prevalence of varying levels of nutrient inadequacy in the population, with percentages on the y-axis and MAR values on the x-axis. This figure provides supplementary insight into the spread of nutrient inadequacies observed in the study.

Table A5.1. Mean daily micronutrient intake by farm production diversity category among women of reproductive age and children 6–23 months, pre- and post-harvest seasons combined.

Group	Nutrient	Production diversity	n	Mean ± SD	p-value*
Children (6–23 months)					
	Calcium (mg/day)	≤3 food groups	418	236.5 ± 170.3	**0.001**
		≥4 food groups	63	323.0 ± 178.3	
	Iron (mg/day)	≤3 food groups	418	19.7 ± 10.2	**0.045**
		≥4 food groups	63	22.2 ± 9.1	
	Vitamin A (µg RAE/day)	≤3 food groups	418	318.5 ± 467.1	**0.011**

		≥4 food groups	63	484.5 ± 474.9	
	Zinc (mg/day)	≤3 food groups	418	4.0 ± 2.3	**0.006**
		≥4 food groups	63	4.8 ± 2.1	
Women (15–49 y)					
	Calcium (mg/day)	≤3 food groups	822	410.2 ± 261.6	**<0.001**
		≥4 food groups	143	637.3 ± 410.9	
	Iron (mg/day)	≤3 food groups	822	47.4 ± 25.0	**<0.001**
		≥4 food groups	143	62.2 ± 32.9	
	Vitamin A (µg RAE/day)	≤3 food groups	822	385.2 ± 449.7	**<0.001**
		≥4 food groups	143	721.2 ± 722.6	
	Zinc (mg/day)	≤3 food groups	822	8.2 ± 4.2	**<0.001**
		≥4 food groups	143	11.1 ± 5.5	

Note: The Wilcoxon rank-sum test was used. Bold p-values indicate statistical significance at $p < 0.05$.

6. Chapter Six: Perceived Influence of the Food Environment on Food Access - Insights from Qualitative Research

This Chapter presents the third set of findings from this thesis and provides an in-depth exploration of how communities perceive and navigate their local food environments in rural and peri-urban Ethiopia. Drawing on focus group discussions and key informant interviews, the study examines how agricultural production, market access, cultural norms, and institutional factors shape food access and dietary choices.

By foregrounding community and stakeholder perspectives, this chapter complements the quantitative analyses in earlier chapters by explaining why improvements in availability, access, or production do not always translate into better dietary outcomes. The qualitative insights presented here help contextualize observed dietary patterns and affordability constraints, offering a participant-centered perspective that informs the interpretation of results throughout the thesis.

Abstract

This qualitative study examines how local food environments affect dietary quality in rural and peri-urban communities in Ethiopia's Oromia and Sidama regions.

Through a reflexive thematic analysis of six focus group discussions (FGDs) with participants from six woredas and four key informant interviews (KIIs) in two woredas, the study explores perceived connections among agricultural production, market access, and the consumption of nutrient-rich foods.

Although focus group participants generally acknowledge the nutritional benefits of diverse diets, the consumption of fruits, vegetables, and animal-source foods (ASFs) remains low. This gap is caused by several overlapping constraints, including economic barriers, seasonal shortages, small landholdings, water scarcity, high input costs, and significant post-harvest losses of perishable items, especially fruits and vegetables. The findings show that cereal-focused production aligns more with

market incentives and food security goals than with nutritional aims. Cultural practices, especially religious fasting, and a focus on animal products for income further limit ASF consumption.

Several interconnected themes emerged from the findings: food access pathways, perceived availability, seasonality, affordability barriers, production and storage challenges, decision-making dynamics, and coping strategies during scarcity. Small landholdings and water scarcity emerged as the most frequently cited agricultural constraints, further limiting production diversity. Key informants emphasized the need for multisectoral coordination, especially between the agriculture and health sectors. They also highlighted gaps in the government bodies overseeing nutrition issues—the Nutrition Technical Committees—and called for leadership commitment, joint planning, and nutrition-sensitive policies.

The study highlights that dietary inadequacy mainly results from structural and economic barriers in the food environment rather than from knowledge gaps. Participants suggested practical solutions, such as improving irrigation systems, subsidizing inputs for vegetable farming, stabilizing markets, and encouraging women-led home gardens.

By incorporating community voices with policy insights, this work provides context for the quantitative dietary deficiencies reported in earlier thesis chapters, offering a participant-centred narrative to support evidence-based interventions. Achieving year-round access to diverse, affordable foods requires transforming both the supply side (production and infrastructure) and demand side (income and preferences) components of the food environment. Future efforts should emphasize scalable, locally relevant strategies—such as cooperative irrigation schemes and fortified safety nets—to create sustainable improvements in diet quality and nutritional outcomes in Ethiopia's smallholder-dominated landscapes.

6.1. Introduction

The food environment, defined as the physical, economic, political, and socio-cultural contexts where consumers engage with the food system to make decisions about acquiring, preparing, and eating food, has become a crucial factor influencing dietary quality and nutritional outcomes worldwide (Turner et al., 2018). In low- and middle-income countries (LMICs) like Ethiopia, where over 80% of the population depends on agriculture for food and income, the structure and function of local food environments strongly influence household access to diverse, nutrient-rich diets (FAO et al., 2025; HLPE, 2017).

Despite significant investments in agricultural development and strong ambition to alleviate food insecurity, Ethiopia still faces high rates of stunting (39%), micronutrient deficiencies, and limited dietary diversity, especially among rural and low-income communities (EPHI, 2023). Quantitative research consistently reports inadequate consumption of fruits, vegetables, pulses, and animal-source foods (ASFs), but often fails to explain the underlying mechanisms, such as perceived trade-offs between income and nutrition, and socioeconomic or cultural determinants of food choice, that shape these patterns (Chea and Groen, 2023; Neve et al., 2021). This qualitative chapter helps to fill this gap by examining how community members in the peri-urban and rural areas of the Oromia and SNNP regions perceive and navigate their food environments, providing contextual insights alongside findings from previous quantitative studies.

Ethiopia's agrarian economy is centred on smallholder-dominated systems, in which average farm sizes have shrunk to 1 hectare due to population pressure and land fragmentation (Rapsomanikis, 2015). While cereal crops mainly drive production—fuelled by food security needs and market incentives—nutrient-rich crops like vegetables and legumes remain marginal, contributing little to both farm output and household diets (Deribe and Mintesinot, 2016). Meanwhile, rapid urbanization, climate variability, and unstable input and output markets have altered food availability and affordability (Minten et al., 2020). These changes have led to complex food environments where households must balance immediate caloric needs with long-term nutritional goals, often under

severe resource constraints. Although national surveys provide solid data on dietary deficiencies, they offer limited insight into individuals' experiences, perceptions, and adaptive strategies within these systems (Downs et al., 2020). Understanding these subjective factors is essential for designing interventions that are both technically feasible and socially acceptable, encouraging lasting behavioral change.

Using Braun and Clarke's (2006) reflexive thematic analysis framework, the study systematically finds patterns in how participants describe challenges within their overall food environment, including perceived access (both physical and economic), agricultural production, food access routes, barriers to consumption, and decision-making processes. The analysis is guided by three interconnected research questions: First, how do community members perceive the links among elements of the food environment, such as local agricultural production, food availability, and dietary diversity? Second, what structural, economic, and socio-cultural factors limit access to and consumption of fruits, vegetables, and animal-source foods (ASFs)? Third, how do households prioritize their food choices during different seasons and times of scarcity, and what coping strategies do they use to reduce food insecurity? These questions aim to investigate the perceived relationship between supply-side factors (production and markets) and demand-side factors (preference and affordability).

The primary goal of this qualitative study is to analyze and explain participants' lived experiences to contextualize and interpret the empirical relationships identified in earlier chapters. Specifically, the study aims to identify and examine key challenges in the food environment and their influence on dietary choices; to explore perceptions of the availability, affordability, health benefits, and cultural acceptability of nutritious foods; and to elucidate community-informed strategies for strengthening linkages across different components of the food environment through which households access food.

6.2. Methods

6.2.1. Study design and setting

The qualitative study was conducted during the second round of the household survey, which took place from March to April 2023. Due to resource constraints, only two regions were purposively selected from among the household survey sampling regions. Within these regions, woredas and FGD kebeles were also purposively chosen to capture variation in agroecological zones, settlement characteristics, and farming systems.

Agroecological zones and farming systems are vital in determining food availability and dietary diversity (Moges et al., 2021). Highland regions (*Dega*, 2300–3200 m) with mixed crop-livestock systems primarily focus on barley and wheat production, while mid-altitude zones (*Woina Dega*, 1500–2300 m) support a variety of crops, including cereals, pulses, coffee, and ense*t*. Lowland areas (*Kolla*, 500–1500 m) often depend on small-scale irrigated horticulture and livestock due to limited rainfall. These differences affect the types of foods produced and consumed locally, as well as market reliance, impacting household access to fruits, vegetables, and animal-source foods. Recognizing these regional differences in food environments is crucial for designing nutrition-sensitive agricultural programs and analyzing dietary patterns in the study.

This study was conducted in five woredas in the Oromia regional state and one woreda in the Sidama regional state in central Ethiopia. Table 6.1 presents the distribution of focus group participants across the study locations. In total, 66 participants took part in six focus group discussions held in six woredas. These include Wondo Genet in the Sidama region and Bacho, Gelan Dugda, Jimma town, Sabata Hawas, and Arsi Hitosa in the Oromia region. In addition, four key informants from Meta and Adama woredas in the Oromia region were interviewed to provide expert insights on policy and institutional perspectives. Figure 6.1 shows geographic locations of qualitative data collection within the household survey frame.

Table 6.1. FGD and KII participant distribution

Type	Region	Woreda	agroecology	Settlement	Farming system	N
FGD	Oromia	Bacho	Mid-altitude (Woina Dega)	Rural	Mixed crop-livestock (cereals, pulses)	11
	Oromia	Gelan Dugda	Highland (Dega)	Peri-urban	Mixed crop-livestock (cereals, pulses)	11
	Oromia	Hitosa	Highland (Dega)	Rural	Mixed crop-livestock (barley, wheat, livestock)	9
	Oromia	Jimma town	Mid-altitude (Woina Dega)	Peri-urban	Peri-urban horticulture, coffee, and livestock	12
	Oromia	Sabata Hawas	Highland (Dega)	Rural	Mixed crop-livestock (barley, wheat, livestock, dairy)	11
	Sidama	Wondo Genet	Mid-altitude (Woina Dega)	Rural	Enset-coffee-based mixed farming	12
KII	Oromia	East Shewa	Lowland (Kolla)	Peri-urban	Irrigated horticulture, livestock	2
	Oromia	West Hararghe	Highland (Dega)	Rural	Mixed crop-livestock (barley, wheat)	2

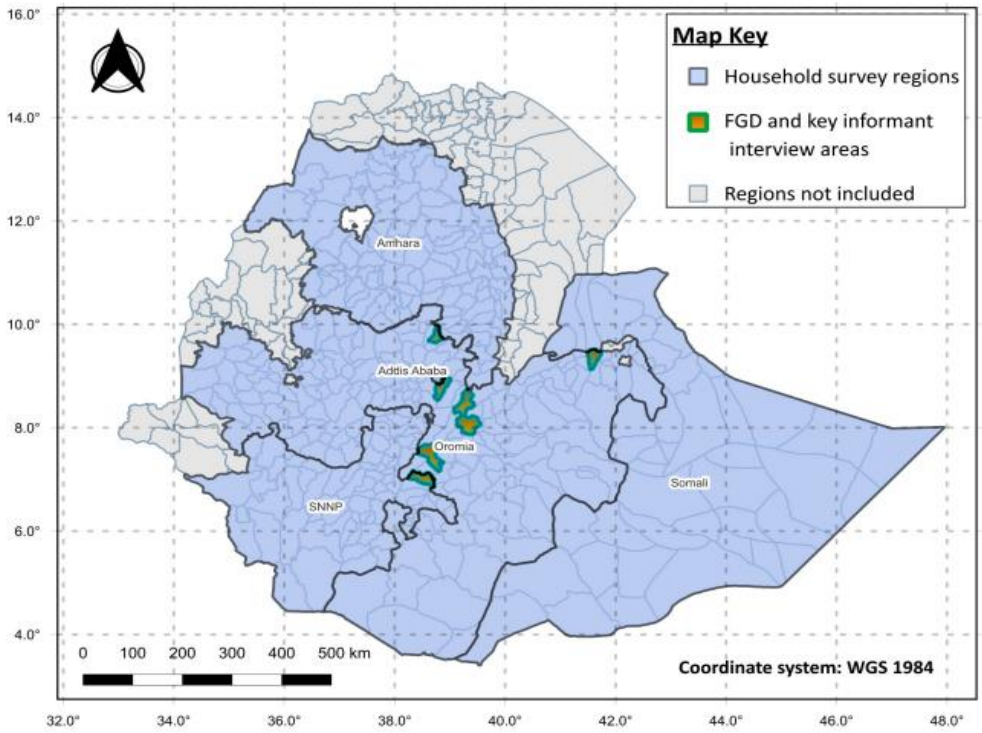


Figure 6.1. Focus groups and key informant interviews.

6.2.2. Participants and sampling

A purposive sampling approach was used to select participants who, based on their roles and community residence, were expected to provide relevant perspectives on food access, dietary practices, and nutrition governance (Patton, 2002). Focus group discussions (FGDs) were held at the kebele level in kebeles where the household survey had previously been conducted, thereby aligning the quantitative and qualitative components while keeping the samples independent.

Eligibility criteria for FGD participation included: (i) residing in the kebele for at least five years to ensure familiarity with local food systems, seasonal patterns, and community dynamics; (ii) willingness and availability to participate in group discussions consisting of 8–12 participants; and (iii) not participating in the household survey. Excluding household survey respondents minimized respondent burden and response bias, ensuring that qualitative findings reflected independent community perspectives rather than being influenced by prior exposure to structured survey instruments. Participants included women and household heads, who represent key caregivers and decision-makers for household food access and dietary practices.

FGD participants were recruited using community-based methods. Information sheets were distributed, and brief meetings were held with local leaders, who were asked to help mobilize eligible community members. This method encouraged inclusive participation while respecting local administrative structures.

Key informant interview (KII) participants were purposively selected from the health and agriculture sectors at the woreda level. Informants were chosen based on their professional roles, direct involvement in nutrition-related programming, and familiarity with the National Nutrition Programme (NNP) and multisectoral collaboration mechanisms. These included sector officials, nutrition focal persons, and frontline implementers responsible for planning, coordinating, and delivering nutrition-sensitive interventions.



FGD at Hitosa, Arsi, Oromia ©Andinet_Abera

6.2.3. Data collection

Data were collected using a qualitative approach that combined focus group discussions (FGDs) at the kebele level and key informant interviews (KIIs) at the zonal level. This approach provided insights into policy implementation and community experiences regarding food access, dietary practices, and nutrition.

All FGDs and KIIs were conducted using semi-structured interview guides. Data were collected via smartphone audio recordings, supplemented by detailed field notes taken during each session to capture nonverbal cues and contextual information.

The FGDs examined community members' experiences and perceptions regarding household food sources (own production and market purchases), seasonal changes in food availability, factors influencing food choices, dietary diversity, access to fruits, vegetables, and animal-source foods, coping strategies during food shortages, and the perceived impact of food access on women's and children's health and wellbeing (Table A6.2, Appendix).

The KIIs were conducted with health and agriculture sector officials to assess the functioning of multisectoral coordination mechanisms for nutrition at lower levels of implementation. Key

informants were asked about the rationale for nutrition programmes, their understanding and implementation of different nutrition initiatives and multisectoral collaboration guidelines, the extent of collaboration between sectors, mainly health and agriculture sectors, and how sectoral activities address community-level challenges identified in the FGDs, such as low diet diversity, market barriers, and seasonal food insecurity (Table A6.3, Appendix).

Participants were also asked to identify barriers and facilitators to effective intersectoral collaboration, as well as emerging opportunities to strengthen integrated nutrition services, especially those aimed at improving complementary feeding practices, diet diversity, and access to nutrient-rich foods for women and children. These tools were developed using the Household Economy Approach (Holzmann and Boudreau, 2000) to address the study's research questions and offer contextual insights for the quantitative findings.

6.2.4. Analytical approach

A thematic analysis approach was applied following the framework of Virginia Braun and Victoria Clarke (2006). Audio recordings from FGDs and KIIs were transcribed verbatim and reviewed multiple times to ensure familiarity with the data. Transcripts were then imported into NVivo 14 for coding and analysis.

Initial codes were generated inductively by identifying text segments relevant to the study objectives, including food access, dietary practices, market barriers, and seasonal food insecurity. These codes were iteratively refined and grouped into broader themes reflecting key dimensions of the food environment and nutrition-related behaviours.

Themes were reviewed and refined through repeated comparison with the original data to ensure consistency and relevance. Final themes were defined and organised to align with the study's research questions, and illustrative quotes from participants were used to support the findings.

To enhance transparency, the frequency of coded references was summarised descriptively to indicate the relative prominence of themes across FGDs and KIIs. These counts were used only to support interpretation and do not represent statistical significance.

Ethical approval for the qualitative study was obtained from the Ethiopian Public Health Institute and subsequently from University College Cork (UCC). Written informed consent, including permission for audio recording, was obtained from all participants prior to data collection.

6.3. Results

6.3.1. Participant demographic characteristics

Tables 6.2 and 6.3 present the sociodemographic characteristics of FGD participants and key informants, respectively. The average age of FGD participants was 35.3 years, with ages ranging from 19 to 75. Most participants were female (73%), while males made up about one-third of participants. The sampling design underscores the study's focus on women's perspectives, as they are often the primary caregivers and central to household food choices.

Participants reported an average family size of 4.7 members, with household sizes ranging from 1 to 10 people. This variation highlights the diversity of household structures and potential differences in food needs and resource allocation.

Most participants were from rural areas (65.2%), while 34.8% lived in peri-urban areas. This rural-urban divide was intentional to examine how residential status influences food access, dietary habits, and livelihood strategies.

Employment status varied among participants. Most were employed, while some individuals reported being unemployed. Farming was the main occupation (44%) among FGD participants, reflecting the agrarian nature of the study regions. Other occupations included government workers, daily laborers, traders, retirees, and local beverage sellers (such as small coffee and tea shops). The demographic profile shown in Table 6.2 provides essential context for interpreting the FGD qualitative findings.

Table 6.2. Demographic characteristics of FGD participants

Characteristic	N (%) or Mean (SD)
Total participants	66
Age, years — Mean (SD)	35.3 (13.1)
Range	19–75
Sex — M (Male/Female)	18 (27.3%)
Sex — F (Male/Female)	48 (72.7%)
Family size — Mean (SD)	4.7 (1.8)
Range	1–10
Residence — Rural	43 (65.2%)
Residence — Urban	23 (34.8%)
Region — Oromia	54 (81.8%)
Region — Sidama	12 (18.2%)
Employment	
Farmer	29 (43.9%)
Government employee	5 (7.6)
Daily Laborer	4 (6.1%)
Merchant	4 (6.0%)
Local beverage making	3 (4.5%)
Retired	2 (3.0%)
Unemployed	19 (28.8%)

Table 6.3. Key informant information

Type	Zone	Sector	N
Key informant interviews	East Shewa	Zone health office head	1
		Zone agriculture office head	1
	West Hararghe	Zone health office head	1
		Zone agriculture office head	1

6.3.2. Thematic findings from focus group discussions

Analysis of the focus group discussions in NVivo identified seven interconnected thematic areas, presented below by the number of coded references for each theme (see Table A6.1 in the Appendix). This order reflects the relative prominence of themes in participants' discussions. Together, these themes capture participants' experiences and perceptions of household and community food environments, illustrating how food is produced, accessed, and consumed, as well as the structural, economic, and sociocultural factors that shape dietary practices. The thematic relationships are illustrated in Figure 6.2.

Theme 1: Agricultural production and food availability

Agricultural production and its influence on food availability were the most frequently discussed themes in the FGDs. Participants described multiple challenges affecting local farming systems, including small landholdings, water scarcity, high input costs, pests, and climate-related shocks. Crop selection was strongly influenced by market demand, productivity considerations, and tradition, often resulting in cereal-dominated systems with limited diversification. Participants also highlighted gaps in access to agricultural extension services, improved technologies, irrigation, and market linkages, all of which constrained production potential and household food availability.

Theme 2: Access to and consumption of fruits and vegetables

Access to and consumption of fruits and vegetables were among the key themes, reflecting both nutritional awareness and structural barriers. Participants consistently reported that fruits and vegetables were available mainly seasonally, limiting regular consumption. High prices were identified as the most significant constraint, particularly for low-income households, along with transportation and infrastructure challenges. Despite these barriers, participants widely recognized the health benefits of fruits and vegetables, underscoring a gap between nutritional knowledge and actual access.

Theme 3: Animal-source food (ASF) consumption

Discussions of ASF consumption—including meat, dairy, and eggs—highlighted economic, cultural, religious practices and seasonal constraints. Cost was the primary barrier, with many households reporting that they sold animal products for income rather than consuming them. Cultural and religious practices, particularly fasting periods, further influenced ASF intake. Nevertheless, ASF was consistently valued for its nutritional importance, underscoring the trade-off among livelihood strategies, cultural norms, and diet quality.

Theme 4: Food insecurity and coping mechanisms

Food insecurity and related coping strategies reflected participants' lived experiences of food shortages and uncertainty, particularly during lean seasons. Participants described persistent

concerns about insufficient food and reported coping strategies, including reducing portion sizes, skipping meals, substituting preferred foods, and relying on community support. Broader health, social, and psychological impacts, including stress, concerns about malnutrition, and social strain, were also frequently reported.

Theme 5: Food access and acquisition pathways

This theme captured how households obtain food daily. Participants described reliance on their own agricultural production, market purchases, or a combination of both, with food aid supplementing during periods of shortage in some areas. Seasonal variation strongly shaped these pathways, prompting shifts between self-sufficiency and market dependence, depending on harvest cycles and income availability. These patterns highlight the interdependence of production systems and market access in determining household food availability.

Theme 6: Community-level food environment and infrastructure

Perceptions of the community food environment were closely tied to food access experiences. Participants reported barriers such as long distances to markets, limited transportation options, price volatility, and limited retail diversity. Although some participants were aware of what constitutes a healthy diet, they emphasized that local food environments often did not support these choices because of affordability and supply constraints.

Theme 7: Food choice and decision-making

Food choices and decisions were primarily influenced by price and affordability, which often outweighed nutritional considerations. Women were widely identified as the primary decision-makers for household food preparation and selection. Participants also noted seasonal shifts in dietary patterns, reflecting changes in food availability, income, and labor demands.

These identified themes illustrate the complex and interconnected nature of household and community food environments, shaped by agricultural production, market conditions, socioeconomic constraints, and cultural practices (Figure 6.2). The following sections present detailed findings of the key thematic areas, drawing on participants' narratives to further elucidate these dynamics.

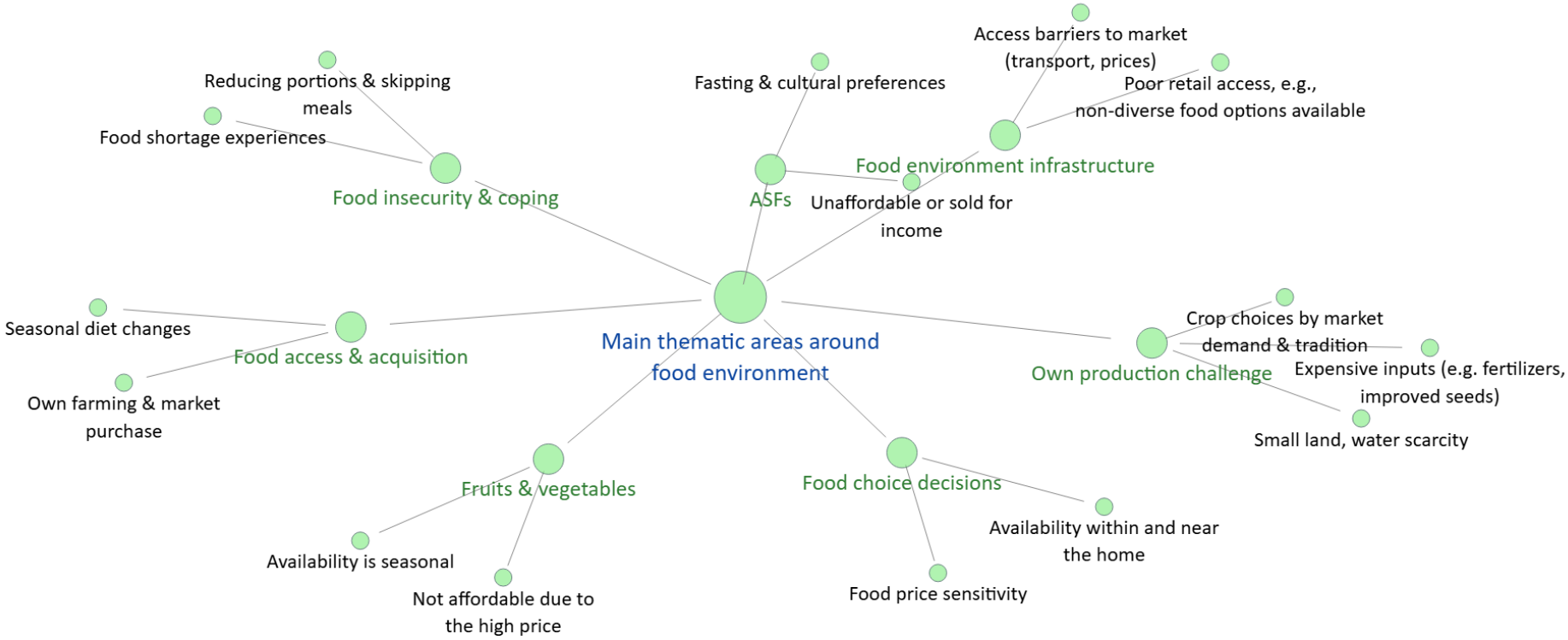


Figure 6.2. Thematic map of focus group discussions, their perceptions of the food environment's influence on diet and food access.

6.3.2.1. Agricultural challenges reported by focus groups

Through FGDs, various structural, environmental, and economic barriers that hinder agricultural productivity and livelihoods have been identified. Thematic analysis of participant narratives revealed six main challenges, ranked by their relative prominence (i.e., the number of references across all discussion groups), as summarized in Figure 6.3. These structural barriers were worsened by market instability, limited extension support, and occasional crop losses, collectively weakening smallholder resilience.

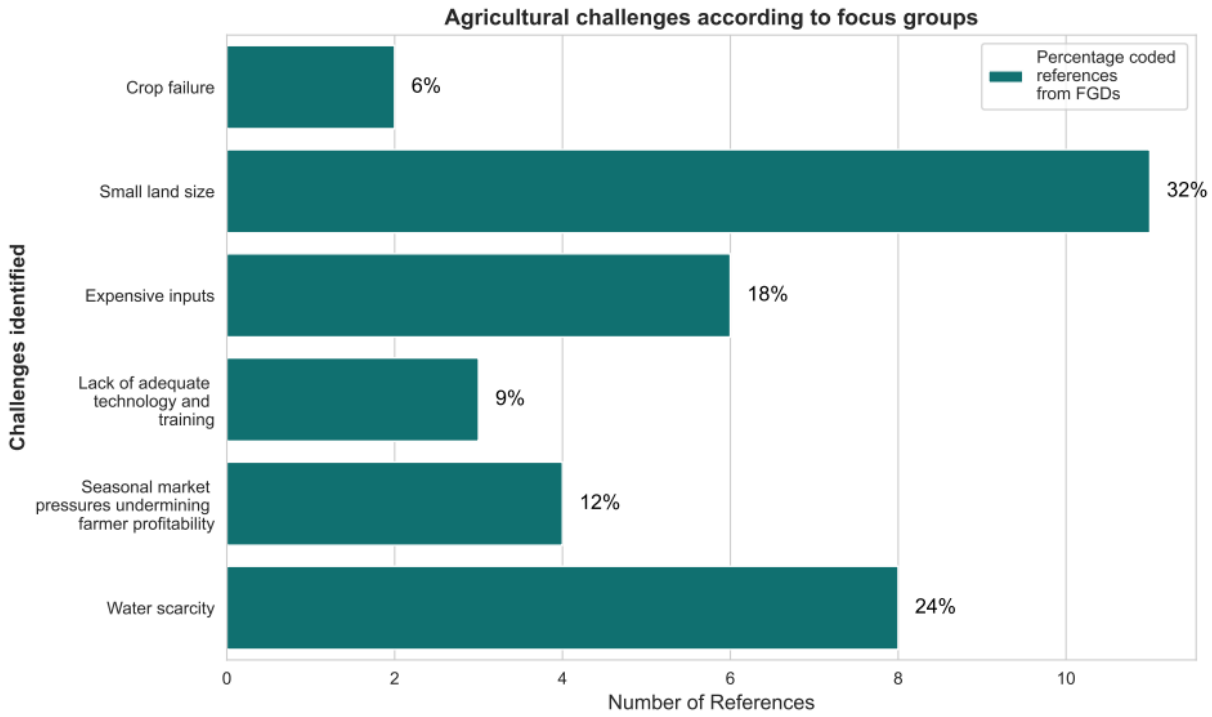


Figure 6.3. Relative frequency of agricultural challenges raised during focus group discussions, highlighting the most prominent issues.

Small land size emerged as the most common challenge to producing a diverse range of foods at the household level across all focus groups. Participants, especially in densely populated rural kebeles such as Aroma (Sidama) and Hadha Bossoo (West Arsi), repeatedly expressed frustration over fragmented and limited farmland, which restricted crop diversification, mechanization, and income potential. Many described inheriting plots too small to support growing families, with one farmer stating:

"I divide the land among my sons—each got less than before. How can I feed ten people from half a hectare?" (Participant from Aroma Kebele, Wondo Genet Woreda, Sidama Region)

Water scarcity was also repeatedly emphasized as a major obstacle. This issue was prevalent in rain-fed farming systems, where unpredictable rainfall and extended dry periods disrupted planting and caused unstable yields. Groups in the Bacho and Hitosa woredas noted the lack of irrigation infrastructure and the reliance on seasonal rivers, which heighten vulnerability during droughts.

"Despite our proximity to the capital city, we face a severe water shortage — not just for irrigation or home gardening, but even for drinking. Ironically, the very water source that supplies the capital flows just beneath our feet, with water pipes running next to our homes, yet we have no access to this vital resource. This situation is not only problematic but also disheartening, as we feel neglected and powerless while the water flows nearby, a stark reminder of our unmet needs." (Male farmer, 51 years old, Girar Barak Kebele, Barak Woreda, Oromia Region)

The high cost of agricultural inputs—including fertilizers, improved seeds, and pesticides—was among the most frequently cited challenges related to own production. Input prices were reported to have risen sharply in recent years, often outpacing gains in crop sales. This created a vicious cycle for smallholder farmers: reduced input use led to lower yields, which in turn diminished their purchasing power. Urban-adjacent participants in Gelan Dugda and Jimma town also reported limited access to subsidized inputs, despite being close to markets.

"Access to fertilizer is the main challenge for farmers; small landholdings are also a problem. Additionally, farmers face significant difficulties in accessing improved crop varieties." (36 years old, local NGO worker, Gelan Dugda, Oromia)

Figure 6.4 further confirms key farming input challenges discussed by FGD participants, with land (mainly small or fragmented holdings), water (scarcity and irrigation issues), and fertilizers (high costs and access barriers) being the most prominent concerns. Surrounding themes emphasize

interconnected problems, including volatile markets and low profits, yield limitations (production), farmers' livelihood struggles, and systemic barriers. Words like shortage, expensive, capital, and harvest underscore resource limitations, input inaccessibility, and seasonal risks. This thematic focus aligns closely with quantitative findings in Chapter 5, which show that small land size, limited irrigation infrastructure, and high fertilizer costs were the most frequently mentioned issues, reflecting smallholder farmers' core vulnerabilities.



Figure 6.4. Word cloud of key own production challenges reported in six focus group discussions (Generated by Nvivo)

According to most groups, seasonal market fluctuations and low farm-gate prices reduced profitability. Participants noted a pattern of oversupply during harvest times, which lowered prices for staple and cash crops such as teff, maize, wheat, and coffee. Middlemen were often criticized for exploiting this timing, leaving farmers with little profit despite high production costs.

Lack of access to modern technology and agricultural training was mentioned several times among the group discussions. Although some participants knew about improved practices—such as row planting, compost use, or pest-resistant varieties—most said they had never received extension support. Participants doubted new methods without demonstrations and criticized the government's extension workers for failing to meet their responsibilities.

"We've heard that compost can be made in many ways, but some methods require chemical fertilizers, which we don't have access to. The agricultural agents in our kebele are not supporting us. The government pays their salaries, but they are doing nothing to help us."

(Participant from Girar Barak Kebele, Barak Woreda, Oromia Region)

Additionally, crop failures caused by pests, diseases, and weather extremes were identified as a problem. Although less frequent, these events were described as devastating when they occurred, often destroying entire seasons' worth of farmers' investments. Participants linked increasing pest pressure to climate variability and counterfeit agrochemicals.

6.3.2.2. Perceived food availability and barriers to consumption of nutritious foods

Across all focus group discussions, participants reported that although fruits and vegetables are usually available in local markets, their consumption remains limited due to several interconnected barriers. For households that rely on market purchases, the high cost of these foods is the main obstacle, making them unaffordable for many families.

In rural areas, where most households rely on their own agricultural production, access to resources is further limited by small landholdings and a focus on staple crops like cereals. When asked about the potential to grow vegetables after harvesting staple crops, participants noted that a lack of irrigation infrastructure and frequent water shortages pose significant obstacles. As a result, nearly all their land is used for cereal farming, mainly during the rainy season, which limits opportunities to diversify year-round diets. During the dry months, households often buy fruits and vegetables from markets, when prices tend to be high, and affordability is low.

"Fruits and vegetables are available in the market, but as others have noted, they are costly and only affordable seasonally. We do not have enough land to grow them. We plant teff and wheat on the small piece of land we have." (Male farmer, 47 years old, Gelan Dugda, Oromia)

In addition to these structural challenges, participants also highlighted behavioral and perceptual factors that affect food choices. Fruits and vegetables—especially fruits—were often seen

as non-essential or luxury foods, considered less important than staple, energy-rich options like cereals and pulses. Many participants said they prioritize foods that fill them up over those perceived as nutritious but expensive. These views further contribute to economic barriers, as fruits and vegetables are frequently given lower priority in daily dietary choices.

Participants also noted that vegetables are generally more available than fruits, which were often described as scarce and expensive, further limiting opportunities for regular consumption.

" Yes, we can get anything we want if we have enough money, especially vegetables. However, fruits are often scarce in the market. When they are available, they are mostly expensive." (Female participant, 41 years old, Sabata Hawas, Oromia)

Focus group discussions indicated that access to animal-source foods (ASFs), such as meat, eggs, milk, and fish, is primarily restricted by economic and structural barriers. Although these foods are often available in local markets, participants highlighted that the main issue isn't their availability but their affordability. Rising food prices and low household incomes are common challenges.

"We struggle to obtain enough nutritious foods because they are too expensive for us. We can't afford to buy meat, for example." (Female farmer, 30 years old, Girar Barak, Sebeta Hawas, Oromia)

Even households that raise livestock face similar difficulties, as they often sell their products to cover other essential needs. As one participant explained:

"People produce milk in our area, but many tend to sell milk because we need to buy other food items like staples and pulses for stew." (Female farmer, 37 years old, Hate Andode, Arsi Hitosa Woreda, Oromia)

Participants also emphasized that ASF consumption is seasonal, typically reserved for special occasions. "*We eat meat only during national holidays, cultural or religious feasting days",* noted one FGD participant, illustrating how affordability and cultural practices limit consumption.

This interplay between economic hardship, seasonal constraints, and behavioral perceptions was a recurring theme throughout discussions and supports the broader "Barriers to Consumption" theme outlined below.

6.3.2.3. Main barriers to the consumption of nutritious foods

Non-affordability

Economic hardship was reported as the primary barrier to increasing fruit and vegetable consumption. Almost every focus group emphasized that, although they understand the health benefits of these foods, low income and high prices prevent them from buying them regularly. Most groups rely on staple cereals to meet their basic energy needs because they are more affordable and filling.

"We know fruits and vegetables are good for our children, but we cannot afford them." (Female farmer, 25 years old, Hate Andode, Arsi Hitosa Woreda, Oromia)

Across all groups, participants highlighted that if their financial situation improved, they would eat more fruits, vegetables, and animal-source foods. This indicates that knowledge and willingness are present, but financial capacity remains the main obstacle.

Available seasonally

Participants also noted that seasonality influences both the availability and affordability of foods. Vegetables like lettuce are mainly seasonal, primarily thriving during the rainy months. During these periods, prices decrease, making them more accessible. However, during the dry season, availability declines sharply, and market prices rise, making these foods unaffordable for many households. Similarly, some fruits were described as available only at certain times, reflecting fluctuations in local production and market supply. This seasonal variation worsens the affordability issue and leads to inconsistent dietary diversity throughout the year.

"Fruits such as mangoes are seasonal, and we purchase them whenever they become available in the market. Similarly, vegetables such as lettuce are also seasonal, primarily flourishing during the rainy months. During their production season, the prices of these

vegetables are significantly lower, making them more affordable. However, outside this season, even when available, prices rise, putting them out of reach for many of us."

(A female tea shop operator, peri-urban Jimma town, Oromia)

Although seasonal fluctuations in food availability and prices primarily affect fruits and vegetables, consumption of animal-source foods (ASFs) in Ethiopian households is also highly irregular. This irregularity reflects both seasonal availability at the household level and limited affordability, which together constrain year-round access to ASFs.

"Since we cannot afford to buy meat, we only eat it during annual feasts (holidays)."

(Female, 32 years old, unemployed, SNNP)

Perceptions of importance for health

Despite barriers to access and consumption, FGD participants demonstrated a strong understanding of the health benefits of fruits and vegetables, especially for children. Caregivers recognized that these foods improve nutrition and overall health, but they also expressed frustration about being unable to provide them regularly due to financial and market constraints.

"We would prefer to purchase vegetables and fruits for our children. But they are not affordable. To produce them, we do not have irrigation. The water problem is a big challenge." (Male farmer, 26 years old, Gerar Barak, Sabata Hawas, Oromia)

"We know that potatoes, vegetables, and fruits are good for children, but we cannot afford to buy them." (Female farmer, 29 years old, Gerar Barak, Sabata Hawas, Oromia)

While almost all groups acknowledged that animal-source foods are essential for health, financial hardship was identified as the primary barrier to access. As one participant summarized it:

"I think carrots, vegetables, kale, potatoes, eggs, and animal-source foods are all nutritious and good for our children." (Female farmer, 50 years old, Aroma, SNNP)

"If we had enough money, we could buy whatever we wanted from the market."

(Female local beverage maker, 35 years old, Gelan Dugda, Oromia)

These reflections indicate that awareness isn't the main barrier—households recognize and appreciate the importance of fruits and vegetables—but instead, economic and structural obstacles stop them from acting on this knowledge.

The FGDs reveal that factors limiting consumption differ across fruits and vegetables and animal-source foods. For fruits and vegetables, the main barriers include high market prices, seasonal availability, and limited irrigation or water access, which restrict home production, especially during the dry season. These constraints make fruits and vegetables unaffordable for households relying on markets and scarce for those dependent on their own production. The limited consumption of animal-source foods is mainly due to financial constraints. Meat, milk, and eggs are considered expensive and often reserved for special occasions or celebrations. Even when available, many households prefer to sell these products rather than consume them, viewing them as income rather than everyday food.

The main reasons for low consumption of animal source foods (ASFs) identified in the focus groups were affordability, religious or cultural preferences, and the community's frequent sale of animal products for income (Figure 6.5). The patterns were almost similar between rural and peri-urban communities. In rural areas, about 50% of coded references cite inability to afford ASFs, 30% referred to religious and cultural reasons, and 20% cite sale of ASFs to buy grains. In peri-urban areas, roughly 50% of coded references state inability to afford ASFs, 35% cite religious and cultural reasons, and 15% sell ASFs to purchase grains. Affordability remains the primary factor in both settings, but rural residents are slightly more likely to sell ASFs for grains, while urban residents are more likely to cite religious and cultural barriers.

Despite these obstacles, participants demonstrated a strong understanding of the nutritional value of nutritious food groups such as fruits, vegetables and ASFs, especially for children’s health. Tackling economic limitations, improving irrigation and water access, and supporting year-round production and affordability could significantly boost dietary diversity and encourage healthier eating habits in these communities.

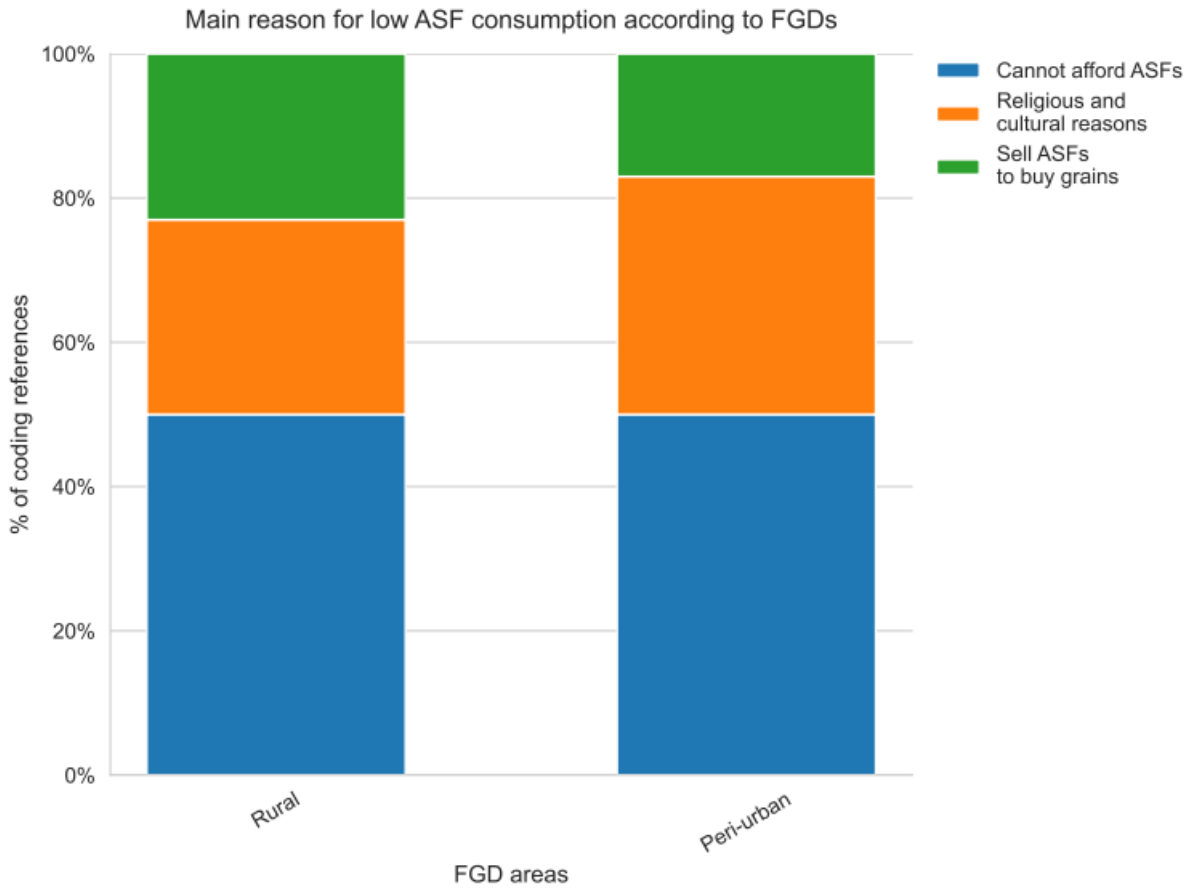


Figure 6.5. Predominantly discussed reasons for low ASF consumption: Rural vs. Peri-urban focus groups.

6.3.2.4. Pathways to food acquisition

Through six focus group discussions (FGDs) in rural and peri-urban communities, we identified the primary food sources in people's daily meals, with a focus on staple grains, tubers, legumes, and vegetables. Spices, condiments, cooking oils, sugar, and other minor ingredients were deliberately excluded from this analysis because participants consistently viewed them as supplementary purchases rather than essential dietary components.

When asked, "Where does the main food you eat every day come from — the rice, maize, cassava, beans, or vegetables that fill the plate?", responses were grouped into four categories: own farming only, market purchase only, both own farming and market purchases, and aid (food assistance).

Figure 6.6 illustrates the relative emphasis placed on different food acquisition pathways in the focus group discussions, expressed as the percentage of coded references rather than the proportion of individual participants. The figure highlights a diverse and overlapping landscape of food acquisition strategies discussed by participants. The most frequently referenced pathway was reliance on both own agricultural production and market purchases, accounting for 47.4% of coded references. This mixed strategy reflects a commonly articulated adaptive practice whereby households produce staple foods when possible and rely on market purchases to supplement dietary needs, particularly during lean seasons or when own production is insufficient.

Approximately 26.3% of references highlighted a strong reliance on own farming, a pattern most often linked to rural households with better land access but limited market connectivity. For these households, self-production was seen as the main element of food security, though participants consistently pointed out vulnerabilities to climate variability, input shortages, and production shocks.

Reliance on market purchases made up 15.8% of coded references. This pathway was often associated with land-scarce peri-urban households, in which income generation, rather than agricultural production, mainly determines food access. Focus groups described market dependence as providing flexibility but also exposing households to price fluctuations and income instability.

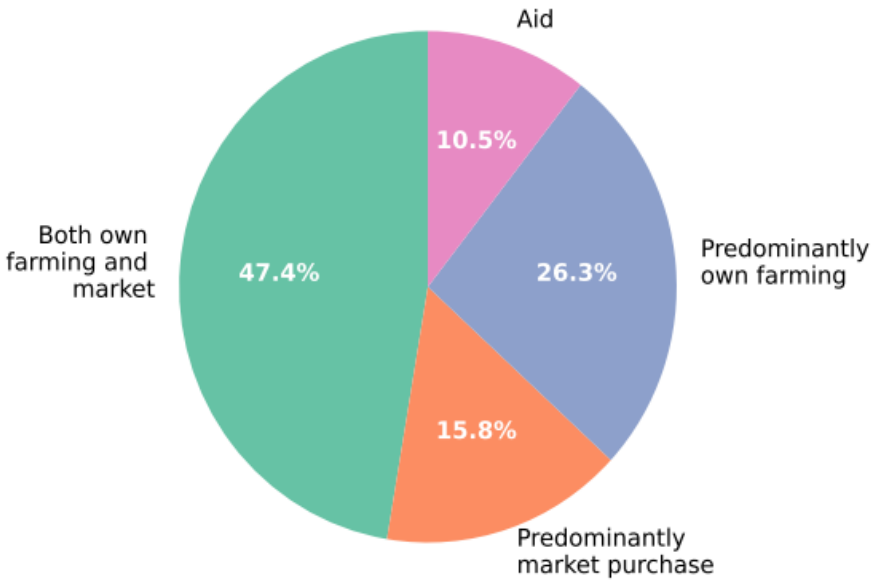


Figure 6.6. Primary sources of main food sources, by proportion of references in the FDGs (excluding spices, condiments, and oils)

Another 10.5% of references focused on dependence on food aid as the primary source of staple foods. These discussions often involved households affected by displacement, drought, conflict, or age-related vulnerabilities. Although food assistance was recognized as essential for survival, participants frequently described it as irregular and inadequate in both amount and quality.

"This year, the rain failed. My field yielded nothing. The relief that keeps us alive, but it's only once a month. The rest? We buy, borrow, and pray."

(Female, 41, drought-affected village, Arsi, Oromia):

"I don't farm. I sell charcoal. Every Birr I make goes to the market. When business is good, we eat maize and beans. When it's not, we just roast plain maize and drink water—that's all." (Male, 35, Arsi, Oromia)

The coded references across these pathways highlight a fragile interdependence among own production, market systems, and social safety nets. Instead of portraying mutually exclusive household categories, the figure shows the relative importance of these strategies in participants' narratives. The prevalence of mixed acquisition strategies underscores the adaptive yet unstable nature of food access, with implications for dietary resilience, gendered responsibilities in food provision, and vulnerability to environmental and economic shocks.

6.3.3. Key informants' perspectives on improving nutrition

Key informant interviews with agriculture and health officials from East Shewa and West Haraghe zones highlighted a strong consensus on the vital synergy between the sectors, especially agriculture and health, to improve nutrition outcomes. Three main themes emerged from the key informant interviews (KIIs): the importance of joint extension efforts, the presence of formal coordination structures, and ongoing barriers to effective collaboration. These themes are summarized in Table 6.4. They reflect both institutional goals and implementation gaps that must be addressed to turn policy into sustainable, community-level results. The following sections provide a thematic overview of KII perspectives, showing that although the vision for multisectoral action on

nutrition is clear, maintaining consistent, year-round collaboration remains the main challenge in creating an enabling food environment.

Value of agriculture–health collaboration

Key informants unanimously emphasized the complementary roles of Agriculture Development Agents (DAs) and Health Extension Workers (HEWs) in improving community nutrition. While ADAs promote crop diversification and vegetable cultivation, HEWs focus on nutrition education and food utilization. As one agriculture officer stated:

"ADAs focus on agricultural education, while HEWs guide food preparation and nutrition. Their collaboration is crucial in increasing community awareness about balanced diets."

(Agriculture Officer, Meta Woreda, West Hararghe, Oromia)

Table 6.4. Main themes on multisectoral collaboration for nutrition from four key informant interviews (KIIs)

Theme	Description	Total References (n)	Key Sub-Aspects
Need for and Value of Multi-Sectorial Collaboration, especially Agriculture–Health	Strong recognition that the agriculture and health sectors must work together to improve nutrition through joint education, crop diversification, and food utilization.	18	• DAs teach how to grow diverse crops • HEWs teach how to prepare and use nutritious foods • Joint screening of malnourished children/mothers • Shared goals: healthy community → higher productivity
Institutional Mechanisms and Coordination Structures	Existence of formal structures (e.g., Nutrition Technical Committees, joint planning, regular meetings), but inconsistent functionality	11	• Woreda-level multisectoral committees exist • Regular *gemgema* (review) meetings in some areas • Nutrition focal persons appointed • Led by woreda administrators or sector heads
Barriers to Effective Collaboration	Structural, attitudinal, and operational challenges that undermine joint action	7	• Sectoral silos and "not my duty" mindset • Lack of joint training • Committees are active only during crises • Heavy workloads reduce follow-up • Limited leadership commitment and accountability

Successful examples of health and agriculture coordinated interventions included joint promotion of protein-enriched maize, home gardening demonstrations, and shared screening of malnourished children and mothers. These initiatives emphasize that good health enhances productivity, while diverse food production leads to improved diets—a reciprocal relationship vital for nutrition-sensitive development.

Institutional Mechanisms and Leadership

The expert informants reported that most woredas have established Nutrition Technical Committees with representatives from health, agriculture, education, and water sectors. In West Hararghe, regular gemgema (review) sessions and a dedicated nutrition focal person were identified as key facilitators of coordination. One respondent noted:

"We have allocated regular discussion times and evaluated activities during our review sessions. Because of this, we can say collaboration has been successful."

However, functionality varies. In East Shewa, committees were often reactive, activating only during crises (e.g., El Niño-induced drought and locust invasions), with little follow-up during stable periods.

Barriers and Policy Recommendations

Despite the original design of the collaborative extension work, sectoral silos, unclear responsibilities, and heavy workloads hinder cross-sectoral teamwork to improve nutrition. A health official observed:

"Each sector has its own targets in the multisectoral nutrition plan, but the implementation is low… Often, they leave certain tasks, claiming nutrition is not their duty."

The informants highlighted the importance of joint training, integrated yearly plans, shared performance metrics, and consistent leadership support from woreda administrators as essential elements for effective intersectoral coordination and implementation of nutrition-sensitive activities. Such collaborative capacity building and coordinated planning have been identified as critical

determinants of the successful adoption of improved agricultural services and extension support, which, in turn, influence food security and livelihood outcomes in Ethiopian smallholder contexts. Positive examples, such as vegetable production demonstrations, home garden initiatives, and other training-linked extension efforts, demonstrate the potential to expand coordinated action when planning and training occur proactively and systematically, as argued by Wordofa et al. (2021).

6.4. Discussion

The qualitative findings provide a detailed, participant-centred understanding of how local food environments influence overall dietary quality and food access. By combining community perceptions with structural realities, this analysis reveals how production challenges, market forces, economic obstacles, and socio-cultural norms interact to maintain low dietary diversity, particularly in the consumption of fruits, vegetables, and animal-source foods (ASFs). These insights support and build upon quantitative evidence from earlier chapters, offering explanations for some of the statistical relationships and aiding in practical interpretation.

The dominance of mixed food acquisition strategies, combining self-production and market purchases, reflects a pragmatic adaptation within Ethiopia's fragmented smallholder systems. This hybrid approach allows households to buffer production shortfalls during lean seasons, but it remains fragile and depends on cash flow and market stability and at times households have to resort to aid. Similar patterns have been observed in other LMICs, where smallholders use markets to supplement homegrown staples but face volatility in both supply and prices. The sizable minority who rely solely on their own farming for food, especially in remote rural kebeles, highlights the potential of their subsistence agriculture despite shrinking landholdings, an argument previously made by Rapsomanikis (2015). However, as reflected in both FGDs and KIIs, this self-sufficiency is becoming increasingly unsustainable due to climate variability and rising input costs, echoing the findings of Minten et al. (2020) on structural transformation gaps in Ethiopian agriculture.

The general reliance on the market, even in rural areas, highlights a shift toward income-driven food security—a trend accelerated by urbanization and land scarcity (Downs et al., 2020). However, this shift does not guarantee better diets; instead, it often forces families to buy energy-dense, low-nutrient foods due to affordability constraints. The reliance of a minority of households on food aid points to systemic failures in both production and market systems, especially impacting vulnerable groups. These pathways together demonstrate that no single source ensures resilience; instead, households navigate a fragile balance between independence through home production and dependence on the market.

Affordability remains the primary barrier to consuming fruits, vegetables, and animal-source foods (ASF), as evidenced by both quantitative income–diet relationships and qualitative findings. Despite awareness of the health benefits, households tend to prioritise calorie-rich staples over nutrient-dense foods due to limited financial resources. This pattern reflects a broader nutrition transition commonly observed in low- and middle-income countries, where economic constraints limit access to diverse diets (Turner et al., 2018; Neve et al., 2021).

Seasonality further exacerbates affordability constraints. Quantitative results indicate that fruit and vegetable consumption is generally higher in the post-harvest period, likely driven by improved household purchasing power and increased market supply. These patterns were largely consistent with insights from FGDs and KIIs, where participants reported that food access improves after harvesting due to increased income and market activity, while the lean (pre-harvest) season is characterised by reduced purchasing power and greater reliance on limited staple foods. At the same time, qualitative findings also highlighted that certain foods—particularly vegetables—may be more physically available and cheaper during the rainy season, but this does not always translate into higher consumption due to cash constraints and market access limitations.

This interplay between seasonal availability and economic access creates a mismatch that constrains dietary diversity and contributes to persistent micronutrient deficiencies, especially among children (Chea and Groen, 2023). Water scarcity for irrigation, highlighted in approximately one

quarter of coded FGD references, further limits off-season production and reinforces dependence on rain-fed cereal systems. As noted by Deribe and Mintesinot (2016), the dominance of crops such as teff, wheat, and maize reflects both agroecological conditions and household food security priorities.

Small landholdings (as noted in 32% of FGD transcript references) further limit diversification. With average plots under one hectare, households lack space for intercropping or home gardens, reducing both the production and consumption of nutrient-rich crops. High input costs (18% of references) create a cycle: limited fertilizer use lowers yields, which reduces income for market purchases. These findings align with national surveys showing stagnant vegetable production despite policies that emphasize diversification (CSA and ICF, 2016).

Cultural practices, especially religious fasting, significantly restrict ASF consumption. While affordability remains a key factor, fasting periods—observed mainly by Orthodox Christians—limit animal product intake for up to 200 days each year, making low-ASF diets common (Haileselassie et al., 2022; Michael and Baye, 2023). Participants in this study viewed meat and dairy as occasional treats rather than daily staples, a perspective reinforced by income priorities: livestock products are sold to buy grains rather than consumed. Although this “sell-to-eat” strategy may seem a rational economic choice, evidence shows that it adversely affects household nutrition (Belay et al., 2021; Valerie et al., 2017).

Gender roles also influence food environments. Women, as primary caregivers and decision-makers, bear the burden of stretching limited resources while managing time constraints from household chores. Their key role in food choices—yet limited control over production assets—creates a gender-nutrition paradox typical in patriarchal farming systems, as argued by Neve et al. (2021).

The convergence of limited land, water scarcity, and difficulty accessing agricultural inputs creates a structural triad that suppresses both farm productivity and dietary diversity. Water shortages, exacerbated by climate change and inadequate irrigation infrastructure, constrain irrigation-based vegetable production and represent a significant missed opportunity for year-round access to diversified and nutrient-dense foods such as leafy green vegetables, onions, tomatoes,

carrots, and pulses. Gaps in agricultural extension services further reflect broader institutional challenges, as this qualitative study reveals. Despite substantial government investment in development agents and extension structures, studies show that farmers frequently report limited access to practical training, follow-up support, and effective technology transfer, particularly for nutrition-sensitive and diversified crop production (Deribe and Mintesinot, 2016; Spielman et al., 2010). This disconnect weakens the adoption of high-yield and nutrient-rich crop varieties, including improved legumes, vegetables, and biofortified staple crops, thereby constraining both agricultural productivity and household dietary quality.

Market dysfunction—oversupply during harvest, dominance of middlemen, and low farm-gate prices—discourages diversification. Rapsomanikis (2015) suggests that farmers grow cereals not for nutrition but for a stable income, which sustains low-diversity diets. These supply-side constraints reflect demand-side barriers, creating a cycle where neither production nor consumption improves dietary quality.

Key informants highlighted that isolated sector-specific approaches—such as focusing solely on agriculture for yield or on health for cures—fail to capture the complexity of nutrition. Effective models, such as integrated HEW-ADA nutrition campaigns, underscore the importance of coordination but remain inconsistent (Ayana et al., 2017). Although formal multisectoral platforms such as Nutrition Technical Committees exist, they lack enforcement, accountability, and adequate resources. Leadership commitment, joint planning, and shared metrics are crucial for overcoming sectoral stagnation.

While some staple crops serve as both food and cash crops, their role in household diets depends on how they are used. In the study context, crops such as cereals are often prioritized as income-generating commodities and sold to meet essential household needs, including non-food expenses. As a result, even when households produce a variety of crops, a significant share may be marketed rather than consumed. This can limit the direct contribution of production diversity to dietary diversity, particularly when income from sales is insufficient to purchase a diverse range of

nutrient-rich foods. Thus, the dual role of food crops as cash crops may reinforce reliance on staple-based diets, especially under conditions of market inefficiencies and low purchasing power.

Policy must therefore address root causes: expanding irrigation, subsidizing inputs for vegetable production, and stabilizing markets through storage and price supports. Home gardening programs, along with women's empowerment initiatives, could improve direct access to vegetables. Nutrition-sensitive safety nets—such as fortified aid and school feeding with locally produced foods—provide immediate relief while building long-term resilience (FAO et al., 2025).

6.5. Conclusion

The strength of this study lies in its reflexive thematic approach, which combines community voices from FDGS with the perspectives of responsible officials across key areas and settings. Using NVivo for coding improves transparency and rigor. However, the sample did not include all regions of Ethiopia, which limits the generalizability of the findings. Future research should explore more diverse socioeconomic and age groups, such as adolescents, and evaluate comprehensive views of the food environment to support long-term national-level nutrition planning.

The value of this qualitative component extends beyond complementing the quantitative findings, as it offers actionable insights for policy and program design in Ethiopia's food system transformation. For instance, while empirical data highlight that both agricultural production and household consumption are heavily grain-based, contributing to poor dietary quality, focus group discussions reveal the underlying rationale: farmers tend to prioritize cereals over horticultural crops due to concerns about risk, storage limitations, and market orientation, which often favours staple grains over nutrition-sensitive produce.

Improving diet quality in Ethiopia requires transforming food environments at multiple levels: helping smallholders grow a variety of crops, making market access affordable, and aligning sector policies with nutrition goals. Community-driven solutions—such as irrigation cooperatives, promoting home gardens, and supporting local entrepreneurship to increase income—stand out as culturally

relevant strategies. By addressing supply- and demand-side constraints and resolving persistent coordination gaps between frontline extension services, particularly in health and agriculture, through integrated planning, harmonized performance targets, and institutional support, Ethiopia can move beyond calorie sufficiency toward genuine nutritional resilience.

6.6. Chapter summary

This chapter complements the quantitative analyses in Chapters 4 and 5 by examining how individuals and communities perceive and navigate their food environments. A qualitative inquiry revealed how economic constraints, sociocultural norms, gender roles, and local market conditions shape food access and dietary decision-making in ways that quantitative indicators alone cannot capture.

Within the overall thesis, this chapter provides critical contextual depth by linking measured characteristics of the food environment to lived experiences and behavioral responses. It shows that food choices are not determined solely by availability or affordability but are also shaped by perceptions, social norms, and intra-household dynamics. These insights help explain observed quantitative patterns and strengthen the thesis's argument for people-centered, context-sensitive nutrition interventions.

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Appendices

Table A6.1. Thematic areas emerging from focus group discussions on household and community food environments

Thematic Area	Description	References (n)
Food access and acquisition pathways	How households obtain food	**19**
Primary sources	Primarily own farming	**5**
	Primarily market purchase	**3**
	Both own farming and market	9
	Aid	2
Community-level food environment and infrastructure	Market access, retail diversity, and affordability	**13**
Market barriers	Transport, price volatility	3
Retail environment	Distance to market, limited diversity	4
Healthy food perceptions	Community views on nutritious options	6
Access and consumption of fruits and vegetables	Availability, affordability, seasonality, and health perceptions	**24**
Availability and seasonality	Only available seasonally	4
Affordability barriers	High cost, non-affordable	11
Access issues	Transport, distance, infrastructure	7
Health perceptions	Recognized as important	2
Animal-source foods (ASF) consumption	Patterns, barriers, and perceived benefits	**23**
Affordability and seasonal access	Cannot afford, sell for income	16
Cultural/religious factors	Fasting, preferences	4
Health perceptions	Valued for nutrition	3
Home production and food availability	Local crop/livestock choices, production patterns, and barriers	**63**
Production challenges	Small land, water scarcity, input costs, pests/drought	35
Crop selection patterns	Cereal-dominant, cash crops, mixed systems, and vegetables	14
Reasons for crop choices	Market demand, Productivity, and tradition	14
Extension and technology gaps	Limited training, irrigation, and market access	10
Food choice and decision-making	Drivers of household food selection	**11**

Price and affordability	Primary influence	6
Gender roles	Women's role in decisions	4
Seasonal diet shifts	Harvest-driven changes	1
Food insecurity and coping mechanisms	Experiences of shortage and adaptive strategies	**21**
Experiences of shortage/worry	Common concern	7
Coping strategies	Reduce portions, skip meals, substitute	2
Health and social impacts	Stress, malnutrition, stigma	9
Community solidarity	Sharing, mutual aid	3

Table A6.2. FGD Topic Guides

Sociodemographic questions

Region	Zone	Woreda	Kebele	Name	Age	Sex	Family size	Have a job?	Type of Job	Food source	Residence

Q1. What are the main ways of obtaining food in your household? Do you use any other ways to access food? *What foods are produced in your household: teff, wheat? But foods for stew (wot), such as potatoes, pulses, and vegetables, are purchased from the market.*

Q2. What sorts of foods do you choose for your household? What are the main factors that influence your food choices? What are the foods you choose in different seasons of the year? What do you think are healthy foods in your opinion?

Q3. How do you feel about your community's current access to food? Are you ever worried that food might run out before you can buy more? What strategies do you engage in to conserve your food supply? If you experience stress or worries about your food supply, how do you cope with this/how does this influence your thoughts, feelings, and behaviour?

Q4. Do you feel that your access to food affects your life in other areas (e.g., physical health, wellbeing, health behaviours, and your children's growth and school performance?

Q5. Where do you tend to purchase food? What do you find to be the main barriers to purchasing and obtaining food in your local area? How do you think these barriers could be overcome?

Q6. Now I would like to understand the typical dietary habits in your area/community. What foods do you mainly obtain from the market, and how often do you eat them?

Q7. What are the foods you do not often eat? Why are these foods not eaten?

Q8. Do you think fruits and vegetables are adequately available and accessible in your surroundings? What do you think are the barriers to access to fruits and vegetables?

Q9. In your opinion, what do you think is the adequacy of the foods consumed by children? Fruits and vegetables are good for women's and children's health. Do you think your children, as children in your community, are eating an adequate number of fruits and vegetables? If not, why? Animal-source foods (ASFs), such as meat, chicken, fish, eggs, and milk products, are beneficial for women's and children's health. Do you think your communities are eating an adequate amount of ASFs? If not, why?
Q10. What do you produce, and why do you choose the types of crops you produce? What are the opportunities for agricultural production in your area? What are the challenges regarding your products and agricultural activities in general?

Table A6.3. Key informant interview questions

Purpose: This Key Informant Interview (KII) guide is customized to align national- and sector-level nutrition policy discussions with community-level realities. It focuses on food access, diet diversity, agricultural production, markets, and child and women nutrition, while examining the role of multisectoral collaboration in Ethiopia.
Target informants: Health and agriculture sector officials.

1. Rationale for Nutrition Programmes in Ethiopia (Linked to Community Food Realities)
    - In your view, why are nutrition programmes necessary in Ethiopia today?
    - Based on your experience, what are the main nutrition problems affecting women and children (e.g., diet diversity, food insecurity, micronutrient deficiencies)?
    - How do challenges related to household food access, seasonality, and market dependence (as discussed at the community level) justify the need for nutrition programmes?
    - Probes: rural vs urban differences, seasonal hunger, poverty, child growth, maternal nutrition.
2. Awareness and Use of the Multisectoral Collaboration Guideline
    - What is your understanding of the national guideline for multisectoral collaboration on nutrition?
    - How does the guideline encourage collaboration between the health and agriculture sectors to address food availability, access, and utilization?
    - To what extent is this guideline operationalized at the regional, woreda, or community level?
3. Importance of Health–Agriculture Collaboration for Nutrition Outcomes
    - Why is collaboration between the health and agriculture sectors essential for delivering effective nutrition programmes and services?

- How does collaboration help address community-level challenges, such as low dietary diversity, limited fruit and vegetable intake, and inadequate consumption of animal-source foods?
- Can you share examples where joint efforts improved maternal or child nutrition outcomes?

4. Sectoral Implementation of NNP and Multisectoral Guidelines
    - Please describe what your sector has implemented in line with the NNP and the multisectoral collaboration guideline.
    - Which activities directly or indirectly support household food production, market access, or dietary diversity?
    - What planned activities have not yet been implemented, and why?
5. Enablers of Successful Intersectoral Collaboration
    - What factors contribute to successful collaboration between the health and agriculture sectors?
    - How do shared goals, joint planning, or data sharing support improved nutrition outcomes?
    - What role do community structures (e.g., HEWs, development agents, women's groups) play in facilitating collaboration?
6. Barriers to Effective Intersectoral Collaboration
    - What are the main barriers to effective collaboration between the health and agriculture sectors?
    - How do institutional, financial, or capacity constraints affect implementation at the local level?
    - Are there challenges linking policy intentions with community realities, such as market barriers or seasonal food shortages?
7. Emerging Opportunities to Improve Nutrition through Collaboration
    - What new or existing opportunities do you see for the health and agriculture sectors to work together more effectively?
    - How can collaboration improve complementary feeding practices and diet diversity among young children?
    - What opportunities exist to strengthen fruit, vegetable, and animal-source food consumption through nutrition-sensitive agriculture?

7. Chapter Seven: Using the Cost of the Diet Modelling to Assess the Food Environment's Influence on Diet Affordability

This chapter builds on earlier analyses of household food environments (FE) by examining diet affordability using the Cost of the Diet (CotD) modeling approach. While earlier chapters assessed how food environments shape dietary diversity, nutrient intake, and food choices through quantitative and qualitative methods and identified affordability as an important element of the FE, this chapter focuses specifically on households' ability to afford nutritionally adequate diets. By applying CotD modeling, the chapter estimates the minimum cost of diets that meet nutritional requirements and evaluates how food prices, income constraints, and market food diversity influence diet affordability. In doing so, this chapter complements the empirical findings presented in previous chapters and provides policy-relevant insights into the economic barriers that limit the translation of food availability and knowledge into healthy dietary practices.

Abstract

This chapter examines the affordability of nutritionally adequate diets in Ethiopia using the Cost of the Diet (CotD) modeling approach, building on earlier analyses of the food environment. While previous chapters explored how food environments influence dietary diversity, nutrient intake, and food choices, this chapter focuses specifically on economic access to healthy diets. By integrating secondary food price data with linear optimization modeling, the study estimates the minimum cost of diets that meet recommended nutrient requirements and assesses affordability across regions and seasons.

The findings show that nutrient-adequate diets cost substantially more than energy-only diets—three to six times higher—highlighting a significant gap between meeting caloric needs and achieving nutritional adequacy. Affordability remains a major constraint, with only about one-third of households able to afford a nutrient-adequate diet, compared with the majority who can meet basic

energy requirements. Regional disparities are pronounced, with higher costs in areas with limited market food diversity and weaker market integration. A strong negative relationship between food diversity and diet cost underscores the importance of diversified food systems for improving affordability.

Seasonal variations further exacerbate affordability challenges, as diet costs peak during lean periods because of reduced food availability and greater reliance on markets. Over time, rising food prices have significantly increased the cost of nutritious diets, reflecting broader macroeconomic pressures. The analysis also highlights intra-household disparities, with adolescent girls and women bearing a disproportionate share of nutritional costs due to their higher physiological requirements.

Scenario modelling demonstrates that targeted interventions—including agricultural diversification, home production of nutrient-rich foods, and food fortification—can meaningfully reduce diet costs. For instance, combining staple crop diversification with vegetable production and introducing fortified wheat flour substantially improves affordability.

Overall, the chapter underscores that improving diet quality in Ethiopia requires integrated, multisectoral strategies that address both food availability and economic access. Enhancing market diversity, strengthening supply chains, promoting nutrition-sensitive agriculture, and increasing household purchasing power are critical to making nutritious diets affordable and achievable.

7.1. Introduction

Nutrition is central to building a healthy and productive population. Adequate nutrition improves physical growth, cognitive performance, disease resilience, and labor productivity (Black et al., 2013; Grantham-McGregor et al., 2007). The Lancet Maternal and Child Nutrition Series has identified evidence-based interventions—ranging from micronutrient supplementation and food fortification to dietary diversification—that can yield both immediate and long-term health and socio-economic benefits (Bhutta et al., 2013). Effective scaling of these interventions requires coordinated action across food production systems, market environments, social protection mechanisms, health

platforms, and education systems, informed by context-specific constraints and opportunities (Ruel et al., 2018).

The quantitative and qualitative analyses above consistently identified poverty, food price volatility, and limited economic access as major constraints to achieving adequate diets. Assessing the affordability of nutritious diets relative to households' actual food expenditures and income is therefore essential for determining whether observed dietary gaps primarily reflect economic infeasibility rather than knowledge or preference-based constraints. This comparison allows the analysis to quantify how far nutritious diets are from being financially feasible for households, identify periods and population groups at greatest risk, and provide evidence on whether improvements in diet quality are realistically achievable under prevailing income and price conditions. Such insights are critical for informing policy responses that address affordability, including income support, price stabilization, and market-level interventions. In this chapter, secondary food price data from the Central Statistical Agency of Ethiopia (CSA), corresponding to the same pre-harvest and post-harvest periods as the household surveys analysed in earlier chapters, are combined with the CotD linear optimisation model using the methods described by Deptford et al. (2017). This integrated approach extends the preceding analyses by examining the availability of nutritious foods, seasonal fluctuations in market prices, and the affordability of recommended diets. The CotD model calculates the lowest cost needed to meet nutrient requirements for different household types using locally available foods, while also allowing scenario testing of interventions aimed at reducing diet costs or increasing household purchasing power (Deptford et al., 2017). Policy-relevant solutions to improve diet affordability—such as diversifying the food supply, increasing agricultural productivity, providing targeted subsidies, and promoting behavioral change—are evaluated for their potential impact based on CotD outputs. This modeling approach thus extends earlier findings by identifying practical, evidence-based intervention options within Ethiopia's food environment.

To better understand the nutritional potential of the market food environment and the factors influencing access to nutritious diets in Ethiopia, the CotD analysis examines the availability,

accessibility, affordability, and consumption of healthy foods. Additionally, it aims to generate evidence on the potential effectiveness of existing, locally prioritized multisectoral nutrition interventions. This evidence will support the refinement of priorities and help identify opportunities to strengthen ongoing efforts.

7.2. Methods

The CotD software was used to conduct this analysis. Developed by Save the Children, CotD is a linear optimization tool widely used in low- and middle-income country settings to assess diet affordability, nutrient adequacy, and the cost implications of food price changes using local market data (Deptford et al., 2017). The CotD uses linear programming to assess the extent to which poverty, food availability, and food prices may impact individuals' ability to meet their nutrient needs. Using price data collected from markets or secondary sources, the software calculates the amount, combination, and lowest possible cost of local foods required to meet the average energy needs of individuals or households, as well as their recommended intake of protein, fat, and micronutrients as defined by the Food and Agricultural Organization (FAO) and the World Health Organization (WHO) (Joint FAO/WHO Expert Consultation, 2004). These diets are calculated within defined constraints on food choice and quantities to avoid unrealistic consumption patterns and to ensure nutritionally adequate and culturally plausible diets (Deptford et al., 2017; Parlesak et al., 2016).

Figure 7.1 shows a framework for applying CotD analysis to assess the food environment and guide policy decisions. It consists of two main components: the Food Environment, which examines access to nutritious foods using data from food systems literature and databases; and the CotD Analysis, which estimates the minimum cost and affordability of a nutrient-adequate diet using food prices (July 2022–June 2023) and inflation-adjusted expenditure data. The framework supports identifying interventions to improve diet affordability and assessing economic access to nutritious diets, ultimately informing evidence-based food system strategies.

The modelled diet represents a calculated least-cost diet rather than actual eating patterns, and it estimates the lowest-cost ways to meet minimum nutrient intake requirements, rather than an ideal diet defined by dietary guidelines (Shepperdley et al., 2024). Regional food availability and cultural acceptability are incorporated by including locally consumed staple foods and excluding foods that are culturally or religiously unacceptable. For example, foods such as goat or camel milk are included only in regions where they are culturally accepted and commonly consumed, such as the Somali region. This diet is referred to as the 'nutrient adequate diet' throughout this chapter. It meets requirements for nutrients, including protein, nine vitamins, and four minerals, and does not exceed energy and fat requirements (EPHI and WFP, 2020; FAO et al., 2020).

Using this analytical framework, population expenditure data is compared to the cost of a nutrient adequate diet to estimate the proportion of people who cannot afford it (Shepperdley et al., 2024). This non-affordability was assessed across the study regions and seasons. The estimate is conservative, assuming optimal food choices at the lowest cost. In reality, the cost—and thus non-affordability—is likely higher, as a healthy diet includes greater food group diversity and variety within groups (FAO et al., 2020).

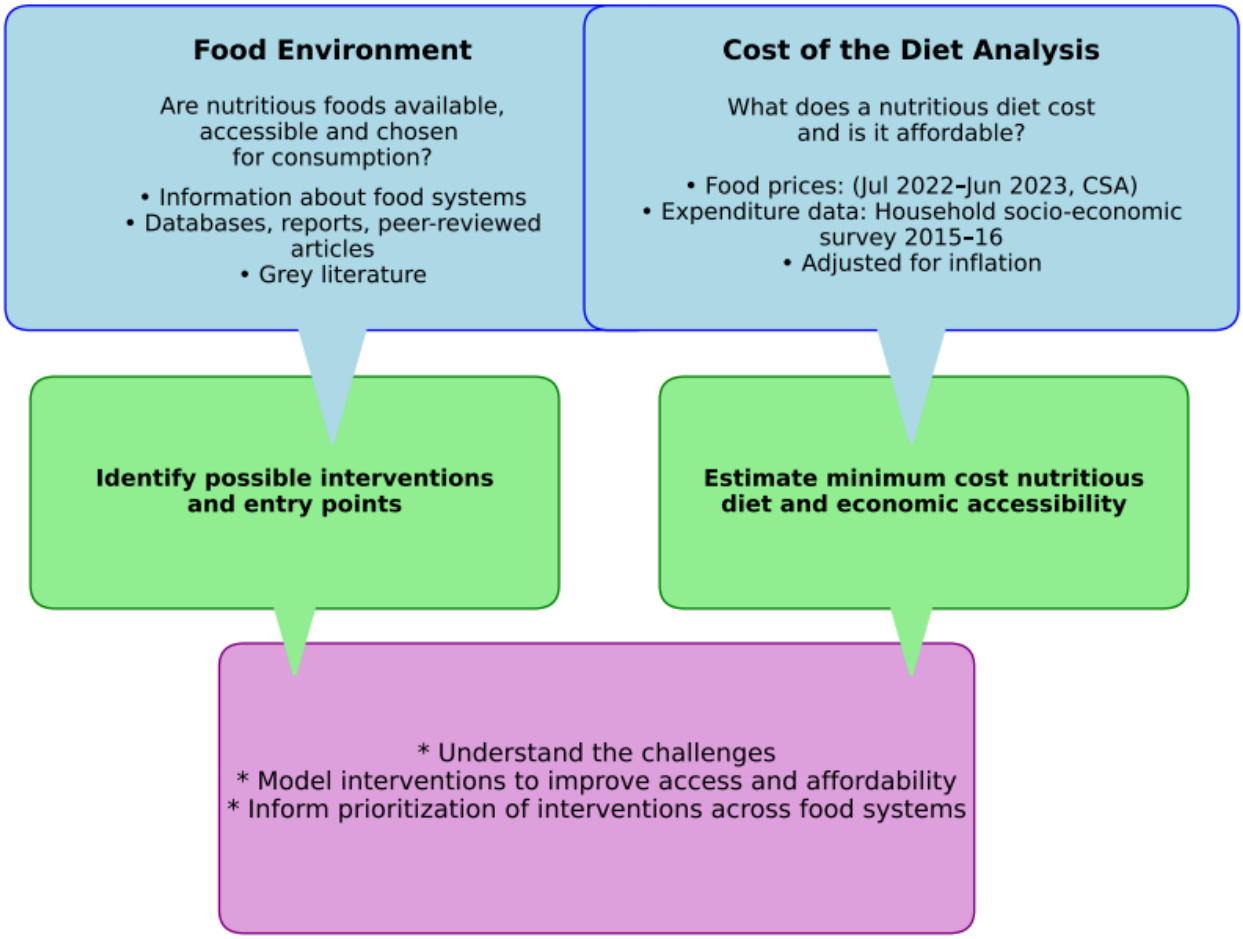


Figure 7.1. Analytical framework using the CotD analysis

(adapted from Fill the Nutrient Gap analysis; Bose et al., 2019).

7.2.1. Data sources for CotD analysis

Food price data collected monthly by the Central Statistical Agency (CSA) of Ethiopia to construct the Consumer Price Index (CPI) (CSA, 2023) were used to calculate the cost of the diet. These food price data covered 52 markets across the study regional states. Aligned with the household survey study period and used in previous chapters for food price and affordability dimensions of the food environment score, the monthly price data for this chapter covered the 12 months from July 2022 to June 2023 and included 100–140 food items. The main periods of price change were identified for each zone, and the average price for each commodity was calculated to reflect the seasonal average, guided by the seasonal calendar information available from the Famine Early Warning Systems Network (FEWS NET, 2013). Non-affordability was estimated using weighted percentiles of total

monthly food expenditure, extracted at the regional level from the Ethiopian Socioeconomic Survey (ESS) of 2015–2016, and measured at the zonal and regional levels against the costs of two diets: the energy-only diet and the nutrient-adequate diet. To compare food expenditure with the cost of a nutrient-adequate diet in 2022-2023, the 2015-16 expenditure data were adjusted for inflation using the Food CPI (CSA, 2017). Food consumption data from the household survey were used to determine regional staple preferences by selecting the top two or three most-consumed items.

7.2.2. Household composition and target groups for the diet modelling analysis

Diet costs were estimated for a household of five to reflect national average household sizes and groups vulnerable to nutritional issues. According to the 2016 Demographic and Health Survey for Ethiopia, the average household size was 4.6 nationwide (CSA, 2017). The household composition used in the analysis accounts for different life stages and nutritional needs and was selected to provide a reasonable per capita average for the population. The model household used for diet optimization includes a breastfed child under 2 years old, a school-age child, an adolescent girl, a breastfeeding adult woman, and an adult man.

7.2.3. Modelling the impact of potential intervention scenarios on diet affordability

Typical food environment interventions were modelled to demonstrate their impact on diet affordability. The selection of these interventions was defined based on secondary data compiled by nutrition stakeholders in Ethiopia (Figure 7.2). These interventions are sectoral priorities aimed at improving nutrition in Ethiopia as defined by the Ethiopian Public Health Institute (EPHI) and other nutrition stakeholders (EPHI and WFP, 2020).

This modelling analysis can be used to identify and assess the potential of interventions across sectors to improve access to nutritious diets. Four key types of interventions can be considered with the food environment framework: those that enhance the availability of nutritious foods; those that improve the nutrient content of available foods; those that are targeted to specific individuals based on need or vulnerability; and those that aim to increase purchasing power, enabling households to afford a more nutritious diet. Figure 7.2 presents selected examples of modeling specific interventions

within the food-environment framework to illustrate potential improvements in affordability; however, these examples are not exhaustive.

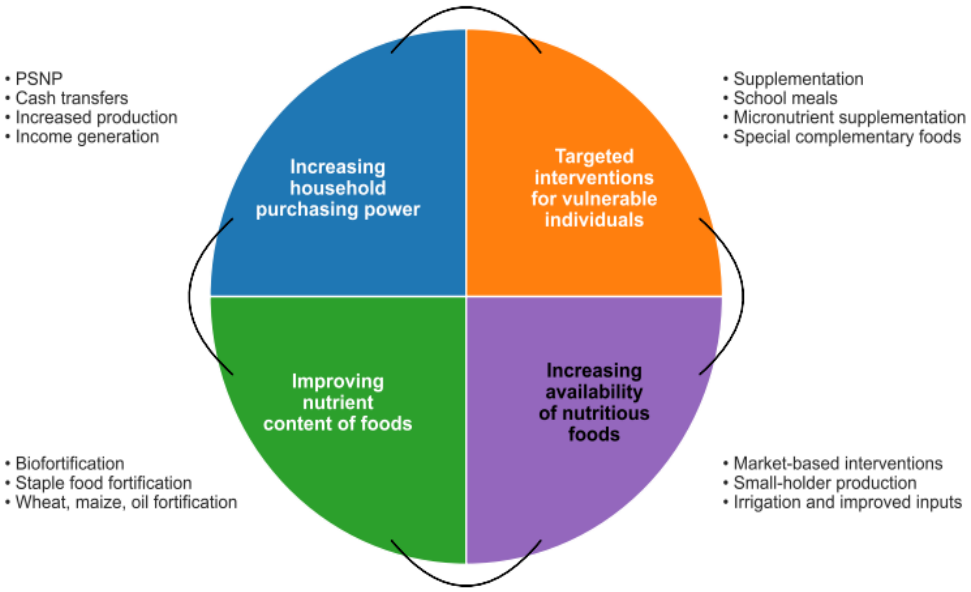


Figure 7.2. Potential entry points and interventions modelled to estimate the reduction in the cost of a nutritious diet.

(Adapted from Fill the Nutrient Gap Analysis, EPHI and WFP).

7.2.4. Considerations for interpretation, data gaps, and limitations

The estimated costs of energy-only and nutritious diets should be interpreted as economic reference points for minimally adequate diets given local market conditions, rather than as ideal diet standards or reflections of actual consumption (Shepperdley et al., 2024). Owing to gaps in CPI coverage, the analysis excludes certain zones of Ethiopia, and the underlying food list may not capture foraged, wild, or highly seasonal foods. Cost estimates draw on price data from July 2022 to June 2023 and from November 2018 to October 2019 to assess temporal trends, though these may not represent current prices or prevailing market availability. Affordability estimates based on regional food expenditure data from the ESS 2015–16 may therefore overstate or understate actual household affordability, even though the data are inflation-adjusted.

The modelled interventions demonstrate their potential to reduce the cost of nutritious diets by enabling individuals to meet macro- and micronutrient requirements more affordably, thereby

improving economic access to nutritious foods. The interventions included in this analysis are drawn from current or planned initiatives; however, they do not represent the full range of nutrition-related efforts underway in Ethiopia.

7.3. Results

7.3.1. Composition and cost of nutrient-adequate diets

The composition of the least-cost nutrient-adequate diets generated by the Cost of Diet (CotD) model varied across regions, reflecting differences in local food availability, cultural preferences, and relative prices (Table 7.1). Despite this variation, several common food items were consistently selected across most regions, including staple grains such as maize and teff, dark green leafy vegetables (e.g., spinach and collard leaves), legumes (particularly soybean), and animal-source foods such as eggs. In addition, milk products and fats (notably ghee) were frequently included, highlighting their importance in meeting micronutrient requirements. Some region-specific foods were also identified, such as fish in Somali and SNNP, drumstick leaves in Somali, and wheat products in urban areas like Addis Ababa. Breast milk was included in all regions, reflecting its critical role in meeting the nutrient needs of young children. Overall, the CotD model demonstrates that achieving nutrient adequacy requires a diverse combination of food groups, including staples, legumes, vegetables, and animal-source foods, although the specific composition differs by region.

Table 7.1. Composition of nutrient-rich diet by region (CotD model)

Food group	Food item	Amhara	Oromia	Somali	SNNP	Addis Ababa
Legumes, nuts and seeds	Bean, broad	✓		✓		✓
	Bean, navy	✓			✓	
	Bean, pinto	✓	✓		✓	✓
	Bengal gram (split)	✓	✓	✓		✓
	Bengal gram (whole)					
	Flaxseed		✓	✓	✓	
	Linseed			✓		
	Soybean	✓	✓	✓	✓	✓
	Lentil					

Grains and grain-based products	Maize	✓	✓	✓	✓	✓
	Millet	✓	✓	✓	✓	✓
	Oat bran	✓	✓	✓	✓	
	Teff	✓	✓	✓	✓	✓
	Wheat (whole)		✓	✓	✓	
	Wheat flour			✓		
	Sorghum (white)			✓		
Roots and tubers	Sorghum (red)	✓	✓	✓		
	Taro		✓			
Vegetables	Cabbage	✓				
	Carrot		✓	✓		
	Collard leaves	✓	✓	✓	✓	✓
	Spinach	✓	✓	✓	✓	✓
	Drumstick leaves			✓		
Fruits	Prickly pear		✓			
Animal source foods	Chicken				✓	
	Egg	✓	✓	✓	✓	✓
	Sardines (canned)	✓	✓	✓		✓
	Tilapia			✓	✓	
	Pork			✓		
Milk and milk products	Cow milk		✓		✓	✓
	Goat milk			✓		
	Yogurt	✓		✓		
	Ghee	✓	✓	✓	✓	✓
Oils and fats	Palm oil	✓	✓		✓	✓
Infant food	Breast milk	✓	✓	✓	✓	✓

Note: The table shows food items selected by the Cost of Diet linear programming model for each region. Quantities are omitted for clarity; all listed foods contribute to meeting nutrient requirements at least cost. (✓ indicates food items included in the optimized diet)

The monthly cost of a Nutrient Adequate diet for a household of five was consistently and considerably higher than that of an Energy Only diet across all regions in Ethiopia from July 2022 to June 2023 (Figure 7.3). The Somali region had the highest cost for a nutrient-rich diet, exceeding 10,000 ETB, while the least expensive was in the SNNP and Oromia regions. Diets that meet nutrient adequacy requirements generally cost between 3 and 6 times as much as energy-sufficient diets across regions.

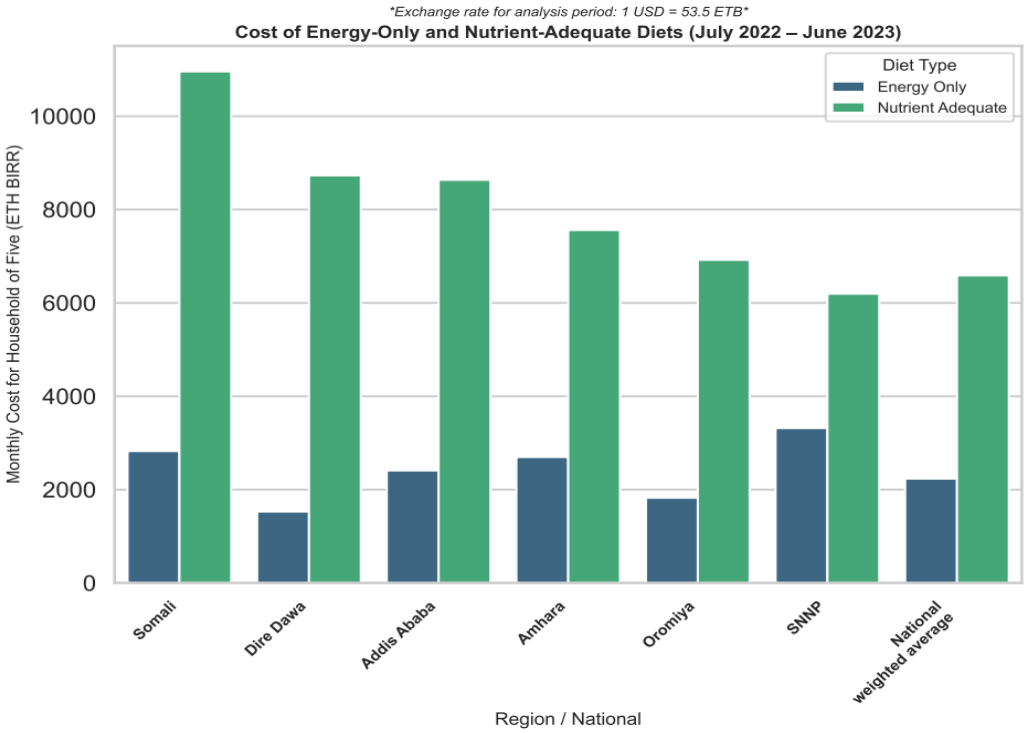


Figure 7.3. Monthly cost comparison of energy-only vs. Nutrient-adequate diets for a household of five across Ethiopian regions (July 2022 – June 2023).

Figure 7.4 illustrates seasonal fluctuations in the cost of a nutritious diet across Ethiopian regions. Consistent with the earlier chapter on production diversity and seasonality, which showed that seasonal shifts in food availability influence dietary diversity and nutrient intake, the CotD results demonstrate that the financial cost of achieving a nutritious diet also varies substantially across seasons. Diet costs rise notably during the Lean season, when household food stocks are depleted, and market dependence increases, while the Harvest season tends to be the least expensive. Somali consistently shows the highest costs, particularly in the Lean season, reflecting both limited production diversity and heightened vulnerability to seasonal shortages. In contrast, SNNP and Sidama exhibit relatively stable, lower costs across seasons, suggesting greater resilience due to more diversified production systems, better market integration, or improved year-round availability of key foods.

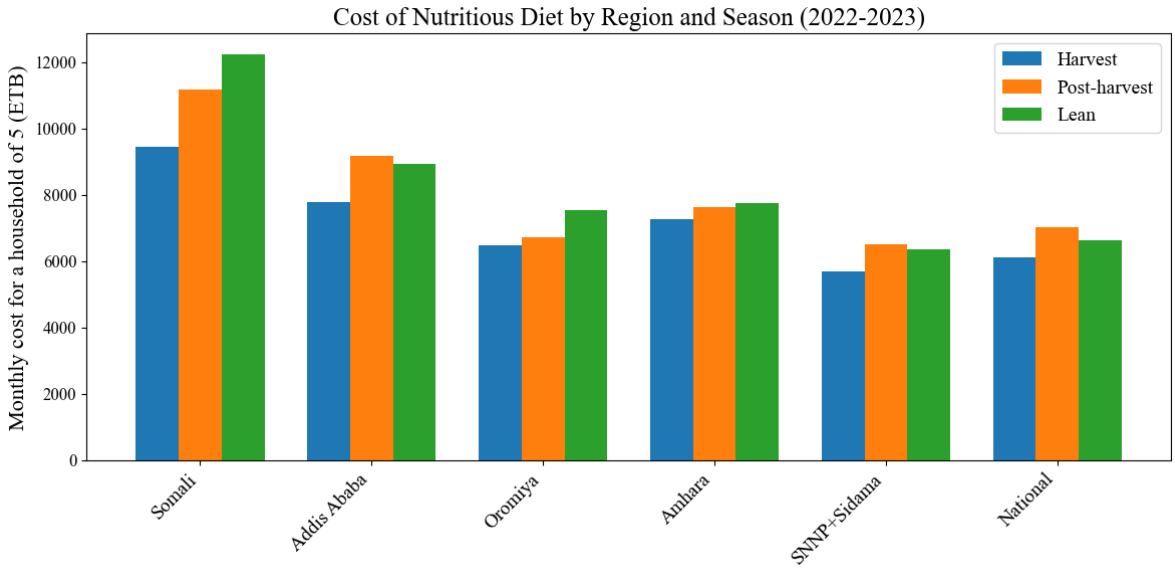


Figure 7.4. Monthly cost of a nutritious diet for a household of five by region and season in Ethiopia, 2022-2023.

The trend in the cost of a modelled nutrient-adequate diet by region and year over the periods 2018-2019 and 2022-2023 is illustrated in Figure 7.5. The data reflect a clear upward trend in costs across all regions over the four years, with notable regional variations. In 2018-2019, costs were relatively low, ranging from 2,742 ETB (national average) to 4,288 ETB (Somali). By 2022-2023, these costs had risen significantly, with Somali increasing by about 156% over the four years. Addis Ababa saw a substantial 151% rise. The national average observes a 129% increase, as shown in Figure 7.5.

The steepest growth is observed in Somali, where the cost more than doubled, likely due to regional economic or supply challenges. Other regions, such as Addis Ababa and Amhara, also experienced significant jumps, exceeding 150%, while SNNP and Sidama showed a relatively moderate rise. This trend suggests a broad increase in food prices or reduced affordability over time, with Somali and urban centres like Addis Ababa facing the most pronounced effects.

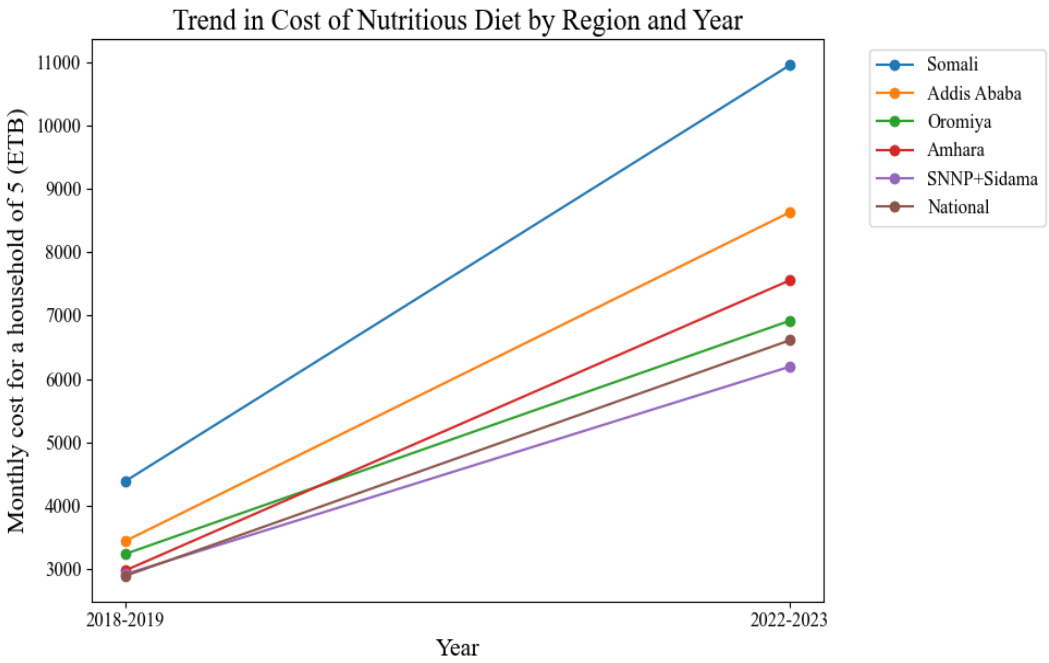


Figure 7.5. Cost of a nutrient adequate diet for a household of five at two different time periods by region in Ethiopia, 2018-2023.

Nutrient-adequate diets tended to cost more in areas with fewer foods available in local markets, reflecting regional differences in their availability. The relationship between the monthly cost of a nutrient-adequate diet for a household of five (in ETB) and market food diversity, measured by the number of available food items, is shown in Figure 7.6, across six Ethiopian regions. A strong negative correlation (r = -0.906) is observed, indicating that higher market food diversity is associated with lower diet costs. For example, Somali had the highest cost (~11,000 ETB) and relatively low diversity (~105 items), while SNNP and Sidama had the lowest cost (~6,000 ETB) and the highest diversity (~135 items). This pattern suggests that regions with greater food variety tend to offer more affordable nutrient-adequate diets, potentially due to improved market access and competition.

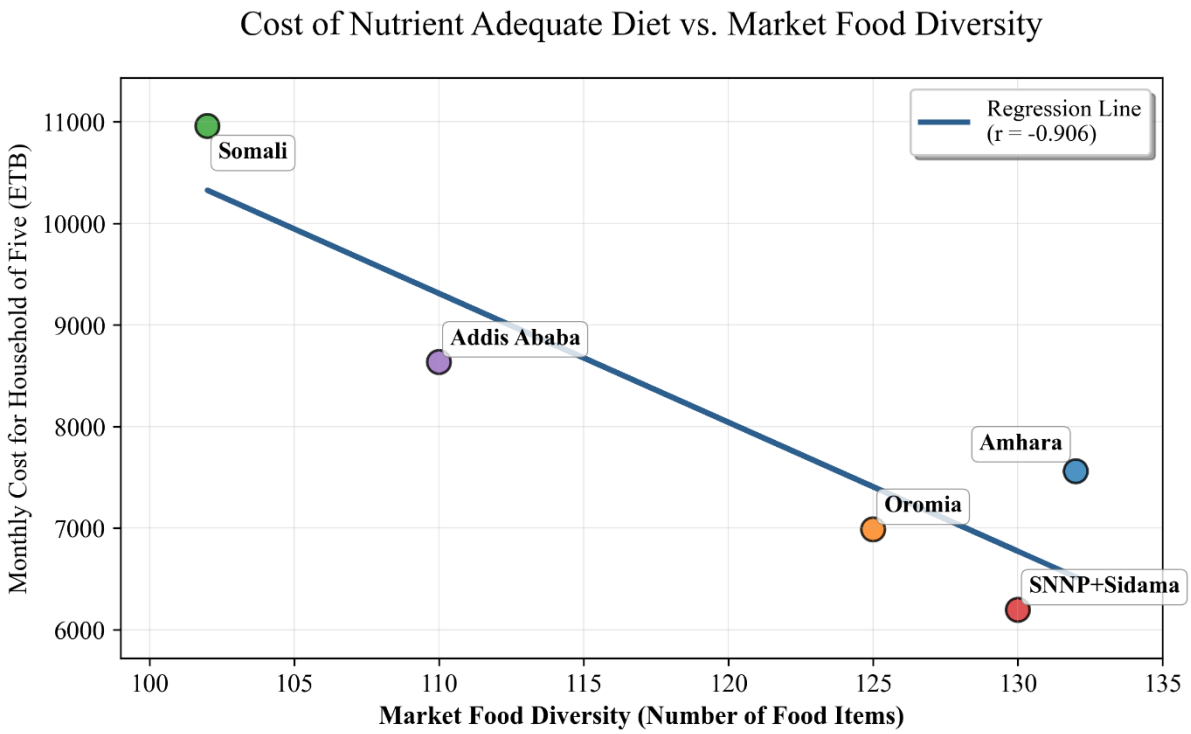


Figure 7.6. Monthly cost of nutrient-adequate diet vs. Market food diversity by region in Ethiopia, 2022-2023.

Figure 7.7 shows the regional average cost per kg of different food groups. Across all regions, animal-source foods (ASFs), such as meat and eggs, are more expensive per kg than crop-based foods like grains, legumes, and vegetables, while milk and milk products are relatively cheaper due to their high water content. It is important to note that the CotD model identifies foods for inclusion in the least-cost nutrient-adequate diet. In our analysis, as typical in CotD applications, the lowest-cost diets are primarily composed of crop-based foods, with ASFs included only in small amounts or not at all, depending on regional availability and cultural acceptability. Thus, although ASFs are nutrient-dense, their higher per-kg cost generally limits their contribution to the lowest-cost diets designed to meet nutrient requirements. Addis Ababa typically reports higher costs across multiple food groups, indicating potential affordability challenges in urban settings. These regional cost differences are critical for understanding barriers to access to nutritious diets and for tailoring interventions to improve affordability and dietary quality.

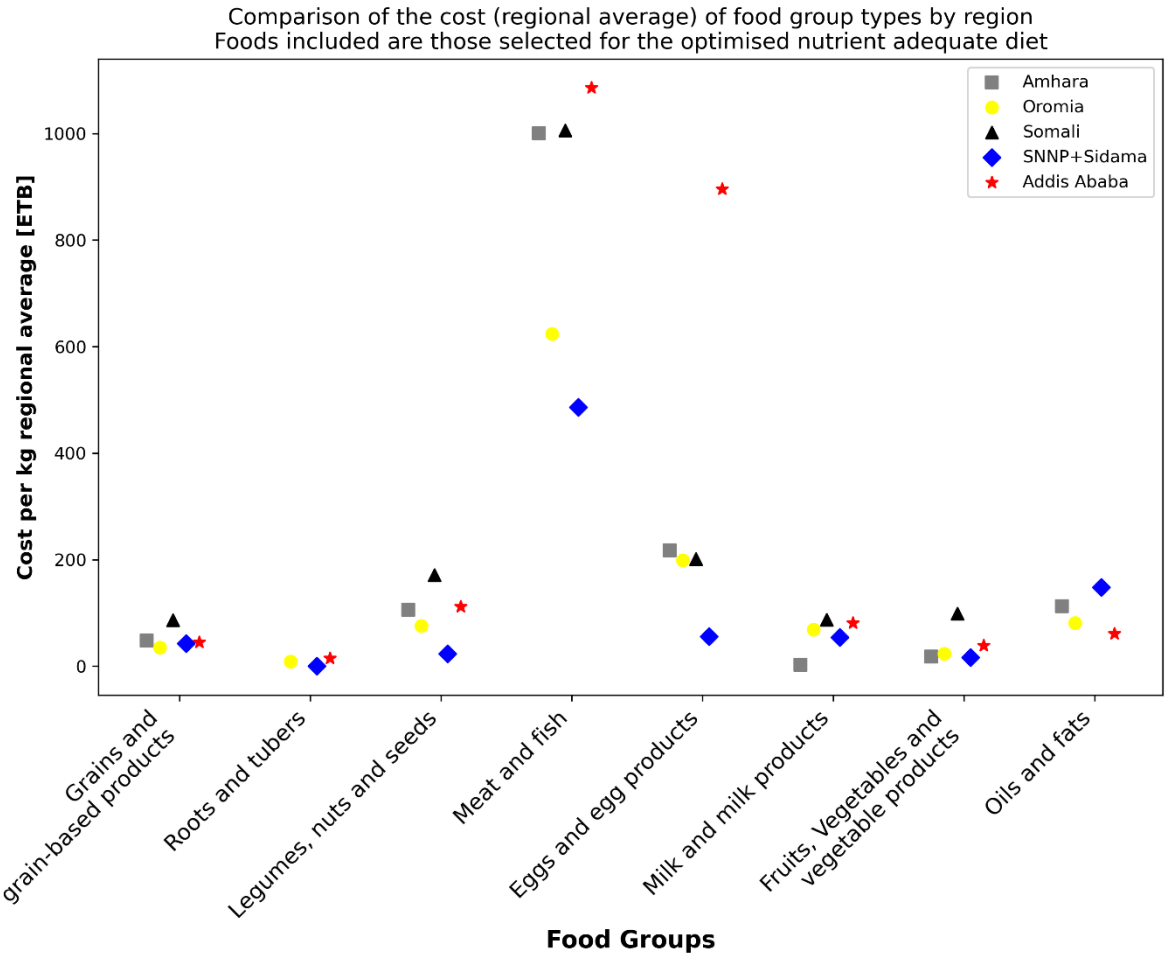


Figure 7.7. Regional comparison of average cost per kilogram of food groups for optimized nutrient adequate diets in Ethiopia (2022-2023).

Regarding the intra-household cost of a nutrient-adequate diet for a modelled household, the diets of adolescent girls and pregnant and lactating women (PLW) account for two-thirds of the total household cost for a nutritious diet for five people, as displayed in Figure 7.8. Nutritious diet costs are highest during adolescence and adulthood for girls and women, reflecting their needs for growth and reproduction. During adolescence, pregnancy, and breastfeeding, women require twice as much iron per kilocalorie as adult men or school-aged children. Foods rich in micronutrients (e.g., animal-source foods) typically cost more than foods low in micronutrients, making it more expensive to meet nutrient needs.

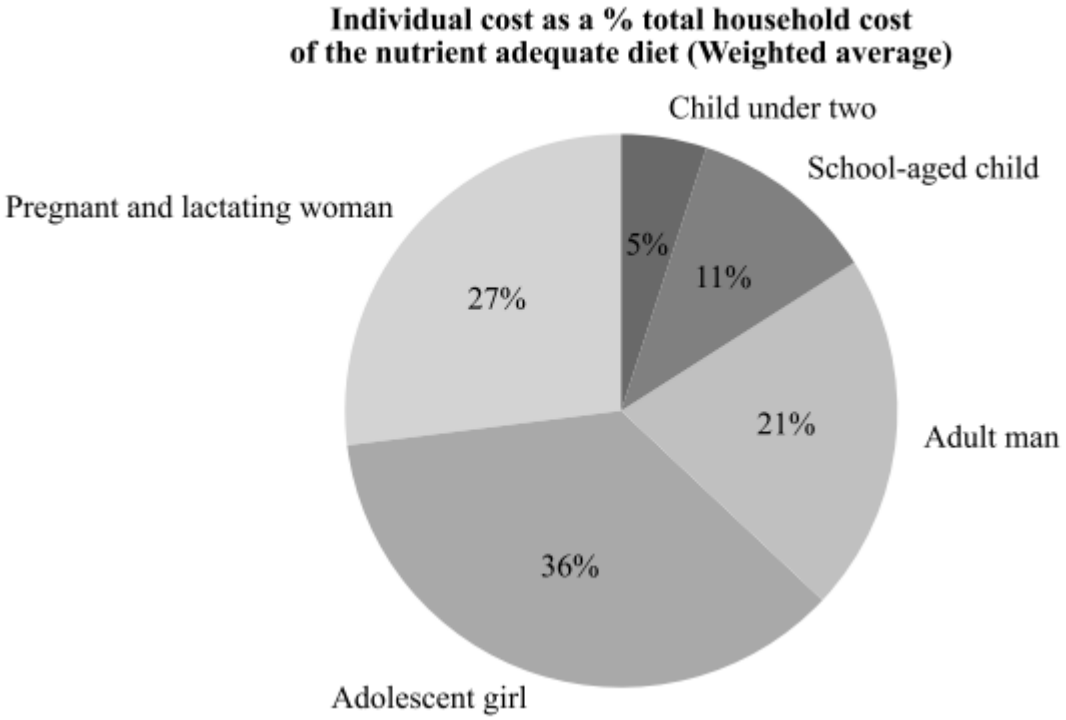


Figure 7.8. Intra-household share of the cost of a nutrient adequate diet calculated using the CotD model.

7.3.2. Affordability of a nutrient-adequate diet

Almost nine in ten households (87 percent) would be able to afford low-cost diets modelled to meet energy requirements alone, yet only one in three households would be able to afford a low-cost diet adequate in all nutrients (Figure 7.9). Considerable gaps were revealed between the amount the poorest 10 percent of households currently spend on food and the cost of a nutrient-dense diet, with the latter estimated to be up to five times as much as what households in the lowest-income decile typically spend.

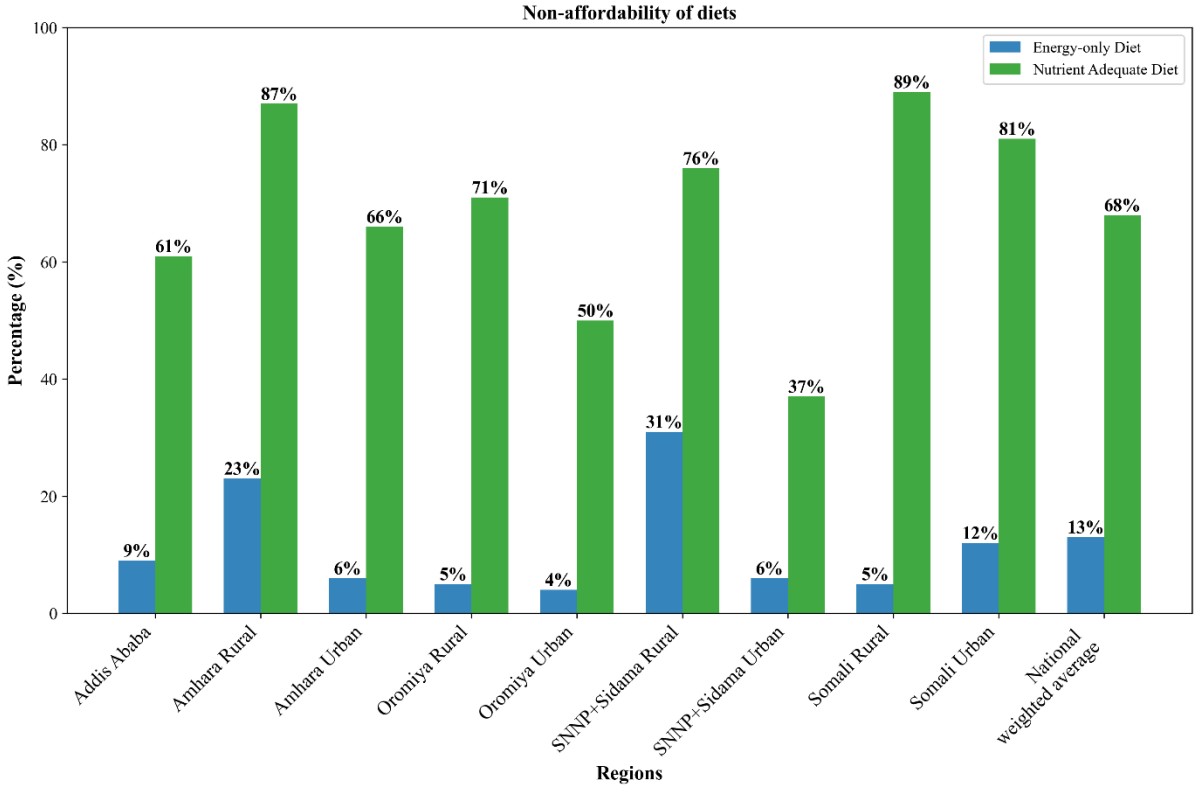


Figure 7.9. Percentage of households that would be unable to afford energy-only (blue) and nutrient-adequate (green) diets by rural-urban regions and the national average in Ethiopia (2022-2023).

7.3.3. Comparison of the current versus the modelled diet

Figure 7.10 shows a detailed comparison of the average composition of actual consumption and a modelled Cost of Diet (CotD) Nutrient Adequate Diet, based on the food weight of the dietary composition. This analysis reveals significant differences in dietary patterns, reflecting current eating habits and the nutritional adjustments proposed by the modelled diet to achieve adequacy.

In the current diet, grains are the predominant component, accounting for 47% of total food weight. This heavy reliance on grains underscores their role as a staple food source, likely driven by accessibility, affordability, and cultural dietary preferences. Roots and tubers rank second largest at 16%, indicating a supplementary reliance on starchy foods. Oils and fats contribute 8%, suggesting a moderate inclusion of energy-dense foods, while pulses, nuts, and seeds (6%), fruits (8%), and vegetables (5%) provide additional variety but in smaller proportions. Meat, eggs, and fish (2%), dairy (4%), sugar (2%), and herbs and condiments (3%) are the least-consumed categories, highlighting

limited intake of protein-rich and micronutrient-dense foods. This composition suggests a diet that prioritizes caloric intake over nutritional diversity, potentially leading to gaps in essential nutrients, including vitamins, minerals, and high-quality proteins.

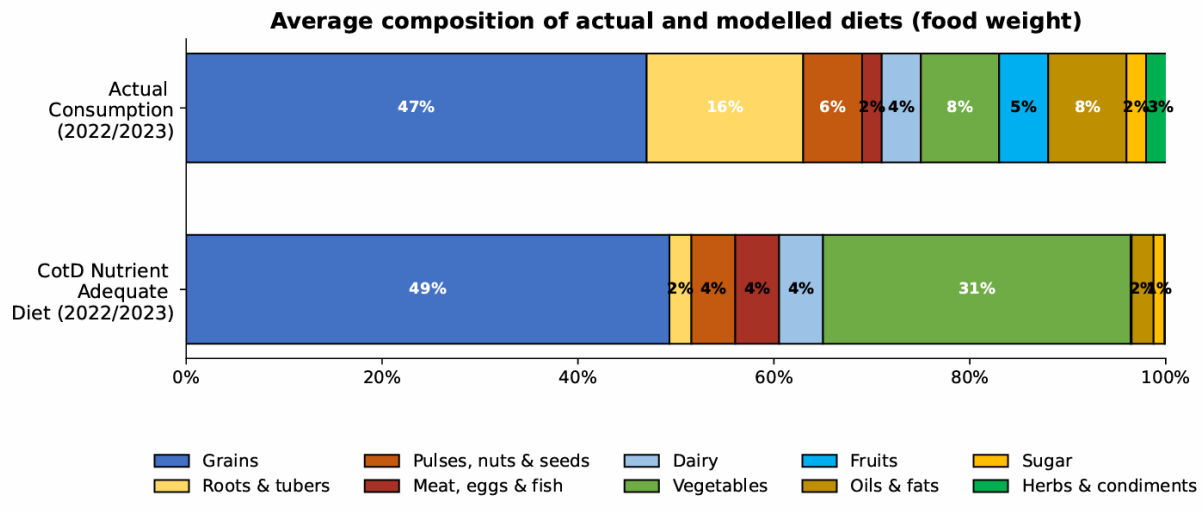


Figure 7.10. Comparative composition of actual consumption and modelled nutrient-adequate diets by food weight (2022/2023).

In contrast, the CotD nutrient adequate diet is designed to address these nutritional deficiencies, resulting in a more balanced distribution. Grains remain the most significant component at 49%, almost similar to the actual diet, indicating a continued reliance on staple cereals, which are a cheap source of nutrients, though with a shift toward greater diversity. A remarkable feature of the modelled diet is the substantial increase in the proportion of vegetables (31%) compared with their proportion in the current diet. This adjustment emphasizes the lowest-cost micronutrient-rich foods necessary to enhance the diet's nutritional profile. Roots and tubers see a sharp decline to 2% as the model prioritizes making room for more nutrient-dense options if available in specific areas, rather than calorie-dense foods. Pulses, nuts, and seeds (4%), meat, eggs and fish (4%), and dairy (4%) each contribute modestly, providing essential proteins and fats, while oils and fats, sugar, and herbs and condiments remain minimal.

7.3.4. Modelling the impact of specific interventions on diet cost and affordability

Building on the conceptual framework in Figure 7.2, which outlines key intervention points across the food environment to improve nutrition outcomes, this section examines how targeted changes can enhance the affordability and accessibility of nutrient-adequate diets. The CotD analysis in the preceding sections highlighted persistent gaps in dietary quality and affordability, particularly for vulnerable households. To address these gaps, a series of hypothetical yet policy-relevant intervention scenarios was modeled. These scenarios simulate improvements at different levels of the food environment—ranging from increasing household purchasing power and enhancing the nutrient content of foods to boosting the availability of nutritious foods and providing direct, targeted support to individuals. By assessing the potential impact of these interventions on the cost and affordability of a nutrient-adequate diet, this analysis provides insights into prioritized, context-specific strategies for improving dietary outcomes in rural Ethiopia.

Figure 7.11 illustrates the potential impact of household-level production diversification on the monthly cost of a nutrient-adequate diet, utilizing data from a pilot intervention in the Arsi zone of Oromia, one of the study areas (World Bank, 2019). The analysis compares three modelled diet scenarios across three seasonal periods: Harvest (October–January), Post-harvest (February–May), and Lean (June–September). The baseline scenario (light blue line) represents the lowest-cost nutritious diet composed exclusively of locally available market-purchased foods. The second scenario (dark blue line) incorporates a household potato surplus equivalent to typical excess production from the pilot intervention (assumed to be available at zero marginal cost to the household). The third scenario (green line) includes half of that potato surplus combined with a comparable surplus of home-grown spinach (also at zero marginal cost). This visualization highlights how incorporating surplus homegrown crops can mitigate seasonal cost fluctuations and offers insights into agricultural interventions to improve food affordability and nutritional security.

In the baseline market-only scenario, the cost of a nutritious diet rises steadily across the seasons—from 6,476 Ethiopian Birr (ETB) per household per month during harvest to 6,735 ETB post-

harvest and 7,551 ETB in the lean season. This pattern reflects reduced food availability and higher market prices during lean months, a common driver of seasonal food insecurity in rural Ethiopia.

Introducing potato surplus (dark blue line) lowers costs across all seasons—to 5,986 ETB (harvest), 6,389 ETB (post-harvest), and 7,122 ETB (lean)—achieving an average reduction of 7–8% relative to the baseline. Potatoes serve primarily as an energy-dense, storable staple that substitutes for more expensive purchased grains or roots, thereby reducing expenditures. Notably, potatoes were not selected in significant quantities in the baseline CotD model despite their local availability, because the model used prevailing market prices; the surplus introduced here is treated as "free" (zero additional cost) home production that would otherwise be underutilized, stored ineffectively, sold at low prices, or potentially wasted. This highlights an opportunity to improve dietary affordability by encouraging greater household consumption of existing surplus rather than relying on market purchases.

The greatest cost reductions occur when half the potato surplus is combined with the spinach surplus (green line), yielding costs of 5,355 ETB (harvest), 5,517 ETB (post-harvest), and 6,312 ETB (lean)—an average saving of 17–18% compared with the baseline. Spinach, a micronutrient-dense leafy vegetable, efficiently fills gaps in vitamin (especially vitamin A) and mineral (iron, calcium, zinc) intake, allowing the model to reduce reliance on more expensive market-sourced alternatives. Using only half the potato surplus in this scenario reflects nutritional constraints: excessive starchy foods cannot indefinitely substitute for other nutrient sources without violating dietary requirements or acceptability limits built into the model.

Like potatoes, spinach was selected only minimally in the baseline market-only diet because the CotD optimization prioritized the lowest-cost combination at market prices. The surpluses modeled here represent home-produced foods available to the household at zero marginal cost. Households with good market access might choose to sell such surpluses rather than consume them, creating an opportunity cost. However, pilot data from Arsi suggest that much of this surplus is

currently under-consumed or not fully utilized for household nutrition, indicating scope for behavior-change or extension interventions to promote home consumption alongside (or instead of) sale.

Overall, these findings—while context-specific to the Arsi zone—demonstrate that even modest diversification into storable roots (potatoes) and nutrient-rich vegetables (spinach) can substantially buffer seasonal cost increases and improve the affordability of nutritious diets, particularly when surplus production is directed toward household consumption.

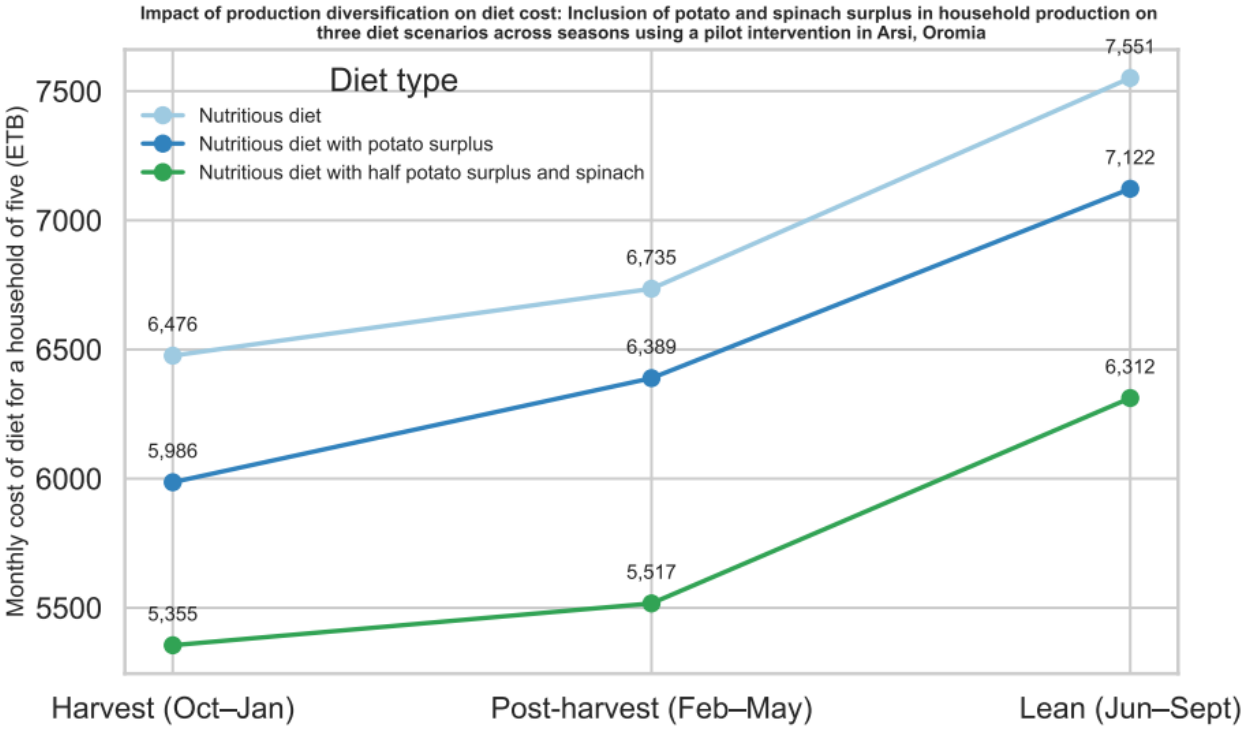


Figure 7.11. Impact of a specific agricultural intervention on the cost of a nutrient-adequate diet in the Arsi zone, Oromia region.

The figure illustrates the monthly cost of a nutritious household diet under three scenarios: (1) no agricultural intervention (Business as usual), (2) retention of a surplus of 20 quintals of potato for home consumption, and (3) diversification of production with 10 quintals of potato and 2.5 quintals of spinach retained for home use. Note: The additional impact of income generation from surplus produce is not included in the model.

A potential strategy for improving diet quality is to enhance the micronutrient content of staple foods through post-harvest fortification. In Ethiopia, while mandatory fortification of wheat flour has not yet been fully enforced, the Ministry of Trade and Industry has developed voluntary national standards that specify the composition and dosage of fortification premixes. These guidelines

recommend the addition of a micronutrient premix—containing key nutrients such as iron, zinc, folic acid, and B vitamins (including thiamine, riboflavin, niacin, pyridoxine, and vitamin B12)—at a rate of approximately 600 g per metric ton of wheat flour. The standards also define acceptable fortification levels to ensure both nutritional adequacy and safety.

If implemented effectively, access to fortified wheat flour through local markets could substantially improve household nutrient intake. The Cost of the Diet (CotD) analysis indicates that, depending on geographic context and market access, the availability of fortified wheat flour could reduce the cost of a nutrient-adequate diet by up to 19 percent (Figure 7.12). This highlights fortification's potential as a cost-effective intervention to address micronutrient deficiencies, particularly in settings where dietary diversity remains limited.

However, achieving these benefits requires more than the existence of standards. Strengthening regulatory frameworks to transition from voluntary to mandatory fortification, alongside incentives for private-sector compliance, is essential. Equally important are investments in implementation systems, including quality assurance, monitoring, and enforcement mechanisms, to ensure that fortified products consistently meet national standards. Without such operational support, the nutritional impact of fortification initiatives is likely to remain limited (GAIN, 2024).

The monthly cost of a nutritious diet for a family of five across six regions—Amhara, Oromia, Somali, SNNP and Sidama, and Addis Ababa—comparing two diet scenarios is presented in Figure 7.12. The diet scenarios are a baseline nutrient-adequate diet and the same diet with fortified wheat flour instead of ordinary wheat flour. The data, reflecting 2022/2023 trends, highlight the cost implications and percentage reductions achieved through fortification, offering a regional perspective on economic and nutritional interventions.

In the baseline nutrient adequate diet, costs vary significantly across regions. Somali exhibits the highest price at 10,957 ETB, potentially driven by higher food prices or logistical challenges, while SNNP records the lowest at 6,195 ETB, possibly due to local agricultural abundance and stronger market networks. Other regions fall within this range: Amhara (7,559 ETB), Oromia (6,987 ETB), and

Addis Ababa (8,634 ETB). This variability underscores the influence of regional factors such as market access and production costs on dietary expenses.

Before estimating cost implications, the model incorporated a multi-micronutrient fortification profile for wheat flour based on national standards set by the Ethiopian Ministry of Trade and Industry. The premix composition included vitamin B1 (9 mg/kg flour), vitamin B2 (6 mg/kg), niacin (50 mg/kg), vitamin B6 (6 mg/kg), folate (2 mg/kg), vitamin B12 (0.02 mg/kg), and zinc (80 mg/kg). These fortification levels were selected to address commonly observed micronutrient gaps, particularly in B vitamins and zinc, which are often limited in cereal-based diets. By enhancing the nutrient density of a widely consumed staple, the model assumes improved micronutrient adequacy without requiring substantial changes in dietary patterns.

The introduction of multiple micronutrient–fortified wheat flour reduces these costs across all regions, with the fortified diet costing between 5,466 ETB (SNNP) and 9,666 ETB (Somali). The percent reduction is indicated by a downward arrow, quantifying the impact on the cost of a nutrient-adequate diet and thereby improving affordability. Amhara records the largest reduction, at 18.5%, as shown in Figure 7.12. These reductions, averaging around 14%, suggest that fortified wheat flour effectively lowers the cost of achieving nutritional adequacy, with the most substantial savings observed in Amhara and Oromia, possibly due to higher baseline grain dependency. The consistent downward trend across regions indicates the broad applicability of fortification as a cost-mitigation strategy and as a potential intervention to alleviate micronutrient deficiencies.

The results further highlight the economic benefits of fortifying wheat flour, particularly in regions with higher baseline costs, such as Somalia, where the absolute reduction (1,291 ETB) is most significant. However, the modest reductions, such as those in SNNP, suggest that fortification's impact may be less pronounced where costs are already optimized, or grain usage is lower. The graph underscores the potential of fortified wheat as a scalable intervention to enhance the affordability of nutritious diets. However, its effectiveness may vary by region, warranting further investigation into local dietary patterns and market dynamics.

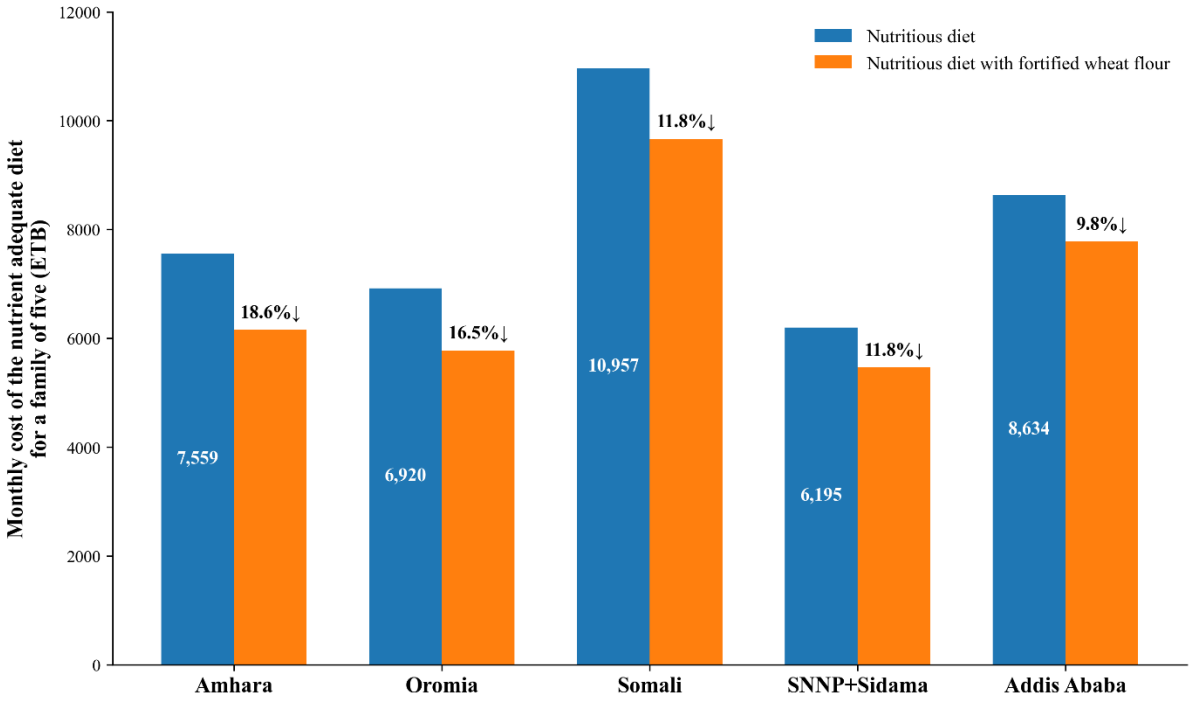


Figure 7.12. Cost of a nutritious household diet if the household could access fortified wheat flour on the market (at the same price as non-fortified wheat flour).

(Note: The figure does not reflect changes in food quantities or dietary diversity. It isolates the effect of substituting fortified wheat flour for conventional wheat flour on total diet cost, holding food consumption quantities constant.)

Table 7.2 presents a comparison of the minimum-cost nutrient-adequate diet composition, expressed in grams per day per person, along with their respective percentage contributions for two dietary scenarios: one without egg powder and another with egg powder incorporated. This analysis highlights the adjustments to food group allocations required to achieve nutritional adequacy at the lowest possible cost and illustrates the impact of fortifying dietary patterns with egg powder, following the cost-of-the-diet modelling approach described by Baye et al. (2021).

Table 7.2. Composition of the optimized diet by food group when a 2.5-gram egg powder is included in the daily diets of a household of five (adapted from Baye et al. 2021)

Food Group	Minimum cost of a nutrient adequate diet	
	Without egg powder	With egg powder
Grains and grain-based products	403.3 (44%)	416.3 (53%)
Roots and tubers	7.2 (1%)	12.3 (2%)
Legumes, nuts, and seeds	39.9 (4%)	41.3 (5%)
Meat	0.0 (0%)	0.0 (0%)
Fish and seafood	9.2 (1%)	9.2 (1%)
Eggs and egg products [a]	40.1 (4%)	2.5 (0.3%)
Milk and milk products	88.9 (10%)	115.6 (14.8%)
Vegetables and vegetable products	310.3 (34%)	164.2 (21%)
Fruits and fruit products	0.0 (0%)	0.0 (0%)
Oils and fats	14.1 (2%)	17.9 (2%)

[a] In line with the optimisation strategy described by Baye et al (2021), the linear programming model replaces 'eggs and egg products' with egg powder as a lower-cost, nutrient-dense alternative in the optimized diet scenario. Source: Adapted from Baye et al. 2021

In the "Without egg powder" scenario, grains and grain-based products dominate the diet, accounting for 44% of total intake, reflecting their role as a cost-effective staple. Vegetables and vegetable products are the second-largest component (34%), underscoring their importance for micronutrient intake and dietary fibre. Milk and milk products contribute 10% of the diet, serving as key sources of calcium and protein. Eggs and egg products (40.1 g/day) are included to meet micronutrient and protein requirements in the baseline optimized diet.

The introduction of egg powder in the "With egg powder" scenario results in notable shifts in food-group composition. Grains and grain-based products increase slightly to 416.3 g/day (53%), reinforcing their role as dietary staples under constrained costs. The inclusion of egg powder substantially reduces the allocation to vegetables, as the optimization model substitutes nutrient-dense egg powder for more costly sources of selected micronutrients. Milk and milk products increased to 115.6 g/day (14.8%), reflecting their relative cost-effectiveness in providing calcium and other micronutrients when vegetable intake is reduced. Eggs and egg products decline sharply to 2.5

g/day (0.3%) due to the high nutrient concentration of egg powder relative to whole eggs, thereby reducing the quantity required to satisfy nutritional constraints.

Legumes, nuts, and seeds (41.3 g/day; 5%), oils and fats (17.9 g/day; 2%), and roots and tubers (12.3 g/day; 2%) show modest increases, indicating minor compensatory adjustments to maintain nutritional adequacy. However, the reduced vegetable intake observed in these optimized scenarios may bring certain nutrient intakes—such as vitamin C and dietary fibre—closer to their minimum constraint levels, even though all requirements are satisfied within the Cost of the Diet (CotD) framework.

7.4. Discussion

This study reveals notable regional differences in the affordability of nutritious diets in Ethiopia, highlighting both structural and seasonal factors within the food environment. The fact that nutrient-adequate diets cost three to six times more than energy-only diets underscores a persistent gap between meeting caloric needs and achieving nutritional quantity and quality. The higher costs of a nutrient-rich diet in Somali and urban areas such as Addis Ababa are linked to limited local food diversity and higher transaction costs, respectively, consistent with trends reported by Ameye et al. (2021). The strong negative correlation between food market diversity and diet cost ($r = –0.90$) in this study underscores the importance of diverse food availability across production and marketing systems for improving access to affordable, nutritious foods.

The CotD assessment, which uses linear programming to identify the lowest-cost combination of local foods that meet nutrient requirements, selected green leafy vegetables (mainly spinach and Ethiopian kale), eggs, and dairy (milk and yogurt) as key affordable sources to fill micronutrient gaps (particularly iron, calcium, zinc, and vitamin A) after accounting for energy and macronutrients from staple foods. However, staple grains such as maize, wheat, teff, and sorghum—which the model constrained to reflect typical household consumption frequencies and regional predominance—

formed the primary, low-cost base of the optimized diets, providing most of the energy and contributing to nutrients such as iron (especially from teff) and zinc, though with limited bioavailability.

The analysis showed the gap between current eating habits and a more balanced, optimized diet. While relying on grains and starch-based foods may meet basic energy needs, it can also cause deficiencies in essential micronutrients, especially among vulnerable groups. The CotD nutrient-adequate diet, however, provides a guide for improving dietary quality by promoting higher intake of nutrient-rich foods, including vegetables. The nutrient-adequate diet identified by the CotD analysis is practical and feasible, as it relies exclusively on locally available foods at current market prices and incorporates typical household consumption frequencies of staple grains. Widespread adoption of this diet would, however, require increased production and consumption of fruits, vegetables, and legumes to meet micronutrient needs. This shift could offer additional environmental and resource advantages, as plant-based foods generally require less land, labour, water, and other agricultural inputs per unit of nutrient density than animal-source foods. Evidence from food-systems research shows that horticultural production generally uses fewer resources per unit of micronutrient output and can lead to greater improvements in dietary quality than livestock production (FAO, 2019a). This analysis highlights both the benefits of dietary diversification and the broader challenges faced by food systems as they transition from a cereal-based, low-diversity diet to a nutritionally balanced one that, in theory, the market could support.

Seasonal patterns of the cost of a nutrient-adequate diet — with price surges during lean periods — reflect agricultural seasonality and supply constraints. Studies show consistent intra-annual peaks in staple and nutritious food prices before harvest and associated seasonal declines in dietary diversity and affordability (Bai et al., 2020; Hirvonen et al., 2016; Sibhatu et al., 2015).

The findings reveal that the affordability of a nutrient-dense diet remains low, with only one-third of households able to afford it. This situation highlights the interaction between rising food prices and stagnant real incomes (Bachewe et al., 2017). The 129 percent increase in the cost of a nutrient-dense diet from 2018 to 2023 reflects macroeconomic inflation, COVID-19, and climate shocks that

have disrupted food distribution and access, consistent with observations by The World Bank (2022) and the Global Nutrition Report (2022).

The findings from this chapter underscore the need for multifaceted, multisectoral actions to improve access to and affordability of nutritious diets in Ethiopia. Strategies should focus on enhancing food diversity by promoting agricultural diversification and small-scale irrigation to enable out-of-season production of nutrient-rich foods such as vegetables and legumes (Awulachew et al., 2010; Biru et al., 2025); investing in improved post-harvest storage technologies to reduce losses and stabilize year-round availability and prices (FAO, 2019b; Tesfaye and Tirivayi, 2018); strengthening and scaling mandatory large-scale food fortification programs for staples such as wheat flour, oil, and salt to enhance nutrient content (Tang et al., 2025) and supporting rural income growth through livelihood diversification, productive safety nets, and off-farm opportunities to bridge the affordability gap for vulnerable households (Baye and Hirvonen, 2020).

The intra-household distribution of nutrient-adequate diets shows disparities based on gender and life stage. Notably, the dietary needs of adolescent girls and pregnant and lactating women (PLW) account for two-thirds of total household nutrition spending, reflecting their higher physiological demands (Joint FAO/WHO Expert Consultation, 2004). This highlights the need for targeted nutrition-specific interventions, such as supplementation and nutrition-sensitive Productive Safety Net Programs (PSNP), along with livelihood initiatives that include Behaviour Change Communication (BCC) to promote fair food sharing within households (Berhe et al., 2019; Irenso and Atomsa, 2018; Ruel et al., 2018).

The modelling results show that household production diversification, such as potato-spinach combinations, led to a clear cost reduction of up to 18 percent in an adequate nutrient diet, indicating that smallholder crop diversification can help families cope with seasonal food shortages. Similar results from the Horti-LIFE project emphasize the importance of integrating nutrient-rich vegetables into farming systems to improve diet quality and economic stability (Ethiopian Ministry of Agriculture and SNV, 2019).

Micronutrient fortification also demonstrates promise as a cost-effective intervention. The analysis indicates that including multiple micronutrient-fortified wheat flour in the diet could reduce costs by about 14 percent nationwide if it is available at the same price as regular wheat flour, aligning with evidence from fortification trials across Sub-Saharan Africa that show improved cost-to-nutrition ratios and micronutrient status (Adams et al., 2024; Cardoso et al., 2019; Coomson et al., 2025). Fortification is especially relevant in Ethiopia, where wheat is a staple, but its success depends on robust regulation and private-sector involvement to ensure premix quality and sustained coverage (Hafebo et al., 2015). Similarly, adding egg powder lowered overall costs while still providing adequate nutrition, meeting energy, protein, fat, and 13 micronutrients. Controlled trials demonstrate that eggs significantly enhance nutrient adequacy and child growth when affordable (Iannotti et al., 2017; Lutter et al., 2021).

7.5. Conclusion

This study shows that achieving a nutrient-adequate diet in Ethiopia remains a significant economic challenge for most households, with costs higher in areas of low food diversity and high reliance on markets. By integrating the Cost of the Diet (CotD) analysis with the thesis's earlier findings—particularly the relationships among local food environments, agricultural diversity, market access, and dietary quality—the results highlight how structural constraints directly translate into unaffordable nutrient requirements for many population groups. The CotD estimates demonstrate the economic implications of the food environmental barriers identified throughout the study, reinforcing the conclusion that improving nutrient adequacy cannot be achieved through a standalone intervention.

The analysis indicates that enhancing market food diversity, promoting agricultural diversification, and implementing effective fortification strategies can substantially reduce dietary costs and improve affordability. These recommendations build on the thesis's broader insights, which show that regions with more diverse food environments and stronger market integration offer

households better opportunities to meet nutrient needs. It is essential to prioritize interventions targeting women and adolescent girls within national nutrition strategies, as they face relatively higher nutrient costs and greater vulnerability—an issue that aligns with the thesis's emphasis on life-stage nutritional disparities.

Strengthening supply chains, supporting local production of nutrient-dense foods, and adopting cost-saving technologies, including fortification and biofortification, are vital to sustainable progress toward affordable, healthy diets. Taken together, these findings link the behavioral, environmental, and economic dimensions explored throughout the thesis, underscoring the need for coordinated investment across the agriculture, trade, and social protection sectors. Such alignment will be critical to translating the thesis's evidence-based recommendations into practice and ultimately making nutritious diets feasible and accessible for all Ethiopians.

7.6. Chapter summary

This chapter extended the analysis to the economic dimension of the food environment by estimating the cost and affordability of nutrient-adequate diets across regions and seasons. Using cost-of-the-diet modeling, it assessed whether local food environments can support nutritionally adequate diets and identified affordability gaps faced by households.

This chapter contributes to the thesis by translating food-environment constraints into concrete economic terms and highlighting affordability as a critical bottleneck that links food availability to actual consumption. By quantifying the cost of meeting nutrient requirements and identifying potential intervention scenarios, the chapter provides policy-relevant evidence that complements the dietary and production-focused analyses in earlier chapters. It reinforces the thesis's central conclusion that improving diet quality in Ethiopia requires not only increased food availability, through market or home production, but also targeted actions to reduce the cost of nutritious diets and improve household purchasing power.

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8. Chapter Eight: General Discussion and Conclusion

8.1. General discussion

The earlier chapters detailed the quantitative analyses from the household survey, the qualitative insights from focus group discussions (FGDs) and key informant interviews (KIIs), and the cost of the diet (CotD) modelling. This chapter synthesizes these findings into an integrated discussion of how structural, economic, and sociocultural factors interact within Ethiopia's evolving food system, in light of the research questions set out in Chapter 1. It examines broader theoretical, policy, and methodological implications, emphasizing how this study from Ethiopia contributes to food systems research in low- and middle-income countries (LMICs).

This discussion is structured around the analytical framework used in this study (Figure 8), which illustrates how the four individual study chapters collectively explore the food environment and its effects on diet quality in Ethiopia. Four specific studies guide this integrated discussion:

- The relationship between the food environment and dietary quality among women and households.
- The impact of home production diversity and seasonality on the nutrient intake of women and children.
- Community perceptions of the food environment, highlighting the socioeconomic and cultural factors that influence food access and dietary choices.
- The cost and affordability of a nutrient-adequate diet across the study regions of Ethiopia.

Collectively, the four analyses provide insights into how market conditions, production practices, economic factors, perceptions, and constraints interact to affect dietary quality and nutrient adequacy in Ethiopia, particularly for its most vulnerable social groups.

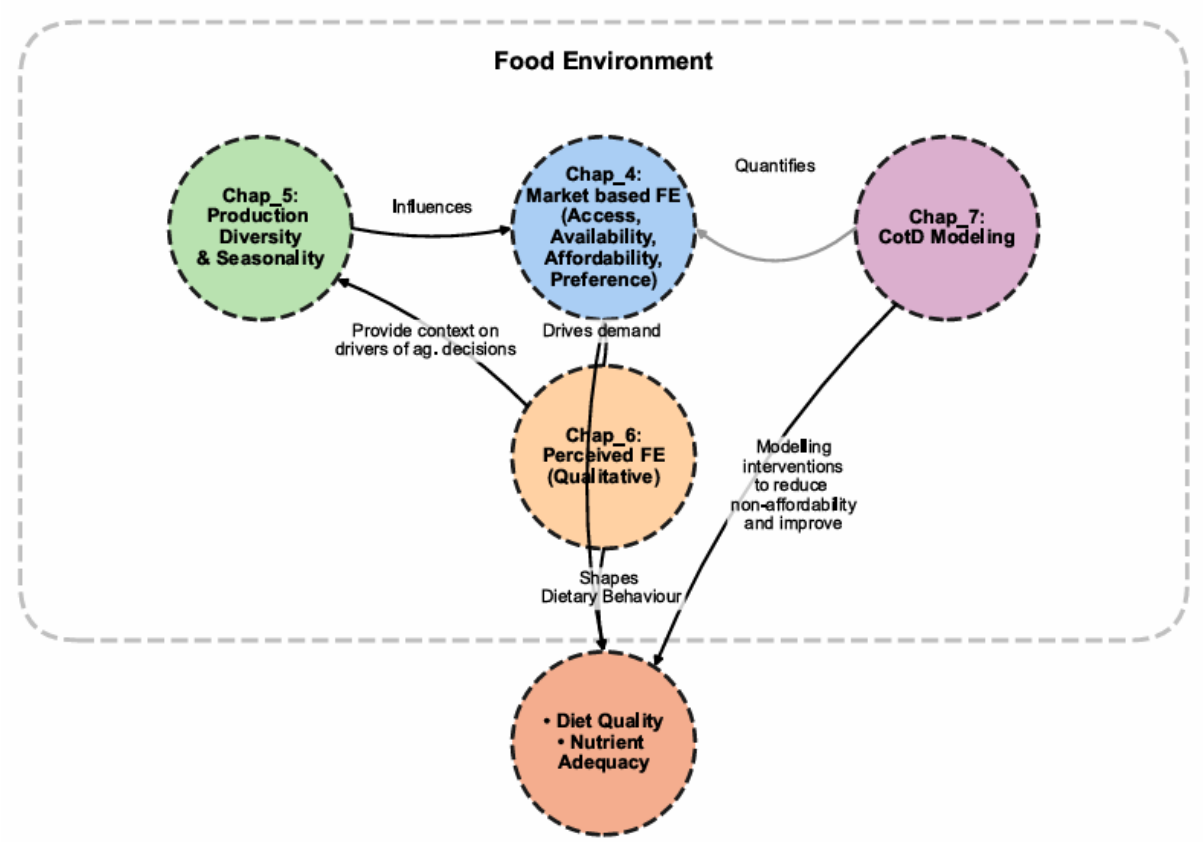


Figure 8.1. A simplified framework illustrating the connection of the individual food environment studies within the PhD thesis.

There is limited empirical research examining how various aspects of the food environment influence dietary quality in low-income settings, such as Ethiopia. To address this gap, a composite food environment (FE) score was developed and utilized in this study, as detailed in Chapters 4 and 5. The purpose of this composite score was to offer a multidimensional evaluation of the food environment—covering availability, accessibility, affordability, convenience, desirability, and supporting infrastructure—and to assess its combined effect on household and women's dietary outcomes.

The food environment (FE) score was designed to capture both physical and economic access to a diverse diet, providing a more comprehensive and integrated understanding of the FE's influence. For analytical purposes, households were grouped into low, medium, and high food-environment categories, allowing the model to compare diet-quality outcomes across differing levels of FE performance. This framework makes it possible to examine how the dimensions of the food

environment jointly influence multiple measures of diet quality, including the Women's Dietary Diversity Score (WDDS), the Global Diet Quality Score (GDQS), the Fruit and Vegetable Score (FVS), and the Household Dietary Diversity Score (HDDS).

The findings reveal that women living in households with high food environment scores achieved significantly higher dietary outcomes than those in households with low scores. This relationship remained consistent across several measures of dietary quality. The analysis showed that key factors influencing dietary outcomes were food diversity in nearby markets, affordability, and market proximity, indicating that improvements in these areas have the greatest potential to enhance nutritional adequacy.

The study highlights the synergetic impact between the FE dimensions. For example, while individual improvements, such as higher food availability scores or greater market diversity, can improve dietary diversity score indicators, the magnitude of nutritional benefits is limited unless paired with greater affordability or improved infrastructure. When markets offer a wider variety of foods, these may still be inaccessible to low-income households if prices are too high or transportation systems are inadequate. These findings emphasize the need for a comprehensive approach that addresses multiple facets of the food environment simultaneously to achieve lasting improvements in diet quality.

In low-income settings like Ethiopia, affordability remains a significant challenge. Even when a variety of foods are available, high prices often restrict the purchase and consumption of nutrient-rich foods. The analysis revealed that bridging the affordability gap—defined as the difference between household food expenditure and the minimum cost of a healthy diet—led to a 33% increase in the Fruit and Vegetable Score (FVS). This clearly demonstrates that improved financial access (through higher income or lower food prices) correlates with significantly higher fruit and vegetable scores (FVS) and hence intake.

However, these same affordability improvements had only a weak impact on the Global Diet Quality Score (GDQS). This difference occurs because FVS counts the total number of unique food

items consumed (regardless of quantity or nutritional value within categories), while GDQS is specifically designed to measure healthy dietary patterns. The GDQS assigns higher points to protective food groups (such as fruits, vegetables, nuts, fish, and other animal-source foods) eaten in moderate to high amounts and penalizes excessive intake of high-risk groups (such as red meat, processed foods, and sweets). Importantly, GDQS uses graded scoring based on the calculated quantity of each food group consumed, rather than just presence or absence.

In this context, the modest GDQS improvement likely reflects improved financial access, allowing households to add more plant-based items (fruits and vegetables). However, it is still not enough to overcome the much higher costs and access barriers for animal-source foods (dairy, eggs, fish, and meat). These animal-source foods carry particularly high GDQS point values when consumed in nutritionally meaningful amounts. Therefore, while households may have diversified their diets, including fruits and vegetables, in terms of variety (well captured by FVS), this shift was insufficient to significantly alter the overall nutrient density and balance of their diets, as measured by GDQS.

Beyond economic factors, convenience and preference-related aspects of the food environment significantly influenced dietary choices according to the findings. Households that reported consumption of certain foods they desired to consume were more likely to have higher WDDS and FVS scores. Prior research has shown that factors such as time availability and household workload influence the ability to prepare diverse and nutritious meals (Melesse and Van Den Berg, 2021; Roba et al., 2024; Yalew et al., 2025). These results highlight the importance of incorporating behavioral insights into food environment frameworks to better understand how dietary decisions are made.

Infrastructure development, particularly improvements in all-weather road networks and market connectivity, significantly enhances dietary diversity. Better infrastructure reduces physical barriers, lowers transportation costs, and encourages more trade in nutrient-rich foods. These findings align with earlier research by Abay and Hirvonen (2017), who demonstrated that improved rural connectivity increases food availability and dietary variety.

The composite FE score offers a new, data-driven tool for identifying spatial and socioeconomic disparities in the food environment. It could enable researchers and policymakers to visualize areas of relative advantage and disadvantage, supporting the development of geographically targeted nutrition interventions.

The findings from this study indicate that the food environment performance in Ethiopia remains uneven and inequitable, with pronounced spatial and socioeconomic disparities that directly contribute to nutritional inequalities among women. These patterns align with and help explain persistently low levels of dietary diversity observed nationally. While our analysis shows that women's dietary outcomes vary substantially by household food environment, the national average indicates that only about 20% of women meet the Minimum Dietary Diversity for Women (MDD-W) threshold. These findings suggest that widespread inadequacies in women's diets are not only a matter of individual or household characteristics but are structurally linked to inequities in the food environment across regions and socioeconomic groups.

To draw comprehensive conclusions about dietary outcomes and nutritional adequacy in Ethiopia, it is important to recognise that home food production, in particular the diversity and seasonality of production, is a key factor shaping the food environment and, in turn, improving nutritional outcomes. Although food environment frameworks often emphasise market-based availability, accessibility, and affordability, in predominantly agrarian settings such as Ethiopia, home-grown production plays a central role in food choice and consumption. For many rural households, own-farm production determines not only what foods are available, but also when they are accessible throughout the year. Consequently, the diversity of crops produced and seasonal variations in production strongly influence the year-round availability and affordability of nutritious foods. Seasonal fluctuations in crop yields and market supplies can therefore either exacerbate or mitigate existing nutritional inequalities, particularly among women and children.

In settings where households rely heavily on their own farm production, the variety of crops and livestock they raise is crucial for ensuring year-round access to nutrient-rich foods. The findings

show that increased production diversity consistently correlates with better dietary adequacy, especially for key micronutrients such as iron, zinc, calcium, and vitamin A. Similar patterns have been seen across sub-Saharan Africa, where diverse farming systems boost resilience to seasonal shortages and improve household food and nutrition security (Jones, 2017; Bakhtsiyarava and Grace, 2021; Ahmed et al., 2023). Diversification also serves as a buffer against market and seasonal shocks, providing households with more stable access to nutritious foods throughout the year (Jones et al., 2014).

However, the findings of this study also reinforce a key insight from prior research: increased production diversity does not automatically lead to better nutritional outcomes unless it results in the actual consumption of diverse foods. Determinant factors identified through both regression analysis and qualitative evidence in this study highlight several structural and behavioral barriers that weaken the farm-to-plate link. Land constraints, recurrent droughts, and limited irrigation capacity limit farmers' ability to grow diverse crops. Even when nutrient-dense foods are produced, households often sell them to meet urgent cash needs, as seen in other contexts like Tanzania and Nepal (Harris-Fry et al., 2017; Bai et al., 2020). These dynamics reflect a broader tension between income generation and nutritional goals, underscoring that production diversity improves diet quality only when households have both the resources and incentives to retain nutrient-rich foods for home consumption.

Seasonality further complicates these relationships. Dietary diversity and nutrient adequacy increase modestly after harvest but drop sharply during lean seasons, reflecting the cyclical patterns of food insecurity seen in farming systems (Hirvonen et al., 2016; Sibhatu and Qaim, 2017; Stevens et al., 2017; Bonuedi et al., 2021; Aweke et al., 2022). These results emphasize that seasonal fluctuations in production and market supply remain key drivers of nutritional vulnerability, especially for women and children. Ensuring year-round access to a variety of foods, therefore, requires measures beyond diversification—such as improved storage, preservation, and market integration.

Gender aspects of agricultural production have implications for nutrition, as the qualitative study reveals (see Chapter 6). Women's limited decision-making power over farm income and production choices often restricts how much increased diversity can improve diets. Similar gender differences in control over food resources have been observed in four African and Asian countries, where men usually decide on crop sales while women handle meal preparation (Quisumbing et al., 2021). Additionally, cultural practices such as fasting and food taboos can reduce intake of nutrient-rich foods, even when these foods are available—a pattern also observed in earlier studies from Ethiopia and East Africa (Harris-Fry et al., 2015; Potts et al., 2019).

Agroecological differences also influence the link between production diversity and nutrient intake. For instance, agropastoral systems boost calcium intake because dairy is readily available in livestock-dominated livelihoods, whereas cereal–pulse systems are generally more effective for iron. However, even in more diverse systems, nutrient gaps persist, indicating that diversification must be supported by market, behavioral, and infrastructural factors to achieve genuine nutritional improvements.

Overall, the findings show the importance of production diversity and seasonality in the Ethiopian food environment. These factors are closely connected to market access, affordability, and infrastructure—meaning efforts in agriculture and the food system must be coordinated to achieve nutrition-sensitive outcomes. Similar to the broader food environment analysis, production diversity alone cannot fully address ongoing nutrient deficiencies without improvements in market connectivity, household decision-making power, and year-round food access.

Together, these findings highlight that while production diversity and seasonal patterns affect the physical availability of foods, they do not solely determine what households ultimately eat. Nutritional outcomes are also influenced by people's perceptions of their food environment, the cultural and social norms guiding food use, and the behavioral trade-offs households make in response to economic or seasonal pressures. Therefore, understanding diet quality in Ethiopia requires looking

beyond structural food availability to explore the cognitive, cultural, and behavioral factors that shape daily food choices.

The qualitative findings highlight a complex interplay among material constraints, sociocultural norms, and household behavioral adaptations that shape the food environment in rural Ethiopia. While quantitative results showed that availability, accessibility, and affordability are key factors affecting diet quality, the qualitative analysis explains why improvements in these areas might not fully lead to better dietary intake. In line with emerging global evidence (Herforth and Ahmed, 2015; Downs et al., 2020), perceptions, norms, and intra-household dynamics influence how people navigate their food environments, affecting both food acquisition and consumption.

A key insight is that households operate within a complex, risk-aware food environment, relying on their own production, markets, social networks, and seasonal coping strategies (Maxwell et al., 2014; Roba et al., 2019). This diversified approach reflects adaptive behavior in response to widespread resource limitations—such as limited land, unpredictable rainfall, and fluctuating market prices—but it also normalizes nutritional vulnerability during lean seasons (Bakhtsiyarava and Grace, 2021). Similar patterns are observed across East Africa, where households balance production and food purchases to meet basic calorie needs but often struggle to consistently access nutrient-rich foods (Koppmair et al., 2017; Lachat et al., 2018).

Crucially, the study demonstrates that perceptions of affordability and value are powerful determinants of food choice. Although fruits, vegetables, and animal-source foods (ASFs) may be physically available, they are widely perceived as too expensive for regular consumption and are instead reserved for special occasions. These findings underscore affordability as a central constraint shaping dietary quality and are consistent with a broader body of evidence showing that nutritious diets remain economically inaccessible for low-income households (Bai et al., 2020). Perception acts as a behavioral filter; unless foods are perceived as affordable, they are effectively absent from the diet, regardless of actual availability.

The findings further emphasize the powerful social and cultural forces that influence dietary choices. Religious fasting imposes a significant restriction on nutrient intake, reducing consumption of ASFs for extended periods. Although fasting is a key part of Ethiopian Orthodox identity, its nutritional effects—especially decreases in iron, zinc, and vitamin A—are well documented (Kimani-Murage et al., 2011; Potts et al., 2019). These insights highlight that cultural practices should be integrated into nutrition-sensitive agriculture and behavior change strategies rather than treated as minor influences.

Gendered power relations also deeply influence diet quality. Although women are often responsible for preparing meals, they frequently lack control over income and food choices, limiting their ability to purchase or maintain access to nutrient-rich foods. This aligns with evidence from South Asia and Africa showing that women's decision-making power is directly linked to improved dietary diversity and child nutrition (Harris-Fry et al., 2017; Quisumbing et al., 2021). The current findings indicate that gender constraints worsen the affordability barrier: even when markets provide a wider variety of foods, women may not be able to act on their nutritional knowledge without economic independence. Time poverty worsens these issues. Women described how long hours spent on farm work and heavy domestic responsibilities limited the time available to prepare a diverse range of meals, even when a variety of foods was available. This aligns with broader evidence that time constraints greatly limit dietary variety in rural Africa (Yalew et al., 2025). As a result, relying on quick-to-make staples becomes a main way to cope with labor shortages.

Insights from interviews with key informants highlight institutional limitations that weaken the supportive environment for healthy diets. Although both the agriculture and health sectors recognize their complementary roles—producing diverse foods on one hand and promoting nutritious consumption on the other—coordination remains limited (Burchi et al., 2011; Chea et al., 2025). These governance gaps mirror earlier critiques of Ethiopia's multisectoral nutrition policies, where inconsistent implementation, weak accountability structures, and fragmented institutional responsibilities have repeatedly constrained policy effectiveness (Hirvonen et al., 2017; Hawkes et al., 2020).

The findings highlight perceived access, cultural norms, gender power dynamics, and institutional capacity as key behavioral and structural issues in the food environment. They clarify why simply improving availability or market diversity hasn't led to widespread dietary improvements, and why nutrition-sensitive interventions must go beyond production or affordability to address sociocultural realities and household decision-making processes.

The analysis of the CotD provides evidence about the economic barriers that restrict households' access to nutritious diets in Ethiopia. The results reveal a clear difference in affordability between calorie-only diets and nutrient-rich diets. While nearly 90% of households could afford an energy-only diet, only about one-third can afford a diet that meets essential micronutrient needs. The fact that nutrient-rich diets cost three to six times more than energy-only diets underscores the severity of the affordability gap and helps explain the ongoing issues of stunting (39%), micronutrient deficiencies, and poor maternal diets reported nationwide (EPHI, 2023).

A key factor driving high unaffordability is the limited diversity in market food environments and the high prices of nutrient-rich foods. Chapter 7 showed a strong negative correlation between market food diversity and the cost of nutrient-adequate diets ($r = –0.90$), indicating that regions with fewer available foods, such as Somali and parts of Amhara, face higher diet costs. This supports broader evidence that limited market diversity restricts competition, raises prices, and limits low-income households' ability to access nutrient-dense foods, as argued by Ameye et al. (2021).

Seasonality further worsens these barriers. In certain regions, the cost of nutritious diets rises sharply during the lean season due to reduced local food availability, higher transportation costs, and greater reliance on markets. Evidence from elsewhere in Ethiopia and East Africa shows seasonal spikes in food prices and corresponding drops in dietary diversity, especially among women and children (Bai et al., 2020; Hirvonen et al., 2016). In line with the earlier section on home production diversity and seasonality, the CotD results show that seasonal changes in affordability primarily affect households' ability to secure sufficient nutrient intake, and that interventions must address both the timing and location of food access.

This study also highlights significant differences in nutrient requirements and costs by gender and life stage. Cost-of-diet modelling shows that meeting the nutrient needs of adolescent girls and pregnant or lactating women (PLW) accounts for nearly two-thirds of the total cost of a nutrient-rich diet for a typical rural Ethiopian household, a pattern documented in similar analyses across low-income settings (FAO, 2020). This estimate is based on a reference household comprising two adults, one adolescent girl (14–18 years), one school-age child (7–10 years), and one under-five child (<5 years). The higher cost contribution associated with adolescent girls and pregnant and lactating women reflects their greater physiological nutrient requirements relative to adult men, as widely documented in the nutrition literature (Joint FAO/WHO Expert Consultation, 2004). Moreover, many nutrient-dense sources of these micronutrients, including animal-source foods, fortified products, and adequate amounts of dark-green leafy vegetables, are relatively expensive or seasonally scarce in rural Ethiopia (Baye, 2021; Hirvonen et al., 2017). Consequently, meeting the nutrient needs of adolescent girls and PLW accounts for the largest share of the modelled diet cost. These findings support the argument that women and adolescent girls in low-income contexts bear a disproportionate burden of poor dietary quality, reinforcing the need for targeted interventions such as supplementation, income support, and gender-responsive behavior change communication (Lassi et al., 2020; Ruel and Alderman, 2013).

A key insight from the modelling results is the potential for agriculture-based strategies to reduce the cost of nutritious diets under specific conditions. In areas where potato production exceeds immediate household consumption, a portion of the surplus is often intended for market sale but may be lost due to poor market access, price volatility, or limited storage. In such contexts, incorporating some of this otherwise underutilised production into household diets, when combined with greater production of dark leafy vegetables such as spinach, was associated with a 7–18% reduction in the cost of nutrient-adequate diets, with the most significant benefits observed during lean seasons. This finding does not imply the absence of opportunity costs —for example, selling potatoes could generate income to purchase other foods —but rather highlights a potential pathway through which improved

use of home-produced foods—especially where market constraints limit effective monetization—can complement dietary diversification efforts. In the case of sweet potatoes, both the tubers and the nutrient-rich green tops may offer additional scope to enhance diet quality at relatively low cost. This supports a growing body of evidence that nutrition-sensitive agriculture, especially the inclusion of nutrient-dense vegetables and small livestock, can protect families against seasonal food shortages and improve dietary quality (Sibhatu and Qaim, 2018; Ethiopian Ministry of Agriculture and SNV, 2019).

However, as shown in earlier chapters, the nutritional benefits of production diversity are realized only when diverse crops are grown for household consumption rather than sold in income markets. Qualitative findings as set out in Chapter 6 highlight that several key barriers often lead households to prioritize marketable crops over nutritious ones: high input costs (especially for improved seed and fertilizer), limited land access or inability to reserve plots for less commercially attractive crops (such as legumes, vegetables, or indigenous nutrient-dense varieties), and insufficient agronomic knowledge or extension support for profitably growing diverse species. When these barriers are significant, increased production is less likely to improve diets, emphasizing that one's own production contributes to better nutrition only when it is possible to keep crops for home use and when these input, land, and knowledge barriers are adequately addressed.

Fortification also proves to be a cost-effective approach. Adding multiple micronutrient-fortified wheat flours can lower diet costs by as much as 19% in some areas, supporting global evidence that staple-food fortification significantly boosts micronutrient intake without changing eating habits (Adams et al., 2024; Cardoso et al., 2019). Likewise, using egg powder reduces the cost of meeting nutrient needs by replacing more expensive animal-source foods with a concentrated, cheaper micronutrient source—an approach backed by controlled trials showing the nutritional advantages of affordable egg-based interventions (Iannotti et al., 2017). However, the success of fortification relies on strong regulation, dependable supply chains, and consumer acceptance, all of which vary across Ethiopia.

Despite the potential of these interventions, structural barriers still exist. Regional differences in market integration, transportation infrastructure, and food storage capacity contribute to high transaction costs, especially in remote and drought-prone areas. Studies show that poor road connectivity and limited cold-chain infrastructure hinder the movement of perishable, micronutrient-rich foods, increasing rural–urban inequalities in diet affordability (Abay and Hirvonen, 2017). Additionally, inflationary pressures, conflict-related supply disruptions, and the lingering effects of COVID-19 might have further strained households' purchasing power, leading to a 129% increase in the cost of nutritious diets between 2018/19 and 2022/23, as detailed in Chapter 7.

8.2. Key findings and synthesis

This thesis shows that diet quality significantly improves when various access factors—specifically, physical, economic, and infrastructural—interact synergistically rather than independently. Physical access is enhanced by a diverse selection of market foods, providing a variety of nutritious options. Economic access, including household income and the affordability of nutritious foods, plays a crucial role in determining what individuals can buy and regularly consume.

Supporting infrastructure, such as functioning roads, banking services, and efficient transportation options, was significantly associated with improved diet-quality indicators and served as a means of access. For example, proximity to the nearest bus station enables consumers to reach various food markets more easily and helps ensure fresh produce is available. When these elements—physical access, economic access, and infrastructure—work together, they create an environment where people can make better dietary choices, ultimately leading to improved dietary outcomes in communities.

The evidence from this thesis highlights several clear priorities that emerge directly from the findings presented in Chapter 4. First, the observed spatial and socioeconomic disparities in diet quality indicate that strengthening rural market infrastructure—including improved roads, storage facilities, and reliable transport—is fundamental to improving access to diverse and affordable foods.

In Chapter 4, households located farther from markets and with poorer physical access consistently faced higher costs for nutrient-adequate diets and lower dietary diversity, underscoring the central role of market functioning in shaping food-environment inequities. These findings suggest that investments in market infrastructure are not only complementary to nutrition-sensitive agriculture but are essential for translating agricultural production into improved dietary outcomes. Many of the bottlenecks in the availability of diverse foods and price fluctuations identified result from weak market linkages that restrict the flow of perishable foods, especially fruits and vegetables. Rural market and transport infrastructure, such as all-weather roads and market centres, can reduce travel time and transport costs by 20–40%, thereby significantly improving access and affordability in the food environment. Expanding cold-chain capacity would help reduce seasonal losses and encourage farmers to invest more confidently in nutrient-rich crops, as the current losses of perishable produce in Ethiopia range from 30–50% according to a report by Debebe (2022). Small-scale solar-powered cold rooms have the potential to reduce post-harvest losses by 25–35% and increase shelf life by 50%, according to a study by Amjad et al. (2023), enabling farmers to retain more diverse production for home consumption and obtain better prices.

Second, diversifying production systems is a vital strategy not just for increasing food production but also for stabilizing household diets across seasons and improving dietary quality as explained in Chapter 5. However, evidence consistently shows that production diversity enhances nutrition only when supported by effective market linkages that reduce the pressure to sell all nutrient-rich crops. Combining diversification with targeted market incentives—such as offering extension support for high-value fruits and vegetables, establishing local aggregation centres, improving rural infrastructure, or providing guaranteed off-take agreements—can encourage the production and retention of nutrient-dense foods for home consumption while maintaining income opportunities. Without these incentives, smallholder farmers often favor marketable cereals or cash crops over diverse, perishable, nutrient-rich species due to high transaction costs and post-harvest risks.

Third, the findings of this thesis suggest that priorities should be on affordability and access barriers, which are the most significant constraints across the studies. Affordability was a major issue in the market-oriented food environment, with CotD modeling showing that 37–90% of households cannot afford a nutrient-adequate diet, mainly due to the high cost of iron- and calcium-rich foods for adolescent girls and pregnant or lactating women. Qualitative evidence also highlighted perceived high costs and cultural preferences as primary reasons households avoid animal-source foods and certain fruits and vegetables, even when they are seasonally available.

The qualitative findings highlight the significant role of sociocultural and behavioral factors, particularly fasting norms and gendered power dynamics. Evidence from previous studies similarly indicates that cultural restrictions can often offset the benefits of improved market access or production diversity (Aemro et al., 2013; Kimani-Murage et al., 2011; Nguyen, 2018). Aligned with behavioural nutrition frameworks, the findings show that food choices are shaped not only by the objective food environment but also by cultural norms, social perceptions, and household power dynamics. These findings highlight the importance of comprehensive interventions that not only improve economic and agricultural conditions but also challenge restrictive fasting norms, improve awareness of perceptions on nutritious foods, and promote equitable household decision-making.

The cost of diet modeling highlights a major concern: nutrient-rich diets remain unaffordable for many low-income households. The strong inverse relationship between market diversity and diet cost supports global evidence that improving supply chains, market connections, and competition can reduce the cost of nutritious foods. However, the modeling also shows that affordability is not solely an economic issue: cultural acceptance, awareness, and trust also play a role in whether households adopt cost-saving innovations such as fortification or preservation.

Although this study does not directly evaluate integrated multisectoral interventions within a single experimental design, which would require a different methodological approach, the convergent findings align closely with and provide empirical support for a growing consensus in the literature. Specifically, prior work argues that sustained improvements in nutrition outcomes are most likely

when interventions simultaneously address supply-side constraints, such as agricultural production and market functioning; demand-side determinants, including affordability and household income; and behavioral factors related to food choice, knowledge, social norms, and convenience (Ruel and Alderman, 2013; Fanzo et al., 2020). The consistency between the patterns observed in this study and these established frameworks reinforces the relevance of integrated food systems and nutrition strategies in contexts such as Ethiopia.

Improving nutritional outcomes in Ethiopia requires addressing not only food availability but also the structural factors that influence affordability and access. A comprehensive approach, including agricultural diversification, market expansion, food fortification, poverty alleviation, and gender-sensitive initiatives, is essential to close the nutrient adequacy gap. Upgrading infrastructure, stabilizing food prices, and diversifying market supply are crucial for making nutritious diets affordable for all households, especially the most vulnerable.

8.3. General conclusion

This thesis explored the complex relationship between the food environment and dietary quality in Ethiopia, with particular focus on women of reproductive age and young children. By breaking down the food environment into its market-based and personal aspects (food diversity in market, physical access, affordability, desirability, and convenience), own-production features (crop diversity and seasonal stability), and behavioral factors (perceptions, cultural norms, and intra-household decision-making), the study offers a context-specific understanding of why nutrient-rich diets are still out of reach for many households.

Reflecting on the key quantitative evidence, a clear conclusion emerges. Although each aspect of the food environment shows statistically significant, independent links to dietary quality, the effects of individual dimensions are modest. Their full nutritional potential is realized only when multiple constraints are removed simultaneously. The regression results show that improving any single domain of the food environment improves the expected counts of food groups or items consumed by

5–20% (IRRs mostly range from 1.05 to 1.20). However, when all external and personal food-environment domains are combined, households in the highest quintile of the composite score consume diets that are 27–47% more diverse across outcomes such as WDDS, FVS, GDQS, and HDDS than those in the lowest category (Chapter 4). This substantial increase in effect size far exceeds the sum of individual domain contributions, confirming notable synergistic and overlapping explanatory variance.

This means that although each dimension makes a unique and identifiable contribution—as expected in any well-structured multivariate framework—the substantive improvements in dietary quality are significantly greater when households experience simultaneous improvements across multiple domains. Interventions focusing on only one constraint (e.g., building roads without addressing price barriers or promoting crop diversification without tackling gendered preferences) will therefore yield noticeable yet inherently limited nutritional gains. Conversely, coordinated, multidimensional strategies that improve market functioning, reduce economic barriers, stabilize own-production, and influence behavioral factors offer the most promising path toward transformative change in diet quality and nutrient adequacy in Ethiopia. This key finding, consistently supported across the four papers of this thesis, provides strong empirical evidence for current calls to move beyond sectoral silos and toward genuinely integrated food systems and nutrition programs.

An important contribution of this thesis is the development of a composite food environment (FE) score based on six dimensions of the FE. The FE score revealed significant spatial and socioeconomic disparities in the food environment and demonstrated that higher FE scores are consistently associated with better dietary outcomes. Another contribution involves demonstrating that production diversity and seasonality are essential aspects of the food environment, particularly in rural communities. The results confirmed that diverse farming systems increase micronutrient intake and help households manage seasonal shortages. However, structural barriers, such as land constraints, climate change, and market incentives that favor selling over consuming nutrient-rich foods, limit the extent to which increased production diversity improves nutrition. These findings

challenge the idea that diversification alone suffices and instead highlight the importance of a comprehensive approach that includes market-based, gender-based, and behavior-change initiatives.

The qualitative findings deepen and expand the quantitative analysis by revealing aspects of the food environment that the survey data only partially captured. While the quantitative models included variables such as the perceived importance of certain foods, gender, and religion, these measures were necessarily limited—for instance, gender was represented primarily through the household head, and religious fasting was treated as a binary response and did not show a significant impact. As a result, these factors were not examined in their full complexity. The qualitative evidence indicates that these factors operate in much more nuanced ways: perceived availability and affordability, fasting practices, women's limited decision-making power, and culturally rooted norms influence when and how households consume fruits, vegetables, and animal-source foods, even when such foods are physically available or locally produced. By revealing these behavioral and sociocultural mechanisms, the qualitative analysis explains why some quantitative associations are weak or inconsistent and where unmeasured influences may be present. Together, these approaches demonstrate that food environments in Ethiopia are not just physical and economic systems, but also social spaces shaped by norms, beliefs, and power dynamics—dimensions that future interventions need to address to improve dietary quality and nutrient intake.

The Cost of Diet analysis reveals that most households cannot afford a nutritious diet, especially during lean seasons, and that market diversity significantly affects its cost. Scenario modeling highlights promising strategies—including fortification, diversification of production systems, and the use of nutrient-dense substitutes such as egg powder—that can substantially reduce the cost of meeting nutrient needs. However, persistent infrastructural weaknesses, regional disparities, and governance challenges continue to restrict the reach and effectiveness of these interventions.

In summary, these contributions build on existing research by demonstrating that improving nutrition requires a systems approach—one that recognizes the interconnectedness of agricultural

production, market systems, cultural norms, and household behaviors. This thesis shows that food environments are dynamic and context-specific, influenced by local agroecological conditions, sociocultural expectations, seasonal cycles, and economic realities. In Ethiopia, where women and children face disproportionate challenges due to poor dietary quality and micronutrient deficiencies, addressing these interconnected barriers is essential for reaching national nutrition goals.

8.4. General recommendations

8.4.1. Policy Implications

The findings point to several actionable priorities:

- Investments in infrastructure—especially rural roads, storage facilities, and market linkages—are essential to enhancing access to a variety of foods and lowering seasonal price fluctuations.
- Targeted affordability interventions, such as fortification, vouchers, cash transfers, and subsidies for nutrient-rich foods, are essential to bridge the nutrient adequacy gap.
- Behavior change strategies must address cultural norms, fasting practices, gender roles, and time poverty, especially among women of reproductive age.
- Local food environment monitoring tools, like the composite FE score created here, can help support more accurate and geographically focused nutrition interventions.
- Integrated, multisectoral programming is crucial. Nutrition-sensitive agriculture, market development, and gender empowerment need to be coordinated so that each reinforces the others rather than operating in silos. The qualitative findings offer several concrete illustrations. Women described limited control over household income, restricted decision-making power in food purchases, and time constraints shaped by unpaid care work. These constraints often diluted the benefits of improved production or market access. Coordinated action could therefore include:

  – Agricultural programmes that explicitly target women with training, inputs, and control over the crops they manage;

– Market and price-stabilisation policies that recognise women's limited mobility by supporting closer, safer, and better-stocked local markets;

– Social and behavioural interventions that address intra-household decision-making, including joint budgeting or nutrition-focused community dialogues; and

– Labour-saving technologies or childcare support that reduce the time burdens identified in qualitative inquiry.

8.4.2. Research Implications

This thesis emphasizes several priorities for future research.

- Tracing pathways from the food environment to nutrition outcomes. While anthropometric measures are common, they are affected by many factors beyond food access and diet. Future research should develop and use more specific nutrition indicators—such as biomarkers, nutrient Adequacy Ratios, individual-level diet quality scores, and time-sensitive intake data—to better understand how changes in the food environment affect nutritional status.
- Designing and testing scalable, multisectoral interventions. Given the interconnected barriers identified in this thesis, future research should evaluate integrated approaches that combine agricultural diversification with improved market access, policies that enhance affordability (such as cash or voucher transfers linked to diet costs), and behavior-change programs tailored to local norms and decision-making structures.
- Assessing the impact of climate variability on seasonal food environments. Although climate change is not a primary focus of this thesis, the findings highlight the importance of home production in shaping diets. As extreme temperatures, droughts, and unpredictable rainfall increase, households will need more resilient and diverse production systems. Further research is necessary to understand how climate shocks affect seasonal food availability, prices, and dietary patterns—and how rural markets and infrastructure (especially roads and storage facilities) can be reinforced to withstand these pressures.

Overall, these research avenues could enhance understanding of how changing food environments influence what people eat and help develop more effective strategies to improve dietary quality in Ethiopia and similar settings.

8.5. Final reflections

Ultimately, this PhD thesis demonstrates that improving dietary quality in Ethiopia requires not only making foods physically available and economically accessible, but also understanding how households perceive, value, and utilize foods within their social, cultural, and economic contexts. Central to this contribution is the development and application of an innovative food environment score, which offers a practical and systematic way to measure the performance of local food environment. The food environment approach adopted in this thesis enabled a comprehensive assessment of the multiple, interconnected factors shaping dietary quality, integrating agricultural production, market access, affordability, seasonality, and sociocultural influences. By combining quantitative and qualitative evidence, the thesis provides a nuanced understanding of how these factors interact to influence nutrition outcomes. The findings underscore that sustained improvements in dietary quality will require strong political commitment, cross-sectoral collaboration, and locally grounded solutions that reflect community realities.

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