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基礎設施可及性與史瓦帝尼王國家戶糧食不安全之研析

Examining the Role of Infrastructure Access in Household Food Insecurity in Eswatini

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Examining the Role of Infrastructure Access in

Household Food Insecurity in Eswatini

本論文係 Sibusiso Agape Lushaba (R12627039) 在國立臺灣大學生農學院農業經濟學系暨研究所完成之碩士學位論文，於民國 114 年 6 月 11 日承下列考試委員審查通過及口試及格，特此證明。

The undersigned, appointed by the Department of Agricultural Economic, College of Bioresources and Agriculture on June 11, 2025, have examined a Master's Thesis entitled above presented by Sibusiso Agape Lushaba (R12627039) and hereby certify that it is worthy of acceptance.

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My family and friends, with heartfelt thanks to my mother, whose tireless prayers and unwavering belief in me were a constant source of strength. Your love and encouragement sustained me every step of the way.

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DEDICATION

This thesis is dedicated to the Almighty God, whose unfailing love, grace and mercy made this journey possible. The opportunity to pursue and complete this Master's degree is a manifestation of a long-standing prayer and a dream fulfilled. Through every challenge and moment of doubt, it was God's presence, strength, and provision that sustained me. To God be all the glory and honor for this answered prayer and making this academic milestone a reality.

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CHINESE ABSTRACT

本研究探討基礎設施與資訊通訊技術（Information and Communication Technology, ICT）可及性對史瓦帝尼王國家戶糧食不安全（food insecurity）之影響。研究資料取自 2016/17 年具全國代表性的史瓦帝尼家庭收入與支出調查（Eswatini Household Income and Expenditure Survey, EHIES），共計 3,066 戶樣本，並採用有序與廣義有序 logit 模型，分析家戶糧食不安全程度量表（Household Food Insecurity Access Scale, HFIAS）與糧食消費分數（Food Consumption Score, FCS）；HFIAS 主要衡量與糧食獲取相關的心理壓力與主觀經驗，FCS 則用以評估飲食多樣性與營養充分性。研究結果顯示，資訊通訊技術（特別是廣播與網路）以及實體基礎設施（如安全供水與衛生設施）之可及性，有助於提升家戶的糧食安全。此外，較高的家庭收入與戶長教育程度亦為重要的保障因素；反之，糧食價格上升與氣候衝擊則顯著加劇糧食不安全。結合 HFIAS 與 FCS 的異質性分析進一步揭示兩類特殊家戶：「沉默匱乏」型（quietly deprived）之糧食困境可透過改善清潔用水與衛生設施獲得緩解；而「糧食充足卻焦慮」型（anxious but well-fed）則因基礎設施的可及性減少其極端糧食不安全情形。綜上所述，本研究顯示 HFIAS 與 FCS 兩指標的整合能更精準描繪家戶糧食不安全的多元面貌，並指出強化實體與數位基礎設施、提升教育水平與社會保障體系之重要性，對制定跨部門糧食安全政策具高度參考價值。

關鍵字：糧食不安全，基礎設施可近性，糧食消費分數，家戶糧食不安全程度量表

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ENGLISH ABSTRACT

This study examines the role of physical and ICT infrastructure in shaping household food insecurity outcomes in the Kingdom of Eswatini. It uniquely combines two complementary measures: The Household Food Insecurity Access Scale (HFIAS), which captures psychological distress and subjective experiences related to food access, and the Food Consumption Score (FCS), which assesses dietary diversity and nutritional sufficiency, using nationally representative data from the 2016/17 Eswatini Household Income and Expenditure Survey (EHIES) covering 3,066 households. The study revealed a complex picture of food insecurity using ordered and generalized ordered logit models for both the HFIAS and FCS measures. Household food security was consistently improved by ICT (particularly radio and the internet) and physical (improved water and sanitation) infrastructure, however, the strongest overall protection was provided by higher income and education. Shocks related to the market and climate exacerbated food insecurity, and larger households were more vulnerable despite better consumption scores. Two hidden profiles emerged from heterogeneity analysis: "quietly deprived" households, whose inadequate diets are mitigated by stable leadership and decent access to Water, Sanitation and Hygiene (WASH), and "anxious but well-fed" households, whose dietary adequacy is offset by infrastructure gaps and shock exposure. These findings demonstrate that combining HFIAS and FCS captures both visible and hidden types of deprivation and points to the need for multisectoral action, expanding physical and digital infrastructure, strengthening education and social protection systems, and institutionalizing the use of multi-dimensional monitoring systems to support equitable and evidence-based policy making.

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Keywords: Food insecurity, Infrastructure access, Food consumption score, Household food insecurity access scale

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CHAPTER 1 INTRODUCTION

1.1 Background

The world remains significantly behind in achieving Sustainable Development Goal 2, Zero Hunger (FAO;, 2024). As reported by the Food and Agriculture Organization of the United Nations (FAO), approximately 2.33 billion people (28.9% of the world's population) faced varying degrees of food insecurity, from moderate to severe in 2024. Of these, 864 million people (10.7%) were classified as severely food insecure, indicating that individuals had occasionally exhausted their food supplies and, in worst cases, endured an entire day without food to eat. In 2023, 9.1% of people were affected by undernourishment, a crucial indicator of world hunger, up from 7.5% in 2019 (FAO;, 2024). Since 2020, the situation has remained largely unchanged following a sharp rise due to the COVID-19 pandemic (FAO;, 2024).

While some countries have made significant progress in reducing hunger and malnutrition, others, particularly the African continent, remain the most affected region, with an estimated 58% of the population enduring mid to high levels of food insecurity in 2023, nearly double the global average. Extreme deprivation affects 21.6% of the continent's population, with Middle Africa recording the highest prevalence (77.7%), Eastern Africa (64.5%), and Western Africa (61.4%). Southern Africa (24.9%) and Northern Africa (33.8%) had lower, yet still concerning, levels of food insecurity (FAO;, 2024). FAO's projections indicate that by 2030, Africa is expected to be home to over half of the global undernourished population. Without significant intervention, food insecurity is expected to persist at crisis levels.

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Food insecurity is driven by a complex web of interconnected and overlapping factors. Armed conflict displaces millions of people and exacerbates food crises by disrupting supply chains and systems for food production. Climate change manifests in extreme climatic conditions such as droughts, floods, and unpredictable rainfall that lower agricultural production and exacerbate food price volatility. Economic downturns resulting from the COVID-19 pandemic, the Ukraine conflict, and global inflation further reduce household purchasing power. As a result, nearly 2.83 billion people worldwide cannot afford food due to the rising costs of nutritious diets, which reached $3.96/day in 2022, indicating an 11% increase (FAO;, 2024). Additionally, systemic injustices, including gender inequality, further increase food insecurity among women and marginalized groups. These detrimental effects highlight the urgent need for structural transformation to achieve sustainable food security levels rather than temporary relief.

Southern Africa is home to the tiny landlocked economy of the Kingdom of Eswatini, whose economic livelihood largely depends on exports and export revenue. However, the nation's export base remains narrow, primarily composed of limited commodities, and the inability to diversify and grow its export industry enough to effectively generate sufficient employment and alleviate widespread poverty (Manual, 2019). Currently, approximately 59% of the people in Eswatini faces living condition below the poverty threshold, and one-fourth lives in extreme poverty (IMF, 2023). Despite its economic classification (lower-middle-income), these figures indicate deep vulnerabilities and rooted inequalities. Additionally, recent droughts have also put one in four individuals at risk of food and water shortages. Reliance on markets and humanitarian relief is growing as maize output fell 12.04% in the 2023–2024 agricultural season, only reaching 53% of the country's needs

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(IPC, 2024). The latest analysis by the Integrated Food Security Phase Classification (IPC) developed by the FAO, estimates that around 243,000 individuals (20%) in Eswatini are currently in Crisis (IPC3), Emergency (IPC4), and Catastrophe/Famine (IPC5) severity of acute food insecurity. This figure is projected to increase to 304,000 (25%) of the total population by 2025.

Eswatini's ICT and physical infrastructure are developing, although significant disparities persist, particularly between urban and rural areas. While approximately 82.3% of the population has access to electricity (Macrotrends, 2022), largely due to initiatives such as the World Bank's ASCENT initiative, domestic energy production remains insufficient to meet national demand in 2022. Access to water and sanitation has significantly improved in urban areas, however, rural communities face considerable challenges in accessing these essential services. In the ICT sector, mobile use is common, and internet penetration has reached between 57.6 percent yet fixed broadband connectivity remains limited, and data costs are among the highest in the region (datareportal dated March 2025). Regardless of the presence of a nationwide fiber-optic backbone and rising digital infrastructure, rural connectivity remains poor. These infrastructure deficiencies constrain equitable development, economic resilience, and food security.

Despite various policy frameworks, including international interventions like the UN Sustainable Development Goals and the Paris Agreement, and national strategies such as climate-resilient agricultural initiatives and social safety nets, the deeper systemic causes of food insecurity have not been sufficiently addressed in Eswatini. The effectiveness of these interventions has been undermined by structural problems such as low rural development, market dependency, and restricted access to infrastructure. The persistent nature of food

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insecurity points to a more serious systemic issue that goes beyond temporary solutions and calls for a deeper comprehension of vulnerabilities at the household level. Therefore, understanding the influence of physical and ICT infrastructure access, socioeconomic factors, and exposure to shocks on household food security is critically important. With limited empirical data that breaks these aspects down meaningfully in Eswatini, this gap significantly hampers the development of efficient, targeted, and long-lasting solutions aimed at improving food security outcomes.

1.2 Research question

The primary question driving this study is. "In what ways does access to physical and ICT infrastructure influence household food security outcomes in Eswatini?"

1.3 Objectives

The study seeks to investigate how access to physical and ICT infrastructure influences household food security in Eswatini, using the Food Consumption Score (FCS) and the Household Food Insecurity Access Scale (HFIAS) to evaluate both objective and subjective food insecurity dimensions.

1.4 Research Focus and Significance

This study examines the influence of access to physical and ICT infrastructure on household food security outcomes in Eswatini. Although a substantial body of literature exists on food security in larger developing nations like South Africa, Nigeria, and Kenya, there remains a notable gap in research focused exclusively on structurally constrained economies like Eswatini. These smaller countries often face unique vulnerabilities such as limited infrastructure, a small geographical mass, substantial economic dependency on neighboring countries, and large rural populations, which are often not fully captured in a

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broader context. While infrastructural, socioeconomic, and demographic factors have been emphasized in Eswatini studies (e.g., Mangaliso & Dlamini, 2018; Sibiya, 2023), less is known about how household food security outcomes are influenced by access to ICT assets (e.g., internet, radio, television) and physical infrastructure (e.g., water, electricity, sanitation). This paper seeks to address this disparity by exploring infrastructure access as both a facilitator and a barrier to food security, an area that regional studies partially address.

Additionally, much of the research work in the field relies on a single metric that focuses narrowly on food availability or access. Through the integration of the HFIAS and the FCS, this study contributes a dual-metric approach that captures both subjective sentiments of insecurity and objective dietary adequacy, revealing hidden strengths and vulnerabilities across household sub-populations such as "anxious but well-fed," and "quietly deprived." This dual approach makes it possible to focus interventions more precisely and equitably. Finally, despite having its origins in Eswatini, the study's conclusions and insights offer policy relevance for other small, developing nations like Lesotho, facing similar structural challenges, enhancing the understanding of food security patterns in under-researched states.

1.5 Outline of the study

This paper provides insight into the key factors influencing food security in the Kingdom of Eswatini. Chapter 2 reviews relevant literature from Eswatini and comparable developing nations, establishing theoretical and empirical foundation for the research. Chapter 3 outlines the sampling procedure and analytical methods used to address the study's objectives. Chapter 4 shows the results and offers a critical discussion of the findings. Finally,

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chapter 5 summarizes the study and concludes by outlining key recommendations and future research avenues.

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CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter summarizes existing research work regarding food security, with a focus on identifying gaps that the study seeks to address. It introduces the concept of food security and critically reviews studies conducted in Kingdom of Eswatini, emphasizing the underlying factors that shape patterns of food insecurity. Research from other developing economies is incorporated into the debate in the following section, which compares the variables that affect food security in various settings. Special emphasis is paid to the variables that are commonly used, the measuring techniques adopted, and the empirical procedures employed in earlier research.

2.2 Definition of Food Security

Food security is a universal challenge that affects millions of people worldwide. The World Food Summit defined food security as a condition where everyone continuously has physical and financial access to enough safe, nourishing food to satisfy their dietary requirements and preferences in order to sustain a healthy and active way of life (FAO, 1996). This consensus led to a comprehensive definition of food security, encompassing four essential dimensions, namely availability, accessibility, utilization and stability.

Pinstrup-Andersen (2009) describes a household as food secure if it can consistently obtain sufficient food for every member. The critical role of food security in supporting overall health and welfare is indisputable. Food insecurity and deprived health not only hinder individuals from reaching their full potential and productivity but also inflict substantial social and economic burdens on families, communities, nations, and the globe (Oduniyi & Tekana, 2020). Hence, achieving a sustainable livelihood, in alignment with the

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United Nations Sustainable Development agenda, necessitates a comprehensive understanding of food security challenges and solutions.

Numerous research work has been done on food security and its determinants (Awoyemi et al., 2023; Gebre, 2012; Habyarimana, 2015; Iram & Butt, 2004; Kassie et al., 2012). These studies shed important light on the roots of food insecurity in different settings, the people who are most impacted, and potential remedies to improve food security. Findings from these studies inform humanitarian initiatives, policy decisions, and sustainable farming methods in order to ensure consistent and sufficient food access for all people, regardless of location. These studies also offer literature to improve knowledge of food security as a phenomenon impacting supply and value chains, the economy, and socioeconomic well-being, especially in agricultural food systems.

2.3 Food Security in Eswatini

Like in many developing nations, food security is a major concern for development practitioners and policymakers in Eswatini. The factors influencing food security in Eswatini and their effects on household well-being, economic stability, and agricultural output have been the subject of several studies. Improving food availability, accessibility, and affordability for all households necessitates a thorough understanding of the major elements determining of food security, including infrastructure access, income levels, employment status, access to agricultural resources, climate conditions, and social protection programs.

Mangaliso and Dlamini (2018) adopted a logistic modeling approach to explore the key predictors of food security in Eswatini and identified multiple interlinked factors such as dependency on oil lamps for illumination, lack of indoor sanitation, and reliance on rainwater harvesting and boreholes. These infrastructural deficiencies intersected with economic

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difficulties such as low household income, high expenditure on staple foods, and high transportation expenses, ultimately exacerbating household vulnerability. Additionally, household food insecurity was also largely caused by dependence on crop cultivation, ill health, and disabilities. Similarly, Mabuza and Mamba (2022) explored food insecurity among urban household in Msunduza, Mbabane and identified gender, family size, household income, and employment status as the primary determinants. Notably, no household earning less than SZL 600 per month was classified as food secure, and the majority of family units experiencing food insecurity had monthly incomes below SZL 1,300, underscoring how economic adversities directly translates to food deprivation.

Sibiya (2023) adds a gender dimension to the above socioeconomic narrative, revealing that women tend to be self-employed compared to men, who are commonly employed in the formal sector. Additionally, female headed households tend to be older and oversee larger families than their male counterparts, both of which make them more susceptible to food insecurity. The study also revealed gender based differences in the predictors of food insecurity: marital status, family size, and non-food expenditure were important factors for families headed by men, while household size and non-food expenditure were the main factors for households headed by women. His findings demonstrate how gender interconnects with economic marginalization, implying that socioeconomic vulnerabilities are categorized based on demographics rather than being homogeneous.

Diverging slightly from the socioeconomic emphasis, Low et al. (2022) examined the interconnected dynamics of food insecurity and HIV infection in sub-Saharan Africa, revealing how chronic illness interacts with food deprivation. Their findings also indicated that food deprivation is prevalent in urban settings, especially in homes headed by women

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and that vulnerabilities are exacerbated by the substantial correlation between SFI and chronic HIV infection. However, social support programs such as food assistance mitigated these risks, highlighting the need for integrated health and food security strategies, especially for vulnerable urban populations.

From a structural and system level perspective, Hamadjoda Lefe et al. (2024) analyzed the impact of physical infrastructure on food security outcomes across 40 African nations, including Eswatini. Their findings indicated that food security in several SSA nations was positively impacted by transportation, energy, information and telecommunication, water supply and sanitation. Specifically, food security improved by 0.916%, 0.664%, 0.448%, and 0.758%, respectively, when transportation, electricity, water supply and sanitation, and information and telecommunication technology (ICT) are enhanced. This is in line with broader calls to integrate infrastructure planning into frameworks for food policy, especially in nations where deprivation is made worse by rural isolation and inadequate service delivery.

These studies collectively show that food insecurity in Eswatini is influenced by both socioeconomic factors and broader institutional constraints. Research work by Mangaliso and Dlamini (2018) highlights how infrastructural deficiencies combine with socioeconomic factors to deepen household vulnerability. Similarly, Mabuza and Mamba (2022), and Sibiya (2023) highlight the clear relationship between food access and household socioeconomic and demographic factors particularly noting heightened risks faced by female headed households. Expanding this perspective, Low et al. (2022) and Hamadjoda Lefe et al. (2024) demonstrate the role of health vulnerabilities and infrastructure systems, respectively, in shaping food security outcomes. Together, these findings lend credence to the growing

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consensus that tackling food insecurity in Eswatini necessitates a multi-sectoral approach that combines poverty reduction with enhancing infrastructure, public health, social protection systems.

2.4 Food Security in Developing Economies

Beyond Eswatini, research work from other developing contexts offer comparative insights into food security determinants and measurement. Several studies emphasize the role of socioeconomic attributes such as gender, level of education, income and family size as key factors shaping household food security. In Lesotho, Nkoko et al. (2024) utilized the HFIAS and Household Dietary Diversity Score (HDDS) to assess food security status through logistic regression analysis, focusing on agricultural households. The study found that the extreme cases of food deprivation occurred in highland areas and were strongly associated with household earnings, number of household members, relationship status, and respondent's literacy level. Likewise, Lelimo et al. (2021) studied the implications of off-farm employment on food security among rural-based households in Lesotho. Their study identified access to farm income, ecological zones, gender, household size, head's age, education, non-farm income, and transfers as important determinants of food security. The findings point to the need for policies that promote and enhance non-farm income prospects in order to stimulate rural development and lessen poverty. In a related study, Hlatshwayo et al. (2022) employed an extended ordered probit regression model to explore factors influencing market involvement and its impact on household food security in smallholder farming communities in rural areas of South Africa's Mpumalanga and Limpopo provinces. The analysis revealed that household food insecurity is positively correlated with household size, presence of HIV-positive family member, and agricultural assistance while levels of

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household head education, livestock ownership, older household heads, female-headed households, and social grant access demonstrated a negative and significant impact, emphasizing critical role of health and education in shaping food security outcomes. In Ghana Awoyemi et al. (2023) utilized data from the Living Standards Survey to assess the key factors that influences food security. A Partial Proportional Odds (PPO) analysis revealed that low educational attainment, unemployment, and rural residence were all substantially correlated with food consumption poverty in Ghana, suggesting expansion of access to education especially nutrition education, encouraging job creation and investments that aims to close the gap between rural and urban growth.

A second set of studies focuses on how environmental shocks and climate change undermine household food security. In Afghanistan, Ahmadzai and Morrissey (2024) examined the influence of shock exposure on a various indicators of food security, dietary diversity, household spending on food, agricultural earnings and income levels by matching households impacted with those not affected. The scholars' found that floods were the most significant shock affecting dietary diversity, food consumption, and farm income, emphasizing the need for improved planning and catastrophe risk reduction techniques to help impacted communities prepare for and recover from climate shocks. Similarly, Ahmed (2024) evaluates how Bangladesh farm communities' agricultural income and food security are affected by climate shocks using ordered probit regression. The study revealed that, at various food insecurity experience scale levels, climate shocks such as floods and excessive heat dramatically elevated household food insecurity. However, larger farms and better-educated households, were significantly more resilient to food insecurity, suggesting that enhancing education can strengthen household food security and that livestock raising can

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supplement agricultural revenue. Still on the environmental narrative, in Ethiopia and Ghana, Wossen et al. (2018) investigated the outcomes of climate unpredictability and fluctuations in food prices on earnings and food security of farm households, finding that both factors negatively affect income and food security. While self-coping strategies were found to be important, they were deemed insufficient to lessen the negative consequences of variability, suggesting the necessity of legislative actions to build resilience. In Sudan, Fadol et al. (2024) examined factors influencing Sudanese households' level of food security and highlighted that households relying solely on agriculture were more vulnerable. Urban residency, household head's advanced age, male leadership, paid work, and diversified income sources were all positively correlated with food security.

A notable set of studies emphasize the role of infrastructure and technology, particularly ICT and land systems, in shaping food security. In Nigeria, Ibrahim et al. (2023) investigated the interplay between food security and land tenure using generalized ordered logit regression and an adaptable conditional difference-in-difference framework. The results indicated that land tenure security influenced dietary diversity and asset accumulation. Due to high HDDS, livelihood coping strategy, and low food expenditure share, land holders with informal land tenure rights exhibited higher chances of experiencing for deprivation. Oluwatayo and Ojo (2019) examined how ICT affected food insecurity in Nigerian farming households, employing a probit regression model, descriptive statistics, and the Foster, Greer, and Thorbecke (FGT) technique in their analysis. The findings showed that ICT access significantly reduced food insecurity mainly through information dissemination and market access. Variables such as household size, marital status, region of residence, distance to market, and rural or urban location shaped this relationship. At regional level, using panel

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data from 15 countries between 2005 and 2018 and the system GMM technique, Anser et al. (2021) examined how the relationship between governance and ICT adoption affects food security in West Africa and found that ICT adoption and governance particularly anti-corruption efforts jointly improved food security by up to 15%. Similarly, Gouvea et al. (2022) used data from 106 nations between 2012 and 2018 to investigate the connection between innovation, ICT, and food security. Their study revealed that technological innovation improved food security, with ICT particularly boosting affordability of food in less developed countries. This underscores the important role ICT infrastructure plays in enhancing food security.

With regards to market access and social assistance in rural Tanzania, Hadley et al. (2007) studied the dynamics between perceived social support and seasonal food insecurity. Results indicated a notable link between food security, social support and household wealth metrics in both groups. Fascinatingly, social assistance seemed to work better in the wealthier community or ethnic group suggesting that the benefits of social networks may be amplified by economic status. The results imply that enhancing community-wide economic prosperity can reduce food deprivation both directly and indirectly because the relationship between social support and wealth provides greater resilience to seasonal food shortages. Hlatshwayo et al. (2022) also emphasized the importance of infrastructure and institutional support by pointing out restricted market access as a barrier to food security.

Research from developing nations shows that food insecurity is shaped by a combination of ecological, socioeconomic, and infrastructure factors. Studies from Ghana, South Africa, and Lesotho emphasize the roles of income, education, household size, and gender while highlighting the protective role of non-farm income and social grants in

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reducing household vulnerability (Nkoko et al., 2024; Lelimo et al., 2021; Hlatshwayo et al., 2022; Awoyemi et al., 2023). Environmental shocks, including drought, floods, and fluctuations in food prices, exacerbate food insecurity, particularly in rural households (Ahmadzai & Morrissey, 2024; Ahmed, 2024; Wossen et al., 2018; Fadol et al., 2024). Technology and infrastructure also play an important role, with evidence from Nigeria, West Africa, and beyond highlighting the positive association between ICT, land tenure security, and good governance with improved food security outcomes (Ibrahim et al., 2023; Oluwatayo & Ojo, 2019; Anser et al., 2021; Gouvea et al., 2022). Furthermore, market accessibility and social support improve food security; however, their effectiveness may be better in wealthier communities (Hadley et al., 2007). These results collectively highlight the necessity of comprehensive strategies that tackle the structural, economic, and environmental dimensions of food insecurity.

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CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter presents the research methodology adopted to examine the role of infrastructure access in shaping food security outcomes in Eswatini. It begins by detailing the sampling and data cleaning procedure. The outcome variables are then explained, with particular attention paid to the HFIAS and the FCS, explaining how they are calculated and categorized. The chapter also introduces explanatory variables, which include physical infrastructure, ICT access, shock exposure, and socioeconomic characteristics. Lastly, the analytical framework is detailed, covering descriptive statistics, bivariate analysis and regression models to examine the factors influencing household food security, as well as heterogeneity analysis to explore subgroup differences.

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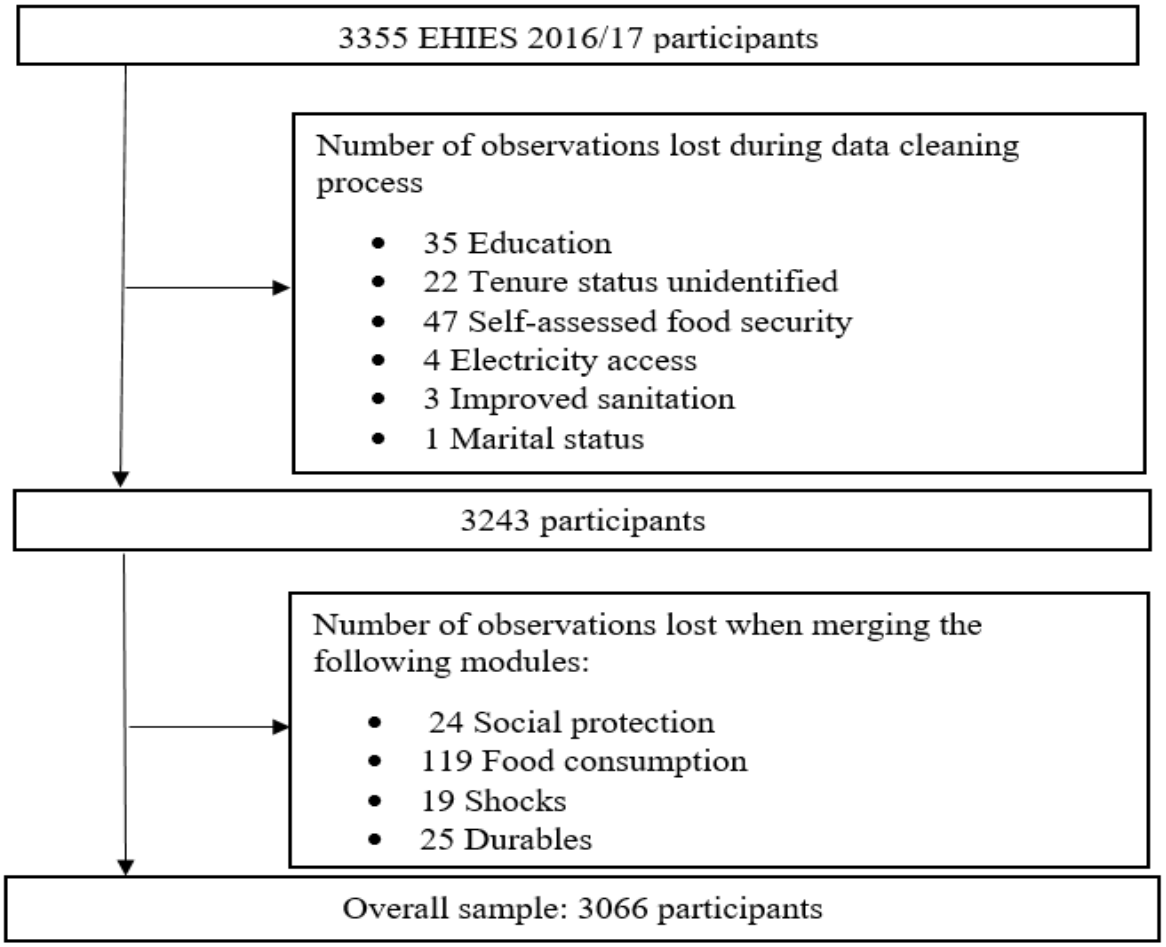

Figure 1 Data cleaning and sampling process

Source: Author's computation

The 2016/17 Eswatini Household Income and Expenditure Survey (EHIES) served as the master dataset for the study. A total of 3,456 households were sampled from 288 enumeration areas, providing national representation across Eswatini's four regions. 3,355 of the 3,456 households chosen for the study were interviewed, resulting in a 97 percent response rate. The Central Statistical Office conducted this fifth round of the EHIES from March 2016 to February 2017. This cross-sectional data covers sixteen topics in total: household and household member demographics, education, health status and spending,

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employment, health-related behaviors, wages, social protection, housing, utilities, and durable goods, household enterprises (non-agricultural), agricultural income and spending, spending during the last seven, thirty, and twelve months, loans, transfers received and sent out, recent deaths of adult household members, shocks, and anthropometric measurements for children under five years old.

While the dataset predates current global challenges, its usage remains both relevant and well justified. The 2016/17 EHIES serves as a pivotal pre-shock baseline for assessing household welfare and food security results prior to the COVID-19 pandemic and the Russia-Ukraine conflict, which have both had significant global economic and food system impacts. Global supply chains were disrupted, food prices rose, and household incomes decreased due to the COVID-19 epidemic, while low-income and import-dependent nations like Eswatini were disproportionately affected by the Russia-Ukraine conflict, which increased the volatility of grain and fuel prices globally. Using the 2016/17 dataset enables a better understanding of the country's structural vulnerabilities before these compounded shocks occurred, providing a reference point for comparing pre- and post-crisis conditions and guiding future policy responses.

The data cleaning and sampling process is presented in Figure 1. Participants were eliminated during the data cleaning phase due to missing or insufficient information across several key variables, such as education (35), tenure status (22), self-assessed food security (47), access to electricity (4), improved sanitation (3), and marital status (1). The sample size was consequently lowered to 3,243 households. Other modules, including food consumption, shocks, social protection, and durables, were merged to enhance the dataset. There were additional losses as well, including 119 cases involving food consumption, 19 cases

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involving shocks, 24 cases involving social protection, and 15 cases relating to durables. The final sample size for analysis was 3,066.

3.2 Outcome Variables and Computation

Food security measurement principally requires procedures to differentiate households based on their food security status (Sileshi et al., 2023). This study examines food security as the primary outcome variable, measured using two indicators: (i) the Household Food Insecurity Access Scale (HFIAS) derived from nine specific questions related to food availability and access, (ii) the Food Consumption Score (FCS), which evaluates the dietary diversity and quality of food eaten in the household over a seven-day period.

3.2.1 Household Food Insecurity Access Scale (HFIAS)

The study assesses food security in Eswatini using the HFIAS sourced from (Coates et al., 2007). This method has also been applied in recent research work, including (Brewis et al., 2020; Cele & Mudhara, 2024; Hlatshwayo et al., 2022), demonstrating its applicability and reliability in similar research context. Nine standardized self-reported questions were used in the evaluation to gather information about food insecurity experienced by households over the previous four weeks due to shortage of resources. From worries about food supply to sensations of hunger and meal reduction, each item assesses a distinct facet of food insecurity. The respondents used a binary (Yes/No) response for each question and a frequency assessment if the result was "Yes." Families that never faced a shortage were categorized as food secure, meaning everyone in the home always had sufficient food to lead an active and healthy life. Table 1 presents the nine questions included in the assessment.

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Table 1 Household Food Insecurity Access Scale Assessment Questions

Question	Occurrence Response	Frequency
1. Over the last four weeks, have you been worried about the food supply in your home?	Yes = Q1a; No = Q1a = 0	Q1a = 1 (Rarely), 2 (Sometimes), 3 (Often)
2. Did a shortage of resources, such as income or your own production, prevent you or any family member from eating the type of food you preferred during the last four weeks?	Yes = Q2a; No = Q2a = 0	Q2a = 1, 2, or 3
3. Over the previous four weeks, have you or any family members had to limit your diet due to lack of resources?	Yes = Q3a; No = Q3a = 0	Q3a = 1, 2, or 3
4. During the previous four weeks, did you or any family member have to eat anything you truly didn't want to eat because you didn't have the money to buy other foods?	Yes = Q4a; No = Q4a = 0	Q4a = 1, 2, or 3
5. During the last four weeks, did a lack of food force you or any family member to consume fewer meals than you believed you needed to?	Yes = Q5a; No = Q5a = 0	Q5a = 1, 2, or 3
6. Did a lack of food force you or any family member to eat fewer meals each day over the last four weeks?	Yes = Q6a; No = Q6a = 0	Q6a = 1, 2, or 3
7. Did your household ever go four weeks without any food at all due to a lack of means to purchase food?	Yes = Q7a; No = Q7a = 0	Q7a = 1, 2, or 3
8. Was there insufficient food during the past four weeks, causing you or any household member to go to bed hungry?	Yes = Q8a; No = Q8a = 0	Q8a = 1, 2, or 3
9. In the past four weeks, did you or any family members go a full day or night without eating?	Yes = Q9a; No = Q9a = 0	Q9a = 1, 2, or 3

Source: Adapted from Coates et al. (2007)

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3.2.2 Categorizing process

According to Coates et al. (2007), each household responds to nine occurrence and nine frequency questions in order to calculate their scores (0–27). Responses are classified according to frequency (0 = never, 1 = rarely, 2 = sometimes, 3 = often). Frequency is marked as 0 if the occurrence response is "no." These nine frequency codes add up to the HFIAS score. Then, each household is categorized into one of four groups based on the severity and combination of reactions (e.g., frequency of food-related worries, meal size reduction, and going without food) presented in Table 2 below:

Table 2 Household Food Insecurity Access Scale categories

Household Food Insecurity Access Scale categories	
Access Category	**Condition**
HFIAS category 1= Food Secure	if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
HFIAS category 2= Mildly Food Insecure	if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
HFIAS category 3= Moderately Food Insecure	if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]
HFIAS category 4= Severely Food Insecure	if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

Source: Adapted from Coates et al. (2007)

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3.2.3 Food Consumption Score (FCS)

The Food Consumption Score (FCS) is an index created by the World Food Program (WFP) in 1996 to assess household food security. It evaluates dietary diversity, food consumption frequency, and the nutritional significance of various food groups consumed by households (Maxwell et al., 2013). Household dietary intake data were collected through a seven-day recall diary, where respondents recorded a variety of foods consumed by members of the household. In order to create the FCS, data on food consumption was gathered for thirty different food items, which were then categorized into eight conventional food groups: dairy, meats, vegetables, fruits, fats, sweets, pulses, and staples. The frequencies of various foods from the same groups were then added together for every home. A new weighted food group score was then produced by multiplying the acquired value for each food group by its assigned weight. A weighted score was given to each food group according to how frequently they were consumed during the seven days. The weighted values employed adhere to the World Food Programme's (WFP) methodology, which assigns larger weights to nutrient-rich food groups like dairy and animal proteins. The FCS was computed as:

FCS = (2×Staples) + (3×Pulses) + (4×Meats) + (4×Dairy) + (1×Vegetables) + (1×Fruits) + (0.5×Sugars) + (0.5×Fats)

Households were categorized based on their FCS into the following thresholds, with higher scores indicating better food security and dietary diversity;

1. Poor food consumption (FCS $\leq$ 21)
2. Borderline food consumption (21 < FCS $\leq$ 35)
3. Acceptable food consumption (FCS > 35).

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3.3 Explanatory variables

The set of independent variables selected for the study includes: physical infrastructure, ICT infrastructure, shocks, and socio-economic factors. The selection of explanatory variables was primarily informed by existing literature on the determinants of food insecurity. Table 3 presents a list of explanatory variables, their description, and measurement.

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Table 3 Description of variables used in the model

Variables	Description and measurement
Physical Infrastructure	
Use of improved water sources	1= Yes 0= No
Use of improved sanitation	1= Yes 0= No
Access to electricity	1= Yes 0= No
ICT Infrastructure	
Having television	1= Yes 0= No
Having radio	1= Yes 0= No
Access to the internet	1= Yes 0= No
Socio-economic factors	
Household Size	The total number of household members
Age of Household Head	Age of the household head 1= <30 2= 31-40 3= 41-50 4= 51-60 5= >60
Education of Household Head	0= No formal education 1= Low education 2= High education
Gender of Household Head	1= Male 2= Female
Marital Status of Household Head	1= Married 0= Not married
With Children	1= No children 2= 1-3 3= >4
Residence	1= Urban 2= Rural
Access to social assistance support	1= Yes 0= No
Income group	1= Less than 942

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	2= 943-2000 3= 2001-4853 4= Above 4853
Shocks	
Exposure to weather shocks	1= Yes 0= No
Exposure to food price shocks	1= Yes 0= No

Source: Author's computation

Table 4 outlines the key variables considered in the study, along with the anticipated associations with household food security and supporting references from previous research. The variables are primarily divided into physical infrastructure, ICT infrastructure, shocks and socio-economic characteristics. Brief explanations and citations to previous research are provided and each variable is predicted have positive, negative, or mixed impact on food security.

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Table 4 Explanatory variables, their expected effects and supporting references

Variables	Expected effect	References
Household Characteristics		
Use of improved water	Positive: High levels of food absorption are ensured by having access to quality drinking water, which is essential for overall health.	(Ejaz Ali Khan et al., 2012) (Iram & Butt, 2004)
Use of improved sanitation	Positive: Food security is greatly impacted by the use of better sanitation since it is connected to general well-being, nutrition, and health.	(Ejaz Ali Khan et al., 2012) (Hamadjoda Lefe et al., 2024)
Access to electricity	Positive: Access increases the effectiveness of cooking and food storage.	(Vysochyna et al., 2020) (Hamadjoda Lefe et al., 2024) (Cao & Nguea, 2025) (Candelise et al., 2021)
Having television	Positive. Television ownership may be associated with better socioeconomic status and more stable incomes suggesting better access to nutrition, health and market information access.	(Anser et al., 2021) (Oluwatayo & Ojo, 2019)
Having radio	Positive. Having a functional radio can increase awareness of government food programs, weather forecasts and best agricultural practices.	(Anser et al., 2021) (Oluwatayo & Ojo, 2019) (Picho et al., 2018)
Access to internet	Positive. Access to internet makes it easier for households to plan by improving access to information on farming practices, weather, and food costs. Additionally, having access to the internet improves market connectedness, shock early warning, and social protection program connections.	(Ardianti et al., 2023) (Akinboade et al., 2022)
Household Size	Negative: Larger households tend to require more food to satisfy their nutritional demands.	(Feleke et al., 2005) (Tambe et al., 2023) (Mungai, 2014) (Lelimo et al., 2021)
Age of Household Head	Mixed: Older heads may have better stability and experience in securing food, but may also face reduced income-earning capacity.	(Sileshi et al., 2023) (Bulawayo et al., 2019) (Mustapha et al., 2016) (Lelimo et al., 2021)
Education of Household Head	Positive: Because of improved job prospects, income, and food planning, higher education is linked to greater food	(Sultana & Kiani, 2011) (Bulawayo et al., 2019) (Obayelu, 2012)

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	security.	(Awoyemi et al., 2023) (Mutinda, 2015)
Gender of Household Head	Mixed: Households headed by women prioritize food security yet are frequently more susceptible to food insecurity.	(Tambe et al., 2023) (Bulawayo et al., 2019) (Jega et al., 2018) (Ndakaza et al., 2016)
Marital Status of Household Head	Positive. Due to their combined income and support networks, married households might have greater food security than single-headed households, which might be viewed as more vulnerable.	(Jega et al., 2018) (Obayelu, 2012) (Mustapha et al., 2016)
With Children	Negative: The likelihood of food insecurity may rise with the number of dependents.	(Obayelu, 2012) (Sisha, 2020)
Residence	Mixed: Although urban households have greater access, they may be more dependent on their income to buy food and are subject to shocks to food prices.	(Sultana & Kiani, 2011) (Bulawayo et al., 2019) (Mustapha et al., 2016) (Mohamed et al., 2024) (Awoyemi et al., 2023)
Access to social support	Positive. Social assistance reduces food insecurity by augmenting household income and food access, especially for disadvantaged populations.	(Mokari-Yamchi et al., 2020) (Hadley et al., 2007)
Income	Positive: The affordability of food increases with increased earnings.	(Sileshi et al., 2023) (Tambe et al., 2023) (Bulawayo et al., 2019) (Jega et al., 2018) (Obayelu, 2012)
Exposure to weather shocks	Negative. Food insecurity increases as a result of weather shocks (droughts, floods) that have a detrimental effect on food production, income, and availability	(Sisha, 2020) (Ahmadzai & Morrissey, 2024) (Ahmed, 2024)
Exposure to food price shocks	Negative. Price changes can increase the likelihood of experiencing food insecurity by restricting access to food, particularly for lower-income households.	(Sisha, 2020) (Wossen et al., 2018)

Source: Author's computation

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3.4 Analytical Framework

Data analysis for this study was conducted using Stata version 17. Given that food insecurity is multifaceted, an analytical framework that combines econometric modeling and descriptive statistics was employed to explore the role of infrastructure access in shaping food security in Eswatini. Descriptive statistics provided an overview of the dataset, summarizing important variables including food security status, physical infrastructure, ICT infrastructure, exposure to shocks, and household socioeconomic characteristics. The correlation between explanatory variables and food security status was evaluated through bivariate statistical tests, including Pearson's chi-square test to assess categorical data and independent sample t-tests to analyze continuous variables.

For a more comprehensive analysis, the study employs both Ordered Logit and Generalized Ordered Logit models. The Ordered logit model assumes proportional odds, meaning that the impact of explanatory variables is consistent throughout all food insecurity thresholds, while the Generalized ordered logit model relaxes this assumption (Williams, 2016), offering more flexibility, by allowing factors to affect the different food security thresholds in varying ways. This dual approach guarantees a more holistic and detailed analysis, improving the precision and reliability of the results. Ultimately, offering deeper insights on food insecurity dynamics in Eswatini. The two models apply to both outcome variables, HFIAS and HCS, with the same explanatory variables. The models are specified as follows;

The ordered logistic model is specified as follows:

A latent variable y_i*, which is unobserved, is introduced in the case of ordered logit model.

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- y = 1; if household is food secure
- y = 2; if household is slightly food insecure
- y = 3; if household is moderately food insecure
- y = 4; if household is severely food insecure

Thus, the depiction of the latent continuous variable model, which incorporates the logistic error factor, is explained as follows:

$$y_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots\ldots \beta_n X_{ni} + \varepsilon_i$$

In contrast, the following is a description of the observed ordered categorical variable *yi* model specification:

$$pr(yi>j)/pr(yi<j) = \exp\{- Y_j + \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots\ldots \beta_n X_{ni}\}$$

Where,

y_i = food security category and food consumption category

X_{ni} = determinants

β_0 = intercept

β_n = coefficients to be estimated

ε_i = error terms

Although the variables are naturally organized to produce slight, moderate, and severe security levels, it is uncertain how these differ from one another. We can express the

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association between the latent (y_i *) and observed (y_i) model specification as follows by adding threshold variables:

$y_i = 1$ *if* $y_i * \leq Y_1$

$y_i = 2$ *if* $Y_1 \leq y_i * \leq Y_2$

$y_i = 3$ *if* $Y_2 \leq y_i * \leq Y_3$

$y_i = 4$ *if* $y_i * > Y_3$

To examine the key contributors to food security status, this study employs the Generalized Ordered Logistic Regression Model, which relaxes the proportionate odds assumption for variables that violate it. This makes it possible to estimate the influence of predictors on an observation's probability of falling into a higher or lower food security category with greater flexibility.

The Generalized ordered logistic model is specified as follows:

$$\text{logit}\,(P(Y \leq j)) = \alpha j - X\beta_j \text{ for } j = 1, 2, \ldots, J-1$$

Where:

Y = food security status (food secure, slight, moderate, and severe security)

j = indicates the threshold or cut-off points between categories

α_j = are the threshold-specific constants

X = determinants

β_j = is a vector of coefficients that may vary across different thresholds.

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The generalized ordered logistic model utilizes the logistic distribution as its cumulative distribution function, although alternative distributions may also be applicable. The logistic distribution enables the model to be interpreted through logits, facilitating a clearer understanding between explanatory variables and the probability of each outcome.

$$\log [P (Y > j) / P (Y \leq j)] = X\beta_j \qquad j = 1, ..., J-1$$

For each division point j = 1,..., J-1, the proportional odds model requires the βj coefficients to be the same. In the partial proportional odds model, certain βj coefficients must remain constant across all division points, while others are allowed to change.

The generalized ordered logit model explicitly limits the range of the X variables, in contrast to models such as binary logit and OLS regression. Valid combinations of the X variables must meet the following inequality since probabilities are by definition limited to the interval [0,1]:

$$X\beta_1 \geq X\beta_2 \geq X\beta_3 ... \geq X\beta_{j-1}$$

(1). Use of improved water X_1

Food security outcomes improve from the usage of improved water sources. Better health and nutrient absorption are ensured by clean drinking water, which lowers the risk of foodborne illnesses and malnutrition. A more food-secure environment is facilitated by having access to clean water, which enhances overall household well-being.

(2). Improved sanitation X_2

Likewise, food security is positively impacted by the adoption of improved sanitation. By lowering the incidence of illnesses, proper sanitation improves productivity and health

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outcomes. Food security is improved when households have better sanitation facilities because they are less likely to get sick, which might limit their capacity to work and make money.

(3). Access to electricity X_3

By enhancing food preparation, preservation, and storage, electrical access also contributes to food security. Perishable foods can be refrigerated in households with power, which lowers waste and guarantees a more consistent food supply. Additionally, it makes cooking easier and meal preparation more effective.

(4). Having television X_4

The primary way that television ownership enhances food security outcomes is through facilitating information access. Weather forecasts, market pricing, health and nutrition-related education, and agricultural techniques are all covered by television. Television-owning households are more likely to be informed about catastrophe alerts, dietary guidelines, and food programs that are accessible, which helps them make better plans and lowers their risk of food insecurity.

(5). Having radio X_5

Particularly in rural areas, radio continues to be one of the most accessible and reasonably priced mass communication medium. It can spread important information regarding market accessibility, climate change adaptation, farming methods, dietary advice, and government aid initiatives. Even in isolated areas, having a radio helps households stay informed, increasing their ability to withstand shocks that lead to food insecurity.

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(6). Access to internet X_6

Access to the internet offers more specialized and interactive information in real time. Families can search for optimal agricultural techniques, new technologies for crops, market values, government assistance initiatives, platforms for online sales (e-commerce for farmers), and flood or drought early warning systems. Additionally, it facilitates direct communication (for example, by joining online support groups, co-ops, or farmers' forums). As a result, having internet connectivity improves household's ability to increase their food production, market accessibility, and nutritional variety.

(7). Household size X_7

Because larger households need more food resources, which can put additional pressure on the household's food supply. More individuals living in a home can increase the demand for food, making it more difficult to guarantee adequate access for all members, especially in low-income environments. The effect of household size on food security has been the subject of numerous research. Tambe et al. (2023) in South Africa looked into the influence of household size on food security and found that large households tend to experience food insecurity. Similarly, a study on food security conducted in Nigeria shows that large family size heightens the likelihood of being food insecure (Amaza et al., 2006). The cited studies highlight the importance of household size in shaping food security outcomes.

(8). Age X_8

Food security is impacted by the head of household's age in different ways. The stability and experience that older family heads have accrued may help them secure food, but

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retirement or deteriorating health may also limit their ability to earn an income. Hence, the impact of age on food security is unclear due to this dual effect.

(9). Education X_9

The literacy level of the household head is anticipated to positively influence food security. Higher educational attainment is typically associated with better employment opportunities, increased income, and improved financial planning, all of which contribute to better food security. Educated individuals are also more likely to make informed dietary choices and manage resources efficiently.

(10). Gender X_{10}

The impact of the household head's gender is not entirely uniform. Food security is frequently a top priority for households headed by women, however, they may face heightened risk due to limited resources, discrimination in the workplace, and lack of access to productive resources. Despite their reputation in handling food well, women's economic disadvantages can hinder their ability attain food security. Literature shows that the association between age and food security varies. For instance, Habyarimana (2015) in Rwanda found that female households headed are disproportionately affected by food insecurity compared to their male headed counterparts.

(11). Marital status X_{11}

Food security is favorably correlated with marital status as well. Married households are generally better equipped to handle financial challenges and secure food, often benefitting from stronger support systems and shared incomes. In contrast, single-headed households may be more susceptible to food insecurity due to limited financial resources.

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(12). Having children X_{12}

Food security is predicted to be negatively impacted by having children in the household. The presence of dependents increases food requirements, which can strain household resources, particularly in low-income families. More children often mean higher expenses, leading to financial constraints that could limit access to adequate supply of healthy and nourishing food.

(13). Urban area X_{13}

The implications of urban residence on food security are not completely uniform. While urban households generally have better access to markets and a more diverse food supply, they are also more vulnerable to price shocks and income changes. Their heavy reliance on purchased food, makes them particularly susceptible to higher food prices, despite the economic prospects urbanization may offer.

(14). Access to social support X_{14}

Social support positively impacts food security by enhancing food access and augmenting household income. Food insecurity is less likely when social assistance programs, including cash transfers or food aid, help disadvantaged households deal with financial difficulties.

(15). Income X_{15}

Food security tends to improve with rising income levels, as higher purchasing power enables households to access more diverse and nutritious food supply. A stable food supply

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and protection from economic shocks are made possible in households with financial stability.

(16). Exposure to floods/drought X_{16}

Food security is adversely affected by weather shock exposure. Food production is disrupted, income is decreased, and food availability is limited by extreme weather events including drought and flooding. Reduced agricultural output, rising food costs, and greater vulnerability among impacted households are all common outcomes of climate-related shocks.

(17). Exposure to high prices X_{17}

In a similar vein, experiencing shocks to food prices has a detrimental impact. Essential food items become less affordable with abrupt price spikes, especially for low-income people. Price changes may compel families to cut back on their food intake or substitute for less nutrient-dense, less expensive options, which raises the risk of malnutrition.

3.5 Heterogeneity analysis

This analysis examines how various factors' impacts differ for various situations or subgroups. Each subgroup reflects a distinct experience of food insecurity, and the following question is posed: Which household-level factors have varying effects on food (in)security based on the vulnerability type? According to various household circumstances, this approach enables comprehension of the complex pathways into and out of food insecurity rather than assuming one-size-fits-all causes of food insecurity. Figure 2 below shows the typology category indicating how the two outcome variables were fused to come up with the

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subgroups.

	Poor Diet (1)	Borderline Diet (2)	Acceptable Diet (3)
1. Food Secure	Quiet Deprivation	Quiet Deprivation	Fully Food Secure
2. Mild Insecurity	Quiet Deprivation	Quiet Deprivation	Anxious but Well-Fed
3. Moderate Insecurity	Quiet Deprivation	Quiet Deprivation	Anxious but Well-Fed
4. Severe Insecurity	Fully Food Insecure	Fully Food Insecure	Anxious but Well-Fed

Figure 2 Typology categories

Source: Author's computation

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CHAPTER 4 RESULTS AND DISCUSSION

4.1 Variance Inflation Factor test

The Variance Inflation Factor (VIF) test was employed to check for multiple correlations between independent variables prior to the regression analysis. The OLS regression was employed as a workaround because VIF cannot be calculated directly after running ordered logit and generalized ordered logit models. As seen in Table 5, the data point to no significant multicollinearity issues (VIF values below 10 are usually considered acceptable) with a mean VIF of 1.86 and the maximum VIF value of 4.63 (having children). The models were then estimated since multicollinearity was not a problem, guaranteeing consistent and reliable outcomes.

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Table 5 Variance Inflation Factor for the models

Variable	VIF
Use of improved water	1.11
Use of improved sanitation	1.19
Access to electricity	1.88
Having television	1.09
Having radio	2.15
Access to internet	1.09
Household Size	3.62
Age of Household Head	2.44
Education of Household Head	1.90
Gender of Household Head	1.27
Marital Status of Household Head	1.32
With Children	4.63
Urban Area	1.33
Access to social support	1.67
Income	2.42
Exposure to weather shocks	1.27
Exposure to food price shocks	1.19
Average VIF	1.86

Notes: VIF values below 10 are usually considered acceptable. For categorical variables, the category with the highest VIF was recorded.

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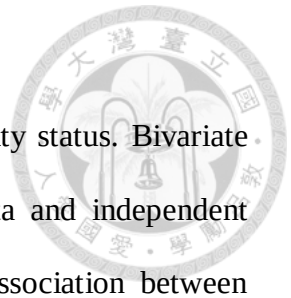

4.2 Descriptive Analysis

Table 6 displays descriptive statistics by household food security status. Bivariate statistical tests including Pearson's chi-square test for categorical data and independent sample t-tests for continuous variables, were used to examine the association between explanatory variables and food security status. By comparing observed and expected frequency distributions, the chi-square test determined if categorical factors were substantially correlated with food security status. The statistical significance of the mean differences between families with and without food insecurity was assessed using t-tests for continuous variables, offering preliminary information about possible determinants of food insecurity.

Among 3,066 households surveyed, 73.9% were food insecure (n=2,267). Food security appears to be closely related to demography, socioeconomic position, and physical infrastructure, as demonstrated by statistically significant differences ($P < 0.05$) across all factors. Basic physical infrastructure is far more accessible to families with food security. Only 66.3% of households experiencing food insecurity use improved water sources, whereas 82.9% of food-secure households did. In the same way, 81.9% of homes with food security had access to electricity and 57.7% of households with improved sanitation, compared to just 44.6% and 54.3% of those without food security, respectively.

Regarding ICT infrastructure, households with food security had a higher likelihood of having radios (65.8% vs. 48.9%), televisions (73.2% vs. 43.1%), and internet connection (32.4% vs. 19.9%). Both economic and informational inequities are highlighted by these gaps. In terms of demographics, food-secure households often had fewer members (an average of 3.3) than those with food insecurity (4.7). Compared to the 5.3% of households

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in food insecurity, the household heads in food-secure households tend to be younger (30.3% were between the ages of 31 and 40) and educated (27.3% had tertiary education). Additionally, households with food security were more likely to be married (52.8% vs. 47.6%), reside in urban areas (39.2% vs. 17.8%), had a male head of household (57.1% vs. 45.4%), and had fewer children overall.

Households affected by food insecurity tended to have access to social assistance (62.1% vs. 35.4%), which probably reflects the fact that vulnerable households receive targeted support. It can also suggest that households cannot escape food poverty with the help of current social support. The distribution of income was uneven, with 30.5% of food-insecure households in the lowest income group and 50.4% of food-secure households in the highest income group. Food-insecure households were prone to shock exposure: 59.6% reported food price shocks (compared to 53.8%), and 69% reported weather shocks (compared to 47.2% food-secure households). Additionally, 88.1% of homes that were food secure had appropriate food consumption scores, but only 75.5% of households that were food insecure did. Lastly, 50.1% of households experiencing food insecurity also experienced severe food insecurity.

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Table 6 Descriptive statistics by household food insecurity status

Variables	All	Food Secure	Food Insecure	P value
	n = 3066	n = 799	n = 2267	
Physical Infrastructure Indicators				
Use of improved water sources				0.000
1= Yes	72.1	82.9	66.3	
0= No	27.9	17.1	31.7	
Use of improved sanitation				0.000
1= Yes	48	57.7	44.6	
0= No	52	42.3	55.4	
Access to electricity				0.000
1= Yes	61.5	81.9	54.3	
0= No	38.5	18.1	45.7	
ICT Infrastructure Indicators				
Having television				0.000
1= Yes	51	73.2	43.1	
0= No	49	26.8	56.9	
Having radio				0.000
1= Yes	53.3	65.8	48.9	
0= No	46.7	34.2	51.1	
Access to internet				0.000
1= Yes	23.1	32.4	19.9	
0= No	76.9	67.6	80.1	
Socioeconomic Characteristics				
Household Size				0.000
Food secure	799	3.3	2.4	
Food insecure	2267	4.7	3.1	
Age of Household Head				0.000
1= <30	16.7	19.9	15.6	
2= 31-40	25.1	30.3	23.3	
3= 41-50	19.3	22.2	18.3	
4= 51-60	15.6	13.9	16.1	
5= >60	23.3	13.7	26.7	

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Education of Household Head				0.000
1= None	41.7	21.5	48.9	
2= Low education	21.7	16.2	23.6	
3= Junior and High	25.6	35	22.2	
4= Tertiary	11	27.3	5.3	
Gender of Household Head				0.000
1= Male	48.4	57.1	45.4	
2= Female	51.6	42.9	54.6	
Marital Status of Household Head				0.010
1= Married	48.9	52.8	47.6	
0= Not married	51.1	47.2	52.4	
With Children				0.000
1= No children	29.9	42.3	25.5	
2= 1-3	48.3	46.9	48.7	
3= >4	21.8	10.8	25.8	
Urban Area				0.000
1= Urban	23.4	39.2	17.8	
2= Rural	76.6	60.8	82.2	
Access to social assistance support				0.000
1= Yes	55.1	35.4	62.1	
0= No	44.9	64.6	37.9	
Income				0.000
1= Less than 942	25.3	10.6	30.5	
2= 943-2000	25.1	16.4	28.2	
3= 2001-4853	24.7	22.5	25.4	
4= Above 4853	24.9	50.4	15.9	
Shocks				
Exposure to weather shocks				0.000
1= Yes	63.3	47.2	31	
0= No	36.7	52.8	69	
Exposure to food price shocks				0.004
1= Yes	58.1	53.8	59.6	
0= No	41.9	46.2	40.4	
Food security indicators				

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Food insecurity scale				0.000
1= Food secure	26.1	100	0	
2= Mildly food insecure	9	0	12.2	
3= Moderately food insecure	27.9	0	37.7	
4= Severely food insecure	37	0	50.1	
Food consumption score (FCS)				0.000
1= Poor	4.9	5.3	4.8	
2= Borderline FC	16.3	6.6	19.7	
3= Acceptable	78.8	88.1	75.5	

Notes: Household size values indicate mean and standard deviation; other variables are expressed as percentages (%).

4.3 Ordered Logit Regression model results for the HFIAS

Based on an Ordered Logit Model, the findings presented in table 7 highlight several important factors associated with household food insecurity in Eswatini. Significant predictors include a number of important structural and socioeconomic characteristics that represent the country's vulnerabilities.

Households benefiting from improved water sources had a 17% lower risk of food insecurity relative to those with no access, as indicated by an adjusted odd ratio (OR) of 0.83 (95% CI: 0.69–1.00). Similarly, access to improved sanitation was linked to a 33% decrease in the likelihood of food insecurity (adjusted OR = 0.67, 95% CI: 0.57–0.79). This reinforces the pivotal role of basic infrastructure in enhancing food security. In Eswatini, where rural households frequently lack access to improved water and sanitation, these services not only lessen the burden of disease but also free up time and resources for food acquisition and preparation.

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Having access to information and communication technology (ICT) infrastructure appeared to have a positive effect, indicating that access to information may enhance consumption practices and connect households to vital resources and support systems. While having radio and internet access were linked to 19% and 22% lower odds of food insecurity, respectively (radio: adjusted OR = 0.81, 95% CI: 0.69–0.96; internet: adjusted OR = 0.78, 95% CI: 0.64–0.96), households with a television had 20% lower odds (adjusted OR = 0.80, 95% CI: 0.64–1.00). These findings imply that increased digital connectivity can promote food security in the context of Eswatini, where mobile phone penetration is comparatively high but internet access is still uneven, particularly in rural and low-income areas. Improved digital connectivity may support food security by facilitating access to market information, social assistance programs, nutrition education, and job opportunities.

On the other hand, household size showed a positive association with food insecurity, with the odds rising by 14% for every additional household member possibly due to higher resource needs (adjusted OR = 1.14, 95% CI: 1.08–1.19). This illustrates how household resources are strained in environments where employment opportunities are limited and the cost of living is rising steadily. This is especially important in Eswatini, where social support networks are frequently informal and extended family structures are prevalent. Higher levels of food insecurity were linked to the household head's age falling into older age groups. Household heads over age 60 had a 27% greater risk (adjusted OR = 1.27, 95% CI: 0.96–1.68), while household heads aged 51–60 had a 34% increased chance (adjusted OR = 1.34, 95% CI: 1.00–1.80) compared to younger counterparts. This probably indicates a decrease in older persons' ability to be productive and generate income, particularly in the absence of strong pension plans or sustained support.

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One of the most potent protective factors was observed to be education. The probability of experiencing food insecurity was 19% lower for household heads with low literacy (adjusted OR = 0.81, 95% CI: 0.65–1.00), 40% lower for those with junior or high school education (adjusted OR = 0.60, 95% CI: 0.48–0.75), and 57% lower for those with tertiary education (adjusted OR = 0.43, 95% CI: 0.31–0.61) than for those with no education. These findings are consistent with more extensive research that shows education improves livelihood strategies, raises nutritional knowledge, and increases economic mobility. In Eswatini, improving educational access and retention should be viewed as a long-term investment in reducing poverty and ensuring food security, especially for young people and females living in rural areas.

A 19% decrease in the likelihood of food insecurity was related to marriage, potentially due to combined income sources, shared responsibilities, and household stability (adjusted OR = 0.81, 95% CI: 0.68–0.97). This is consistent with the sociocultural background of Eswatini, where marriage frequently strengthens social and economic support systems; however, the protective impact may differ based on gender dynamics and household responsibilities.

Food insecurity and income level were significantly inversely correlated, as expected. The odds were 36% lower for those in the second income group (adjusted OR = 0.64, 95% CI: 0.51–0.81), 58% lower for those in the third income group (adjusted OR = 0.42, 95% CI: 0.34–0.54), and 80% lower for households with the uppermost income (adjusted OR = 0.20, 95% CI: 0.15–0.26) than for those in the lowest income group indicating that wealthier households are substantially food secure. This glaring disparity illustrates how important economic access is in guaranteeing food security. It also emphasizes how critical it is to

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address income inequalities and increase economic prospects in Eswatini, where poverty rates are still high, especially in rural residences.

Lastly, there were notable adverse impacts from being exposed to external shocks in the previous 5-year period. Food insecurity was 44% more likely to occur in households that experienced weather shocks (adjusted OR = 1.44, 95% CI: 1.21–1.72) and 22% more likely to occur in households that experienced food price shocks (adjusted OR = 1.22, 95% CI: 1.03–1.44). These results highlight how shocks in Eswatini are cumulative and long-lasting, with many households finding it difficult to fully recover from previous setbacks. Because of frequent droughts, unpredictable rainfall patterns, and a heavy reliance on imported food commodities, the country's food systems continue to be particularly vulnerable. Over time, such exposure impairs household coping mechanisms, resulting in chronic vulnerability as opposed to isolated, transient consequences. Access to electricity, social assistance, gender, having children, and urban/rural residence demonstrated significance in the unadjusted model and lost significance in the adjusted model.

These results corroborate the conceptual relationship between infrastructure, income, information access, and shock resilience, aligning well with prior expectations. While most factors followed predicted trends, several revealed unexpected or contradictory patterns. For instance, the risk of food insecurity (HFIAS) was predicted to increase with household size, but there was an unanticipated correlation with higher food consumption scores (FCS), possibly due to resource sharing or a prioritization of dietary adequacy. Similarly, households headed by women had much greater FCS but no discernible change in felt insecurity, indicating a "nutrition-first" strategy in spite of systemic limitations. The counterintuitive relationship between social support access and higher food insecurity at lower HFIAS

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thresholds suggests that targeted aid is already reaching vulnerable people, rather than a failure of support systems. Lastly, infrastructure alone may not be enough in the absence of supplementary assets, as seen by the modest impact of electricity availability on perceived insecurity and the minimal influence on consumption.

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Table 7 Odds ratios of household food insecurity (Ordered Logit Model) (HFIAS)

Variables	Adjusted OR (95% CI)	Variables	Adjusted OR (95% CI)
Use of improved water sources		Gender of Household Head	
1= Yes	0.83 (0.69,1.00) **	1= Male	1.00
0= No	1.00	2= Female	0.94 (0.79,1.12)
Use of improved sanitation		Marital Status of Household Head	
1= Yes	0.67 (0.57,0.79) ***	1= Married	0.81 (0.68,0.97) **
0= No	1.00	0= Not married	1.00
Access to electricity		With Children	
1= Yes	0.84 (0.70,1.05)	1= No children	1.00
0= No	1.00	2= 1-3	1.15 (0.90,1.47)
		3= >4	1.26 (0.86,1.86)
Having television		Urban Area	
1= Yes	0.80 (0.64,1.00) **	1= Urban	1.00
0= No	1.00	2= Rural	1.04 (0.84,1.28)
Having radio		Access to social assistance support	
1= Yes	0.81 (0.69,0.96) **	1= Yes	1.07 (0.88,1.31)
0= No	1.00	0= No	1.00
Access to internet		Income	
1= Yes	0.78 (0.64,0.96) **	1= Less than 942	1.00
0= No	1.00	2= 943-2000	0.64 (0.51,0.81) ***
		3= 2001-4853	0.42 (0.34,0.54) ***
		4= Above 4853	0.20 (0.15,0.26) ***
Education of H. Head		Exposure to weather shocks	
1= None	1.00	1= Yes	1.44 (1.21,1.72) ***
2= Low education	0.81 (0.65.1.00) **	0= No	1.00
3= Junior and High	0.60 (0.48,0.75) ***		
4= Tertiary	0.43 (0.31,0.61) ***		
Age of H. Head		Exposure to food price shocks	
1= <30	1.00	1= Yes	1.22 (1.03,1.44) **
2= 31-40	1.25 (0.97,1.61) *	0= No	1.00
3= 41-50	1.19 (0.90,1.56)		
4= 51-60	1.34 (1.00,1.80) *		
5= >60	1.27 (0.96.1.68) *		
Household Size	1.14 (1.08,1.19) ***		

Notes: OR = 1.00 for the reference group. Characters denote significance at the 1% ***;

5% **, and 10% * levels

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4.4 Generalized Ordered Logit Regression model results for the HFIAS

Table 8 presents the analysis of the generalized ordered logit model showing several important factors related to varying levels of household food insecurity. While some factors, such as internet access, age group, and social security access, violate the equal slopes criterion, the majority of independent variables appear to hold, according to the Wald test of the parallel lines assumption, which produces a p-value of 0.0555, which is just above the 0.05 threshold. The use of the generalized ordered logit model, which permits some coefficients to differ within outcome categories, is justified by this. The parallel assumption appeared to hold for almost all the explanatory variables, indicating consistent outcomes between the two models. Hence, this discussion focuses only on access to the internet, age group, and social security, which violates the assumption, and their association differs across thresholds. The variables with symmetrical effects across different categories of food insecurity were left blank in the second and third columns.

Access to internet affected food insecurity thresholds differently, lowering the odds at a much higher magnitude, 30% and 29% in the first and second threshold respectively compared to 21% reduction from the previous model, suggesting that digital connectivity may enhance access to important information, social networks and economic opportunities, which can help alleviate slight and moderate levels of food insecurity. However, this variable lost its statistical significance at the most severe threshold, indicating that digital tools alone may be insufficient to buffer against extreme insecurity where a mix of structural issues exists. Similarly, household heads aged between 51-60 had varied effects across all thresholds. Compared to household heads below age 30, the first two thresholds revealed a lower and insignificant relationship, the last one indicated a much higher association; a 56% elevated

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risk of food insecurity relative to 34% increase observed in the previous model. This pattern indicates vulnerability among older populations in Eswatini, who may possibly face declining income, limited access to productive resources, or increasing dependency ratios. Interestingly, access to social security gained statistical significance in the second model, though it maintained the same direction of the effect in the first two thresholds, being associated with a 49% and 33% higher chance of food insecurity, respectively. In contrast, for the highest threshold, access to social security was linked to a 20% decrease in the odds of food insecurity. This is probably due to social programs targeting already disadvantaged populations rather than indicating a causal relationship. It also underscores the ability of targeted social assistance to alleviate the worst forms of food deprivation.

According to the analysis from both models, the results identified a range of protective and risk-enhancing factors that considerably influence food insecurity across its severity spectrum. Protective indicators such as access to information and communication technologies (ICTs), including the internet, radio, and television, access to physical infrastructure (improved water and sanitation), higher income levels, and improved educational attainment, all reduce the likelihood of food insecurity and enhance household resilience. Conversely, environmental and market shocks, larger households, and structural poverty increase the risk of food insecurity.

Findings from the Generalized Ordered Logit and Ordered Logit models verify that a complex interaction between environmental shocks, infrastructure deficiencies, and socioeconomic vulnerabilities shapes food insecurity in Eswatini. It highlights that food insecurity is not uniform but rather stratified and dynamic due to its ability to distinguish consequences across food insecurity thresholds. In households with mild to moderate food

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insecurity, preventive measures like increasing access to education and digital infrastructure are most successful in lowering risk. Income-generating initiatives, climate adaptation plans, and relief-focused activities are crucial for people at risk of extreme insecurity. These results highlight the pressing need for multifaceted, multi-tiered policy solutions that tackle Eswatini's food insecurity's underlying causes as well as its changing trends.

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Table 8 Generalized ordered logit model on household food insecurity (HFIAS)

Variables	**Food secure vs. mildly, moderately and severely food insecure OR (95% CI)**	**Food secure and mildly food insecure vs. moderately and severely food insecure) OR (95% CI)**	**Food secure, mildly and moderately food insecure vs. severely food insecure OR (95% CI)**
Use of improved water sources			
1= Yes	0.84 (0.70,1.01) *		
0= No	1.00		
Use of improved sanitation			
1= Yes	0.67 (0.57,0.80) ***		
0= No	1.00		
Access to electricity			
1= Yes	0.84 (0.67,1.05)		
0= No	1.00		
Having television			
1= Yes	0.79 (0.63,0.98) **		
0= No	1.00		
Having radio			
1= Yes	0.81 (0.69,0.96) **		
0= No	1.00		
Access to internet			
1= Yes	**0.70 (0.55,0.88)** ***	**0.71 (0.57,0.88)** ***	**0.94 (0.74,1.20)**
0= No	1.00	1.00	1.00
Household Size	1.14 (1.08,1.19) ***		
Age of Household Head			
1= <30	1.00	1.00	1.00
2= 31-40	1.25 (0.98,1.61) *	1.25 (0.98,1.61) *	1.25 (0.98,1.61) *
3= 41-50	1.19 (0.90,1.56)	1.19 (0.90,1.56)	1.19 (0.90,1.56)
4= 51-60	**1.06 (0.76,1.49)**	**1.17 (0.85,1.60)**	**1.56 (1.15,2.15)** ***
5= >60	1.28 (0.97,1.70) *	1.28 (0.97,1.70) *	1.28 (0.97,1.70) *
Education of Household Head			
1= None	1.00		

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2= Low education	0.80 (0.64,0.99) **		
3= Junior and High	0.60 (0.48,0.75) ***		
4= Tertiary	0.45 (0.32,0.63) ***		
Gender of Household Head			
1= Male	1.00		
2= Female	0.94 (0.79,1.12)		
Marital Status of Household Head			
1= Married	0.81 (0.68,0.97) **		
0= Not married	1.00		
With Children			
1= No children	1.00		
2= 1-3	1.14 (0.89,1.45)		
3= >4	1.28 (0.87,1.89)		
Urban Area			
1= Urban	1.00		
2= Rural	1.05 (0.85,1.29)		
Access to social assistance support			
1= Yes	**1.49 (1.17,1.90)** ***	**1.33 (1.06,1.66)** **	**0.80 (0.64,1.00)** **
0= No	1.00	1.00	1.00
Income			
1= Less than 942	1.00		
2= 943-2000	0.64 (0.51,0.81) ***		
3= 2001-4853	0.42 (0.33,0.53) ***		
4= Above 4853	0.20 (0.15,0.26) ***		
Exposure to weather shocks			
1= Yes	1.45 (1.21,1.72) ***		
0= No	1.00		
Exposure to food price shocks			
1= Yes	1.24 (1.05,1.47) **		
0= No	1.00		

Notes: Characters denote significance at the 1% ***; 5% **, and 10% * levels. The blank columns indicate variables with symmetrical effects across different levels of food insecurity.

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4.5 Ordered Logit Regression model results for the FCS

Table 9 below present the adjusted and unadjusted odds ratios (ORs) for factors associated with higher food consumption scores, interpreted as better food security outcomes. These results show that infrastructure, education, gender, income, and shock exposure all interact in intricate ways to shape household food dynamics.

Households with access to improved water had a 21% higher chance of achieving better food consumption scores (OR = 1.21, 95% CI: 0.96–1.51), suggesting a meaningful, though marginally significant association between water access and food security. This finding underscores the critical role of clean water in promoting food preparation, hygiene and ultimately dietary quality. Similarly, food consumption and improved sanitation were substantially correlated; families with improved sanitation facilities had a 25% higher chance of achieving better food outcomes (OR = 1.25, 95% CI: 1.00–1.56). This lends credence to the idea that improving cleanliness lowers the incidence of disease, facilitating greater food usage and nutritional absorption, contributing positively to food utilization.

The findings also indicate a strong positive association between information access and food consumption outcomes. Ownership of a radio (OR = 1.58, 95% CI: 1.25–1.99) and internet access (OR = 1.56, 95% CI: 1.14–2.14) significantly increased the likelihood of having better food scores by 58% and 56% respectively. Having a television also trends positively, with a 33% increase in the odds (OR = 1.33, 95% CI: 0.96–1.85). Digital and broadcast media can be vital resources for spreading nutrition knowledge, encouraging agricultural practices, creating opportunities for income generation, and linking people to social services and markets in Eswatini's increasingly interconnected society. These findings imply that, when combined with appropriate and easily accessible content, ICT infrastructure

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can serve as a potent facilitator of food security.

There was a positive association between food security and household size: the likelihood of attaining higher consumption scores increased by 8% for every extra person (OR = 1.08, 95% CI: 1.01–1.15), signaling better food security. The presence of multiple income earners, availability of more labor for farming and informal work, sharing of resources among extended family members, and potential prioritization in food or cash assistance programs aimed at vulnerable groups are some of the reasons why larger households in Eswatini may have better food security. Despite having more people living in the home, these factors can work together to improve food access and consumption.

A household's head education level was a strong predictor; households with a head with low (OR = 1.70, 95% CI: 1.27–2.26), junior/high (OR = 2.14, 95% CI: 1.55–2.96), or tertiary (OR = 2.21, 95% CI: 1.14–4.27) education had significantly better food security than those with no education, with odds increasing by 70%, 114%, and 121% respectively. These results highlight how education has a transformative role in Eswatini, enhancing household decision-making abilities, nutritional awareness, and employment opportunities. Therefore, increasing access to better education, particularly for underserved populations, is crucial for long-term food security as well as social development.

Additionally, the odds of reporting improved food consumption were 34% higher for families headed by women (OR = 1.34, 95% CI: 1.05–1.71), indicating that women may be better able to prioritize and control food-related decisions. There was no clear benefit to having more than four children, but households with one to three children had considerably higher food security (OR = 2.04, 95% CI: 1.49–2.81), according to the association between food security and child count. This might be a reflection of how caregiving duties and

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financial limitations are balanced, allowing modest family sizes to manage enough food consumption without going beyond. The rural-urban divide demonstrates a marginal effect: rural dwellers are 27% less likely to achieve higher food security outcomes compared to urban dwellers (OR = 0.73, 95% CI: 0.53–1.02). The results demonstrate the ongoing spatial disparities in infrastructure, service delivery, and market access in Eswatini.

Household income remains one of the strongest predictors: households in the second (OR = 2.03, 95% CI: 1.58–2.61), third (OR = 2.55, 95% CI: 1.86–3.50), and highest (OR = 3.44, 95% CI: 2.19–5.41) income groups had significantly higher food security than people in the lowest income group. In contrast, exposure to weather-related shocks did not significantly increase the likelihood of food insecurity in the adjusted model, while exposure to shocks linked to food prices did (OR = 1.34, 95% CI: 1.07–1.68), reflecting more immediate and disruptive impacts of food price volatility on household purchasing power. After adjusting for other factors, social assistance did not have a substantial independent effect. This could be because of the relatively small size of benefits, inefficient targeting, or restricted coverage. The most food insecure households may not be adequately reached or supported by the safety net programs that Eswatini has implemented, according to these findings.

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Table 9 Odds ratios of household food insecurity (ordered logit model) (FCS)

Variables	Adjusted OR (95% CI)	Variables	Adjusted OR (95% CI)
Use of improved water sources		Gender of Household Head	
1= Yes	1.21 (0.96,1.51) *	1= Male	1.00
0= No	1.00	2= Female	1.34 (1.05,1.71) **
Use of improved sanitation		Marital Status of Household Head	
1= Yes	1.25 (1.00,1.56) **	1= Married	0.94 (0.73,1.22)
0= No	1.00	0= Not married	1.00
Access to electricity		With Children	
1= Yes	1.17 (0.87,1.57)	1= No children	1.00
0= No	1.00	2= 1-3	2.04 (1.49,2.81) ***
		3= >4	1.46 (0.90,2.37)
Having television		Urban Area	
1= Yes	1.33 (0.96,1.85) *	1= Urban	1.00
0= No	1.00	2= Rural	0.73 (0.53,1.02) *
Having radio		Access to social assistance support	
1= Yes	1.58 (1.25,1.99) ***	1= Yes	0.99 (0.78,1.26)
0= No	1.00	0= No	1.00
Access to internet		Income	
1= Yes	1.56 (1.14,2.14) ***	1= Less than 942	1.00
0= No	1.00	2= 943-2000	2.03 (1.58,2.61) ***
		3= 2001-4853	2.55 (1.86,3.50) ***
		4= Above 4853	3.44 (2.19,5.41) ***
Education of H. Head		Exposure to weather shocks	
1= None	1.00	1= Yes	0.93 (0.74,1.18)
2= Low education	1.70 (1.27,2.26) ***	0= No	1.00
3= Junior and High	2.14 (1.55,2.96) ***		
4= Tertiary	2.21 (1.14,4.27) **		
Age of H. Head		Exposure to food price shocks	
1= <30	1.00	1= Yes	1.34 (1.07,1.68) **
2= 31-40	0.90 (0.63,1.29)	0= No	1.00
3= 41-50	0.76 (0.51,1.13)		
4= 51-60	0.72 (0.50,1.06) *		
5= >60	0.81 (0.57,1.14)		
Household Size	1.08 (1.01,1.15) **		

Notes: OR = 1.00 for the reference group. Characters denote significance at the 1% ***;

5% **, and 10% * levels

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4.6 Generalized Ordered Logit Regression model results for the FCS

Table 10 below show results of the generalized ordered logit analysis, highlighting how household factors have significant and distinct effects on the likelihood of falling into one of the three food consumption score (FCS) categories: acceptable, borderline, or poor. By interpreting the findings across both thresholds (2) poor/borderline vs. acceptable and (1) poor vs. borderline/acceptable we can comprehend how each component affects either escaping the greatest food insecurity or achieving full food security. The parallel assumption holds for most of the explanatory variables, indicating consistent outcomes between the two models. Hence this discussion focuses only on access to internet, access to electricity, household size, rural residence and income which violated the assumption and their association differ across thresholds. The variables with symmetrical effects across different levels of food insecurity were left blank in the second and third columns.

Regarding access to electricity, no discernible significant association with food security outcomes, however, the direction of the effect differs between the two thresholds, indicating a 25% increase in the odds of achieving better food consumption in the second threshold compared to 17% in the first model. Internet connectivity became important at the model's second threshold, showing transition from borderline to acceptable consumption. Internet connectivity also played a key role, households having access to internet were 63% more likely to achieve higher food consumption levels, a slight increase compared to 56% likelihood in the previous model, still cementing the narrative that digital connectivity facilitates access to markets, services, and information about food, moving households to acceptable levels of food consumption.

Larger households tended to have better food consumption outcomes; the odds of

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better consumption rose by 33% for every extra household member, a sharp increase compared to 8% in the previous model, however the statistical significance became marginal in the second threshold. This could be a sign of better allocation of resources due to awareness of their family sizes and family labor dynamics that improve food preparation and access. As expected income level was one of the most influential determinant of food consumption scores. Compared to the same income group in the previous model: the chances were 86% higher for income group 3 a slight reduction in the first threshold, however the odds picked up again in the second threshold, still reinforcing that economic security dramatically enhance dietary quality and food access. In contrast to urban households, rural households are 30% unlikely to consume food in an acceptable manner, a slight increase compared to 27% reduction in the previous model. However, the comparison revealed no statistically significant variation between households with borderline or appropriate food intake and those in poverty (OR = 1.12). Rural location did not clearly distinguish between different food insecurity thresholds, according to these data, even though rural households are generally more prone to food insecurity. This illustrates how rural households generally have less access to infrastructure, essential services, and adequate food.

Better food security in Eswatini is positively correlated with improved water and sanitation, and radio access, education and income according to both the Ordered Logit and Generalized Ordered Logit models. Nonetheless, the Generalized model has threshold-specific effects for certain variables. When moving from borderline to acceptable food security levels, for example, household size and internet access have a greater influence than when transitioning from poor to borderline. Access to electricity has conflicting associations, and being in a rural area has a greater impact on preventing extreme insecurity than on

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restricting full food security. Overall, the Generalized model shows more complex, stage-specific dynamics, even if both models align on key predictors.

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Table 10 Generalized ordered logit model on household food consumption score (FCS)

Variables	**Poor vs. borderline + acceptable OR (95% CI)**	**Poor + borderline vs. acceptable OR (95% CI)**
Use of improved water sources		
1= Yes	1.21 (0.96,1.51) *	
0= No	1.00	
Use of improved sanitation		
1= Yes	1.26 (1.01,1.57) **	
0= No	1.00	
Access to electricity		
1= Yes	**0.74 (0.46,1.18)**	**1.25 (0.94,1.66)**
0= No	1.00	1.00
Having television		
1= Yes	1.31 (0.96,1.80) *	
0= No	1.00	
Having radio		
1= Yes	1.58 (1.26,2.00) ***	
0= No	1.00	
Access to internet		
1= Yes	**0.86 (0.55,1.35)**	**1.63 (1.20,2.22)** ***
0= No	1.00	1.00
Household Size	**1.33 (1.18,1.50)** ***	**1.07 (1.00,1.15)** *
Age of Household Head		
1= <30	1.00	
2= 31-40	0.88 (0.62,1.25)	
3= 41-50	0.75 (0.51,1.12)	
4= 51-60	0.72 (0.49,1.05) *	
5= >60	0.79 (0.56,1.12)	
Education of Household Head		
1= None	1.00	
2= Low education	1.71 (1.29,2.28) ***	
3= Junior and High	2.15 (1.56,2.94) ***	
4= Tertiary	2.18 (1.16,4.10) **	

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Gender of Household Head 1= Male 2= Female	 1.00 1.35 (1.05,1.72) **	
Marital Status of Household Head 1= Married 0= Not married	 0.94 (0.73,1.22) 1.00	
With Children 1= No children 2= 1-3 3= >4	 1.00 1.99 (1.43,2.76) *** 1.43 (0.86,2.38)	
Urban Area 1= Urban 2= Rural	 1.00 **1.12 (0.70,1.79)**	 1.00 **0.70 (0.51,0.97)** **
Access to social assistance support 1= Yes 0= No	 1.00 (0.78,1.28) 1.00	
Income 1= Less than 942 2= 943-2000 3= 2001-4853 4= Above 4853	 1.00 2.12 (1.64,2.74) *** **1.86 (1.20,2.88)** *** 3.57 (2.29,5.55) ***	 1.00 2.12 (1.64,2.74) *** **2.74 (2.02,3.74)** *** 3.57 (2.29,5.55) ***
Exposure to weather shocks 1= Yes 0= No	 0.92 (0.73,1.17) 1.00	
Exposure to food price shocks 1= Yes 0= No	 1.36 (1.08,1.71) *** 1.00	

Notes: Characters denote significance at the 1% ***; 5% **, and 10% * levels. The blank columns indicate variables with symmetrical effects across different levels of food insecurity.

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4.7 Heterogeneity Analysis results

4.7.1 The anxious but well fed households: what might cause perceived insecurity despite good diets

Even in nutritionally secure households, perceptions of food insecurity persist, driven not by actual dietary sufficiency but by broader structural vulnerabilities. The odds of anxiety were 36% lower in households with improved sanitation, even if they were well-fed (OR = 0.64, 95% CI: 0.50–0.82). Similarly, having internet access decreased the likelihood of feeling insecure by 33% (OR = 0.67, 95% CI: 0.51–0.86) likely due to its role in improving access to information, opportunities, and networks.

Conversely, as a result of their understanding of underlying vulnerabilities, households that received social assistance were 44% more likely to report experiencing this type of worry (OR = 1.44, 95% CI: 1.09–1.91). Anxiety risks were significantly raised by exposure to weather shocks by 55% (OR = 1.55, 95% CI: 1.21–1.98) and by food price shocks by 32% (OR = 1.32, 95% CI: 1.03–1.69). Being married slightly reduced anxiety by 23% (OR = 0.77, 95% CI: 0.59–1.00), while larger families exhibited a 14% greater probability of reporting this type of perceived insecurity (OR = 1.14, 95% CI: 1.05–1.23). Income showed a clear dose-response effect: belonging to income group 2 reduced anxiety odds by 41% (OR = 0.59, 95% CI: 0.41–0.85) and income group 3 by 74% (OR = 0.26, 95% CI: 0.18–0.38) as opposed to the lowest income level.

The results suggest that beyond food sufficiency, perceived insecurity stems from instability and risk, indicating that low income, exposure to price and weather shocks, inadequate sanitation, and restricted internet access all affect this view. Households with better infrastructure and digital access feel more secure, while those exposed to shocks or

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reliant on aid remain anxious. A comprehensive intervention requires not just food programs but also robust WASH systems, digital inclusion, psychosocial support, and resilience-building initiatives.

4.7.2 Quietly deprived households: what factors prevent deeper insecurity in households with poor diets but low distress

This part explores some factors that can prevent households with poor diets and low levels of psychological distress from experiencing more acute food insecurity. The likelihood of avoiding more severe food insecurity was considerably raised by the use of improved water by 186% (OR = 1.86, 95% CI: 1.20–2.89) and improved sanitation by 177% (OR = 1.77, 95% CI: 1.15–2.71). Larger families, counterintuitively, were better protected; each additional member lowered the risk by 22% (OR = 0.78, 95% CI: 0.67–0.91). Although not always significant, higher education seems to be protective: tertiary education had an OR of 3.55 (95% CI: 0.33–38.6) and junior/high education had an OR of 1.63 (95% CI: 0.86–3.11), both with large confidence intervals. Household heads between the ages of 41 and 50 were 53% less likely to experience further insecurity (OR = 0.47, 95% CI: 0.22–0.98), suggesting that age also provided protection. The odds of protection were 62% greater for married people (OR = 1.62, 95% CI: 1.04–2.51). The results indicate that the value of relationships, mature household leadership, and WASH services serve as buffers against deepening deprivation. Policy should support these areas while paying attention to younger, larger, and unmarried households.

According to this heterogeneity analysis, different household types experience food insecurity in varying ways, emphasizing the need for tailored policy responses. Low income, vulnerability to shocks, and inadequate WASH infrastructure often impact "anxious but well-

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fed" households, those with adequate diets but high perceived insecurity, underscoring the psychological and emotional aspects of food insecurity. Conversely, "quietly deprived" households, typically urban, undereducated, and without internet access, face actual nutritional deficiencies without displaying signs of suffering, which makes them simple to ignore in assessments. Protective variables that reduce the likelihood of slipping further into food insecurity include female headship, higher education, wealth, and access to knowledge (via radio and the internet). Additionally, smaller households, improved water and sanitation, and stable marriages all act as buffers for vulnerable populations. These results highlight the necessity of addressing the structural and social factors of vulnerability in addition to calorie-based measures and felt distress in order to implement successful food security interventions.

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Table 11 Heterogeneity analysis

Variables	Anxious but well-fed vs. fully food secure	Quietly deprived vs. fully food insecure
Use of improved water sources		
1= Yes	0.86 (0.65,1.13)	1.86 (1.20,2.89) ***
0= No	1.00	1.00
Use of improved sanitation		
1= Yes	0.64 (0.50,0.82) ***	1.77 (1.15,2.71) ***
0= No	1.00	1.00
Access to electricity		
1= Yes	0.82 (0.59,1.17)	1.27 (0.77,2.10)
0= No	1.00	1.00
Having television		
1= Yes	0.75 (0.54,1.04) *	1.07 (0.59,1.92)
0= No	1.00	1.00
Having radio		
1= Yes	0.88 (0.69,1.12)	1.40 (0.89,2.19)
0= No	1.00	1.00
Access to the internet		
1= Yes	0.67 (0.51,0.86) ***	0.77 (0.40,1.52)
0= No	1.00	1.00
Other explanatory variables	**Controlled but not presented**	

Notes: OR = 1.00 for the reference group. Characters denote significance at the 1% ***; 5% **, and 10% * levels.

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CHAPTER 5 CONCLUSION

5.1 Summary

The study examined how infrastructure access influences household food security in Eswatini by integrating two complementary measures: the Household Food Insecurity Access Scale (HFIAS), which measures subjective experiences of food access anxiety, and the Food Consumption Score (FCS), that assesses dietary diversity and nutritional adequacy. Each outcome variable was examined using both ordered logistic and generalized ordered logit models to ensure robustness and capture threshold level variations. The dual-measure approach allowed for more comprehensive analysis, identifying both visible and hidden forms of vulnerability, such as "quietly deprived" and "anxious but well-fed" households. The analysis drew data from the 2016–17 EHIES, a nationally representative survey, examining the role of infrastructure availability and access in shaping household food insecurity, controlling for socioeconomic factors and prior shock exposure. Results consistently show better access to improved water and sanitation, and media/information infrastructure (internet, and radio) substantially enhance food security. Meanwhile, lower educational attainment of the household head, households with larger size, lower incomes, and those that have experienced shocks to food prices and drought or flood in the past five years were the most vulnerable to food insecurity.

Across all models, access to improved water and sanitation strengthened the known link between WASH and nutrition. In contrast, electricity was linked with lower food insecurity, the result is, however, not statistically significant, partly due to relatively well-established access to the electricity system. The role of access to information was also noteworthy. Significantly better food security outcomes were obtained by households with

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radios and internet access, underscoring the importance of information flows in influencing eating habits, nutritional awareness, and service accessibility.

Educational attainment was found to be the most reliable and protective factor for household food security. Specifically, households with a head with primary, secondary, and post-secondary education were all associated with notable reductions in food insecurity and enhancements in nutritional quality compared to those without formal education. Similarly, a clear correlation was observed between higher income levels and improved food security, highlighting the importance of economic capacity in attaining food security. The findings did, however, also highlight the dual nature of family size: larger families had higher food insecurity risks, most likely as a result of higher consumption requirements, but they also had higher food consumption scores, possibly as a result of caregiving dynamics and resource sharing.

Crucially, by identifying threshold-specific effects, the generalized ordered logit model offered a more profound understanding, demonstrating that specific factors had the most impact at specific levels of food insecurity. For instance, internet connection was most important in assisting households transition from borderline to acceptable food consumption levels.

The heterogeneity analysis showed that population subgroups experience food insecurity in different ways. In spite of having healthy diets, "anxious but well-fed" households suffer from psychological anxiety due to structural vulnerabilities such as low income, inadequate sanitation, restricted internet access, and exposure to price or climate shocks. Additionally, people who receive social help report feeling more anxious, probably as a result of being aware of the risks that are present. Higher income, digital access, better

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infrastructure, and marital status are also protective variables. Despite having inadequate nutrition, "quietly deprived" households exhibit little psychological suffering. Due to their frequent urbanization, limited access to education, and technology, their nutritional challenges are less visible. Improved water and sanitation, larger households, stable marriages, older household leaders (ages 41–50), and, to some extent, greater education are protective factors against deeper disadvantage. These disparate experiences highlight the necessity of specialized interventions that address the unique vulnerabilities of various family types.

The study concludes that food insecurity in Eswatini is a complex issue influenced by socioeconomic status, environmental shocks, and infrastructure access. In order to combat it, measures that enhance education, media, and internet connectivity, and WASH services while fostering economic resilience are necessary. Merely making sure that people consume enough calories is not enough. Closing these structural divides is a fundamental approach to food security, not just a development objective. Finally, addressing the hidden as well as the visible aspects of food insecurity necessitates multi-layered, integrated strategies that are sensitive to the intricate and ever-changing dynamics of household vulnerability in Eswatini.

5.2 Policy implications

The following suggestions are put forth in light of the findings in order to enhance food security outcomes in Eswatini:

1. Scaling Up Investments in Physical and ICT Infrastructure: The government must prioritize expanding access to improved water and better sanitation, alongside ICT infrastructure, particularly in disadvantaged and rural areas. These have demonstrated clear effects on lowering food insecurity and enhancing the quality of diets.

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Infrastructure development should be seen as a vital pillar of national food security policy in Eswatini.

2. Specialized Assistance for Different Population Groups: The government and related agencies should implement shock-responsive safety nets (such as weather-indexed insurance and emergency cash transfers) alongside expanded access to digital infrastructure and improved sanitation. This tackles the structural dangers that underlie worry even in the face of sufficient food intake, as well as the emotional anguish brought on by perceived vulnerability to the anxious but well-fed households. For the quietly deprived households, the government should introduce targeted nutrition assistance programs (such as subsidized nutritious food baskets or food vouchers) in conjunction with enhanced WASH and access to basic education. By addressing hidden hunger, this ensures that these underserved populations receive enough nutritional support even when there isn't any obvious discomfort.

3. Strengthen Shock Resilience: The National Disaster Management Agency, the Ministry of Tourism and Environmental Affairs, the Ministry of Agriculture, and related agencies should work together to enhance climate adaptation by supporting climate-resilient agriculture and diversified income streams to lessen the impact of weather and food price shocks. Development of robust early warning systems and risk insurance programs to help households better cope with weather and market-related shocks is also critical.

4. Promote education and skills development: The government must promote access to adult education and vocational training, recognizing the strong linkages between better food security outcomes and higher educational attainment.

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5. Institutionalize Multidimensional Food Security Monitoring: To capture both diverse and overlapping aspects of food insecurity, institutionalize the adoption of multiple food security measures in national food security monitoring. Disaggregate food security data by vulnerability status, gender, and region to ensure more responsive, inclusive, and evidence-based policymaking.

5.3 Future Research

This study lays a critical foundation for deeper exploration into the multidimensional nature of food insecurity in Eswatini. However, several areas warrant further investigation to build on its insights. First, with urbanization accelerating in Eswatini, much focus is needed on quietly deprived urban households who experience poor diets without evident distress. Future studies should investigate how formal food networks, infrastructure gaps, and employment insecurity influence food access in urban settings. Second, the psychological burden observed among anxious but well-fed households underscores the potential interplay between food insecurity and mental health issues. For example, how food-related anxiety impacts wellbeing and explores possible coping strategies and resilience mechanisms used by such households warrants further studies. Finally, future research should employ panel data to monitor the progression of food security across different periods, especially in response to targeted interventions, climate variability, and macroeconomic shocks. This will enhance the understanding of both immediate and sustained trends in household food resilience in Eswatini.

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APPENDICIES

Appendix 1 Odds ratios of household food insecurity (Ordered Logit Model) (HFIAS)

Variables	Unadjusted OR (95% CI)
Use of improved water sources	
1= Yes	0.50 (0.43,0.59) ***
0= No	1.00
Use of improved sanitation	
1= Yes	0.58 (0.50,0.67) ***
0= No	1.00
Access to electricity	
1= Yes	0.34 (0.29,0.40) ***
0= No	1.00
Having television	
1= Yes	0.32 (0.28,0.37) ***
0= No	1.00
Having radio	
1= Yes	0.51 (0.44,0.59) ***
0= No	1.00
Access to internet	
1= Yes	0.56 (0.47,0.67) ***
0= No	1.00
Household Size	1.15 (1.12,1.18) ***
Age of Household Head	
1= <30	1.00
2= 31-40	1.02 (0.82,1.28)
3= 41-50	1.08 (0.85,1.37)
4= 51-60	1.66 (1.28,2.16) ***
5= >60	2.19 (1.75,2.73) ***
Education of Household Head	
1= None	1.00
2= Low education	0.62 (0.51,0.76) ***
3= Junior and High	0.28 (0.23,0.34) ***
4= Tertiary	0.09 (0.07,0.12) ***
Gender of Household Head	
1= Male	1.00
2= Female	1.35 (1.17,1.55) ***

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Marital Status of Household Head 1= Married 0= Not married	 0.82 (0.71,0.94) ** 1.00
With Children 1= No children 2= 1-3 3= >4	 1.00 1.49 (1.25,1.77) *** 3.01 (2.44,3.71) ***
Urban Area 1= Urban 2= Rural	 1.00 2.38 (1.99,2.83) ***
Access to social assistance support 1= Yes 0= No	 2.06 (1.78,2.39) *** 1.00
Income 1= Less than 942 2= 943-2000 3= 2001-4853 4= Above 4853	 1.00 0.59 (0.48,0.73) *** 0.36 (0.29,045) *** 0.11 (0.09,0.14) ***
Exposure to weather shocks 1= Yes 0= No	 2.08 (1.79, 2.42) *** 1.00
Exposure to food price shocks 1= Yes 0= No	 1.22 (1.06,1.41) 1.00

Source: Author's computation

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Appendix 2 Odds ratios of household food insecurity (ordered logit model) (FCS)

Variables	Unadjusted OR (95% CI)
Use of improved water sources	
1= Yes	1.78 (1.45,2.17) ***
0= No	1.00
Use of improved sanitation	
1= Yes	1.83 (1.50,2.22) ***
0= No	1.00
Access to electricity	
1= Yes	3.05 (2.49,3.73) ***
0= No	1.00
Having television	
1= Yes	3.77 (3.02,4.70) ***
0= No	1.00
Having radio	
1= Yes	2.44 (2.00,2.98) ***
0= No	1.00
Access to internet	
1= Yes	2.51 (1.90,3.32) ***
0= No	1.00
Household Size	1.09 (1.05,1.13) ***
Age of Household Head	
1= <30	1.00
2= 31-40	1.14 (0.83,1.57)
3= 41-50	1.08 (0.77,1.51)
4= 51-60	0.81 (0.58,1.14)
5= >60	0.74 (0.55,1.00) **
Education of Household Head	
1= None	1.00
2= Low education	1.92 (1.50,2.45) ***
3= Junior and High	3.46 (2.63,4.56) ***
4= Tertiary	6.50 (3.86,10.9) ***
Gender of Household Head	
1= Male	1.00
2= Female	1.14 (0.94,1.38)

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Marital Status of Household Head	
1= Married	1.34 (1.11,1.64) ***
0= Not married	1.00
With Children	
1= No children	1.00
2= 1-3	2.10 (1.68,2.62) ***
3= >4	1.65 (1.28,2.12) ***
Urban Area	
1= Urban	1.00
2= Rural	0.53 (0.41,0.70) ***
Access to social assistance support	
1= Yes	1.20 (0.99,1.45) *
0= No	1.00
Income	
1= Less than 942	1.00
2= 943-2000	2.52 (1.99,3.20) ***
3= 2001-4853	4.22 (3.18,5.61) ***
4= Above 4853	8.04 (5.57,11.62) ***
Exposure to weather shocks	
1= Yes	0.83 (0.67,1.01) *
0= No	1.00
Exposure to food price shocks	
1= Yes	1.39 (1.15,1.69) ***
0= No	1.00

Source: Author's computation

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