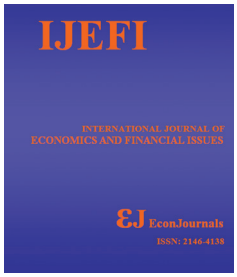

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Food Insecurity and Poverty Dynamics among Rural Households in Eastern Sudan: Evidence from the Red Sea State

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ABSTRACT

This study investigates the relationship between food insecurity and poverty among rural households in Red Sea State, Eastern Sudan. Drawing on a cross-sectional household survey conducted across three localities—Suakin, Port Sudan, and Arbaat—the analysis applies the FAO Food Insecurity Experience Scale (FIES) and chi-square statistical tests to examine how gender, migration status, education, and household size influence welfare outcomes. Based on a field survey of 394 households across Suakin, Port Sudan, and Algonub (Arbaat), the study examines demographic characteristics, income-generating strategies, food insecurity, and poverty prevalence. Results reveal that 47.2% of households experience moderate to severe food insecurity, and 84.5% live living below the international poverty threshold of USD 1.90/day. Disaggregated findings reveal significant disparities: Only 17% of female-headed households are food secure compared to 39.9% of male-headed households, while 94.3% of females live below the poverty line versus 81.7% of males. Migration status further amplifies vulnerability—none of the refugee households were food secure, and 100% live in poverty, compared to 13.8% food security and 93.3% poverty among IDPs, and 37.8% food security and 83.2% poverty among host communities. These insights underscore the importance of gender-sensitive and migration-aware policy interventions to build resilience and reduce poverty in fragile rural contexts.

Keywords: Food Security, Poverty Dynamics, Rural Livelihoods, Gender Vulnerability, Displacement, Eastern Sudan, Red Sea State
JEL Classifications: A1, L66, Q12, Q18, R31, R51

1. INTRODUCTION

Food insecurity and poverty remain deeply intertwined challenges that continue to undermine rural livelihoods in Sub-Saharan Africa, particularly in fragile and conflict-affected states. In Eastern Sudan's Red Sea State, the convergence of environmental degradation, weak market integration, limited access to services, and protracted displacement has compounded household vulnerability and eroded resilience (FAO, 2022; De Waal, 2007; Onyebueke et al., 2019; El Shiekh and Osman, 2021). The complexity of these overlapping crises necessitates context-specific, disaggregated analyses to inform inclusive development interventions.

While Sudan has long grappled with chronic poverty and food insecurity, the situation has been exacerbated in recent years due to economic collapse, political instability, and climate shocks (Abdalla et al., 2020; UN OCHA, 2023). In the Red Sea region specifically, rural households face persistent livelihood constraints, compounded by drought cycles, poor infrastructure, and limited access to agricultural inputs and markets (Ali and Elasha, 2021; Maxwell et al., 2020; IFAD, 2018).

Despite a growing body of literature on food security in Sudan (Eldoma and Ali, 2020; IPC, 2023), most studies adopt national-level or sectoral perspectives, overlooking localized household dynamics—especially in marginalized rural settings. A critical gap remains in understanding how structural poverty interacts with food insecurity at the micro level, and how this intersection is shaped by gender and migratory status—both key dimensions of social vulnerability (Quisumbing et al., 2015; WFP, 2021).

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In Eastern Sudan, women and displaced populations remain disproportionately affected by these vulnerabilities due to limited control over productive assets, restricted mobility, and weak institutional support (Osman et al., 2019).

This study aims to fill this empirical void by investigating the relationship between food insecurity and poverty among rural households in Red Sea State, Sudan. Using a baseline household survey conducted across Suakin, Port Sudan, and Arbaat, it offers disaggregated evidence based on gender of household head and migration category (host communities, internally displaced persons, and refugees).

Employing the Food Insecurity Experience Scale (FIES) alongside Chi-square tests, the analysis quantifies disparities in food security and poverty outcomes across demographic groups. Preliminary results indicate severe levels of deprivation: 47.2% of households experience moderate to severe food insecurity, while 84.5% live below the international poverty line of USD 1.90/day. Particularly vulnerable are female-headed households and displaced populations—underscoring the need for tailored and inclusive policy responses.

By sitting in household food insecurity within a broader framework of structural poverty and demographic exclusion, this study contributes to the literature on rural vulnerability in fragile states. It also offers evidence-based insights for humanitarian programming, national social protection strategies, and donor targeting efforts in under-researched areas of Sudan, especially in Eastern regions where gaps in data and policy attention remain pronounced.

This paper is structured as follows: Section 1 presents the introduction and outlines the research problems and objectives. Section 2 reviews the relevant literature on food insecurity and poverty in Sub-Saharan Africa and Sudan. Section 3 describes the methodology, including data collection and analytical tools. Section 4 reports the key findings, including household characteristics, food security status, and poverty levels. Section 5 discusses the findings concerning literature. Finally, Section 6 concludes the paper with policy implications and recommendations.

2. LITERATURE REVIEW

The interconnection between food insecurity and poverty has been extensively discussed in development literature. Food security, as defined by the FAO (2023), implies that all people always have physical, social, and economic access to sufficient, safe, and nutritious food. Barrett (2010) emphasizes the multidimensional nature of food insecurity, linking it with income poverty, livelihood instability, and vulnerability to shocks. In rural Sudan, previous research highlights structural constraints such as low agricultural productivity, limited access to markets, and weak infrastructure (Babiker et al., 2017; Alozie et al., 2018; Osman et al., 2021).

Gender inequalities further exacerbate household food insecurity, particularly in female-headed households with limited access to land, credit, and decision-making power (World Bank, 2020). Migration and displacement also shape poverty dynamics, with internally displaced persons (IDPs) and refugees facing significant barriers to employment, asset ownership, and social services (Bailey et al., 2021; UNHCR, 2023).

Environmental constraints, including aridity, soil degradation, and water scarcity, are prevalent in Eastern Sudan and disproportionately affect rural households (UNEP, 2022). Studies recommend integrated interventions that consider environmental, social, and economic factors in addressing food insecurity and rural poverty. This study builds on this foundation by analyzing recent data from the Red Sea State.

Recent empirical studies have also emphasized the importance of context-specific assessments in fragile settings. For example, Alinovi et al. (2010) developed a framework for understanding food insecurity that integrates resilience, livelihood access, and institutional support, which is particularly relevant to conflict-affected regions like Eastern Sudan. Additionally, Abdulrahman et al. (2025) noted that the Building Resilience for Poverty Reduction (BRPR) program in Sudan has worked well, even though there have been problems like political instability and money. The community is more resilient now because of things like the creation of village savings and loan institutions, more people getting involved in the community, and improvements in livestock health, sanitation, and agricultural productivity. Furthermore, Headey and Ecker (2013) argue that poor policy responses and lack of investment in rural development contribute significantly to persistent poverty and malnutrition. These insights reinforce the need for integrated, data-driven approaches that combine food access, asset ownership, and environmental resilience—elements that this study seeks to explore in the Red Sea State.

3. METHODOLOGY

The sample size of 394 households was determined using the Cochran formula for categorical data:

$$n = (Z^2 \times p \times (1-p))/e^2$$

Where:

- $Z = 1.96$ (standard value for 95% confidence level)
- $p = 0.5$ (assumed proportion for maximum variability)
- $e = 0.05$ (margin of error)

This yields a required minimum sample size of 384 households. To ensure better representation and allow for non-response, the final sample was increased to 394 households. Stratified random sampling was applied to ensure adequate representation across the three localities and key demographic subgroups.

This study is drawing on data collected through a baseline survey conducted in 2023 across 11 rural villages and settlements in three localities of the Red Sea State: Suakin, Port Sudan, and Algonub (Arbaat). A total of 394 households were randomly selected using stratified sampling to ensure adequate representation across gender, migratory status, and livelihood types. Structured household questionnaires were administered by trained enumerators and

supplemented with focus group discussions (FGDs) and key informant interviews (KIIs) to gain qualitative insights.

The survey tool covered socio-demographic characteristics, education, access to land and water, livelihood sources, agricultural practices, income levels, food consumption, and perceptions of food insecurity. The Food Insecurity Experience Scale (FIES), developed by the FAO, was used to assess household food security levels. Poverty was measured using the World Bank's international poverty line (USD 1.90/day/person). Descriptive statistics were computed using Excel and SPSS to analyze trends and disaggregated indicators by sex and migratory status.

4. RESULTS AND ANALYSIS

The survey included 394 respondents, with 54.1% male and 45.9% female. Age distribution revealed that 92.5% of respondents were within the productive age group (18-59 years), indicating high labor potential (Figure 1). Education levels were generally low, with 67% having only primary education or less, and <10% having higher education. Household sizes averaged six members, with an average of three children under 5 years of age and two people with disabilities per household.

Women—especially elderly women—faced higher food insecurity levels than men across various age groups in Sub-Saharan Africa.

These findings reinforce the results of the Red Sea State study and confirm that structural inequalities based on gender, education, age, and livelihood access are consistent predictors of food insecurity and poverty across fragile and marginalized communities in Sub-Saharan Africa.

Age distribution shows that 52% of respondents were aged 18-39 years, 40.5% were aged 40-59 years, and 7.5% were 60 years or older (Figure 2). This indicates that most of the sample population falls within the productive age range. FIES-based analysis in Sub-Saharan Africa showed that older adults (≥50 years) faced significantly higher rates of severe food insecurity compared to younger adults (38.6% vs. 35.8%, $P < 0.0001$).

In terms of education, 67% of respondents had primary education or less, 7.8% had intermediate education, 15.9% completed secondary education, and 9.3% held post-secondary or university-level degrees (Figure 3).

A study in Togo using Gallup World Poll data (2014-2018) found that both poverty and food insecurity declined with increasing levels of education. Individuals without education were more likely to suffer from both conditions compared to those with higher education. Similarly, in the Congo Basin, educational attainment was associated with reduced food insecurity due to improved knowledge and productivity.

Figure 1: Gender distribution of respondents

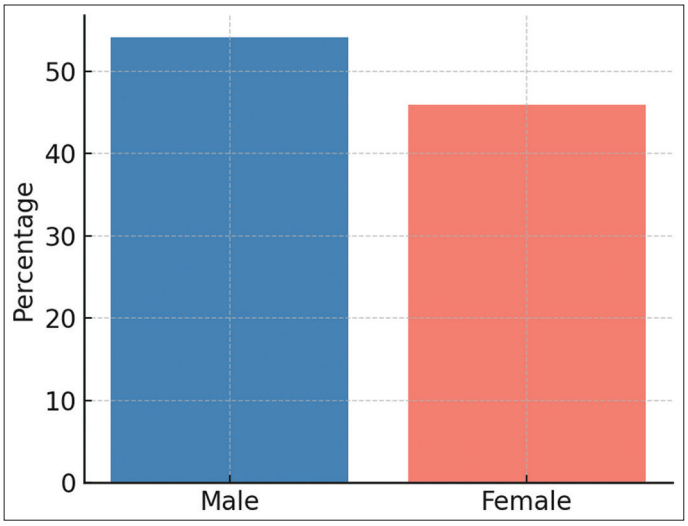


Figure 2: Age group distribution of respondents

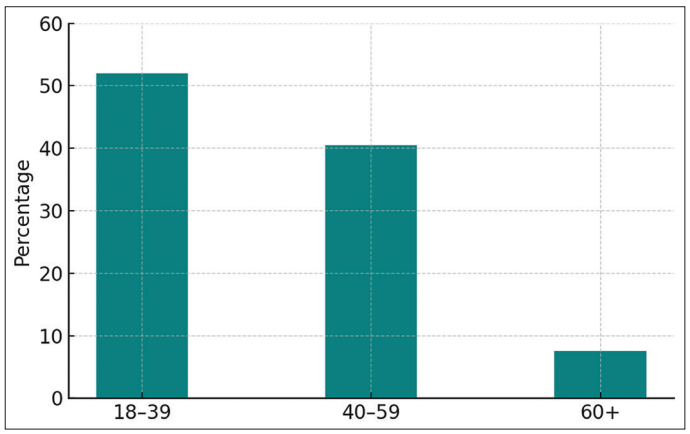


Figure 3: Educational attainment of respondents

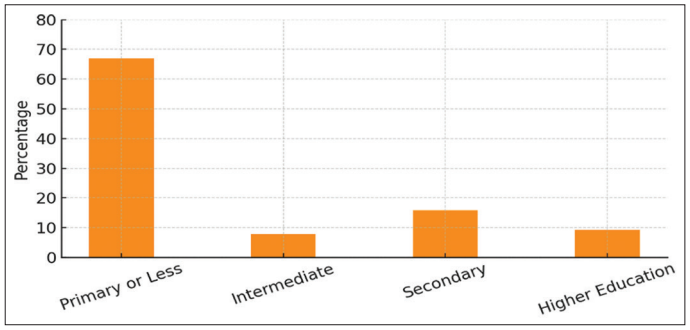


Figure 4: Respondents disaggregated by main livelihood activity

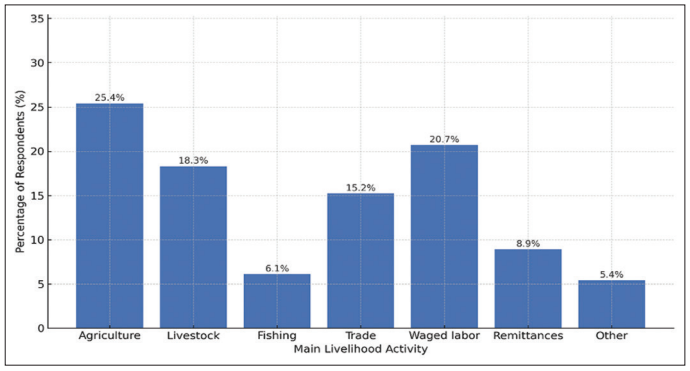


Figure 4 illustrates the distribution of respondents by their main livelihood activity. Agriculture constitutes the most common livelihood source (25.4%), followed by waged labor (20.7%) and livestock (18.3%). Fishing and trade represent 6.1% and 15.2%, respectively, while remittances and other minor sources account for a combined 14.3%. This highlights the rural economy's dependence on natural resources and informal labor. This figure shows that agriculture is the most common source of livelihood among rural households, accounting for 25.4%, followed by waged labor (20.7%) and livestock (18.3%). Fishing and trade are also notable, representing 6.1% and 15.2% respectively, while remittances and other activities account for smaller shares. These patterns reflect a heavy dependence on natural resources and informal employment in the surveyed communities. This figure shows that the sample is composed of 54.1% male and 45.9% female respondents. This reflects a relatively balanced gender representation in rural areas.

A significant proportion (67%) of respondents have only primary education or less, which reflects limited educational access in rural areas.

Studies in Kenya, Nigeria, and Uganda demonstrated that rural households relying on wage labor were more food insecure than those engaged in agriculture or forest-based livelihoods. Access to agricultural extension and credit improved food security by up to 17%.

4.1. HHs Food Security Status

Figure 5 illustrates that 47.2% of households experience moderate to severe food insecurity, while only 9.4% are food secure. This underscores widespread vulnerability within the study area.

Figure 5: HHs food security status based on FIES

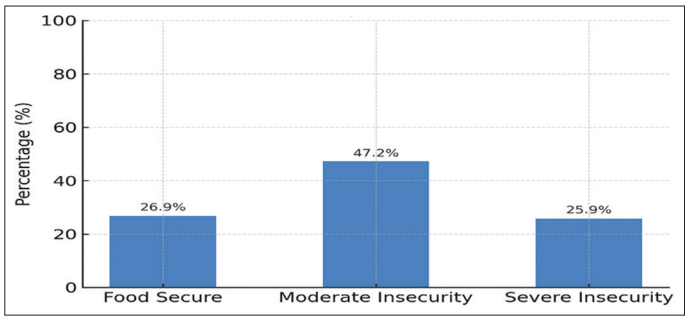


Figure 6: HHs food security status by migratory status

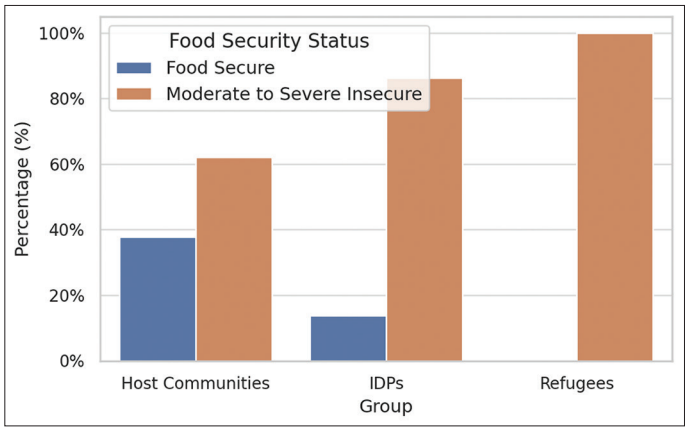


Figure 6 illustrates that refugee households are the most vulnerable, with 100% experiencing food insecurity and none being food secure. Host communities show comparatively better food security status.

This Figure 7 presents a comparison between male-headed and female-headed households across three food security levels. Male-headed households have a significantly higher share of food secure status (39.9%) compared to female-headed households (17%). Female-headed households also exhibit higher levels of both moderate and severe food insecurity, highlighting gender-based vulnerability in food access.

4.2. HHs Poverty Status

Figure 8 reveals that 84.5% of households live below the international poverty line of USD 1.90/day, indicating a high prevalence of poverty across surveyed communities. When disaggregated by gender, the fig, shows that 81.7% of male-headed households are below the poverty line, the percentage rises to 94.3% among female-headed households.

4.3. Hypotheses Testing

This section presents the analysis of the study's key hypotheses concerning the relationships between household characteristics and food security and poverty outcomes. Chi-square tests and cross-tabulations were used to assess associations between gender of household head, migratory status, educational attainment, and livelihood type with food security status (based on FIES) and poverty status (based on the international poverty threshold)

Figure 7: HHs food security status by gender

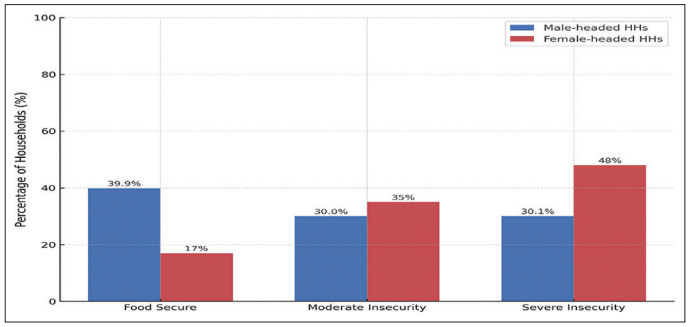
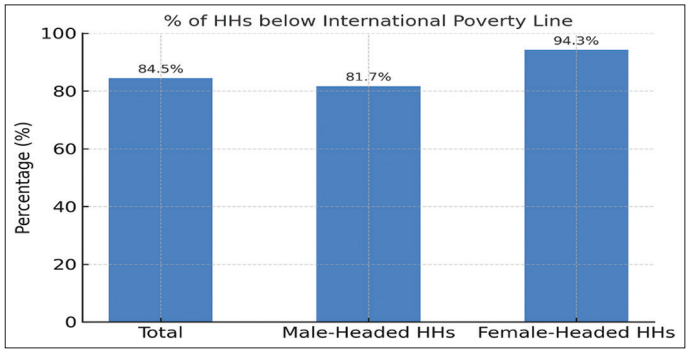


Figure 8: HHs poverty status



(Table 1). The results confirm significant disparities across gender and migratory groups, with female-headed households and displaced populations showing higher vulnerability to both food insecurity and poverty. Educational level and livelihood activity also exhibit statistically significant relationships with poverty levels (Table 2).

Chi-square tests were conducted to assess the significance of associations between key variables. The association between gender of household head and food security status was statistically significant ($\chi^2 = 12.47$, df = 2, $P < 0.01$), indicating a clear disparity between male- and female-headed households. Similarly, migration status showed a strong and significant relationship with both food insecurity ($\chi^2 = 21.83$, df = 2, $P < 0.001$) and poverty status ($\chi^2 = 19.56$, df = 2, $P < 0.001$). Education level and livelihood type were also significantly associated with poverty status ($P < 0.05$), suggesting that socio-economic characteristics remain key determinants of rural vulnerability in Red Sea State.

This Table 3 illustrates the strong relationship between migration status and food security outcomes. Host communities show relatively better food security with 37.8% classified as food secure,

Table 1: Summary of Chi-square test results

Variable pair	Chi-square (χ^2)	df	P-value	Significance
Gender×food security	12.47	2	<0.01	Significant
Migration×poverty	19.56	2	<0.001	Significant
Education×poverty	9.82	3	<0.05	Significant
Livelihood×poverty	8.36	3	<0.05	Significant
Household size×food security	10.27	2	<0.01	Significant

Table 2: Food security status by gender of household head

Gender	Food secure (%)	Moderate insecurity (%)	Severe insecurity (%)	Total (%)
Male-headed HHs	39.9	30.0	30.1	100
Female-headed HHs	17.0	35.0	48.0	100

Table 3: Chi-square test–food security status by migration status

Migration status	Food secure (%)	Moderate insecurity (%)	Severe insecurity (%)	Total (%)
Host Community	37.8	40.0	22.2	100
IDPs	13.8	45.6	40.6	100
Refugees	0.0	32.0	68.0	100

Chi-square (χ^2)=22.43, df=4, P<0.001. Food insecurity severity increases significantly among displaced groups, particularly refugees

Table 4: Poverty status by educational level of household head

Education level	Above poverty line (%)	Below poverty line (%)	Total (%)
No education	5.3	94.7	100
Primary	10.6	89.4	100
Secondary	24.5	75.5	100
Higher education	36.8	63.2	100

compared to only 13.8% among IDPs and 0% among refugees. The majority of refugee households (68%) experience severe food insecurity, highlighting their extreme vulnerability. These findings point to the need for migration-sensitive food assistance programs, with priority given to displaced populations.

Table 4 confirms statistically significant associations between key socio-demographic variables and food security or poverty. Gender, migration status, education, livelihood, and household size are all significantly linked to the outcome variables. Food security improves with higher educational attainment. Only 13.4% of households with no education are food secure, compared to 48.5% among those with higher education.

Larger households are significantly more food insecure. Food security is highest among small households (≤5 members), while households with ≥9 members face the highest food insecurity (84.3%). Households engaged in agriculture and remittances show relatively lower poverty rates, while those depending on wage labor are more likely to fall below the poverty line (91.9%).

This table 4 shows a clear inverse relationship between educational attainment and poverty incidence. Households headed by individuals with no education have the highest poverty rate (94.7%), while those with higher education have the lowest (63.2%). Chi-square (χ^2) = 10.27, df = 2, $P < 0.01$. Larger households are more food insecure.

Food insecurity escalates as household size increases (Table 5). Larger families often face higher dependency ratios and resource constraints, indicating the need to scale assistance based on household composition.

Education proves to be a strong determinant of poverty. The findings indicate that higher educational attainment is associated with a lower likelihood of falling below the poverty line, reaffirming the role of education in economic resilience. Female-headed households display a substantially higher rate of food insecurity than male-headed households. The gender gap highlights systemic inequalities in access to resources, income, and social support mechanisms.

The data clearly indicate that refugee and IDP households suffer from significantly higher poverty levels than host communities. This disparity underscores the importance of integrating migration status into poverty alleviation strategies and social protection policies.

This analysis demonstrates that younger household heads (18–39 years) are more likely to maintain food security compared to older counterparts, likely due to greater physical capacity and

Table 5: Chi-square test–food security by age of household head

Age group	Food secure (%)	Food insecure (%)	Total (%)
18–39 years	42.0	58.0	100
40–59 years	30.5	69.5	100
60+years	18.2	81.8	100

Table 6: Chi-square test–food security status by livelihood source

Livelihood source	Food secure (%)	Moderate insecurity (%)	Severe insecurity (%)	Total (%)
Agriculture	38.5	42.0	19.5	100
Wage Labor	17.0	34.2	48.8	100
Remittances	44.4	33.3	22.3	100
Others	25.0	40.0	35.0	100

Chi-square (χ^2)=13.96, df=6, P<0.05

Table 7: Chi-square test–poverty status by food security status

Food security status	Above poverty line (%)	Below poverty line (%)	Total (%)
Food secure	41.2	58.8	100
Moderate Insecurity	22.6	77.4	100
Severe insecurity	9.3	90.7	100

Chi-square (χ^2)=15.64, df=2, P<0.001. Poverty increases significantly with worsening food security

engagement in productive labor. This suggests the need for age-sensitive targeting in food security programming.

Households relying on wage labor are significantly more food insecure than those in agriculture or receiving remittances.

This table 6 highlights a significant association between livelihood source and food security. Households that depend on wage labor show the highest rate of severe food insecurity (48.8%), while those involved in agriculture or receiving remittances have better food security outcomes. This reflects the vulnerability of precarious labor-based incomes and the stabilizing effect of diversified or external income sources.

This cross-tabulation reveals a strong association between food insecurity and poverty. As food insecurity severity increases, the likelihood of being below the poverty line also rises significantly. Only 58.8% of food secure households are poor, while this rate increases to 90.7% among those experiencing severe food insecurity (Table 7). This finding underscores the cyclical and mutually reinforcing relationship between hunger and poverty.

5. DISCUSSION

The findings of this study underscore the multidimensional nature of food insecurity and poverty in the Red Sea State. High rates of food insecurity and poverty reflect systemic challenges rooted in both structural and environmental factors. Agricultural livelihoods are constrained by limited access to arable land, water, and inputs, particularly in Suakin and Port Sudan. Despite the potential for improved productivity in Algonub, seasonal water availability and lack of mechanization limit year-round cultivation.

Gender disparities in food security and poverty align with existing literature emphasizing the marginalization of women in resource access, education, and employment opportunities. The significantly lower food security among female-headed households calls for gender-sensitive policy interventions. Similarly, the extreme vulnerability of displaced and refugee populations necessitates humanitarian and development actors to coordinate responses that address both immediate needs and long-term integration strategies.

The strong correlation between food insecurity and poverty among surveyed households supports the notion of "food poverty," where income constraints directly limit dietary diversity and caloric intake. Addressing food security, therefore, requires a comprehensive approach that includes poverty alleviation, livelihood diversification, and improved infrastructure.

6. CONCLUSION AND POLICY RECOMMENDATIONS

6.1. Conclusion

This study provides robust empirical evidence on the multidimensional nature of food insecurity and poverty among rural households in Red Sea State, Sudan. Using gender- and migration-disaggregated data and employing chi-square statistical analysis, the findings confirm the existence of statistically significant disparities in household welfare outcomes.

Female-headed households, displaced populations (IDPs and refugees), and households with larger family sizes were found to be disproportionately affected by both food insecurity and poverty. Education level and livelihood source also emerged as strong predictors of vulnerability, with wage laborers and uneducated household heads being the most affected.

A particularly strong association was observed between food insecurity and poverty, suggesting a mutually reinforcing relationship where lack of access to adequate food is both a cause and a consequence of household poverty.

These results emphasize the urgent need for integrated, gender-sensitive, and migration-responsive policies to enhance food security, reduce poverty, and build long-term resilience among vulnerable rural communities.

6.2. Recommendations

1. Gender-responsive programming: Prioritize female-headed households in food assistance and asset-transfer programs, and support women's cooperatives in agriculture and food processing.
2. Migration-sensitive social protection: Design targeted safety net interventions for IDPs and refugees, including mobile cash transfer systems, e-vouchers, and skills-based support for economic reintegration.
3. Expand educational access and literacy: Invest in adult literacy, especially for household heads in rural areas, and link education incentives (school meals, scholarships) with food security programming.
4. Tailored assistance based on household size: Adjust food and cash transfers based on family size, ensuring that larger households receive proportional support to mitigate dependency-related food insecurity.
5. Diversification of rural livelihoods: Promote climate-smart agriculture, livestock restocking, and small-scale rural

enterprises to reduce reliance on casual labor, especially in displacement-affected communities.

6. Integrated food and poverty monitoring system: Establish a real-time data system using the FIES and poverty tracking tools to inform dynamic policy responses and early warning triggers.
7. Revive state-level food security coordination: Institutionalize a red sea state food security task force with representatives from local authorities, UN agencies, NGOs, women's groups, and refugee committees

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