



From Education to Food Security: A Capability-Based Perspective on Household Well-being in Indonesia

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Abstract

This study investigates the role of household head education in reducing the likelihood of moderate or severe food insecurity in Indonesia, drawing on Sen's Capability Approach. Rather than treating education as a proxy for income, it is conceptualized as a foundational capability that enhances agency, access to information, and household resilience. Using nationally representative data from the Indonesian National Socioeconomic Survey (SUSENAS, 2019–2023), the study employs multilevel mixed-effects logistic regression to assess how education interacts with district-level Human Development Index (HDI) and poverty rates in shaping food security outcomes.

Results confirm that higher educational attainment significantly lowers the odds of food insecurity. However, this protective effect varies by context. Education is most effective in lower-HDI districts, where institutional supports are weaker and individual agency becomes critical. In contrast, its impact diminishes in high-HDI urban areas, where high living costs and structural inequality constrain capability realization. Similarly, in high-poverty districts, the benefits of education are reduced by limited opportunities to convert educational capital into tangible well-being. A three-way interaction shows the greatest constraint where development and deprivation coexist.

These findings highlight the need for context-sensitive policies combining educational investment with structural reforms to ensure meaningful expansion of capability and food security.

Keywords: food insecurity, household head education, Indonesia, multilevel mixed-effects model, Sen's Capability Approach

1. Introduction

1.1. Background

Food insecurity remains a pressing development challenge in Indonesia, with millions of households lacking stable access to adequate nutrition. Despite sustained economic growth and various policy interventions, structural vulnerabilities and institutional gaps—especially in remote areas—continue to expose communities to persistent food-related risks [1]–[3]. Globally, the situation is no less serious. According to *The State of Food Security and Nutrition in the World 2024*, an estimated 713 to 757 million people—roughly one in every eleven—experienced hunger in 2023 [4]. In Indonesia, moderate and severe food insecurity declined from 8.7% in 2017 to 4.0% in 2024, corresponding to an estimated 11.3 million individuals in 2024. However, national averages mask sharp regional disparities across districts and provinces, where local development conditions and household vulnerabilities differ significantly.

Understanding these disparities requires moving beyond income- or availability-based explanations. Food insecurity involves not just material deprivation but also the constrained capacity of households to access, utilize, and sustain adequate nutrition over time [5], [6]. This study draws on Amartya Sen's Capability Approach [7] to explore how educational attainment—particularly that of the household head—shapes food security. Prior evidence shows that education can enhance household resilience [8], but its effectiveness depends on the broader structural context. This motivates a closer look at how local development conditions affect the realization of education's potential benefits.

Despite the relevance of structural context, little is known about how education interacts with local development conditions to influence food insecurity outcomes in Indonesia. District-level indicators like the Human Development Index (HDI) and poverty rates are proxies for institutional quality and economic opportunity. Even highly educated households may struggle to translate their capabilities into improved well-being in areas with low HDI and high poverty. This dynamic reflects a broader concept within the Capability Approach—conversion factors—which will be discussed in more detail later [9]–[13].



This study addresses these gaps by applying the Capability Approach to reconceptualize food insecurity as a lack of food or income and a deprivation of the freedom to achieve nutritional well-being [7]. Education is a foundational capability that enhances agency and expands adaptive strategies. However, its impact is context-dependent. This study explores how education's effect on food security is shaped by regional development and deprivation patterns, proxied by district-level HDI and poverty. It situates food insecurity within the broader context of social inequality and uneven development in Indonesia.

1.2. Aims of the Study

This study investigates the role of education—specifically the education level of the household head—as a key determinant of household food security in Indonesia. Anchored in Sen's Capability Approach, education is viewed not simply as a proxy for income, but as a capability that strengthens individuals' capacity to achieve valued outcomes. It enhances decision-making, health knowledge, and access to livelihood opportunities, contributing to household resilience.

However, education alone is not enough. Its effectiveness depends on the structural context in which households are embedded. This study also examines how contextual factors—particularly district-level Human Development Index (HDI) and poverty rates—moderate the protective effect of education on food insecurity.

Five aims guide the inquiry. First, to evaluate how household head education affects the likelihood of food insecurity. Second, to assess whether this effect varies across districts with different HDI levels. Third, to examine differences in the protective role of education across varying poverty contexts. Fourth, to explore the interaction between economic development (HDI) and deprivation (poverty) in shaping education's role. Fifth, to inform policy by identifying how educational investments, when supported by structural improvements, can enhance food security. Collectively, these aims contribute to education and development scholarship by illuminating how individual capabilities intersect with contextual inequality to influence well-being outcomes.

1.3. Novelty and Contribution of the Study

This study offers four key contributions to education, development, and food systems through a capability-based lens. First, it provides a theoretically grounded perspective by showing how education enables households to convert entitlements into valued functionings, particularly under structural constraints. Second, it adopts a multilevel framework using nationally representative data from SUSENAS (2019–2024), combining household characteristics with district-level indicators like HDI and poverty.

Third, it introduces two-way and three-way interaction models to examine how structural conditions shape the realization of education's protective effect. Findings reveal that education is most effective in underdeveloped regions but less impactful in areas where development and poverty coexist—such as urbanized but unequal districts. Fourth, the study contributes to policy discourse by emphasizing that education, while vital, is insufficient. Structural reforms targeting poverty, regional inequality, and public service provision are essential to translate educational gains into improved food security.

2. Theoretical Framework: The Capability Approach and Food Insecurity

The Capability Approach, as articulated by Robeyns and Byskov [14], provides a comprehensive normative framework for evaluating well-being—not by the mere possession of goods or resources, but by people's actual freedoms, or capabilities, to achieve valued states of being and doing, known as *functionings*. This emphasis on what individuals can do and be shifts the focus from inputs (e.g., income, food availability) to outcomes, aligning well with the issue of food insecurity. Food insecurity is not solely a consequence of low income or food unavailability, but also reflects a household's constrained ability to convert available resources into adequate nutrition and health [15].

In this study, the education level of the household head is conceptualized as a foundational capability that enhances agency and strengthens household strategies to reduce food-related vulnerability. Within the Capability Approach, education is a basic functioning and a means to expand other capabilities. It contributes to better decision-making, health literacy, and information and support systems. In this context, *agency* refers to individuals' ability to pursue goals they value and act in ways that promote their and their household's well-being. A more educated household head is more likely to seek assistance, plan resources, and manage food security challenges effectively. Following Sen's formulation, education improves the capacity to convert entitlements into achieved functionings, particularly under conditions of economic or structural constraint [16].

However, the ability to translate education into improved food security is not uniform across contexts. District-level factors—such as the Human Development Index (HDI) and poverty rates—shape the structural environment in which educational capabilities are exercised. HDI reflects broader development conditions, including access to health services, education, and economic opportunities, which collectively enhance the potential for education to yield positive outcomes. Conversely, high poverty rates signal widespread material deprivation and often coincide

with weak institutional support, which can hinder the conversion of educational attainment into tangible improvements in well-being. These dynamics illustrate the importance of *conversion factors*—a central concept in the Capability Approach—that influence whether capabilities can be transformed into functionings [9]–[13].

This study applies the Capability Approach to examine how the interaction between household head's education and structural conditions at the district level (HDI and poverty) influences the likelihood of experiencing moderate or severe food insecurity. It is hypothesized that the protective role of education is strongest in districts with higher HDI and lower poverty, where the structural environment supports capability realization. In contrast, in districts characterized by low HDI and high poverty, even well-educated household heads may encounter barriers that limit the impact of education on food security outcomes.

Although household per capita expenditure is not central to this theoretical framework, it is included in the empirical model as a control variable. Its inclusion helps account for variation in material resources and ensures that the estimated effects of education are not confounded by household wealth. This is consistent with Sen's argument that resources alone are inadequate indicators of well-being without considering individuals' capabilities to use those resources effectively [17].

By embedding this inquiry within a multilevel framework, the study investigates how individual capabilities interact with structural constraints to shape food security outcomes. Education is treated as a foundational capability, but its effectiveness depends on the surrounding institutional and economic environment. This approach offers a more nuanced understanding of how regional disparities and socioeconomic inequalities influence Indonesia's food insecurity risk.

3. Methodology and Data

3.1. Methodology

This study employs a multilevel mixed-effects logistic regression model, which is well-suited for handling both hierarchical data structures and binary outcome variables. Households represent the first level of analysis and are nested within districts at the second level, justifying the use of this modeling approach. The binary nature of the dependent variable is also appropriately accommodated. By including random intercepts for districts, the model captures unobserved heterogeneity and accounts for variations in socioeconomic conditions across regions. This framework enables the integration of both household- and district-level predictors, allowing for a nuanced examination of the factors associated with moderate or severe food insecurity [18].

The empirical model is based on a latent variable that captures the underlying likelihood of experiencing moderate or severe food insecurity. It explores how household-level characteristics and district-level contextual factors influence this latent construct:

$$y_{ij}^* = x1_{ij}\beta1 + x2_j\beta2 + z_{ij}u_j + \epsilon_{ij}$$

The relationship between the observed binary outcome y_{ij} and the latent variable y_{ij}^* is defined through a simple measurement equation:

$$y_{ij} = \begin{cases} 1 & \text{if } y_{ij}^* > 0 \\ 0 & \text{if } y_{ij}^* \leq 0 \end{cases}$$

where y_{ij}^* denotes the unobserved propensity of household i and district j to experience moderate or severe food insecurity, $x1_{ij}$ captures household-level characteristics, while $x2_j$ includes contextual variables at the district level; z_{ij} represents covariates associated with the random effects; in a random intercept model, this reduces to a scalar value of 1; u_j denotes the random effects; and ϵ_{ij} represents the idiosyncratic error term, which follows a logistic distribution with mean zero and variance $\pi^2/3$ and is assumed to be independent of u_j .

3.2. Data: National Socioeconomic Survey (SUSENAS)

This study utilizes data from the National Socioeconomic Survey (*Survei Sosial Ekonomi Nasional*, SUSENAS), an annual household survey administered by Indonesia's Central Statistics Agency (*Badan Pusat Statistik*, BPS). Recognized as one of the country's most comprehensive sources of socioeconomic data, SUSENAS is designed to generate nationally and subnationally representative estimates across all 514 districts (regencies/*kabupaten* and municipalities/*kota*). The survey employs a stratified two-stage sampling design: census blocks are selected using probability proportional to size based on the number of households, followed by random sampling of a fixed number of households within each block. Each wave covers approximately 320,000 households, representing around 1.2 million individuals, enabling granular analysis at both provincial and district levels. This study draws on pooled cross-sectional data from five consecutive SUSENAS waves spanning the years 2019 to 2023.

3.3. Moderate and Severe Food Insecurity

This study uses the prevalence of moderate and severe food insecurity, as measured by the Food Insecurity Experience Scale (FIES), as the primary indicator of food insecurity. FIES, developed by the Food and Agriculture

Organization of the United Nations (FAO) and further refined in prior research [19], is a globally recognized tool that assesses individuals' experiences with food insecurity by capturing both the tangible and psychological aspects of food access.

Moderate and severe food insecurity represent escalating challenges in accessing food, as defined by the FIES [20]. Moderate food insecurity occurs when individuals face uncertainty about obtaining food, resulting in a reduced quality or quantity of intake due to financial or resource constraints. This disrupts eating patterns and negatively affects nutrition, health, and well-being. Severe food insecurity, on the other hand, is a critical state where individuals run out of food, experience prolonged hunger, and may go days without eating, putting their health and survival at grave risk. This definition aligns with SDG Indicator 2.1.2, which measures the prevalence of moderate or severe food insecurity in the population based on the FIES. Using this definition as the focus of analysis enhances the study's relevance, as the findings can provide valuable insights for policymakers seeking to improve food security and reduce hunger.

The FIES is commonly measured using a standardized set of eight questions, which can be adapted to local contexts during data collection [21]. In the case of SUSENAS, the questions are phrased as follows:

1. During the past year, were you or a household member worried about not having enough food to eat due to lack of money or other resources?
2. During the past year, was there a time when you or a household member were unable to eat healthy, nutritious food due to lack of money or other resources?
3. During the past year, were you or a household member eating only a few types of food due to lack of money or other resources?
4. During the past year, have you or a household member ever missed a meal on a particular day because you did not have enough money or other resources to obtain food?
5. During the past year, have you or a household member eaten less than you should have due to lack of money or other resources?
6. During the past year, has the household run out of food due to lack of money or other resources?
7. During the past year, have you or a household member ever been hungry but did not eat because of lack of money or other resources to obtain food?
8. During the past year, have you or a household member not eaten for a whole day due to lack of money or other resources?

Each item offers four response options: yes, no, do not know, and refuse to answer.

This paper focuses on identifying individuals who are moderately or severely food insecure, using classifications derived from the Rasch model applied to the eight-item FIES. The one-parameter logistic item response theory framework was employed to estimate a continuous latent severity score that captures both the frequency and relative severity of affirmed food-related experiences. Following FAO guidelines, the threshold for moderate or severe food insecurity was determined using the latent trait value corresponding to the upper boundary of mild food insecurity, typically represented by respondents with a raw score of three. Individuals with latent scores exceeding this threshold were classified as moderately or severely food insecure. This Rasch-adjusted binary classification improves upon raw score-based thresholds by incorporating information on item severity and response patterns, enabling a more robust identification of food-insecure individuals [20].

Table 1 provides a concluding overview for this section. It displays descriptive statistics for all variables used in the study, covering the period from 2019 to 2023.

Table 1. Descriptive Statistics of Variables Used in the Study

Variable	2019		2020		2021		2022		2023		All Observations	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Moderate or Severely Food Insecured	0.054	0.227	0.048	0.215	0.047	0.211	0.045	0.207	0.045	0.207	0.048	0.213
Household Head: Female	0.150	0.357	0.153	0.360	0.144	0.351	0.147	0.354	0.147	0.354	0.148	0.355
Household Head: Age	48.93	12.44	49.26	12.46	48.37	12.57	48.74	12.41	49.39	12.24	48.94	12.43
Household Head: Married	0.813	0.390	0.807	0.395	0.818	0.386	0.812	0.390	0.808	0.394	0.812	0.391
Household Head: Education	8.08	4.30	8.23	4.35	8.40	4.30	8.41	4.44	8.49	4.40	8.33	4.36
# Household Members: Aged 0-4	0.34	0.57	0.32	0.56	0.32	0.56	0.29	0.54	0.27	0.52	0.31	0.55
# Household Members: Aged 60+	0.35	0.62	0.36	0.63	0.36	0.63	0.35	0.63	0.37	0.64	0.36	0.63
# Household Members: Disabilities	0.10	0.37	0.09	0.33	0.08	0.32	0.08	0.32	0.06	0.28	0.08	0.32
Household Per Capita Expenditures	-0.151	0.644	-0.093	0.642	-0.077	0.642	0.011	0.643	0.111	0.644	-0.037	0.650
Urban	0.412	0.492	0.411	0.492	0.420	0.494	0.420	0.494	0.421	0.494	0.417	0.493
District HDI	-0.455	6.232	-0.347	6.132	0.010	6.198	0.630	6.163	1.324	6.098	0.249	6.199
District Poverty Rate	-0.421	7.127	-0.373	6.822	-0.065	6.833	-0.608	6.674	-0.815	6.575	-0.458	6.808
Observations	301,162		320,075		325,454		326,657		331,157		1,604,505	

Source: Author's calculations based on SUSENAS 2019-2023 and BPS publications.

Notes: The dependent variable (moderate or severe food insecurity) and key independent variables (female household head, marital status, urban residence) are expressed as proportions. Age and years of schooling refer to the household head and are measured in years. Counts of household members aged 0–4, aged 60+, and with disabilities are measured in persons. Household per capita expenditure is in log form. Household per capita expenditure, District HDI, and District Poverty Rate are grand-mean centered.

4. Estimation Results

4.1. Model Selection and Goodness-of-Fit

Establishing the validity of the analytical approach begins with evaluating the overall performance and comparative fit of the estimated multilevel logistic regression models. This step is critical not only for confirming the appropriateness of the multilevel structure—given the nested nature of the data—but also for identifying the most robust specification for explaining household-level food insecurity across districts. The full set of estimation results, including key fit statistics and model comparisons, is presented in Table 2, which serves as the foundation for this assessment.

Table 2. Odds Ratios from Multilevel Mixed-Effects Logistic Models Predicting Moderate and Severe Food Insecurity

	Basic Model		Interaction Model 1		Interaction Model 2		Interaction Model 3	
	[1]		[2]		[3]		[4]	
Household Head: Female	0.8956	(0.0139) ***	0.8938	(0.0138) ***	0.8937	(0.0138) ***	0.8933	(0.0138) ***
Household Head: Age (years)	0.9943	(0.0005) ***	0.9941	(0.0005) ***	0.9940	(0.0004) ***	0.9940	(0.0004) ***
Household Head: Married	0.5153	(0.0074) ***	0.5163	(0.0075) ***	0.5165	(0.0075) ***	0.5167	(0.0075) ***
# Household Members: Aged 0-4	0.9176	(0.0065) ***	0.9167	(0.0065) ***	0.9172	(0.0065) ***	0.9169	(0.0065) ***
# Household Members: Aged 60+	0.8932	(0.0074) ***	0.8918	(0.0074) ***	0.8925	(0.0074) ***	0.8920	(0.0074) ***
# Household Members: Dissabilities	1.5705	(0.0136) ***	1.5703	(0.0136) ***	1.5685	(0.0136) ***	1.5690	(0.0136) ***
Household Per Capita Expenditures (log)	0.3251	(0.0027) ***	0.3266	(0.0027) ***	0.3264	(0.0027) ***	0.3267	(0.0027) ***
Urban	1.1911	(0.0129) ***	1.1936	(0.0129) ***	1.1943	(0.0129) ***	1.1964	(0.0129) ***
Household Head: Education (years)	0.9368	(0.0010) ***	0.9333	(0.0010) ***	0.9328	(0.0010) ***	0.9312	(0.0011) ***
District HDI	1.0244	(0.0068) ***	1.0207	(0.0068) ***	1.0244	(0.0068) ***	1.0214	(0.0069) ***
District Poverty Rate	1.0240	(0.0053) ***	1.0253	(0.0053) ***	1.0289	(0.0053) ***	1.0304	(0.0060) ***
HH Education X HDI			0.9977	(0.0005) ***			0.9991	(0.0002) ***
HH Education X Poverty					1.0021	(0.0001) ***	1.0011	(0.0002) ***
HDI X Poverty							1.0003	(0.0004) ***
HH Education X HDI X Poverty							1.0000	(0.0001) ***
Year 2020	0.9611	(0.0116) ***	0.9602	(0.0115) ***	0.9605	(0.0115) ***	0.9598	(0.0115) ***
Year 2021	0.9376	(0.0118) ***	0.9368	(0.0118) ***	0.9368	(0.0118) ***	0.9356	(0.0118) ***
Year 2022	0.9909	(0.0135) ***	0.9900	(0.0135) ***	0.9899	(0.0135) ***	0.9901	(0.0135) ***
Year 2023	1.1143	(0.0178) ***	1.1147	(0.0178) ***	1.1149	(0.0178) ***	1.1163	(0.0178) ***
Constant (x 10 ⁵)	4.1545	(0.5001) ***	3.9788	(0.4791) ***	3.9949	(0.4809) ***	3.9965	(0.4831) ***
Variances: District (constant)	0.6207	(0.0401)	0.6220	(0.0401)	0.6190	(0.040)	0.6214	(0.0401)
LR-test (p-value)	0.0000		0.0000		0.0000		0.0000	
ICC	0.1587		0.1590		0.1584		0.1589	
AIC	535,688		535,409		535,372		535,340	
BIC	535,897		535,630		535,593		535,599	
Observations	1,604,505		1,604,505		1,604,505		1,604,505	
Groups (Districts)	514		514		514		514	

Notes: The constant is scaled in units of $\times 10^5$ for readability. Standard errors are in parentheses. *** statistically significant at the 1% level, ** 5%, * 10%.

The model comparison statistics justify employing a multilevel mixed-effects logistic regression framework. The LR-test p-values for all models, including the null model (not shown in the table), are 0.0000, confirming that the multilevel specification significantly improves model fit over a standard single-level logistic regression. This supports the assumption that contextual differences at the district level partially shape household-level food insecurity and validates the inclusion of random effects.

The Intraclass Correlation Coefficient (ICC) from the null model is 0.1497, indicating that nearly 15% of the variance in food insecurity exists between districts [18]. The ICC values remain relatively stable across subsequent models (ranging from 0.1584 to 0.1590), demonstrating that the inclusion of household-level covariates and

district-level contextual variables—along with their interactions—does not eliminate but rather confirms the importance of district-level heterogeneity in shaping food insecurity outcomes.

Regarding overall model fit, the Akaike Information Criterion (AIC) consistently decreases across the models, with the lowest value observed in Interaction Model 3 (AIC = 535,340). This suggests that the progressive inclusion of interaction terms enhances the model's explanatory power. While the Bayesian Information Criterion (BIC), which more heavily penalizes model complexity, shows a slight increase in Interaction Model 3 compared to Interaction Models 1 and 2, the increase is modest. These results indicate that Interaction Model 3 provides the best statistical fit and offers the most comprehensive specification for capturing how education (as a capability) interacts with district-level structural conditions to influence food security [22].

Multicollinearity was assessed using Variance Inflation Factor (VIF) scores derived from an ordinary least squares (OLS) regression that included the covariates specified in Models 1 to 4. The results showed that all VIF values were well below the commonly used threshold of concern, with the highest value being 3.04. This indicates a low risk of multicollinearity and strengthens confidence in the reliability and interpretability of the model estimates [22].

The diagnostic results provide compelling evidence that the multilevel models are robust and appropriately specified. This solid foundation strengthens the credibility of the findings in the substantive analysis.

4.2. Educational Attainment and Its Protective Role Against Food Insecurity

Model 1 reveals a strong linear association between the household head's completed years of education (grand-mean centered) and the likelihood of experiencing moderate or severe food insecurity. Each additional year of schooling is associated with a 6.32% reduction in the odds of food insecurity (OR = 0.9368, $p < 0.001$), indicating that education is a consistent protective factor across the population. While this linear specification assumes a constant marginal effect, it effectively captures the inverse relationship between educational attainment and household vulnerability to food deprivation.

An alternative specification, presented in Table 3, introduces a quadratic term to assess potential nonlinearity in the relationship between education and food insecurity. Results show that the linear effect remains protective (OR = 0.9328, $p < 0.001$), while the squared term (OR = 0.9980, $p < 0.001$) suggests a modest diminishing return. This pattern implies that although additional years of education continue to lower food insecurity risk, the marginal benefit becomes slightly smaller at higher education levels. For example, the transition from no schooling to primary education yields a stronger benefit than the transition from senior secondary to tertiary education. These findings underscore the value of accounting for curvature in modeling education's impact.

Table 3. Alternative Specifications of Household Head's Education: Linear, Quadratic, and Categorical Models

	Estimates	AIC	BIC
Linear Specification (Model 1 in Table 2)			
Household Head: Education (years)	0.9368 (0.0010) ***	535,688	535,897
Quadratic Specification			
Household Head: Education (years)	0.9328 (0.0011) ***	535,588	535,810
Household Head: (Education (years)) ²	0.9980 (0.0002) ***		
Categorical Specification			
Household Head: Completed Primary	0.7512 (0.0078) ***	535,501	535,747
Household Head: Completed Junior Secondary	0.6703 (0.0088) ***		
Household Head: Completed Senior Secondary	0.5235 (0.0068) ***		
Household Head: Tertiary	0.3414 (0.0076) ***		

Notes: Odds ratios are reported. Robust standard errors are in parentheses. *** statistically significant at the 1% level, ** 5%, * 10%.

A further refinement replaces the continuous measure with dummy variables for completed education levels, allowing for a more granular assessment of threshold effects. Compared to households whose heads did not complete primary education, the odds of food insecurity are significantly lower across all higher education categories. Completing primary education reduces the odds by 24.9%, junior secondary by 32.97%, senior secondary by 47.65%, and tertiary education by 65.86% (all $p < 0.001$). These results suggest that each educational milestone confers progressively greater protection, with the most pronounced gain occurring between senior

secondary and tertiary education. This approach underscores educational attainment as a continuous investment and a series of structural transitions that enhance household resilience.

The three specifications offer a coherent narrative: education is a powerful and robust determinant of food security. The linear and quadratic models emphasize a general downward trend in food insecurity risk with increased years of schooling, while the categorical model reveals that crossing specific educational thresholds—especially tertiary education—yields substantial protective effects. Although the quadratic form signals slightly diminishing marginal returns, the dummy variable specification demonstrates that meaningful structural gains occur at key stages of educational attainment, particularly beyond secondary school.

Model fit statistics reinforce these insights. The quadratic model improves upon the linear one, with lower AIC (535,588 vs. 535,688) and BIC (535,810 vs. 535,897), suggesting added explanatory power. The dummy variable model provides the best fit overall, with the lowest AIC (535,501) and BIC (535,747), indicating that modeling education through discrete milestones better captures the variation in food insecurity outcomes. Nevertheless, for the remainder of the analysis, the continuous form of completed years of schooling will be retained to maintain model parsimony, allow for interaction testing, and ensure comparability across specifications.

These model-based findings resonate with global patterns. A broad international body of evidence supports the protective effect of household head education on food insecurity, including studies from Africa [23]–[25], Asia [26]–[28], and the Americas [29]–[31]. While these studies primarily adopt economic or demographic lenses, none explicitly apply the Capability Approach to interpret how education functions to expand households' substantive freedoms—an analytical perspective that this study advances.

Building on this theoretical framing, these results offer strong empirical support for the study's first aim: *to evaluate the extent to which the education of the household head reduces the likelihood of food insecurity, conceptualized as a functioning within Sen's Capability Approach*. In this framework, functionings represent realized achievements—such as being well-nourished—while capabilities denote individuals' fundamental freedoms to achieve those outcomes. Education is a foundational capability that expands agency, improves access to resources, and enhances individuals' ability to navigate structural constraints. The consistent and significant negative association between education and food insecurity suggests that more educated household heads are better equipped to convert available resources and entitlements into sustained food security. Promoting educational attainment is a critical lever for expanding human capabilities and addressing deprivation.

4.3. Local Development Contexts and the Effectiveness of Education

Model 2 of Table 2 introduces an interaction term between the household head's education and the district-level Human Development Index (HDI) to assess whether education's protective effect varies across economic development levels. Results show that completed years of education remain strongly and significantly associated with lower odds of experiencing moderate or severe food insecurity (OR = 0.9333, $p < 0.001$), reaffirming education's role as a key protective factor. However, the interaction term is negative and statistically significant (OR = 0.9977, $p < 0.001$), indicating that the strength of education's protective effect declines slightly as HDI increases. In lower-HDI districts—where institutional support and basic services are more limited—education is critical in helping households manage food insecurity. In contrast, in higher-HDI districts with stronger structural conditions, the marginal value of education becomes less pronounced. This pattern aligns with the Capability Approach, which emphasizes that realizing individual capabilities, such as food security, depends not only on personal assets like education but also on the enabling environment in which they are exercised [7].

To further unpack the contextual dynamics, an interaction term between urban location and district-level HDI was introduced into the basic model (Model 1 in Table 2). Although the results are not shown here, they reveal that the positive association between HDI and food insecurity is significantly more pronounced in urban areas (interaction OR = 1.0105, $p < 0.001$). In rural districts, a one-unit increase in HDI corresponds to a 1.88% rise in the odds of food insecurity (OR = 1.0188, $p = 0.006$), whereas in urban districts, the combined effect reaches approximately 2.9%. This suggests that HDI, while indicative of average development progress, may obscure hidden vulnerabilities in urbanized and economically stratified settings. In such contexts, high living costs, dependence on informal labor, and unequal access to services can disproportionately affect low-income or less-educated households—undermining the assumption that high HDI equates to food security.

This pattern is consistent with the Capability Approach articulated in [7], which emphasizes that achieving valued outcomes—such as food security—requires more than individual resources; it depends on the broader environment that enables or constrains the conversion of those resources into real opportunities. This perspective is extended in [32] through the concept of conversion factors, which highlight that the same level of education may yield different outcomes depending on local conditions. In lower-HDI districts, where institutional voids are more pronounced, education is a vital personal asset that enables households to navigate food insecurity. Conversely, in higher-HDI districts, even less-educated households may benefit from improved public services

and infrastructure, thereby reducing the marginal benefit of education. The argument in [33] further supports this interpretation, emphasizing that food security should be understood regarding nutritional capabilities. While education enhances these capabilities, its effectiveness is contingent upon local development conditions. These sources reinforce the idea that education's protective power is context-dependent and most impactful where structural constraints are most significant.

These findings provide clear empirical support for the study's second aim: *to assess whether the protective effect of education varies across districts with differing levels of economic development, as measured by the HDI*. They highlight that education's effectiveness in reducing food insecurity is shaped by broader contextual conditions that differ across rural and urban settings, and that high HDI alone does not guarantee equitable access to food. These insights reinforce the importance of place-based strategies that combine educational advancement with targeted structural reforms, ensuring that all households, particularly those in urban poor and underserved areas, can translate education into tangible improvements in food security.

4.4. Poverty as a Constraint on the Protective Role of Education

The results from Model 3 of Table 2 reinforce the foundational role of education in reducing the likelihood of food insecurity. Each additional year of completed schooling by the household head is associated with a 6.72% reduction in the odds of experiencing moderate or severe food insecurity (OR = 0.9328, $p < 0.001$), underscoring education's robust protective effect. However, this individual-level advantage operates within broader structural environments. At the district level, higher poverty rates are independently associated with significantly greater odds of food insecurity (OR = 1.0289, $p < 0.001$), indicating that systemic deprivation heightens vulnerability across the population—regardless of personal attributes such as educational attainment. This underscores the persistent impact of structural economic hardship on household food access.

Crucially, the interaction between the household head's education and district-level poverty rate is positive and statistically significant (OR = 1.0021, $p < 0.001$). This suggests that education's protective effect diminishes as poverty increases—remaining beneficial, but with reduced marginal returns in poorer districts. This attenuation likely stems from constrained local opportunities to convert educational attainment into tangible gains—such as stable employment, affordable food access, or public service utilization—especially in areas plagued by underdeveloped infrastructure, limited labor demand, or weak market linkages.

These results provide strong empirical support for a key insight from Sen's Capability Approach: individual capabilities, such as education, must be complemented by enabling environments to translate into valuable functionings like adequate nutrition. In contexts of pervasive poverty, even well-educated households may be structurally restricted from fully exercising their agency. The protective power of education is thus conditioned not only by personal achievements but also by the presence—or absence—of systemic support. This reinforces the need to address food insecurity through individual-level interventions and coordinated structural reforms that reduce economic deprivation and enhance institutional capacity in underserved areas.

Evidence from other countries reinforces the critical role of education and poverty in shaping food insecurity. In Cameroon [34], household head education—especially at the tertiary level—significantly improves food security and reduces poverty, with stronger effects in rural and high-poverty areas. Education outperforms access to credit, highlighting its centrality to sustainable development. Viewed through Sen's Capability Approach, education serves as both a basic capability and a means to secure well-being, though its effectiveness depends on contextual factors like poverty. Similarly, in Sudan [35], lower educational attainment strongly predicts household food insecurity. Poverty-related factors such as unemployment, lack of money, limited assets, and inflation exacerbate vulnerability. These studies underscore the need for integrated strategies addressing educational access and structural poverty.

Taken together with this international evidence, our findings offer clear empirical support for the third aim of this study: *to examine whether the strength of education's protective effect differs in areas characterized by varying degrees of economic deprivation, as captured by district-level poverty rates*. A significant interaction effect confirms that the broader socioeconomic context meaningfully shapes the return on educational investments, making a compelling case for integrated, place-based development strategies.

4.5. Intersecting Inequalities: How Development and Deprivation Jointly Shape Education's Protective Role

The results from Model 4 offer a nuanced view of how individual-level education interacts with district-level development and deprivation in shaping food insecurity. Consistent with earlier models, each additional year of education is associated with a 6.88% reduction in the odds of experiencing moderate or severe food insecurity (OR = 0.9312, $p < 0.001$), underscoring its role as a foundational capability for navigating food-related risks.

Contextually, higher Human Development Index (HDI) and poverty rates are both positively associated with food insecurity (HDI: OR = 1.0214; poverty: OR = 1.0304; $p < 0.001$). While the HDI finding may appear counterintuitive, it reflects localized vulnerabilities in urbanized districts—such as high living costs, spatial

inequality, and precarious labor markets—often coexisting with aggregate development gains. High poverty, by contrast, reflects structural deprivation that amplifies food insecurity risks regardless of individual characteristics.

Interaction terms provide additional insight. The education \times HDI interaction is slightly negative (OR = 0.9991, $p < 0.001$), suggesting education is more protective in low-HDI districts where institutional supports are weaker. Conversely, the education \times poverty interaction is positive (OR = 1.0011, $p < 0.001$), indicating that the marginal benefit of education is diminished in high-poverty settings, likely due to underdeveloped service networks and limited employment opportunities. The HDI \times poverty interaction is insignificant, implying that their coexistence alone does not systematically worsen food insecurity.

The three-way interaction (education \times HDI \times poverty) is statistically significant ($p < 0.001$), despite its odds ratio being close to 1.0000. This suggests a consistent pattern: the protective effect of education is shaped by the broader structural context. In high-HDI but high-poverty districts—often urban, unequal, and expensive to live in—education's impact is weakened. Educated households in these areas may still face barriers like informal labor, limited safety nets, and high living costs. By contrast, education can have a more transformative effect in less developed but less deprived areas, improving access to food through enhanced agency and opportunity.

These patterns are consistent with prior empirical work showing that the benefits of education in reducing food insecurity are often context-dependent. For example, education has significantly improved food access in rural sub-Saharan Africa, but only in regions where basic services and markets function adequately [33]. Other studies emphasize that the effect of maternal education on reducing food insecurity—often reflected in improved child nutritional outcomes—is strongest when supported by access to infrastructure, health services, and social protection [35]. Evidence from Brazil shows that despite national declines in severe food insecurity between 2004 and 2013, substantial inter- and intra-regional disparities persisted—particularly in municipalities facing structural poverty and service delivery gaps [36]. These studies reinforce the idea that structural conditions can either enable or constrain the realization of individual capabilities. As such, educational gains alone are insufficient unless embedded within broader systems of opportunity and support.

Framed within the Capability Approach, these results affirm that education's protective potential depends on enabling environments. The significant three-way interaction supports the study's fourth aim: *to assess how the interaction between economic development (HDI) and economic deprivation (poverty rates) influences the extent to which education reduces the risk of food insecurity*. Therefore, policies that expand education must be coupled with structural reforms that address poverty, inequality, and spatial exclusion to realize food security outcomes fully.

4.6. How Household Profiles and Living Conditions Influence Food Insecurity

The Basic Model includes a set of demographic and household-level controls to isolate the effects of education, Human Development Index (HDI), and poverty on food insecurity. These variables reflect personal conversion factors (such as age, gender, and disability status) and household resources that influence individuals' ability to convert capabilities into functionings, as articulated in Sen's Capability Approach.

Results show that households headed by women have slightly lower odds of food insecurity than those headed by men (OR = 0.8956, $p < 0.001$). This may reflect women's roles as primary caregivers who prioritize food needs more effectively. From a capability perspective, gendered norms can act as informal conversion factors enhancing food security [37]. However, this finding contrasts with most studies, which report that female-headed households are generally more vulnerable to food insecurity due to structural and economic disadvantages [38], [39].

Older household heads are slightly less likely to experience food insecurity (OR = 0.9943), possibly due to life experience, stable routines, or access to pensions [37]. However, this finding contrasts with many studies that link older age to greater food insecurity due to declining health, limited income, or social isolation [23], [24]. Being married (OR = 0.5153) offers a substantial protective effect, likely due to shared income, caregiving, and food responsibilities, which expand the household's capability set and reduce individual vulnerability [23], [38].

Household composition plays a critical role in shaping food access. Surprisingly, having additional members aged 0–4 or 60+ is associated with lower odds of food insecurity (OR = 0.9176 and 0.8932, respectively), possibly due to the positive effects of state-supported programs such as child nutrition assistance and elderly social protection. Although evidence is limited, studies suggest that young children and older adults are generally more vulnerable to food insecurity than other age groups [38], [40], [41]. In contrast, the presence of a household member with a disability significantly increases food insecurity (OR = 1.5705), reflecting structural barriers and capability deprivation [42].

Economic status, proxied by log-transformed household per capita expenditures, is strongly protective (OR = 0.3251), underscoring the foundational role of material resources in expanding fundamental freedoms. Households with more economic capital can better access nutritious food, healthcare, and coping mechanisms during crises, translating capabilities into tangible well-being outcomes like food security [30], [38].



Urban residence, however, is associated with higher odds of food insecurity (OR = 1.1911). While urban areas generally offer greater services and opportunities, converting these resources into food security may be hampered by high living costs, spatial exclusion, and labor informality—structural constraints that limit the realization of capabilities despite developing infrastructure [37].

Finally, temporal variations captured through year dummies suggest resilience and vulnerability dynamics over time. Compared to 2019, food insecurity risks decreased during the early COVID-19 years (2020 and 2021), possibly due to emergency assistance and community support. However, by 2023, risks rose again (OR = 1.1143), potentially reflecting erosion of safety nets, inflationary pressures, and uneven post-pandemic recovery. These shifts highlight how macroeconomic shocks and policy responses condition the environment where individuals pursue valued functionings like food security.

These results show that avoiding food insecurity is not just about personal effort but also depends on the environment in which people live. Even when individuals have the agency—the ability and motivation—to improve their situation, whether they succeed often depends on local conditions like poverty levels, access to services, and the broader economy. This idea is central to the Capability Approach, which emphasizes that turning opportunities into real achievements requires personal agency and supportive surroundings.

5. Discussion

5.1. Capabilities and Constraints: Explaining Food Insecurity through Sen's Framework

This study engages with Sen's Capability Approach to illuminate how food insecurity is shaped not merely by access to resources, but by individuals' substantive freedoms to achieve valued functionings [7]. In this framework, food security is conceptualized as a functioning—the realized outcome of a person's genuine opportunity to be well-nourished and free from hunger. Education, especially that of the household head, emerges in this analysis as a foundational capability: it expands informational, cognitive, and navigational resources that enhance agency—the capacity to pursue goals and respond to risks. More educated household heads are better positioned to convert entitlements into food security through improved decision-making, labor market access, and engagement with institutional support systems.

However, capabilities do not automatically lead to functionings. Sen emphasizes the importance of conversion factors—personal, social, and environmental conditions that mediate the relationship between resources and achieved outcomes [32]. This study uses the district-level Human Development Index (HDI) and poverty rates as key structural conversion factors. HDI reflects institutional capacity and human development infrastructure, while poverty indicates pervasive material deprivation that can obstruct the realization of otherwise meaningful capabilities.

Building on this, the observed moderation effects underscore the contextual nature of capability realization. In lower-HDI settings, education carries greater marginal utility, likely because institutional voids elevate the importance of individual agency in securing food access. Here, education serves as a compensatory mechanism in an otherwise constrained environment. Conversely, in higher-HDI areas—where structural supports are ostensibly stronger—the incremental benefit of education in mitigating food insecurity declines. This paradox illustrates that average development levels may conceal significant internal disparities, particularly in urban areas where high living costs and segmented labor markets may restrict the efficacy of educational capital [43], especially for disadvantaged populations.

Extending this analysis, the interaction between education and poverty further refines the narrative. While education continues to offer protection, its marginal returns decline in high-poverty districts. This suggests that even when individuals possess critical capabilities, the enabling environment—the broader opportunity structure—can restrict their ability to achieve valued outcomes. Such findings reinforce the argument that development must expand capabilities and the freedom to exercise them effectively. Where markets are thin, infrastructure is underdeveloped, and social safety nets are inadequate, the agency of even well-educated individuals is curtailed [44].

Most critically, the three-way interaction between education, HDI, and poverty demonstrates that intersecting inequalities jointly determine the effectiveness of individual capabilities. The protective role of education is shaped not only by its presence but also by how it intersects with broader conditions of development and deprivation. Educational attainment alone cannot overcome entrenched structural barriers in districts marked by both high development and persistent poverty—a pattern increasingly visible in urbanizing but socially unequal contexts. This aligns with relational capability deprivation, where the absence of complementary institutional, economic, and spatial supports renders personal assets, such as education, insufficient for securing well-being [45].

These findings reinforce a central tenet of the Capability Approach: food security cannot be fully understood through resource access or individual characteristics alone. Instead, it emerges from the dynamic interaction

between personal capabilities and the structural conditions that shape their realization. Addressing food insecurity, therefore, demands a dual strategy—on one hand, enhancing human capital through education, and on the other, transforming the local opportunity structure to ensure that capabilities can be meaningfully exercised. As Robeyns argues, expanding real freedoms depends on personal empowerment and institutional reforms that dismantle systemic constraints [32]. In line with the study's fifth aim, this underscores the need to embed educational interventions within broader structural reforms—particularly those aimed at alleviating poverty and strengthening local institutions—to improve household resilience and food security sustainably.

5.2. Policy Implications: Leveraging Education and Structural Reform for Food Security

This study highlights the need for integrated and place-sensitive policy strategies to strengthen household resilience against food insecurity in Indonesia. While education is a key protective factor, its effectiveness depends on structural conditions such as district-level poverty and human development. Consistent with Sen's Capability Approach, education requires enabling environments to translate into real food security outcomes.

First, education policies should prioritize vulnerable groups—female-headed households, rural communities, and urban informal workers—by expanding school retention, adult literacy, and vocational training programs. However, in high-poverty districts, education alone is insufficient. Complementary poverty alleviation measures—such as *Bantuan Langsung Tunai* (BLT, direct cash assistance), *Program Keluarga Harapan* (PKH, Family Hope Program), and food subsidies—reinforce educational impacts.

Second, spatial disparities must be addressed. In lower-HDI regions, especially in eastern Indonesia, targeted investments in infrastructure, healthcare, and school quality are critical for enhancing the returns to education. In high-HDI urban areas such as Jakarta or Surabaya, policies should target the urban poor, who remain vulnerable due to elevated living costs and gaps in social protection.

Third, cross-sectoral coordination—among the Ministries of Education, Social Affairs, Health, and the National Planning Agency (Bappenas)—is vital to align educational, poverty, and food security goals. Through *Dana Alokasi Khusus* (DAK, Special Allocation Fund) or *Dana Desa* (Village Fund), local governments should be empowered to tailor programs using instruments such as *Rencana Aksi Daerah Pangan dan Gizi* (RAD-PG, Regional Food and Nutrition Action Plan).

Finally, monitoring systems should adopt a capability-based lens, assessing whether households have real freedoms—not just access—to secure adequate nutrition.

These recommendations directly support the study's fifth aim: *to inform policy by identifying how educational interventions, supported by structural reforms, can build long-term food security and resilience*. The findings highlight that education alone is insufficient in disadvantaged areas, underscoring the need for integrated strategies that strengthen individual capabilities and structural conditions to ensure lasting improvements in household well-being.

6. Conclusion

6.1. Summary of Key Findings

This study finds that higher educational attainment—measured by the household head's completed years of schooling—significantly reduces the likelihood of moderate or severe food insecurity in Indonesia. Each additional year of education lowers food insecurity risk, with the strongest protective effects observed between primary and senior secondary schooling. However, the effect plateaus slightly at higher education levels.

Importantly, this protective role of education is context-dependent. The district-level human development index (HDI) significantly moderates the relationship. Education is a compensatory asset in low-HDI districts with limited institutional support, offering stronger protection. In contrast, its effect weakens in high-HDI areas, possibly due to rising living costs and labor market challenges. Similarly, poverty moderates the link between education and food insecurity. While education reduces food insecurity across all poverty levels, its impact diminishes in high-poverty districts, where structural barriers limit the conversion of educational attainment into improved well-being.

Crucially, the combined effects of HDI and poverty reveal that in urban, high-development but high-poverty areas, education's benefits are significantly constrained. These findings underscore that education, while vital, is not sufficient on its own. Structural conditions critically shape food security outcomes, highlighting the need for context-sensitive, integrated policies that address individual capabilities and environmental constraints.

6.2. Study Limitations and Directions for Future Research

This study offers valuable insights into how education and structural development conditions jointly influence household food insecurity in Indonesia. However, several limitations should be noted. First, using cross-sectional data limits the ability to capture the dynamic process through which capabilities evolve. As the Capability Approach emphasizes, functionings—such as food security—emerge from ongoing interactions between personal

agency and structural conditions. Longitudinal or panel data would better capture how capabilities are formed, converted, and realized in response to changing institutional and economic contexts [46].

Second, although the study identifies key interaction effects between education and district-level indicators, it does not include qualitative perspectives. Mixed-methods approaches [47], such as fieldwork in high-poverty or low-HDI districts, could deepen understanding of how households navigate constraints, exercise agency, and perceive their capability to achieve food security. Such qualitative insights help contextualize and complement the quantitative findings.

Third, this study focuses on formal education and includes only two structural conversion factors: HDI and poverty. While these are important, future research should incorporate social capital [48], gendered agency [49], access to public services [50], and quality of local governance [51] to better capture how multidimensional influences shape household resilience and the conversion of capabilities into food-related outcomes.

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