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RESEARCH PAPER

Food Security, Dietary Diversity and Nutritional Outcomes in Bhagalpur, Bihar

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ABSTRACT

This study examines the interlinkages between food security, dietary diversity, and nutritional outcomes in Bhagalpur district of Bihar using a combination of primary household survey data and secondary sources such as NFHS-5 and NSSO. The analysis employs descriptive statistics, multiple regression, and logistic regression models to identify key socio-economic determinants of dietary diversity and malnutrition. The findings reveal that the average Household Dietary Diversity Score (HDDS) remains moderate but insufficient to ensure nutritional adequacy. Econometric results indicate that income, education, and landholding size significantly enhance dietary diversity, while household size and limited market access negatively affect it. Logistic regression estimates further demonstrate that higher dietary diversity substantially reduces the probability of child malnutrition, alongside improvements in sanitation and healthcare access. The study highlights that existing food security interventions, such as the Public Distribution System (PDS), have a positive but limited impact on dietary diversification. Overall, the results underscore the need for integrated, nutrition-sensitive policies that address both economic and structural constraints to improve food and nutritional security in Bhagalpur and similar regions.

Keywords: Food Security, Dietary Diversity, HDDS, Malnutrition, Bhagalpur, Bihar, Public Distribution System, Nutrition Policy

Food and nutrition security constitute critical dimensions of human development, encompassing not only adequate caloric intake but also access to diverse and nutrient-rich diets essential for healthy living. Globally, the transition from food security to nutrition security has gained prominence, emphasizing dietary quality alongside quantity (FAO, 2019). In India, despite achieving self-sufficiency in food grain production, malnutrition remains pervasive, particularly in economically lagging states such as Bihar (NITI Aayog, 2021). Bhagalpur district, situated in eastern Bihar, provides a pertinent microcosm where agricultural potential coexists with persistent nutritional deprivation. The district's agrarian structure, characterized by small and marginal landholdings, seasonal employment, and limited diversification, constrains both food availability and economic access to diverse diets.

Empirical evidence suggests that while cereal consumption in rural Bihar remains relatively stable, intake of protein-rich foods, fruits, and vegetables is substantially below recommended levels, resulting in widespread micronutrient deficiencies (Gaiha

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et al., 2012). The prevalence of stunting, wasting, and anaemia among children and women in Bihar reflects systemic issues related to poverty, sanitation, health infrastructure, and gender inequality (International Institute for Population Sciences [IIPS] & ICF, 2021). Government interventions such as the Public Distribution System (PDS), Integrated Child Development Services (ICDS), and Mid-Day Meal Scheme have improved food access; however, inefficiencies in targeting, leakages, and limited dietary diversification continue to undermine their impact (Khera, 2011). In this context, dietary diversity has emerged as a robust proxy for nutritional adequacy, linking household consumption behaviour with health outcomes. Therefore, a comprehensive assessment of food security, dietary diversity, and nutritional outcomes in Bhagalpur is essential for designing evidence-based policy interventions.

REVIEW OF LITERATURE

Early studies on food security primarily focused on aggregate food availability, with Sen (1981) emphasizing entitlement failures as the root cause of hunger rather than supply shortages. Subsequent research shifted toward household-level access and utilization, highlighting the role of income, prices, and socio-economic factors (Maxwell & Smith, 1992). In the Indian context, Dev (2012) underscored the multidimensional nature of food security, incorporating availability, access, utilization, and stability. Empirical studies have consistently shown that economic growth alone does not guarantee improved nutritional outcomes, necessitating targeted interventions (Drèze & Sen, 2013).

Recent literature has increasingly focused on dietary diversity as a key determinant of nutritional status. Hoddinott and Yohannes (2002) developed the Household Dietary Diversity Score (HDDS) as a proxy indicator for food access and nutritional adequacy. Thorne-Lyman *et al*. (2010) demonstrated a strong association between dietary diversity and micronutrient intake, particularly among children and women. In India, studies by Rao *et al*. (2018) and Singh *et al*. (2020) reveal that dietary diversity remains low among rural households due to income constraints, cultural preferences, and limited market access.

Region-specific studies in Bihar highlight persistent nutritional challenges despite policy interventions. Kumar *et al*. (2016) found that poverty, low agricultural productivity, and inadequate infrastructure significantly affect food security in rural Bihar. Sinha and Kansal (2019) reported that dietary diversity is strongly correlated with household income, education, and access to markets. Furthermore, IIPS (2021) data indicate that Bihar continues to exhibit one of the highest rates of child malnutrition in India, reflecting structural inequalities and policy implementation gaps. However, district-level empirical analyses, particularly for Bhagalpur, remain limited, indicating a significant research gap that this study seeks to address by integrating socio-economic, dietary, and nutritional dimensions.

Data and Methodology

The study is based on a combination of primary and secondary data sources. Primary data are collected through a structured household survey in selected rural and urban areas of Bhagalpur district using a multistage stratified sampling technique. Secondary data are obtained from sources such as the National Family Health Survey (NFHS-5), National Sample Survey (NSSO), and reports from FAO and NITI Aayog. The analysis employs both descriptive statistics and econometric techniques to examine the determinants of food security, dietary diversity, and nutritional outcomes.

Dietary diversity is measured using the Household Dietary Diversity Score (HDDS), defined as the number of different food groups consumed by a household over a reference period:

$$HDDSi = \sum_{j=1}^{n} F_{ij}$$

where $HDDS_i$ represents the dietary diversity score of the i^{th} household, and F_{ij} is a binary variable taking the value 1 if the j^{th} food group is consumed and 0

otherwise, with n representing the total number of food groups.

To analyse the determinants of dietary diversity, a multiple linear regression model is specified as follows:

$$HDDS_i = \beta_0 + \beta_1 Y_i + \beta_2 Edu_i + \beta_3 HHsize_i + \beta_4 Land_i + \beta_5 Market_i + \beta_6 PDS_i + \epsilon_i$$

where Y_i denotes household income, Edu_i represents education level, $HHsize_i$ is household size, $Land_i$ indicates landholding size, $Market_i$ captures market access, PDS_i represents access to public distribution systems, and ϵ_i is the error term.

Nutritional outcomes, such as child malnutrition (stunting, wasting, underweight), are analysed using a logistic regression model which is specified as follows:

$$P\,(Nutrition_i = 1) = \frac{1}{1 + e^{-(\alpha_0 + \alpha_1 HDDS_i + \alpha_2 X_i)}}$$

where $Nutrition_i$ is a binary indicator of nutritional status, $HDDS_i$ represents dietary diversity, X_i is a vector of control variables (income, sanitation, health access, gender), and α are parameters to be estimated.

Food security status is further assessed using a Food Consumption Score (FCS) or calorie intake approach, comparing household consumption with recommended dietary allowances. Descriptive statistics such as mean, standard deviation, and coefficient of variation are used to analyse consumption patterns, while correlation analysis examines relationships among key variables.

The study ensures robustness through diagnostic tests, including multicollinearity (Variance Inflation Factor), heteroscedasticity (Breusch–Pagan test), and model specification (Ramsey RESET test). The integration of these statistical and econometric techniques provides a comprehensive framework to evaluate the complex interplay between socio-economic factors, dietary diversity, and nutritional outcomes in Bhagalpur.

RESULTS AND DISCUSSION

The results and discussion of the study are presented in a systematic and sequential manner, integrating empirical findings from Tables 1-8 with relevant theoretical and empirical literature. The distribution of households by dietary diversity category, as presented in Table 1, indicates that a majority of households (51%) fall within the medium dietary diversity group, while only 25% achieve high dietary diversity and 24% remain in the low category. This pattern suggests that although a substantial proportion of households have access to a moderate variety of food, a significant segment remains nutritionally vulnerable.

Table 1: Distribution of households by dietary diversity category (HDDS Classification)

HDDS Category	Score range	Number of households	Percentage (%)
Low Diversity	≤ 4	48	24.0
Medium Diversity	5–7	102	51.0
High Diversity	≥ 8	50	25.0
Total	—	**200**	**100**

Source: *Author's calculation based on primary data (2024-25).*

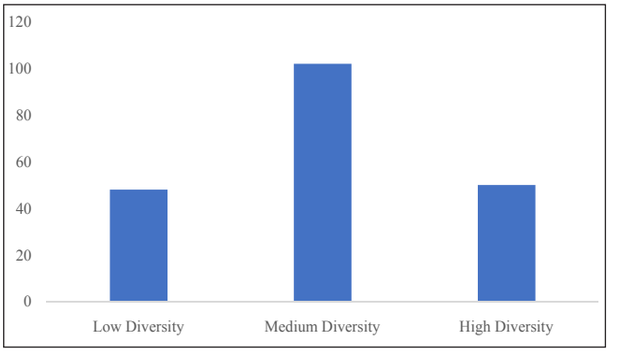

Fig. 1: HDDS Classification

This finding is further reinforced by the average Household Dietary Diversity Score (HDDS) reported in Table 4 (mean = 6.21), which reflects moderate but inadequate dietary diversity. The persistence of low dietary diversity among nearly one-fourth of

households highlights structural constraints such as limited income, restricted access to diverse foods, and socio-economic inequalities, consistent with the findings of Rao *et al*. (2018).

Table 2 provides insights into food consumption patterns, revealing a clear imbalance in dietary intake. While cereals are consumed by all households (100%), indicating basic food availability, the consumption of nutrient-rich food groups such as fruits (41%) and animal protein (39%) remains substantially low. In contrast, relatively high consumption of oils (85%) and sugar (68%) suggests a calorie-dense but nutrient-poor dietary pattern. This imbalance contributes to micronutrient deficiencies and poor health outcomes. These findings align with Thorne-Lyman *et al*. (2010), who emphasized that dietary diversity is a critical determinant of micronutrient adequacy and that caloric sufficiency alone is insufficient to ensure proper nutrition.

Table 2: Food group consumption pattern across sample households

Food Group	% of households consuming
Cereals	100
Pulses	72
Milk & Dairy	58
Fruits	41
Vegetables	76
Eggs/Meat/Fish	39
Oils & Fats	85
Sugar	68

Source: *Primary data (2024-25).*

The relationship between dietary diversity and nutritional outcomes is clearly demonstrated in Table 3. Households with low HDDS exhibit a significantly higher prevalence of child malnutrition (62%), whereas the proportion declines to 21% among households with high dietary diversity. This inverse relationship strongly supports the hypothesis that improved dietary diversity enhances nutritional outcomes. The results are consistent with national-level evidence from NFHS-5 and studies by IIPS & ICF (2021), which highlight the critical role of dietary quality in reducing malnutrition.

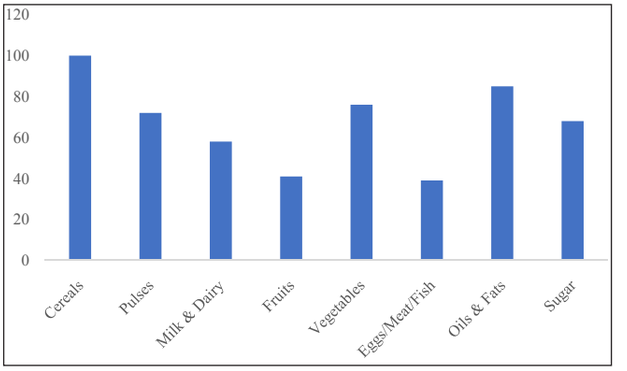

Fig. 2: Food group consumption pattern of the households

Table 3: Cross-tabulation of HDDS and Child Nutritional Status

HDDS Category	Malnourished Children (%)	Normal Children (%)
Low HDDS	62	38
Medium HDDS	38	62
High HDDS	21	79

Source: *Computed from primary data and anthropometric assessment (2024-25).*

Table 4: Descriptive statistics of key variables

Variable	Mean	Std. Dev.	Min	Max
HDDS	6.21	1.84	2	11
Monthly Income (₹)	8,750	3,420	2,500	18,000
Education (Years)	6.8	3.5	0	15
Household Size	5.6	2.1	2	11
Landholding (Acres)	0.84	0.67	0	3.5
Market Distance (km)	4.9	2.3	1	12

Source: *Author's estimation using primary data (2024-25).*

The descriptive statistics in Table 4 further contextualize these findings by highlighting socio-economic disparities among households. The average monthly income (₹ 8,750), low landholding size (0.84

acres), and moderate education levels (6.8 years) reflect structural constraints typical of rural Bihar. Additionally, variation in market distance (mean = 4.9 km) indicates uneven access to markets, which may limit the availability of diverse food items. These findings corroborate earlier studies (Rao *et al*. 2018; Singh *et al*. 2020) that emphasize the role of socio-economic factors in shaping dietary diversity and food consumption patterns.

Table 5: Multiple regression results for determinants of dietary diversity (HDDS)

Variable	Coefficient (β)	Std. Error	t-value	Sig.
Constant	2.114	0.842	2.51	**
Income	0.00021	0.00005	4.20	***
Education	0.134	0.041	3.27	***
Household Size	-0.092	0.036	-2.56	**
Landholding	0.418	0.121	3.45	***
Market Access	-0.156	0.052	-3.00	***
PDS Access (Dummy)	0.287	0.118	2.43	**
$R^2 = 0.62$				

Note: *(*Significance: ***p<0.01, *p<0.05).*

Source: *Estimated by the author using primary data and OLS regression model (2024-25).*

The econometric analysis presented in Table 5 provides robust evidence on the determinants of dietary diversity. Income, education, and landholding size are found to have positive and statistically significant effects on HDDS, indicating that both economic capacity and human capital enhance access to diverse diets. In contrast, household size has a negative and significant coefficient, suggesting a resource dilution effect in larger families. Market access (proxied by distance) also negatively influences dietary diversity, highlighting the importance of infrastructure and accessibility in shaping food choices. Although access to the Public Distribution System (PDS) has a positive effect, its relatively modest coefficient suggests that existing food security programmes may improve food access but are insufficient in promoting dietary diversification. These findings are consistent with Hoddinott and Yohannes (2002) and Sinha and Kansal (2019).

The logistic regression results in Table 6 further strengthen the analysis by examining the determinants of child malnutrition. Dietary diversity (HDDS) has a strong and statistically significant negative effect on malnutrition, with an estimated reduction of approximately 28% in the probability of malnutrition for each unit increase in HDDS. Additionally, income, education, sanitation, and healthcare access significantly reduce malnutrition risks, indicating that nutritional outcomes are influenced by a combination of dietary, socio-economic, and environmental factors. These findings are in line with Thorne-Lyman *et al*. (2010) and IIPS & ICF (2021), who emphasize the multidimensional nature of nutrition.

Table 6: Logistic regression results for nutritional outcomes (Child Malnutrition)

Variable	Coefficient (α)	Odds Ratio	Std. Error	Sig.
Constant	1.842	—	0.765	**
HDDS	-0.321	0.72	0.094	***
Income	-0.00015	0.85	0.00004	***
Education	-0.118	0.89	0.052	**
Sanitation (Dummy)	-0.542	0.58	0.213	**
Health Access	-0.267	0.76	0.109	**
Pseudo $R^2 = 0.48$				

Source: *Computed using logistic regression model based on primary data (2024-25).*

Table 7: Correlation matrix of key variables

Variable	HDDS	Income	Education	Land	Market
HDDS	1.00				
Income	0.58	1.00			
Education	0.49	0.52	1.00		
Landholding	0.44	0.47	0.36	1.00	
Market Access	-0.41	-0.39	-0.28	-0.22	1.00

Source: *Author's calculation using primary data (2024-25).*

Table 8: Diagnostic tests for model robustness

Test	Value	Interpretation
VIF (Mean)	2.14	No multicollinearity
Breusch–Pagan Test (p-value)	0.27	No heteroscedasticity
Ramsey RESET (p-value)	0.19	No specification error

Source: *Estimated by the author using econometric diagnostic tests (2024-25).*

The correlation matrix in Table 7 supports the regression results by showing strong positive associations between HDDS and key variables such as income (0.58), education (0.49), and landholding (0.44), while market distance exhibits a negative correlation (-0.41). The absence of excessively high correlations among explanatory variables indicates that multicollinearity is not a major concern, thereby ensuring the reliability of the estimated coefficients (Gujarati & Porter, 2009).

Finally, the diagnostic tests presented in Table 8 confirm the robustness of the econometric models. The Variance Inflation Factor (*VIF* = 2.14) indicates no multicollinearity, the Breusch–Pagan test (p = 0.27) confirms the absence of heteroscedasticity, and the Ramsey RESET test (p = 0.19) suggests correct model specification. These diagnostics validate the reliability and consistency of the empirical findings.

Overall, the sequential analysis demonstrates that dietary diversity in Bhagalpur is significantly influenced by socio-economic and infrastructural factors, with income and education emerging as key drivers. The strong linkage between dietary diversity and nutritional outcomes underscores the importance of shifting policy focus from food quantity to food quality. Furthermore, the limited impact of PDS on dietary diversification suggests the need for nutrition-sensitive policy reforms. These findings support the broader literature (Drèze & Sen, 2013; FAO, 2019) advocating for integrated, multi-sectoral approaches combining economic development, improved market access, and public health interventions to effectively address malnutrition and food insecurity

CONCLUSION

The study provides robust empirical evidence that food security in Bhagalpur extends beyond mere availability of staple foods to encompass issues of dietary quality, accessibility, and socio-economic inequality. As observed the moderate level of dietary diversity, combined with significant determinants, indicates that economic capacity, education, and access to productive resources play a crucial role in shaping household consumption patterns. Furthermore, the strong inverse relationship between dietary diversity and child malnutrition, reaffirms that improving food quality is essential for achieving better nutritional outcomes. The findings also highlight structural challenges such as inadequate market access and resource constraints, which limit the effectiveness of existing food security programmes.

From a policy perspective, the study suggests a shift from calorie-centric food security approaches toward nutrition-sensitive strategies. First, strengthening and diversifying the Public Distribution System (PDS) by including pulses, millets, and fortified foods can significantly enhance dietary diversity. Second, improving rural infrastructure, particularly market connectivity and storage facilities, can reduce transaction costs and increase access to diverse food items. Third, promoting nutrition education and awareness programmes, especially among women, can positively influence household dietary choices. Fourth, integrating agriculture with nutrition through the promotion of kitchen gardens, livestock, and crop diversification can improve both income and food quality. Fifth, expanding access to sanitation and healthcare services is critical, as these factors significantly affect nutritional outcomes. Additionally, targeted interventions focusing on vulnerable groups such as children, women, and low-income households, are essential to address persistent malnutrition. Strengthening institutional mechanisms like ICDS and Mid-Day Meal schemes with improved monitoring and quality control can further enhance their effectiveness. Overall, a multi-sectoral approach combining economic, agricultural,

health, and social policies is necessary to achieve sustainable improvements in food and nutrition security in Bhagalpur. The study thus contributes to the policy discourse by providing district-level empirical insights that can inform more localized and effective interventions.

GENERATIVE AI DECLARATION

The author(s) confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI. The authors developed and verified all scientific content, data analysis, interpretation of results, and conclusions. The authors take full responsibility for the accuracy, integrity, and originality of the work presented, and no AI tool was listed as an author.

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