



Household food insecurity and its determinants in tribal households in Paschim Medinipur district of West Bengal: A cross-sectional study

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Abstract

Food insecurity (FI) is a significant challenge marked by insufficient, unsafe and nutritionally inadequate food consumption due to lack of resources. Factors such as poverty, household type, education, ethnicity, household occupation, and income contribute to food insecurity, particularly in underprivileged communities, including tribal households. This study aims to investigate the status and determinants of household food insecurity (HFI) among scheduled tribe (ST) households in Paschim Medinipur districts of West Bengal. A cross-sectional survey was conducted across five selected blocks, and data were collected from 450 ST households using a structured questionnaire and Household Food Insecurity Indicator (HFII) module, which consists of 18 questions. Descriptive statistics, including bivariate cross-tabulation and chi-squared test, were utilized to analyze FI levels based on demographic and socioeconomic backgrounds. This study employed the dichotomous “*Rasch model*” to measure HFI severity and evaluated the reliability of the HFSI through Item Reliability Statistics, Cronbach’s alpha, and other measures. The reliability results indicated a good fit with Rasch Reliability at 0.861 ($p < 0.001$) and Cronbach’s alpha at 0.904. The study found that the overall prevalence of severe food insecurity (SFI) was 19.05%, with a higher rate among the Bhumij tribe (28.57%), women-headed households (24.24%; $p < 0.05$), and households engaged in off-farm activities (28.57%; $p < 0.05$). SFI was lower in households with higher per capita income. The logistic regression revealed that Bhumij households in Binpur-2 districts and those involved in off-farm activities were significantly more likely to experience severe food insecurity, with odds of 13.568 ($p < 0.05$), 3.746 ($p < 0.05$), and 3.577 ($p < 0.05$), to their respective counterparts. In contrast, higher per capita income reduced the likelihood of SFI by 73.5% ($p < 0.05$). These findings highlight the compounded vulnerability of tribal households due to geographical isolation, poverty, limited access to resources and their occupational pattern, suggesting the need for targeted policies to address the unique challenges faced by these communities.

Keywords

household food insecurity, Rasch model, socioeconomic status, Scheduled tribes, West Bengal

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Introduction

Food insecurity (FI) refers to inadequate, unsafe, and less nutritious food consumption due to food shortages or inadequate resources, with varying levels of severity and challenges in accessing and securing adequate food. It can lead to life-threatening phenomena that exist on a continuum of severity and potentially negatively affect health and well-being (Pool & Dooris, 2022). Several factors influence this multidimensional issue, including poverty and household-related factors such as type of household, educational attainment, ethnicity, occupation, and income. These factors, both directly and indirectly, contribute to an increased risk of FI due to lower socioeconomic status and higher levels of poverty (Shuvo et al., 2024). Globally, FI is a rising public health concern. (Pollard & Booth, 2019)

According to the Global Food Security Index (2022), India ranked 68th out of 113 countries globally, with scores of 59.3, 62.3, 62.1, and 51.2 in food affordability, availability, quality-safety, and sustainability-adaptation. FI in India is strenuous among disadvantaged and marginalized social groups, which primarily affects these underprivileged social groups, making them more exposed to extreme hunger, chronic ailments, and socio-economic inequalities. Scheduled tribes (ST) are the most backward, socio-economically disadvantaged and Indigenous social groups with distinctive characteristics from others, especially in West Bengal. Predominantly, tribal households rely on small agriculture, agricultural labour, and forest-based activities, which support the affordability of food. ST households are often beset by endemic poverty, chronic FI and the severe anxiety that comes with poor socioeconomic backgrounds and ever-more unpredictable threats to lives.

There are many policies and schemes launched by states and central government that have been implemented in India, such as the National Food Security Act (NFSA), which aimed to improve household food security through entitlement and is the first country across the world to provide subsidised food grain as a legal entitlement. Priority households and Antyodaya households (poorest of the poor) are entitled to provide 5 kgs of foodgrains/per person/per month and 35 kgs/per household/per month, respectively (NFSA, 2013). Similarly, Antyodaya Anna Yojana initiated a social welfare initiative to ensure food security for the most destitute people of society in India. Another innovation was fortified rice distributed over the Public Distribution System (PDS) to ensure the nutritional elements, including iron, folic acid, and vitamin B12, for food and nutrition security (NFSA, 2013). These flagship programmes were launched to ensure sustainable development goals (SDGs) such as SDG 1- end all forms of poverty and SDG 2 - end hunger and accomplish food security and nutritional improvement (UN DESA, n.d.). Despite the presence of existing schemes, the marginalized social groups lag behind the mainstream society and are trapped in poverty and unstable economic activities due to the un-dilution of the schemes up to the grassroots. Therefore, this study is needed to understand the severity of FI in the context of social, economic, and demographic factors at the regional and community levels. Therefore, this study aims to investigate household food insecurity (HFI) status and its determinant factors among ST households in Paschim Medinipur districts of West Bengal.

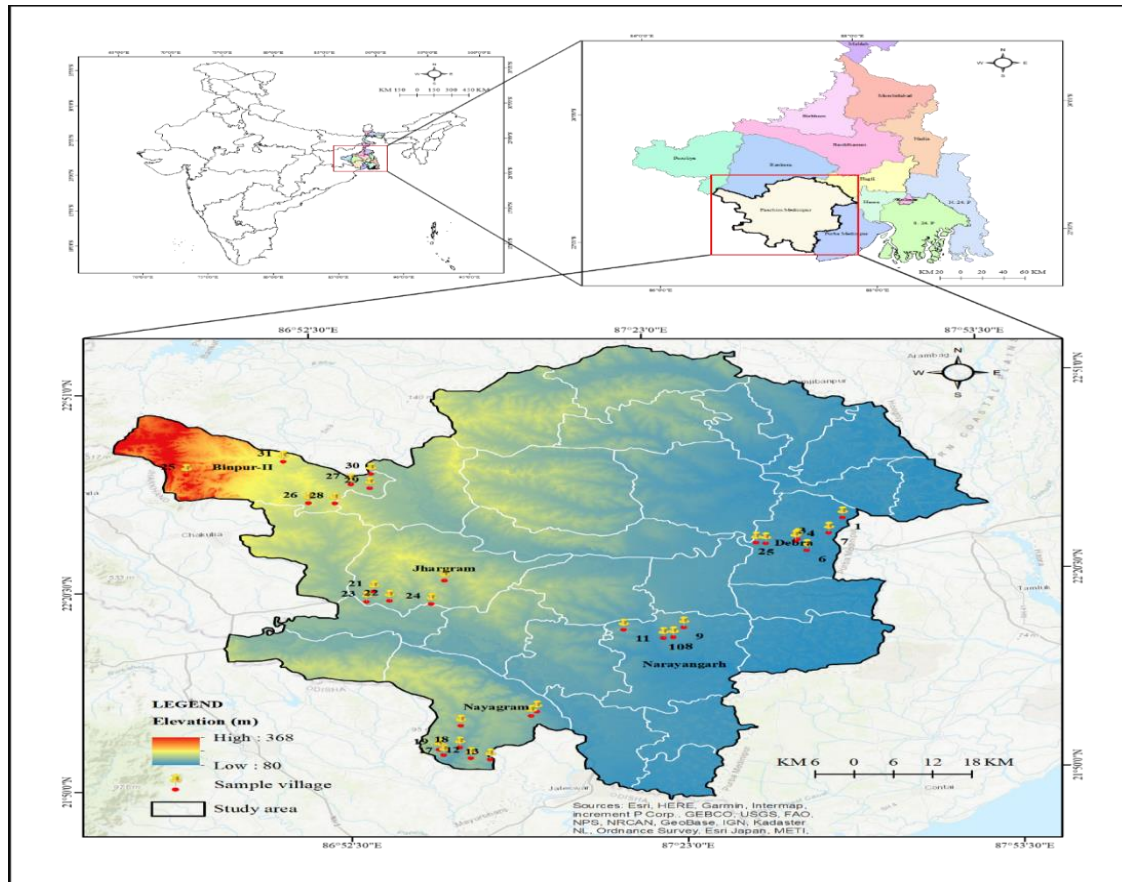


Figure 1 Location map of the study area

Materials and Methods

Study Area

The study was conducted at Paschim Medinipur district, one of the important districts of West Bengal state situated in eastern India. The district is geographically located at 21°45'53" North to 22°21'28"N latitude and 86°33'29" East to 87°53'25"E longitude with a 9,368 sq. km area. The district is divided into 29 community development blocks (CDBs) with a total population of 59 lakh and contributes 14.9% of the tribal population of the state (Census of India, 2011). The present study area consists of five CDBs, including Binpur - II, Debra, Narayangarh, Nayagram, and Jhargram, out of 29 CDBs.

Selection of sample

The present study considered 450 samples using the Yamane, Y. (1967) sampling method to determine the study's sample size. The total sample was collected from 31 villages in 5 CDB clusters considering proportional probability to size (PPS), where the size of the villages was considered based on the number of households (WHO, n.d.). The mathematical formula for sample estimation by Yamane (1967) is as follows (Yamane, 1967):

$$n = \frac{N}{1 + Ne^2}$$

Where n represents the estimated sample size; N is the total household size of 1,98,105 (Census of India, 2011); e = error (0.05) confidence level 95%.

Data

This cross-sectional study was conducted in Paschim Medinipur district of West Bengal from December 2023 to March 2024. This survey collected information from 450 ST households randomly based on a structured questionnaire that considered FI, livelihoods, demographics, and socioeconomic backgrounds of the households. Data entry was performed using KoBo Toolbox software.

Outcome Variable

The dependent variable was Household Food Insecurity (HFI) for this present study. The Household Food Insecurity Indicator (HFII) comprises eighteen questions, and the US HFIIAS questionnaire measures the rising severity of FI experienced over the last 12-month recall period in the tribal household to evaluate HFI (Supplementary 1) (Coates et al., 2007). Initially, the questions were asked to the household head, and multiple responses were recorded as affirmative (yes/ often true/ sometimes true) and non-affirmative (no/ never true). In the preliminary stage, those households responded with non-affirmative responses from all the first five HFI questions (q1-q5) are defined as food secure (FS), else food insecure households (Coates et al., 2007). The rationale for defining household food security (HFS) was to eliminate those households from the sample to perform a robust model of the HFI level. This signifies that these households are already food secure at the first level, hence they do not qualify for further query by any HFI questions.

However, each HFI question includes two parts: an occurrence question and a frequency-of-occurrence question. If the respondent replies affirmatively to the incidence question, then a subsequent query was placed to

understand the frequency as almost every month, some months but not every month, and only 1 or 2 months. Then the all responses were codified into binary form as “0=no” if the participant responded, “no or never true” in any of the item and “1=yes” if the occurrence of the question was “often true, or sometimes true, or almost every month, or some months but not every month, or only 1 or 2 months” (Kharisma & Abe, 2020). Therefore, the final response score for all households ranges from 0 to 18, which is used for the dichotomous “*Rasch model*” analysis.

Then, each household was assigned a raw score of 0 to 1, using the Rasch latent traits Gaussian probabilistic approach (Supplementary 2). Furthermore, a fixed threshold value was adopted to compute the severity level of HFI; if a household had a value beyond the fixed threshold value, then it had a chance to be a severely food-insecure household (FAO et al., 2019). Therefore, the severity of HFI is clearly defined in a binary form (1 and 0): if a household has a score value equal to or greater than 0.5 codified as severe food insecurity (SFI) (SFI=1); else mild to moderate food insecurity (MFI) (MFI=0) to evaluate levels of HFI (FAO et al., 2019; Kharisma & Abe, 2020; Onori et al., 2021).

Explanatory Variable

A set of explanatory variables from different demographic and socioeconomic characteristics of the ST households were considered based on several previous literature that were significantly associated with HFI (Coates, Wilde, et al., 2006; Demont, 2022; Kharisma & Abe, 2020; Rafiei et al., 2009; Soldavini et al., 2019). A detailed description of each explanatory variable is explained in Table 1.

Table 1 Descriptions of explanatory variables

| Explanatory variables | Descriptions | Coding |
|--------------------------------------|--|--|
| Scheduled tribes | Household heads were asked about native ethnicity, and this variable is considered as types of Scheduled Tribes. We recorded the responses as Bhumij, Ho, Kora, Korwa, Lodha/Lohara/Lohra, Munda, Santal, Oraon, and Savar. Further, for convenience of the study, the responses were categorised based on major tribal groups such as Bhumij, Lodha, Munda, Santal, and other tribes. | 1=Bhumij 2=Lodha 3=Munda 4=Santal 5=Other tribes |
| Name of the blocks | The blocks were recorded as their residing place of the households. The blocks are Binpur - 2, Debra, Jhargram, Narayangarh, and Nayagram. | 1=Binpur - 2 2=Debra 3=Jhargram 4=Narayangarh 5=Nayagram |
| Age of Household Head in year | Household heads were asked about their current age. For the analysis, age has been classified into three categories: less than 35 years old, 35-45 years old, and more than 45 years old. | 1=<35 years 2=35-45 years 3=>45 |
| Sex of Household Head | Household heads were asked about their sex, and the responses were recorded as Female and Male. | 1=Female 2=Male |
| Educational Status of Household Head | Household heads were asked how many years they had spent in school, and this indicator was considered the level of education, which was classified into four categories: No education, Literate without school, Primary completed, Secondary completed, and Higher. | 0=No education 1=Primary completed 2=Secondary completed 3=Higher |
| Religion of Household Head | Household heads were asked about religion and recorded as Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Others, and no religion. As per the collected data, we classified the religious category into three categories: Christian, Hindu, and Others. | 1=Christian 2=Hindu 3=Others |
| Occupation | The primary occupational information was captured as households engaged in different types of activities such as agriculture in owned or borrowed land or rented land, forest resources gathering and hunting, wage-earning on a monthly or daily basis, business, services, manufacturing, construction, and mining activities. Furthermore, these activities have been categorised into four major categories: Farm (agriculture in owned or borrowed land or rented land or livestock). Off-farm (processing, packaging, forest resources gathering, and hunting). Non-farm (wage-earning, business, services, manufacturing, construction, and mining activities). The combined livelihood activities refer to the combination of the above strategies where households engage in diversifying their livelihood options and income sources | 1=Farm 2=Off-farm 3=Non-farm 4=Combination |
| Per capita income | The household per capita income was calculated as the household's total income in Indian national rupees (INR) from all sources by the total number of household members. The per capita income range was then classified into low (1000-5000 INR), medium (5001-10000 INR), and high (10001-50000 INR). | 1=Low 2=Medium 3=High |
| Family size | The number of Household members residing in a family was asked of the respondent, and these were categorized as less than five members, and more than five members. | 1=<5 members 2=>5 members |

| | | |
|-------------------------|---|---------------|
| Agricultural land | The respondents were asked about their own agricultural land, and responses were recorded as having no land (0) and having land (1). | 0=No 1=Yes |
| Participated in MGNREGA | The respondents were asked if any members of the households were engaged in Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) activities under the MGNREG Scheme, and the responses were recorded as no and yes. | 0=No 1=Yes |
| Availed SHG Assistance | Respondents were asked about the status of Self-Help Groups (SHG), which is a part of the National Rural Livelihood Mission (NRLM) started by the government of India, and if any household members are currently involved in it. Therefore, the responses were recorded as No and Yes. | 0=No 1=Yes |

Statistical Analysis

Descriptive statistics were used, including bivariate cross-tabulation and chi-squared test, to analyze the baseline characteristics of the sample households. Further, we have used the dichotomous “*Rasch model*” to measure the severity of HFI. Additionally, to calibrate the HFII, Item Reliability Statistics (IRS), used along with the individual item’s reliability measures of Cronbach’s alpha, were employed before Rasch model estimation. The analysis is grounded on item response theory (IRT), which allows for the uncertainty in the response HFII (Gordon, 2015; Nord, 2014). The Rasch model (1966) utilizes probabilistic principles to estimate each item's severity level (Gordon, 2015). In the study of experience-based food insecurity, the latent trait is “food insecurity,” with the observed items corresponding to varying levels of “severity” on a continuum (Coates, Wilde, et al., 2006). To develop the scale, fit statistics and severity parameters- representing a continuous interval-level measure of FI- are incorporated into the dichotomous Rasch model. The dichotomous Rasch model explains the probability of a household endorsing an HFII as a function of household latent FI and their level of severity (Tanaka et al., 2020). The model is expressed as:

$$\ln \left(\frac{P_{ni1}}{P_{ni0}} \right) = \theta_n - \delta_i \quad (1)$$

Where, P_{ni1} defining the probability of n households endorsing item i , P_{ni0} defining the probability of n households not endorsing item i , θ_n represent the latent food insecurity measure of n households and δ_i defining the severity level of item i . Furthermore, the Rasch model estimates fit statistics, especially infit and outfit, by comparing the likelihood of affirmative response prediction of an item by the model with the actual responses provided by respondents (Nord, 2014). A detailed overview of the dichotomous Rasch model is explained elsewhere (Nord, 2014; Tanaka et al., 2020).

Finally, the multivariable binary logistic regression model is considered which is a suitable econometric analysis to study the association between dichotomous outcome variables (HFI) and multiple explanatory variables as either continuous or categorical (Maharjan & Joshi, 2011; Soldavini et al., 2019). Since we considered a binary logistic model in this study, we treated the outcome variable HFI as binary in nature, where 0 represents MFI, and 1 represents SFI. The statistical analysis and mapping were done using Stata 17.0, Jamovi and ArcGIS software (ESRI, 2011; Stata Corp, 2021; The jamovi project, 2025).

Results

Table 2 Demographic and socioeconomic characteristics of Tribal households in Paschim Medinipur, west Bengal

| Demographic and Socioeconomic Characteristics | Tribal Households | |
|---|-------------------|-----|
| | % | N |
| Schedule Tribes | | |
| Bhumij | 9.33 | 42 |
| Lodha | 12.22 | 55 |
| Munda | 9.78 | 44 |
| Santal | 58.22 | 262 |
| Others | 10.44 | 47 |
| Name of the blocks | | |
| Binpur - 2 | 24.89 | 112 |
| Debra | 22.67 | 102 |
| Jhargram | 13.11 | 59 |
| Narayangarh | 22.22 | 100 |
| Nayagram | 17.11 | 77 |
| Age of Household Head | | |
| <35 | 9.56 | 43 |
| 35-45 | 29.33 | 132 |
| >45 | 61.11 | 275 |
| Sex of Household Head | | |
| Female | 14.89 | 67 |
| Male | 85.11 | 383 |
| Educational Status of Household Head | | |
| No education | 56.22 | 253 |
| Primary completed | 31.56 | 142 |
| Secondary completed | 7.56 | 34 |
| Higher | 4.67 | 21 |
| Religion | | |
| Christian | 3.33 | 15 |
| Hindu | 55.11 | 248 |
| Others | 41.56 | 187 |
| Occupation | | |
| Farm | 30.44 | 137 |
| Off-farm | 26.44 | 119 |
| Non-farm | 22.67 | 102 |
| Combination | 20.44 | 92 |
| Per capita income | | |
| Low | 49.78 | 224 |
| Medium | 24.67 | 111 |
| High | 25.56 | 115 |
| Family size | | |
| <5 | 50.22 | 226 |
| >5 | 49.78 | 224 |
| Agricultural land | | |
| No | 69.56 | 313 |
| Yes | 30.44 | 137 |
| Participated in MGNREGA | | |
| No | 86.67 | 390 |
| Yes | 13.33 | 60 |
| Availed SHG assistance | | |
| No | 68.44 | 308 |
| Yes | 31.56 | 142 |
| Total | 100 | 450 |

Demographic and socioeconomic background of tribal household

Table 2 represents the demographic and socioeconomic background of ST households in Paschim Medinipur districts of West Bengal. The results revealed that 58.22% of the households belong to the Santal tribes, followed by Lodha (12.22%), and other tribal groups comprise the remaining. Regarding educational attainment, 56.22% of household

heads have no formal education, while 43.78% completed formal education (Primary, Secondary, and Higher). Moreover, one-third of the households (30.44%) are engaged in farm activities, 26.44% are in off-farm occupations, and 69.56% have no land. The government's scheme, MGNREGA, reaches 13.33% of the households, while the vast majority (86.67%) do not participate in the program, and 31.56% have received SHG assist.

Table 3 Item Reliability Statistics of Household Food Insecurity Indicator (HFII) by severity

| Items | Mean | SE | 95% Confidence Interval | | SD | Item-rest correlation | Cronbach's α | McDonald's ω |
|------------------------------|--------|--------|-------------------------|-------|-------|-----------------------|---------------------|---------------------|
| | | | Lower | Upper | | | | |
| q1 | 0.9289 | 0.0121 | 0.9051 | 0.953 | 0.257 | 0.399 | 0.903 | 0.917 |
| q2 | 0.8978 | 0.0143 | 0.8697 | 0.926 | 0.303 | 0.42 | 0.903 | 0.917 |
| q3 | 0.8711 | 0.0158 | 0.84 | 0.902 | 0.335 | 0.452 | 0.902 | 0.916 |
| q4 | 0.8022 | 0.0188 | 0.7653 | 0.839 | 0.399 | 0.463 | 0.902 | 0.916 |
| q5 | 0.7467 | 0.0205 | 0.7063 | 0.787 | 0.435 | 0.455 | 0.903 | 0.916 |
| q6 | 0.6756 | 0.0221 | 0.6321 | 0.719 | 0.469 | 0.477 | 0.903 | 0.916 |
| q7 | 0.22 | 0.0195 | 0.1816 | 0.258 | 0.415 | 0.614 | 0.897 | 0.91 |
| q8 | 0.2044 | 0.019 | 0.167 | 0.242 | 0.404 | 0.598 | 0.898 | 0.911 |
| q9 | 0.1867 | 0.0184 | 0.1505 | 0.223 | 0.39 | 0.56 | 0.899 | 0.912 |
| q10 | 0.1711 | 0.0178 | 0.1362 | 0.206 | 0.377 | 0.603 | 0.897 | 0.911 |
| q11 | 0.0956 | 0.0139 | 0.0683 | 0.123 | 0.294 | 0.644 | 0.897 | 0.909 |
| q12 | 0.0978 | 0.014 | 0.0702 | 0.125 | 0.297 | 0.687 | 0.896 | 0.907 |
| q13 | 0.0911 | 0.0136 | 0.0644 | 0.118 | 0.288 | 0.701 | 0.896 | 0.906 |
| q14 | 0.1044 | 0.0144 | 0.0761 | 0.133 | 0.306 | 0.638 | 0.897 | 0.908 |
| q15 | 0.0933 | 0.0137 | 0.0664 | 0.12 | 0.291 | 0.669 | 0.896 | 0.907 |
| q16 | 0.0867 | 0.0133 | 0.0606 | 0.113 | 0.282 | 0.668 | 0.897 | 0.907 |
| q17 | 0.1044 | 0.0144 | 0.0761 | 0.133 | 0.306 | 0.608 | 0.898 | 0.91 |
| q18 | 0.0778 | 0.0126 | 0.0529 | 0.103 | 0.268 | 0.647 | 0.897 | 0.908 |
| Scale Reliability Statistics | | | | | | | | |
| Overall | 0.359 | | | | 0.213 | | 0.904 | 0.916 |

Table 3 shows the item reliability statistics of the household food insecurity indicator (HFII) to measure the severity of FI further. The results revealed that as the mean values decrease, severity increases, with early items (e.g., q1–q6) showing higher means, indicating greater endorsement by the households, and later items (e.g., q11–q18) showing lower means, reflecting greater severity were less

common in the households. Reliability metrics (Cronbach's alpha α) remain consistently high across items, ranging from 0.896 to 0.903, demonstrating strong internal consistency. The overall scale reliability also reflects robust consistency, with Cronbach's alpha = 0.904 and McDonald's ω = 0.916, supporting the reliability of the HFSI scale.

Table 4 shows that the Rasch model analysis reflects the severity of FI by calibrating the scale formed by the results to HFSL. The item parameter of the severity revealed that lower parameter values indicated less severe experiences, while higher ones indicated more severe, ranging from -4.86 to 4.44 in HFII. The item “q18” had the highest severity measure (4.44) with the lowest affirmative response (7.78%), whereas the item “q1” had the lowest severity measure (-4.86), which obtained the

highest affirmative response (92.89%). From the item infit statistics, the mean infit score was 0.605 and infit values ranged between 0.602 and 1.046 for all HFII items, indicating the Rasch model exists in a good fit situation. Finally, the Rasch Reliability and Cronbach's alpha values for this model were 0.904 and 0.861, respectively, above the cutoff acceptance and considered a strongly satisfactory model fit.

Table 4 Estimates of Rasch model analysis for the Household Food Insecurity Indicator

| Items | % (n) | Measure | SE | Infit | Outfit |
|------------------------|-------------|----------------|-------|--------|--------|
| q1 | 92.89 (418) | -4.86 | 0.236 | 0.634 | 0.152 |
| q2 | 89.78 (404) | -4.17 | 0.21 | 0.734 | 0.778 |
| q3 | 87.11 (392) | -3.68 | 0.194 | 0.699 | 1.776 |
| q4 | 80.22 (361) | -2.69 | 0.165 | 0.838 | 1.845 |
| q5 | 74.67 (336) | -2.07 | 0.15 | 0.929 | 1.929 |
| q6 | 67.56 (304) | -1.41 | 0.138 | 0.955 | 1.135 |
| q7 | 22 (99) | 2.2 | 0.154 | 0.889 | 1.019 |
| q8 | 20.44 (92) | 2.37 | 0.159 | 0.956 | 1.146 |
| q9 | 18.67 (84) | 2.58 | 0.165 | 1.046 | 1.224 |
| q10 | 17.11 (77) | 2.77 | 0.171 | 0.974 | 0.847 |
| q11 | 9.56 (43) | 4.02 | 0.218 | 0.775 | 1.003 |
| q12 | 9.78 (44) | 3.98 | 0.216 | 0.663 | 0.366 |
| q13 | 9.11 (41) | 4.12 | 0.223 | 0.602 | 0.203 |
| q14 | 10.44 (47) | 3.84 | 0.211 | 0.819 | 0.707 |
| q15 | 9.33 (42) | 4.07 | 0.221 | 0.697 | 0.305 |
| q16 | 8.67 (39) | 4.22 | 0.227 | 0.67 | 0.289 |
| q17 | 10.44 (47) | 3.84 | 0.211 | 0.91 | 0.832 |
| q18 | 7.78 (35) | 4.44 | 0.237 | 0.662 | 0.633 |
| Descriptive Statistics | | | | | |
| Mean | | -0.0558 | | 0.6054 | 0.544 |
| SD | | 2.923 | | 0.908 | 1.402 |
| Model Fit Statistics | | | | | |
| Rasch Reliability | | 0.861 (<0.001) | | | |
| Cronbach's α | | 0.904 | | | |
| McDonald's ω | | 0.916 | | | |

Note n= number of affirmative responses; SE=standard error; H0= the data fit the Rasch mode

Figure 2 shows the level of HFI across several tribal groups in Paschim Medinipur districts of West Bengal. The SFI was higher among Bhumij at 28.57 per cent, followed by Santal (15.27%), Lodha (14.55%), and Munda

(13.64%) tribes, while lower to be found in other tribal groups (4.26%). On the other hand, other tribal groups were more prevalent to MFI at 95.74 per cent and higher among Bhumij tribal groups (71.43%).

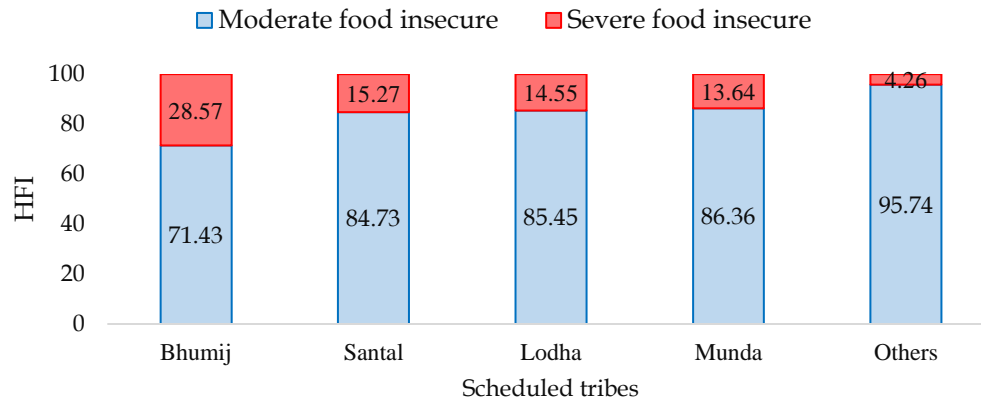


Figure 2 Household Food insecurity level across tribal groups of Paschim Medinipur, West Bengal

Table 5 reflects the levels of FI across the socioeconomic and demographic background of tribal households. The overall percentage of MFI households was 80.95%. MFI is significantly higher among male-headed households (81.92%) and households engaged in combination or diversified occupations (92.31%). Moreover, households with higher per-capita income (91.01%) and agricultural land (84.25%) were more likely to be MFI.

Moreover, the overall prevalence of SFI households was 19.05% and was significantly identified among the Bhumij tribe at 28.57%. Similarly, SFI was higher among women-headed households (24.24%) and households engaged in off-farm activities (28.57%). Identically, household income shows a substantial relationship with FI ($p < 0.05$), with households in the higher per-capita category experiencing much lower SFI (8.99%) than those in the low and medium-income groups (16.52% and 21.62%, respectively).

Table 6 shows the association and determinants of HFI among tribal households. The logit model revealed that households from the Bhumij tribe were more likely to experience SFI with an AOR of 13.568 ($p < 0.05$) than their counterparts. Geographically, households in the Binpur-2 blocks show 3.746 times ($p < 0.05$) higher odds of FI compared to the corresponding blocks, indicating that location plays a significant role in FI. Moreover, households involved in off-farm livelihoods were 3.577 times ($p < 0.05$) more likely to be SFI than the households engaged with combined livelihoods. On the contrary, households with higher per capita income were 73.5% less likely ($p < 0.05$) to be severely food insecure than corresponding groups. Additionally, the number of household members and participation in the MGNREGA or SHG programs do not appear to be significant predictors that affect HFI, nor does the household own agricultural land. Overall, the regression model shows a reasonable fit (pseudo r-squared: 0.171), with significant predictors identified through chi-square (65.17, $p < 0.05$).

Table 5 Levels of Household Food Insecurity across Socio-Demographic Characteristics of tribal Households in Paschim Medinipur, West Bengal

| Demographic and Socioeconomic Characteristics | Moderate food insecurity (MFI) | | Severe food insecurity (SFI) | | N | (χ^2) |
|---|--------------------------------|-----|------------------------------|----|-----|------------|
| | % | n | % | n | | |
| Name of the blocks | | | | | | 0.209 |
| Binpur - 2 | 76.47 | 78 | 23.53 | 24 | 102 | |
| Debra | 82.83 | 82 | 17.17 | 17 | 99 | |
| Jhargram | 74.51 | 38 | 25.49 | 13 | 51 | |
| Narayangarh | 81.25 | 78 | 18.75 | 18 | 96 | |
| Nayagram | 88.89 | 64 | 11.11 | 8 | 72 | |
| Age of Household Head | | | | | | 0.707 |
| <35 | 80.95 | 34 | 19.05 | 8 | 42 | |
| 35-45 | 78.57 | 99 | 21.43 | 27 | 126 | |
| >45 | 82.14 | 207 | 17.86 | 45 | 252 | |
| Sex of Household Head | | | | | | <0.05 |
| Female | 75.76 | 50 | 24.24 | 16 | 66 | |
| Male | 81.92 | 290 | 18.08 | 64 | 354 | |
| Educational Status of Household Head | | | | | | 0.798 |
| No education | 80.75 | 193 | 19.25 | 46 | 239 | |
| Primary completed | 79.56 | 109 | 20.44 | 28 | 137 | |
| Secondary completed | 86.21 | 25 | 13.79 | 4 | 29 | |
| Higher | 86.67 | 13 | 13.33 | 2 | 15 | |
| Religion of Household Head | | | | | | 0.154 |
| Christian | 92.31 | 12 | 7.69 | 1 | 13 | |
| Hindu | 77.83 | 179 | 22.17 | 51 | 230 | |
| Others | 84.18 | 149 | 15.82 | 28 | 177 | |
| Occupation | | | | | | <0.05 |
| Farm | 80.29 | 110 | 19.71 | 27 | 137 | |
| Off-farm | 71.43 | 80 | 28.57 | 32 | 112 | |
| Non-farm | 83.87 | 78 | 16.13 | 15 | 93 | |
| Combination | 92.31 | 72 | 7.69 | 6 | 78 | |
| Per capita income | | | | | | <0.05 |
| Low | 78.73 | 174 | 21.27 | 47 | 221 | |
| Medium | 77.27 | 85 | 22.73 | 25 | 110 | |
| High | 91.01 | 81 | 8.99 | 8 | 89 | |
| Family size | | | | | | 0.121 |
| <5 | 78.04 | 167 | 21.96 | 47 | 214 | |
| >5 | 83.98 | 173 | 16.02 | 33 | 206 | |
| Agricultural land | | | | | | 0.057 |
| No | 79.52 | 107 | 20.48 | 20 | 127 | |
| Yes | 84.25 | 340 | 15.75 | 80 | 420 | |
| Participated in MGNREGA | | | | | | 0.126 |
| No | 82.29 | 302 | 17.71 | 65 | 367 | |
| Yes | 71.70 | 38 | 28.30 | 15 | 53 | |
| Availed SHG assistance | | | | | | 0.826 |
| No | 80.68 | 238 | 19.32 | 57 | 295 | |
| Yes | 81.60 | 102 | 18.40 | 23 | 125 | |
| Total | 80.95 | 340 | 19.05 | 80 | 420 | |

Table 6 Determinants and association of Household food insecurity among tribal households of Paschim Medinipur, West Bengal

| Demographic and Socioeconomic Characteristics | Household food insecurity | |
|---|---------------------------|---------------------------|
| | UOR [CI: 95%] | AOR [CI: 95%] |
| Name of the Scheduled Tribe | | |
| Bhumij | 9.000 [1.879-43.113] *** | 13.568 [2.435-75.588] *** |
| Lodha | 3.830 [0.771-19.017] | 2.670 [0.419-17.012] |
| Munda | 3.553 [0.677-18.638] | 4.179 [0.682-25.605] |
| Santal | 4.054 [0.945-17.384] * | 6.043 [1.122-32.540] ** |
| Others | 1 | 1 |
| Name of the blocks | | |
| Binpur - 2 | 2.584 [1.048-6.370] ** | 3.746 [1.203-11.658] ** |
| Debra | 1.461 [0.553-3.856] | 1.569 [0.492-5.006] |
| Jhargram | 2.292 [0.829-6.332] | 3.470 [1.048-11.493] ** |
| Narayangarh | 1.628 [0.623-4.254] | 1.372 [0.345-5.459] |
| Nayagram | 1 | 1 |
| Age of Household Head | | |
| <35 | 1 | 1 |
| 35-45 | 3.115 [0.891-10.889] * | 2.935 [0.759-11.354] |
| >45 | 2.270 [0.670-7.689] | 2.421 [0.610-9.606] |
| Sex of Household Head | | |
| Female | 1 | 1 |
| Male | 0.501 [0.266-0.943] ** | 0.730 [0.333-1.602] |
| Educational Status of Household Head | | |
| No education | 1 | 1 |
| Primary completed | 0.999 [0.572-1.746] | 1.392 [0.708-2.739] |
| Secondary completed | 0.500 [0.146-1.714] | 0.676 [0.170-2.692] |
| Higher | 0.259 [0.034-1.980] | 0.499 [0.055-4.542] |
| Religion of Household Head | | |
| Christian | 1 | 1 |
| Hindu | 2.937 [0.376-22.930] | 2.219 [0.253-19.475] |
| Others | 2.061 [0.259-16.393] | 0.733 [0.075-7.118] |
| Occupation | | |
| Farm | 2.308 [0.885-6.021] * | 1.708 [0.451-6.471] |
| Off-farm | 5.049 [2.006-12.712] *** | 3.577 [1.093-11.704] ** |
| Non-farm | 1.911 [0.687-5.319] | 0.596 [0.170-2.094] |
| Combination | 1 | 1 |
| Per capita income | | |
| Low | 1 | 1 |
| Medium | 1.394 [0.786-2.473] | 1.110 [0.538-2.289] |
| High | 0.328 [0.141-0.760] *** | 0.265 [0.082-0.854] ** |
| Family size | | |
| <5 | 1.000 [0.000-0.000] | 1 |
| >5 | 0.713 [0.424-1.200] | 0.733 [0.397-1.354] |
| Agricultural land | | |
| No | 1 | 1 |
| Yes | 0.546 [0.292-1.021] * | 0.613 [0.212-1.776] |
| Participated in MGNREGA | | |
| No | 1 | 1 |
| Yes | 1.685 [0.856-3.316] | 1.030 [0.446-2.379] |
| Availed SHG assistance | | |
| No | 1 | 1 |
| Yes | 1.044 [0.601-1.814] | 0.668 [0.327-1.366] |
| Constant | | 0.025 [0.001-0.646] ** |
| Pseudo r-squared | | 0.171 |
| Log-likelihood | | -158.49946 |
| Chi-square | | 65.17 |
| Akaike crit. (AIC) | | 368.999 |
| Bayesian crit. (BIC) | | 475.839 |

Note UOR - unadjusted odds ratio; AOR - adjusted odds ratio; [CI: 95%]- Confidence Interval at 95% significance level; statistical significance (p-value) is denoted by asterisks where *p-value < 0.1, **p-value < 0.05, and ***p-value < 0.01; ®- reference category. *** p<.01, ** p<.05, * p<.1.

Discussion

The present study investigated the status of HFI among tribes in Paschim Medinipur districts of West Bengal. Several important findings and predictors emerged from this study based on FI experiential conditions. It is often highlighted that 15 per cent of households belong to SFI conditions. In households experiencing marginal food security, the severity of the situation manifests through a complex and structured process. Initially, the household faces heightened anxiety regarding food availability and the challenge of prioritizing food over other basic needs. As food options become limited, households may respond by reducing both the quantity and quality of food consumption. This coping mechanism often leads to a diminished ability to access preferred or varied foods (Kharisma & Abe, 2020). In the early stages, households may cope with the condition by eating repetitive meals or reducing the frequency of food consumption. However, as the household recites food and reduces food frequency, households are forced to drastically curtail food consumption, leading to experiences of hunger and, ultimately, the inability to consume food for an entire day (Coates, Frongillo, et al., 2006).

The probability of SFI is higher than that of Bhumij Tribes in the present study. This finding also aligned with other studies captured in the Indian context (Yasmin et al., 2018). The rationale for the outcome may be due to the lower socioeconomic settings as the mainstream of the Bhumij households are engaged in low-wage earning livelihoods. The monetary upholding and educational attainments might not be sustainable enough to cater to food for the family as the

households have lower incomes (Goswami et al., 2010). FI and livelihood support are integral to long-term community and household resilience emergency response. We found that off-farm activities increased FI among tribal households, offering them income diversification to ensure food security. On the contrary, the influence of off-farm livelihoods on food security positively and significantly improved all food security indicators (Dsouza et al., 2020). The general argument is that tribal households have distinct demographic and socioeconomic backgrounds compared with others and are severely food insecure as the outcome of households solely depends on off-farm.

The outcome further revealed the relationship between household income and FI; higher-income households tend to lead to less SFI. Income can potentially reduce or lower the severity of FI to stabilise the economic strength of the household and determine the buying capacity of food items and other essential goods. Therefore, households with higher incomes were less severely food insecure and enormous evidence shows that income and poverty can laid a household at a greater risk of experiencing higher FI (Haddad et al., 1994; Maitra & Rao, 2015). The impact of SHGs on coping with FI has an outstanding relationship. The evidence supports that SHG households were less likely to be trapped in SFI in tribal households. Credits and assistance from SHG play an important role in securing food in households as an alternative way of risk-mitigating strategy and well nutritional outcome (Demont, 2022; Kumar et al., 2024). One of the primary ways SHGs promote sustainable agriculture is through education,

awareness, and training sessions among tribal households.

The initiatives by the Government of India's food-based social protection schemes to reach out to the targeted population for access-to-safe and nutritious-food (SDG 2.1), end of all malnutrition forms (SDG 2.2) and self-help group collectives. This will increase social and financial mobility and higher productivity and incomes of small-scale food households (SDG 2.3) by 2030. Community-Based Food Security Networks might be another intervention to establish ethnic food cooperatives or community food hubs for accessible, affordable, culturally appropriate food. Supporting Small-Scale Farmers and Food Suppliers could involve financial support and logistical assistance to improve supply chains and ensure accessibility to their traditional foods.

However, this study has some limitations which need to be recognized. First, the recall period of responses may have a potential bias to the results of FI status because of the seasonality, which could not be captured in the study as it was a cross-sectional study. Second, the subjectivity is consistent with the qualitative dataset because item measurements were quantified using comprehensive statistical modelling.

Conclusion

The findings of this study underscore the prerequisite for target-based policy interventions to address the determinants of FI among vulnerable tribal households in Paschim Medinipur districts of West Bengal. Tribal communities, particularly the Bhumij and Santal groups, show significantly higher levels of food insecurity, indicating that

government programs should prioritize these tribes by improving access to food assistance, social safety nets, and livelihood programs. Despite limited direct impacts, programs like MGNREGA and SHG can be strengthened to address FI by increasing coverage, ensuring timely payments, and enhancing the quality of assets created. Additionally, food security policies must focus on improving the nutritional quality of food distributed through schemes like the PDS, particularly for vulnerable tribal households. Furthermore, the vulnerability of FI is exacerbated by the identified blocks, indigenous groups, due to geographical isolation, poverty, limited access to resources and their occupational pattern in tribal households. Ecological democracy, recognizing and integrating this Indigenous knowledge into broader policies, strengthens sustainable development and ensures equitable resource distribution.

Conflict of Interest

No conflict of interest was reported by all authors.

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Supplementary:**Supplementary 1 Household Food Insecurity Indicator (HFII) questionnaire**

| Sl. no. | Questions | Responses |
|---------|--|---|
| q1 | “Did you ever worry whether food in your household would run out before you got money to buy more” How often was that true in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q2 | “The food that you brought for your household just didn’t last and you didn’t have money to buy more” How often was that true in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q3 | “We couldn’t afford to eat balanced meals” How often was this true for your household in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q4 | “We relied on only a few kinds of low-cost food to feed the children because we were running out of money to buy food” How often was that true for your household in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q5 | “We couldn’t feed the children a balanced meal because we could not afford that” How often was that true for your household in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q6 | “The children were not eating enough because we just could not afford enough food” How often was that true for your household in the last 12 months? | Often true, Sometimes true, Never true, DK |
| q7 | In the last 12 months did you or any adult member of the household ever cut the size of meals or skip meals because there wasn’t enough money for food? | Yes, No, DK |
| q8 | If yes, how often did this happen in the last 12 months? | Almost every month, Some months but not every month, Only 1 or 2 months, DK |
| q9 | In the last 12 months, did you ever eat less than you felt you should because there wasn’t enough money to buy food? | Yes, No, DK |
| q10 | In the last 12 months, were you ever hungry but didn’t eat because you couldn’t afford enough food? | Yes, No, DK |
| q11 | In the last 12 months, did you lose weight because you didn’t have enough money for food? | Yes, No, DK |
| q12 | In the last 12 months, did you or any other adult member in this household ever not eat for a whole day because there wasn’t enough money for food? | Yes, No, DK |
| q13 | If yes, how often did this happen in the last 12 months in your household? | Almost every month, Some months but not every month, Only 1 or 2 months, DK |
| q14 | In the last 12 months did you ever cut the size of meal for any children in this household because there wasn’t enough money for food? | Yes, No, DK |
| q15 | In the last 12 months, did any children of the household ever skip meals because there wasn’t enough money for food? | Yes, No, DK |
| q16 | If yes, how often did this happen in the last 12 months in your household? | Almost every month, Some months but not every month, Only 1 or 2 months, DK |
| q17 | In the last 12 months, were any children in this household ever hungry but you just couldn’t afford more food? | Yes, No, DK |
| Q18 | In the last 12 months, did any of the children ever not eat for a whole day because there wasn’t enough money for food? | Yes, No, DK |

Supplementary 2: Raw Mean Score of Household Food Insecurity Indicators (HFII)

| HFII | Raw Mean score |
|------|----------------|
| q1 | 0.056 |
| q2 | 0.111 |
| q3 | 0.167 |
| q4 | 0.222 |
| q5 | 0.278 |
| q6 | 0.333 |
| q7 | 0.389 |
| q8 | 0.444 |
| q9 | 0.500 |
| q10 | 0.556 |
| q11 | 0.611 |
| q12 | 0.667 |
| q13 | 0.722 |
| q14 | 0.778 |
| q15 | 0.833 |
| q16 | 0.889 |
| q17 | 0.944 |
| q18 | 1.000 |