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EDITED BY
Ademola Braimoh,
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REVIEWED BY
Aditya Sinha,
Bihar Agricultural University, India
Dilshad Ethen,
Ghent University, Belgium

*CORRESPONDENCE
Mohammad Jahangir Alam
✉ alambau2003@yahoo.com

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The association between household's asset ownership and food security: panel data evidence from Bangladesh

Zannatul Ferdous Shifat[1], Mohammad Jahangir Alam[1]*, Ismat Ara Begum[2], Md Asif Iqbal[1], Paresh Kumar Sarma[3] and Andrew M. McKenzie[4]

[1]Department of Agribusiness and Marketing, Bangladesh Agricultural University, Mymensingh, Bangladesh, [2]Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh, [3]Bangladesh Agricultural University Research System, Bangladesh Agricultural University, Mymensingh, Bangladesh, [4]Department of Agribusiness and Agricultural Economics, University of Arkansas, Fayetteville, NC, United States

Food security remains a critical challenge in Bangladesh, with many households experiencing periodic shortages and nutritional deficiencies. It is necessary to ensure a consistent and adequate food supply for its rapidly growing population, amidst economic and environmental vulnerabilities. In light of this, this study looks into the association between food security and household asset ownership, addressing whether increasing asset accumulation can significantly improve food security status among households. Using panel data and the two rounds of comprehensive and inclusive Bangladesh Integrated Household Surveys (BIHS-2015, 2018), a fixed-effects model is used in this study to take endogeneity issues and unobserved heterogeneity into consideration. The food consumption score and per capita calorie consumption are employed to determine food security. The result found that households with productive assets positively and considerably impact the availability of food calories and asset ownership strengthens households' income-generating capacity. Furthermore, there are additional significant variables that support the ownership of resources, like annual income and farm size, which are closely linked to enhancing calorie intake and food security as well. Enhancing asset ownership among vulnerable households could significantly bolster food security. Moreover, policies aimed at diversifying household assets and improving access to markets can provide a buffer against food insecurity. By focusing on asset-building strategies, policymakers can foster a more resilient food system that ensures consistent access to food for all households while also increasing households' incomes by owning assets.

KEYWORDS

asset, food security, ownership, panel data, fixed effects, Bangladesh

1 Introduction

Assets, not just income, are crucial in reducing poverty (Nancy et al., 2011). People's well-being depends on their ability to own and control their assets. Additionally, owning assets can strengthen one's control over resources in the household (Doss et al., 2020). Household assets refer to the valuable possessions or resources owned by a household or a family. These assets can be tangible or intangible and are recognized as a trustworthy indicator of the wealth and financial standing of the residence. Household assets can vary widely depending on the

economic status, lifestyle, and preferences of the household (Wamani et al., 2004). Therefore, wealth is a household characteristic that frequently has a significant impact on health because it makes it possible to identify issues that are unique to both the wealthy and the poor (Felker-kantor and Wood, 2012). Severe malnutrition affects about 815 million people globally, most of them residing in countries with lower and moderate incomes (FAO et al., 2020). The quantity of food intake is insufficient to facilitate optimal well-being, even though it is a major contributing factor to malnutrition or undernutrition (FAO et al., 2017).

Undernourishment and a daily food shortfall are prevalent issues in rural Bangladesh, where 160 million people live in poverty and cannot purchase the necessary nutrition (Roy et al., 2019; Kalapara, 2013; ICDDRB, 2021). Food security is a prerequisite for the growth of human capital and an essential component for the general advancement of society. The concept of food security offers a logical way to understand how and why malnutrition happens, as well as what can be done to address and prevent it (Rahman and Islam, 2013). Bangladesh ranks third globally in terms of poverty rates, behind China and India, with over 60 million people being hungry, and more than half of the nation's children being undernourished (Parvin, 2013; National Workshop Paper, 2005). With local agricultural production, stable prices, and consistently rising real earnings and incomes, Bangladesh has achieved significant progress in feeding a sizable population in recent times. Between 2000 and 2019, there was a decrease in poverty from 52.3 to 20.5%. From US$525 in 2000 to US$1,280 in 2021, the gross domestic product per capita developed (ICDDRB, 2021; Giménez et al., 2021). While food availability is improving overall, small improvements are still being made in other areas of food safety, including consumption and accessibility to food (WFP, 2004). There are several perspectives on food security: national, local, household, and intra-household. Having enough resources available at the national level for the entire population determines food security (Siddique, 2017). Because total landholding can greatly increase food production and significantly affect the food supply for households by expanding the area under cultivation (Pritchard et al., 2016). As compared to homes experiencing food insecurity, a greater percentage of those that are food secure have livestock ownership (Doss et al., 2020). The equitable distribution of assets within households and communities plays a crucial role in determining how effectively they contribute to food security for all members.

Numerous investigations have clarified the concerns about child nutritional status and determinants regarding food sufficiency (Feleke et al., 2005; Pritchard et al., 2016; Abegaz, 2017). Compared to mono-crop farming, enhancing food production through integrated farming could lead to better use of resources and productivity of food produced (Ahmed and Garnett, 2011). Giving women more control over their wealth can boost their financial stability and negotiating strength, which could have a big impact on the health and well-being of their kids (van der Meulen Rodgers and Kassens, 2018). Improving the services' affordability along with availability for the impoverished and lowering household income inequality enhance the general health and dietary requirements of children (Hong et al., 2006).

Emphasizing the ownership of various resources contributes to household food production and economic stability in Bangladesh. Empowering women through asset ownership further enhances their financial stability and bargaining power, which positively impacts children's health and nutrition. Additionally, the majority of research has analyzed associations using cross-sectional data, which restricts policy's potential to be interpreted and attributed and can be vulnerable to a few biases (Sadey et al., 2018). Using the Bangladesh Integrated Household Survey (BIHS) and reliable data, this study aims to uncover new information and offer useful policy recommendations.

Thus, this study aims to evaluate practical approaches to alleviate food insecurity. Against the background of the study, the study will provide a more thorough comprehension of the possession of assets, and close the current gap in the literature on food sufficiency in Bangladesh by assessing the present status of household asset ownership and food security and determining the connection between asset ownership and food security.

The document's remaining part is structured as follows: Review of literature within section 2, our methods and data are shown in section 3. In sections 4 and 5, the findings and outcomes are presented and addressed. Section 6 closes with policy implications and section 7 lists the study's limitations.

2 Review of literature

Assets produce and diversify revenue, serve as security for loans, reduce financial restrictions during shocks and confer social standing (Doss et al., 2020). Either alone or with others, the microdata on asset ownership is typically gathered primarily at the household level, frequently with just one respondent per family. Consisting of five capitals, the concept of assets is established: Natural resources include things like land, livestock, water, and forests; physical resources include things like housing, agricultural products, and household durables; financial resources include money, savings (official or informal), and investments in shares and equities; human resources include things like health, knowledge, schooling, labor force, and skills; and social resources include things like social networks and group membership. In contrast to financial, human, and cultural resources, they classify property, housing, livestock, as well as durable items as physical assets (Diana Deere et al., 2012; Ruel and Hauser, 2013).

The relative bargaining power of household members may be significantly impacted by land ownership. Laws that redistribute money within families are less likely to affect property rights than person-specific income transfer schemes. While money is easily divided among family members, ownership rights to a residence must be "pooled" by all members of the household. Additionally, a person's capacity to meet their demands for sustenance outside of the family is directly tied to their ability to possess property (Field, 2003).

Most households in the country hold their primary residence as well as certain consumer durables. They have some ownership in enterprises and animals. Concerning inequality and multigenerational accessibility, assets are a reservoir of wealth that can be bequeathed (Caner and Wolff, 2004). The degree of income or consumption has been used to gauge the well-being of households or individuals. However, people's access to a variety of options inside their homes for generating income or consuming it is largely influenced by the assets they possess (Torche and Spilerman, 2006). These resources could be personal, physical, financial, natural, or social. Using an asset-based approach to welfare research has the advantage that assets are stocks or inventories, whereas income and

expenses are flow variables. One of the primary methods for producing income and, by extension, becoming a consumer means having material and monetary possessions. This is especially evident when considering land ownership and its relationship to produce from agriculture. Furthermore, a household's physical holdings of assets are a significant predictor of its crisis susceptibility and chance of becoming chronically impoverished (Carter and Barrett, 2006).

The ability to preserve wealth is essential because assets can be traded or sold to offset the negative consequences of economic shocks. As assets promote income diversification, they also improve a household's capacity to recover from adverse events (Rahman and Islam, 2019).

The ability of women to own land empowers them and improves the health of their offspring. Research revealed that owning assets increases a woman's position, which improves both her personal and household well-being. Research from South Asia suggests that owning land makes women more involved in decision-making (Pradhan et al., 2019). The ability of women to produce and their bargaining power at home can be enhanced through agricultural initiatives that are sensitive to nutrition and include asset transfers (van den Bold et al., 2015). Giving women more control over their wealth can boost their financial stability and negotiating strength, which could have a big impact on the health and well-being of their kids (Allendorf, 2007). The health of children can be impacted by a woman's ability to handle her finances in several ways, including their capacity to spend on products and services that enhance their kids' general and nutritional health. The empirical study uses information from the Papua New Guinea HIES conducted in 2009–2010. The HIES covers six asset categories: house/apartment, furniture/household items, cattle, poultry, machinery for agriculture, and fishing vessels. Among the six assets in the survey, land is not mentioned. The ownership data for the six distinct assets will be combined using three aggregate indexes. All six resource factors are combined using principal components analysis (PCA), which creates an index by linearly combining the variables. They only utilize the initial PCA element because it allows for the largest possible variation between households by assigning the greatest value to assets that vary substantially among households (van der Meulen Rodgers and Kassens, 2018; Mishra and Sam, 2016).

Several studies (Wamani et al., 2004; Allendorf, 2007) defined assets as follows: (1) capital derived from natural resources (land); (2) capital derived from physical assets (livestock, farmland, or household assets); (3) capital derived from human capital (skills, wellness, education); (4) capital derived from finance (savings, credit); (5) capital derived from social capital; and (6) capital derived from politics.

Research on resource distribution within households and upon marriage using data from South Africa, Bangladesh, Ethiopia, and Indonesia hypothesized that intra-household asset allocation affects individuals' bargaining power. The person who is in charge of assets might affect the well-being of those living there since men and women usually have distinct preferences when it comes to resource allocation (Quisumbing and Maluccio, 2003). Initiatives for agricultural development may be the most effective way to close the gaps in the control and access to assets by men and women, while also improving income equality, gender emancipation, and overall prosperity (Fafchamps and Quisumbing, 2002).

From the above review, it is found that many studies focused on two variables: household food security and ownership of property. These previously mentioned factors occasionally differed amongst societies and may have had distinct settings depending on the socioeconomic circumstances. Existing information clarifies asset ownership variables and the significance of their determinants to ensure food security sustainably. Moreover, current studies lack a detailed analysis of how determinants of asset ownership—such as land access, income, and education—vary by socioeconomic context and how these variations affect the sustainability of food security. This study aims to address these gaps by investigating the associations between asset ownership and food security, providing insights that are more adaptable to diverse settings.

3 Survey, methods, and data

This study uses information from the BIHS in two phases, conducted in 2015 and 2018. BIHS survey exhibits statistical representativeness in the southwest region of Bangladesh's rural areas nationally. To ascertain the 6,503 dwellings in 325 key selection areas (i.e., villages) included in the BIHS survey questionnaires, a reliable and suitable statistical procedure is employed. Two methods are used to choose the sample size: first, primary sampling units (PSUs) are chosen, and then, households inside PSUs are chosen. Furthermore, the households that were divided between 2015 and 2018 are not included to create a well-balanced database within the typical households that participate in two waves of these surveys. As a result, our sample size is lower than the original BIHS statistics. Making up the final sample of 9,720 individuals in a balanced panel from the 4,860 farm households, with all survey data drawn from each round.

The questionnaires used for the BIHS study included questions about families, livestock, farming, and fisheries, as well as questions about food intake, state of nutrition, and community. Data on household attributes, such as assets, income, and food item intake for roughly 299 days leading up to the survey, are included in the data. This study has analyzed the relevant connections indicated by the research questions.

3.1 Empirical methods

Selection bias is plagued by cross-sectional studies, which can lead to an under or overestimation based on the form of bias of the real correlation (Shively and Sununtnasuk, 2015). A unique panel dataset that is nationally representative was gathered in two rounds in Bangladesh, in 2015 and 2018, and can be used to address these limitations. Researchers can account for unobserved variability among farm households because of the use of panel information. The choice is using a model (fixed or random effects) (Muriithi and Matz, 2015). One key source of endogeneity in our analysis is omitted variable bias, which occurs when unobserved factors influence both asset-building efforts and food security outcomes. If these factors are not accounted for, the estimated relationship between asset-building and food security may be biased (Muriithi and Matz, 2015). To address these potential sources of bias, we use a fixed-effects model, which controls for unobserved, time-varying traits across households. The underlying premise of the random effects model is that changes among entities

occur randomly and have no relationship to the independent variables, in contrast to the fixed effects model (Panangian and Siregar, 2019). Recently, fixed effects models have been applied to numerous scenarios to account for selection bias (Kouser and Qaim, 2011). Formally speaking, in our case, we observe two possible outcomes in the status of food security with values j = 2. Since there is a binary outcome of food security, an OLS regression does not fit the data as well as the logit model does. Usually, the outcome variable z_j is coded as $z_1 = 0$ and $z_2 = 1$. Furthermore, $\beta = 1$ is a standard definition for the base outcome. This corresponds to:

$$\Pr\left(y_{it}=1|\alpha_i,\beta,x_{it}\right)=\frac{\exp\left(\alpha_i+x_{it}\beta\right)}{1+\exp\left(\alpha_i+x_{it}\beta\right)}$$

$$\Pr\left(y_{it}=0|\alpha_i,\beta,x_{it}\right)=\frac{1}{1+\exp\left(\alpha_i+x_{it}\beta\right)}$$

Since it solely represents the difference between outcomes $z_2 = 1$ and $z_1 = 0$, the heterogeneity factor, αi, is now a scalar in this case. Similarly, just this contrast is reflected by the remaining coefficient vector, β. Moreover, the log-likelihood function's basis can be compressed to:

$$fy_i\,|\,\alpha_i,\beta,x_i,\theta_i=\frac{\exp\left(\sum_{t=1}^{Ti}y_{it}x_{it}\beta\right)}{\sum_{\upsilon_i i\varepsilon\gamma_i}\exp\left(\sum_{t=1}^{Ti}\upsilon_{it}x_{it}\beta\right)}$$

Here, in measuring food security status, the logistic regression model is a natural starting point (Mitra et al., 2020). This study employed logistic regression models in the following form to investigate the connection between household wealth and food security:

$$Z_i=\beta_0+\beta_1A_i+\beta_2X_i+u_i$$

Where Z_i = Food Security Status for household i; A_i = Asset index for household i; X_i = A vector representing the attributes of the family, including gender, literacy, age, and the family's size, and u_i = error term.

3.2 Key explanatory and outcome variables

This research primarily focuses on understanding ownership of household assets, which includes household productive and nonproductive resources. Asset ownership is the key explanatory variable. Various categories of assets are included in the BIHS: Agricultural assets, livestock, transport equipment, informative equipment, financial assets, electronics equipment, home appliances, furniture and other assets. Different aggregate indices are to be used in the regression models to combine the ownership information on these different assets. The asset index, which is composed of a variable generated, using principal component analysis is henceforth referred to as the PCA asset index (Filmer and Pritchett, 2001). The financial situation of a household has been substituted by an asset index. Principal Component Analysis (PCA) compresses these asset variables by using a linear mixture of the asset-related variables to construct an index (Sahn and Stifel, 2003). Using five variables, (agricultural assets, livestock, transport equipment, informative equipment, electronics equipment) a household wealth (asset) index was created with the principal component method (Table 1). Because it assigns the largest weight to assets that differ greatly among households, allowing for the largest feasible disparities between households, they only employ the first PCA component (van der Meulen Rodgers and Kassens, 2018). The explanatory variable, asset indices generally employ the same fundamental transformation:

$$A_i=b_1a_{1i}+b_2a_{2i}+\ldots+b_ka_{ki}$$

Where, the weights that are used to aggregate each indicator into an index are (b_1, b_2,…, b_k), needed to combine indications into an index Ai, principal components are utilized (Filmer and Pritchett, 2001). We set a cutoff point for the quantity of each asset.

The primary outcome measure is the food security status. "A situation in which every individual, at all periods, have financial, social, and physical access to enough food that is safe and nutritious to satisfy their food preferences and dietary requirements for an adequate standard of living" is known as food security (FAO, 2014). Three basic pillars make up this definition: utilization, access, and availability (Ahn and Norwood, 2021). Food security requires availability, access indicates personal capacity, and utilization verifies whether households can effectively employ their access. Food security in a residence is assessed using food calorie availability (Hossain et al., 2019). Direct Calorie Intake (DCI) is a metric for measuring food consumption that considers both the amount of nutrients that people consume and the presence of a large variety of foods in the house. The calorie intake specified in these guidelines is the total of all the different food kinds that a family or a person has ingested throughout the last 24 h to obtain energy. The purpose of everyday food calorie intake is to provide a quick overview of the financial capacity of a home to obtain a range of food nutrients. A common method of calculating calorie intake is to utilise a calorie conversion chart to convert the information about various foods consumed by a household into calories. Research has indicated that a rise in caloric consumption is linked to both household food security and social and economic standing (FAO, 2014; Carletto et al., 2013). The suggested amount of calories per day technique is employed to assess each household's food security. Next, each home's food sufficiency is determined as a result of multiple independent characteristics using a Logit model. A household member who consumed up to 2,122 kcal per day per capita was considered food secure, while those who consumed less than that amount were considered inadequate food accessibility (Ahmed and Garnett, 2011; Dugan et al., 2006).

The following are the mathematical representations:

$$Z_i=Y_i\,/\,R$$

Where,

Z_i is the food security status of each household, where 0 represents a food-insecure resident, and 1 represents a food-secure resident;

Yi represents the daily caloric intake per person for the ith household, whereas R represents the daily caloric intake that is advised.

TABLE 1 The description of the explanatory variables' measurement.

Variable	Description	Measurement
Productive assets		
Agricultural Assets	Assets owned by the household related to agriculture like harrow, rake, plough/yoke, reaper/sickle, tractor, power tiller, thresher, swing basket, tube well, rower pump, jumbo pump, trolley/trailers, fodder cutting machine, bullock cart, push cart, machinery, pesticide sprayer and shallow tube well (STW), deep tube well (DTW), spraying machines, diesel motor pumps, electric motor pump, and reaper.	Number
Livestock	Animals raised on the farm like—cows, goats/sheep, ducks/hens.	Number
Transport equipment	Vehicles owned by the household like—bicycles, rickshaws, vans (tricycle vans), boats, engine boats, and motorcycles.	Number
Informative Equipment	Equipment used for gathering information like—radio, an audio cassette/CD player, television (B/W), television (color), mobile phone set, computer/laptop, flash drive/memory card, printer, tab, camera/video camera weather stations, soil testers.	Number
Electronic Equipment	Electronics equipment owned by households like—solar energy panels, electricity generators, IPS etc.	Number
Non-productive assets		
Home Appliances	Household appliances used for daily tasks like—buckets/pots, stove/gas burner, metal cooking pots, hukka, electric fan, electric iron, wall clock/watch, sewing machine, and a wristwatch.	Number
Furniture	Household furniture items like—trunk/suitcase, chowki, cabinet/alna, table, and chair.	Number
Annual Income	The entire household income from all sources is aggregated for the preceding year.	Taka
Market Distance	The gap between the home and the closest market	Kilometres
Farm Size	The amount of land that the family owns.	Decimals
Age of HH head	The family leader's age	Years
Sex of HH head	The family leader's gender (male, female).	Dummy 1 for male; 0 otherwise
Literacy of HH head	Reading and writing knowledge of the head of the family.	Dummy 1 for yes; 0 otherwise
Marital Status of HH head	Marital relationship of the head of the family (married, unmarried).	Dummy 1 for married; 0 otherwise
Occupation of HH head	Family's head is engaged in agricultural activities specifically related to crop farming, as a sharecropper or tenant, on a homestead, as a fisherman (using a non-owned or non-leased water body), as a fish pond raiser, as a poultry raiser, as a cattle raiser, as a dairy producer or farmer, or as another type of self-employed worker.	Dummy 1 for yes; 0 otherwise
Household Size	The house's dimensions are contingent upon the aggregate number of members comprising the family.	Number
Share of Children	The proportion of kids (aged below 18) about the overall household size.	Number
Share of Working-Age Adults	Percentage of earning-age adults (18–64 years) as members of the total household size.	Number
Share of Elders	Percentage of elderly persons (aged above 64 years) as members of the total household size.	Number

Consumption of food is another way to measure food security. The food consumption status is a calculated score that represents the adequacy of food consumption within a household. This score is typically derived by dividing a household's actual food consumption score by a predetermined maximum or threshold score, reflecting an ideal level of consumption based on nutritional guidelines. The food consumption status is calculated by dividing the maximum food consumption score that is allowed. The frequency with which, over 7 days, the household absorbed every category of food leading up to the survey was used to determine the food consumption score. Using 7-day recall data, the FCS aggregated data on eating frequency and variety in diet (World Food Programme, 2008). The frequency of consuming eight different food groups (peanuts, fruits, vegetables, meat and fish, dairy products, sugar, oil, and salt) is multiplied by a given weight to determine the FCS. The resulting values are then added together. The BIHS dataset contained information on how frequently food items from the previous 7 days were spent consuming 10 distinct food categories (cereals, roots and tubers, vegetables, fruits, meat and fish, dairy products, pulses, nuts and seeds, sugar, and oil), in addition to the consumption of these particular food items (Hossain et al., 2019). Food consumption categories were established for Bangladesh as insufficient intake (≤52) and a criterion was set, to differentiate insufficient intake households (≤52) from sufficient intake households (>52) (World Food Programme, 2008).

4 Findings

4.1 Descriptive statistics

To investigate the correlation between the independent and dependent variables, descriptive and inferential analyses are required. A descriptive analysis is carried out before moving on to an econometric analysis to ascertain the type and structure of the data.

TABLE 2 Descriptive Statistics.

Variables	Mean and standard deviation			Mean diff. (2015 vs. 2018)
	Pooled	Round 1 (2015)	Round 2 (2018)	
Outcome variables				
Food security status	0.627 (0.483)	0.613 (0.487)	0.641 (0.479)	0.028*** (0.009)
Food consumption status	0.909 (0.286)	0.889 (0.313)	0.929 (0.255)	0.040** (0.005)
Explanatory variables				
Productive assets				
Agricultural assets	3.387 (0.039)	3.362 (0.059)	3.412 (0.052)	0.049*** (0.079)
Livestock	1.302 (0.009)	1.284 (0.013)	1.320 (0.013)	0.035*** (0.019)
Transport equipment	0.472 (0.006)	0.461 (0.008)	0.482 (0.008)	0.020*** 0.012
Informative equipment	1.760 (0.009)	1.755 (0.013)	1.765 (0.013)	0.010** (0.018)
Electronics equipment	0.157 (0.003)	0.161 (0.005)	0.152 (0.005)	−0.008* (0.007)
Non-productive assets				
Home appliances	3.373 (0.018)	3.367 (0.018)	3.377 (0.019)	0.010 (0.026)
Furniture	3.352 (0.008)	3.347 (0.012)	3.358 (0.011)	0.011 (0.016)
Annual income	114967.1 (121719.7)	98273.5 (110001)	131660.6 (130294.6)	33387.14*** (2433.511)
Farm size	80.214 (103.881)	79.635 (117.049)	80.793 (88.790)	1.157* (2.096)
Market distance	1.808 (2.494)	1.895 (1.793)	1.722 (3.035)	−0.173* (0.050)
Age of HH head	46.283 (13.433)	45.348 (13.592)	47.218 (13.208)	1.870*** (0.270)
Sex of the HH head (dummy)	0.797 (0.401)	0.806 (0.394)	0.787 (0.408)	−0.019 (0.008)
HH head literacy (dummy)	6.588 (3.720)	6.483 (3.591)	6.693 (3.841)	0.210** (0.017)
Marital status of HH head (dummy)	0.891 (0.310)	0.899 (0.300)	0.883 (0.320)	−0.015** (0.006)
Occupation of HH head (dummy)	0.355 (0.478)	0.372 (0.483)	0.339 (0.473)	−0.033*** (0.009)
Household size	5.192 (2.084)	4.893 (1.940)	5.490 (2.179)	0.596*** (0.041)
Share of children	32.390 (20.433)	34.513 (20.805)	30.267 (19.830)	−4.246** (0.410)
Share of earning-age adults	84.171 (26.188)	82.119 (27.413)	86.222 (24.737)	4.102** (0.526)
Share of elder member	20.908 (22.960)	16.358 (21.349)	25.459 (23.607)	9.101** (0.454)
Number of observations (HH group)	9,720	4,860	4,860	-

Source: The author analyzed the BIHS panel survey from 2015 and 2018. The standard deviation is displayed with mean values in parentheses.

Daily per capita calorie availability has the potential to be regarded as a marker of the situation of food availability and security in the family.

Table 2 shows a noticeable increase in the household's food security state from the first to the second round. The food consumption situation is higher between 2015 and 2018. The significant shift in food consumption patterns between 2015 and 2018 guarantees that family food security has improved at an increasing rate. This highlights effective interventions or socioeconomic advancements that had a positive effect on households with lower food security.

The results also show how the explanatory factors have changed over time. Almost all productive resources found overall positive and significant change across the 4 years. The most abundant resource owned by the families is agricultural equipment. Other particular assets such as livestock, transport and informative equipment were positively and significantly raised. Non-productive assets like home appliances and furniture were found insignificant. Changes that happen in the annual income of households are positively significant. Farm size increased significantly, but market distance decreased significantly. The age, educational attainment, household size, and working-age adults experience substantial growth over time. These changes support the asset ownership of households.

When considering the advisable daily consumption of 2,122 kcal of calories, 61.32% of the houses in the first round are food secure (Table 3). The households which are food-secured consume an average of 2797.54 kcal, which is 24.15% more than the national standard calorie consumption. However, the average calorie consumption of households experiencing food insecurity is 1715.89 kcal, which is 23.66% less than the average consumption of calories in the country. In round 2, only 35.85% of households cannot consume the suggested intake of 2,122 kcal per day per person in calories. In contrast to houses that had food security, around 35.8% of the households experienced food insecurity (Yehuala et al., 2018). Roughly 64.15% of families are food secure and capable of meeting this daily requirement between the first and second rounds.

While food security was generally maintained across most households, the dynamics of food security, as indicated by these percentiles, suggest that improvements between 2015 and 2018 likely benefited individuals who were previously in more vulnerable

circumstances. Thus, the outcome showed that, compared to the prior year, dietary choices, and eating habits were improving in most households.

For all households, the average daily calorie availability increased slightly from 2,378.98 kcal in 2015 to 2,432.04 kcal in 2018. This slight increase suggests an overall improvement in the population's food availability. However, the statistics also reveal a notable discrepancy: while households with food security have access to a significantly greater number of calories, those without food security continue to consume far fewer. Despite the overall increase in the average, a significant portion of the remains at risk of inadequate nutrition, as evidenced by this disparity, which drags down the average. The data indicates that, although overall food security has improved, the persistent gap between food-secure and food-in-secure households highlights the need for targeted interventions to address the nutritional needs of vulnerable populations.

4.2 Relationship between asset ownership and food security

This study looked into how asset ownership benefited agricultural households' food security, using panel data and binary logistic regression techniques.

Table 4 demonstrates the positive and substantial association between the asset index and food security. Here, the explanatory variable is the asset index which influences food security. Based on a series of specification assessments, owning assets affects food security through a household's capacity to generate revenue. Households having assets enhance financial security, and all members of the home experience improved nutritional conditions. The information shows a strong correlation between the asset index and the state of food stability. More specifically, a unit increase in the asset index results in a 0.361 unit increase in the food security status.

This study has assessed the enduring impact of alternative food security measures, specifically household-level food consumption status. The analysis of this study was conducted using a fixed effects model. The Likelihood Ratio and Hausman test results are 0.334 at a significant level of 1%, indicating the basis for the fixed effects statement.

The key finding is that, even with these different parameters, a household's likelihood of improving food security with asset ownership is higher.

To lessen the problem of omitted variable bias, we conduct a new study by re-estimating the models using regression techniques even after accounting for all of the proximate factors (environmental factors, home composition, and socioeconomic status) that influence the health of family members. Our findings can be better understood by comparing parameter estimations in terms of sign and significance. Table 5 displays the re-estimated regression findings that have identified certain socioeconomic and demographic variables as statistically significant. Observing the predicted coefficients for a few explanatory variables, we can observe variations in their sizes and signs. A positive sign in a coefficient denotes an association between the related parameter and increased food security in the data presented in Table 5, whereas a negative sign suggests increased food insecurity.

The coefficient for agricultural assets is 0.278, which is both positive as well as statistically significant at the 1% level indicating ownership of agricultural machinery and tools facilitates the cultivation process, leading to higher agricultural productivity. The regression coefficient for livestock ownership is significant at the 5% level, suggesting that food security outcome increases by 0.116 units if the families have livestock ownership. Regarding the coefficient of vehicle ownership, access to transportation enables the smooth movement of food from producers to consumers, reducing the risk of spoilage and ensuring that perishable goods reach markets in optimal condition by 0.126 units.

The coefficient for informative equipment is positive and significant implying that, mobile, television can help farmers, including women, by providing them with the information needed to make decisions that improve their livelihoods and well-being by 0.151 units. Results show that electronic equipment decreases food security by 0.194 units if IPSs and generators are used in areas where they are unreliable or inefficient, they may fail to provide consistent power for essential agricultural operations, such as irrigation or food preservation. The resulting power unreliability could lead to crop losses, and spoilage of perishable foods, negatively impacting food security. The coefficients for home appliances and furniture are 0.109 and 0.070 and both are statistically insignificant. These non-productive

TABLE 3 Food security status for two rounds of panel data.

	Food Security Status	Food-Secure Households	Food-Insecure Households	All Households
Round 1 (2015)	Percentage of households (%)	61.32	38.68	100
	Average per capita daily calorie availability	2797.54	1715.89	2378.983
	25th Percentiles	2375.129	1520.521	1878.879
	50th Percentiles	2667.014	1764.486	2309.229
	75th Percentiles	3080.557	1957.564	2794.021
	100th Percentiles	5803.743	2121.771	5803.743
Round 2 (2018)	Percentage of households (%)	64.15	35.85	100
	Average per capita daily calorie availability	2837.92	1705.89	2432.038
	25th Percentiles	2405.257	1523.257	1925.514
	50th Percentiles	2713.143	1768.671	2374.143
	75th Percentiles	3147.171	1957.571	2877.657
	100th Percentiles	6098.857	2121.486	6098.857

TABLE 4 Regression findings of pooled, random, fixed-effects binary logistic regression between productive asset and food security status.

Variables	Food Security Status	
	Pooled	Fixed effects
Asset Index	0.235***(0.078)	0.361***(0.164)
Constant	0.552***(0.083)	-
Log-likelihood	−6279.032	−1113.815
Hausman test	-	0.334
Observations	Wald chi^2 = 5.83*** 9,720	LR chi^2 = 5.16*** 9,720

Source: BIHS 2015 and 2018. The standard errors are displayed in parentheses. The symbols ***, **, and * are enclosed in parenthesis to denote, respectively, statistical significance thresholds of $p < 0.01$, $p < 0.05$, and $p < 0.1$.

TABLE 5 Effect of asset ownership on household security of food (fixed-effect model).

Variables	Food Security Status	Food Consumption Status
Agricultural assets	0.278*** (0.161)	0.273** (0.156)
Livestock	0.116** (0.082)	0.130** (0.142)
Transport equipment	0.126* (0.022)	0.171* (0.157)
Informative equipment	0.151* (0.154)	0.094* (0.033)
Electronics equipment	−0.194* (0.153)	−0.172 (0.157)
Home appliances	0.109 (0.062)	0.098 (0.052)
Furniture	0.070 (0.010)	0.064 (0.010)
Annual income	0.059* (0.034)	0.063* (0.033)
Farm size	0.008*** (0.001)	0.007*** (0.001)
Market distance	−0.097*** (0.013)	−0.093*** (0.013)
HH head age	0.004 (0.008)	0.007 (0.008)
HH head sex (dummy)	−0.105 (0.210)	−0.116 (0.208)
HH head literacy (dummy)	0.491** (0.251)	0.586** (0.250)
HH head's marital status (dummy)	0.626** (0.244)	0.588** (0.241)
HH head's occupation (dummy)	0.168 (0.134)	0.143 (0.133)
Household size	0.324*** (0.041)	0.307*** (0.040)
Share of children	0.006* (0.004)	0.006 (0.004)
Share of earning-age adults	0.004* (0.002)	0.004** (0.002)
Share of an elder member Log likelihood	0.002	0.002
	(0.006)	(0.003)
	−1090.311	−940.213
	LR chi^2 = 83.20***	LR chi^2 = 54.95***
Observations	9,720	9,720

Source: BIHS 2015 and 2018. The robust standard errors are displayed in the parenthesis. The symbols ***, **, and * indicate $p < 0.01$, $p < 0.05$, and $p < 0.1$.

assets found a negligible and non-significant impact on food security measures as these assets serve no direct role in production.

It becomes apparent that having a high annual income raises the capacity of having adequate food security by 0.059 units since food security is significantly improved by annual income. Farm size also positively impacts food security by 0.008 units at the 1% level of significance. In contrast, market distance negatively impacts food security by 0.097 units, implying that more market distances possess opposite impacts on the food security condition. The coefficients for literacy, family size, and marital status are highly significant. The values are 0.491, 0.324, and 0.626, respectively. Based on the research, educational attainment significantly enhances the degree of food sufficiency and the size of its family has a positive relationship and contributes to the availability of more labor for production. In contrast, results exhibit no significant impact between the degree of food sufficiency and how old the head of a family. HH head sex have a negative effect on the number of meals by 0.105 units.

Here, the occupation of household heads with on-farm activities experiences food insecurity by 0.168 units. The quantity of senior individuals in a home increases, and the amount of food availability decreases by 0.002 units. But regarding the coefficient of working-age adults, the proportion of youngsters and working-age individuals among other factors exerts a beneficial and statistically substantial impact on the food sufficiency condition of families by 0.004 unit. This indicates that adults of working age are more susceptible to work on their farm and it raises the possibility that their families will eat adequate food.

Figure 1 illustrates the relative importance of variables affecting food security, ranked by their regression coefficients. Agricultural assets and household size have the most influence on food security. Other positive coefficients, such as livestock, information and transport equipment, significantly improve food security, while negative coefficients, such as market distance, suggest a detrimental impact.

5 Discussion

Using panel data, this study investigates the connection between asset ownership and food security in Bangladesh. According to the study, food security and food consumption status are positively correlated with agricultural assets. Studies of Arthur et al. (1988), Foster and Rosenzweig (2004), Awotide et al. (2015), and Djebou et al. (2017) reported similar findings and observed that agricultural equipment such as tractors, harvesters, and irrigation systems can significantly increase food security situation and lead to higher productivity and greater food availability. However Adams et al. (2021) contrasting that farmers often incur high levels of debt to afford this equipment, which can be difficult to repay, increasing food insecurity. Agricultural equipment reduces the time and labor required for tasks such as ploughing, planting, and harvesting, allowing farmers to produce more food. This result aligns with Li et al. (2024) and Smith et al. (2019). They noted that families holding more agricultural assets were better able to withstand economic shocks and maintain stable food consumption levels. These findings suggest that investment in agricultural equipment can have a multiplicative effect on food security by increasing direct production and creating a more resilient agricultural system.

The positive coefficients for livestock highlight the importance of livestock ownership for the family. These results align with those of Rashid et al. (2024), Jodlowski et al. (2016), and Fratkin and Roth (2005). They highlighted that livestock can serve as a form of financial security and the role of livestock in buffering households against economic shocks and seasonal food shortages, thereby contributing to greater food security. However, Souza and Jolliffe (2016) and

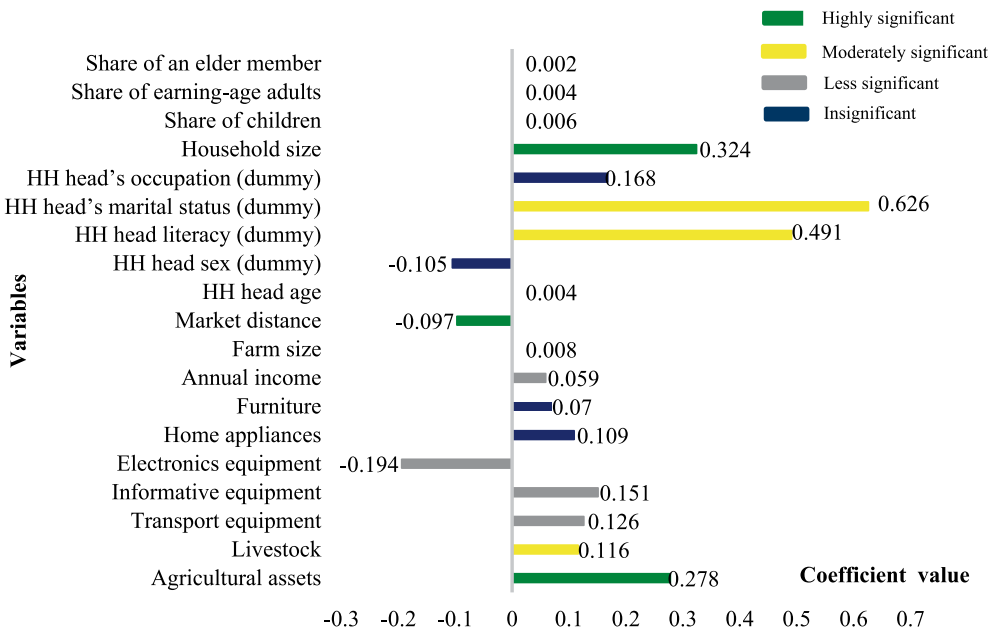

FIGURE 1
Importance of variables contributing to improved food security.

Christian et al. (2019) offer a different perspective, arguing that in certain contexts, particularly where livestock diseases are prevalent or where market access is limited, the advantages of having cattle for ensuring food security may be mitigated. Galiè et al. (2015) and Ali and Khan (2013) supported animal products, including milk, milk derivatives, meat, and eggs, account for 7–16 percent of household energy use, and milk is a daily requirement in rural households. These findings encourage vulnerable populations to raise more livestock to maintain food security.

Owning a vehicle correlates with better food security. Results align with Guo (2011) and Ukonze et al. (2020). They highlighted that by owning vehicles, farmers can access distant markets that would otherwise be inaccessible. Transport equipment extends their market reach. Contrarily, Yenesew (2015) and Morland et al. (2002) found a negative association that the cost of maintaining and operating vehicles can be substantial, potentially diverting resources away from food purchases and other essential needs. Vehicle emissions contribute to air pollution, which can adversely affect public health, particularly in densely populated or low-income areas. Collins and Hayes (2010) supported that having a vehicle enhances a household's ability to respond to emergencies. With a vehicle, families can better manage their time and balance work more efficiently.

Findings from several studies indicate that owning informational equipment enhances food security. Carranza and Niles (2019) and Ramatu (2013) found that radio and TV platforms provide opportunities for advocacy efforts aimed at influencing food and agriculture policies, resource allocation decisions, and development priorities. However, Sekhampu (2013) reported negative relationship that households may not have the resources to act on the information received due to financial constraints or lack of access to necessary inputs. While Beyene et al. (2023), Ray et al. (2015) and Eadey et al. (2018) supported that advanced technological equipment provides accurate and timely weather forecasts, helping farmers plan their activities to avoid adverse weather conditions and reduce crop losses. Informative equipment provides real-time data on market prices, demand, and supply to help farmers and traders which ensures a more steady supply of food at markets.

The regression outcomes demonstrate a negative correlation between electronic equipment on food consumption status. Abdo and Amera (2020), and Silvestri et al. (2015) discovered similar outcomes that the initial investment in solar technology can be significant, and if not managed properly, this could divert resources away from other areas, including food production. Results found the small and non-significant coefficients between furniture and household goods ownership and food security. Ownership of productive assets, such as farm machinery and cattle, had an association with food security more strongly compared to ownership of non-productive assets like furniture and electronics. Frongillo et al. (2017) contradicted the findings that ownership of furniture and household goods may contribute to household resilience by providing comfort and stability, which could indirectly influence food security outcomes.

Higher income allows for greater access to food, and better food quality. These results align with Danso-Abbeam et al. (2024) and Obayelu (2012), suggesting that when the overall economic condition improves, the probability of food security rises. A household's asset base, including savings and financial resources, plays a significant role in food security. Having more assets generally means a greater ability to afford food, especially during times of economic hardship, thus reducing the risk of food insecurity. Assets particularly, financial resources, act as a buffer against potential food shortages or price

fluctuations. To purchase healthful foods and maintain good nutrition, consumers must have regular and sufficient earnings, as stated by FAO et al. (2017). Regression results found a favourable connection between the amount of overall cropland and food security. Nevertheless, disputing the study's findings Awoke et al. (2022) showed that expanding farmland without utilizing new technology does not ensure an improvement in the country's level of food security. However, Welderufael (2014), Echebiri and Onwusiribe (2017), and Altieiri (2009) found a positive relationship that small farms tend to use more sustainable and traditional agricultural practices. This motivates households to own large-scale farms which leads to higher overall production and impacts local food security.

Therefore, increasing market accessibility through shorter travel times or better market infrastructures could promote the nutritional variety. Hayat and Islam (2018) and Dorosh et al. (2012) also agreed that farmers located far from markets have limited access to sell their produce, which can reduce the overall food supply and exacerbate local food insecurity. Rashid et al. (2024) and Sani (2019) is consistent with the outcome that there is a decreased likelihood of food sufficiency in older households due to the possibility of falling effectiveness and productivity. Mota et al. (2019) investigated a significant association between family size and food security. However, Kassa and Eniyew (2018) disagree with this outcome of the negative impact of HH head sex on food security. Kotze (2003) found insignificant associations and reached similar conclusions.

The findings of occupation are similar to Li et al. (2024) and Faridi and Wadood (2016). Adhikari et al. (2019), Quisumbing and Pandolfelli (2010), and Mota et al. (2019) supported that educated individuals are better equipped to diversify their income sources, increasing the capacity of working-age adults and reducing vulnerability to economic shocks that can impact food security. The findings concluded that educational conditions and the influencing capacity of working-age adults are statistically beneficial to food availability conditions.

6 Conclusions and policy

This study provides insightful information about the connection between household ownership of assets and Bangladesh's food security. The results of this examination, using panel data, shed light on the complex dynamics that affect food security, making a substantial contribution to our understanding of the issues that affect disadvantaged households in the region. The investigation has irrefutably demonstrated that the ownership of assets significantly affects food sufficiency in Bangladesh. The ownership of productive assets, such as agricultural equipment, amplifies a member's capacity for the production of food and the generation of revenue, thereby enhancing food security. Policies should facilitate farmers' access to equipment-sharing programs to reduce the financial burden on farmers and mitigate the risks of debt-related food insecurity. Additionally, policies should encourage livestock rearing among vulnerable populations by expanding veterinary services, providing training in disease management, and improving access to livestock markets. Asset ownership notably shapes household income, emphasizing its strong connection to food security. Households possessing a greater array of assets tend to enjoy higher incomes, subsequently enhancing their food security. This underscores the potential for interventions aimed at enhancing asset ownership to trigger a positive ripple effect, both on income and food security. Households that own agricultural land have a greater chance of achieving food security than people who do not own land. In Bangladesh, households with larger landholdings have higher infant intake of calories and increased food availability (Rammohan and Pritchard, 2014; Pritchard et al., 2016; Holland and Rammohan, 2019). Ownership of various assets significantly contributes to heightened household food security. Conversely, an increased distance to the marketplace does not yield positive effects, as it escalates the costs associated with reaching it. Policies should focus on improving farmers' access to markets by developing and maintaining rural roads, which will reduce transportation costs and enable farmers to reach markets more efficiently (Beyene et al., 2023; Hoddinott et al., 2015; Vitale Brovarone and Cotella, 2020). Investing in modern storage facilities will reduce post-harvest losses, and help farmers manage supply more effectively. Providing rural areas with internet access will improve access to agricultural information, and connect farmers directly to markets (Li et al., 2024). Additionally, encouraging crop diversification through input subsidies and education will enhance resilience against market and climate shocks while improving food security (Herman, 2024). Establishing grain reserves will ensure price stability, and reduce food insecurity. Supporting cooperatives and farmer groups will strengthen bargaining power, improve access to finance, and foster collective decision-making among farmers (Kaiser and Barstow, 2022). Monitoring and regulating intermediary activities will help prevent exploitation and ensure a fair pricing mechanism. Promoting agro-processing industries will encourage local employment and allow farmers to capture a greater share of value (Jumabayeva et al., 2023). Together, these measures will contribute to enhancing food security.

Besides, to reduce the disparity between the two groups, policymakers should focus on enhancing access to affordable, nutrient-dense food, addressing the underlying causes of food insecurity—such as poverty, unemployment, and inequality—and potentially expanding food assistance programs (subsidized food, food banks, and direct financial assistance for vulnerable groups).

The research also highlights the increased vulnerability of households that lack access to crucial assets. Precise evaluation of asset ownership, authority, and use is required to identify issues and formulate suggestions to tackle these difficulties in developing nations. Vulnerable households, often characterized by limited asset ownership, face a heightened risk of food insecurity. Disparities in income might negatively impact the well-being of individuals (Ho et al., 2014). Also, relative deprivation might significantly harm people's overall health, according to the relative wealth hypothesis (Pickett and Wilkinson, 2010). Educating the public on nutrition can empower communities to make informed decisions about their food security. Moreover, prioritizing productive asset-building programs, particularly for vulnerable households, is an effective strategy for augmenting food security. Future research endeavors can delve further into the specific types of assets that prove most effective in enhancing food security and examine the long-term implications of asset ownership for households.

7 Study limitations

The food security concept is multifaceted and encompasses variables such as food availability, usability, accessibility, and consistency. While the study focuses on total kilocalorie and food

consumption measures, there are other aspects involved in determining food security. The study may not adequately account for factors such as agricultural policies, and market dynamics that could influence household asset ownership and food security in Bangladesh. Without up-to-date data and sufficient financial support, it is challenging to reach all vulnerable households and provide the level of assistance necessary for sustainably improving their long-term food security. Funding limitations often restrict programs` ability to offer adequate asset-building opportunities to these households. To fully comprehend the situation across the entire country, future studies should strive to include all pertinent measures related to food security.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://bangladesh.ifpri.info/bangladesh-integrated-household-survey/.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

ZS: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft. MA: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Visualization, Writing – review & editing. IB: Conceptualization, Investigation, Methodology, Validation, Visualization, Writing – review & editing. MI: Conceptualization, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – review & editing. DS: Conceptualization, Methodology, Visualization, Writing – review & editing. AM: Funding acquisition, Validation, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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