

Original Paper

Assessing the Determinants of Food Security Status in Bangladesh: A Micro-Econometric Analysis

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Abstract

Food security is an intricate issue which includes diverse aspects as well as many linkages. In Bangladesh, food security is tried to be achieved by increasing the production of rice both by employing modern agricultural technology as well as by increasing the area under rice production. Despite the impressive gains in increasing domestic food grain production, problems of food and nutrition security still remain. Bangladesh is yet to achieve comprehensive food security that resolves the problems of inadequate food intake and chronic malnutrition among those who are poor and vulnerable. The main objective of this paper is to the contribution of different factors behind household food security status of 180 households in three Northern districts of Bangladesh. The study area was chosen because relatively little energy consumption data are available concerning this geographical area. The study used both primary and secondary data. Food security status of each household was assessed on the basis of the food security line using the daily calorie intake recommended by FAO. This method has proven to be efficient in measuring food security at household level. Additionally, the use of a logistic regression model identified the factors that plays crucial role in determining the food security status of the households. Results from the food security index revealed that more than 60 percent of households were with food insecurity. In addition, we found that total monthly household income, age of household head, education level of household head, household size, farm size, gender of household head, livestock ownership and quantity of cereal production had significant influence on food security status at the household level.

Keywords

food security, food security index, dichotomous models

1. Introduction

Food security exists when all people, at all times, have access to sufficient, safe and nutritious food to maintain healthy and productive lives (FAO 2002). There are three major components of food security such as food availability, food access and food utilization. The concepts of these of food security's components are availability of food from domestic production and imports, access of the people to food all times at their available income or financial resources, and that the food ensures enough safety and nutrition to maintain good health (Omonona & Agoi, 2007; Kuwornu et al., 2013). Recently nutrition, food safety and quality have attained considerable importance in food security issue. Because food intake related problems are not only hunger and malnutrition, but underweight, obesity also. However, safety food is a part of food utilization, impacted by the preparation, processing and cooking of food in the community and household (Nath, 2015). A household is food secured if it has enough food, distributed by dietary needs and ages, and ensured to nutritional needs of all members of the household. Bangladesh is an agriculture dependent country in South Asia with a total population of around 163.7 millions (BBS 2018). The major source of livelihood of the people in Bangladesh is agriculture. However, rapid population growth, increased food demand, natural disasters and urbanization are the main reasons which have created tremendous pressure on agricultural land, making it an increasingly scarce resource. As a result agricultural land per capita has been decreasing over the years in the country. Food security, therefore, remained as an important concern in Bangladesh and nearly 22 percent of the population, in fact, still cannot afford an adequate diet (BBS 2018).

An adequate food intake, in terms of quantity and quality, is essential for healthy and productive life. Although enough food is available in the world, a huge population, about 822 million people are affected by hunger in the world and 11.3 percent of it live in the Asian countries, and the trend is not falling quickly enough to achieve the goal of food security (FAO 2019). Ensuring the availability of food requires enough production or import of food in terms of calories available per day for every person in the population. The Nobel laureate economist Amartya Sen pointed out in his analysis of famines that it occurs not because of unavailability of food, but due to non-accessibility to the food (Sen, 1981). In the last several years, the overall condition of the Bangladesh economy keeps getting better and the economy begins to find some stability. For example, Bangladesh is one of the fastest growing economy in the world with a rate of 7.9 percent real GDP growth and per capita income US\$ 1909 (BBS 2018). More importantly, the incidence of absolute poverty decreased from 31.5 percent in 2010 to 24.3 percent in 2016 (HIES 2016). However, food security still remained as an issue to the people of Bangladeshi because, in spite of important economic progresses achieved, the country remains highly food-insecure. In fact, Bangladesh is ranked 88th out of 117 countries in the 2018 Global Hunger Index (GHI 2019).

The core food items in Bangladesh are rice, pulse, edible oil, wheat (coarse flour and flour), powered milk, salt, sugar, potato, chick pea/gram, fish and fish products, livestock and livestock products, onion, garlic, ginger, etc. (Muzaffar & Haszn, 2009). In Bangladesh, food security is tried to be achieved by

increasing the production of rice both by employing modern agricultural technology as well as by increasing the area under rice production. Despite the impressive gains in increasing domestic food grain production, problems of food and nutrition security still remain. Bangladesh is yet to achieve comprehensive food security that resolves the problems of inadequate food intake and chronic malnutrition among those who are poor and vulnerable. Addressing these problems satisfactorily would not only require rethinking of strategies and policies to promote food security in the country but also require decisive actions by all stakeholders—the government, the NGOs, the private sector and individual households. In fact, ensuring food security through physical availability and economic access to food would continue to be a major challenge for Bangladesh in the coming years. Food security has been emphasized on the policy agenda of the government of Bangladesh and the government has been making efforts to augment domestic production of food grain through technological innovations and investments in irrigation, infrastructure development and subsidies. Food security is an intricate issue which includes diverse aspects as well as many linkages. Thus, the objective of this study is to assess the contribution of different factors behind food security status of Northern Bangladesh.

The rest of the paper is organized as follows. Section 2 briefly reviews the most recent published articles that discuss the concept of food security in Bangladesh and in other countries in the world. Section 3 provides the methodology used in the empirical analysis of the study including data collection, research method, and micro-econometric model. Section 4 presents the results with required discussions and Section 5 concludes the study.

2. Recent Studies of Food Security

First, we present a brief review of those studies that examined factors that affected food security in Bangladesh. Second, we discuss the issue in other developing countries, such as Ethiopia, Nigeria, Ghana, Mozambique, and Pakistan.

2.1 Evidence from Bangladesh

Food security in Bangladesh is one of the important issues that have been analyzed comprehensively by different studies. For example, Chen and Lu (2018) studied key influencing factors of the food security situation in the country using the Food Security Index (FSI) and measured the food security level during 1990-2013. They found that although the grain production increased significantly, the food demand was in shortage by around 10 percent in most years prior to 2008. Because, the grain production increase was mainly driven by the improvement of crop yield, while the grain consumption increase stemmed from increasing in the rate of population growth. Chen and Lu (2018) suggested that it was essential to improve the irrigation and drainage systems, and crop management to increase the land use efficiency and crop yield to meet the ongoing increase in the demand for food. In addition, the adaptation of appropriate policy for family planning could be very important to slow down the rapid change in the rate of population growth and, in turn, the demand for food. Ara and Ostendorf (2017)

analyzed that the regional variation of food security in terms of food availability, food access, and food utilization under natural and socio-economic circumstances people became vulnerable to low food security in Bangladesh. They suggested that development of food policies would contribute to improved food security by considering regional food security conditions, region-specific deficits, climate change, other future risks, and devised actions related to the respective components.

In another study, Hossain et al. (2013) investigated the link between internal migration and food security in Bangladesh. The results of their study showed that the number of migrants at household level had significantly positive impact on the per capita calorie intake which was found to be increased by 2.2 percent for one unit increase in number of migrants. The researchers concluded that food security outcome was highly appreciable both at the origin and destination of migration. Anik et al. (2013) analyzed the impact of farm level corruption on households' food security using survey data collected from 210 Bangladeshi rice farmers. The researchers specified a regression model by using a multi-stage sampling technique and found that an average daily calorie intake for the sample households was 2,693 kilocalorie per person, whereas the national daily average for 2005 was 2,238 kilocalorie per person. The results showed that the cost of corruption adversely affected households' calorie consumption as the marginal effect of corruption was higher for the low expenditure households relative to the high expenditure households. Furthermore, variables such as the women education level and land ownership positively contributed to solving the problem of food security in the country.

Rahman and Islam (2012) explored the nutritional status and food security of farm households under different land use patterns. The study revealed that households of alternate shrimp and rice farming consumed the highest amounts of food followed by year round shrimp farming whereas the highest per capita calorie intake was observed in households of alternate rice and wheat production. Large households consumed the highest amount of food and protein followed by medium, small and marginal households, respectively. Ahmed and Garnett (2011) examined the challenges of food security and found that rice monoculture could not provide a sustainable food supply without harming the environment in the long run. The authors suggested that higher yields might be achieved by increasing inputs in the integrated farming system. Using a Cobb-Douglas production function, the researchers suggested that higher yields might be achieved by increasing inputs in the integrated farming system. Ahmed and Garnett (2011) concluded that rice and fish production should be increased to meet the demand for food in the country. Kashem and Faroque (2011) focused on the availability of food as an essential element of food security and the role of government to get food sufficiency. The researchers found that Bangladesh attained self-sufficiency in food production which marginally met the country's per capita on a daily basis in 2010-2011. Kashem and Faroque (2011) concluded that the government was trying to integrate all the elements associated with food security to achieve the target of the Millennium Development Goals (MDG) set for Bangladesh by the United Nations Millennium Summit in 2000.

Kazal et al. (2010) analyzed the determinants of food insecurity and formulated the strategies to overcome the food insecurity problem in the Haor basin using both multiple binary and logistic regression models. The result showed that the decrease in landholdings increase the risk of food insecurity significantly irrespective of scale and the household level of education. Furthermore, the researchers concluded that an increase in the level of household income reduced the risk of food insecurity significantly for all the scales. Faridi and Wadood (2010) investigated factors that affected households' food security using a logistic regression model. The result of the study indicated that (i) food security indicator was highly sensitive to changes in the price of rice, and (ii) wage earners (permanent and temporary employees) were worse off in terms of food security status compared to self-employed in all economic sectors. Islam et al. (2009) analyzed that farmers changed their land use crop patterns and introduced new products along with rice in different areas of Bangladesh which increased households' income and helped them chose appropriate food items that increased nutritional status of households. Khanam et al. (2009) observed that mushroom cultivation was a potential source of food security for small households in the country. The result of their study showed that mushroom cultivation was profitable and increased farmers' annual income. Chowdhury (2009) investigated physical and economic access to food by exploring the link between landlessness and access to food in rural Bangladesh and found that landlessness of the farmers led to their insufficient purchasing power to buy adequate nutritious food for their families.

2.2 Evidence Outside Bangladesh

There are some studies which examined the determinants of household food security using different quantitative techniques. For instance, Osabohien et al. (2018) explained that the efficiency of credit facility positively contributes to agricultural sector of the agro-based economy in Nigeria by the Autoregressive Distribution Lag (ARDL) econometric approach on the time series data. The results of the study showed that commercial banks' credits and agricultural credit guaranteed scheme fund (ACFSF) increased food security by 8.12 and 0.002 percent, respectively, while the rate of population reduced food security by 0.001 percent. They recommended that population growth rate should be controlled through family planning and adequate financing of the ACFSF by the government and monitor commercial banks lending interest rates on credit facilities. Fawole and Ozkan (2016) investigated the food security status at the household level in Nigeria using daily per capita calorie consumption method. The researchers found that 54 percent of the households surveyed were food insecure implying that their daily per capita calorie intake fell below the recommended daily per capita calorie requirement and food insecurity gap of 0.0038. The main limitation to this study was the inability to collect data on the income distribution, budget share on foods and socio-economic characteristics of the households which could affect households' food security status. Endalew et al. (2015) examined the factors that affected food insecurity in Ethiopia. The authors found that poverty was not the only reason that caused food insecurity, but also population pressure, drought, shortage of farmland, poor soil fertility, and poor farming technologies had significant impacts on the food security

situation in the country (see also Mohamed 2017). Iorlamen et al. (2014) found that household size and income, and the prices of food commodities were major factors influencing urban household food demand decisions in Nigeria. Kuwornu et al. (2013) examined the food security status of farming households in the forest belt of the Central Region of Ghana. The study applied a multistage random sampling method to obtain a sample of 134 farm households. The result of the research showed that 60 percent of farmers were food insecure. In addition, the researchers concluded that an increase in household's income, having access to credit as well as an increase in the quantity of own farm production might have the probability of improving the food security status of farming households. Ahungwa et al. (2013) analyzed the food security status of farming households in Benue State of Nigeria. The researchers assessed the socio-economic characteristics of the households using descriptive statistics and measured the household food security status using the "food security index" set by the FAO benchmark of 2,500 kilocalorie per capita per day. The result of the research showed that households were profiled into food secure (36.7 percent) and food insecure (63.3 percent). Ahungwa et al. (2013) recommended that the government and all stakeholders should take advantage of existing structure such as the Fadama Development Project to improve their food security status. In another study, Iorlamen et al. (2013) examined factors (i.e., socio-economic variables) that affected the food security status of urban households in Nigeria. The result of the research showed that 67.3 percent of urban households were food secure in Benue state of Nigeria. In particular, the researchers concluded that factors such as mean age, education, household income, food expenditure, and quantity of food consumed by households were amongst other factors that had a positive impact on the food security of urban households. These results have already expressed by other researchers (e.g., Omonona & Agoi, 2007). McDermott et al. (2013) assessed the contribution of agriculture to households' nutritional security in the context of developed economy. The researchers found that agriculture improved households' nutritional and suggested producing diversified crops, highly nutritious crops, bio-fortified foods etc. to improve nutrition of people.

Adeniyi and Ojo (2013) investigated the food security status of rural farming households in selected Local Government Areas (LGA's) of Osun State in the South-west Geo-political zone of Nigeria. They estimated the extent and magnitude of food insecurity in the aforementioned region and determined factors that affected households' food security. The result of the research showed that majority of the rural farming households were food insecure as most of them subsisted below the food security line which was 2,280 Kilocalorie. Moreover, food secure households had a small family size, earned a high monthly income and used modern farm inputs.

Sultana and Kiani (2011) examined the determinants of urban households' food security in Pakistan using a logistic regression model. The study used five main variables in addition to some other demographic indicators that might affect food security which were place of residence, dependency ratio, social capital, employment status and household's level of education. Sultana and Kiani (2011) concluded that three factors were statistically significant with expected signs which were place of

residence (urban), dependency ratio and households' level of education. Babatunde et al. (2010) investigated the nature of the relationship between income and calorie intake among farming households in rural area of Nigeria using both parametric and nonparametric techniques. The result of the research showed that the average daily per capita calorie intake in the region was 2,428 kilocalories, which was below the recommended intake level. Moreover, the findings of the study showed a positive relationship between calorie intake with income and farm size. Babatunde et al. (2010) suggested that a combination of policy strategies, including income growth, agricultural development and targeted food programs might be reduced the problems of inadequate calorie consumption among poor households. Finally, Khan and Gill (2009) examined the determinants of three aspects of food security, i.e., food availability, accessibility, and absorption in rural areas of Pakistan using district level data. The study found that the production of wheat, rice, maize, pulses, oilseeds, poultry meat and fish at the district level had a positive effect on the availability of food. The researchers concluded that all the district except of Sindh were more probable to be food insecure in availability. In addition, electrification and adult literacy emerged as the factors having negative impact in the food accessibility. Besides, child immunization, safe drinking water, and number of hospitals had positive effects on food absorption.

In summary, most of the above articles focused on different issues of food security with diversified findings worldwide. Some studies found that total annual income, household size and level of educational, and quantity of food obtained from own production were the significant factors of food security in different countries. Most of the studies carried out in Bangladesh have analyzed the food security situation at the national level and not at the household level using production, import, and aid based data of food grains. In addition, the literature showed a few studies in the context of food security in the country for which strong quantitative tools were used in their empirical analysis. Moreover, precedent studies did not cover all part of the country, such as north western Bangladesh as it contains distinct geophysical and socioeconomic characteristics. Our study contributes substantially to the literature on the following grounds. First, we used quantitative tools in the empirical section of the paper. Second, the geographical area of our study is north western Bangladesh. Finally, our study is at the household level since the data collected at the national level were unable to identify differences in food security amongst the households as it is the case and data specific.

3. Methodology

3.1 Study Area

The study is undertaken in the north western part of Bangladesh which is covered 43 percent area of Rajshahi Division known as Rajshahi, Natore and Naogaon districts. Geographically, this part of the country has been identified as the most important area for food production because of the availability of cultivable land. Nearly 40 percent of total population of Rajshahi Division lives in this area (see Figure 1).

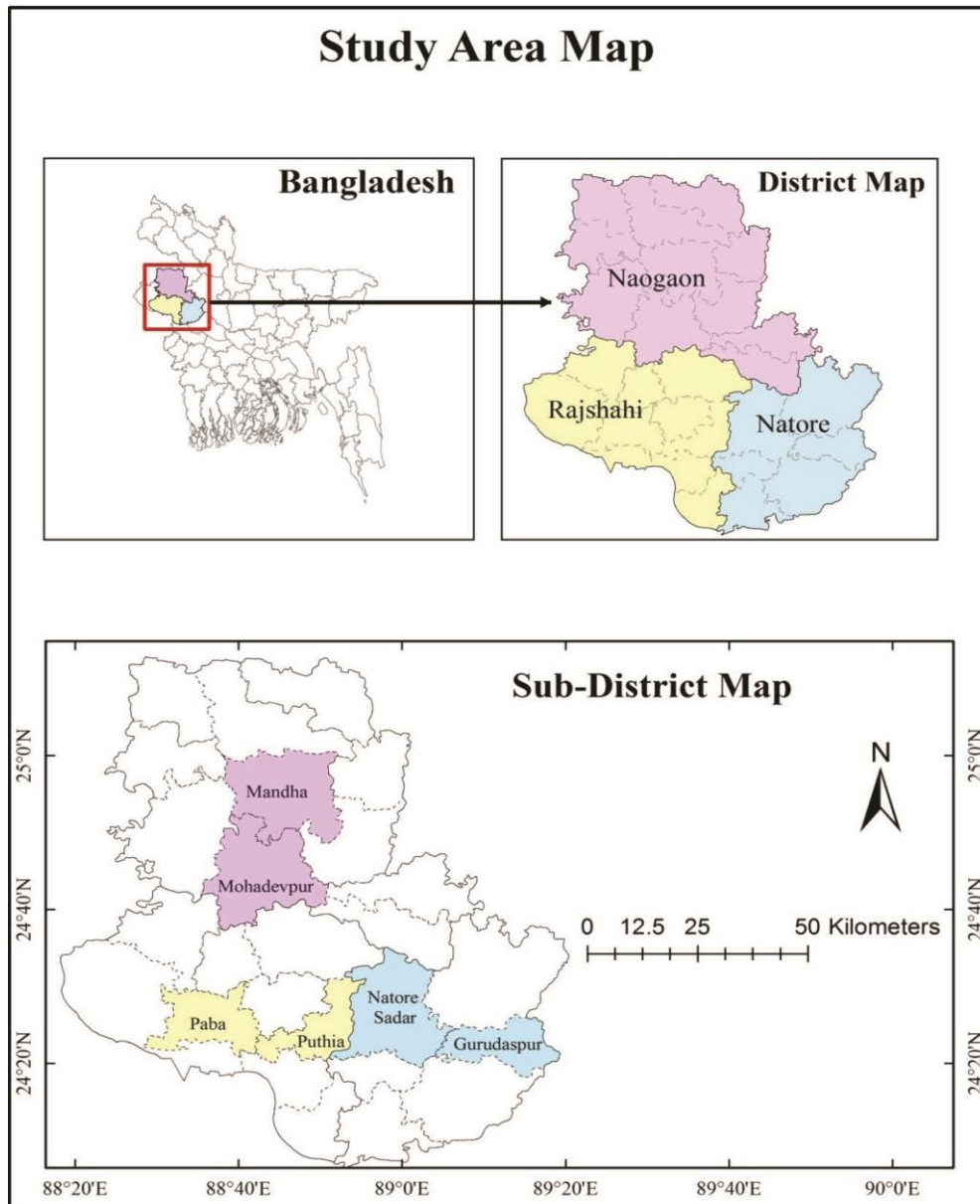


Figure 1. Study Area Map

Source: Adopted from <https://en.wikipedia.org>

3.2 Data Sources

We used a multistage sampling technique to select the households and interviewed them. The first stage involved the selection of districts from which the participants in the survey were selected for interview. This was done using purposive sampling techniques where the districts were grouped into northern part of Bangladesh. The second stage involved selection of sub-districts, unions and villages using the simple random sampling method. This was achieved with the help of district's recorded information. The second stage involved a random selection of two sub-districts from each of the three selected districts and two unions from each of the six selected sub-districts, and one village was selected for the

selected unions. The final stage was the selection of the households that were interviewed. We selected households using simple random sampling and collected primary data regarding their socio-economic characteristics, food production, food consumption, and other factors. The population for the study comprised both farm-and-non-farm households of northern part of the three districts of Bangladesh. In the last stage, 180 households were selected from the earlier 12 villages sampled for the study, i.e., 15 household per village.

3.3 Research Methods

This research mainly relies upon primary data collected from sample households of the northern part of Bangladesh. With a view to fulfilling the research objectives with regards to determining the food security status, identifying the factors having influence on food security and drawing a comparison among the different households belonging to different living standards and different socioeconomic characteristics, the sample was selected in such a way that it covered all the aforementioned criteria. To identify the factors influencing food security status of the households, we carried out a two-stage analysis method which was as follows. First, we constructed a Food Security Index (FSI), and second we specified a logistic regression model to estimate the food security status of households as a function of a set of independent variables.

3.3.1 Food Security and Head Count Indexes

This study analyzed the food security of rural households by employing a quantitative approach. To do this some statistical techniques, such as adult equivalent unit, Food Security Index (FSI), and head count index were applied. A couple of methods have intensively been used in the literature which were the expenditure and calorie intake methods (Maxwell, 1996). In this study we chose the calorie intake method, through constructing a FSI, as this method reflects the actual food consumption pattern of households (e.g., Adeniyi & Ojo, 2013; Ahungwa et al., 2013; Babatunde et al., 2010; Iorlamen et al., 2013, 2014; and Kuwornu et al., 2013). Food security status of each household is a measure based on the food security line using the daily calorie intake recommended by FAO (2005). The average daily calorie requirement for a moderately active adult is 2,850 kilocalorie and a safe minimum daily intake should not fall below 80 percent of the above calorie requirement (i.e., 2,280 kilocalorie). This food security line is used in this study after converting all household members into adult equivalent units (e.g., May 1996, Swindale & Ohri-vichaspati, 2005).

For construction of the index, first, we took the quantity of food consumed by the households in 7 days period and then estimated the obtained calorie intake. We converted the quantities to gram and estimated the calorie content by using the nutrient composition table of commonly eaten foods in Bangladesh (GoB 2005; BIDS 1997). A household whose daily per capita calorie intake was at least 2,280 kcal was regarded as food secure household, while any number beyond that was regarded as food insecure household. We also calculated the head count index on the basis of the food security status of households (FAO, 2005; Fakiyesi, 2001; Olayemi, 1998).

3.3.2 A Micro-Econometric Model

In addition to measuring the food security status of participants in the survey, we used a logistic regression model to identify the factors that determined their food security condition. To do this, precedent studies have used various models, such as the Cobb-Douglas production function model (e.g., Ahmed & Garnett, 2011), multiple regression model (e.g., Babatunde et al., 2010), probit regression model (e.g., Yusuf et al., 2011), and logistic regression model (e.g., Adeniyi & Ojo, 2013; Babatunde et al., 2007; Iorlamen et al., 2013, 2014; Kuwornu et al., 2013). We chose the logistic model in our study because of the nature of the dependent variable, which is dichotomous and for the fact that it can estimate the probability that an event occurs or not by predicting a binary dependent outcome from a set of independent variables (Greene, 2018). The model also accommodates both discrete and continuous variables, which can be ranked in a hierarchy to show which of the independent variables significantly affects the response variable and the relationship between the independent variables. The food security status of household is the dependent variable of the model that takes the value of 1 if the household is food secured and zero otherwise. The explanatory variables are Total Monthly Household Income (TMHI), Age of Household Head (AHH), education level of household head (ESHH), Household Size (HS), Farm Size of the household (FS), Gender of Household Head (GHH), livestock ownership (OL), and Quantity of Cereal Production (QCP).

A logit model is defined as follows. Let the probability that a household is food secure can be written as

$$P_i = E(Y=1/X_i) = \beta_1 + \beta_2 X_i \quad (1)$$

where, X_i is the independent variable and $Y=1$ means that the household is food secure. By taking logarithm of both sides of equation [1] we wind up

$$L_i = \ln [P_i / 1 - P_i] = \beta_1 + \beta_2 X_i \quad (2)$$

which means the log of the odds ratio is not only linear in X_i but also linear in the parameters. The parameters of the logit function (L_i) are estimated using the Maximum Likelihood (ML) approach. In this study the empirical relationship between the dependent and independent variables is specified in equation [3]:

$$L_i = \ln [P_i / 1 - P_i] = \beta_1 + \beta_2 TMHI + \beta_3 AHH + \beta_4 ESHH + \beta_5 HS + \beta_6 FS + \beta_7 GHH + \beta_8 OL + \beta_9 QCP + \mu_i \quad (3)$$

where,

L_i =log odds ratio in favor of a household being secure in food,

TMHI=total monthly household income,

AHH=age of household head,

ESHH=education level of household head,

HS=household size,

FS=farm size of the household,

GHH=gender of household head,

OL=livestock ownership,

QCP=quantity of cereal production.

Since the collected sample data in the model was cross sectional the multicollinearity problem might arise. Thus, we calculated partial correlation coefficients among the independent variables used in the model and found that the values of correlation coefficients were less than 0.5 implying that multicollinearity among variables did not appear to be a serious problem in the model. Table 1 lists the definition of variables, their measurements and expected hypotheses.

Table 1. Description of the Variables Used in the Model

Variables	Value	Expected sign	Citations
Food security status	1=food secure, 0=food insecure		Omonona et al., 2007; Yusuf et al., 2011; Adeniyi and Ojo, 2013; Ahungwa et al., 2013; Kuwornu et al., 2013; Iorlamen et al., 2013, 2014
Total monthly household income	BDT	+	Omonona et al., 2007; Babatunde et al., 2010; Adeniyi and Ojo, 2013; Kuwornu et al., 2013; Iorlamen et al., 2013, 2014
Education level of household head	Years	+	Babatunde et al., 2010; Yusuf et al., 2011; Adeniyi and Ojo, 2013; Kuwornu et al., 2013; Ahungwa et al., 2013; Iorlamen et al., 2013, 2014
Age of household head	Years	+/-	Omonona et al., 2007; Babatunde et al., 2007, 2010; Yusuf et al., 2011; Adeniyi and Ojo, 2013; Ahungwa et al., 2013; Kuwornu et al., 2013
Household size	Number (adult equivalent)	+/-	Babatunde et al., 2010 Yusuf et al., 2011; Adeniyi and Ojo, 2013; Iorlamen et al., 2013, 2014
Farm size	Acre	+	Ramakrishna and Demeke, 2002; Babatunde et al., 2007, 2010; Kuwornu et al., 2013; Ahungwa et al., 2013
Gender of household head	1=male, 0=female	+	Yusuf et al., 2011; Kuwornu et al., 2013; Ahungwa et al., 2013; Iorlamen et al., 2014
Livestock ownership	1=own, 0=otherwise	+	Ramakrishna and Demeke (2002)
Quantity of cereal production	Quintal	+	Babatunde et al., 2007, 2010; Kuwornu et al., 2013; Ahungwa et al., 2013

4. Results

In this section, we presented the results of the empirical analysis on the issue of food security at the household level.

4.1 Food Security Situation: Aggregate Level

Ensuring food security for all is one of the major challenges in Bangladesh today. Despite the impressive achievements in food grains production during the last few decades, food security at the households and individual levels remains a major concern for the government. Different aspects and conditions of the food security at household level are described in this section.

4.1.1 Food Expenditure Pattern in the Sampled Districts

In general food access depends upon the price food, household income and its distribution within households, and household size. In addition, the sources of income and their reliability for a steady flow and reliable amounts are important to both individuals and households for ensuring food. Table 2 shows the actual food expenditure scenarios in Bangladesh and selected districts in 2016. It is observed that the required food expenditure of household per month at the national level was 5,346.29 (Tk) with a food expenditure gap of 524.47 (Tk). Moreover, the average required and actual food expenditure of households in Natore was higher than that of in the other two regions (Table 2). When access gap is compared amongst the three regions the same pattern was observed (Table 2).

Table 2. Food Expenditure Scenario (Tk)

Food Consumption Indicators	National	Rajshahi	Natore	Naogaon
Household Size	4.06	4.1	4.6	3.9
Required Food Expenditure	5870.76	5928.6	6651.6	5639.4
Actual Food Expenditure	5346.29	5395.6	6053.6	5132.4
Gap/Surplus of Food Expenditure	-524.47	-533	-598	-507

Source: HIES, 2016.

4.1.2 Per Capita Food Intake Per Day

In order to achieve food security, the food ingested must be safe and enough to meet the physiological requirements of each individual. The daily per capita food intake is essential to ensure nutritional requirement of body. Figure 2 shows the distribution of food consumption on the basis of minimum requirement. It has been documented that an adult person in Bangladesh requires a minimum of 906 grams of food per day, which is converted to a 2,122 kilocalorie energy (Government of Bangladesh 2005). The suggested food combination is 47 percent of rice, 5 percent of wheat, 4 percent of pulse, 6 percent of milk, 2 percent of oil, 1 percent of meat, 5 percent of fish, 3 percent of potato, 17 percent of

vegetables, 2 percent of sugar, and another 2 percent of fruits. Cereals, largely rice, are the main food in Bangladesh. Nearly two-thirds of the daily diet of Bangladeshi people consists of rice, some vegetables, a little amount of pulses and small quantities of fish. Milk, dairy products and meat are consumed occasionally and in a very small amount (Islam & Buysse, 2012; Kabir et al., 2018). The consumption of protein and micronutrient-rich foods like fish, meat, eggs, milk, dairy products, fats and oil is often low at the rural poor areas in Bangladesh (Lalita et al., 2007).

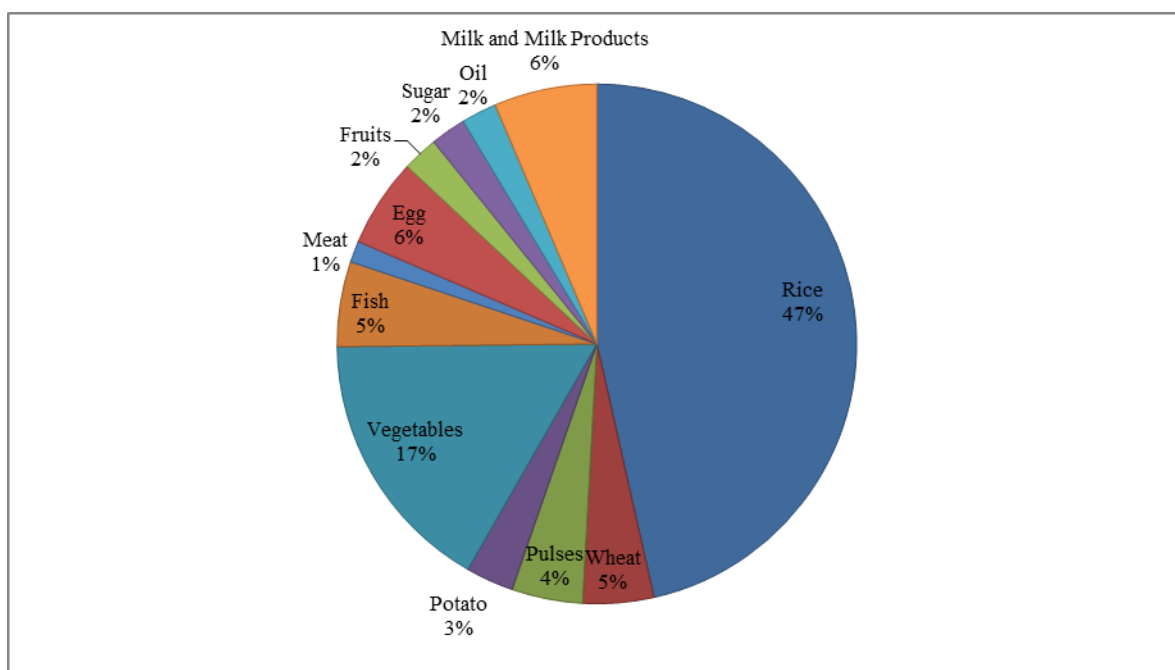


Figure 2. Minimum Required Food Intake

Source: Government of Bangladesh 2005.

Figure 3 depicts the percentages of food consumption according to food items by the households per capita on a daily basis in the study area. It is revealed that the staple food and vegetables, respectively, included 50 percent and 20 percent of total consumption of food. Moreover, households received most of the calories from the consumption of rice and vegetables. The next important food item is wheat followed by potato, fish, pulse, milk and milk product, egg, sugar, oil, fruits and meat.

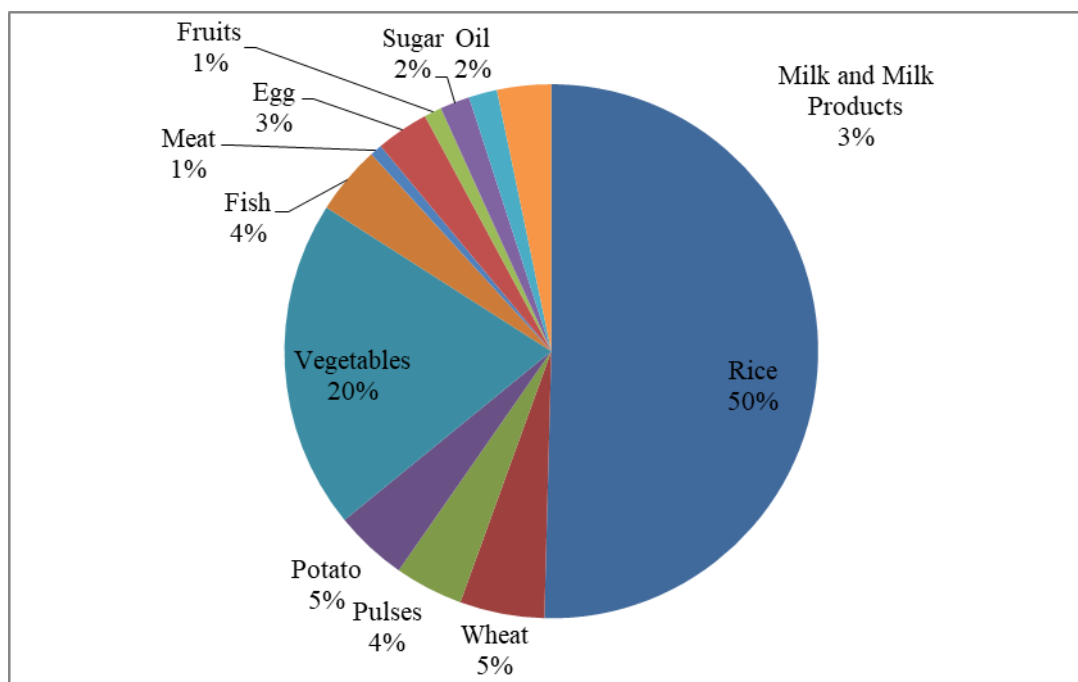


Figure 3. Actual Food Consumption

Source: Sample data.

4.2 Results from Indices: Micro-Level

To assess whether a household in the sample observation was food secured or not, we calculated the food security index suggested by Fakiyesi (2001). We also compared the food security status of household in different districts which is explained as follows.

4.2.1 Head Count Index

We classified respondents in the survey into food secure and insecure on the basis of recommended daily calorie intake of 2,280 kilocalorie suggested by FAO (2005). Figure 4 shows the headcount index calculated for the participants in the survey. It is observed that the ratio of all sample food unsecured households was 0.61 indicating 61 percent (110 households) of the total participants in the survey were food insecure. However, this scenario was different for the three districts in the study. The headcount index of food secure for the Naogaon region (0.47) was higher than the other two regions. Table 4 shows that the most food insecure district was Natore followed by Rajshahi.

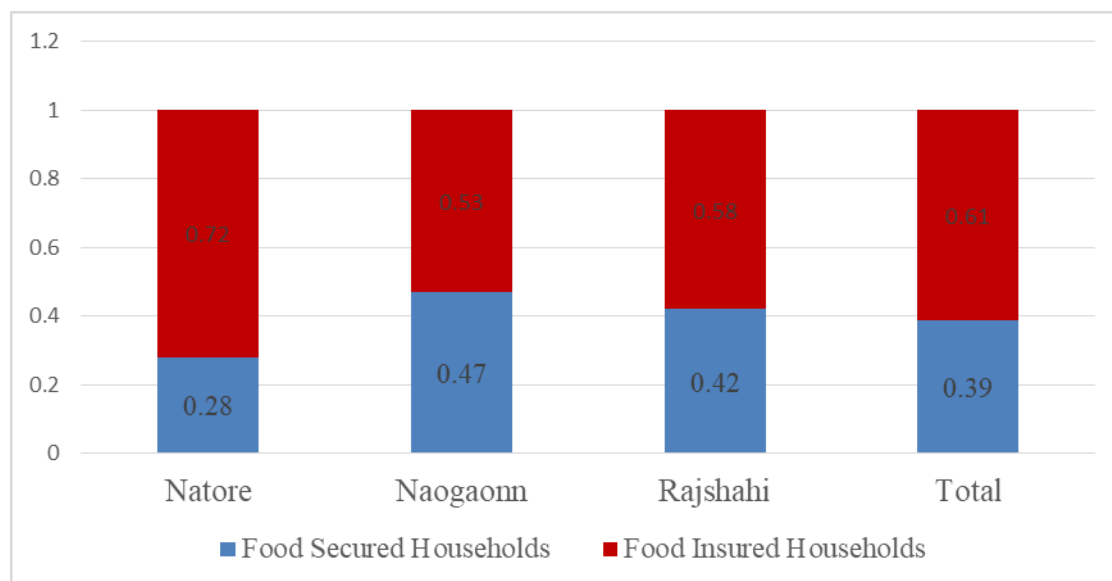


Figure 4. Headcount Index for the Study Area

Source: Sample data.

4.2.2 Food Security Status at the Household Level

We calculated a food consumption index (FSI) that enabled us to understand whether an individual was secured in the availability of food. Table 3 presents the mean value of FSI for a participant in our survey measured in kilocalorie (kcal). Table 3 shows that in case of all households in the survey the mean value of FSI was higher in Naogaon district than that of the other two districts. Furthermore, respondents in the Rajshahi district were more food secure when compared to the other regions in the survey.

Table 3. FSI Value of Sample Households

Region	All households	Food secured households	Food insecure households
Naogaon	0.999	1.03	0.91
Natore	0.942	1.01	0.91
Rajshahi	0.996	1.11	0.92
All regions	0.979	1.08	0.91

Source: Sample data.

4.3 Estimation Results

Table 4 presents the empirical results of the logit model obtained from collecting data from 180 participants in the survey. We conducted our analysis in three phases to explore the influence of the key factors on food security status. First, we combined all the collected data and estimated the parameters of the regression. Second, we separated the sample observations into three districts where the data were collected and estimated the parameters of the regression separately.

Finally, we compared the estimation results of the three regions to find any significant variations amongst the districts.

Comparisons of regression results

Table 4 shows the comparative analysis of food security determinants in all three districts. It is observed that four out of eight variables included in the regression model were statistically significant at the 0.01 level. These variables were total monthly income, quantity of cereal production, educational status of household, and farm size in all study areas. Table 4 indicates that McFadden R-squared was 0.709 which means that 71% of variation in the food security was explained by the independent variables of the model. The obtained log likelihood ratio was -70.66 and the Likelihood Ratio (LR) statistic for the goodness of fit for the model was 99.24 which were statistically significant with 99 percent confidence.

Table 4. Comparison of Regression Results

Variable	Total study area	Naogaon district	Natore district	Rajshahi district
	Coefficient			
C	-3.5159	-0.6615	0.3052	-10.2593
TMHI	0.0006***	0.0005	0.0016***	0.0015***
AHH	-0.0164	-0.0583*	0.0656	-0.0161
ESHH	0.1124*	0.0262	0.3535***	0.0741
HS	0.2161	-0.6979*	-0.8195	0.6008
FS	0.2891**	0.2973*	8.3880*	11.9347*
GHH	-0.5921	-0.8667	2.0232**	0.3104
OL	-0.4657	-0.0694	-0.9857	-1.5949
QCP	0.1342***	0.0998**	-0.2121	0.5279*

Note. *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Source: Sample data.

In the following we briefly provide the explanation for each of the statistically significant coefficients.

4.3.1 Total Monthly Income

An increase in the household income helped it afford more food for the family which made the family secured in food. It was found that the coefficient of the variable “monthly income” (0.0006) was positive and statistically significant at the 0.01 level. The coefficient of the variable monthly income was positive and statistically significant with 99 percent in the Natore and Rajshahi districts implying that the households with higher income level had the higher probability of being secured in the consumption of food but this coefficient was not statistically significant in the region of Naogaon. This result indicated that the higher the income of a household was the higher the probability that the household would be secured in the consumption of food. This result was consistent with Adeniyi and Ojo (2013), Ahungwa et al. (2013), Babatunde et al. (2010), Iorlamen et al. (2013; 2014), and Kuwornu et al. (2013).

4.3.2 Age of Household Head

The coefficient of the variable “age” had a negative sign and statistically significant at the 0.1 level only in the Naogaon district reflecting that household head with higher age was less likely to be food secure compared to the other regions. This might stem from the fact that the respondents with less than 50 years of old were more energetic and agile to do farm work, seek off-farm income earning activities to improve the welfare and food security of their households (Ahungwa et al., 2013). Other precedent studies reported similar conclusions (e.g., Adeniyi & Ojo, 2013; Babatunde et al., 2010; Iorlamen et al., 2013, 2014).

4.3.3 Education Level of Household Head

An educated household is more informative about the consumption of food. The result of the study showed that the coefficient of education was positive and statistically significant with 99 percent confident only in the Natore district implying that respondents in the Natore district were more conscious about food consumption than the other two districts. This result suggested those households with relatively higher level of education strived better than those with lower level of education (see, e.g., Adeniyi & Ojo, 2013; Ramakrishna & Demeke, 2002).

4.3.4 Household Size

The coefficient of the household size variable was negative (-0.69) and statistically significant at the 0.1 level only in the Naogaon district. This indicated that as the household size increased, the probability of food security decreased in this district than that of those respondents who lived at the Rajshahi and Natore districts. In other words, large size households were more likely to be food insecure than small size households. The result of our study was in line with the findings of Adeniyi and Ojo (2013) and Yusuf et al. (2011).

4.3.5 Farm Size

The result of the study showed that a household with more cultivable land could produce more crops which ensure food for the family. The coefficient of farm size (0.289) was positive and statistically significant with 95 percent confidence.

4.3.6 Gender of Household Head

The result of the research showed that the gender of household head had a positive impact on the household food security. The coefficient of gender of household head was statistically significant at the 0.1 level only in the Natore district. This result showed that a household with male headed was more likely to be secured in food compared to the one with female headed. Precedent studies concluded the same result as the finding of this study (e.g., Babatunde et al., 2010). However, this conclusion should be interpreted cautiously because the coefficients of the gender of household head were not statistically significant at the aggregate level and other districts.

4.3.7 Livestock Ownership

The coefficient of the livestock ownership was not statistically significant for the food security status. This finding was not in line with theoretical expectation outlined in Table 1. One reason that could justify this result is that most of the households participated in the survey did not own sufficient livestock population.

4.3.8 Quantity of Own Cereal Production

The result of the regression model showed that the coefficient of the quantity of own cereal production (0.134) was positive and statistically significant with 99 percent confidence in the region. This implies that those households who produced more cereal crops were more likely to have security in food through increasing either their purchasing power food self-consumption.

The finding of our study was also consistent with the results of Ahungwa et al. (2013), Babatunde et al. (2010) and Kuwornu et al. (2013).

5. Conclusions and Policy Implications

The main objective of this study was to assess the contribution of different factors behind food security status of Northern Bangladesh. To achieve our research objectives we constructed a food security index and used a binary logit model. Finding from the food security index revealed that households in the study areas were nearly food-secure as the mean of the FSI value was slightly below one. Moreover, using the index along with the food security line based on calorie intakes we found that 39 percent of the respondents were food-secure. The estimation results of the econometric model showed that some factors such as monthly household income, level of education of household head, farm size, and quantity of own cereal production had positive effect on the food security of the households. Any changes in these factors would change the status of food security. However, the findings of the research varied across the districts (i.e., Natore, Rajshahi and Naogaon). It was found that four statistically significant variables which were age of household head, household size, quantity of owned cereal production and farm size

for Naogaon whereas total monthly income, educational status of household, gender of household head and farm size were statistically significant for Natore. In the Rajshahi district, only three variables namely total monthly income, quantity of owned cereal production and farm size were statistically significant. Moreover, food security situation at national/aggregate level and household level in the study area are completely different and influencing factors the food security situation in this area are also different. Because, at the national level, food security situation has improved in context of availability side, although Bangladesh remains a food insecure country in terms of access to food and utilization of food. Considering income and food expenditure of household it is found that the households lacked to achieve the ability of food expenditure which is necessary to meet food requirement for the members of their households.

Based on the major findings of this study some policy recommendations might be devised. We recommended the government should expand alternative income generating activities for the people who lived in the rural regions. We also suggested that the household heads and other members who engaged in farming activities should be educated or trained through programmes like training and farmers' field schools which would have potential to enhance their capabilities, which, in turn, would improve households' productivities. Educated households will be more conscious about their dietary composition for better health. Furthermore, we recommended that farmers should have easy access to reliable and quality inputs such as seeds, fertilizers and credit support to increase production. These suggestions will help the marginal farmers enhance their farm production practicing. Finally, farming households should take advantage of the food security by increasing their farmland holding through government owned land distribution. However, globalization is connect with achieving food security because globalization refers to the way in which developments in one country or area or region can rapidly come to have significant consequences for the security and well-being of communities in quite distant countries or areas or regions of the world. As a result, it has a positive influence on the globally household food security status, especially in the developing countries like Bangladesh where food related crises are frequently occurring.

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