DETERMINANTS OF FOOD INSECURITY IN RURAL HOUSEHOLDS IN NORTH-WESTERN REGION OF BANGLADESH

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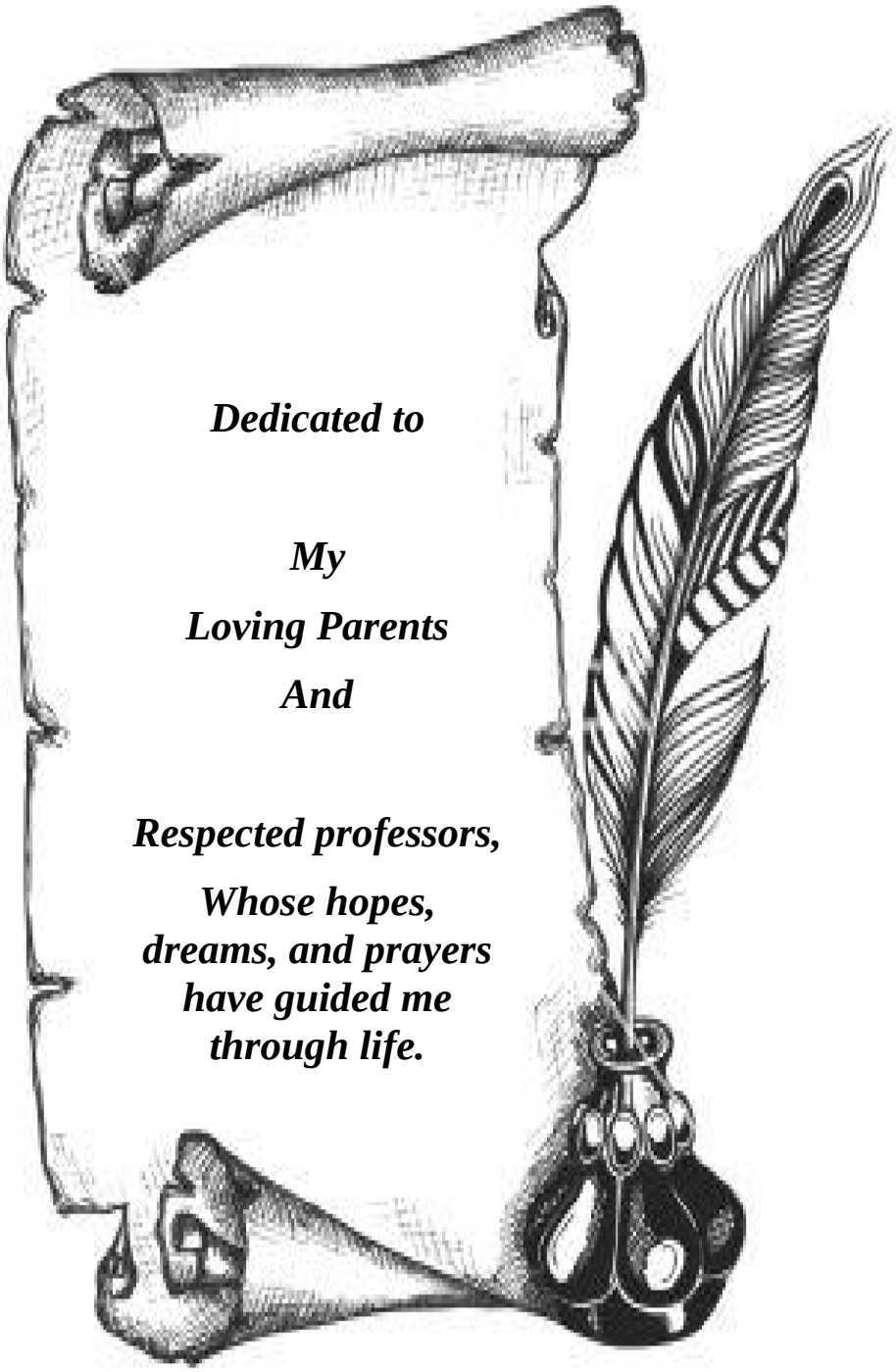

Dedicated to

My

Loving Parents

And

Respected professors,

Whose hopes,
dreams, and prayers
have guided me
through life.

DEPARTMENT OF AGRICULTURAL STATISTICS

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Certificate

This is to certify that the thesis entitled **"DETERMINANTS OF FOOD INSECRITY IN RURAL HOUSEHOLDS IN NORTH-WESTERN REGION OF BANGLADESH".** submitted to the department Agricultural Statistics, Faculty of Agribusiness Management, Sher-e- Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka 1207 in partial fulfillment of the requirements for the degree of Master of Science (M.S.) in Agricultural Statistics, embodies the result of a piece of bona fide research work carried out by **Maunjera Khatun, Registration Number :19-10198** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, as has been availed of during the course of this investigation has been duly acknowledged by the Author.

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ABSTRACT

The main objective of the study was to identify some of the factors that influence household food insecurity in the North-South region of Bangladesh. Two upazilas one from Rajshahi and another upazila from Chapainawangonj district. A simple random sampling method was employed to select the final sampling units. The study period was from June 2021 to June 2022. A household food balance food model was adopted and the recommended daily calorie requirement was used to determine the household food security status. Household food insecurity causation was then examined using the logistic regression model. The descriptive result observed that 42.50% of the respondents said that their food is secure and 57.50% of the respondents said that their food is insecure. We have used the chi-square test to describe the relationship between food security status and its determinants. From the chi-square test, it is seen that family size, annual income, and annual yield, were significantly related to household food security status at 1%, 97.5%, and 99% level of significance. The values of Cox and Snell and Nagelkerke R Square .536 and .720 indicate that 53.6% and 72% of the total variation of household food security status was explained by family size, annual income, and annual yield. The Hosmer- Lemeshow test result reported chi–a square value of 2.062 with a p-value of .846 on 5 degrees of freedom. Showing that there is no difference between observed and expected values. The model fits the data at an acceptance level. Assessment of the interaction terms showed that none of them were statistically significant and hence were excluded from the model. Internal consistency reliability of the data used in the study is concerned; Cronbach alpha coefficient of .182 is obtained. This means on average, household heads have similar opinions or judgments towards considering the 4 items or variables (Family Size, Annual Income Annual Yield) as major determinants of food insecurity.

INDEX

LIST OF FIGURES

LIST OF FIGURES

ABBREVIATIONS

GDP	Gross Domestic product
BBS	Bangladesh Bureau of statistics
HYV	High Yielding Variety
BBS	Bangladesh Bureau of Statistics
FAO	Food and Agriculture Organization
LR	Likelihood Ratio
Df	Degrees of Freedom
DAE	Department of Agricultural Extension
VIF	Variance Inflation Factor
^{0}C	Degree Celsius
et al	And others
HFBM	Household Food Security Balance Method
HFS	Household Food Security
EDUC	Education
FSIZE	Family Size
LSIZE	Land Size
SPSS	Scientific packages for social science
Tk	Taka
S.E mean	Standard error of mean
Sl	Serial

No.	Number
%	Percent
SAU	Sher-e-Bangla Agricultural University
WB	World Bank
≤	Less than equal
>	Greater than
P	Probability

CHAPTER I: INTRODUCTION

1.1 General

Today's world paying increasing attention to the problem of food security Stability in this context refers to both avail ability and accessibility of the food in all its forms. Food accessibility, use stability, and availability is the four parts that make up food security. Bangladesh has a population density of 1104 people per square kilometer., making it an over populated nation. The sector that contributes the most to Bangladesh's GDP, at 14.74% is agriculture. The vast majority of the nation's population relies on the agricultural industry for both food and living. Bangladesh's population is growing at a 1.03% annual rate. By 2050, the population will increase to 233.2 million at this rate. Every year in Bangladesh, 0.08 million acres of arable land are lost to production. (Mondal, 2010).

However, the country faces tremendous challenges in providing food security to the increasing population. Therefore, it is important to increase food production in order to meet the growing demand for food emanating from population growth. Although, there are significant achievements in food grain production but, food insecurity both in national and household level remains a matter of major concern in Bangladesh. Like many other developing countries, food security in Bangladesh is also threatened by the global economic crisis and soaring price of essentials. Food security is viewed as the number one priority of the government. In Bangladesh the major food security problem is poverty. According to world food summit, 1996food security is defined as when all people all the times access to sufficient, safe, nutritious food to maintain a healthy and active life. Commonly, the food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. Food security is built on four pillars namely: Food availability, Food access, Food use and Food utilization. People are considered food secure when they have availability and adequate access at all times to sufficient, safe, notorious food to maintain a healthy and active life. Food security analysts look at the combination of the following four main elements such as food availability, food accessibility food utilization and food use.

Bangladesh has achieved self- sufficiency in rice production that would not imply food security. About 25% of population is still food insecure. Due to nutritional imbalance Bangladeshi people

still lack dietary diversity. Several socio demographic factor associates household food insecurity including land size, land slope, family size, literacy status, marital status, gender, food aid and age of household's head.

Fridi and wadood (2010) studied to investigate the determinants of household food security situation in Bangladesh apply the logistic regression. They found different household characteristics which are strongly correlated with food security indicator. They also showed that price changes of rice are highly sensitive to food security.

Ks Rahman et.al (2019) found that income of household head, age of the household and level of education were found to positive and significant influence houdehold head food security.

Sahajan Ali et.al (2016) studied that income and age of household as consequential determinants of food security. They impact positively on food security. Older household heads significant to be food secure.

Most of the studies have been introduced regression technique. As therefore, it is our particular interest to investigate the determinants of household's food insecurity of Bangladesh using household level data. Most of the studies have been introducing regression techniques having without or partial involvement of econometric test may questionable on their application.

1.2 Background of the Study Area

Godagari upazilaa if Rajshahi district unde Rajshahi division.where mohanonda river fallen to Padma. The upazila boundeb by chapainawbganj upazila. Tanore and chapainawbganj district on the north while tanore and paba are on the east.

According to the Bangladesh bureau of statistics (BBS, 2011) the total population of godagari upazila is estimated 330924 whose 50.24% male and 49.76% female the population density of th eupazila is 700 per squae kilometer, which become densely populated area among Rajshahi district. Land area approximately 47.13 kilometer square and total household about 8008. The Economy of the district major in agriculture. Out of total holdings of the district almost 56% holdings are farms that are produce varieties of crops namely: local and HYV paddy, wheat and other minor cereal crops. Out of 2407square kilometer of the district, organized forestry is

14.48.square kilometer and riverine areas occupied about 96.80% square kilometer. Which is (3.99%) of the total area. According to nonfarm economic activities, the non-farm activities are not very much significant. Still in developing stage.

Chapainawbganj is the most western district located in Bangladesh. It is the part of Rajshahi division. Rajshahi and naogaon is on the east, while on the india side malda of west Bengal , the rest of the india is on the north. West side is bounded by the river Padma and malda district oof murshidabad. It was the part of ancient gour capital.it is said that this area has strategic and commercial importance due to its location.

According to Bangladesh Bureau of Statistics (BBS, 2011) the total population estimated at 530592 whose male (47.99%) and female (52.01%). The population of the district about 1174 per kilometer square, total household 112748, average household 11.74. The economy of the district mainly depends on agriculture. Out of total land holdings 320388 holdings of the district (48.97%) holdings are farms that produce varieties of crops namely: local and HYV paddy, wheat, vegetables, spices, cash crops, pulses, oilseed and other minor crops. Numerous fruits similar to mango, banana, jackfruits, guava, coconut etc. *are grown*. In terms of growing mango chapainawbganj holds special positions which are significant cash crop of the district. The quality and quantity of mangos are best over the country. The mango growers are earn huge amount of money by selling's the delicious fruit.

Barind Tract (in English it is called varendra Tract and in bangld it's called Borendro Bhumi) is the largest Pleistocene era physiographic unite in the basin. its covers almost Rangpur, Dinajpur, pabna, Rajshahi, Bogura, Joypurhat district of Rajshahi and Rangpur division in Bangladesh. As well as entire daksin dinajpur, uttor dinajpur, and most of the malda district of murshidabad west Bengal india. It is made up of several separate sections in thhe north – western part of Bangladesh and northern part of west Bengal, the country covered total area approximately 10000 square kilometers (3900sq.mi) of mostly old alluvium. On the estern part of the tract lower fault escarpment. Although the fault trough run the some of jamuna , atria and some of punorvaba rivers. On the west, the main area is tilted up and on the east this area is tilted downwards. The climate of the tract varies since that of much of india. In those more extreme temperature variations (ranging from 45 degree Celsius down to five degree Celsius) are encountered there. It is divided into three parts: the recent alluvial fan, the barind pleistoncene and the recent floodplain. Rajshahi

region is especially suited to lentil, chickpea, tomato and potato. Mango, litchi, palmyra palms and guava are also the major fruit crops in this area. Cropping pattern in a definite region is not inert; gradually it is varying. The cropping pattern and the changes depend on a large number of factors like climate, soil type, rainfall, irrigation facilities, agricultural technology and other inputs, marketing and transport facilities and growth of Argo industries (Gadge, 2003; Rashid et al., 2005)

The reason behind selecting Godagari and Chapainawbganj sadar upzila as study area, those areas under Barind or Varendra. The areas experienced high temperature at 49 ^{0} C during July- august with low soil moisture and unpredictable rain fall while minimum temperature recorded at 6 ^{0} C in January. Those caused by drought, flood, natural calamities, low production, low supply of food grains. As a result, seasonal food insecurity happed. DAE and varendra authority working to minimize those types of situations. It's helpful for my study to identify most important determinants that affecting the food insecurity.

1.3 Statement of the problem

With the exception of brief crises brought on by monga or drought, food insecurity in Bangladesh has largely become chronic. When all three of the essential requirements for food security are not met, there is a type of food insecurity known as chronic food shortages. These three requirements are sufficiency, accessibility, and availability. Chronic food shortages happen when a population lacks the fundamental ability to generate food, even in normal circumstances, in contrast to temporary food shortages, which largely result from natural calamities that hinder a people's ability to produce food. Third-world countries frequently experience chronic food shortages because they lack the resources to produce or obtain enough food to meet their own needs.

Hossain et al. (2005) the economic growth of Bangladesh increases rapidly since 2000 with the decline in extreme poverty rate to 25% in 2014 from 31% of 2010 (Planning Commission, 2015:09). However, Bangladesh taking enormous population and very limited natural resources is continuously on the edge of food insecurity

(Islam, 2012) the traditional food system of Bangladesh deeply depends on climatic occurrences like rainfall, weather & temperature, water level, soil condition, etc. Moreover, because of the geographical site any climatic change will unfavorably influence the food security of Bangladesh.

Mzhar Mughal, (2020) in Asia, 54 percent of the world's hungry people due to its large population base, and the two countries with the largest number of hungry people is in Asia. A 1% rise in cereal production and yield is allied with up to 0.84% decline in the occurrence of starvation.

Per capita growth of production of main food items in the study area have not been adequate to content the demand of an increasing population. Proportion of population growing is increasing due to deficiency of knowledge on family planning services on the part of the household head, imperfect or no health-related service suppliers and socio-cultural effect. For example, a household who has greater family size (children) is deliberated to be rich in the society. Although the significance of food shortage various from year to year, farm households encountered seasonal food shortage practically every year. Food insecure and food secure farm households belong to as neighbors and might share common climate and weather condition and mostly parallel socio-economic, cultural and land topography. So far, one faces seasonal food crisis and become dependent on food aid, while the other remains food secure, lacking no food aid. Recent literature discovered that even in years of satisfactory rainfall and good harvest, the households in the study area remain in need of food assistance. This obviously returns the intensely entrenched poverty and transitory situation of the area irrespective of adequate rainfall. Although drought plays a dominant role in activating food emergency the consistency in consumption status of farm households between good year and bad year is not so important to claim that drought is fundamental cause of famine or transitory food insecurity. This suggests the being of structural, socio-economic, cultural, demographic and other factors fundamental the poverty and seasonal food insecurity problem in the study area. Accordingly, the fundamental research question of this study is what factorial changes make one household food secure and the other seasonally food insecure.

1.4. Objectives of the Study

The general objective of this study is to identify the most important factors influencing food insecurity in rural households of north – western region of Bangladesh.

The specific objectives of the study are:

- To examine the effects of some variables that may influence food insecurity of rural households and identify the most important determinants.
- To describe the relationship between food insecurity and its determinants; and
- To analyze the impact of major determinants on the probability of household food security.

1.5 Limitations of the Study

The study concentrated on identifying a few of the variables that were anticipated to affect household food insecurity in rural areas of Bangladesh's north-western Region. Some of the most significant contributing factors, such as climate, weather, natural catastrophes, and ecological conditions, could not be included in the study due to a lack of information. The comparative analysis of the issue of food insecurity between urban and rural areas was not the study's primary objective. The study did not address the reasons of chronic food insecurity since it was only interested in the temporary food insecurity that farm households experienced, which could range in severity from mild to severe. The study solely included cereal goods when calculating the household head's available caloric intake; it excluded additional items that might consumed And the national recommended 2300 kilocalorie per day per person might main to a loss of information. For example, a household head who have 2300 kilo calorie per day 14 person and another household who have 2290 kilo calorie per person could be categorized as food insecure while their level of insecurity is different. Since deficiency of secondary evidence, it was not probable to get conversion factors to change each member of the household head (infants, male, female and age differences) into the corresponding adult equivalent. In defining the number of predictor variables, this study considered a rule of thumb of having a minimum of 10 interpretations for each predictor variable. The univariate approach overlooked the probability that a collection of variables, each of which is weakly associated with the outcome variable, could become an important predictor of outcome when taken together.

CHAPTER II: REVIEW OF LITERATURE

When each person, all the time, has physical, social, and economic access to enough, safe, and nutritious food that satisfies their dietary needs and food choices for an active and healthy life, then there is food security (FAO, 2006). The World Food Program describes food security as a complicated phenomenon that takes into justification the physical and biological aspects of food production, distribution, and consumption and leads to a sustained level of food stability (2004) This commonly accepted definition underlines the availability, access, usage, and stability of food as the four main components of food security (FAO, 2006). Realizing food security goals requires balancing all four dimensions at once (FAO, 2008); doing so is essential for ensuring the prospects of future generations (World Bank, 2020). However, the vulnerable groups to food insecurity exist in the developing regions and the global south (Shams & Shohel, 2016). Food security refers to the ability to establish access to productive resources such as land, livestock, agricultural inputs, and family labor combined to produce food or cash based on the context of subsistence farm households Tolosa (1995). Consistent with this, Bonnard (1999) argued that Agriculture constitutes the most important factor in availability concerning the three components of food security, a primary factor in access where livelihoods are agriculture-based and a corresponding aspect concerning food quality and processing for utilization. A focus on household livelihoods and assets is deemed necessary to understand the ability of households to access food either through production, purchase, or transfers (Maxwell, 2003, Hart, 2009). A further large number of different definitions have been proposed. Market integration, pricing policies, and temporal market conditions are now considered key to accessing food and are dependent on household purchasing power (Webb et al., 2006). Asia lies at the center of the global food-security challenge of the twenty-first century. The region – especially China and India – is drawing on world stocks and importing more staples, as its farms strain to meet the growing middle classes' desire for more meat and processed foods. In the meantime, the smallholder farmers who supply 80% of the region's food challenge continuous deficiency, as they struggle to raise output in the face of creeping environmental degradation, looming water shortages, and the unpredictable effects of climate change. Asia is seated at the core of global food insecurity, with more than half the world’s population and around two-thirds of global hungry and poor. How countries in the regions particularly china and India. Several studies have been accompanied concerning food insecurity

status. A study explored the factors associated with food insecurity among vulnerable women. Another study was conducted in the seven districts (administrative areas of Bangladesh) of Bangladesh that represented the relationship concerning food insecurity and the dietary diversity and nutritional status of under-five children.

Based on the temporal dimension, two types of household food insecurity can be distinguished as chronic and transitory. Chronic food shortages are a form of food insecurity that occurs when all four of the basic conditions for food security are not met. These four conditions are. Food availability, access, utilization, and stability chronic food shortages occur because a population does not have the basic ability to produce food, even under normal circumstances. Chronic food shortages often occur in third-world countries, where the nation does not have sufficient food to meet its needs, is unable to produce or procure sufficient food regularly, and does not have sufficient resources to procurement food from external sources. This occurs in areas where the population cannot bear its food requirements and food insecurity results. While transitory is relatively unpredictable and can emerge suddenly. It occurs when there is a cyclical pattern of inadequate access to food, such as a unexpected droplet in the availability of produce or access to enough food to maintain good nutritional status.

The observation of seasonal food security falls between chronic and transitory food insecurity. It is similar to chronic food insecurity as it is typically predictable and follows a sequence of known events. Though, as per seasonal food insecurity is of inadequate duration it can also be seen as frequent, transitory food insecurity. It happens when there is a cyclical pattern of insufficient availability and access to food. This is accompanying with seasonal instabilities in the climate, cropping patterns, work opportunities (labor demand), and disease.

Sebastian Zug (2006) the biggest group of people affected by monga are those families whose income mainly depends on agricultural labor and marginal farming. The above-mentioned employment opportunities like construction works or all types of migration are mainly done by those people, who do agricultural labor at other times. Particular groups or individuals are eventually affected by the agricultural lean season. This is the situation for all those who depend on the income of people affected by the agricultural lean season. Monga is an outcome of chronic poverty in the northern districts of Bangladesh and it is also an important reason for it. It is a

cyclical setback for the development of the individual family, the community, and the whole region.

Md. Tariqujjaman et.al. (2023) found that in rural Bangladesh one out of three households is food insecure where poverty is considered the primary cause in those rural regions. Food insecurity was greater in the northwestern, followed by central-southwestern and coastal districts of Bangladesh associated to the other districts. The wealth status of the households, education of household heads and the education of mothers or caregivers, low income, a major portion of northern parts are suffering from a cyclical occurrence of poverty and hunger named as Monga.

Nazrul Islam (2016) among the 39 causes of seasonal food insecurity (Monga) are the Lack of job opportunities in the Monga season especially from September to December every year, riverbank erosion in the charred area, frequent flood inundation, no agricultural work, no business activities due to excessive rainfall, dense fogs, hailstorms, severe cold, etc.

Mazahua et.al (2013) the study suggest that the nature of household food insecurity appears to be an outcome of a variety of risk factors, as well as the inability to manage those risks due to income and resource limitations. Households with more medical expenses (68 %), cultivable landholding (9 %), and households living by the riverside (4 %) have a greater probability of food insecurity than their counterparts. On the contrary, relatively large size families (-16 %), higher income (-4 %), and safety net coverage (-19 %) have reduced the probability of food insecurity during the Monga period. Around 30 to 50% of the country experienced severe climate shocks each year. Also, cyclones in the country account for 70% of all storm surges in the world. Rural Bangladesh faces the worst of these storm surges, and it distresses the entire harvest. Consequently, it subsidizes to food insecurity in the nation. Seasonal hunger comes and hits the majority rural of areas of Bangladesh. At the same time, low-skill labor opportunities turn out to be accessible in other regions of the country. Seasonal relocation for these jobs, which usually involves leaving farms to move to more worthwhile cities, is a common practice. It is a practice that the rural poor in Bangladesh use to afford for their families so they can consume on a regular basis.

Mohammad J. Raihan et. al (2018) examine that, Seasonal insecurity happened during the period post-as harvest period (the perceived lean period) and aman harvest season in comparison to the boro harvest season. The important factor that affects Seasonal insecurity is the household head being a farmer, the educational status of the Household head, and household monthly income

having a higher impact on food insecurity with a significant association between household food security status and its determinants.

Chris Hillbruner et.al (2008) the occurrence proportions of food insecurity, wasting, and inadequate growth were all significantly upper throughout the monsoon season as associated with the dry season. Dietary diversity and lost work owing to the weather were recognized as specific pathways through which season affected household food security. On the other hand, mechanisms hypothesized to contribute to seasonal declines in nutritional statuses, such as childhood illness, were not found to be significant. It was found that the household's number of dependents, the income of the household head, the age of the household head, and the level of education were found to significantly and positively influence household head food security in the study area. They recommended that social security measures must ensure that the benefits of public efforts to improve food security and nutrition are universal. On the other hand, the sex of the household head, Per Capita monthly food expenditure was found to influence food security negatively at the household level. (Rahman et.al.2019) .riverine households' lack of access to many necessities and services, such as food, safe drinking water, education, and health, results in increased vulnerability to food insecurity which could lead to an unfortunate vicious cycle of poverty which has important policy implications to improve the health conditions of rural households by ensuring access to food and health care, particularly since life expectancy has increased to 69 years in Bangladesh (G.M. Monirul Alam,2019).

Sanaullah Panezai et. al. (2021): The regression model revealed that farm size, farm income, off-farm income, crop production, input cost of production, and Education of the household's head had positive impacts on household food security.

Satyajit Kundu et.al (2020) explain that having no formal education, occupation of household head other than a government job and low monthly income were potential determinants of lower Household food security and Household dietary diversity.

Sultana and Kiani (2011) studied to examine the determinants of household food security in Pakistan using microdata for the year 2007-08 and found that place of residence has a significant and negative effect on a household's food security status. They also identified that the dependency ratio has a significant impact on food security and has expected sign negative. The educational attainment level of the household's head beyond the intermediate level has also a significant and

positive impact on the food security status of the household. Whereas social capital and employment do not affect household's food security significantly. They advised different policies and programs that should be needed to address the well-being of their people.

Gebre (2012) applied a logistic regression model to examine the determinants of food insecurity among urban households in Addis Ababa city and pointed six important factors out of ten factors. The identified significant factors are household size, age of household head, education of the household head, access to credit, household asset possession, and access to employment

Alem-meta Assefa Agidew (2018) applied a logistic regression model to evaluate determinants of food insecurity in Teleyayen sub-watershed and pointed out important factors. Age of household head, family size, number of the agricultural labor force, off-farm income, relief support/food aid, farming experience, and agro-ecological zone revealed that deficiency of farmland, poverty, continuing drought and climate change, shortage of rainfall, and land degradation are important aspects. Especially, the age of the household head, family size, off-farm income, relief support (food aid), and agro-climatic zone had a negative influence on the food security of the rural households. Other variables of significance, namely the number of the agricultural labor force and farm experience, were found to exert a positive impact.

Al-Zabir (2020) this study observed the variance in food security status of receivers and non-receivers of recognized support living under comparable socioeconomic circumstances. The consequences presented that number of ultra-poor, hardcore poor and absolute poor were greater in the case of non-receivers of institutional support as their per capita food consumption was low. Rice was stated as the most consumed food item by both groups per day. People with access to institutional support had more dietary diversity scores than the counterpart group food security of the farming households was found to be influenced by educational level, family size, number of accommodations received and size of cultivable land area. The positive consequence of education of particularly non-receivers of institutional support on food security calls for policies targeted at strengthening the education of farming households.

G. R. Joshi et.al (2016) they recognize the determinants of household-level food security in the eastern region of Nepal. The size of the land holding, immediacy to the market, male-headed household, household's members with agriculture and associated employment and the educational level of household head were positive and significant variables while household proportions was

negative and significant variable to food security. Was also shown that the hills and the mountains were more food insecure than Terrain region. Therefore, investment in human capital, formation of off-farm engagement opportunities, aggregate physical access through markets and roads expansion and access to land and supplementing their quality are needed to further improve the food security situation. Equally, special programs should be employed targeting female headed households as they are more food insecure than male headed households

Wooden Awoke et.al (2022) binary logit model was employed to identify the determinants of food security status of household food insecurity. the result revealed that Access to training, sex, family size, the number of oxen, off-farm, farmland size, and age, tropical livestock unit, livelihood diversification, and household on-farm income was significant. The majority of the households were food insecure appropriate stakeholder selection to support household engagement in different income-generating activities as well as providing a timely and adequate supply of agricultural technologies should be considered to advance the prevailing food security situation. Numerous notable studies have been cited in the literature [Iram and Butt (2004), Hazarika and Khasnobis (2005); Omotesho et. al., (2010); Arene and Anyaeji (2010); Sisay and Edriss, (2012); Bogale and Shimelis (2009) and Mitik et. al., (2012)] to investigate and identified some important factors through their research in the food security area.

As therefore; it is our particular interest to investigate the determinants of food security of Bangladesh using household level data. Most of the studies have been introduced regression techniques having without or partial involvement of econometric tests may questionable on their application. As therefore, it is our particular interest to investigate the determinants of food security of Bangladesh using Logistic Regression Analysis approach which could be able to meet the existing research gap. Therefore, the study is very important to have an idea about the factors affecting.

CHAPTER III: METHODOLOGY

3.1 Data Source and Sampling Technique

The research implementation that was based on this study used primary and secondary data.

Primary data sources

A structured questionnaire was distributed to rural households in Godagari and Chapainawbganj Sadar upazilas to collect primary data. The questionnaire was employed to accumulate qualitative and quantitative data concerned with demographic, resource endorsements, attitudinal, and other facts about households, including food and non-food consumption, for the period covering June 2021 to June 2022.

Secondary Data Sources

Importance was formed based on the determination of the size of the sample, which was mainly based on the purpose of the study, available resources, and variance (precision) required. Although the sample size is expressed in terms of variance when the variance is unknown**.**

Sampling Technique

The simple random sample of rural household used in this study covering the periodfrom june 2021 to june 2022 at the north western region of Bangladesh (Godagari and Chapainawbganj sadar upazila) two upazilas has 8 rural unions namely (Basudebpur , Mohonpur,Godagari , Phakri, Debinagor, Islampur, Char Anupnagar, Char- bagdanga) where randomly selects sub set of participants from a population .Every households has an equal chance of being select as final sampling unite.

3.2 Measurement of Variable

Based on previous research and available primary and secondary data on the subject, household food security status was chosen as the variable that was supposed to influence independent variables were mostly categorical and measured through the use of indicators, where the ordinal scale of measurement was involved.

3.2.1 Response Variable

The household food balance model (HFBM), which was used and adapted by Haile et al. (2005), Shiferaw et al. (2004), and Ramakrishna and Assefa (2002), was used to determine the response variable, household food security status (HFS). The HFBM was used to quantify the net available grain food for each of the 120 sampled rural households in the North-Western region for the period covering June 2021 to June 2022. All variables required for the HFBM model were then converted from the local grain measurement units into the corresponding kilogram grain equivalent.

The HFBM model was expressed as follows:

$$q_i = (p_i + b_i + f_i + r_i) - (l_i + e_i + g_i + d_i)$$

The index i in this model ranges from 1 to 120, and pi represents the net amount of grain food available to household i.

Were,

p_i = *total* grain produced by household *i*

b_i = total grain purchased by household *i*

f_i = total grain obtained through food-for-work by household *i*

r_i = total relief grain food received by household *i*

l_i = total crop utilized for seed by household *i*

e_i = total marketed output by household *i*

g_i = total grain given out to relatives by household *i*

d_i = repayment of grain borrowed by household *i*

To end with, previous Haile et al (2005) and others, the response variable was determined in four steps. First, net grain available for each household in kilogram (q_i) was converted into equivalent total kilo calories using conversion factors used for Bangladesh. Second, the food supply at the household level calculated in step (i) was used to calculate the calories available per person per

day for each household. Third, steps, 2300 kilo calories per person per day was used as a measure of calories required (i.e., demand) to enable an adult to live a healthy and active life. Then an association among the accessible (supply) and essential (i.e., demand) grain food was made. Finally, a comparison between calories available and calories demanded by a household was used to determine the food security status of a household. A household whose regular per capita caloric accessible (supply) is less than his/her demand was viewed as food insecure, and coded as 0, while a household that did not experience a calorie shortage during the year under study was viewed as food secure and was assigned a code of 1. Owing to this, the response variable,

The food security status of the i^{th} household, HFS_i was measured

$$0, Y_i. R < \text{(food insecure)}$$

$$1, Y_{i,} R > \text{(food secure)}$$

where Y_i daily per capita calorie available (supply); R is the minimum recommended national standard rate of calories per person per day, which is 2122 kilo calorie (i.e., demand) and HFS_i food security status of the i^{th} household, i =1, 2, 3… 120.

Headcount ratio denoted as H= m/n

Where m = number of food insecure households and n = number of households in the sample was calculated to measure of extent of undernourishment.

Surplus index $P = \sum (Y_i - R)/mR$

Index p measures the proportion of surplus of the average daily dietary energy intake of undernourishment from the national nutritional requirements, expressing the depth of undernourishment.

3.2.2 Predictor Variables

As investigated and set to significance, the dependent variable of the study, household food security status, is a dichotomous variable (food secure and food insecure) and a function of numerous explanatory variables. It assumes that the explanatory variable is linearly related to the predictors. The list of predictor variables that were expected to influence household food insecurity was all categorical and grouped under socio-demographic characteristics. As indicated one binary-dependent variable (food security status) and 11 explanatory variables (predictors) were selected

for this analysis. Then, the binary logistic regression model was applied to screen out the most significant variables. If the assumption that the logit is linear in the 30 covariates is not met, then grouping and use of dummy variables could be considered. In this study, dichotomizing particular of the continuous variables was made to have a sound interpretation of predictor variables. Deprived of a grouping of some kind, it is difficult to examine the lack of fit. Yet, as the number of explanatory variables rises, a simultaneous grouping of values for each variable can result in a contingency table with many cells that have low counts. In these circumstances, a different method of grouping or categorizing is formed by the observed and fitted values based on a division of expected probability. Nonetheless, classifying the continuous factors for the aforementioned reasons can prevent the loss of important data.

Socio-Demographic Variables

- **AGE** = Household heads ages (in years).

AGE was used as a proxy for the experience of the household head since he/she started farming. Younger household heads were expected households.

- **GENDER** = Gender of the household head in this study, female-headed households were expected to be more food insecure than male-headed households. A dummy variable was employed to symbolize this variable with

1, male

2, female

- **EDU C**= Literacy status of the household head.

The impact of education on household food production might be through promoting awareness of the possible advantages of modernizing agriculture through technological inputs and by diversifying household incomes, which in turn enhance household supply. Households led by non-literate heads are less likely to recognize modern farming technologies provided to them finished any media (extension workers, radio, etc) than literate household heads.

1. Primary (1-5)

2. Secondary (6-10)

3. Higher (>10)

❖ **MARITAL STATUS**

Marital status in this study of married-headed household heads was expected to be more secure than windowed-headed households. A dummy variable was employed to indicate this variable with

1. Married.
2. Windowed.

❖ **FSIZE** = Family size of the household's head (in number)

The larger the household size (economically inactive) the more implication on food consumption than on labor supply to boost production. In this study, it was expected that the larger the household size, the more likely to have an impact on food consumption. The average household size of 6.16 was obtained from the sampled households and used to categorize the variable.

1. >6 = members
2. ≤6 = members

❖ **CROPINGLAND**

Cropping land of the household in this study was expected to be more secure than those who had not. A dummy variable was employed to signify this variable with

1, Yes

2. No

❖ **LSIZE** = Farm land size of household's head measured in hectares

Farmland size refers to the total farmland owned by the household and measured in hectares. The smaller the farmland owned by the household, the smaller the level of production and the more likely to be food insecure. The mean farmland size of the sampled households was 0.60 hectares and was used for categorizing this variable.

1, ≤ 1.60 Hectare

2, > 1.60 Hectare

❖ **AID** = Household's attitude of dependence on food aid

Food aid literature advises that food aid is a short-term solution to food insecurity and does not subsidize to strength-making or rehabilitation of beneficiary groups.

1. Good
2. Not good

3.4. Logistic Regression

To predict a response variable based on continuous, discrete, dichotomous, or a combination of any of these predictor variables, to calculate the percentage of the response variable's variance that can be attributed to the predictor variables, to rank the predictor variables' relative importance, to evaluate interaction effects, and to comprehend the influence of covariate control variables. Strong predictive power is possessed by the logistic model. The logistic model is more often used than the other related models because of its close relationship to the log-linear analysis of contingency tables and linear discriminant function analysis. Logistic regression is frequently used as a benchmark by which other models are measured. The logistic model is less sensitive to outliers than its rival, the probit model. In comparison to its rival, the probit model, the logistic model is less susceptible to outliers and simple to rectify a bias (Copas, 1988). Logistic is preferred over discriminant analysis when the independent variables are categorical or a combination of continuous and categorical. Requisite presumptions for statistics. For each category of the answer variable, there is no explicit necessity for multivariate normality, homoscedasticity, or linearity of the independent variables. However (McCullagh and Nelder, 1983) have made significant contributions to its significance in application fields. To solve the difficulties under objectives I (ii), and (iii) of this with categories 1 (food insecurity) and 0, the logistic (logit) regression model was utilized (food secure). With the leading column of 1s removed, the regression matrix Xn(p+1) is known as the predictor data matrix the conditional probability that a household head is food insecured known the X set is denoted by P (y_i= 1/x) =

p_i = p(x). The expression p(x) has the form.

$$P_i=p(x)=p[y_i=1/x]=\frac{1}{1+e(\beta_0+\beta,x,+\beta_2x_2+\cdots\beta_nx_n)}=\frac{1}{1+e^{x\beta}}=\frac{1}{1+e^{-x\beta}} \quad \ldots\ldots..(1)$$

Where p_i refers to the probability of household i being food insecure, y_i is the observed food insecurity status of household i, $\beta \sim (p+1) \times 1$ is a vector of unknown coefficients. Equation (1) is called Binary Logistic Regression Model. The logarithmic conversion of equation (1) yields the Logit Regression Model which is given as:

n_d the set of p-predictor variables.

Log it [p(x)] = ln $p(x)$/1-p(x) $=\beta_0 + B_1x_1 + \beta_2x_2 + \cdots + \beta_nx_n$

3.5 Parameter Estimation

The two estimation techniques most frequently employed in fitting a logistic regression model that is in direct competition are maximum likelihood and non-iterative weighted least squares (Hosmer-Lemeshow, 1989; Greene, 1991, Collet, 1991 and others). Non-iterative weighted least squares approach is less effective when the predictors are not assumed to be normal (Maddala, 1997). Due to the less stringent nature of the underlying assumptions, in (logit) model parameters (Hosmer-Lemeshow, 1989). Thus, the maximum likelihood estimation technique was used in this work to estimate the model's parameters. Think about the logistic model.

$P_i=\frac{e^{x\beta}}{1+e^{x\beta}}$ Since observed values of Y say, y_i's (i 1, 2..., n) i = are independently distributed as binomial with parameter $p_i \sim$y bin(p,1) the likelihood function of Y is given by

$$l(\beta,Y)=\prod_{i=I}^{n}P_i^y i\,(1-p)=\prod_{i=1}^{n}\left[\frac{e^{x\beta}}{1-e^{X\beta}}\right]^{y_i}\left[\frac{1}{-1+e\times\beta}\right]^{1-y_i} \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Our objective is then to get an estimator) ($\hat{\beta}$ = β_0+ $\beta_{1+\ldots}$ +β_p) of β which maximizes the likelihood function expressed in equation (2). Since the likelihood equations are non-linear in the parameters, the Newton-Raphson iterative maximum likelihood estimation method that expresses $\hat{\beta}$ at the th (u +1) [th] cycle of the iteration is expressed as $\hat{B}_{u+1}=\hat{\beta}_u$ + (X$\hat{v}_u$xX) $-X1Ru$ ′ where u=0,1,2, 3…… and V is a diagonal matrix with its diagonal elements = diag $p_i(1-p_i)$ = Cov Y . Finally, $\hat{\beta}$ is the resultant maximum likelihood estimator of β with residual R = Y − $\hat{P}$ (Collet, 1991; Greene, 1991). Newton's method usually converges to the maximum of the log-likelihood in just a few iterations

without the data are particularly completely conditioned (Greene, 1991). All the parameters $\hat{\beta}_{1:Q} + \beta_1 \ldots \beta_p$ and estimates of P [$y_{i=}$ 1 / X] i = for each subject were computed using the SPSS software.

3.5.1. Logistic Regression Models Coefficients Interpretations

Hosmer-Lemeshow(1989). The slope or rate of change of a function of the outcome variable per unit of change in the predictor variable represents the estimated coefficients for the predictor variables. Thus, interpretation contains two issues: (i) determining the functional relationship between the outcome variable and the predictor variable and (ii) correctly defining the unit of change for the predictor variable. Assuming that all other predictors remain constant, the estimated logistic coefficients s $\hat{\beta}_j$ reflects both linear and non-linear relationships. They will be understood as the change in the log odds for every unit increase or decrease (depending on the variable change in j x). As a result, the probabilities of being in the category of interest for the *i* th subject, given by $e^{B_j} = \frac{\hat{p}}{1-\hat{p}}$ where i = 1, 2, 3... p, reflects the multiplicative factor by which the odds change for every u-units change in x_j while adjusting for the other predictor variables. One of the L-levels was used as a reference category for interpreting predictor variables with L levels (L,≥2). As a result, the study makes use of SPSS software and codes the dependent and predictor variables.

Dependent Variable Coding

Original Value	Internal Value
Food secure	0
Food insecure	1

3.6 Variable Selection and Goodness-of-fit

By posting the null hypothesis H_0: $\beta_i = 0$ versus the alternative H_1: $\beta_i \neq 0$ for at least on i=1, 2..., n, the individual effects of each predictor variable in explaining the outcome varible were made. UsingWald chi-square($\left[\frac{\hat{\beta}}{s \cdot e(\beta)}\right]^2$)e (e, which is distributed as a chi-square with one degree of freedom, and the Likelihood Ratio Test, the significance test for each coefficient in the model was performed. The Wald statistic does, however, have some unfavorable characteristics for big

coefficients since the inflated standard error reduces the Wald statistic's (chi-square) value and produces type II errors. However, Agresti (1996) claimed that the likelihood ratio (LR) test outperformed the Wald test in terms of accuracy when using small sample sizes. To evaluate the importance of each predictor variable in this study, the Wald and LR statistic was utilized. Hosmer-Lemeshow (1989). (1989). Additionally, any predictor variable with a zero-cell frequency was handled when cross-classified with the outcome variable by either collapsing the categories of the predictor variables in a logical way to eliminate the zero cell or eliminating the category; or, if the variable is cordially scaled, modeling the variable as if it were continuous. Some literature suggests that there should be 50 cases for each predictor, while others advise 10 cases per predictor, to decide how many predictor variables should be taken into account in a study. While logistic dependents, when classified, have lower information quality, there should often be much fewer independents than in an ordinary least squares regression. A general guideline in this regard is that there should be no more while logistic dependents, when classified, have lower information quality, there should often be much fewer independents than in an ordinary least squares regression. Generally speaking, there shouldn't be more than one independent for every ten cases in the sample. If categorical independents exist, such as dichotomous ones, then the number of cases should be calculated using the smaller of the two groups. For each of the predictor variables included in the analysis, this study took the general rule of thumb of 10 observations into consideration. A stepwise approach was employed for multivariate models, in which variables were sequentially chosen for inclusion or deletion from the model based only on statistical criteria.

Hence, advertisements were taken into account in this investigation. The stepwise approach can be broken down into two basic variations: (a) forward selection with a test for backward elimination, and (b) backward elimination followed by a test for forward selection. To narrow down the list of predictor variables that will work together to influence the outcome variable, the study used the stepwise forward likelihood ratio approach. The final determination of whether to include each predictor variable was based on an analysis of its Wald statistic and a comparison of its estimated coefficient on the multivariate regression model with its univariate estimate in the model that contained just that predictor. Using these criteria, variables that don't add to the model were removed, and a new Ward model suited the data. Via the LR test, the new model was contrasted with the previous one. In addition, the entire model coefficients were contrasted with

the estimated coefficients for the remaining variables. This led to the completion of (deletion, refitting, and/or validating). After acquiring a model that included the crucial variables.

3.6.1. Goodness-of-fit

Statistical tests are existent for determining the significance or goodness-of-fit of a logistic regression model. These measures include Deviance; Pearson; Likelihood Ratio Test; Hosemer-Lemeshow Goodness-of-Fit Test (assesses the fit of the model by comparing the observed and expected frequencies); and Nagelkerke Pseudo R_2. The goodness of fit of the model can also be assessed by considering how well the model classifies the observed data (in the Classification Table) or examining how "likely" the sample results are, given the estimates of model parameters (SPSS, 2022). In this concern, examination of the confusion matrix by transforming the threshold value whenever required will help to analyze the overall performance of the model. The fit is considered to be good if the overall correct classification rate exceeds 50%. According to Collet (1991), the selection of an appropriate threshold value is made either by categorizing the value that minimizes the overall proportion of misclassification or by compromising between the minimization of the two misclassification probabilities, that is the probability of declaring an individual to be in group 0 (food secure) when it should be in group 1 (food insecure) and vice versa. The study used the default threshold cut value of 0.5 which was fixed by SPSS software. The computed value of the likelihood ratio (LR) test, which is defined as -2 $[L_0 - L_1]$ (where L_0 and L_1 are the maximized log-likelihoods under the null and alternative hypothesis) was used to test the null hypothesis that the p-coefficients for the covariates in the model are not significant in explaining the response variable against the alternative that at least one of the covariates is important. Under the null hypothesis, the LR is distributed as $\chi^2_p(\alpha)$ and hence if LR exceeds that of $\chi^2_p(\alpha)$, we reject the null hypothesis and conclude that at least one of the p-covariates included in the model is important in explaining the variation in the outcome variable. Similarly, the null hypothesis that the model fits the data against the alternative that the model does not fit was tested using Hosemer-Lemeshow Test. A non-significant Hosemer-Lemeshow means that the observed and predicted values are close to each other and the model defines the data well. Also, if the Omnibus test of model coefficients is significant, it implies that the model fits the data.

CHAPTER IV: RESULTS AND DISCUSSION

4.1.1 DESCRIPTIVE SUMMARY

It was observed that 42.5% of the sampled households of the Chapainawbganj Sadar and Godagari upazila were food secure while 57.5% of sampled households were food insecure. Predictor variables are presented in Table 4.1.1.

Table 4.1.1 Descriptive summary of some selected predictor variables

I	Variables	Household food security				Test Statistic (Z)
		Food secure (n_1=51)		Food insecure (n_2=69)		
		Mean	S.E of mean	Mean	S.E of mean	
1	Age (in years)	53	1.60	50	1.29	1.34
2	Family size (in numbers)	5.96	.30	7.12	.34	-2.44
3	Land size (in hectors)	1.65	.25	1.73	.14	-.264
4	Calorie per person per day (kilo calorie)	2643.05	41.39	1737.58	19.69	21.41
5	Annual yield (kg)	857.24	14.81	397.90	10.18	26.42
6	Annual income (tk)	207821.13	4816.01	166109.04	3236.35	7.31
7	Head Count Ratio (H)	0.42		0.57		-
8	Shortfall/surplus index (P)	0.25		-0.30		-

Source: Author analysis

Table 4.1.1, shows the significant difference between food-secure and food-insecure groups. A group of households was made regarding the respective variables summarized in the table with a level of Significance; the z-test result shows that there is a significant difference in family size, calorie per person per day, Annual yield, and Annual income**.**

From table 4.1.1, we can see that the national recommended 2122 kilo calories per person per day can be met by 42.5% of households while the majority 57.5% of households are unable to meet the daily recommended calorie intake. Surplus index P (-0.30) indicates that the insecure household deficits daily recommended calories by (-30%) and (0.25) indicates that food secure household exceeded the calorie requirement by (25%). The mean age is 53 food-secure household heads with a standard error of 1.60 and the mean age of a food-insecure household is 50 with a standard error of 1.29. A family member of a food-secure household is 5.96 with a standard error of .30 and the average member of a food-insecure household is 7.12 with a standard deviation of .34. The mean cropping land size of a food-secure household (1.65) hectares with a standard error

(.25) while food insecure household holds (1.73) hectors of land with a standard error (.14). On average, food secure households produce 857.24 -kilogram food grain with standard error 14.81 while food-insecure households produce approximately 397.90 kilograms of food grain with standard error of 10.18. The annual average income of food-secure households is about 207821 tk per year with a standard error of 4816.01. On the other food insecure households' annual average income is 166109.04 tk per year with standard error 3236.35.

Table 4.1.2 Calorie intake of different groups

Calorie intake group	Average calorie intake	Frequency	Percent
Ultra poor	1523.628	17	14.20
Hardcore poor	1702.168	27	22.50
Absolute poor	1922.071	25	20.80
Non- poor	2663.054	51	42.50

Source: Author analysis

Table 4.1.2 represents about 15 % of households belonging to the ultra-poor (<1600) whose per day per person calorie intake was 1523.628 Kcl. 14.20% of households from the hardcore poor group (1805) whose daily average calorie intake is 1702.168 Kal. 22.50% of household belongs to the absolute poor (<2122) whose daily average calorie intake 1922.071 Kcl. 20.80% of household is non-poor (>2122) daily average calorie intake is 2663.054 Kcl. The maximum number of households belongs to the non-poor group 42.50%.

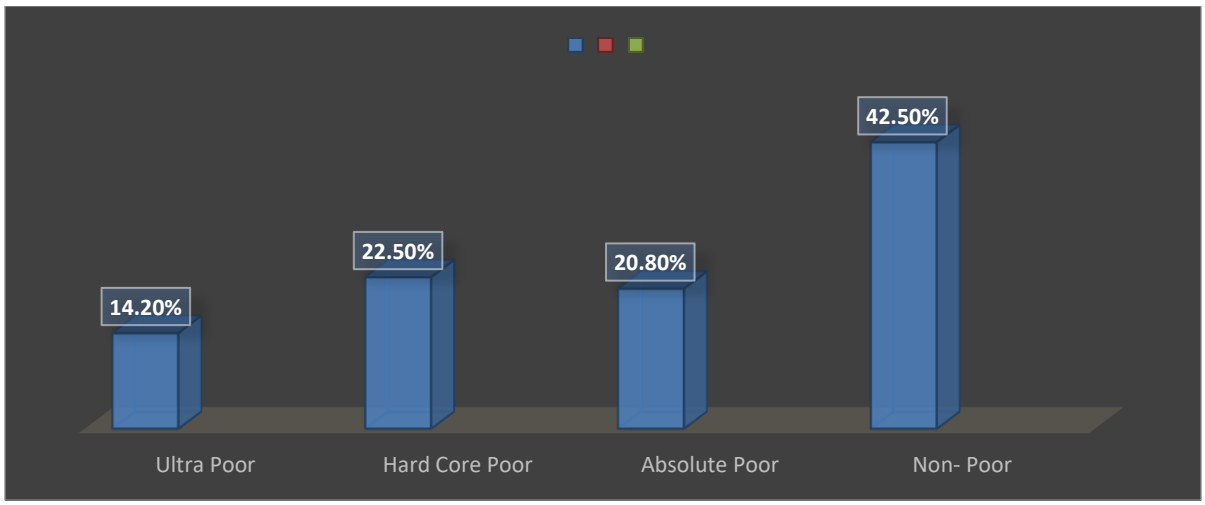

Figure 4.1.2: Calorie Intake of Different Groups

4.2 Univariate Results

The systematic association between each predictor variable and household food security status was conducted by cross-tabulating each predictor variable against the outcome variable performed to select the significant candidate predictor variables that would qualify for the binary logistic regression model.

Table 4.2.1 Distribution of Household Food Security Status by Gender.

Variables		Male	Female	Chi-square	LR	df
Gender	Food secure	48	3	0.45	0.144 (0.705)	1
	Food insecure	66	3	(0.703)		
	n	114	6			

Source: Author analysis

From Table 4.2.1 we can see that the total number of male-headed households is (114) and female-headed households are (6). Between food security and insecure group growing number of male-headed households in food insecure households(66), and female-headed households is only 3. On the other hand, the number of male-headed householdsin food insecure household is(48), and female is only 3. with statistically insignificant.

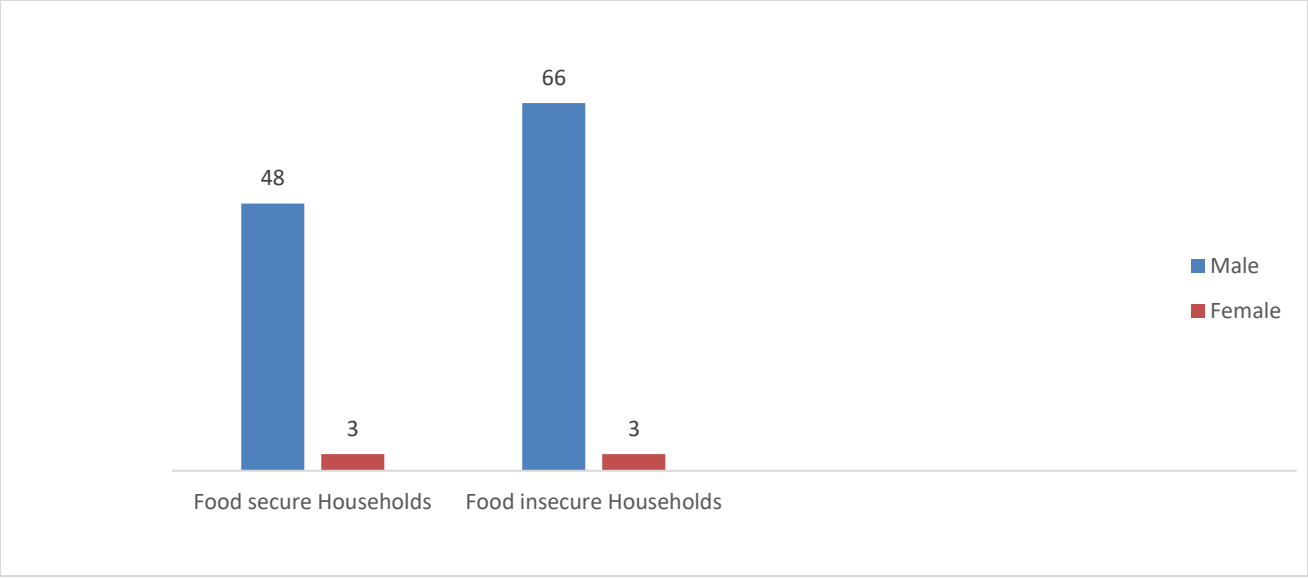

Fig 4.2.1: Household Food Security Status by Gender

Table 4.2.2 Distribution of Household Food Security Status by Age

Variables		≤ 52 Years	>52 Years	Chi-square	LR	df
Age	Food Secure	25	26	.946 (0.331)	.946 (0.331)	1
	Food insecure	40	29			
	n	65	55			

Source: Author analysis

Table 4.2.2 indicates the average age of the sampled household is 52 years. The total number of household heads belonging to less than equals 52 is (65) and the total number of age of household heads greater than 52 is (55). In food, insecure households (40) respondent belongs to less than 52 years further the number of (26) respondents belongs to greater than equal 52 years. On the other hand, for food-secure households (25) respondent belongs to less than 52 years, and (26) respondent belongs to greater than 52 years. Food insecure households have the maximum number of aged respondents with statistically insignificant.

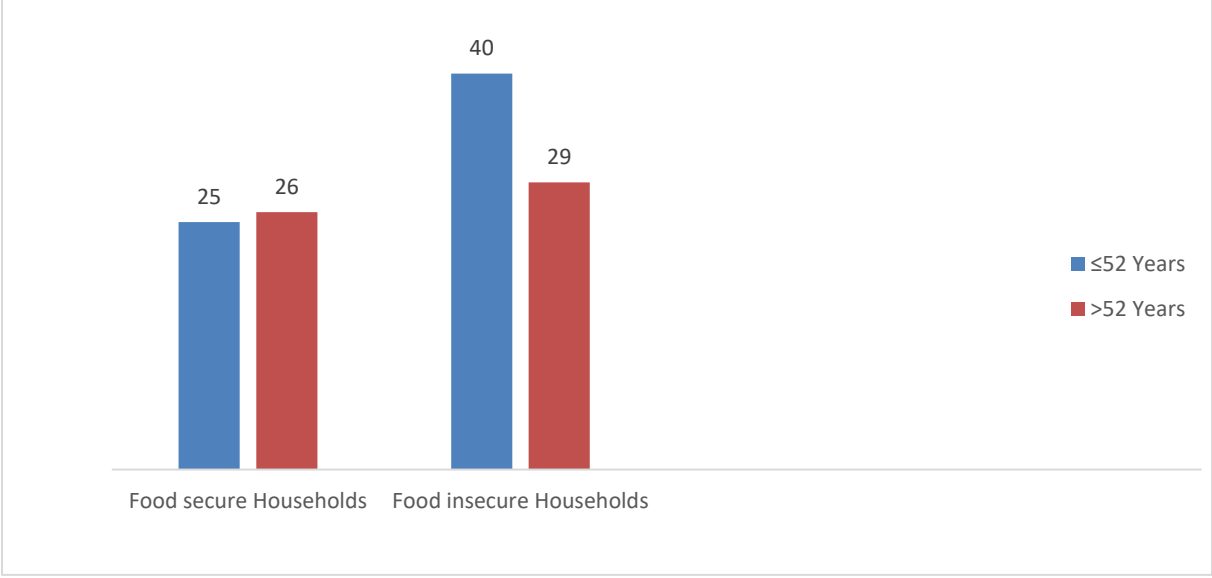

Figure 4.2.2: Household Food Security Status by Age

Table 4.2.3 Distribution of Household Food Security Status by Family Size

Variables		≤ 6 Members	>6 Members	Chi-square	LR	df
Family Size	Food secure	35	16	4.494 (0.034)	4.556 (0.033)	1
	Food insecure	34	35			
	n	69	51			

Source: Author analysis

From Table 4.2.3 we can see that family size is an important indicator of food insecurity the average family size in sampled households is 6. The total number of family sizes less than or equal to six is (69), and the total number of family sizes greater than six is (51). Family size less than or equal to 6 is 34 in food-insecure households, and family size greater than or equal to 6 is 35. Food secure households with family sizes less than six are (35) and those with family sizes greater than six are (16) with statistically insignificant significance at the 1% level of significance.

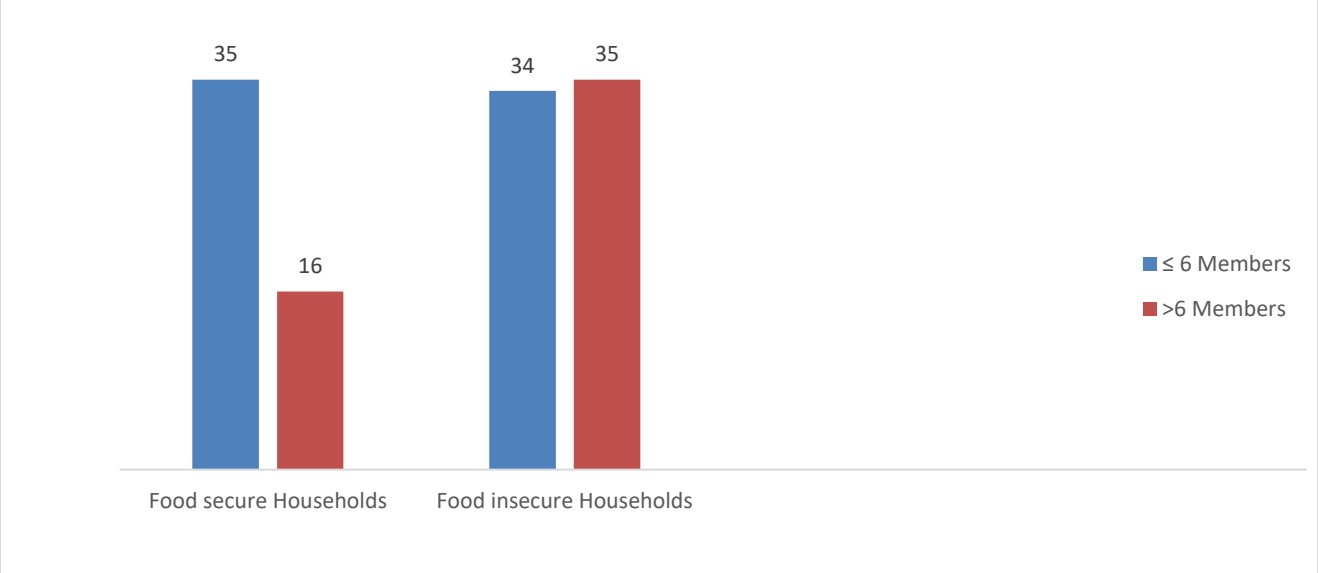

Figure 4.2.3: Household Food Security Status by Family Size

Table 4.2.4 Distribution of Household Food Security Status by Marital Status

Variables		Married	Widowed	Chi-square	LR	df
Marital Status	Food secure	42	4	. 132 (.716)	.133 (.715)	1
	Food insecure	55	14			
	n	97	23			

Source: Author analysis

Table 4.2.4 indicates that the total number of married and widowed household heads (was 97 and 23), (55) married households from food insecure households, and 42 married household heads from secure households. On the other hand, the food insecure group has only 4 widowed household heads, while the food insecure household has 14 with statistically insignificant.

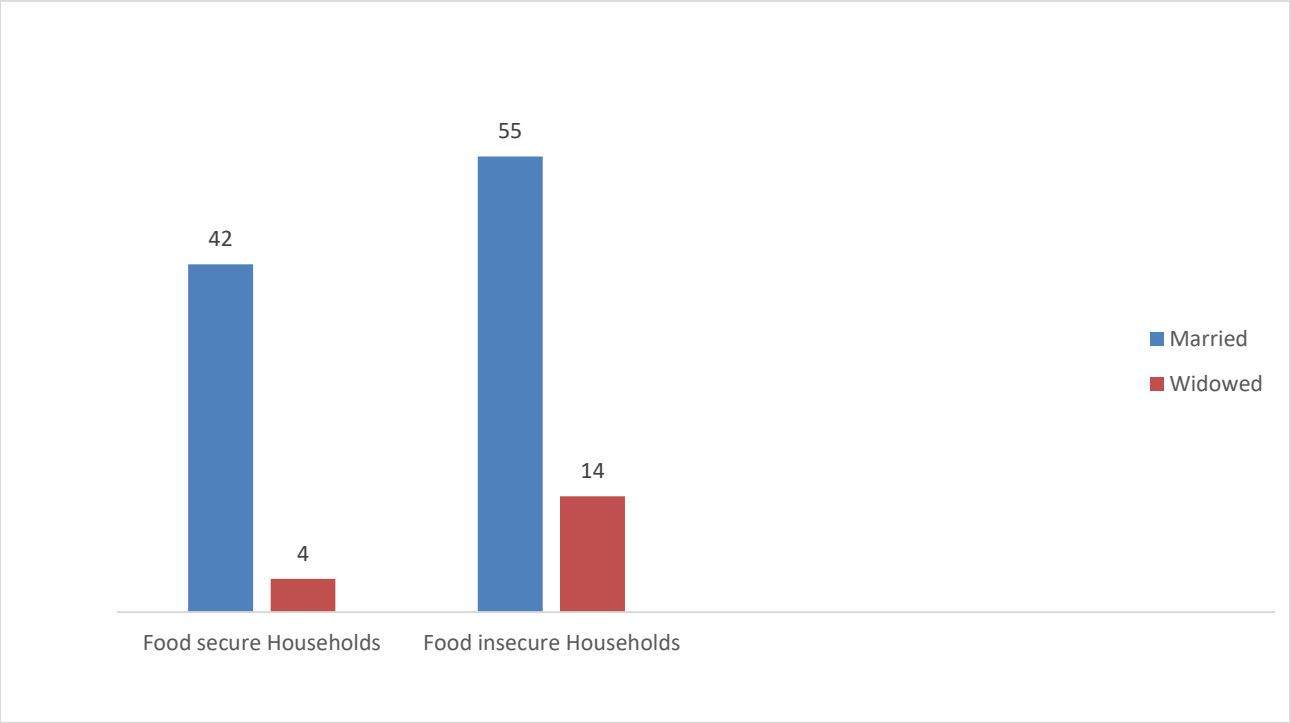

Figure 4.2.4.: Household Food Security Status by Marital Status

Table 4.2.5 Distribution of Household Food Security Status by Literacy Status

Variables		Primary (1-5)	Secondary (6-10)	Higher (>10)	Chi-square	LR	df
Literacy Status	Food secure	29	15	7	1.728 (.421)	1.776 (.411)	2
	Food insecure	34	19	16			
	n	63	34	23			

Source: Author analysis

From Table 4.2.5, we can see that the education levels of sampled households are primary, secondary, and higher (63, 34, and 23). The education levels of food-insecure household heads are primary (34), secondary (19), and higher (16). On the other hand, food-secure households head education levels primary (29), secondary (19), and higher (7) It can be seen that the number of higher educations is less. Level of education helps in promoting awareness of the possible advantages of modernizing agriculture through technological inputs and by diversifying household incomes, which in turn enhance household's supply with statistically insignificant.

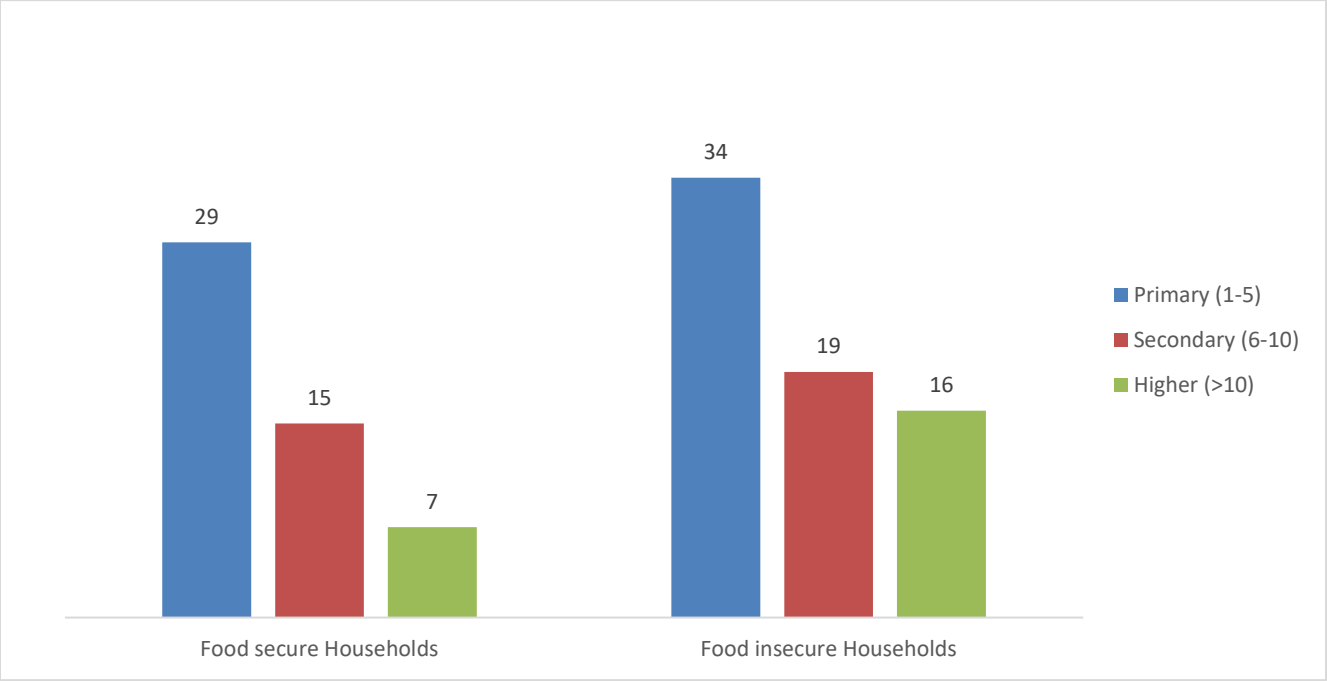

Figure 4.2.5 Household Food Security Status by Literacy Status

Table 4.2.6 Distribution of Household Food Security Status by Own Land for Cropping

Variables		Yes	No	Chi-square	LR	df
Land for Cropping	Food secure	35	16	.209 (.648)	.028 (.648)	1
	Food insecure	50	19			
	n	85	35			

Source: Author analysis

Table 4.2.6 indicates the total number of households that have their land for cropping (85) and the number of households who have not own land for cropping or pasture (35). The number of food-secure households (35) households has their land for cropping or pasture while the number of food-insecure households (50) households has their land for cropping. In contrast, the number of food-insecure households (19) have no land for cropping while the number of food-secure households (16) that have no land with statistically insignificant.

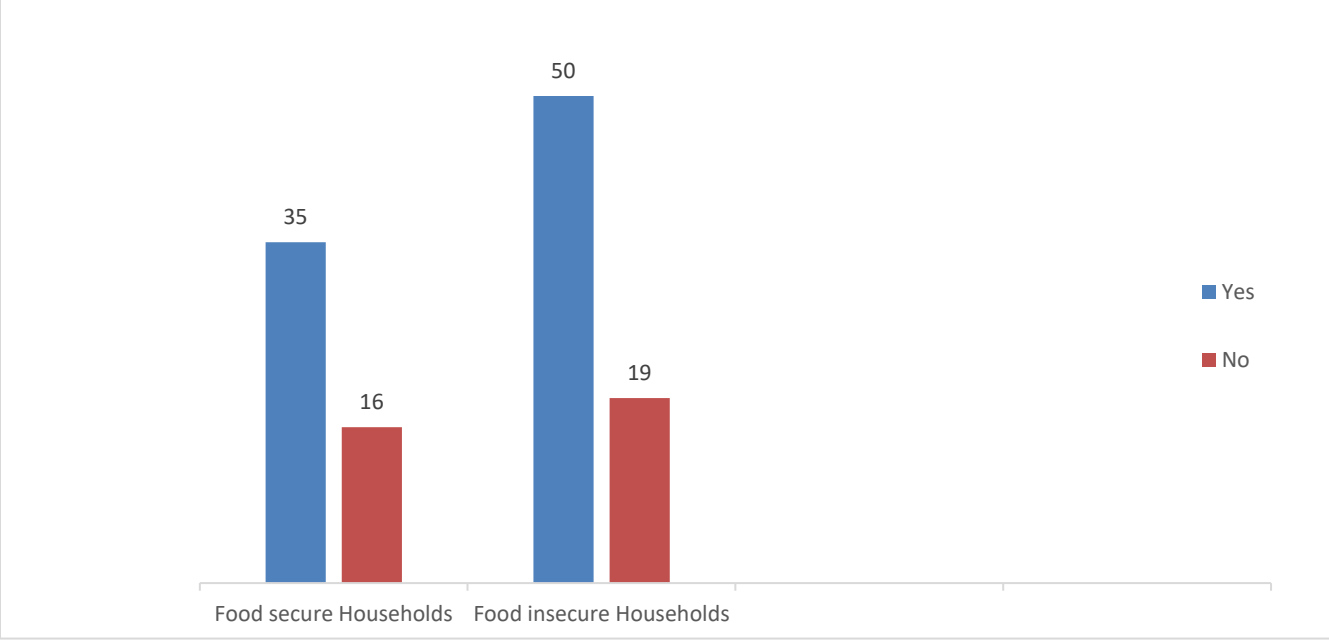

Figure 4.2.6: Household Food Security Status by Own Land for Cropping

Table 4.2.7 Distribution of Household Food Security Status by Land Size

Variables		≤1.69 Hectares	>1.69 Hectares	Chi-square	LR	df
Land Size	Food secure	35	16	.513 (.474)	.516 (.473)	1
	Food insecure	43	26			
	n	78	42			

Source: author analysis

Table 4.2.7 indicates the total number of land sizes less than 1.69 hectares (78) and greater than 01.69 hectares (42). The number of Cultivated lands of food insecure households land size is (43) and the number of land sizes greater than 1.69 is (26). In contrast, the number of food-secure households with land sizes less than equal 1.69 is (35) household's land sizes greater than 1.69 is (16) statistically Insignificant.

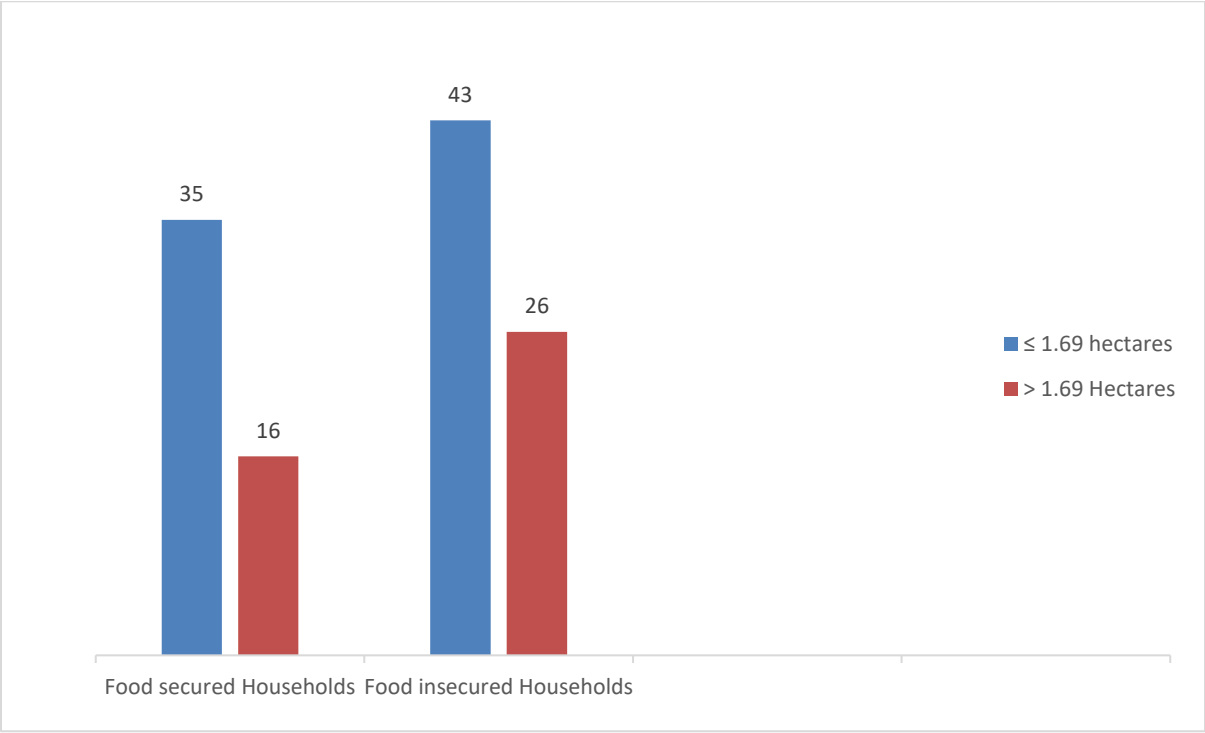

Figure 4.2.7: Household Food Security Status by Land Size

Table 4.2.8 Distribution of Household Food Security Status by Land Fertility

Variables		Less fertile	Medium fertile	Chi-square	LR	df
Land Fertility	Food secure	31	20	.023 (.880)	.023 (.880)	1
	Food insecure	41	28			
	n	72	48			

Source: Author analysis

Table 4.2.8 shows that the total number of less fertile and medium fertile land is (48) and (72) respectively. The number of food insecure households with less fertile land (41 households) has a farmland fertility status of medium, while the number of food insecure households (28) has less fertile land. Again, the number of food-secure households with farmland (31) is medium fertile, whereas the number of food-secure households with arable land (28) is less fertile and with statistically insignificant.

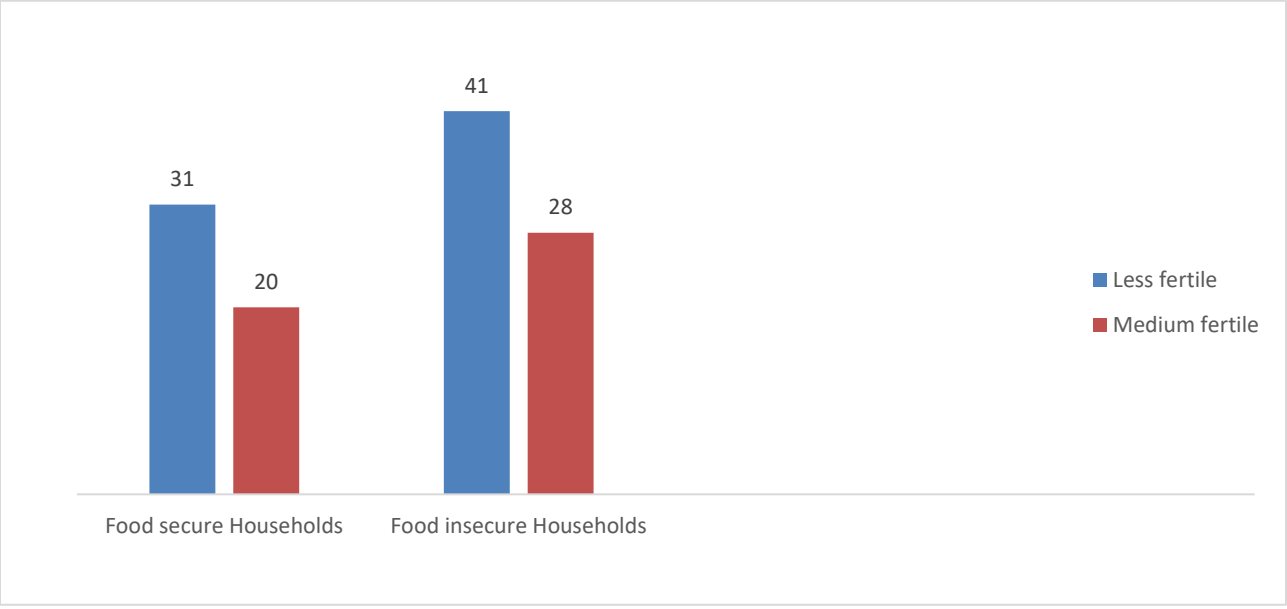

Figure 4.2 8: Household Food Security Status by Land Fertility

Table 4.2.9 Distribution of Household Food Security Status by Annual Income

Variables		≤183577 tk	>183577 tk	Chi-square	LR	df
Annual Income(tk)	Food secure	11	40	44.469 (.000)	47.272 (.000)	1
	Food insecure	57	12			
	n	68	52			

Source: Author analysis

Table 4.2.9 represents the number of food insecure households (58) households whose yearly income is less than the equal sample average while the number of (12) food secures households (of households with yearly income less than the equal sample average. On the other hand, the number of food insecure households of households earning per year is greater than the sample average while the number of food secure households (11) and (40) of households earning is greater than the sample average with a statistically significant at .99% level of significance.

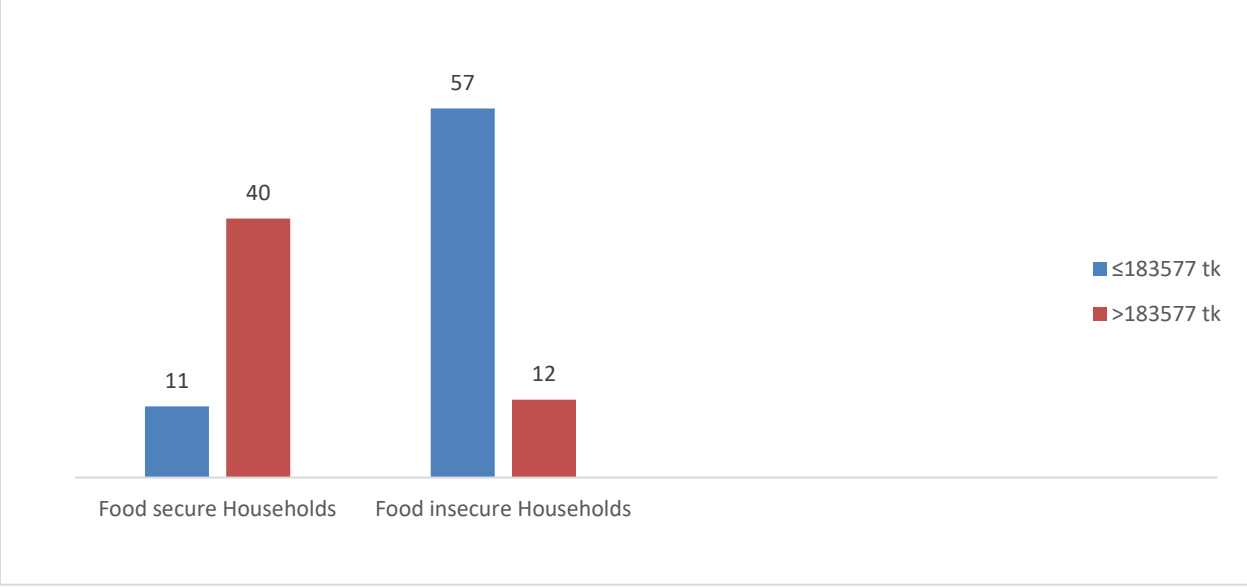

Figure 4.2.9: Household Food Security Status by Annual Income

Table 4.2.10 Distribution of Household Food Security Status by Annual Production

Variables		≤ 593 Kilogram	>593 Kilogram	Chi-square	LR	df
Annual Production	Food secure	5	46	62.244 (.000)	69.744 (.000)	1
	Food insecure	57	12			
	n	62	58			

Source: Author analysis

Table 4.2.10 indicates the number of food insecure households (57) households who have yearly grain production less than equal to the sample average yield of 593 kilograms while food secure households (5) have grain production less than equal to the sample mean. On the other, the number of food insecure households is (12) households whose yearly grain production is larger than the sample average while food secure households (46) households have yearly grain production greater than the sample average of 593 kilograms with statistically significant at .99% level of significance.

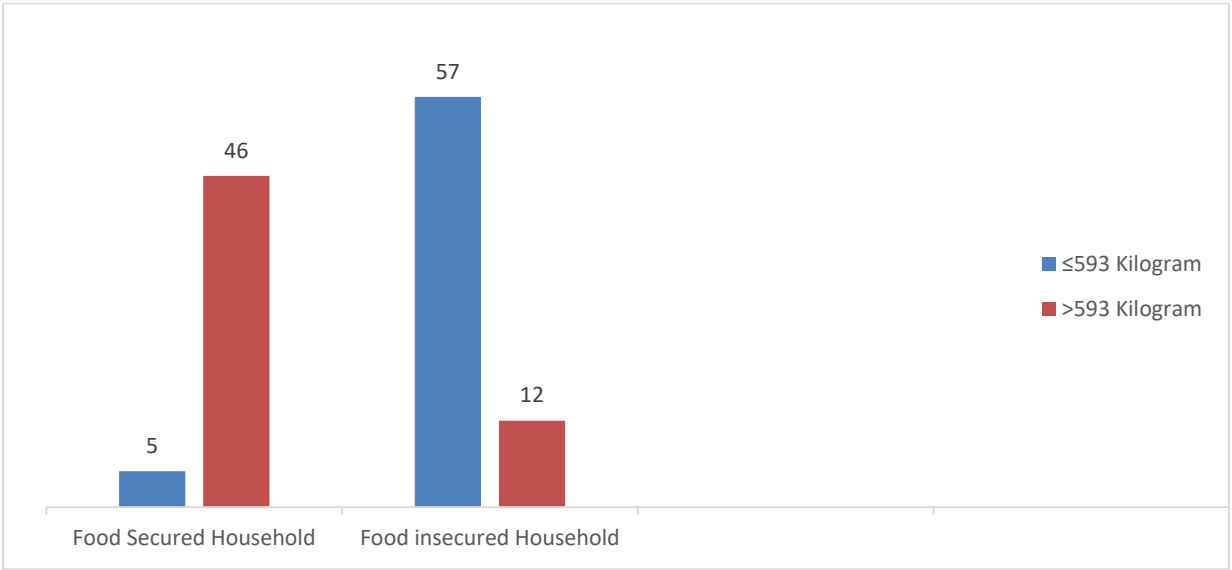

Figure 4.2.10: Household Food Security Status by Annual Production

Table 4.2.11 Distribution of Household Food Security Status by Food Aid

Variables		Food aid is good	Food aid is not good	Chi-square	LR	df
Food Aid	Food secure	24	27	2.319 (.128)	2.314 (.128)	1
	Food insecure	23	46			
	n	47	73			

Source: Author analysis

Table 4.2.11 depicts the attitudes of food insecure households toward food aid: 23 households said food aid is good, while 46 households said food aid is bad. Again, the number of food secure households (24) Households said that food aid is good while the proportion of food secure households (46) households said food aid is not good with statistically significant.

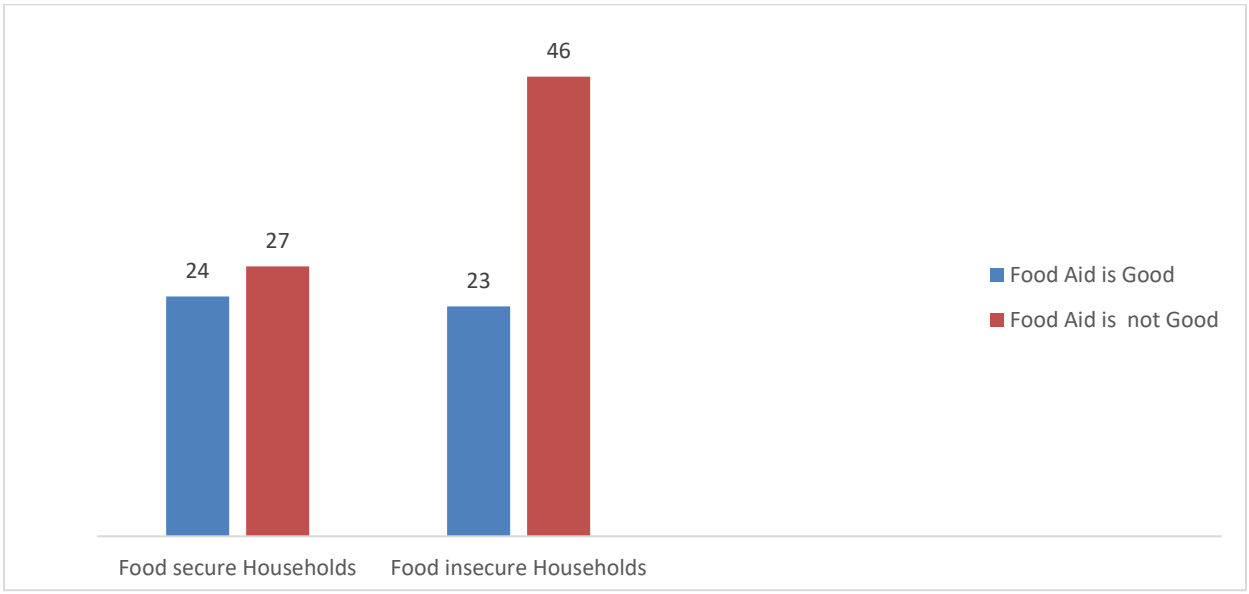

Figure 4.2.11: Household Food Security Status by Food Aid

To describe the relationship between food security status and its determinants, we have used the chi-square test. From the chi-square test, it is seen that age, family size land size, and annual

income were significantly related to household food security status at 1%, 97.5%, 99%, and 1% levels of significance**.**

4.3 Univariate logistics regression result

Variables	B	S. E	Wald	P value	Odds Ratio	95% CI for the Odds Ratio	
						Lower	Upper
Gender	-.318	.838	.144	.704	.727	.141	3.760
Age	.361	.371	.944	.331	1.434	.693	2.971
Marital Status	.172	.474	.132	.716	1.188	.469	3.007
Family Size	-.812	.386	4.421	.036	.444	.208	.946
Own Land	-.185	.405	.209	.648	.831	.376	1.837
Land Size	.280	.391	.512	.474	1.323	.615	2.846
Land Quality	-.057	.377	.023	.880	.945	.451	1.979
Annual Income	-2.849	.466	37.445	.000	17.273	.023	.144
Annual Yield	-3.777	.568	44.227	.000	.023	.008	.070
Food aid	.57	.379	2.300	.129	1.778	.845	3.379
Literacy Status			1.695	.429			
Literacy Status (1)	-.668	.519	1.655	.198	.513	.181	1.693
Literacy Status (2)	-.590	.570	1.073	.300	.554	.181	1.693

Source: Author analysis

Result 4.3 describes the wald statistics for Family size, Annual income and Annual yield were positively related with household food security status and were also statistically significant. That's mean the separate effect of each of the predictors on household food security status was significant.

On the other hand, the predictor variables, gender, age, literacy status, marital status, own cropping land, land size, land fertility, there is no systematic relationship between variables

Hence, based on the univariate results, the predictor variables that were selected for multivariate logistic regression model were Family Size, Annual yield and Annual Income.

4.4 Multivariate logistic regression result of food security status and socio-demographic variables

11 selected predictor variables and some selected interaction terms were included in the binary analysis. Using the stepwise (likelihood ratio) method, four out of ten predictor variables were selected and have a significant joint impact in determining household food insecurity. The binary logistic regression result is summarized in Table 4.4.

Table 4.4 Multivariate logistic regression between household food security status and socio-demographic variable

Variables	B	SE	Wald	P value	Odds Ratio	95% CI for the Odds Ratio	
						Lower	Upper
Family Size (1)	.875	.641	1.866	.172	2.400	.683	8.426
Annual Yield (1)	-3.585	.674	28.297	.000	.028	.007	.104
Annual Income (1)	-2.651	.645	16.864	.000	.071	.020	.250
Constant	3.260	.685	22.676	.000	26.58		

Source: Author analysis

Table 4.4 Demonstrates binary logistic regressions used to identify the most important factors of household food security status. The omnibus test of model coefficients had a chi-square value of 92.073 on 3 degrees of freedom which is highly significant indicating that the predictor variables in Table **4.4**. Have a joint significant importance in predicting household food security status. The model chi-square is 71.572 on 5 degrees of freedom with a .000 level of significance. Indicating that the inclusion of the explanatory variables contributed to the improvement in the fit of the full

model. The values of Cox and Snell and Nagelkerke R Square .536 and .720 indicate that 53.60% and 72.00% of the total variation of household food security status was explained by annual yield and annual income. The Hosmer- Lemeshow test result reported chi–square value of 2.026 with a p-value of .846 on 5 degrees of freedom. Showing that there is no difference between observed and expected values. The model fits the data at an acceptance level. Assessment of the interaction terms showed that none of them were statistically significant and hence were excluded from the model.

To analyze the impact of major determinants on the probability of household food security status, we have used a binary logistic regression model. According to the binary logistic regression model, Respondents whose family members were less than or equal to 6 had 2.40 times less chance to get food security than respondents whose family members were greater than 6. Households who annually produce a 593-kilogram yield have .028 less chance to get food security. A household earning less than the sample average has .071 times the chance of obtaining food security as those earning more than the average.

Table 4.5 Classification table for the household food security status

Observed		Predicted		Percentage Correct
		Food Secure	Food Insecure	
Household Food Security Status	Food Secure	44	7	86.30
	Food Insecure	8	61	88.4
Overall percentage				87.50

N.B.: The cut value is 0.50

Table 4.5 shows the model's accuracy in predicting the right category (Food secured/Food insecure) for each case is shown in Table **4.5** for our reference. It is observed that the model was correctly classified in (87.50%) of cases. A cut point was identified that optimized sensitivity (88.30%) which is the percentage of correct prediction of the category of interest and specificity (88.40%) which is the percentage of true negative. In general, the goodness-of-fit assessment of the binary logistic regression model implied that the model fits the data well.

The multicollinearity diagnostics test was conducted using condition number, tolerance, VIFs, and Kendall's correlation matrix of the predictor variables summarized in Table 4.6.

Table 4.6 Results of Co-linearity Statistics

Model Coefficients	Co-linearity Statistics			
	Eigenvalue	Condition Index	Tolerance	VIF
Family Size	.473	2.682	.974	1.027
Annual Yield	.099	5.871	.771	1.298
Annual Income	.030	10.627	.781	1.280
Condition number = 19.18				

Source: Author analysis

Table 4.6 indicates all the tolerance values are close to unity and the values of VIFs do not exceed 5 implying that multi-co-linearity may not be a cause of concern. Condition number 19.18 indicates that there is no serious problem with multi-co-linearity.

4.7 Kendall's tau-b correlation matrix

	Family Size	Annual Yield	Annual Income
Family Size	1	-.157	-.105
Annual Yield	-.157	1	.467
Annual Income	.105	.467	1

Source: Author analysis

Table 4.7 indicates that none of the bivariate correlation between the two variables exceeds 0.8 indicating that there is no serious Multi co-linearity among the categorical predictor variables

Internal consistency reliability of the data used in the study is concerned; Cronbach alpha coefficient of 0.182 is obtained. This value is an estimate and a lower bound for the true reliability of the sample survey. This means on average, household heads have similar opinions or judgments towards considering the 3 items or variables (Family Size, Annual Yield and Annual Income) as major determinants of food insecurity.

CHAPTER V: SUMMARY AND CONCLUSIONS

The main objective of the study was to identify some of the factors that influence household food insecurity in the North-Western Region of Bangladesh. A primary and secondary source of data was used to conduct the study. In gathering the primary data, a simple random sampling method was employed to select the final sampling units. All the predictor variables were obtained from the primary data. The period of the study was from June 2021 to June 2022. To determine the outcome variable (household food security status) an HFBM was adopted and the recommended daily calorie requirement was used as a national food security line. Household food insecurity causation was then examined using the logistic regression model. At first, the study employed 11 predictor variables that were categorized under socio-demographic characteristics. In addition, some interaction terms that were expected to have socio-economic and/or demographic importance were included in the model.

To determine the food security status of rural households, we have used frequency distribution. From the frequency distribution, it is observed that 42.50% of the respondents said that their food is secure and 57.50% of the respondents said that their food is insecure. Again, 60.80% of the respondents said that their food is not good for their health and 39.20% of the respondents said that their food is good for their health.

To describe the relationship between food security status and its determinants, we have used the chi-square test. From the chi-square test, it is seen that family size annual yield and annual income were significantly related to household food security status at 1%, 97.5%, and 99% levels of significance.

To analyze the impact of major determinants on the probability of household food security status, we have used a binary logistic regression model. According to the binary logistic regression model, Respondents whose family members were less than or equal to 6 had 2.400 times less chance to get food security than respondents whose family members were greater than 6. Households who annually produce a 593-kilogram yield have .028 less chance to get food security. A household

earning less than the sample average has .071 times the chance of obtaining food security as those earning more than the average.

In general, in our opinion, the food security indices estimated in this study were fair representations of the extent and dimension of food security/insecurity in the North-Western Region of Bangladesh. To accomplish food security, strategies should be deliberate in a way that would focus on and address the identified determinants as well as other factors that are useful to achieve household food security.

CHAPTER VI: POLICY IMPLICATIONS

The study identified important three factors that influenced household food insecurity in the North-Western Region of Bangladesh. The policy implications of the study are summarized here under

- The size of the family compromises food insecurity for an increase in household size by one household would decrease the likelihood of a farming household being food insecure. It should be mentioned that one of the main contributors to food insecurity in the research area is household size. This suggests that governmental initiatives aimed at improving family planning to decrease household size should receive sufficient attention and priority.

- Households with only earners having less income may make it difficult to buy enough food for all of the family members while income is the most important factor of getting food insecurity. Off firm's activities are in the developing stage in the study area. The government should take initiatives to income generation activities to increase household income. Women also can participate in income generation activities to enhance their family's income with their male counterparts.

- Increasing the productivity of major cereal crops through the use of increasing farm inputs such as fertilizers, improved seeds, pesticides, credit service, access to irrigation facilities and post-harvest loss management would help to address food insecurity and it will meet the necessity of good and nutritious food towards achieving sustainable development goals.

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