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Original Article

Rearing and marketing of livestock in the Hakaluki Haor: Impact on livelihood, food and nutrition security

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A B S T R A C T

The study aims at assessing and analyzing the core food security indicators to formulate policy option to improve food and nutrition security of the haor people. A survey was conducted using structured questionnaire covering 200 households in 2017. Socio-economic and demographic characteristics influence the production, income and consumption process of farm household. Average family size, literacy rate and dependency ratio were 6.45, 0.48 and 0.69, respectively. Average land area and income of the farm household were 250.62 decimal and BDT 246300.72 respectively. Total income increased notably with the increase in income from agriculture and livestock. The annual family expenditure increased significantly with the increase in food expenditure, land size and education. The yearly family expenditure was BDT 2,48,309. Farmers consumed 22 food items among which rice, potato; leafy vegetables, milk, meat and egg are the most important food items. Average daily per capita food, calorie and protein intake were 1172 g, 2419 kcal and 86 g, respectively. Average daily per capita calorie and protein received from livestock and their products were 148.16 kcal and 16.62 g respectively. Average proteins from animal origin were 21.25 g of which fisheries contributed 22% and livestock contributed 78%. Average HDDS was 11.85. Binary and multinomial logistic regressions suggested that food security decreased with the increase in family size and increased with the increase in weekly cost of all food items. Marketing and adopting value chain by the farm households increased the income significantly. Absolute poverty was 33% and hard core poverty was 14% on the basis of DCI method. Absolute and hard core poverty were 29% and 20% respectively on the basis of CBN method. The major problems of the peoples were loss of assets due to natural calamities, high price of food items, improper marketing channels and inadequate supply of agricultural inputs. There are vast scope of utilizing land and water resources for ensuring food and nutrition security of livestock in the haor area. A package of policy options is suggested to increase food and nutrition security of the haor people.

Introduction

Bangladesh is the most disaster prone and climatic vulnerable country in the world. It is still lacking natural and human resources to increase livelihood and food security of people. The Government of Bangladesh has declared five regions as hard to reach (H to R) region such as North-Eastern Haor area, South-Eastern hilly area, tea garden, North-Western river erosion area and South-Western salinity prone coastal area where Hakaluki haor is a vulnerable and ecologically critical area (Rahman and Razzaque, 2000). Hakaluki Haor comprising upazillas namely Barlekha, Juri and Kulaura of Moulivibazar district and Fenchugonj and Golapgonj of Sylhet district. Haor is the wetland ecosystem inundated in water for six to seven months. It is located in the North- Eastern region of Bangladesh covering seven districts namely Sylhet, Sunamganj, Habiganj, Moulvibazar, Kishoreganj, Brahmanbaria and Netrokona which is one fifth of the country. It is one of Bangladesh's largest and one of Asia's larger marsh wetland resources.

Although the area is blessed with wonderful landscape and water resources, it bears some inbuilt characteristics like natural calamities (early flood, flash flood, upstream water flow), lack of resources, connectivity, selective enterprises to support livelihood, vulnerability, underdeveloped market, lacks of government's intervention, infrastructure, initiatives from NGOs and international organizations, nutrition knowledge, health and sanitation, prevalence of diseases, less height with respect to age (stunting) and less weight with respect to height (wasting) (Craig *et al*., 2004; FSHB, 2012; IFAD, 2011). It is low lying mono cropped rice area where loss of the crop causes lessening of availability of output, increases risk and uncertainty and the area is affected mostly by unprecedented upstream water (Roy *et al*., 2011). Per capita food consumption especially animal protein, vitamins, micronutrients are extremely lower compared to required reference amounts (Rahman and Islam, 2013). In the present socio-economic context of Bangladesh emphasis should be given on livelihood improvement towards attaining food security of the haor people as opined by various researchers, scientists and policy makers (Rahman 2002, 2012; Rahman and Khan 2005). That is why food security has been taken as one of the three frameworks as research area. In the project, three dimensions like food availability, access and utilization of food security have been addressed considering time and resource limitations. Food security is an interdisciplinary concept which requires experts of agriculture including livestock for food production, Statistician for model building, measurement of indicators and testing of hypothesis. Large numbers of studies were done in the Haor areas however, food security research of such type is completely absent due to the lack of initiative to address the special problem of the area.

The large water bodies could be used as a productive resource, full of flora and fauna by judiciously managing it for the production of crop, livestock and fisheries. Domestic food production can largely be increased by properly selecting crops for low lying areas and uplands including homestead. In addition to crop, there is a great opportunity to increase livestock and poultry production and their products to enhance livelihood and food security. On the other hand, the natural water bodies can be used to produce more fishes of different species with high financial and nutritious values. A well functioning market can be developed to promote livelihood improvement by developing connectivity of different dispersed haor areas. Proper connectivity over different wetland ecosystems and regions would further enhance livelihood, development of dynamic market, enterprises and mobility. Tourism can be developed as an alternative livelihood option.

Objectives

The overall objective of the study was to assess and analyze the core food security indicators to formulate policy options to enhance livelihood of the haor people. The specific objectives are:

(i) To assess existing indicators of food availability especially availability of animal protein;
(ii) To measure access to food from own production, market, social safety net program (SSNP), NGOs and international organizations;
(iii) To assess food utilization efficiency through evaluating health care facilities and health conditions, per capita food, calorie and protein intakes, nutrition education, water and sanitation;
(iv) To evaluate natural, policy and social environments to support food security dimensions;
(v) To evaluate nutrition sensitive agriculture and nutrition education to support food security; and
(vi) To suggest policy guidelines to improve the food security components the constraints of available resources.

Research Questions

Research questions are:

(i) Is food available from domestic food production, food aid, food stock, food import to maintain food security?
(ii) Is food accessible to people by food production, market (considering market actors, food price and cash income), and transfer payments from Govt. NGOs and International Organizations?
(iii) Is food utilization efficient in terms of quality of care, dietary intakes, and health status and nutrition education?
(iv) Are natural, policy and social environments congenial to ensure the three dimensions of food security like food availability, access and utilization?

Methodology

Data

This research project was based on primary data collected through direct interview method using pre-tested and structured interview schedule. Two hundred rural households comprising small, medium and large were selected randomly through stratified random sampling techniques using arbitrary allocation. Data on various socio-economic aspects mentioned above ranging from physical to economic, social to institutional were collected. Data on all food security indicators and activities mentioned above were collected to realize the aforesaid objectives and testing of prescribed hypotheses. Data were collected on various food items consumed by the households to measure household dietary diversity score (HDDS). The multiple questions like quantitative, qualitative (yes/no questions; likert scale of 5 options; open questions; multiple choice questions, etc.) were asked to the farm households. During data collection cross interview, strong observation and monitoring were done to have correct information on food consumption, livestock resources, income and livelihood. In addition to survey, Focus Group Discussions (FGDs), Key Informants Interviews (KIIs) were carried out to include various section of populations.

Two MS students were awarded scholarship for their MS researches. One student worked on food availability and another one worked on food access and utilization using the same set of households and questionnaires. However, special emphasis was given by the students on their focal objectives of the proposed research. The reason to have the same set of households was to write a comprehensive report in synergistic manner with larger sample size so that accuracy can be maximized. Normally for such type of research survey on more than 100 households was unrealistic for one student. However, both the students were benefitted from 200 household's data although they individually collected data from 100 households. Accordingly, objectives, research questions, hypotheses and methods were divided between the students.

Analytical Techniques

Descriptive statistics: Some descriptive statistical analyses like, average per capita income, food production and intake, education and health status, standard deviations, tables, charts, diagrams were performed. As mentioned earlier, the research was based on primary data collected from the selected households.

Modeling and inferential statistics: Some statistical models relating to food production and consumption were estimated encompassing essential explanatory variables to characterize dependant food security indicators. Multiple regression analyses with linear and log linear models were performed. Specifically, production functions of rice, milk, meat for both large and small ruminants, chicken and duck, revenue functions of milk and meat, chicken and duck, income functions, expenditure function, consumption function and nutrition function were estimated in both linear and log linear forms. To avoid multicollinearity problem in case of multiple regressions, stepwise regression analyses were carried out along with total regressions in some respects. In addition, logistic regression and multinomial logistic analyses using dummy dependent variables were carried out. All the regression analyses were carried out to characterize the influential indicators. To measure poverty indices Foster-Greer-Thorbecke (FGT) method was used. Accordingly, poverty indices and change of poverty indices were calculated using Direct Calorie Intake (DCI), poverty line estimation or Cost of Basic Needs (CBN) methods. Daily per capita calorie intake was calculated on all food items using food conversion ratios. A person whose daily per capita calorie intake is less than 2122 kcal is said to be under the absolute poverty line. On the other, a person whose calorie intake is less than 1805 kcal is said to be under hard core poverty line. Furthermore, some statistical tests such as t, F and Chi-square tests were carried out to draw valid inferences.

Production Function of Rice

Linear production function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + U_i$

Log-Linear production function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + \beta_6\ln X_6 + \beta_7\ln X_7 + U_i$

Where Y = amount of rice produced (kg), X_1 = area (decimal), X_2 = amount of seedling (kg), X_3 = amount of labour (man-days), X_4 = tillage cost (BDT), X_5 = irrigation cost (BDT), X_6 = amount of fertilizer (kg) and X_7 = pesticide cost (BDT).

Milk Production Function for Large Ruminant

Linear production function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + U_i$

Log-Linear production function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + U_i$

Where Y = amount of milk produced (litre) in a lactation period, X_1 = area of housing (decimal), X_2 = number of large ruminant, X_3 = amount of feed (kg), X_4 = medication cost (BDT) and X_5 = AI cost (BDT).

Meat Production Function for Large Ruminant

Linear production function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + U_i$

Log-Linear production function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + U_i$

Where Y = amount of meat production (kg), X_1 = area of housing (decimal), X_2 = number of large ruminant, X_3 = amount of feed (kg), X_4 = medication cost (BDT) and X_5 = AI cost (BDT).

Revenue Function of Milk and Meat for Large Ruminant

Linear revenue function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + U_i$

Log-Linear revenue function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5\ln X_5 + U_i$

Where Y = revenue received (BDT) from selling of milk and meat in a year, X_1 = area of housing (decimal), X_2 = number of large ruminant, X_3 = amount of feed (kg), X_4 = medication cost (BDT) and X_5 = AI cost (BDT).

Production Function of Chicken and Duck

Linear production function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + U_i$

Log-Linear production function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + U_i$

Where Y = number of chicken and duck, X_1 = area of housing (decimal), X_2 = amount of feed (kg), X_3 = medication cost (BDT)

Revenue Function of Chicken and Duck

Linear revenue function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + U_i$

Log-Linear revenue function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + U_i$

Where Y = revenue received (BDT) from selling of egg, chicken and duck, X_1 = area of housing (decimal), X_2 = amount of feed (kg), X_3 = medication cost (BDT)

Household Income Function (where income from agriculture is one of the explanatory variable)

Linear income function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + U_i$

Log-Linear income function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5X_5 + U_i$

Where Y = Total household's income (BDT) from all sectors in a year, X_1 = income from agriculture (BDT), X_2 = total land size (decimal), X_3 = family size, X_4 = age of farmer (year) and X_5 = Education (year of schooling), Note: education is used without log in the model.

Household Income Function (where income from livestock is one of the explanatory variables):

Linear income function

$Y_i = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + U_i$

Log-Linear income function

$\ln Y_i = \beta_0 + \beta_1\ln X_1 + \beta_2\ln X_2 + \beta_3\ln X_3 + \beta_4\ln X_4 + \beta_5X_5 + U_i$

Where Y = Total household's income (BDT) from all sectors in a year, X_1 = income from livestock (BDT), X_2 = total land size (decimal), X_3 = family size, X_4 = age of farmer (year) and X_5 = Education (year of schooling), Note: education is used without log in the model.

The Bangladesh Bureau of Statistics (BBS) used the following semi-log or exponential model to estimate the poverty line:

$\ln Y = \beta_0 + \beta_1 X + U$

Where Y = per capita monthly expenditure (food and non-food)

X = per capita per day calorie intake

U = disturbance term

To calculate the HDDS total food items were grouped into twelve groups such as A = Cereals, B= Root and tubers, C = Vegetables, D = Fruits, E = Meat (beef, mutton, chicken, duck etc.), F = Eggs, G = Fish and seafood, H = Pulses/legumes/nuts, I = Milk and milk products, J = Oil/fats, K = Sugar/honey, L= Miscellaneous.
Tabulation of the HDDS was a relatively simple matter that could be done by hand or with the aid of computer software such as a database or spreadsheet. First, the HDDS variable was calculated for each household. The value of this variable would range from 0 to 12.

HDDS (0 -12)	Total number of food groups consumed by members of the household. Values for A through L will be either "0" or "1". Sum (A + B + C + D + E + F + G + H + I + J + K + L)

Second, the average HDDS indicator was calculated for the sample population.

Average HDDS	Sum (HDDS)/ Total Number of Households

Logistic regression and multinomial logistic regressions in the following forms have been used.

Binary Logistic Regression Model: Let Y be a dichotomous dependent variable say food security where Y = 1, the household is food secured and Y = 0 otherwise. Let X be an independent variable, the form of logistic regression model (Gujarati, 2003) is

$$F = p(Y = 1/X) = \frac{e^{\beta_o + \beta_1 X}}{1 + e^{\beta_o + \beta_1 X}}$$

$$\text{And } 1 - p = p(Y = 0/X) = \frac{1}{1 + e^{\beta_o + \beta_1 X}}$$

$$\therefore Logit\ L_1 = \log\left[\frac{p}{1-p}\right] = \beta_o + \beta_1 X$$

For more than one independent variables-

$$Logit\ L_1 = \beta_o + \sum_{i=1}^{k} \beta_1 X_{i1} \quad \text{l = 1, 2, ... k, and i = 1, 2, ..., n}$$

Financial Analyses: Some financial analyses like household total income from all enterprises, costs were performed. SPSS software mostly was used to analyze the data generated by the research project.

Results and Discussion

Socioeconomic characteristics of farm households

Socioeconomic and demographic characteristics influence the production, income and consumption processes of farm household. Middle aged persons were found to be the heads of farm households, average age was 44.64 years and farming experience was 24.49 years where average education of the heads of farm households was calculated as about 4 years of schooling. Literacy rate and dependency ratio were 48 percent 0.69 respectively and average family size was 6.45 persons (Table 1).

Table 1. Socioeconomic and demographic profile of farm households

Variables	Mean	SD
Age	44.64	13.75
Education	3.93	3.57
Experience of farming	24.49	14.89
Number of educated male	1.78	1.23
Number of uneducated male	1.80	1.16
Number of educated female	1.34	0.99
Number of uneducated female	1.53	1.14
Family size	6.45	2.56
Literacy rate	0.48	0.19
Dependency ratio	0.69	0.14

Source: Own calculation, data from field survey, 2017.

Land is the most important input of production and economic variable for the farmers where homestead area is highly important for vegetable, fruit production and livestock rearing especially for the haor people. Pond is another important factor for capture fish production. It was observed that farm household's average cultivable area, homestead area, pond area and total land area were about 114 decimal, 13 decimal, 7 decimal and 251 decimal respectively (Table 2).

Table 2. Land area of farm households in decimal

Variables	Mean	SD
Total cultivable land	114.25	97.12
Total rented area	81.00	99.55
Total homestead area	12.63	16.61
Total pond area	7.34	20.06
Total pasture area	3.41	18.41
Total land area	250.62	166.60

Source: Own calculation, data from field survey, 2017.

Livestock is an integral part of farming system and farm household of Bangladesh. It is the main and stable source of protein and nutrition. It is the sustainable source of earning livelihood and enhancing food security. It was observed that people mostly women reared livestock at the homestead area where area under livestock rearing was 2 decimal of land. It was also observed that people reared mostly large ruminant and poultry. However, some of farm households were found to rear small ruminant like goat and sheep. Numbers of large ruminant and poultry birds per farm were 2 and 38 respectively (Table 3). Women were found to rear livestock especially poultry for mostly domestic consumption.
Rice is the most important mono crop produced in low lying haor area. It was observed that rice production was profitable for the haor people although it was frequently subjected to loss due to early flood in some previous years. Average area under rice production per farm was 196 decimal and net return was BDT 49,066 (Table 4).

Table 3. Area under livestock rearing and number of animals and birds

Variables	Mean	SD
Area under livestock rearing	1.99	1.95
Rent of housing	179.71	166.34
No. of large ruminant	1.70	1.59
No. of small ruminant	0.30	0.86
No. of birds	37.95	81.36

Source: Own calculation, data from field survey, 2017.

Table 4. Area under rice production, cost and return from rice

Variables	Mean	SD
Area under rice production (decimal)	196.12	138.78
Total cost of rice production (BDT)	60053.76	39373.44
Total return from rice produced (BDT)	109119.99	75862.59
Net return from rice production (BDT)	49066.23	44698.51

Source: Own calculation, data from field survey, 2017.

Production of different crops

People in the haor area produce a limited number of crops for their own consumption and also for commercial purposes. Farmers produce some vegetables at the homesteads and uplands. However, they produce single crop Boro rice in the haor areas. Amount of rice production in haor areas is one fifth of the country's total rice production. As the area is vulnerable to natural calamities, rice production frequently accrues losses due to flash flood or early flood or upstream water flow. Women rear poultry and livestock to support their livelihoods. Poultry egg is the cheapest source of nutrition for the rural people. Farmers culture fish in the ponds and water bodies of their own and earn money by selling fish. However, fishermen catch fishes on the government owned rivers and canals under the common property right.

Rice production functions in linear and log-linear (Cobb-Douglas type) forms were estimated and presented in Table 5. It was observed that area under rice production, tillage cost and irrigation cost had significantly positive impact on the increase of rice production. However, pesticide cost had significantly negative impact on rice production which was unexpected but not surprising. Overutilization of pesticide might reduce rice production. It was observed that both the models were well fitted to data as evidenced by significant F-values (Table 5).

Table 5. Estimation of production function of rice

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	194.25	203.77	3.51**	0.18
Area	19.19**	1.74	0.83**	0.053
Amount of seedling	13.14	7.30	0.02	0.043
Amount of labour	4.59	5.10	0.07*	0.03
Tillage cost	0.08*	0.04	0.05	0.04
Irrigation cost	0.06*	0.02	0.04	0.03
Amount of fertilizer	3.57	3.20	0.04	0.04
Pesticide cost	-0.21*	0.11	-0.08**	0.03
Adjusted R^2	0.84		0.91	
F-value	148.73**		282.64**	

Source: Own calculation, data from field survey, 2017.

Large ruminants were used to produce both milk and meat. Production functions for milk production were estimated and have been presented in Table 6. Estimation of multiple linear production function showed that milk production was increased by the increase in number of large ruminant and amount of feed. However, milk production was significantly increased by the increase in number of large ruminant, amount of feed, medication and AI costs (Cobb-Douglas type log linear model). Specifically, 1 percent increase in the number of large ruminant increased 0.74 percent milk production and 1 percent increase in the amount of feed generated 0.49 percent increase in milk. However, 1 percent increase in medication cost and AI cost separately increased respectively 0.27 percent and 0.22 percent milk production. Significant F-values showed that the models were well fitted to data (Table 6). To identify the crucial factors to increase milk production, a stepwise regression analysis was carried out using linear model and was observed that number of large ruminant and amount of feed had significantly positive impact on milk production (Table 7).

Table 6. Milk production function for large ruminant

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	1.44	25.98	-0.80	0.45
Area	12.75	10.30	0.02	0.31
No. of large ruminant	67.58**	16.36	0.74*	0.30
Amount of feed	0.45*	0.21	0.49**	0.07
Medication cost	0.03	0.02	0.27**	0.05
AI cost	-0.02	0.06	0.22**	0.05
Adjusted R^2	0.39		0.68	
F-value	26.31**		85.19	

Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

Table 7. Stepwise regression of linear model of milk production for large ruminant

Model	Variables description	Coefficient	Standard error	Adjusted R^2	F-value
1	Intercept	39.02	23.90	0.36	115.07**
	No. of large ruminant	110.37**	10.29		
2	Intercept	14.08	24.99	0.39	63.90**
	No. of large ruminant	75.63**	15.67		
	Amount of feed	0.56**	0.19		

Source: Own estimation, data from field survey, 2017, ** indicates significances at 0.01 probability level.

Meat production from large ruminant was increased significantly with the increase in area under livestock rearing, amount of feed and medication cost which was indicated by both linear and Cobb-Douglas type log-linear model. Both the models were well fitted to data as evidenced by significant F-values (Table 8). In addition to production function, a revenue function of milk and meat for large ruminant was estimated and has been presented in Table 9. It was observed that revenue from selling of milk and meat was significantly increased by the area under livestock rearing, number of animal, amount of feed and medication cost. More specifically, from linear model, a one decimal increased in area increased revenue by BDT. Similarly, an additional one animal increased the revenue by BDT 8,559 where an additional one kg feed generated revenue by BDT 154 and an additional BDT 1 as medication cost increased revenue by

BDT 14 (Table 9). On the other hand, from log-linear model, a 1 percent in area, amount of feed and medication cost increased respectively 1.50 percent, 1.24 percent and 0.82 percent revenue.

Table 8. Meat production function for large ruminant

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	-3.80	11.57	-1.15**	0.43
Area	19.13**	4.59	1.37**	0.29
No. of large ruminant	11.83	7.29	0.03	0.28
Amount of feed	0.24*	0.09	0.46**	0.07
Medication cost	0.03**	0.01	0.25**	0.05
AI cost	0.02	0.03	0.03	0.05
Adjusted R^2	0.46		0.62	
F-value	34.20**		65.25**	

Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

Table 9. Revenue function of milk and meat for large ruminant

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	-823.49	5880.14	-2.37**	0.60
Area	8465.75**	2330.66	1.50**	0.41
No. of large ruminant	8559.05*	3703.07	-0.17	0.40
Amount of feed	153.81**	47.99	1.24**	0.10
Medication cost	13.51**	4.76	0.82**	0.07
AI cost	18.37	12.94	0.01	0.07
R^2	0.52		0.86	
F-value	44.44**		250.54**	

Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

Meat production from small ruminant was significantly and positively influenced by medication cost only (Table 10). However, a stepwise regression analysis which resolved the multicollinearity problem showed that meat production from small ruminant was influenced significantly by the number of animal and medication cost (Table 11).

Table 10. Meat production function for small ruminant

Variables description	Linear model	
	Coefficient	Standard error
Intercept	3.92	3.37
Area	-0.89	1.24
No. of small ruminant	8.10	4.43
Amount of feed	0.17	0.09
Medication cost	0.07**	0.03
Adjusted R^2	0.21	
F-value	14.09**	

Source: Own estimation, data from field survey, 2017, ** indicates significances at 0.01 probability level.

Table 11. Stepwise linear regression of meat production for small ruminant

Model	Variables description	Coefficient	Standard error	Adjusted R^2	F-value
1	Intercept	2.51	2.53	0.17	42.29**
	No. of small ruminant	17.93**	2.76		
2	Intercept	2.27	2.49	0.20	25.74**
	No. of small ruminant	12.98**	3.24		
	Medication cost	0.08**	0.03		

Source: Own estimation, data from field survey, 2017, ** indicates significances at 0.01 probability level.

Number of chicken and duck was increased significantly with the increase in amount of feed and medication cost (Table 12). Similarly, revenue from chicken and duck was also increased significantly with the increase in the amount of feed and medication cost, which was elucidated by both the models (Table 13).

Table 12. Chicken and duck production function

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	-3.99	5.80	0.67*	0.28
Area	0.62	1.95	0.01	0.25
Amount of feed	0.98**	0.04	0.45**	0.06
Medication cost	0.05**	0.01	0.05	0.05
R^2	0.37		0.28	
F-value	39.69**		26.75**	

Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

Table 13. Revenue function from chicken and duck

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	789.88	2275.06	0.60	0.62
Area	-207.08	767.15	-0.50	0.53
Amount of feed	160.83**	15.61	1.65**	0.14
Medication cost	23.03**	3.95	0.34**	0.10
R^2	0.49		0.68	
F-value	65.25**		138.73**	

Source: Own estimation, data from field survey, 2017, ** indicates significances at 0.01 probability level.

Income and expenditure of farm households

There are few enterprises developed to support the livelihoods of people. Farmers produce some vegetables at the homesteads and uplands. However, they produce single crop *Boro* rice in the haor areas. Women rear poultry and livestock to support their livelihoods. Poultry egg is the cheapest source of nutrition for the rural people. Farmers culture fishes in the ponds and water bodies of their own and earn money by selling them. However, fishermen catch fishes on the government owned rivers and canals under the common property right. Poor male people are found to

pulling rickshaw and van on the highway and local road during winter. A very few people are engaged with transport services. A major portion of poor people run their petty businesses in the local markets or along the road sides. As there is no small scale or large scale industry, employment opportunity is very scarce and livelihood is not sustainable. During flooding period, some people migrate to Sylhet, Chittagong and Dhaka for jobs and return to original places after the flood water recedes. Marginal people during flooding virtually engage in fishing and small trading.

It was observed that livestock sector generated the highest yearly family income and it was BDT 56,945. The second important sector was crop sector especially rice production followed by labour selling and service sector respectively. Annual family incomes from rice production, fisheries, transport, business, service, labour selling, government and other sectors were BDT 49,066, BDT 19,547, BDT 16,645, BDT 19,920, BDT 27,450, BDT 44,279, BDT 323 and BDT 12,125 respectively. People received some money from the government under the social safety net programs (SSNP). There were elderly allowance, widowed allowance and school stipend from the government. However, coverage of SSNP was very poor. Total annual family income was observed to be BDT 2,46,301. There were significant variations of income among the farm households as suggested by larger standard deviations (Table 14). However, total income was significantly increased with the increase in income from agriculture (crop, livestock and fisheries) and family size where total income was decreased with the increase in land size (Table 15). In other estimations of income functions, it was observed that family total income was significantly increased by livestock income, land size and family size (Table 16).

Table 14. Yearly income of farm households from all sectors in BDT

Variables	Mean	SD
Rice production	49066.23	44698.51
Livestock and poultry	56944.98	75809.71
Fisheries	19547.00	52334.45
Transport	16645.00	31483.41
Business	19920.00	44076.38
Service	27450.00	93814.99
Labor selling	44279.00	49118.42
Government donation	323.50	1882.69
Others	12125.00	23874.87
Ratio of livestock income to tot	0.23	4.48
Total income	246300.72	137294.31

Source: Own estimation, data from field survey, 2017.

Table 15. Yearly income function where income from agriculture as one of the explanatory variables

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	98146.72**	35456.86	8.68**	1.09
Income from agriculture	0.98**	0.09	0.38**	0.03
Total land size	-98.07*	49.16	-0.23*	0.10
Family size	6834.31*	3112.89	-0.02	0.21
Age	43.26	587.73	0.15	0.25
Education*	1018.38	2224.36	-0.01	0.02
Adjusted R^2	0.40		0.45	
F-value	27.72**		33.64**	

Education* is always without log. Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

Table 16. Yearly income function where income from livestock as one of the explanatory variables

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	130052.42**	38550.84	11.68**	1.32
Income from livestock	0.96**	0.11	0.12**	0.02
Total land size	107.85*	50.55	0.01	0.12
Family size	6712.05*	342803	-0.19	0.26
Age	-312.13	646.55	-0.05	0.31
Education*	1302.07	2442.82	-0.01	0.03
Adjusted R^2	0.28		0.14	
F-value	16.34**		7.53**	

Education* is always without log.
Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

There were 12 components of expenditure. These were expenditures on food, clothing, education, treatment, purchase or repairing of house, purchase of savings certificate, purchase of livestock, purchase of vehicle, water and sanitation, festival, electricity and gases, and others and the corresponding expenditures were BDT 1,83,795, BDT ,9941, BDT 8,150, BDT 11,785, BDT 10,495, BDT 72, BDT 6,095, BDT 4,025, BDT 2,083, BDT 7,000, BDT 3,063 and BDT 716 respectively. Total annual family expenditure was BDT 2,48,309. It was observed that food cost was the largest cost item, which was 74 percent of total expenditure (Table 17). This result conformed to other studies (Rahman and Sousa-Poza, 2010; Rahman and Islam 2012). The yearly family expenditure was increased significantly with the increase in food expenditure, land size, age and education (Table 18).

Table 17. Yearly family expenditure for different cost components in BDT

Variables	Mean	SD
Food expenditure	183794.60	66957.76
Clothing	9941.00	7237.97
Education	8150.00	9279.29
Treatment	11785.00	14574.75
Purchase/repair of housing	10495.00	9161.45
Purchase of savings certificate	72.00	450.37
Purchase of livestock	6095.00	17620.88
Purchase of vehicle	4025.00	13142.22
Water and sanitation	2082.50	2053.98
Festival	7000.00	5103.61
Electricity and gasses	3063.00	1784.39
Others	716.00	1689.26
Total expenditure	248309.10	95475.72

Source: Own calculation, data from field survey, 2017.

Table 18. Yearly family expenditure function

Variables description	Linear model		Log-Linear Model	
	Coefficient	Standard error	Coefficient	Standard error
Intercept	-21961.71	12809.71	-0.15	0.44
Food expenditure	1.24**	0.06	0.99**	0.04
Total land size	67.51**	17.51	0.07**	0.01
Family size	-1884.47	1461.33	-0.08*	0.04
Age	511.69*	220.05	0.10**	0.04
Education*	3861.96**	826.76	0.01**	0.003
Adjusted R^2	0.83		0.87	
F-value	196.81**		255.56**	

Education* is always without log.
Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

As mentioned earlier food expenditure was the highest cost component. Yearly family expenditure was relatively higher than family income where the difference between income and expenditure was found to be negative (Table 19).

Table 19. Yearly income, expenditure, difference between income and expenditure in BDT

Variables	Mean	SD
Total income	246300.72	137294.31
Food expenditure	183794.60	66957.76
Total expenditure	248309.10	95475.72
Ratio of food expenditure to total expenditure	0.74	0.11
Difference between income and expenditure	-2008.38	152247.87

Source: Own calculation, data from field survey, 2017.

Food consumption and nutritional intake of farm households

Rice was the main food item for the people followed by leafy vegetables, potato, wheat, meat, fish and milk respectively. The average daily per capita consumptions of rice, wheat, puffed rice, chira, potato, leafy vegetables, pulse, oil, milk, beef, mutton, chicken, egg, fish, onion, garlic, chili, turmeric, ginger, other spices, sugar, fruits and all food items were respectively 385g, 65g, 34g, 34g, 131g, 152g, 33g, 33g, 44g, 4g, 9g, 56g, 16g, 46g, 33g, 9g, 11g, 6g, 6g, 11g, 21g, 33g, and 1172g. Rice was the main contributor to calorie and protein and amount of daily per capita calorie and protein intakes from rice were respectively 1250 kcal and 19g (Table 20). The second important food item was wheat followed by oil, potato, puffed rice, pulse, chira, chicken, sugar and fish to supply daily per capita calorie which were respectively 211 kcal, 1139 kcal, 120 kcal, 107 kcal, 102 kcal, 98 kcal, 75 kcal, 73 kcal and 48 kcal. Daily per capita calorie and protein intakes from livestock products were respectively 148.16 kcal and 16.62g. This result is consistent with Rahman *et al.*, (2020). The daily per capita calorie intake was 2419 kcal which was consistent with the studies by Rahman and Sousa-Poza (2010), Rahman and Islam (2012) and HIES (2010). According to HIES (2010) daily per capita calorie intake at the national level was 2318.3 kcal. However, the second important food item was vegetables followed by chicken and oil respectively to supply daily per capita protein and they were 13g, 11g and 9g. The daily per capita total protein intake was 86g which was relatively higher but consistent compared to the national level. At the national level daily per capita protein intake was 66.26g (HIES, 2010). As described earlier, people produce a very few crops in the haor areas. The crops are mostly rice, vegetables, pulse and potato. It was observed that people produced abundant amount of rice in the haor area which was significantly higher than family consumption. They used to sell the surplus rice in the local markets or nearby districts to earn revenue to bear costs for other necessities. However, they produced very little amounts of vegetables, pulse and potato at the homesteads and uplands which were very scarce to fulfill their family consumptions. They used to purchase these food items from the local markets (Table 21).

Table 20. Daily per capita food consumption, calorie and protein intakes of farm households

Food items	Food consumption (g)		Calorie intake (kcal)		Protein intake (g)	
	Mean	SD	Mean	SD	Mean	SD
Rice	384.65	109.62	1250.14	356.25	19.23	5.48
Wheat	64.97	43.50	210.51	140.94	7.86	5.26
Puffed rice	34.05	22.70	106.66	65.53	-	-
Chira	33.80	36.74	97.84	89.97	1.69	1.84
Potato	130.64	54.35	120.18	50.00	2.61	1.09
Vegetables	151.87	56.41	45.56	16.92	12.91	4.79
Pulse	33.12	19.77	102.36	55.09	6.62	3.95
Oil	33.22	15.68	138.85	64.97	8.80	3.92
Milk	44.10	31.72	29.11	20.93	0.88	0.63
Beef	4.32	11.53	5.75	8.41	0.86	1.33
Mutton	8.89	14.49	11.83	10.56	1.78	1.68
Chicken meat	56.03	31.33	74.59	22.84	11.20	3.63
Egg	15.84	10.78	26.88	11.44	1.90	1.29
Fish	46.32	33.84	47.60	22.68	4.63	3.38
Onion	33.02	17.17	15.36	7.99	3.96	2.06
Garlic	8.52	5.11	11.67	7.01	0.45	0.27
Chili	11.40	6.66	26.52	12.50	0.18	0.11
Turmeric	6.11	3.68	-	-	-	-
Ginger	6.39	3.85	5.88	3.54	0.34	0.20
Other spices	10.70	6.60	13.69	8.45	0.32	0.19
Sugar	21.22	17.89	73.15	38.78	-	-
Fruits	32.50	30.38	19.98	16.00	0.29	0.27
All food items	1171.70	298.33	2418.89	527.78	86.05	22.87

Source: Own calculation, data from field survey, 2017.

Table 21. Yearly production, consumption and surplus in kg of some food items

Activity	Crops			
	Rice	Vegetables	Pulses	Potato
Production	5243.80 (3684.26)	103.45 (250.51)	6.45 (20.54)	81.33 (209.29)
Consumption	916.15 (381.29)	429.92 (285.18)	74.46 (47.65)	325.11 (179.70)
Surplus	4327.65 (3613.42)	-326.47 (377.17)	-68.01 (48.53)	-243.78 (278.84)

Figures in the parentheses indicate standard deviations, Source: Own calculation, data from field survey, 2017.

Measurement of poverty and food security

The Bangladesh Bureau of Statistics (BBS) used the following semi-log or exponential model to estimate the poverty line:

$$\ln Y = \beta_0 + \beta_1 X + U$$

Where Y = per capita monthly expenditure (food and non-food)

X = per capita per day calorie intake

U = disturbance term

The estimated model is

$\ln Y_i = 6.960^{**} + 0.000458^{**}X$

(0.078) (0.000032)

Adjusted R^2 =0.51, F= 210.45^{**}

$\ln Y_i = 6.960 + 0.000458X$

= 6.960+ 0.000458 x 2122

= 7.931876

Y= Exp (7.931876) -1

= BDT 2783.65

Thus, absolute poverty line is BDT 2783.65

Again, $\ln Y_i = 6.960 + 0.000458X$

= 6.960+ 0.000458 x 1805

= 7.78669

Y = Exp (7.78669)-1

= BDT 2407.33

Thus, hard core poverty line is BDT 2407.33

Table 25. Poverty prevalence of the people living in haor areas

Region	Poverty measurement (%)			
	Direct calorie intake (DCI)		Cost of basic needs (CBN)	
	Absolute poverty	Hard core poverty	Absolute poverty	Hard core poverty
Hakaluki haor	33	14	29	20
Overall	33	14	29	20

Source: Own estimation, data from field survey in 2017.

As mentioned earlier, people produced rice, vegetables, potato, pulse and women reared livestock and poultry. They also got milk from large ruminants and eggs from poultry. As the people produced most of the food items for their domestic consumption, they consumed those food items daily and frequently. However, they did not produce a few food items like oil and spices which were purchased from the local markets. It was observed that people consumed almost all 12 categories of food items and average HDDS was 11.85.

The results of binary logistic regression explained that with 1 unit increase in family size on an average the probability of food security of the people in haor areas could be decreased significantly by 1.94556 times. Again, the binary logistic regression also showed that with 1 unit increase in weakly cost of all food consumed, on an average, the probability of food security of the people could be increased significantly by 0.00181 times (Table 26). However, effects of monthly per capita income, land size and education on food security condition had no effect.

Table 26. Binary logistic regression estimates of the effects of different determinants on food security

Independent variables	ß	Asymptotic S. E.	Wald	Significance level	Odds Ratio (OR)
Family size	-1.94556^{**}	0.168604	42.145	0.000	0.335
Land size	0.000216	0.001205	0.032	0.858	1.000
Education	-0.025411	0.053293	0.227	0.633	0.975
Weekly family food expenditure	0.001810^{**}	0.000330	30.125	0.000	1.002
Per capita monthly income	-0.000038	0.000093	0.165	0.684	1.000
Constant	2.010511^{*}	0.870113	5.339	0.021	7.467

Source: Own estimation, data from field survey, 2017, ** and * indicate significances at 0.01 and 0.05 probability level, respectively.

The multinomial logistic regression was estimated using three levels of food security where reference category was food secure. The multinomial logistic regression revealed that with 1 unit increase in family size on an average the probability of food insecurity could be increased significantly by 2.218429 times (p<.01). On the other hand, it showed that with 1 unit increase in weakly family food expenditure on an average the probability of food insecurity could be decreased significantly by 0.004186 times (p<.01) (Table 27).

Again, the multinomial logistic regression revealed that with 1 unit increase in family size on an average the probability of relatively food security could be increased by 0.82807 times (p<.01) compared to food secure condition. On the other hand, it showed that with 1 unit increase in weekly family food expenditure on an average the probability of relatively food security could be decreased by .001299 times (p<.01) compared to food security condition (Table 27).

Table 27. Multinomial logistic regression estimates of the effects of different determinants on food security

Three level of food security	Independent variables	ß	Asymptotic S. E.	Wald	Significance level	Odds Ratio (OR)
Food insecure	Constant	-5.307748	1.590908	11.131	0.001	
	Family size	2.218429	0.381376	33.836	0.000	9.193
	Land size	0.001966	0.001938	1.030	0.310	1.002
	Education	0.100397	0.086191	1.357	0.244	1.106
	Weekly family food expenditure	-0.004186	0.000801	27.293	0.000	.996
	Per capita monthly income	0.000218	0.000174	1.567	0.211	1.000
Relatively food secure	Constant	-1.947912	0.905682	4.626	.031	
	Family size	0.828070	0.175715	22.208	0.000	2.289
	Land size	-0.000822	0.001335	.380	0.538	.999
	Education	0.006389	0.056288	.013	0.910	1.006
	Weekly family food expenditure	-0.001299	0.000341	14.517	0.000	.999
	Per capita monthly income	0.000012	0.000099	.014	0.905	1.000

Reference category is food secure, Source: Own estimation, Data from field survey, 2017.

Social safety net programs (SSNP) of Govt. and developmental partner's initiatives

In every country there are some social safety net programs (SSNP) to safeguard the vulnerable or marginalized people those who are lacking of income and less access to food, nutrition, water and sanitation. The Bangladesh Government also has some social safety net programs like Food for Work (FFW), Cash for Work (CFW), Vulnerable Group Feeding (VGF), Vulnerable Group Development (VGD), Elderly Allowance (EA), Widowed Allowance (WA), Pregnant Women Allowance (PWA), Cash for Education (CFE) or School Stipend (SS) and Test Relief (TR). However, it was observed field survey that FFW, VGF, EA, SS and TR were existed in the Juri Upazilla of Moulvibazar up to some extent. It was observed that 50 farm households out of 200 households received wheat under FFW program and average wheat received was 19.20kg in a year. Similarly, only 8 households out of 200 households received rice under VGF and average quantity received was 98.5kg in a year whereas 80 elderly people out of 200 households received benefit under EA program and average money received was BDT 3122.50.

Table 28. Some safety net programs

	N	Minimum	Maximum	Mean	Std. Deviation
Food for work (kg)	50	12.00	30.00	19.2000	5.07093
Cash for Work (BDT)	0				
Vulnerable Group Feeding (VGF) (Kg)	8	64.00	120.00	98.5000	24.99714
Vulnerable Group Development (VGD) (BDT)	0				
Elderly Allowance (EA) (BDT)	80	400.00	7200.00	3122.5000	1644.39785
Widowed Allowance (WA)(BDT)	0				
Pregenant Women Allowance (PWA) (BDT)	0				
Cash for Education or School Stipend (BDT)	82	1200.00	5000.00	2302.4390	837.24646
Test Relief (TR) (Kg)	12	4.00	10.00	6.5000	2.61116

Source: Own calculation, data from field survey, 2017.

Household Dietary Diversity Score (HDDS)

As mentioned earlier, household's total food items were grouped into 12 groups to estimate household dietary diversity scores (HDDS). It was observed that the average HDDS was nearly 11.

Conclusions and Policy Implications

The haor area is blessed with wonderful landscape and water resources. However, it bears some inbuilt characteristics like natural and human induced calamities (flash flood and upstream water flow), lacks of diversified resources to feed the vast population, connectivity, a very few enterprises to support livelihood, vulnerability, underdeveloped market, lacks of interventions from the government, NGOs and international development partners, nutrition education, health and sanitation, prevalence of diseases. As the area is low lying mono cropped rice area, per capita food consumption especially animal protein, vitamins, micronutrients are lower compared to required reference amounts. The area can be turned into a higher productive area by judiciously using the scarce resources and nature to have higher production, income and nutrition.

Eight enterprises have been developed in the area to support livelihood, food and nutrition security where rearing of livestock ranked first followed by rice production, labor selling service, business and fisheries, respectively. Income from transport sector can be increased by developing road and connectivity. However, there were 12 expenditure sectors where food expenditure was the highest followed by expenditures for treatment, house repairing, clothing and education, respectively. Total family expenditure was higher than total family income.

People consumed 22 food items where rice was the most important food item in terms of daily per capita food consumption, calorie and protein intakes. Daily per capita food consumption, calorie and protein intakes were 1172 g, 2419 kcal and 86 g respectively. Poverty prevalence was dominant in the haor area where absolute and hardcore poverty were respectively 33% and 14% based on the DCI method and 29% and 20% based on the CBN method. Food security condition increased with the increase in food expenditure and decreased with the increase in family size.

As livestock sector contributes 19% of total daily per capita protein intake, policy should be derived to increase livestock production through providing improve breed, subsidized feed and free treatments for the livestock in the area. A small amount of support may generate a handsome amount of animal protein and income. In this regard, government agencies should come forward along with international development partners and NGOs to make success of the program.

As mentioned earlier, there exists underdeveloped and ineffective market to sale out the various products of farmers with fair prices. Livestock production systems could be sustainable through establishing linkages with various actors and developing infrastructure in the locality. This market mechanism may ensure proper price for the produce and in turn will increase the return of investment by the farmers. Developing marketing channel with dynamic market requires interventions from the government, other development partners and civil societies.

Government's social safety net programmes on various dimensions should be extended and implemented in the area in a sustainable manner to ensure food and nutrition security of people living there.

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