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VEGETABLE PRODUCTION IN FLOOD PRONE AND RIVER EROSION AREAS IN BANGLADESH: IMPACT ON INCOME AND FOOD SECURITY OF PEOPLE

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Abstract

Bangladesh is a land of rivers that is affected by flood every year. Due to the inherent nature of wetland and flood prone areas (haor), it is possible to produce vegetables to reduce the risk of crop failure, and also to increase the income and nutrition of farm households. This study found that production of vegetables was profitable. The shares of vegetables income to crop, agriculture and total income were 17%, 13% and 9% respectively. The average technical efficiency of vegetables production was 88% and there were significant technical inefficiency effects in the production process. Twelve percent (12%) vegetable production could be increased with the existing resources and available technology. Daily per capita calorie intake was 2164 kcal of which 144 kcal received from vegetables. Total per capita protein intake was 67 g of which 13 g received from vegetables. Per capita food consumption was influenced by family size, calorie received from vegetables and region. Food consumption per capita was significantly lower in households with higher family sizes and food consumption increased with the increased amount of calorie intake from vegetables. A package of policy options were suggested, such as efficient production of high value and nutritious vegetables, creation of income generation activities, setting up of small industries, strengthening of government and NGOs activities in *haor* areas.

Key Words: Vegetable production, flood prone area, income, food security, Bangladesh

Introduction

Bangladesh is a small country, full of rivers, canals, estuaries, *haor* (wetland and flood prone land) and other low lying areas. The total area of *haor* type wetland ecosystem in Bangladesh is 8 million hectares where about 5 million hectares of land that remain inundated in water for six months in a year and affected by unprecedented flood and river erosion every year. It includes about 47 major haors and 6300 beels (natural water bodies) of varying size of which about 3500 are permanent and 2800 are seasonal (Hussain & Salam, 2007; BBS, 2011). In a country like Bangladesh where one third of all area can be termed as wetlands, the haor basins are in the north eastern part and are internationally important wetland ecosystems, which are situated in Sunamganj, Habiganj and Moulvibazar districts and Sylhet Sadar Upazila, as well as Kishoreganj, Netrokona and Brahmanbaria districts.

People in these areas face various problems during natural calamities including acute food and drinking water shortages, mobility, displacement, health and sanitation. In terms of mainstream socio-economic development initiatives, they are becoming increasingly

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marginalised. They are yet to enjoy the full access to the essential services by the government. Due to such exogenous shocks originated from flood and river erosion, people of these areas lose their jobs and livelihoods for the time being and face seasonal, temporal crisis of food and lodging, social and environmental problems. A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Carney, 1998). Generally they try to cope with the new situation caused by natural calamities.

Climate change has further aggravated the problems of lives and livelihoods in these areas. Crop production and fisheries are largely affected by climate change. Therefore, sustainable livelihood relies on sustainable management of our ecosystem. For the livelihoods to be sustainable, the natural resources must be sustained (Rennie and Singh, 1996). The impact of climate change causes undermine the development achievements and threaten the food security of millions of people, especially those living in the rural areas. It is imperative to identify and institutionalise mechanisms that enable the most vulnerable people in the ***haor*** (**wetland and flood prone areas**) and river erosion areas and local communities to cope with climate change impacts (IPCC, 2007).

Malnutrition is a serious public health problem in Bangladesh. It retards child growth, increases the risk and duration of illness, reduces work output and slows social and mental development. The 2007 BDHS indicated that among the under five children of Bangladesh, 43 percent were stunted (chronic malnutrition), and 16 percent were severely stunted. About 17 percent of children under five were wasted (acute malnutrition), and 3 percent were severely wasted. About 41 percent of children under five were underweight (under nutrition), and another 12 percent were severely underweight (NIPORT et al. 2009). These scenarios are rather severe for the people living in haor (wetland and flood prone) areas.

Vegetables and fruits are the only source of micronutrients in the family diet especially for the poor households. Vegetables play a vital role to increase nutrition in human diet in Bangladesh. It is an easy source of farm income. Daily per capita vegetable consumption in rural areas is 285 g which supplies 178 kcal energy per capita daily (Rahman and Islam 2011). Helen Keller international's (HKI's) recent national vitamin A survey in rural Bangladesh showed that children of households without a home garden were at greater risk of vitamin A deficiency than children of households with a home garden especially when neither of them had not recently received a high-dose of vitamin A capsule (Talukder, et al. 2000).

The overall objective of the study was to assess the impact of vegetables production on the food security condition of people accommodating all factors and actors dominant in the *haor* and river erosion areas of Bangladesh. The specific objectives are as follows:

(i) to estimate household's and per capita crop production, food and nutrition intakes, income and share of vegetable income;

(ii) to assess the impact of vegetables on increasing nutritional status of poor people;

(iii) to analyse the extent of technical efficiency achieved in vegetable production; and

(iv) to formulate policy options to address food insecurity by increasing vegetable production.

Methodology

This study was based on both primary and secondary data. The primary data were collected through field survey. The regions Sunamganj, Habiganj, Moulvibazar and Kishoreganj and Sirajganj districts were selected as study areas since people of these low lying regions face natural disasters which cause food shortages and livelihood deficiency, thus living in food insecurity and malnutrition conditions. Livelihood influences food demand, supply and consumption. Primary data were collected with direct interview method from the people affected by flood and river erosion. Data from 60 households had been collected from each of the above five regions. The secondary data had been collected from secondary sources such as from published materials, internet etc. For the analysis of data, both partial and functional analyses have been carried out and appropriate statistical tools and techniques were used, such as descriptive statistics, econometric models, t-test, F-test, etc. To identify efficient crop production and the factors influencing vegetables production, Cobb-Douglas Stochastic Frontier Production Function analysis was carried out. Data analysis of this study has been done as follows:

(i) Households and per capita crop production, food and nutrition intakes, income and share of vegetable income were estimated and presented by descriptive statistics.

(ii) To assess the impact of vegetables on increasing nutritional status of people and factors influencing per capita food consumption, functional analyses using dummy variable were carried out.

(iii) To determine the level of productive efficiency and also to identify factors influencing vegetable production, Cobb-Douglas stochastic frontier production function and technical inefficiency effect model were estimated.

(iv) Hard Core Poverty and Absolute Poverty of people were estimated through poverty line estimation using exponential model and Direct Calorie Intake (DCI) method.

Descriptions of Various Models:

(i) For the measurement of nutritional status and poverty, the Direct Calorie Intake (DCI) and Cost of Basic Needs (CBN) methods were used. In the past, DCI method was used to calculate the incidence of poverty where population or household falling below a threshold calorie intake was considered as poor. The threshold per capita per day calorie intake is 2122 kcal. A person whose daily calorie intake is less than 2122 kcal, is considered to be in the 'Absolute Poverty'. Similarly, a person having daily calorie intake less than 1805 kcal is considered to be in the 'Hard Core Poverty'. The cost of basic needs was estimated through poverty line estimation using exponential 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

(ii) The explicit Cobb-Douglas stochastic frontier production function is given below:

$$\ln Y_i = \ln \beta_0 + \sum_{i=1}^{9} \beta_i \ln X_i + \beta_{10} EDU + \beta_{11} EXT + V_i - U_i$$

where Y = Output (kg), X_1 = Area under vegetable production (hectare), X_2 = Human labour (man-days), X_3 = Seed (kg), X_4 = Fertiliser (kg), X_5 = Manure (kg), X_6 = cost of tillage operation, X_7 = Irrigation cost (real value), X_8 = Age of farm operator, X_9 = Experience of farm operator, EDU = Education of farm operator (year of schooling), EXT = Extension service (Dummy variable which receives 1 if the farm has contact with extension agents and receives 0 if it does not have any contact with extension agents).

V_i are assumed to be independently and identically distributed random errors, having N (0, σ_v^2)-distribution; and the U_i are non-negative one-sided random variables, called technical inefficiency effects, associated with the technical inefficiency of production of the farmers. It is assumed that the inefficiency effects are independently distributed with a half normal distribution ($U \sim | N(0, \sigma_u^2) |$).

The model for the technical inefficiency effects in the stochastic frontier production function is defined by

$$U_i = \delta_0 + \delta_1 AGE_i + \delta_2 EDU_i + \delta_3 EXPERIENCE_i + \delta_4 CONTACT_i + \delta_5 FARMSZ_i + \delta_6 FAMSZ + W_i$$

Where AGE represents age of farm operator, EDU is defined as earlier, EXPERIENCE is the experience of the farm operator, CONTACT represents extension contact by the extension agents to the farmers, FARMAZ represents farm size, FAMSZ represents family size and W_i are unobservable random variables, which are assumed to be independently distributed with a positive half normal distribution.

Results and Discussion

It is found that farmers produce some common vegetables such as white gourd, bean, long bean (barboti), lady's finger (okra), brinjal, papaya, potato, sweet gourd, bottle gourd, snake gourd, bitter gourd, pointed gourd, Indian spinach, aroids, etc. in their homesteads and also in uplands near to their homesteads. Kashem et al. (2013) mentioned that few vegetables such as onion, garlic, chilli, bottle gourd, sweet gourd, lady's finger and tomato etc. were found to be cultivated by the farmers in *haor* areas. Among these, onion, garlic and chilli were mostly cultivated. However, Sumon and Islam (2013) reported that the vegetables such as radish, spinach, garden pea, sweet gourd, red amaranth, stem amaranth, bitter gourd, potato, ash gourd and aroid were produced in *haor* areas in Bangladesh. They also mentioned that the cultivation of vegetables was not popular in the *haor* areas and therefore, was not easily practiced by farmers. Only few women members used to cultivate vegetables at the homestead and court yard levels. However, there are huge potentialities of growing vegetables in the *haor* areas. Fallow uplands are potential areas for growing some kinds of vegetables. All the above vegetable crops were found more profitable than many other crops. All the vegetable crops were found to cultivate in the homestead and adjacent areas and fallow uplands and some vegetables like potato, garden pea, bitter gourd etc. are possible to grow in the other lands in the *haor*. All vegetables were possible to harvest before flash flood and proved to be profitable. They also mentioned that January to March months were found peak poverty period in the *haor* areas and the vegetables could be used as cash crops and could highly contribute to address peak poverty situation as well as the flash floods. Below are the some of the photographs of vegetables produced in the *haor* areas are given below.

Socio-demographic and economic characteristics of farm households

Middle aged farmers are more enthusiastic to carry out agricultural production and farming practices. Average age of farmers was 46.53 years which showed significant variation among districts and average education was about 7 years of schooling in the study areas. However, average education also varied significantly among the regions with the highest education (about 10 years of schooling) observed in Moulvibazar district. Average family size was about 5 persons which conformed to national average. Land size per household was 175 decimal at the aggregate level. Family size and land size varied significantly among regions.

Income from vegetables was found to be BDT 9669.68 where farmers of Habiganj district earned significantly higher income (BDT 12918.67) from vegetable production. Farmers generated BDT 75588.53 from the crop sector at the aggregate level. However, income of this sector varied significantly among regions with the highest income (BDT 101017.97) observed in Sunamganj district. Average household income from agriculture sector was observed to be BDT 94460.47 and total household income from all sectors was observed to be BDT 150423.80.

Farmers of Habiganj district generated significantly the highest net return (full cost basis) (BDT 5535.57) from vegetable production followed by that of Sirajganj and Moulvibazar respectively. However, the overall average net return after deducting all costs was observed to be BDT 4045.98. The share of vegetable income to crop income was the highest in Sirajganj district (24%) whereas it was the second highest in Habiganj district (23%) with an average share at 17%. On the other hand, the share of vegetable income to agriculture income was found to be the highest (18%) in Habiganj district followed by that in Sirajganj district (16%). However, for other three districts, such as Sunamganj, Moulvibazar and Kishoreganj, the shares of vegetable income to agriculture income were significantly lower with the average share achieved at 13%. Similarly, the share of vegetable income to total income was the highest (14%) in Habiganj district followed by that (12%) in Sirajganj district. This share was significantly lower in other three districts with the average share observed at 9% at the aggregate level.

Overall per household yearly expenditure on food was about BDT 80899 with the highest food cost per household observed in Sunamganj district (BDT 103629.63) and the lowest observed in Moulvibazar (BDT 68139.91). However, per household yearly expenditure on food varied significantly among districts. Similarly, overall average yearly expenditure per household on clothing was BDT 6905.33 whereas expenditure on education was BDT 7728 with significant variation among districts. Yearly household's expenditure on treatment was BDT 3431 and expenditure on house repairing/purchasing was observed to be BDT 8685.33. However, yearly household's expenditure on livestock purchase was BDT 4550.33 and total yearly expenditure per household was estimated to be BDT 112199 with significant variations among districts.

Estimation of Cobb-Douglas Stochastic Frontier Production Function and Farm-specific Technical Efficiency for Vegetables

Cobb-Douglas stochastic frontier production function and technical inefficiency effect models for vegetable production were estimated simultaneously using statistical package Frontier 4.1. Stochastic frontier production function was used to estimate the farm-specific technical efficiency and also to identify the factors which influence output. On the other hand, factors in the technical inefficiency effect model indicate which factors are responsible to increase or decrease of technical inefficiency. It was observed that in the stochastic frontier model area under production had significantly positive impact on the increase of vegetable production. Other three variables such as labour, fertiliser and cost of tillage were found to have no impact on the productivity of this crop (Table 1).

Table 1. Estimation of Cobb-Douglas Stochastic Frontier Production Function and technical inefficiency effect model for vegetables

Variables	Parameters	OLS estimates (Standard error)	ML estimates (Asymptotic standard error)
Stochastic frontier model:			
Intercept	β_0	3.2099** (0.2267)	3.2093** (0.1804)
ln (Area under vegetable production)	β_1	0.8733** (0.1064)	0.8263** (0.0858)
ln (labour)	β_2	0.0893 (0.0821)	0.1002 (0.0661)
ln (fertiliser)	β_3	-0.0007 (0.0691)	0.0298 (0.0561)
ln (cost of tillage)	β_4	-0.0444 (0.0581)	-0.0164 (0.0467)
Technical inefficiency effect model:			
Intercept	δ_0	-	-3.7186** (1.0760)
Age	δ_1	-	-0.0255** (0.0101)
Education	δ_2	-	0.0471** (0.0123)
Total farm size	δ_3	-	-0.0038** (0.0014)
Family size	δ_4	-	0.3690** (0.1244)
Variance parameters:			
	σ^2	-	0.4952** (0.1117)
	γ	-	0.9638** (0.0093)
Log likelihood function		23.67	81.57
Generalised likelihood ratio (LR) test			115.81**

** indicates significance at 0.01probability level.

In the technical inefficiency effect model, age and total farm size had significant and expected (negative) signs which indicated that technical inefficiency decreased with the increase of these factors. In other words, we can say that technical efficiency increased with the increase of above two factors. On the other hand, education and family size had significantly positive sign which indicated that technical inefficiency increased with the increase of education and family size (Table 1). The impact of education on the inefficiency effect was unexpected but not surprising. This result had the conformity with the result of Rahman et al. (1999). The significant γ value and significant generalised likelihood ratio test suggested that there were significant technical inefficiency effects in the production of vegetables.

Table 2. Frequency distribution of farm-specific technical efficiency

Technical efficiency (%)	Number of farms
46-50	1 (0.33)
51-55	1 (0.33)
56-60	1 (0.33)
61-65	1 (0.33)
66-70	2 ((0.66)
71-75	8 (2.67)
76-80	13 (4.33)
81-85	41 (13.67)
86-90	80 (26.67)
91-95	142 (47.33)
96-100	10 (3.33)
Total	300 (100.00)
Minimum efficiency (%)	46
Maximum efficiency (%)	96
Average efficiency (%)	88

Figures in the parentheses indicate percentages.

Table 2 presents the frequency distribution of farm-specific technical efficiency. It was observed that the highest frequency (47.33%) occurred in the range of 91% to 95% of technical efficiency. That is, most of farmers produced vegetables which were very close to the frontier output ranged from 91% to 95%. The maximum technical efficiency was 96% and the minimum technical efficiency was 46% whereas the average technical efficiency was 88%. It indicated that 12% of vegetable production could be increased with the existing resources and production technology.

Food consumption and nutritional status of farm household

It was found that the food cost was 74 percent of total cost. The result was quite inconformity with the results of HIES (2005) and Rahman and Sousa-Poza (2010).

Overall daily family and per capita consumption of various food items were respectively 4979g and 1060g. However, there were significant variations of average household and per capita food consumptions among the districts. Average daily per capita food consumption was lower than that shown by Rahman and Islam (2012). Rahman and Islam (2012) had shown that daily per capita food consumption was 1182g. However, their study comprised the whole country whereas this study addressed some typical and vulnerable areas of Bangladesh. Daily per capita calorie intake was 2164 kcal which was lower than that mentioned by Rahman and Islam (2012).

It was observed that people of Bangladesh daily consumed at least 17 food items. These were rice, wheat, potato, vegetables, etc. Overall daily per capita rice consumption was about 445g where per capita rice consumption was the highest (500g) in Sunamganj district and the lowest (395g) in Kishoreganj district (Table 3 & 4). The daily per capita rice consumption conformed the results of PMS (2004) and HIES (2005). Although wheat is a similar food as rice, the production and consumption of this food item are very low in Bangladesh. Daily per capita wheat consumption was observed to be 30g with significant variations among the regions. Potato is an important vegetable for the people. It was observed that daily per capita potato consumption was 116g where it varied significantly among regions. Vegetables (leafy) are the cheapest and important food items in Bangladesh. People produce vegetables in their homesteads and fields for home consumptions and commercial purposes. Daily per capita vegetable consumption was 126g although it varied significantly among regions. Lentil is a protein supplier for the poor people of Bangladesh. However, its consumption is very low. It was observed that daily per capita lentil consumption was 12g. Daily per capita consumptions of mustard oil and soybean oil were respectively 7g and 21g.

Onion is the most important spicy crop in Bangladesh. It is used as a spice during cooking and also as a vegetable. Use of onion during cooking of food increases the taste and flavour of it. It is consumed in Bangladesh as cooked and uncooked conditions. It was found that daily per capita onion consumption was 41g. Garlic and ginger are important ingredients of Bangladeshi as well as oriental foods. They increase the flavour of food adding some medicinal values in it. Daily per capita consumptions of garlic and ginger were respectively 11g and 5g (Table 3 & 4). Chilli is an important food ingredient especially in Asian and African foods. Green chilli along with dried chilli powder is used during cooking food. It was observed that daily per capita green chilli consumption was 20g. People also use other spices during cooking of food. These other spices include cinnamon, cardamom, cumin, turmeric, clove, bay-leaf etc. Cinnamon, cardamom, clove, bay-leaf etc. are commonly called condiments. These types of condiments are normally used at the end of cooking to maintain the flavour of food. Daily per capita consumption of other spices was observed to be 3g. The study observed that daily per capita sugar consumption was 15g. Daily per capita consumptions of fish, meat, milk and egg were 68g, 36g, 97g and 7g respectively (Table 3 & 4). However, Table 3 shows that there were significant variations in the daily per capita consumptions of rice, wheat, potato, vegetables, mustard oil, soybean oil, onion, chilli, fish, meat, milk and egg among the regions as evidenced by significant F-values.

Table 3: Detailed information of daily per capita consumption of different food items among Regions (gram)

Food items	Sunam ganj	Habiganj	Moulvi bazar	Kishore ganj	Sirajganj	Overall average	F-value
Rice	499.91 (148.52)	468.85 (105.78)	449.50 (97.03)	395.25 (80.21)	409.99 (92.93)	444.70 (113.39)	9.49**
Wheat	35.49 (34.16)	28.40 (35.61)	41.02 (43.61)	21.25 (18.83)	25.49 (30.78)	30.33 (34.10)	3.33**
Potato	124.57 (64.62)	183.77 (91.36)	96.49 (73.73)	99.55 (71.94)	75.84 (48.54)	115.84 (80.17)	20.49**
Vegetables	117.41 (61.72)	162.22 (91.56)	99.92 (35.25)	122.52 (42.80)	126.57 (78.27)	125.73 (68.10)	7.28**
Lentil	12.61 (8.04)	14.19 (6.60)	10.92 (6.45)	12.51 (12.42)	11.86 (8.81)	12.41 (8.74)	1.13
Mustard oil	6.61 (4.82)	7.20 (5.77)	5.71 (3.31)	5.74 (3.67)	8.74 (5.49)	6.79 (4.81)	4.24**
Soybean oil	24.49 (10.49)	24.18 (12.72)	17.94 (8.06)	18.28 (7.97)	21.50 (7.66)	21.28 (9.92)	6.36**
Onion	50.67 (25.39)	53.97 (31.99)	34.32 (26.66)	35.43 (18.94)	33.09 (19.69)	41.49 (26.40)	9.57**
Garlic	11.22 (6.11)	10.42 (6.98)	11.40 (5.58)	11.16 (3.83)	12.37 (5.86)	11.31 (5.76)	0.88
Ginger	4.47 (2.97)	4.91 (2.56)	4.37 (2.75)	4.12 (2.14)	4.77 (2.50)	4.53 (2.59)	0.89
Chilli (green)	22.72 (8.26)	25.90 (13.30)	16.22 (11.38)	17.71 (9.18)	15.74 (9.19)	19.66 (11.09)	10.95**
Other spices	2.93 (3.30)	2.91 (4.04)	2.24 (1.38)	2.78 (1.61)	3.52 (1.84)	2.87 (2.66)	1.78
Sugar	17.40 (9.69)	15.81 (8.56)	13.32 (7.99)	14.02 (9.85)	14.17 (6.24)	14.94 (8.64)	2.22
Fish	95.09 (41.73)	82.48 (42.46)	46.83 (31.97)	58.44 (38.44)	57.06 (30.25)	67.98 (41.17)	17.28**
Meat	36.05 (22.91)	46.32 (25.24)	27.59 (22.51)	31.40 (25.92)	38.12 (21.61)	35.89 (24.39)	5.42**
Milk	106.99 (55.78)	84.44 (48.43)	86.73 (40.01)	112.07 (35.78)	95.24 (38.04)	97.09 (45.27)	4.55**
Egg	7.79 (5.15)	10.26 (4.54)	5.22 (4.26)	3.73 (2.80)	8.15 (9.29)	7.03 (6.07)	12.39**
Total	1176.41 (294.29)	1226.21 (318.47)	969.74 (284.67)	964.96 (180.11)	962.19 (208.65)	1059.90 (285.86)	14.76**

Figures in the parentheses indicate standard deviations. ** indicates significance at 0.01 probability level.

Table 4. Food item-wise daily per capita food consumption, calorie and protein intakes

Food items	Amount of food (gram)	Amount of calorie (kcal)	Amount of protein (gram)
Rice	444.70 (113.39)	1445.28 (368.52)	22.24 (5.67)
Wheat	30.33 (34.10)	98.27 (110.84)	3.67 (4.13)
Potato	115.84 (80.17)	106.57 (73.76)	2.32 (1.60)
Vegetables	125.72 (68.10)	37.72 (20.43)	10.69 (5.89)
Lentil	12.41 (8.74)	40.83 (28.76)	2.48 (1.75)
Mustard oil	6.79 (4.81)	2.24 (1.59)	1.5 (1.06)
Soybean oil	21.28 (9.92)	90.87 (42.36)	5.32 (2.48)
Onion	41.49 (26.40)	19.30 (12.28)	0.50 (0.32)
Garlic	11.31 (5.76)	15.50 (7.89)	0.60 (0.31)
Ginger	4.53 (2.59)	4.17 (2.39)	0.24 (0.14)
Chilli green)	19.66 (11.09)	46.59 (26.31)	0.32 (0.18)
Other spices	2.87 (2.66)	3.67 (3.41)	0.09 (0.08)
Sugar	14.94 (8.64)	55.73 (32.23)	-
Fish	67.98 (41.17)	72.06 (43.65)	6.80 (4.12)
Meat	35.90 (24.37)	48.80 (33.17)	7.18 (4.88)
Milk	97.09 (45.27)	64.09 (29.88)	1.94 (0.91)
Egg	7.03 (6.07)	12.37 (10.68)	0.84 (0.73)
Total	1059.90 (285.86)	2164.09 (543.43)	67.00 (10.85)

Figures in the parentheses indicate standard deviations.

Rice is major calorie supplier for the people of the country. That is, food is dominated by rice. It was observed that rice alone generated 1445 kcal per capita which was 67 percent of total calorie intake (Table 4). The result was consistent with the results of Rahman and Sousa-Poza (2010) and Rahman and Islam (2012). Potato was the second highest per capita calorie supplier (107 kcal) followed by wheat (98 kcal), soybean oil (91 kcal), fish (72 kcal) and milk (64 kcal) respectively. Overall per capita calorie intake was observed to be 2164 kcal which was significantly lower than that shown by Rahman and Islam

(2012). In Bangladesh, daily per capita calorie intake was recorded to be 2250 kcal (Wikipedia, 2015). Rice supplied the highest amount of protein (22 g) followed by that of vegetables (11 g), meat (7 g), fish (7 g) and soybean oil (5 g) respectively. Total per capita protein intake was 67 g (Table 4).

Poverty Indices Estimation

Poverty is the root cause of food insecurity. Poverty levels have been measured on the basis of Direct Calorie Intake (DCI) method using head count ratio and Cost of Basic Needs (CBN) method through poverty line estimation. It was observed that absolute poverty was 49% and hard core poverty was 29% in the study areas on the basis of DCI method. Absolute poverty was the highest (77%) in the Kishoreganj district whereas the hard core poverty was the highest (42%) in the Sirajganj district (Table 5). However, on the basis of cost of basic needs (CBN) it was observed that both absolute and hard poverty were the lowest in Sunamganj district. But the absolute poverty was the highest in Sirajganj district and hard core poverty was the highest in Moulvibazar district. Absolute and hard core poverty were estimated to be 48% and 34% at the aggregate level (Table 6).

Table 5. Poverty estimates of farm households using Direct Calorie Intake (DCI) method

District	Absolute poverty (%)	Hard core poverty (%)
Sunamganj	30	12
Habiganj	*35*	18
Moulvibazar	50	35
Kishoreganj	77	38
Sirajganj	52	42
Overall average	49	29

The estimated poverty line:

$$\ln Y = 6.679249^{**} + 0.000401^{**}X$$
$$\quad (0.050057) \qquad (0.000022)$$

$F = 318.72^{**}$ and adjusted $R^2 = 0.52$

Where, Y is monthly per capita expenditure for food and non-food items.

Now, $\ln Y = 6.679249 + 0.000401 \times 2122$

Or $\ln Y = 7.530171$

Hence Y = EXP (7.530171) = BDT 1863.42 (Absolute poverty line)

And

$\ln Y = 6.679249 + 0.000401 \times 1805$

Or $\ln Y = 7.403054$

Hence Y = EXP (7.403054) = BDT 1641 (Hard core poverty line)

Table 6. Poverty estimates of farm households using Cost of Basic Needs (CBN) method

District	Absolute poverty (%)	Hard core poverty (%)
Sunamganj	33	22
Habiganj	37	33
Moulvibazar	55	42
Kishoreganj	55	33
Sirajganj	60	40
Overall average	48	34

Conclusions and Policy options

It was found that production of vegetables was profitable in the *haor* areas. People could earn a handsome amount of income from vegetable production. This income could be increased further by ensuring efficient production system. Daily per capita food and calorie intakes were lower in *haor* areas than that of other regions. Vegetables offered large amount of calorie and protein in human diet. Daily per capita food consumption was influenced by family size, calorie received from vegetables and region. Food consumption per capita was significantly lower in households with higher family sizes and food consumption increased with the increased amount of calorie intake from vegetables. There were large numbers of people living under absolute and hard core poverty levels.

A package of policy options is needed to alleviate poverty, livelihood and food security in the *haor* areas. Efficient production of short duration, high-value and nutritious vegetable crops could be one of the options to ameliorate economic condition, health and also to reduce risk of crop failure. Government's extension agents could be engaged to make awareness of the people to produce vegetables ensuring efficient utilisation of scarce land resources. Thus, the household's income as well as the share of vegetable income to total income can be increased.

Creation of income generation activities (IGAs) through appropriate livestock and fish farming could be another option. Wetland ecosystem could be managed and utilised properly to enhance fish production and also to rear ducks. Setting up of small scale industry to the locality to reduce the burden of employment on crop sector and also to transfer some labourers to non-farm activities could be the third option.

The activities of Bangladesh *Haor* and Wetland Development Board (BHWDB) should be strengthened and proper execution of the *Haor* Infrastructure and Livelihood Improvement Project (HILIP) should be ensured as designed to reach the expected goals in the haor areas. Water and Sanitation Sector (WSS) services should be strengthened emphasising Hard to Reach (HtR) areas.

This study further advocates capital development initiatives as the *haor* ecosystem fails to promote sustainable livelihoods to the seasonal domestic migrant who are the victims of that ecosystem's intrinsic climates. Seasonal migrants mainly comprise the uneducated and capital deficient wage labourers seeking work in other agricultural high land regions during flooding season.

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