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Economic Efficiency of Rearing Livestock in Vulnerable Regions in Bangladesh: An Analysis of Stochastic Cost Frontier

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Abstract

The study aimed at estimating economic efficiency and minimum input cost demand equations of rearing livestock by farm households living in three vulnerable regions of Bangladesh. Based on primary data collected from 210 households, the study performed both descriptive and functional analyses to attain the objectives. The study observed that aggregate livestock rearing cost was positively influenced by cereal and labour prices and value of output whereas it was negatively influenced by age, education and experience of farm operators. Aged farmers were economically more efficient than younger farmers. Experienced farmers and more educated farmers were economically more efficient than inexperienced and less educated farmers. Farmers with smaller farm operations were more efficient than farmers with larger farm operations. Farm-specific efficiency varied from 12 percent to 99 percent. Overall mean economic efficiency of livestock rearing was 62 percent, which implied that farmers could reduce 38 percent cost for rearing livestock keeping the value of output constant. If the rearing cost could have been reduced by 38 percent, the full cost basis net return from livestock could be increased by 122 percent and cash cost basis net return could be increased by 25 percent whereas total households' income could be increased by 50 percent. Demand for cereal in poultry enterprises was negatively influenced by its price and positively influenced by value of output whereas it was

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positively influenced by price of straw and value of output in the cattle and goat enterprises. Labour demand was negatively influenced by its price and cereal price but positively influenced by value of output. As a policy option, all farmers rearing livestock should be given training on technical know-how to reduce rearing cost. Only regular training by Department of Livestock Services (DLS) could help farmers save resources.

1. Introduction

Bangladesh is the most densely-populated non-industrialised and agricultural country in the world. The geographical location and topographical features have exposed the country to almost all kinds of natural and human induced disasters. The rural economy of Bangladesh is highly prone to natural disasters like flood, cyclone, river erosion and drought etc. As a result, a large number of people can not afford subsistence level of income for meeting their basic needs, thus living below the poverty line. The poor people are in a state of economic, social and psychological deprivation having insufficient ownership, control or access to resources as required for an acceptable standard of living. The Poverty Reduction Strategy Paper (PRSP) (2005) of Bangladesh has identified the following major determinants of poverty. First, there are the quality and demographic aspects of households, viz. the gender of the household head, the literacy level of the household head, skill level of the household head, the religion of the household, the size and location of the household (i.e. rural or urban). Then there are the policy intervention variables, i.e. whether the household has electricity connection and is the recipient of female stipend. Finally, land ownership and income from assets owned are the income and asset variables. That is, the various causes of poverty to mention are low economic growth, inequitable distribution of income, unequal distribution of productive assets, unemployment and underemployment, high rate of population growth, low level of human resources development, natural disasters like, cyclone, flood, river erosion, drought, crop failure for many reasons and limited access to public services and utilities. Logically, therefore, poverty alleviation and creation of rural employment are top priorities in the development agenda of the Government of Bangladesh (GOB), which has adopted a broad-based approach to poverty alleviation, emphasising macroeconomic stability, economic liberalisation, and support for a number of government agencies and non-government organisations (NGOs).

To make it compatible with development agenda of the government to reduce poverty, rearing livestock could be termed as an appropriate strategy to achieve the goal of the government. Livestock rearing in Bangladesh is an integral

agricultural activity among most rural households, particularly the landless, marginal and small landholders. It has significant positive impact on equity in terms of income, employment and poverty reduction in rural areas as distribution of livestock is more egalitarian as compared to land. Apart from its multi-faceted roles in socio-economic development, the livestock sector constitutes about 17 percent of agricultural gross domestic product and provides nutritionally rich food to many people in both rural and urban areas (BBS, 2010). Small animals like sheep, goat and poultry are largely kept by the land scarce poor households for commercial purposes due to their low initial investment and operational costs. Demand for animal based products such as milk, meat and eggs has significantly increased due to sustained growth in income, urbanisation, change in food preferences and increased awareness of nutritional food intake.

Land and livestock are the major assets of rural households for livelihood support in general and of the landless, marginal and small households in particular. As distribution of land holdings in rural Bangladesh is highly skewed towards medium and large farmers, rearing of livestock is considered to be a potential option for poor landless and small farming households to earn their livelihoods on a sustainable basis. Empirical evidence shows that livestock rearing has a positive impact on equity of income and employment for resource-poor rural households (Ali, 2007; Birthal & Ali, 2005; Birthal & Singh, 1995; Rao et al., 2003; Singh & Hazell, 1993). The ongoing global climate change and erratic nature of rainfall had often affected crop production in the immediate past few years. Hence, livestock has become a source of dependable income for poor farmers. In years of drought the livestock population faces severe shortage of feed and fodder.

Poverty, food insecurity and malnutrition are the usual phenomena for the rural Bangladesh. Poverty is the root cause of food insecurity. The above three phenomena can be improved by increasing the domestic food production and by reforming the market (Rahman and Schmitz, 2007). Uses of appropriate livestock enterprises can help increase the domestic production, which in turn can increase income or increase access to food of the households. Labour intensive sustainable livestock enterprises would also increase the income of landless labourers and marginal farmers, thus increasing the food security of the people of rural Bangladesh. To increase income from livestock based enterprises or to increase to access to food, the cost of rearing livestock should be minimised. Cost or economic efficiency is one strategy of minimising total cost of rearing livestock.

The overall objective of this paper is to estimate the economic efficiency of livestock rearing in vulnerable regions of Bangladesh.

2. Methodology

This study was based on primary data collected from farmers with pre-tested questionnaires through a field survey. Trained enumerators were employed to collect data from the farmers practicing crop and livestock enterprises. The regions Shirajgonj, Bogra and Jamalpur districts have been selected as study areas since poor people of these regions face food shortages due to flood and river erosion in some months in a year, thus living in food insecurity and malnutrition conditions. These flood prone and river erosion areas are called vulnerable areas and poor people both male and female living there are called vulnerable people. Two hundred ten poor and marginal farmers practicing livestock enterprises commercially had been selected through simple random sampling technique from the above three districts from the population of 1200 farmers. From each district 70 farmers rearing livestock and poultry for livelihood had been selected and data on various factors like feed, feed prices and output prices were collected through direct interview method. For the analysis of data, both partial and functional analyses have been carried out and appropriate statistical tools and techniques have been used, such as descriptive statistics, econometric models, etc. using SPSS and Frontier 4.1c.

Explicit Analytical technique:

i. **Descriptive analysis**: Average, percentage, standard deviation, standard error, chart, diagram etc.
ii. **Functional Analysis:** Cobb-Douglas normalised stochastic cost frontier function, minimum cost input demand equations in rearing livestock. Economic efficiency of producing livestock has been estimated using Cobb-Douglas normalised stochastic cost frontier function and minimum cost input demand equations have been derived from the translog cost function.
iii. Test statistics: t-test, Wald test, Generalised likelihood ratio test and F-test.

The Cobb-Douglas normalised stochastic cost frontier function:

$$\ln C_i = \beta_0 + \beta_1 \ln EDU + \beta_2 \ln AGE + \beta_3 EXP + \beta_4 \ln Q_i + \beta_5 \ln P_{wi} + \beta_6 \ln P_{si} + \beta_7 \ln P_{cei} + \beta_8 \ln P_{coi} + \beta_9 \ln P_{gi} + V_i + U_i \quad (1)$$

Where C_i = normalised cost of rearing livestock for i-th farm, EDU = education of farm operator, AGE = age of farm operator, EXP = experience of farm operator, Q_i = livestock output (in value in BDT) for i-th farm, Pw = wage per labour per day in BDT, P_S = price per kg of straw in BDT, P_{ce} = price per kg of cereal, P_{co} = price per kg of concentrate and P_g = price per kg of green grass.

U is a non-negative cost inefficiency effect which is assumed to have a half-normal distribution and V is a two-sided uniform random variable having normal distribution. U is added in the cost frontier, instead of being subtracted, as in case of the production frontier. This is because the cost function represents minimum cost, whereas the production function represents maximum output.

Economic inefficiency effect model

$$U_i = \delta_0 + \delta_1 \text{ EDU} + \delta_2 \text{ AGE} + \delta_3 \text{ EXP} + \delta_4 \text{ FARMSZ} + W_i \quad (2)$$

Where FARMSZ = farm size and other variables as defined earlier.

W_i is a unobservable random variable, which is assumed to be independently distributed with a positive half normal distribution.

β- and δ- coefficients are unknown parameters to be estimated with variance parameters which are expressed in terms of

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \quad (3)$$

and

$$\gamma = \sigma_u^2 / \sigma^2 \quad (4)$$

It is important to note that the above model for the inefficiency effects (2) can only be estimated if the inefficiency effects are stochastic and have a particular distributional specification.

Null hypotheses

(i) The economic inefficiency effects are not present:
$H_0: \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$

(ii) The inefficiency effects are not stochastic, $H_0: \gamma = 0$

(iii) The coefficients of the variables for the model of inefficiency effects are zero,
$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$

The above null hypotheses will be tested using generalised likelihood ratio test, which can be calculated as

$$LR = -2[\ln\{L(H_0)/L(H_1)\}] = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}] \quad (5)$$

The Uis provide information on the level of the cost or overall economic efficiency (EE) of the i-th farm. This may be calculated as the ratio of frontier minimum cost ($U_i = 0$) to observed cost and is equal to

$$EE = \exp(-U_i)$$
$$= \exp\{-E(U_i/e_i)\}$$
$$= 1 - E(U_i/e_i) \quad (6)$$

Mean economic efficiency

$$\text{Mean EE} = E[\exp\{-E(U_i/e_i)\}] = E\{1- E(U_i/e_i)\} \quad (7)$$

Minimum cost input demand equations

Minimum cost input demand equations can be derived from the following translog cost function using Shephard's Lemma of `The Envelope Theorem´ in Duality (Coelli et al., 1998; Beattie and Taylor, 1985):

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{wi} + \alpha_2 \ln P_{si} + \alpha_3 \ln P_{cei} + \alpha a_4 \ln P_{coi} + \alpha_5 P_{gi} + \alpha_6 \ln Q_i + (1/2)\beta_{11}(\ln P_{wi})^2 + \beta_{12} \ln P_{wi} \ln P_{si} + \beta_{13} \ln P_{wi} \ln P_{cei} + \beta_{14} \ln P_{wi} \ln P_{coi} + \beta_{15} \ln P_{wi} \ln Pgi + \beta_{16} \ln P_{wi} \ln Q_i + (1/2)\beta_{22} (\ln P_{si})^2 + \beta_{23} \ln P_{si} \ln P_{cei} + \beta_{24} \ln P_{si} \ln P_{coi} + \beta_{25} \ln P_{si} \ln P_{gi} + \beta_{26} \ln P_{si} \ln Q_i + (1/2)\beta_{33} (\ln P_{cei})^2 + \beta_{34} \ln P_{cei} \ln P_{coi} + \beta_{35} \ln P_{cei} \ln P_{gi} + \beta_{36} \ln P_{cei} \ln Q_i + (1/2)\beta_{44} (\ln P_{coi})^2 + \beta_{45} \ln P_{coi} \ln P_{gi} + \beta_{46} \ln P_{coi} \ln Q_i + (1/2)\beta_{55} (\ln P_{gi})^2 + \beta_{56} \ln P_{gi} \ln Q_i + (1/2)\beta_{66} (\ln Q_i)^2 + V_i + U_i \quad (8)$$

Various factor share equations or minimum cost input demand equations are:

$$(P_w H/C) = \delta \ln C/\delta P_w = a_1 + \beta_{11} \ln P_{wi} + \beta_{12} \ln P_{si} + \beta_{13} \ln P_{cei} + \beta_{14} \ln P_{coi} + \beta_{15} \ln P_{gi} + \beta_{16} \ln Q_i + e_1 \quad (9)$$

$$(P_s S/C) = \alpha_2 + \beta_{12} \ln P_{wi} + \beta_{22} \ln P_{si} + \beta_{23} \ln P_{cei} + \beta_{24} \ln P_{coi} + \beta_{25} P_{gi} + \beta_{26} \ln Q_i + e_2 \quad (10)$$

$$(P_{ce} C_e/C) = \alpha_3 + \beta_{13} \ln P_{wi} + \beta_{23} \ln P_{si} + \beta_{33} \ln P_{cei} + \beta_{34} \ln P_{coi} + \beta_{35} P_{gi} + \beta_{36} \ln Q_i + e_3 \quad (11)$$

$$(P_{co} C_o/C) = \alpha_4 + \beta_{14} \ln P_{wi} + \beta_{24} \ln P_{si} + \beta_{34} \ln P_{cei} + \beta_{44} \ln P_{coi} + \beta_{45} P_{gi} + \beta_{46} \ln Q_i + e_3 \quad (12)$$

$$(P_g G/C) = \alpha_4 + \beta_{15} \ln P_{wi} + \beta_{25} \ln P_{si} + \beta_{35} \ln P_{cei} + \beta_{45} \ln P_{coi} + \beta_{55} \ln P_{gi} + \beta_{56} \ln Q_i + e_5 \quad (13)$$

3. Results and Discussion

Recent climate change and frequent crop failures have insisted farmers to search for alternative livelihood by rearing livestock in the face of price volatility and global price spirals of essentials in the last few years. Livestock has emerged as commercially market oriented profitable enterprises and attracted young and innovative farmers. Younger farmers were engaged in livestock enterprises to earn an affordable income in different regions. Most of the farmers were middle aged and they were found to be enthusiastic about the performance of their works. Average age of farmers at the aggregate level was 44.69 years with significant variations ($F = 55.16^{**}$) among regions (Table 1). Farmers rearing livestock in Bogra were found to be younger than those of other regions. Farmers of Bogra were mostly involved in poultry enterprises.

Most of the farmers were educated and average education was 8.41 years of schooling. Farmers of Jamalpur regions have significantly ($F = 6.98^{**}$) higher

education (9.97 years of schooling) than those of other regions. All farmers had own land and some cultivable land. Overall, own and total cultivable land were observed to be 149.47 decimals and 152.60 decimals, respectively, with significant variations among regions. All farmers had homestead and some of them had also pond. But pond areas varied significantly among regions (F= 12.36**). Average homestead and pond area was respectively 16.94 decimals and 6.91 decimals. About 79 percent of farmers had previous experience of rearing livestock and poultry but previous experience of farmers was higher in Sirajganj region (40.36 percent) (Table 1).

Family size was 5 persons, which varied significantly among regions (F=7.70**). The number of earning member was 1.74 persons. Dependency ratio was 0.64 with significant variations (F=16.03**) among regions. Overall literacy ratio was 0.66 but it was significantly higher in Jamalpur region (0.82). Literacy ratio of female to male was 0.87 and thus literacy rate of male was higher compared to female. Family composition was 1 male: 1.09 female. That is, the number of female was more than that of male (Table 2).

Table 1: Socio-economic and demographic characteristics of farm

Region	Age of farm operator (year)	Education of farm operator (year of schooling)	Area of own land (decimal)	Area of homestead (decimal)	Area of pond (decimal)	Total land (decimal)	No. of household having previous experience
Sirajganj	47.74	6.01	198.35	14.04	0.47	200.35	67
	(13.28)	(3.98)	(279.35)	(14.75)	(3.94)	(266.83)	(40.36)*
Bogra	33.19	9.24	128.69	20.23	11.50	134.08	66
	(11.54)	(3.48)	(117.94)	(14.71)	(21.64)	(116.10)	(39.76)*
Jamalpur	53.13	9.97	121.39	16.55	8.77	123.37	33
	(9.79)	(10.27)	(118.03)	(10.26)	(8.76)	(92.74)	(19.88)*
All	44.69	8.41	149.47	16.94	6.91	152.60	166
	(14.32)	(6.86)	(190.17)	(13.59)	(14.39)	(178.77)3	(100.00)*
F-values	55.16**	6.98**	3.58*	3.77*	12.36**	3.91*	$\chi^2 = 64.58$**

Note: Figures in the asterisk parentheses indicate percentages. Figures in the parentheses indicate standard deviations.** and* indicate significance at 0.01 and 0.05 probability level, respectively.

Farmers needed credit from outside as their per capita income and resource base were not enough to rear livestock or to start a new livestock business to improve their productivity and livelihoods. As there was huge unused labours in the rural areas, labour intensive enterprises could help increase income and food security of rural people. But farmers especially poor farmers, had little access to the government credit market. Only 62 (about 30 percent of total) farmers got credit from governments' bank and non-government organisations (NGOs). Out of the

Table 2: Demographic profiles of farm households: family information

Region	Family size	Number of earning member	Dependency ratio	Literacy ratio of female to male	Overall literacy ratio	Family composition (ratio of female to male)
Sirajganj	5.77	1.59	0.72	0.84	0.58	1.09
	(2.76)	(0.93)	(0.12)	(0.73)	(0.29)	(0.87)
Bogra	4.53	1.77	0.58	0.72	0.56	0.96
	(1.61)	(0.76)	(0.19)	(0.56)	(0.27)	(0.60)
Jamalpur	4.86	1.87	0.62	1.05	0.82	1.24
	(1.04)	(0.70)	(0.12)	(0.56)	(0.18)	(0.75)
All	5.05	1.74	0.64	0.87	0.66	1.09
	(2.00)	(0.81)	(0.15)	(0.64)	(0.28)	(0.75)
F-values	7.70**	2.29	16.03**	5.17**	23.65**	2.44

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

62 farmers, 12 (19 percent) received credit from ASA, 23 (37 percent) from BRAC, 9 (15 percent) from Grameen Bank, 17 (27 percent) from Bangladesh Krishi Bank and 1 (2 percent) from PDP (Table 3). Farmers did not face any problem in taking loans from the NGOs. The NGO personnel visited farmers' house to enquire about the necessity of credit.

They got credit from the NGOs in time although a small number of farmers reported that they did get less credit than they required. But they faced sometimes

Table 3: Number of households taken credit from different organisations

Region	Organisations from where credit was taken					l Total	Amount of credit taken (BDT)
	ASA	BRAC	Grameen Bank	BKB	PDP		
Sirajganj	2	4	7	-	1	14	29200.00
							(25162.89)
Bogra	6	6	-	4	-	16	56333.33
							(50194.86)
Jamalpur	4	13	2	13	-	32	35468.75
							(27834.75)
Total	12	23	9	17	1	62	39000.00
							(34947.74)
χ^2			51.73**				F = 2.75

Note: Figures in the parentheses indicate standard deviations. ** indicates significance at 0.01 probability level. ASA-Association of Social Advancement, BKB-Bangladesh Krishi Bank (Bangladesh Agricultural Bank), PDP- Palli Development Proias (Rural Development Initiative), BRAC- Bangladesh Rural Advancement Committee.

problem for getting loan from the Bangladesh Krishi Bank as most of the time government officials were found non-cooperative. Average credit taken by farm households was Tk.(BDT) 39000.

Farmers were found to rear different livestock based enterprises such as livestock farm for meat production, dairy farm, goat farm, broiler farm, layer farm and mixed farms. But the majority of farms were the dairy farms followed by broiler farms. Some farmers were found to rear more than one enterprise (Table 4). Sirajganj and Jamalpur regions were dominated by cattle (meat + dairy) farms and Bogra region was dominated by poultry (broiler + layer) farms. But different enterprises varied significantly across regions ($c^2 = 141.35^{**}$). Average land used for livestock enterprises was 5.77 decimals with significant variations among regions ($F= 13.55^{**}$).

Livestock rearing involved various cost items such as feed cost, treatment cost, day old chick (DOC) purchasing cost and labour cost. Among all the cost items, feed cost was the most important cost item. Feed were purchased from the market which accrued huge money cost. Farmers did not produce feed rather they purchased feed from the market in exchange of money. Thus, demand and supply response of feed influenced farmers' income from livestock. Although at the aggregate level labour cost was higher than feed cost, in most of the cases farmers used family labour and they did not encounter this cost always. That is why, labour cost was the second important cost item. Feed cost was the highest in Bogra region as most of livestock farmers were found to rearing poultry especially broiler and layer. Cost of poultry feed was higher than that of cattle feed. Cattle

Table 4: Description of livestock farms surveyed in the study

Region	Name of livestock farm							Land area used for livestock farm
	Livestock farm for meat	Dairy farm	Goat farm	Broiler farm	Layer farm	Others (mixed) farm	Total	
Sirajganj	1	54	0	15	0	0	70	6.90 (6.27)
Bogra	2	0	0	62	3	3	70	7.71 (8.41)
Jamalpur	9	52	1	4	1	3	70	2.71 (1.37)
Total	12	106	1	81	4	6	210	5.77 (6.46)
χ^2				141.35^{**}				$F= 13.55^{**}$

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

(both dairy and beef) relied on mostly green grass and straw which were cheaper than poultry feed. Although farmers fed concentrate to cattle, it was small in quantity. Since Sirajganj and Jamalpur regions were dominated by cattle rearing, the feed cost was significantly lower in these regions (Table 5). F value suggested that there were significant variations of feed cost among regions. Treatment cost was another important cost item of livestock especially for poultry. Poultry was more susceptible to disease attack. The treatment cost was the highest for Bogra region (Tk. 14103) followed by that of Sirajganj region (Tk.7300) and Jamalpur region (Tk. 650) respectively. There were significant variations of treatment cost among regions ($F = 48.86^{**}$). Cost of purchasing day old chick (DOC) was another cost item of livestock. It also varied significantly among regions ($F = 27.04^{**}$). Labour cost was Tk. 126366 at the aggregate level but it did not vary significantly among regions. Total cost of rearing livestock in a year was the highest in Bogra region (Tk. 555246) followed by that in Sirajganj region (Tk.172713) and Jamalpur region (Tk. 67202), respectively.

Table 6 presents the maximum likelihood estimates of stochastic cost frontiers and economic inefficiency effect models. Poultry model and aggregate model included the explanatory variables like cereal price, labour wage, age, education, experience (dummy) and output while the cattle model included all the above explanatory variables in addition to straw price, price of green grass and oilcake price. It was observed that total cost of rearing poultry was significantly and positively influenced by cereal price, labour wage and output. A one percent increase in cereal price entailed 0.29 percent increase in total cost. Similarly, one

Table 5: Yearly cost of rearing livestock (BDT)

Region	Feed cost	Labour cost	Treatment cost	Cost of day old chick (DOC)	Total cost
Sirajganj	38671.93	104468.21	7300.07	22272.86	172713.07
	(105260.05)	(91289.37)	(9672.68)	(50323.76)	(173639.78)
Bogra	236298.29	218916..57	14102.86	85928.57	555246.29
	(216615.88)	(1030549.86)	(89975.75)	(107917.58)	(1106224.78)
Jamalpur	7029.29	55714.64	649.71	3808.29	67201.93
	(39495.68)	(36384.39)	(1187.42)	(15413.05)	(62719.31)
All	93999.84	126366.48	7350.88	37336.57	265053.77
	(173218.25)	(598759.57)	(9722.06)	(77477.52)	(677814.16)
F-values	54.43^{**}	1.38	48.86^{**}	27.04^{**}	11.01^{**}

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

percent increase in labour wage entailed 0.48 percent increase of total cost and one percent increase in value of output caused 0.35 percent increase of total cost. Age and experience of farm operator significantly reduced the total cost of rearing poultry. Aged and experienced farmers could manage inputs in better ways with minimum prices than younger and inexperienced farmers. Although the impact of education on the cost of poultry was negative, it was insignificant.

Total cost of rearing cattle was significantly and positively influenced by oilcake price and cereal price whereas it was influenced negatively by age of farmer. A one percent increase in oilcake price caused an increase of 0.04 percent in total cattle cost whereas 100 percent increase in cereal price caused an increase of 0.2 percent of total cattle cost. But the impact of age on the total cost of rearing cattle was negative. One plausible explanation of the situation was that more aged farmers could mange inputs with minimum prices and thereby reduce total cost than younger farmers. The impacts of education and experience on total cost were also negative but they were not statistically significant.

In the aggregate model, the total cost of rearing livestock was influenced positively by the cereal and labour prices and value of output whereas it was negatively influenced by age, education and experience of farmers. Negative impact of age, education and experience might have been due to the fact that farmers with more age, education and experience could manage inputs and livestock with minimum inputs prices than younger, less educated and inexperienced farmers.

The economic inefficiency effect models included four farm-specific explanatory variables like age, education, experience of farmer and farm size. All the explanatory variables have expected (negative) sign except farm size in the economic inefficiency effect model for poultry. Negative coefficient of age indicated that farmers with more age have less economic inefficiency than younger farmers. Conversely we can say that farmers with more age are economically more efficient than younger farmers. Similarly, experienced farmers and more educated farmers were economically more efficient than inexperienced and less educated farmers for rearing poultry. But the positive coefficient of farm size indicated that farmers with larger farm operations were economically less efficient than farmers with smaller farm operations. This result is in conformity with results of empirical studies elsewhere, which indicate that small farmers are more efficient than large farmers. Similar explanation can be given for the variables for cattle model. In the aggregate economic inefficiency effect, coefficient of age was negative and significant whereas the coefficient of farm

Table 6: Maximum likelihood estimates of stochastic cost frontiers and economic inefficiency effect models

Factors	Poultry model Coefficients (Asymptotic std. error)	Cattle (dairy + meat) model Coefficients (Asymptotic std. error)	Aggregate model Coefficients (Asymptotic std. error)
Stochastic cost frontiers:			
Intercept	7.3544**	10.6390**	9.1232**
	(1.1306)	(1.5294)	(1.1235)
Straw price	-	0.1142	-
		(0.3861)	
Green grass price	-	-0.0003	-
		(0.0006)	
Oilcake price	-	0.0434*	-
		(0.0212)	
Cereal price	0.2949**	0.0019**	0.0017**
	(0.1276)	(0.00029)	(0.0002)
Labour wage	0.4791**	0.0002	0.3349**
	(0.1095)	(0.0003)	(0.1102)
Age	-0.4073**	-0.8942**	-0.4531**
	(0.1614)	(0.2579)	(0.0324)
Education (EDU)	-0.2365	-0.0003	-1.0623**
	(0.2258)	(0.0004)	(0.1902)
Experience (dummy)	-0.4836*	-0.1488	-0.0008**
	(0.2246)	(0.1399)	(0.0002)
Output	0.3487**	0.0026	1.3679**
	(0.0744)	(0.0066)	(0.1809)
Inefficiency effect model:			
Intercept	-6.3702	-0.0032	2.0868**
	(8.1373)	(0.0022)	(0.4341)
Age	-0.0234	-0.0998**	-0.0019**
	(0.0419)	(0.00323)	(0.0003)
Education (EDU)	-0.4577	-0.0358	-0.1173
	(0.4377)	(0.0634)	(0.1308)
Experience (dummy)	-6.2228	-0.0162	-0.0003
	(8.1957)	(0.0136)	(0.0002)
Farm size (FARMSZ)	0.0068	0.0281	0.6863**
	(0.0077)	(0.0757)	(0.1946)
Variance parameters:	1.8245	1.2266**	0.5701**
$ó^2$	(1.0392)	(0.1753)	(0.0755)
γ	0.8408**	0.8913**	0.7705**
	(0.1046)	(0.3095)	(0.1038)
Log-likelihood function	-87.16	-118.36	-222.13
GLR test	4.51*	25.80**	59.20**
F-statistic model	86.94**	21.08**	58.74**
Adj. R^2	0.71	0.61	0.62

Note: Figures in the parentheses indicate standard errors, ** and * indicate significance at 0.01 and 0.05 probability level, respectively.

size was positive and significant, which implied that farmers with more age were significantly more efficient than younger farmers and farmers with larger farms were significantly economically less efficient than farmers with smaller farm operations.

The variance ratio parameter g was significant for all models which implied that there were significant economic inefficiencies in rearing poultry and cattle. It also indicated that 84%, 89% and 77% of the difference between observed cost and minimum attainable cost (frontier cost) were caused by differences in farmers' levels of economic efficiency for poultry, cattle and aggregate livestock, respectively. Significant generalised likelihood ratio (GLR) also suggested that there were significant economic inefficiency effects in rearing all types of livestock whereas F- statistic showed that all the models were well fitted to the data.

Table 7 presents the frequency distribution of economic efficiency estimates. It revealed that there were significant variations of farm-specific economic efficiency estimates, which varied from 33 percent to 99 percent for poultry, from 12 percent to 89 percent for cattle, and 12 percent to 99 percent for aggregate livestock. Average efficiency for poultry was 65 percent which implied that farmers could reduce 35 percent of cost for poultry maintaining the same level of output. Similarly, farmers could reduce 63 percent cattle rearing cost maintaining the same level of cattle output. But for aggregate livestock, farmers could reduce 38 percent cost keeping the value of total output constant.

Maximum likelihood estimates of farm level minimum cost input demand equations are presented in Table 8 where poultry enterprise has shown two input demand equations, and cattle and goat enterprises have shown five input demand equations. Cereal demand in poultry enterprises was significantly negatively influenced by cereal prices. That is, cereal demand was reduced significantly with the increase in cereal prices. But demand for cereal was significantly positively influenced by value of poultry output. That is, demand for cereal was increased with the increase in value of poultry output. Although the coefficient of labour wage on the demand for cereal was negative, it was insignificant. Similarly labour demand in poultry was negatively influenced by cereal price and positively influenced by value of output. Labour wage had minor influence on the quantity demand for labour. Significant g values and GLR test suggested that there were significant inefficiency in managing inputs like cereal and labour among farm households whereas the F-statistic suggested that the demand functions were well fitted to data.

Table 7: Frequency distribution of economic efficiency estimates of livestock farmers in Bangladesh

Efficiency level (%)	No. of farms or frequency		
	Poultry (broiler + layer + mixed)	Cattle and goat (dairy + meat)	Aggregate livestock
10–20	-	11	8
		(9.25)	(3.81)
20–30	-	3	6
		(2.52)	(2.86)
30–40	3	10	12
	(3.30)	(8.40)	(5.71)
40-50	2	12	16
	(2.20)	(10.08)	(7.62)
50-60	6	30	35
	(6.59)	(25.21)	(16.67)
60-70	18	28	42
	(19.78)	(23.53)	(20.00)
70-80	38	20	62
	(41.76)	16.81)	(29.52)
80-90	23	5	25
	(25.27)	(4.20)	(11.90)
90-100	1	-	4
	(1.10)		(1.91)
Total number of farms	91	119	210
	(100)	(100)	(100)
Mean efficiency	65	37	62
Minimum efficiency	33	12	12
Maximum efficiency	99	89	99

In the cattle and goat enterprises, demand for straw was negatively influenced by price of straw and also price of cereal, whereas it was positively influenced by value of output. Similarly, demand for green grass was negatively influenced by its price but positively influenced by prices of straw, labour and value of output. Straw and green grass were substitutes. Demand for oilcake was not influenced significantly by factors although price of it and price of cereal had minor negative influence on it. Demand for cereal was positively influenced by price of straw and value of output. Straw and cereal were also substitutes. Price of straw and labour wage had negative impact on the demand for labour whereas value of output had positive influence on it. All the test statistics suggested that there were significant inefficiency in managing those inputs except oilcake and all the functions were well fitted to data except oilcake function in these enterprises.

Livestock offers dependable and affordable income to households who rear livestock and poultry especially living in vulnerable and river erosion areas. Crop may be destroyed totally or partially due to untimely flood or any other natural calamity arising from climate change. Farmers can save livestock from unprecedented natural calamities if they are well informed quite ahead of such exogenous shocks. Thus livestock loss can be minimised and income can be generated time to time from this sector to enhance access to food for these people. Table 9 presents net returns for both full cost and cash cost bases. Full cost basis net return included labour cost while calculating total cost whereas cash cost basis net return did not include it.

The reason behind excluding labour cost while calculating total cost was that farm households used family labour to rear livestock and also run their businesses and they did not need to pay for that. The difference between total return from livestock and full cost for livestock rearing was said to be full cost basis net return

Table 8 : Maximum likelihood estimates of farm level minimum cost input demand equations for livestock

	Poultry			Cattle and goat			
	Cereal	Labour	Straw	Green grass	Oilcake	Cereal	Labour
	11.749315**	1.050363	6.554133**	4.873049	0.724862	5.168582**	1.311142**
	(1.198972)	(0.112209)	(1.719425)	(2.673620)	(1.798189)	(1.160231)	(0.252114)
	-	-	-0.000001**	0.000001**	0.0000003	0.166695**	-0.0000015**
			(0.0000002)	(0.0000004)	(0.0000002)	(0.018107)	(0.00000004)
Green	-	-	0.168645	-0.787257**	0.651329	0.289382	-0.060458
			(0.365688)	(0.301363)	(0.374517)	(0.252092)	(0.053954)
Oilcake	-	-	0.0000009	1.006002	-0.0000002	0.163411	-0.00000006
price			(0.0000005)	(1.114008)	(0.0000006)	(0.123716)	(0.00000008)
Cereal	-0.000007**	-	-0.708529**	0.038411	-0.103493	-0.080539	0.065562
price	(0.000003)	0.000142**	(0.286014)	(0.447180)	(0.337913)	(0.019399)	(0.042979)
	-0.116659	(0.000004)	-0.0000003	1.265002*	0.0000004	0.0000002	-0.364127**
Labour	(0.308952)	-0.009437	(0.0000003)	(0.567005)	(0.0000003)	(0.0000002)	(0.131458)
wage	0.000049**	(0.027218)	0.918287*	0.271443**	0.246939	0.764349*	0.115888**
Output	(0.000011)	0.842361**	(0.423481)	(0.102273)	(0.537873)	(0.329750)	(0.027711)
		(0.115577)					
	1.830043**		0.654140**	1.584707**	1.632981**	0.678119**	0.033489
$\acute{o}^2$	(0.368153)	0.026106**	(0.201353)	(0.345201)	(0.496142)	(0.162719)	(0.021545)
		(0.001756)					
	0.878164**		0.523013**	0.520612**	0.760592**	0.769061**	0.932145**
γ	(0.057038)	0.872361**	(0.120342)	(0.017429)	(0.187883)	(0.132094)	(0.211325)
	-115.87	(0.124302)	-141.69	-194.34	-157.19	-104.25	107.33
Log-		91.91					
	13.25**		15.38**	23.48**	1.50	2.75*	41.48**
	18.07**	36.88**	4.22**	5.91**	2.07	12.67**	5.69**
-statistic		5.42**					
model	0.36		0.14	0.20	0.05	0.37	0.19
^{2}		0.13					

Note: Figures in the parentheses indicate standard errors, ** and * indicate significance at 0.01 and 0.05 probability level, respectively.

and the difference between total return and cash cost was called cash cost basis net return. The results showed that full cost basis per farm net return was the highest in Sirajganj region (Tk.155904) followed by that in Bogra region (Tk.68244) and Jamalpur region (Tk.23556), respectively, whereas cash cost basis net return was the highest in Bogra region (Tk.287160) followed by that in Sirajganj region (Tk. 260372) and Jamalpur region (Tk.79270), respectively. The overall full cost and cash cost basis net returns were, respectively, Tk.82568 and Tk.208934. If the rearing cost of livestock could have been reduced by 38 percent as suggested by economic efficiency estimate, the full cost basis net return from livestock could be increased by 122 percent whereas cash cost basis net return could be increased by 25 percent.

The analysis of income of the people living in vulnerable regions showed that farmers earned income from eight sectors. These were livestock, agriculture (crop), business, service, foreign service, selling of labour, fishing, and other sources. The livestock was the largest contributor to total income followed by agriculture, business, service, foreign service, other sources, fishing and selling of labour, respectively, at the aggregate level. The overall share of livestock sector in total income was 41 percent with the highest share observed in Bogra region (52 %) and the lowest share observed in Jamalpur region (14 percent). Total income per farm was the highest in Sirajganj region (Tk.307133) followed by that in Jamalpur region (Tk.169098) and Bogra region (Tk.131117), respectively, whereas the total income per farm at the aggregate level was Tk.202450. But there were significant differences of income from business, service, foreign service,

Table 9: Yearly net return from livestock (BDT) in 2010

Region	Net return		Net return after 38% reduction of rearing cost	
	Full cost basis	Cash cost basis	Full cost basis	Cash cost basis
Sirajganj	155903.92	260372.14	221534.89	286305.19
	(218250.67)	(231269.60)	(236830.35)	(249049.01)
Bogra	68243.85	287160.42	279237.44	414965.72
	(1187316.77)	(606978.63)	(843512.71)	(574233.02)
Jamalpur	23555.57	79270.21	49092.30	83635.38
	(90371.45)	(95738.64)	(87990.78)	(93870.90)
All	82567.78	208934.26	183288.21	261635.43
	(697759.87)	(388436.94)	(515344.53)	(388508.77)
F-values	0.65	6.23**	3.88*	14.63**

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

Table 10: Income of farm households from all sectors (BDT) in 2010

Sectors	Regions				F-values
	Sirajganj	Bogra	Jamalpur	All	
Livestock	155903.93	68243.85	23555.57	82567.78	0.65
	(216250.67)	(1187316.77)	(90371.45)	(697759.87)	
Agriculture	50879.31	44387.77	34085.66	43117.58	2.72
	(50043.87)	(38001.92)	(39924.46)	(43334.28)	
Business	59614.29	13785.71	35985.71	36461.91	8.32**
	(91170.69)	(46566.42)	(52775.57)	(68785.51)	
Service	28900.00	2071.43	44414.29	25128.57	13.28**
	(58243.90)	(14608.24)	(60405.51)	(51985.07)	
Foreign service	7000.00	-	18571.43	8523.81	2.98*
	(57366.10)		(53953.43)	(45895.78)	
Selling of	1857.14	285.71	2171.43	1438.09	1.06
labour	(8894.37)	(2390.46)	(10837.36)	(8213.57)	
Fishing	71.43	2342.86	4571.43	2328.57	3.54*
	(597.61)	(9803.70)	(14288.51)	(10131.27)	
Other sources	2907.14	-	5742.86	2883.33	2.93*
	(16515.54)		(17846.11)	(14167.55)	
Total from all	307133.23	131117.33	169098.37	202449.65	1.20
sources	(246218.13)	(1193094.03)	(130624.28)	(708057.35)	
Ratio (livestock	0.51	0.52	0.14	0.41	
to total income)					
Total income	372764.20	342110.92	194635.10	303170.08	2.37
from all sources	(257213.22)	(848554.83)	(130510.89)	(520825.28)	

Note: Figures in the parentheses indicate standard deviations, ** and * indicate significance at 0.01 and 0.05 probability level, respectively. Total income from all sources^{+} means total income after 38 percent reduction in rearing cost of livestock.

fishing and other sources among the regions (Table 10). If the rearing cost of livestock could have been reduced by 38 percent, overall income from all sources could be increased by about 50 percent.

4. Conclusions and Policy Implications

4.1 Conclusions

Younger farmers whose average age was 44.69 years were engaged in livestock rearing. Most of the farmers were educated and their average education was 8.41 years of schooling. Total own land and total cultivated land were, respectively, 149.47 decimals and 152.60 decimals. They all had homestead (16.94 decimal) and some of them had also pond (6.91 decimals). About 79 percent had previous experience of rearing livestock. Family size was 5 persons where about 2 persons were earner. Dependency ratio was 0.64 and literacy ratio was 0.66 where male were more educated than female. But the number of female was higher than the

number of male. Only 30 percent of farmers received credit from the government and non-government organisations for rearing livestock with an average credit received at Tk. 39000. Farmers reared dairy cattle, cattle for meat production, broiler, layer, goat and mixed animals.

Cost of rearing livestock comprised four cost items such as feed cost, labour cost, treatment cost, and cost of day old chick (DOC). Cost of day old chick was related to poultry rearing. The per farm costs of feed, labour, treatment and purchasing of day old chick were, respectively, Tk.94000, Tk.126366, Tk.7351 and Tk.37337. The total cost of rearing livestock per farm was Tk.265054. Three types of stochastic cost frontier models were estimated for poultry, cattle and aggregate livestock. Cost of rearing poultry was positively influenced by cereal price, labour wage and output whereas it was negatively influenced by age and experience of farm operators. Cattle rearing cost was positively influenced by oilcake price and cereal price whereas it was negatively influenced by age of farmers. Similarly, aggregate livestock cost was positively influenced by cereal and labour prices and value of output whereas it was negatively influenced by age, education and experience of farm operators.

Aged farmers were economically more efficient than younger farmers. Experienced and more educated farmers were economically more efficient than inexperienced and less educated farmers for rearing livestock. On the other hand, farmers with smaller farm operations were more efficient than farmers with larger farm operations. There were significant variations of farm-specific economic efficiency estimates, which varied from 33 percent to 99 percent for poultry, from 12 percent to 89 percent for cattle and 12 percent to 99 percent for aggregate livestock. Mean economic efficiency of poultry, cattle, and from aggregate livestock was, respectively, 65 percent, 37 percent and 62 percent, which implied that farmers could reduce 35 percent cost for rearing poultry, 63 percent cost for rearing cattle and 38 percent cost for rearing aggregate livestock, keeping value of output for each category constant.

Cereal demand in poultry enterprises was negatively influenced by cereal prices whereas it was positively influenced by value of poultry output. Similarly, labour demand in poultry was negatively influenced by cereal price and positively influenced by value of poultry output. Labour wage had minor influence on the quantity demand for labour. In the cattle and goat enterprises, demand for straw was negatively influenced by its price and also price of cereal whereas it was positively influenced by value of output. Demand for green grass was negatively influenced by its price but positively influenced by prices of straw, labour and

value of output. Straw and green grass were substitutes. Price of oilcake and price of cereal had minor negative influence on the demand for oilcake. Demand for cereal was positively influenced by price of straw and value of output. Straw and cereal were also substitutes. Price of straw and labour had negative impact on the demand for labour whereas value of output had positive influence on it. There were significant inefficiencies in managing those inputs except oilcake, and all the functions were well fitted to data except oilcake function in cattle and goat enterprises.

The full cost basis per farm net return was the highest in Sirajganj region (Tk. 155904) followed by that in Bogra region (Tk. 68244) and Jamalpur region (Tk. 23556), respectively, whereas cash cost basis net return was the highest in Bogra region (Tk. 287160) followed by that in Sirajganj region (Tk. 260372) and Jamalpur region (Tk. 79270), respectively. The overall full cost and cash cost basis net returns were, respectively, Tk. 82568 and Tk.208934. If the rearing cost of livestock could have been reduced by 38 percent as suggested by economic efficiency estimate, the full cost basis net return from livestock could be increased by 122 percent whereas cash cost basis net return could be increased by 25 percent.

The livestock sector was the largest contributor to total income followed by agriculture, business, service, foreign service, other sources, fishing and selling of labour, respectively, at the aggregate level. The overall share of livestock sector in total income was 41 percent with the highest share observed in Bogra region (52%) and the lowest share observed in Jamalpur region (14 percent). Total income per farm was the highest in Sirajganj region (Tk. 307133) followed by that in Jamalpur region (Tk. 169098) and Bogra region (Tk. 131117), respectively, whereas the total income per farm at the aggregate level was Tk.202450. If the rearing cost of livestock could have been reduced by 38 percent, overall income from all sources could be increased by about 50 percent.

4.2 Policy Implications

As a policy option, all farmers rearing livestock should be given training on technical know-how to reduce rearing cost as the efficiency estimate suggested that farmers could reduce 38 percent rearing cost. Only regular training by Department of Livestock Services (DLS) could help farmers to save resources.

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