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Salinisation In South-West Region Of Bangladesh: Economic Impact On Paddy Production

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Abstract : *The economy of Bangladesh is typically dependent on agriculture which plays a crucial role in ensuring job opportunity, securing food supply as well as upgrading the livelihood practices of the inhabitants. Agriculture sector of Bangladesh involves various crop productions; of which rice is predominant. In recent time, salinity is a major threat to crop productivity, particularly in the coastal areas of Bangladesh which are potentially suited for rice production. The worst salinity conditions are reported from Khulna, Bagerhat, Satkhira and Patuakhali districts. In this background, the present study mainly aims at examining the impact of soil salinisation on paddy production. In this direction, two upazilas namely Paikgachha (having salinity level in the range 2-5 dS m^{-1} EC value) and Morrelganj (having salinity level in the range 10-22 dS m^{-1} EC value) has been selected purposively from Khulna and Bagerhat districts respectively. Here from a total of 120 paddy producing farms have been chosen to collect data on farm specific socioeconomic variables and soil samples to test for salinity. Study period covers September to January of 2014 and the paddy type under consideration is transplanted aman. Collected data were then subjected to descriptive and profitability analyses, hypothesis testing, and, production function estimation; where salinity has been considered as one of the explanatory variables. According to study findings, Paikgachha is found to be low saline area having average salinity level of 3.44 dS m^{-1}; whereas average salinity level is 14.38 dS m^{-1} in Morrelganj. Average production volume per acre are respectively 1639.32 and 1531.45 kilogram in low and high-saline regions. Moreover, per acre total return figures are respectively BDT 26819.27 and BDT 25100.46 in low and high-saline region; and the figures for per acre cost are respectively BDT 16183.82 and BDT 17338.77 in those regions. Consequently, net return figures turn out to be BDT 10635.45 and 7761.69 respectively. According to production function estimation, the coefficient of salinity comes out – 0.08, implying that one per cent increase in salinity, ceteris paribus, reduces paddy yield by 0.08 percent. Hence, on the basis of the analyses carried out, the study concludes that salinity has an adverse impact on paddy production that reduces paddy yield as well as profit margin of the paddy farmers. The study, therefore, suggests controlling salinity through government initiatives and use of salt-tolerant seed varieties by the farmers. Moreover, implementation and coordination of the concerned policies attracts special attention for making the agricultural production system in the coastal regions sustainable.*
Keywords: *Salinisation, South-west Region of Bangladesh, Paddy Production, productivity, net return*

I. Introduction

1.1 Background of the study

The economy of Bangladesh is typically dependent on agriculture which plays a crucial role in ensuring job opportunity mainly for rural poor, securing food supply as well as upgrading the livelihood practices of the people of Bangladesh [1]. Recent statistics shows that agriculture sector contributes 19.41 percent of the total GDP whereas 47.5 percent of the total labor force are occupied in this sector [2]. Agriculture sector of Bangladesh involves various crop production; of which rice alone is cultivated in about 2.83 million hectares [3]. Since the cultivable land of the country is decreasing day by day due to high population growth as well as due to natural calamities such as salinity intrusion into crop land, river bank erosion etc., it becomes challenging to supply enough food stuffs for the growing population.

In Bangladesh, coastal areas constitute about 2.5 million hectare which amounts to about 25 percent of total crop land of the country. Of this, nearly 0.84 million hectare is affected by varying intensities of salinity [4]. According to salinity survey findings and salinity monitoring information, about 1.02 million hectare (about 70 percent) of the cultivated land is affected by varying degrees of soil salinity in Bangladesh [5]. In the coastal areas of Bangladesh, tidal wave, shrimp culture and irrigation with saline water are the main cause of salinity in crop land [6][7]. The extensive shrimp farming system has long-term effect on soil salinisation that negatively affects plant growth and crop production [8][9][10][11].

Salinity is a major threat to crop productivity, particularly, in the coastal areas of Bangladesh, it greatly reduces the yield of rice. Though salinity is considered a recent problem; in actuality, it started several decades earlier that discloses its severity in recent period; which again might exacerbate by climate change and sea level rise [12][13][6]. Due to increasing intensity of salinity of some areas and expansion of salt affected areas, land use for crop production has become limited. Salinity causes adverse environmental impact that limits the normal crop production for the year round and is also responsible for low cropping intensity [5][14][15][16]. According to salinity survey findings and salinity monitoring information, about 1.02 million hectares (about 70 percent) of the cultivated land is affected by varying degrees of soil salinity in Bangladesh [5]. Consequently, farmers become reluctant to cultivate various agricultural crops including paddy and vast land areas remain fallow which ultimately leads to low rice production.

Traditionally, agriculture of south-west region of Bangladesh suffers from low crop productivity and low crop intensity; particularly, in rice production this region is far behind than the other parts of the country. Hence, it is imperative to concentrate on this recent challenging issue, that is salinisation problem and trace the nature of its impact on paddy production to find the way out.

1.2 Statement of the problem

The impact of salinity-intrusion is severe in the south-west region of Bangladesh that makes coastal people more susceptible [17]. Although agriculture is one of the significant sectors of the economy of Bangladesh and rice is the staple food of this country; rice production level still remains low in the south-west region of this country due to high salinity extent in crop land [18]. The coastal areas are potentially suited for rice production but were left idle due to salinity problem. Rice is widely cultivated in coastal region but is considered extremely salt sensitive [19]. Salinity intrusion is a major barrier to crop cultivation and because of the rising trend of salinity in the south-west region of Bangladesh, the farmers are losing willingness to cultivate various agricultural crops. Soil salinity is not only reducing agricultural productivity but also putting long run impact on the livelihood strategies of the small farmers [20][6]. The total area affected by salinity has increased to about 0.1056 million hectares from 0.833 million hectares in the last four decades. The worst salinity conditions are reported from Khulna, Bagerhat, Satkhira and Patuakhali districts [21]. Effective reclamation of the saline soil is difficult and complex due to frequent inundation and tidal flooding [19][20][6]. Increased salinity overtime is likely to result in further decline in rice and wheat production, and more pronounced shortage of drinking water. At present salinity affected areas are producing crops lower than that of non-saline or relatively less affected areas [14].

1.3 Literature review

Salinity is a major barrier to paddy production. To examine the impact of soil salinity on paddy production different descriptive method and econometric models have been used till now. Oosterbaan, et al. examines only the relationship between crop production and soil salinity with the help of segmented linear regression. He discussed the segmented linear (broken line) regression with a break point of the yield of barley, mustard and wheat on soil salinity in Haryana, India. According to his study, he found a critical value of soil salinity below which the yield is not affected by the salinity, whereas beyond this value the yield decreases with the increase in salinity [22].

Thanh et al. estimated that the costs of salinisation due to shrimp farming in Vietnam in terms of paddy production lost, dike construction cost and delayed cost of planting is US$ 0.15 per hectare in the Mekong delta [25]. Salinity intrusion due to sea level rise will decrease agricultural production and huge land degradation will be occurred. Salinity rose by the increased sea level of 0.3 meter will cause a net reduction of 0.5 million metric tons of rice production [26]. In another study, Battacharya et al. report that due to salinisation of agricultural lands caused by semi-intensive methods of shrimp culture there is a production loss of 146,160 metric tons of rice in Bangladesh [27]. Salinity in canal has been a constraint to irrigation water use and it has caused considerable yield reduction over the last four years, the reduction being from 5-5.5 to 2-2.5 ton/ha for *boro* and from 4.5-5 to 2.5 ton/ha for *aus* [28]. Ahmed and Haider found that the average production of rice during *kharip* season is 4,232 kg ha^{-1} in low saline areas, whereas, it is 3,760 kg ha^{-1} and 2,663 kg ha^{-1} for moderate and high saline areas, respectively [23].

In a study, Haider and Hossin have tried to show the impact of salinity on livelihood strategies of farmers in Satkhira, Bangladesh through multiple regression analysis [6]. For the purpose of their study, they used four dependent variables viz., income, expenditure, employment and land-use pattern for four multiple regression models. To test the impact of salinity on livelihood strategies of farmers intensively, they examined it from different points of view in different models. In another study, Tanwir and Nawaz used correlation matrix to examine the impact of salinity on livelihood strategies of small farmers in Faisalabad District, Panjab, Pakistan [20]. In case of examining the impact of salinity on livelihood strategies of farmers, Haider and Hossain conclude that salinity intrusion encourages shrimp culture and constraints rice cultivation which finally reduces income and expenditure of the farmers and also limits employment opportunity of the farmers [6].

In literature, there are different approaches to examine the impact of salinity on crop production including estimating simple Cobb-Douglas production function, Cobb-Douglas production function with pooled regression, etc. A study conducted by Umamaheswari et al. is aimed at investigating the salinisation externalities in south India. In order to assess the salinity externality on paddy production, they used three different specifications. In this case, they used the first model to estimate a Cobb-Douglas production function including variables inputs vis., human labor cost, machinery cost, fertilizer, mean Electrical Conductivity in deci Siemens per meter (EC dS m^{-1}) in log form and also included a village dummy that representing salinity [8]. By estimating Cobb-Douglas production function (model I) with pooled regression using panel data, they found that salinity has a negative and statistically significant influence on paddy yield. In second specification they used all the variables included in first model as well as an additional interaction term of the log of the fertilizer variable interacted with log mean EC to test whether there is a synergistic effect between fertilizer use and salinity and found that the coefficient of interaction variable is positive but not statistically significant. This implies that increased fertilizer use does not counteract salinity, and fertilizer use in combination with salinity does not affect yield. The third specification took into account a possible exponential relationship between salinity and paddy production and in this regression, mean salinity was not logged and found that there is an exponential relationship between salinity and yields [8]. On the other hand, Ahmed and Haider have conducted a research to examine the impact of salinity on rice production in the south-west region of Bangladesh by using Cobb-Douglas production function including four explanatory variables with region dummy variable representing different soil salinity classes. They used cross section data and found negative production elasticity of soil salinity that indicates the decline in rice yield for an increase in the soil salinity of the study sites [23].

1.4 Research gap

From the above literature review, it is seen that previous research works mainly related soil degradation issue with crop production. While some dealt with climatic issues that hinder cereal crop production as well as paddy production. Salinisation in rice growing lands and groundwater in the coastline of Bangladesh have been more or less documented but estimates of the costs of soil salinity that integrate economic and soil aspects are not available in Bangladesh perspective. This implies that there is still room for further enquiring into economic impact of salinisation on paddy production. The present study has used Cobb-Douglas production function and incorporates soil salinity in paddy fields as an explanatory variable in an attempt to find out its impact on paddy production in terms of monetary value in the south-west region of Bangladesh.

1.5 Objectives of the study

The present study mainly aims at examining the impact of soil salinisation on paddy production. The general objective of the study is as follows:
1.5.1 To identify the impact of salinisation on paddy productivity;
The study has the following specific objectives:
1.5.1.1 To estimate the extent of variation in paddy yield due to salinity;
1.5.1.2 To estimate the impact of salinisation on profit margin of paddy production;

1.6 Research questions of the study

In order to address the objectives of the study, answers to the following research questions are attempted to find out.
1.6.1 What is the impact of soil salinity on paddy production?
1.6.2 How cost of paddy production is affected by salinisation?
1.6.3 How profit margin of the paddy production is affected by salinisation?

II. Research Methodology

2.1 Study area selection

This research adopts a multistage sampling technique to select the study area. At first stage Khulna and Bagerhat Districts have been selected from a total of 64 districts of Bangladesh; because these are situated in the south-west region of the country and are vulnerable to climate change as well. At the second stage, the study has purposively chosen two upazilas namely Paikgachha and Morrelganj from Khulna and Bagerhat districts respectively. These two sites represent comparatively low-saline area and comparatively high-saline area as having respectively about 2-5 dS m^{-1} and 10-22 dS m^{-1} EC values [24]. Following table represents the study area with sample size.

2.2 Sample size and sampling technique

Farmers cultivating rice as main crop are considered as population of this study. This study has adopted purposive sampling technique in selecting sample. From the study area, a total of 120 paddy producing farms taking 30 farms from each village has been chosen as sample for the research. The following table presents distribution of sample size by study area.

Table 1: Study area with sample size

	District	Upazila	Union	Villages	Sample Size
	Khulna	Paikgachha	Soladana	Soladana	30
				Gram Paikgachha	30
	Bagerhat	Morrelganj	Nishanbaria	Nishanbaria	30
				Haritakitala	30
Total	**2**	**2**	**2**	**4**	**120**

Source: Author's compilation based on field survey, 2015

2.3 Data sources and data collection technique

All types of data required for this research have been collected from primary as well as secondary sources. At first, for the purpose of primary data collection, an interview schedule has been prepared. The first phase of this study was to collect data on paddy production, input use and cost and return from paddy production of the farms. The second phase was to collect soil sample from the study area. For this purpose, the biggest plot of each of the surveyed 120 farmers was considered. Soil samples have been collected from a depth of 0 to 10 cm. Collected soil samples were analyzed in the laboratory for getting EC values.

2.4 Selection of production period

In the study areas, paddy is cultivated once a year (September to January) due to salinity and irrigation problem. This time period, is, therefore, under study and the paddy type is transplanted *aman* (*t-aman)*.

2.5 Data analysis

2.5.1 Descriptive analysis

To collect descriptive statistics on paddy farms and paddy production, the study considered some farm and non-farm related variables. These include, age of the farmers, total land holding size of the paddy farmers, laboratory test results for soil salinity, average yield of paddy, average input use in paddy production, cost of production etc.

2.5.2 Profitability analysis

In order to identify the impact of salinity variation on profitability of the farms in the two regions, the study has used cost and return analysis. Cost and return analysis has been done using the following formula:

$\Pi = TR - TVC - TFC$

$= \sum PQ - \sum(P_{xj}X_j) - TFC$ .... (1)

Where,

Π = Net return (BDT/acre);

P = Per unit price of the produce (BDT/kg);

Q = Mean quantity of the produce (kg/acre);

P_{xj} = Per unit price of the j^{th} input used (BDT/kg); j = 1......5 (Labor, machinery, fertilizer, seed and insecticide).

X_j = Quantity of the j^{th} input used (kg/acre);

TFC = Total fixed cost (BDT) includes costs like rental cost of land and interest cost on fixed capital;

2.5.3 Hypothesis testing

While conducting cost and return analysis, the study has calculated mean production, mean profit margin of paddy farms of the selected two regions. To check whether the differences between the mean values are statistically significant or not, two sample t-tests has been used. Accordingly, the following null hypotheses and alternative hypotheses are formed.

H_{01}*:* There is no difference between mean production in high-saline and low-saline areas.

The corresponding alternative hypothesis is:

H_{a1}*:* There is difference between mean production in high-saline and low-saline areas.

H_{02}*:* There is no difference between mean profit margin of paddy production in high-saline and low-saline areas.

The corresponding alternative hypothesis is:

H_{a2}*:* There is difference between mean profit margin of paddy production in high-saline and low-saline areas.

2.5.4 Production function estimation

2.5.4.1 Model specification

Cobb-Douglas production function has been used to estimate the major factors affecting paddy production. Next, on the basis of literature review the study has selected some explanatory variables to estimate it. The variables list is given in table 2 with literature reference.

Table 2: Variable identification for Cobb-Douglas production function

Variable Name	Symbol	Variable Description with Unit of Measurement	Expected Sign	Literature Reference
Dependent Variable				
Paddy yield	Y_i	Total paddy yield of i^{th} farm; (kg $acre^{-1}$)	N/A	[23][8];
Explanatory Variables				
Labor	X_{1i}	Human labor used by the i^{th} farm; (man-day $acre^{-1}$)	+	[23][8];
Machinery	X_{2i}	Rental cost of machinery for the i^{th} farm; (BDT $acre^{-1}$)	+	[23][8];
Fertilizer	X_{3i}	Fertilizer used by the i^{th} farm (Kg $acre^{-1}$)	+	[23][8];
Seed	X_{4i}	Seed used by the i^{th} farm (kg $acre^{-1}$)	+	[23][8];
Insecticide	X_{5i}	Insecticide used by the i^{th} farm (liter $acre^{-1}$)	+	Researcher's selection
Salinity	X_{6i}	EC value of the i^{th} farm dS m^{-1}	-	[23][8][6];
Dummy	D_i	Region dummy; 1 for high saline region and 0 for low saline region	-	[23];

Source: Author's compilation based on literature
Note: N/A = Not applicable

For this study purpose specified model takes the following form:

$$Y_i = \alpha X_{1i}^{\beta 1} X_{2i}^{\beta 2} X_{3i}^{\beta 3} X_{4i}^{\beta 4} X_{5i}^{\beta 5} X_{6i}^{\beta 6} D_i^{\beta 7} e^u \quad \ldots\ldots\ldots (2)$$

This non-linear form of Cobb-Douglas model is transformed into linear form as follows:

$$\ln Y_i = \ln\alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 D_i + u_i \quad \ldots\ldots\ldots (3)$$

Where,
α = Intercept term, u_i = Error term, β_j's = Coefficients to be estimated (j = 1, 2, 3,.................... ,7)

2.5.4.1.1 Model I

Two different specifications of the above model are used to estimate the impact of soil salinity on production. Model I estimates a Cobb-Douglas production function and includes all the variable inputs pointed out in equation (3) except region dummy. Hence, it takes the following form:

$$\ln Y_i = \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + u_i \quad \ldots\ldots\ldots (4)$$

2.5.4.1.2 Model II

Model II includes all the variables used in model I except salinity and include an additional variable as region dummy, which is defined as being equal to 1, if the farm is in high saline area and 0, if the farm is from low saline area. Hence, it is of following form.

$$\ln Y_i = \alpha + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 D_i + u_i \quad \ldots\ldots\ldots (5)$$

III. Results And Discussion

3.1 Descriptive Analysis

3.1.1 Salinity Test

The laboratory test result of soil sample indicates that the salinity level ranges from 2.6 dS m^{-1} EC to 23.2 dS m^{-1} EC in the study areas. That is, the level of salinity in the study sites varies significantly. Nishanbaria Union is highly saline area having average salinity level of 14.38 dS m^{-1}; whereas average salinity level is 3.44 dS m^{-1} in Soladana Union. The laboratory test results of soil samples have been shown in table 3.

Table 3: Laboratory test results for soil salinity

District	Upazila	Union	Village	Sample Size	Soil Salinity (EC dS m^{-1})			
					Min	**Max**	**SD**	**Mean**
			Soladana	30	2.6	4.6	0.48	3.27
Khulna	Paikgachha	Soladana	Gram Paikgachha	30	2.6	4.9	0.65	3.51
			Total of two villages	**60**	**2.6**	**4.9**	**0.57**	**3.44**
			Nishanbaria	30	8.5	21.9	3.39	13.31
Bagerhat	Morrelganj	Nishanbaria	Haritakitala	30	10.1	23.2	3.98	14.38
			Total of two villages	**60**	**8.5**	**23.2**	**3.82**	**14.38**

Source: Author's compilation based on field survey, 2015
Note: Max = Maximum; Min = Minimum; SD = Standard Deviation

3.1.2 Age distribution and land holding size

From the survey data presented in table 4, it is found that the distribution of 60 sample farm households in the low saline region on the basis of land holding size indicates that average land holding is 1.42 acre. However, the distribution of 60 sample farm households in the high saline region on the basis of land holding size indicates that average land holding is 1.40 acre while the average age of the farmers is 43 years and 45 years in low and high saline areas respectively.

Table 4: Information on the respondent farmers

	Low-saline Region (Observation = 60)					**High-saline Region (Observation = 60)**			
Variable Name	**Min**	**Max**	**SD**	**Mean**		**Min**	**Max**	**SD**	**Mean**
Age (Year)	32	55	6	43		35	55	5	45
Land Holding (Acre)	0.78	2	0.36	1		1	2	0.32	1

Source: Author's compilation based on field survey, 2015

3.1.3 Paddy yield and input use pattern

Farm specific variables include production level and corresponding amount of inputs used in the respective farms. Summary of the farm related variables have been shown in table 5. The table demonstrates that the average production volume per acre is 1639.32 kilogram and 1531.45 kilogram in low and high-saline region respectively. Salinity affects the plant growing process that ultimately affects crop production. Thus, the field survey findings indicate that, paddy yield is comparatively lower in the highly saline region than that of in low-saline region. It is clear then, salinity affects crop production negatively.

Table 5: Average production and mean input use

Variable Name	**Low-saline Region (Observation = 60)**				**High-saline Region (Observation = 60)**			
	Min	**Max**	**Mean**	**CV (%)**	**Min**	**Max**	**Mean**	**CV (%)**
Yield (kg acre^{-1})	1461.00	1760.00	1639.32	3.75	1400.00	1692.00	1531.45	4.55
Fertilizer (kg acre^{-1})	46.15	87.69	59.62	14.64	41.66	67.00	53.04	12.59
Seed (kg acre^{-1})	19.23	29.23	22.46	10.95	19.44	35.00	24.19	17.89
Insecticide (liter acre^{-1})	0.40	1.50	0.83	30.12	0.41	1.75	0.91	32.96
Labor (man day acre^{-1})	13.85	24.62	18.81	14.67	20.00	0.32	24.09	13.53
Machinery (BDT acre^{-1})	1600.00	3012.82	2158.00	16.45	1692.30	3000.00	2085.36	13.51

Source: Author's compilation based on field survey, 2015
Note: Coefficient of Variation, CV (%) = (standard deviation/mean) × 100

The field survey findings indicate that the paddy yield is very low in the highly saline region than that of in low-saline region. On average, farmers require 59.62 kilogram fertilizer, 22.46 kilogram seed, and 0.83 liter insecticide per acre of land while 19 laborers are required to accomplish the production process in low-saline region (Table 5). In high-saline region farmers use more seed, insecticide and laborers but use fewer fertilizers than that of low-saline region. The cost of machinery use in high-saline region is loweer than that of low-saline region.

3.2 Profitability analysis

Per acre total returns is calculated by multiplying the total yield of product and selling price. It is clear that per acre yield of *aman* paddy in low-saline area is higher than that of in high-saline area. Table 6 shows that per acre total returns are respectively BDT 26819.27 and BDT 25100.46 in low and high-saline region.

Table 6: Per acre cost and return of paddy production (year 2015)

Items	**Low-saline Region**			**High-saline Region**		
	Average Quantity (per acre)	**Average Price (BDT/unit)**	**Total Value (BDT)**	**Average Quantity (per acre)**	**Average Price (BDT/unit)**	**Total Value (BDT)**
Paddy (Kg)	1639.32	16.36	26819.27	1531.45	16.39	25100.46
A. Total Revenue			**26819.27**			**25100.46**
Labor (man-day)	19.00	295.00	5605.00	24.00	297.47	7139.28
Seed (Kg)	22.46	57.78	1297.73	24.19	55	1330.45
Fertilizer (Kg)	59.62	27.78	1656.24	53.04	27.79	1473.98
Machinery (BDT)	--	--	2158.69	--	--	2085.36
Insecticide (BDT)	--	--	350.33	--	--	363.03
Total Variable Cost			**11067.99**			**12392.10**
Rental Value of Land (BDT)			4395.83			4096.67
Interest (BDT)			720.00			850.00
Total Fixed Cost			**5115.83**			**4946.67**
B. Total Cost			**16183.82**			**17338.77**
Net Return (A-B)			**10635.45**			**7761.69**

Source: Author's compilation based on field survey, 2015

In order to estimate the average total cost per acre, all the resources used in paddy production have been recaptured together. Total cost includes costs of human labor, seed, fertilizers, machinery and insecticide as total variable costs and land rental cost, interest on operating capital as total fixed cost. This analysis revealed that per acre total cost of production in high-saline affected area is higher than that of production in low-saline affected area. Paddy farmers in high-saline region and low-saline region incur BDT 16183.82 and BDT 17338.77 per acre respectively (Table 6).

3.3 Testing hypothesis

To test mean difference of paddy yield and profit of paddy farmers between two regions, the study executes two hypothesis testing. The mean difference in paddy yield of the two regions is statistically significant at 1 percent level of significance (Table 7) and the mean profit of paddy production of the low-saline affected region is higher than that of the high-saline region and the mean difference in profit of paddy production of the two regions is statistically significant at 1 percent level of significance.

Table 7: Two-sample t-test results for paddy yield and profit of paddy production

Area	Paddy Yield					Profit of Paddy Production			
	Obs.	Mean Yield (Kg acre^{-1})	Standard Error	t-value		Obs.	Mean Profit (BDT acre^{-1})	Standard Error	t-value
Low-saline	60	1639.32	7.3024	9.57		60	10635.45	263.14	7.57
High-saline	60	1531.45	8.5723			60	7758.08	271.57	
All	120	1585.38	7.4752			120	9196.76	229.55	
Mean Difference		107.86***	11.2610				2877.37***	378.14	

Source: Author's compilation based on field survey, 2015
Note: *** Statistically significant at 1 percent level of significance; Obs. = Number of Observation

3.4 Cobb-Douglas Production Function Estimation

Estimated results of Cobb-Douglas production function are put simultaneously in table 8. Two different models are used to test the hypothesis that salinity has a significant effect on paddy yield. Model I estimates a Cobb-Douglas production function that includes continuous variables and Model II also estimates a Cobb-Douglas production function that includes continuous variables as well as a region dummy variable for representing salinity.

In case of model I, the elasticity of output with respect to variable inputs, labor, machinery, fertilizer, seed and insecticide are positive (Table 8). The coefficient of labor (X_{1i}) is 0.29, which means that a one percent increase in labor, *ceteris paribus*, increases paddy yield by 0.29 percent. The coefficients of machinery (X_{2i}), fertilizer (X_{3i}), and seed (X_{4i}) are respectively 0.12, 0.41 and 0.37; indicating that a one percent increase in machinery, fertilizer and seed, *ceteris paribus*, increases paddy yield by 0.11, 0.41 and 0.37 percent respectively and these are statistically significant at 1 percent level of significance. The coefficient of insecticide (X_{5i}) though is positive but not statistically significant. The coefficient of salinity (X_{6i}) is – 0.08 and is significant at 1 percent level. This suggests that a one per cent increase in salinity, *ceteris paribus*, reduces paddy yield by 0.08 percent.

Table 8: Estimated production function

	Model I			Model II		
Explanatory Variables	Coefficient	t-value	p-value	Coefficient	t-value	p-value
ln X_{1i}	0.297*** (0.077)	3.82	0.000	0.279*** (0.085)	3.25	0.001
ln X_{2i}	0.117*** (0.036)	3.25	0.002	0.119*** (0.037)	3.19	0.002
ln X_{3i}	0.418*** (0.079)	5.25	0.000	0.439*** (0.862)	5.09	0.000
ln X_{4i}	0.371*** (0.104)	3.54	0.001	0.373*** (0.108)	3.45	0.001
ln X_{5i}	0.030 (0.039)	0.76	0.446	0.035 (0.041)	0.85	0.397
ln X_{6i}	– 0.082*** (0.020)	– 4.06	0.000	--	--	--
D_i	--	--	--	– 0.105*** (0.033)	–3.11	0.002
Constant	2.809 (0.275)	10.18	0.000	2.646 (0.275)	9.60	0.000
R^2	0.85			0.84		
Adjusted R^2	0.84			0.83		
F	106.43			99.81		
Observations	120			120		

Source: Author's compilation based on field survey, 2015
Note: Standard errors in Parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1

In case of model II, the elasticity of output with respect to variable inputs, labor, machinery, fertilizer, seed and insecticide are also positive. The coefficient of labor (X_{1i}) is 0.28 meaning that a one percent increase in labor, *ceteris paribus*, increases paddy yield by 0.28 percent and it is statistically significant at 1 percent level of significance. The coefficients of machinery (X_{2i}), fertilizer (X_{3i}) and seed (X_{4i}) are respectively 0.12, 0.44 and 0.37 indicating that a one per cent increase in machinery, fertilizer and seed, *ceteris paribus*, increases paddy yield by 0.12, 0.44 and 0.37 percent respectively and all of them are statistically significant at 1 percent level of significance. In this case also estimated coefficient of insecticide (X_{5i}) is found statistically insignificant. The coefficient of dummy variable (D_i) is – 0.10 and is significant at 1 percent level of significance. It indicates that holding other things constant, paddy yield in the high-saline region is 10% lower than the yield in the low-saline region.

It is evident from Table 8 that the values of R^2 are 0.85 and 0.84 for model I and model II, respectively. This implies that respectively 85 and 84 percent of the total variation in paddy yield is explained by the variables included in the models.

Therefore, from the above econometric and statistical analysis this study concludes that salinity has an adverse impact on paddy production that reduces paddy yield as well as profit margin of the paddy farmers.

IV. Conclusion

4.1 Conclusion

This study attempts to disclose the economic impact of salinisation on paddy production in the south-west region of Bangladesh with special focus on Paikgachha and Morrelganj upazilas under Khulna and Bagerhat Districts. The salinity in the south-west region of Bangladesh is increasing day by day. Salinity is a severe problem that affects crop production as well as livelihood practices of the existing farmers. The study results confirm the research hypothesis *i.e.* an increase in the soil salinity reduces paddy production and net returns from paddy production in the study sites. The Cobb-Douglas production function estimation result confirms that paddy production reduces with the increase of soil salinity. That means salinity build-up in crop field directly influence crop yield. The statistically significant negative relationship between soil salinity and paddy production in the study area is a matter of great concern for the paddy farmers. A higher soil saline affected region induces decreasing returns in paddy cultivation, which reduces productivity of land that results in decreasing agricultural profitability.

Soil salinity is needed to be controlled through government initiatives and farmers have to use salt-tolerant seed varieties. Recently cultivated rice varieties are not much salt-tolerant and the existing salt-tolerant rice verities are not spread all over the coastal area. Thus the respective authority needs to give effort for spreading salt-tolerant rice varieties. Moreover, implementation and coordination of the concerned policies attracts special attention for making the agricultural production system in the coastal regions sustainable.

V. Scope For Future Research

This section attempts to highlight the scope for further research on the research issue. There may be reasons other than soil salinity in the crop field that cause reduction of paddy yield. Hence, to address this problem accurately, more careful and in-depth research can be carried out through using field experienced data with information on using of HYV seed or salt-tolerant seed varieties. Besides, an interaction variable composed of fertilizer multiplied by salinity level can be considered to estimate the simultaneous impact of salinity and fertilizer application on paddy production. Another study can calculate the excess cost incurred in paddy production due to salinity.

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