Impacts of Salinity on Rice Production of Southwest Coastal Region of Bangladesh

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Outline

- Introduction/Background
- Research Questions and Objectives
- Review of Literature
- Study Area
- Methodology
- Preliminary Results and Discussion
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Introduction/Background

- Salinity is a major factor limiting plant productivity, affecting about 95 million hectares world-wide (Ayers et al., 1994).
- In Bangladesh, salinity occur mainly along the coastal region especially in southwest coastal region of Bangladesh. The adverse effects of salinity will be significant of southwest coastal agriculture.
- Coastal saline soils being silty clay/clay in texture, gets hard on drying, Cracks develop and making tillage operation difficult.
- Most of the rice land kept fellow except Aman season due to the extreme presence of salinity of the southwest coastal region.

Table 1. Rice Production Status

Salinity free region	Name of the variety: Aus Average Prod. = 1878 kg/acre n=129	Name of the variety: Aman Average Prod. =1958 kg/acre n=129	Name of the variety: Boro Average Prod. =2145 kg/acre n=121
Salinity affected region	Name of the variety: Aus Average Prod. = 1372 kg/acre n=103	Name of the variety: Aman Average Prod. =1837 kg/acre n=183	Name of the variety Boron Average Prod. =1423 kg/acre n=152

Source: Collected from household micro-cross section data

Introduction/Background

- Southwest coastal regions contribute approximately 16 percent of the total rice production of Bangladesh and in recent years production of crop yield by gradual change and total or partial damage due to extreme salinity (Compendium of environment statistics of Bangladesh, 2005)

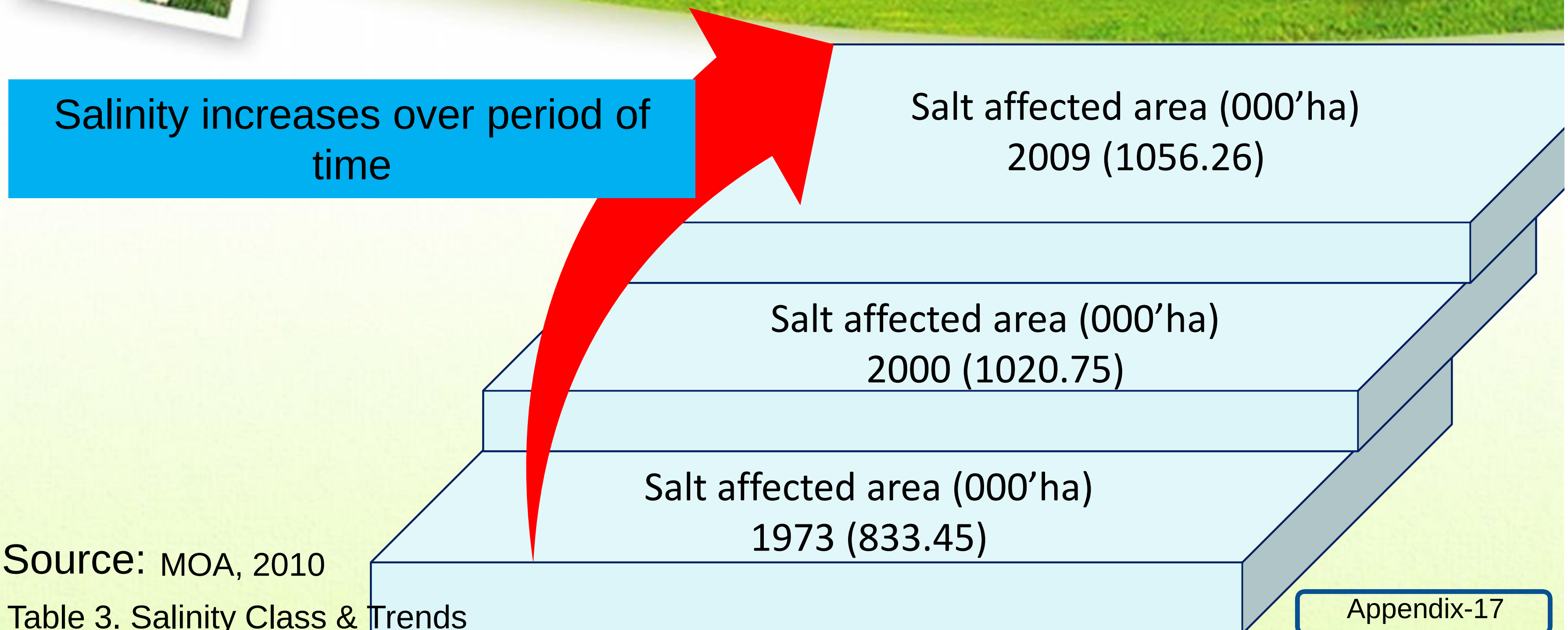
- Degradation of productive land including quality and physical loss are key concern for coastal agriculture due to salinity intrusion.

Table 2. Land use status

Land category	Total cultivated land	Land use for Aus	Land use for Aman	Land use for Boro
Cultivated land under normal soil (n=129 for each variety)	191 acres (3 times use)	143.7 acres (75.23%)	166.03 acres (86.93%)	162.5 (85.09%)
Cultivated land under salinity condition (n=302 for each variety)	430 acres (3 times use)	65.42 acres (15.21 %)	240.2 acres (55.86%)	78.83 acres (18.33 %)

Source: Collected from household micro-cross section data

Introduction/Background



Source: MOA, 2010

Table 3. Salinity Class & Trends

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Salinity Class											
S1 2.0-4.0 dS/m			S2 4.1-8.0 dS/m			S3+S4 8.1-16.0 dS/m			S5 >16.0 dS/m		
'73	'00	'09	'73	'00	'09	'73	'00	'09	'73	'00	'09
287	290	348	426	307	274	80	337	352	40	87	102

*S3=8.1-12.0 dS/m, *S4=12.1-16.0 dS/m

Source: SRDI Report, 2010

Introduction/Background

An electrical conductivity (EC) greater than 2 dS/m, measured on a composite sample, indicates significant areas of a field are salt affected.

Source: Karim, et al,. (1990)

Table 4. Site specific Electrical conductivity (EC) values

EC (dS/m)	Comments
>16	Difficult to grow except few crops
S4: 12.1-16	Very poor growth of tolerant crops
S3: 8.1-12	Poor growth of tolerant crops
S2: 4.1- 8	Suitable for growing salt tolerant crops
S1: 2- 4	Yield of non-tolerant crops reduced
<2	Little effect on yield of any crop

Source: Karim, et al,. (1990)

Introduction/Background

Table 5. Production Status

Statistics	Yield (kg /acre)					
	Normal soil			Salinity		
	Aus (n=129)	Aman (n=129)	Boro (n=121)	Aus (n=103)	Aman (n=183)	Boro (n=152)
Mean	1878	1958	2145	1372	1837	1423
Standard deviation	962	939	874	749	595	742
Maximum	4200	3924	4270	3000	3500	3500
Minimum	600	600	1000	320	337	300
Coefficient of variation	0.51	0.48	0.40	0.55	0.32	0.52

Aus, Aman & Boro under normal soil are produce more than those of salinity condition

Source: Calculated by the author based on his collected household micro-cross section data

$$C.V = \frac{\pm}{\bar{x}}$$

2 Circle= more consistent in rice production

1 Circle=not consistent in rice production

Introduction/Background

Table 6. Average input use pattern under different soil conditions

Inputs	Statistics	Aus		Aman		Boro	
		NS	SAS	NS	SAS	NS	SAS
Fertilizer (kg)/acre	Maximum value	150	90	126	120	160	90
	Minimum value	15	10	15	10	18	10
	Mean value	56.56	37.45	57.51	43.51	60.14	35.88
	Standard Devi.	31.47	20.72	26.68	18.74	28.44	20.28
	Sample size	129	103	129	183	121	152
Labor/acre (man-days)	Maximum value	50	50	52	49	36	45
	Minimum value	9	3	12	8	8	10
	Mean value	23.41	22.14	28.29	24.92	23.47	22.18
	Standard Devi.	8.45	12.21	10.91	9.89	7.59	8.82
	Sample size	129	103	129	183	121	152

Source: Calculated by the author based on his collected household micro-cross section data

NS=normal soil; SAS=salt affected soil

Introduction/Background

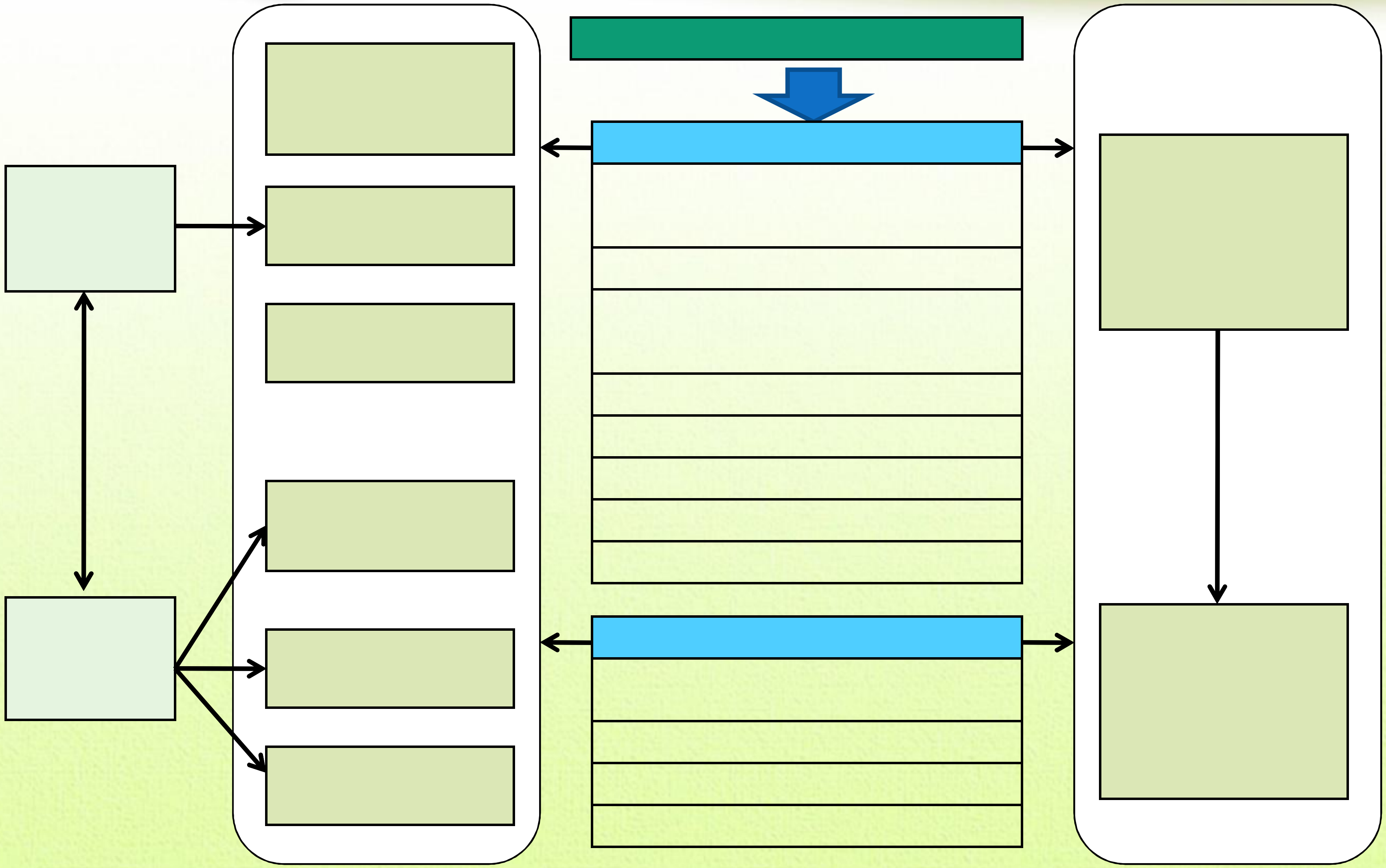
See appendix 16

Table 7. Average yield and returns from rice varieties under different type of soils and salinity

Rice/Soil type	Average Income (Tk/acre)	Average Variable expenses (Tk/acre)	Average Profit (Tk/acre)
Normal soil	33804	8267.	25537
Under salinity condition	26696	7466	19230
Normal soil	35240	9752	25488
Under salinity condition	33066	8433	24633
Normal soil	38610	8364	30246
Under salinity condition	25614	7443	18171

Source: Calculated by the author based on his collected household micro-cross section data

Conceptual Framework



Source: Prepared by the author

Significance of this Study

Guide line for better coastal agrarian economy

Researcher, NGO, GO, International Organizations, Stakeholders, Farmers……

Decision making on rice production
- Farmers of coastal region

Helpful for making adaptation policy
- Policy makers

Generate of new empirical result
- Researchers & policy makers → My position

Better understanding of salinity
- Social & natural scientists

Significance of this study

Source: Prepared by the author

Research Questions & Objectives

Research Questions

1. Does the salinity affect the rice production ? (Generally speaking 'Yes')
2. Does the level of salinity influence the utilization of factors of production?
3. What are the adaptation requirements against the salinity intrusion in the southwest coastal region ?

Research Objectives

1. Investigate the impacts of salinity on rice production.
2. Investigate the utilization of factors of production in the salinity affected rice farm.
3. Develop the device of the necessary adaptation options.

Review of Literature I

Exploring the relationship between climate change and rice yield in Bangladesh: An analysis of time series data
Sarker, M. A. R., Alam, K., & Gow, J.
Agricultural System 112 (2012)11-16
Data: Time series data for the 1972-2009 periods at an aggregate level.
1. Explore the relationship between rice yield and climate variables 2. Estimate the potential effects of climate change
1. Quantile regression (QR) model 2. Ordinary least squire (OLS) method
1. Three climate variables (Max. temperature, min temperature, rainfall) have substantial effects on the rice yield of three different (Aus, Aman and Boro) crops. 2. The overall Aus model is found to be significant 3. Maximum temperature and rainfall have positive effects on Aman production, whereas minimum temperatures affect Aman production negatively. 4. The Boro model reveals that maximum and minimum temperatures have substantial effects on Boro production. 5. Rainfall is significant for the Aus and Aman rice but it is insignificant for the Boro rice.

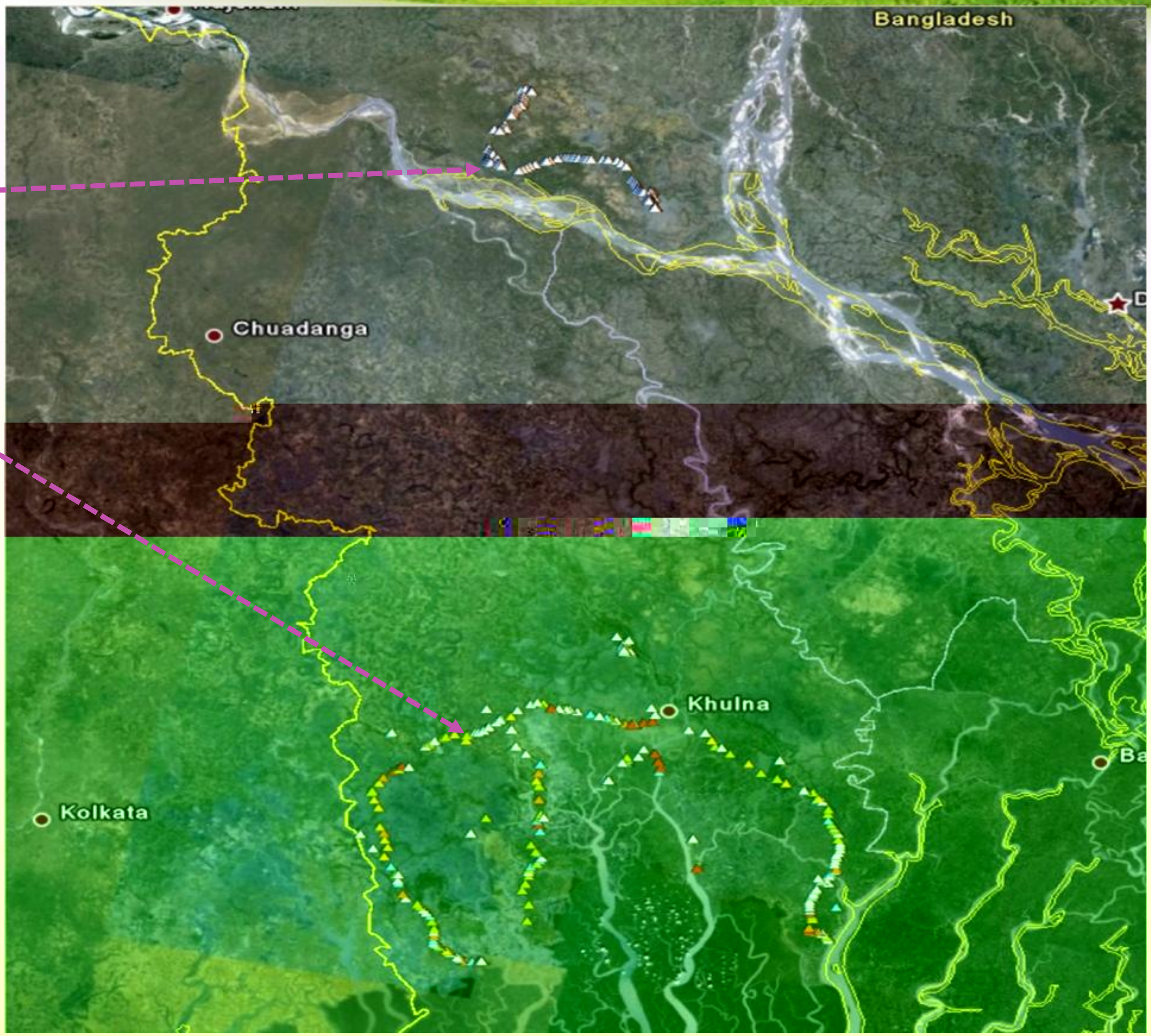
Review of Literature II

Evaluation of energy input and output of sweet sorghum as a bio-energy crop on coastal saline-alkali land.
Ren, L. T., Liu, Z. X., Wei, T. Y., & Xie, G. H.
Energy 47 (2012) 166-173
Cross section data through questionnaire survey for face-to-face interview of 116 farmers.
1. Analyse the energy input and output of sweet sorghum on coastal saline-alkali soils. 2. Evaluate the input sensitivity with Cobb-Douglas (C-D) production function. 3. Compare the energy productivity of the bioenergy crop with the dominant cash and food crops cotton and maize.
1. The energy productivity index 2. The Cobb-Douglas production function 3. Ordinary least square (OLS) method
The energy crop sweet sorghum showed a significantly lower energy input and a higher energy productivity than the cash crop cotton or the food crop maize.

Review of Literature III

Land degradation and economic sustainability.
Singh, J., & Singh, J. P.
Ecological Economics 15 (1995) 77-86
Cross section data through questionnaire survey for face-to-face interview of 248 farmers.
1. Measure the impact of soil salinity and water logging at farm level in terms of resource use, productivity and profitability of crop production. 2. Its consequent effect on employment in affected areas of northwest India.
1. The Cobb-Douglas production function 2. Ordinary least square (OLS) method
1. The incidence of soil salinity and water logging directly affects the farmer in resource allocation and resource transformation. 2. The returns from affected soils decline, and this may even lead to abandoning crop production activities in extreme cases and the production per-unit problem area may be reduced even further because of the cut-back in non-land resource use on such soils. 3. The employment of farm labor, particularly hired labor was restricted due to low crop productivity on moderately degraded lands and abandoning crop production activity in severely affected areas.

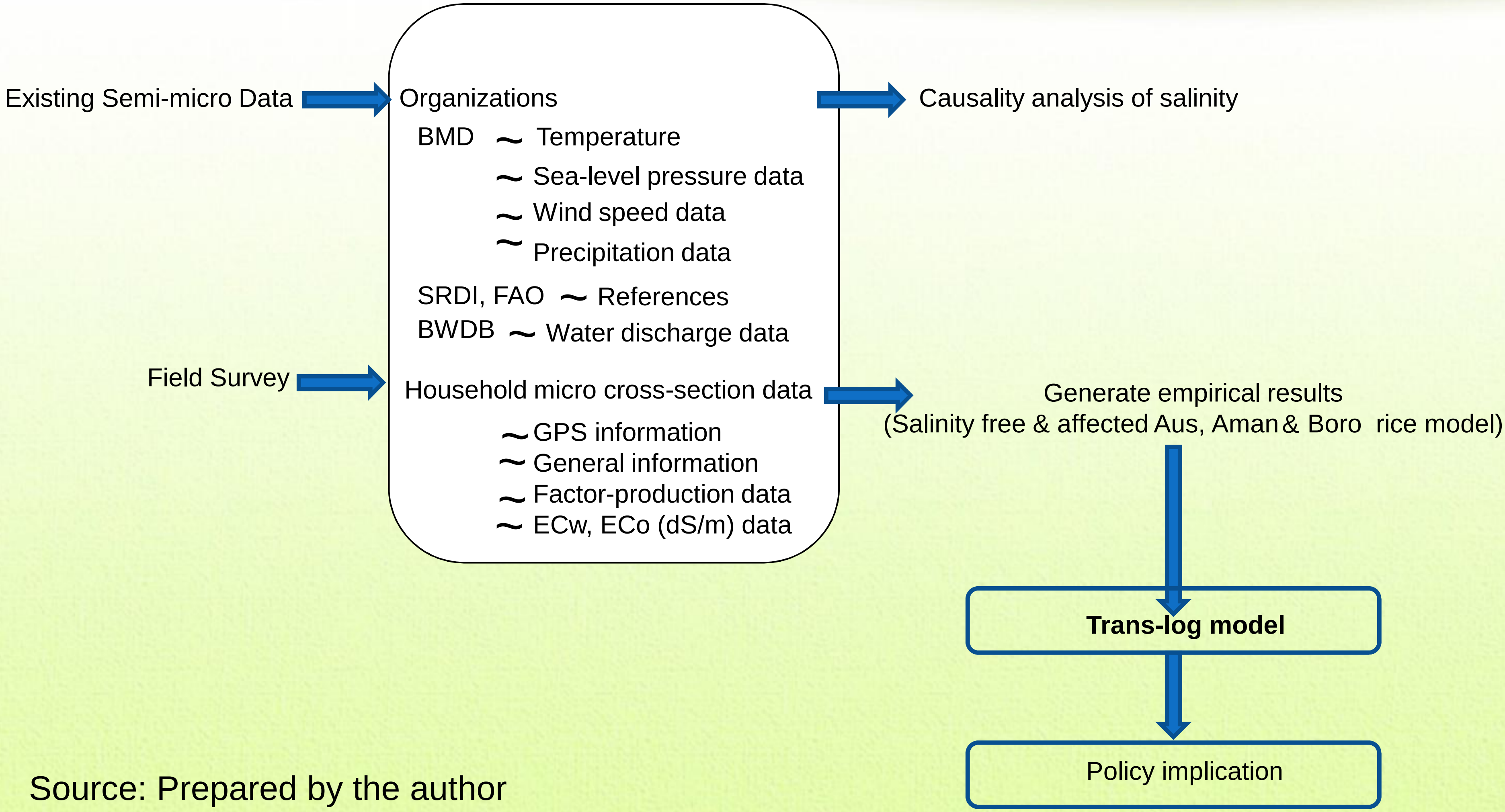
Study Area



Source: Calculated by the author based on his collected GPS & physical value of salinity

Methodology

Organogram of Methodology



Source: Prepared by the author

VII. Methodology

Important Features of Field Survey

Time	:7 September ~ 30 September, 2012 :3 February ~ 10 February, 2013
Area	:Southwest (Khulna, Satkhira & Bagerhat district) region of Bangladesh. (Salinity affected region) $(N:23^{0}0'00''\quad E:90^{0}0'0'')$:Northern (Pabna district) region of Bangladesh (Salinity free region and considered as base line) $(N:24^{0}0'00''\quad E:89^{0}0'0'')$
No. of Respondents	:302 farmers ~ affected by salinity :129 farmers ~ not affected by salinity
Data collection method	: Questionnaire survey, GPS, Salinometer, Secondary source

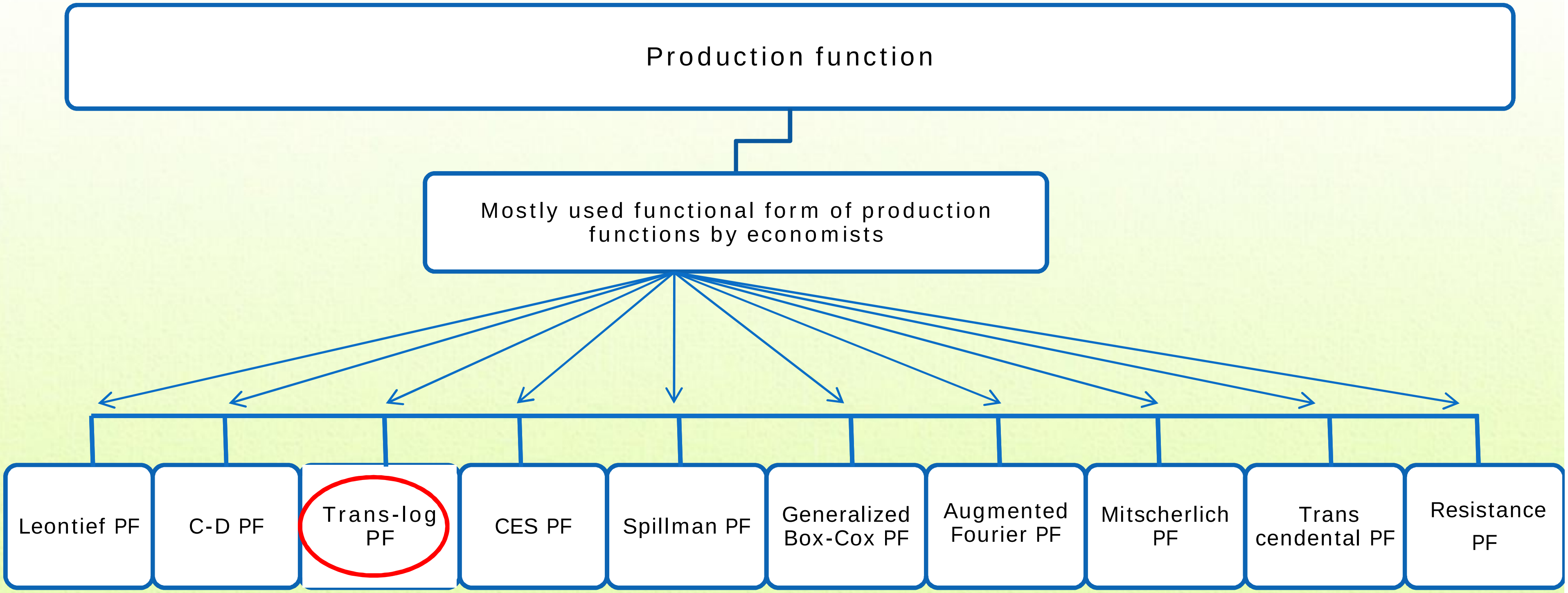
Generate the empirical results

First Step : A convenient production function

Second Step : Elasticity of substitution

Methodology

First steps: **Production function**



Source: Prepared by the author

Methodology

Preferability for taking Trans-log model

- Trans-log model is a generalization of the Cobb-Douglas production function
- It is Commonly used and easy to get elasticity of substitution by applying Shephard duality
- It is a flexible functional form providing a second order approximation
- It is possible to impose restrictions on the parameter (homogeneity condition)
- It is linear in parameters and can be estimated using least squares method

Source: Blackorby & Russell, 1989

See appendix 5

Trans-log (transcendental logarithmic) production function

The trans-log production function is a generalization of the Cobb–Douglas production function.
.The three factor trans-log production function is:

$$\begin{aligned}\ln(q) &= \ln(A) + a_L \ln(L) + a_K \ln(K) + a_M \ln(M) + b_{LL} \ln(L)\ln(L) \\ &\quad + b_{KK} \ln(K)\ln(K) + b_{MM} \ln(M)\ln(M) + b_{LK} \ln(L)\ln(K) \\ &\quad + b_{LM} \ln(L)\ln(M) + b_{KM} \ln(K)\ln(M) \\ &= f(L, K, M).\end{aligned}$$

where L = labor, K = capital, M = materials and supplies, and q = product.

Methodology

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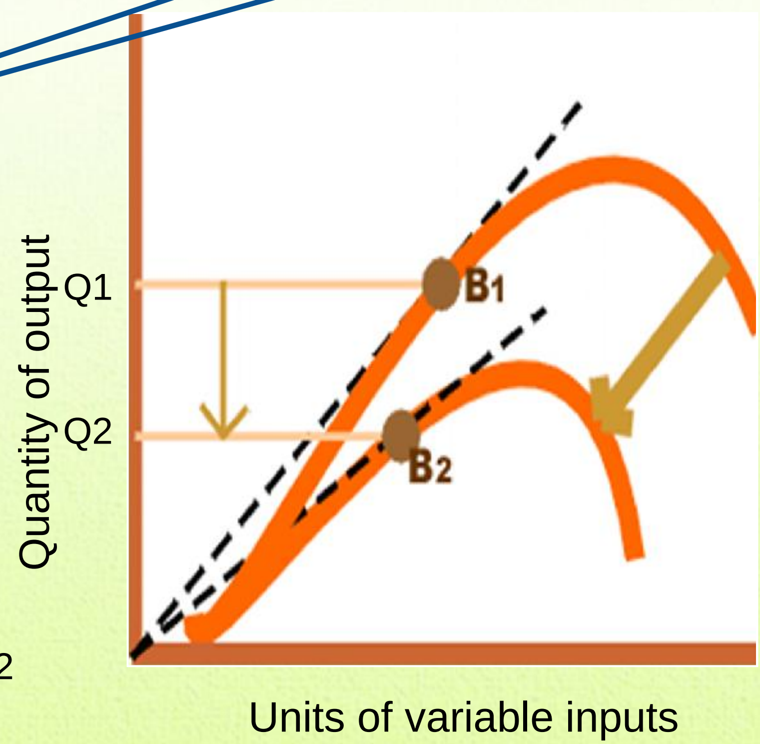
Appendix 6

Important characteristics of Trans-log model

1. Law of variable proportion
2. Constant returns to scale (CRS)
3. Existence of separability and homothetic in their components
4. Established Young's Theorem
5. Satisfied Boarder Hessian Determinant or Concavity condition

Appendix 3

Appendix 19



Source: Segal, et al., 2005; Krishnapillai, et al., 2012; Khalil, 1982

Methodology

<u>Second Stapes</u>: **Elasticity of substitution**

The **elasticity of substitution** is a well known concept which has received much attention in the economics literature. Originated by J. R. Hicks (1932), this concept has become a backbone of applied microeconomic theory. The functional form of **elasticity of substitution** for two inputs is

Appendix 4

$$\sigma_{21} = \frac{d\ln(x_2/x_1)}{d\ln MRTS_{12}} = \frac{d\ln(x_2/x_1)}{d\ln(\frac{df}{dx_1}/\frac{df}{dx_2})} = \frac{\frac{d(x_2/x_1)}{x_2/x_1}}{\frac{d(\frac{df}{dx_1}/\frac{df}{dx_2})}{\frac{df}{dx_1}/\frac{df}{dx_2}}} = -\frac{\frac{d(x_2/x_1)}{x_2/x_1}}{\frac{d(\frac{df}{dx_2}/\frac{df}{dx_1})}{\frac{df}{dx_2}/\frac{df}{dx_1}}}$$

Where, $MRTS$ is the marginal rate of technical substitution.

The inverse of elasticity of substitution is elasticity of complementarity.

It measures the curvature of an isoquant and thus, the substitutability between inputs.

Estimates of Substitution

Allen(1938)-Uzawa(1962)
elasticity of substitution (AES)

Morishima(1967)
elasticity of substitution (MES)

Methodology

Reason for taking Morishima elasticity of substitution

Morishima elasticity of substitution (MES) has several advantages over the Allen-Uzawa elasticity of substitution (AES):

1. The MES measures the curvature of an isoquants.
2. The MES is a sufficient statistic for evaluating changes in relative prices and quantities.
3. The MES is the log derivative of the input quality ratio with respect to the input price ratio like $± = \frac{¢ \ln\left(L/F\right)}{¢ \ln MRTS}$. These characteristics were the original function of J. R. Hicks, but not apply to the AES.
4. The MES, therefore, is the more natural extension to the multi-input case.
5. An important characteristics of the MES is the inherent asymmetry except CES and Cobb-Douglas production. The AES on the other hand, is symmetric for all input pairs by definition. (Blackorby et al., 1989).

Functional form of Morishima elasticity of substitution.

- Own and cross input elasticity of production: $¦_{ii} = \frac{¥_{ii}}{S_i} + S_i - 1$; $¦_{ij} = \frac{¥_{ij}}{S_i} + S_j$; $¦_{ij} \neq ¦_{ji}$
- Morishma elasticity of substitution: $M_{ij} = ¦_{ji} - ¦_{ii}$; $M_{ij} \neq M_{ji}$

Methodology

MRTS between factors (F,L) are independent from S

Production Function

Let $Q = f(F, L, S, \bar{I}, \bar{P})$ ……………………………(1)

Where, Q=rice; F=fertilizer; L=labor; S=salinity; I=irrigation (fixed); P=plough (fixed)

Fertilizer (F), labor (L) are as a group weakly separable from salinity (S): $Q = F[f(F, L); S]$ ……(2)

Let again. Fertilizer (F) and Labor (L) are also separable and homothetic in their components:

$$Q = F[f\{F(fer_1, fer_2, ..., fer_n), L(lab_1, lab_2, ..., lab_n)\}; S(sal_1, sal_2, ..., sal_n)]$$ ……(3)

Trans-log Production Function

2. Salinity affected rice model)

$$\ln\left(\frac{Y}{A}\right) = {}_0 + {}_F \ln\left(\frac{F}{A}\right) + {}_L \ln\left(\frac{L}{A}\right) + {}_S \ln\left(\frac{S}{A}\right) + \frac{1}{2}\, {}_{FF} \ln\left(\frac{F}{A}\right)^2 + {}_{FL} \ln\left(\frac{FL}{A}\right) + \frac{1}{2}\, {}_{LL} \ln\left(\frac{L}{A}\right)^2 + {}_{LF}\left(\frac{LF}{A}\right) + u_i;\ u \quad N(0, \pm^2)$$ ……(5)

Restriction Impose

1. Symmetric restriction on parameters: ${}_{FL} = {}_{LF}$ ……….(6) (Principle of Young's Theorem)

2. Restriction on constant returns to scale:

$$\left.\begin{array}{l} {}_F + {}_L + {}_S = 1 \\ {}_{FF} + {}_{LF} = 0 \\ {}_{FL} + {}_{LL} = 0 \end{array}\right\}$$ ……….(7)

3. Restrictions for existence of Cobb-Douglas ${}_{FF} = {}_{FL} = {}_{LL} = {}_{LF} = 0$ ……………………………(8)

Preliminary Result & Discussion

Table 8.. The results for the Salt free & salt affected Aus rice model

Coefficient	Aus (normal soil)	Aus (Salt-affected soil)	
	Trans-log Model	Trans-log Model	Hybrid Model
	Estimated value	Estimated value	Estimated value
β_0	2.740641*** (1.259121)	1.541964* (1.036832)	2.053447*** (0.988806)
β_F	1.286970*** (0.369612)	0.110400 (0.849068)	0.186934 (0.837031)
β_L	0.373434 (0.593131)	2.580708*** (0.742082)	2.278422*** (0.746285)
β_S	-	-0.617950 (0.587867)	-0.937969)*** (0.182660)
β_{FF}	-0.196472*** (0.051955)	0.776755*** (0.276624)	0.716530*** (0.256726)
β_{LL}	-0.238071*** (0.0899808)	0.720028*** (0.210970)	0.744306*** (0.259911)
β_{SS}	-	-0.121867 (0.142695)	
$\beta_{FL} = \beta_{LF}$	0.315852*** (0.102986)	-1.787463*** (0.459210)	-1.722761*** (0.467879)
$\beta_{FS} = \beta_{SF}$	-	0.163555 (0.290104)	
$\beta_{LS} = \beta_{SL}$	-	-0.087395 (0.284735)	
No. of observation	129	115	103
R^2	0.795560	0.532686	0.49806

*** Significant at 1% probability level; ** 5% probability level and * 10% probability level

Figures in parentheses represent standard errors

Table 8: Wald test for imposed restriction

Null hypothesis (H_0)	Significance level (5%)
Symmetry	
$_{FL} = {}_{LF}$	√
Constant returns to scale	
$_{F} + {}_{L} = 1$	√
Equality	√
$_{FF} + {}_{LF} = 0$	√
$_{FL} + {}_{LL} = 0$	√

Coefficient	Aman (normal soil)	Aman (Salt-affected soil)	
	Trans-log Model	Trans-log Model	Hybrid Model
	Estimated value	Estimated value	Estimated value
	4.070112*** (1.776682)	6.383768*** (1.303078)	5.430944*** (0.717125)
	0.730715* (0.480856)	-2.054511*** (0.566234)	1.588820*** (0.407571)
	0.255481 (0.984153)	2.039350*** (0.470722)	2.610615*** (0.399540)
	-	-1.787704*** (0.401934)	-0.489350*** (0.413457)
	-0.212304*** (0.067722)	0.746837*** (0.130082)	0.720296*** (0.137515)
	-0.325787** (0.067722)	0.196942 (0.133777)	0.283231*** (0.127115)
	-	0.186246*** (0.074672)	-
	0.502500*** (0.150978)	-0.873985*** (0.281435)	-1.127158*** (0.268243)
	-	0.468524*** (0.158096)	-
	-	-0.111797 (0.129313)	-
No. of observation	129		

Preliminary Result & Discussion

Table 10. The results for the Salt free & salt affected Boro rice model

Coefficient	Boro (normal soil)	Boro (Salt-affected soil)	
	Trans-log Model	Trans-log Model	Hybrid Model
	Estimated value	Estimated value	Estimated value
β_0	4.723095*** (1.353556)	1.319271* (0.777548)	1.521592*** (0.614751)
β_F	0.659621*** (0.464042)	0.367891 (0.615834)	0.141213 (0.512753)
β_L	0.192029 (0.585969)	2.357830*** (0.522878)	2.676098*** (0.450816)
β_S	-	-0.647909* (0.426753)	-0.785946** (0.150791)
β_{FF}	-0.119393*** (0.047247)	0.699590*** (0.204584)	0.892015*** (0.170433)
β_{LL}	-0.179976*** (0.085413)	0.665021*** (0.151794)	0.823177*** (0.164953)
β_{SS}	-	-0.162187** (0.101359)	-
$\beta_{FL} = \beta_{LF}$	0.270109*** (0.099429)	-1.653365*** (0.342862)	-2.027354*** (0.312432)
$\beta_{FS} = \beta_{SF}$	-	0.165732 (0.210060)	-
$\beta_{LS} = \beta_{SL}$	-	-0.113042 (0.195772)	-
No. of observation	121	178	152
R^2	0.656856	0.631290	0.694099

*** Significant at 1% probability level; ** 5% probability level and * 10% probability level

Figures in parentheses represent standard errors

Table 8: Wald test for imposed restriction

Null hypothesis (H_0)	Significance level (5%)
Symmetry	
$_{FL} = {}_{LF}$	√
Constant returns to scale	
$_F + {}_L = 1$	√
Equality	√
$_{FF} + {}_{LF} = 0$	√
$_{FL} + {}_{LL} = 0$	√

Preliminary Result & Discussion

Table 11. Average own, cross and Morishima elasticity of demand for factor of production

Elasticity	Aus		Aman		Boro	
Factor Demand	Salt free	Salt affected	Salt free	Salt affected	Salt free	Salt affected
¦ $_{FF}$	-7.5	25.7	-8.28	29.02	-5.22	34.71
¦ $_{LL}$	-18.20	45.52	-24.56	21.20	-17.23	50.44
¦ $_{FL}$	10.50	-63.76	17.32	-46.94	9.65	-81.06
¦ $_{LF}$	25.51	-107.60	35.89	-80.48	24.57	-126.66
MES	Salt free	Salt affected	Salt free	Salt affected	Salt free	Salt affected
± $^{m}_{FL}$	28.7	-109.28	41.88	-71.14	26.88	-131.5
± $^{m}_{LF}$	33.01	-133.3	44.17	-109.5	29.79	-161.37

Appendix 7

Comparison between Aus Rice under Different soil Condition

Salt free Aus	Salt affected Aus
1. We can't say anything about the labor input.	1. Salinity is negatively related with Aus.
2. Like Aman & Boro production, fertilizer plays an important role.	2. We can't say anything about the fertilizer input.
3. Marginal effect of labor and fertilizer are negative and support the law of variable proportion or diminishing marginal effect	3. Marginal effect of labor and fertilizer are positive and not support the law of variable proportion or diminishing marginal effect.
4. Cross effect of fertilizer and labor are positive. Meaning that fertilizer and labor are substitute to each other.	4. Cross effect of fertilizer and labor are negative. Meaning that labor and fertilizer are complements to each other.
5. Production's C.V of normal soil Aus <production's C.V of salt affected Aus. Meaning that normal soil Aus has high production possibility with certainty.	7. Production's C.V of salt affected Aus > production's C.V of normal soil Aus. Meaning that salt affected Aus has less production possibility with uncertainty.
6. The value of MES of normal soil is positive. Meaning that fertilizer and labor are substitute to each other.	8. The value of MES of salt affected soil is negative. Meaning that fertilizer and labor are complements to each other.

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Appendix 8

Comparison between Aman Rice under Different soil Condition

Salt free Aman	Salt affected Aman
1. We can’t say anything about the labor input.	1. Salinity is negatively related with Aman rice.
2. Marginal effects of labor and fertilizer are negative and support the low of variable proportion or diminishing marginal effect.	2. Marginal effects of labor and fertilizer are positive. Meaning that Farmer doesn’t know the optimal utilization level of fertilizer and labor.
3. Cross effect of fertilizer and labor are positive. Meaning that fertilizer and labor are substitute to each other.	3. Cross effect of fertilizer and labor are negative. Meaning that fertilizer and labor are complements to each other.
4. Production’s C.V of salt free Aman> production’s C.V of salt affected Aman. Meaning that normal soil’s Aus has less production possibility with uncertainty. Slide 7	4. Production’s C.V of salt affected Aman< production’s C.V of salt free Aman. Meaning that salt affected Aman has high production possibility with certainty.
5. Fertilizer’s C.V of salt free Aman>fertilizer’s C.V of salt affected Aman. Meaning that fertilizer has less access to the potential Aman rice production activity. Slide 8	5. Fertilizer’s C.V of salt affected Aman<fertilizer’s C.V of salt free Aman. Meaning that fertilizer has high accessibility to the potential Aman rice production activity.
6. Labor’s C.V of salt free Aman< labor’s C.V of salt affected Aman. Meaning that labor has easy access to the potential Aman rice production activity.	6. Labor’s C.V of salt affected Aman> labor’s C.V of salt free Aman. Meaning that labor has not easy access to the potential Aman rice production activity.
7. The value of MES of normal soil is positive. Meaning that fertilizer and labor are substitute to each other.	7. The value of MES of normal soil is Negative. Meaning that fertilizer and labor are complements to each other.

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Appendix 9

Comparison between Boro Rice under Different soil Condition

Salt free Boro	Salt affected Boro
1. We can’t say anything about the labor input.	1. Salinity is negatively related with Boro rice.
2. Marginal effects of labor and fertilizer are negative and support the low of variable proportion or diminishing marginal effect.	2. Marginal effects of labor and fertilizer are positive. Meaning that Farmer doesn’t know the optimal utilization level of fertilizer and labor.
3. Cross effect of fertilizer and labor are positive. Meaning that fertilizer and labor are substitute to each other.	3. Cross effect of fertilizer and labor are negative. Meaning that fertilizer and labor are complements to each other.
4. Production’s C.V of salt free Boro < production’s C.V of salt affected Aman. Meaning that normal soil’s Aus has production possibility with certainty.	4. Production’s C.V of salt affected Aman > production’s C.V of salt free Aman. Meaning that salt affected Aman has less production possibility with uncertainty.
5. Fertilizer’s C.V of salt free Boro < fertilizer’s C.V of salt affected Boro. Meaning that fertilizer has high access to the potential Boro rice production activity.	5. Fertilizer’s C.V of salt affected Boro > fertilizer’s C.V of salt free Aman. Meaning that fertilizer has less accessibility to the potential Aman rice production activity.
6. Labor’s C.V of salt free Aman< labor’s C.V of salt affected Aman. Meaning that labor has easy access to the potential Aman rice production activity.	6. Labor’s C.V of salt affected Aman> labor’s C.V of salt free Aman. Meaning that labor has not easy access to the potential Aman rice production activity.
7. The value of MES of normal soil is positive. Meaning that fertilizer and labor are substitute to each other.	7. The value of MES of normal soil is Nagative. Meaning that fertilizer and labor are complements to each other.

Slide 7
Slide 8
Slide 28

Policy Implications and Conclusion

1. Aman is mainly cultivated rice in the southwest coastal region depending on rainfall. This regain should only produce Aman rice.

2. More fertilizer utilization can play important role to maintain, reduce and control the salinity. There is a big gap between the recommended and actual use of fertilizer in the southwest coastal region. Soil test and the Prescription of the amount of fertilizer plays an important role to produce more rice. Soil test and the optimum level of fertilizer can help to increase rice production.

3. Descriptive statistics and econometrics model suggest that Aus and Boro rice are mostly vulnerable with the existence of salinity of the southwest coastal region of Bangladesh.

4. Aus and Aman rice produce farmers not get profit and cover total cost from the cultivation of Aus and Aman. They can produce Sorghum and Cotton instead of Aus and Aman.

5. Sorghum and Cotton are more salinity tolerance crops and they are easily grows in more than the degree of salinity 16 dS/m (Ayers et al., 1994). Sorghum provides biofuels and promote low carbon society and Cotton production reduce import dependency on Cotton from abroad and it promote our Garments sector.

Limitations

1. This study doesn't consider the effects of seasonal flections (flood, drought, cyclone, fog and other natural issues) on rice production.

2. This study considers only the common three fertilizers like Nitrogen (Urea), Triple Super Phosphate (TSP) and Murite of Potash (MOP). The effects of other fertilizer like Gypsum, Zinc sulphate, DAP, organic fertilizers are not consider in this study.

3. Like all the fertilizer, this study also not considers irrigation, plough and the other cultivating activities.

4. This study is focus on only the southwest coastal region not the whole coastal regions of Bangladesh. Different coastal regions possess different social and natural characteristics.

5. This study measure only the monsoon time salinity. Salinity level is comparative low in the monsoon time . Generally, Pre-monsoon and post-monsoon hold the strong level of salinity.

Pre-monsoon: March- early June
Monsoon: Late June-November
Post monsoon: December-February

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Appendix 1

<u>Detection of Multicollinearity, Heteroscedasticity & Autocorrelation</u>

1. **Multicollinearity:**

There is strong possibility of the presence of multicollinearity in cross-section data. To detect multicollinearity, I use Tolerance (TOL) and Variance inflation factor (VIF).

$$\text{tolerance} = 1 - R_j^2, \quad \text{VIF} = \frac{1}{\text{tolerance}},$$

where R_j^2 is the coefficient of determination of a regression of explanator *j* on all the other explanators. A tolerance of less than 0.20 or 0.10 and/or a VIF of 5 or 10 and above indicates a multicollinearity problem

2. **Heteroscedasticity:**

White (Lagrange Multiplier) test is very popular to detect Heteroscedasticity. It fdepends on the following test statistics:

$$LM = nR^2 \sim \chi^2 df.$$

if the calculating value of χ^2 df > the tabular value, there is an evidence of heteroscedasticity

3. **Autocorrelation:**

Autocorrelation found in time series data. In addition, when lag variable used as explanatory variable, there is a possibility to presence of Autocorrelation. I used the cross-section data and no lag variable in my model, So, I am not interested to test the identification of autocorrelation in my model.

Appendix 2

1. **Multicollinearity test for non-salinity Aus rice model:**

Tolerance (TOL) & Variance inflation factor (VIF) test:

$$Tolerance(TOL) = 1 - R_j^2 = 1 - 0.795560 = 0.20444 > 0.20 \; or \; 0.10$$

$$Variance \inf lation factor(VIF) = \frac{1}{TOL} = \frac{1}{0.20444} = 4.89 < 5 \; or \; 10$$

no multicollinearity

2. **Multicollinearity test for salinity affected rice model:**

Tolerance (TOL) & Variance inflation factor (VIF) test:

$$Tolerance(TOL) = 1 - R_j^2 = 1 - 0.520445 = 0.479555 > 0.20 \; or \; 0.10$$

$$Variance \inf lation factor(VIF) = \frac{1}{TOL} = \frac{1}{0.479555} = 2.08 < 5 \; or \; 10$$

no multicollinearity

Appendix 3

YOUNG'S THEOREM

A very important and useful result in the calculus of functions of several variables is the following.

Theorem: *Let* $f:\mathbb{R}^n \rightarrow \mathbb{R}$ *be twice continuously differentiable on its domain of definition,* $X \subset \mathbb{R}$. *Then on the interior of its domain, the* $n\times n$ *matrix of second-order partial derivatives is symmetric,*

$$\frac{\partial^2 f}{\partial x_i \partial x_j} = \frac{\partial^2 f}{\partial x_j \partial x_i}, \ \forall \ i, j = 1, \ldots, n.$$

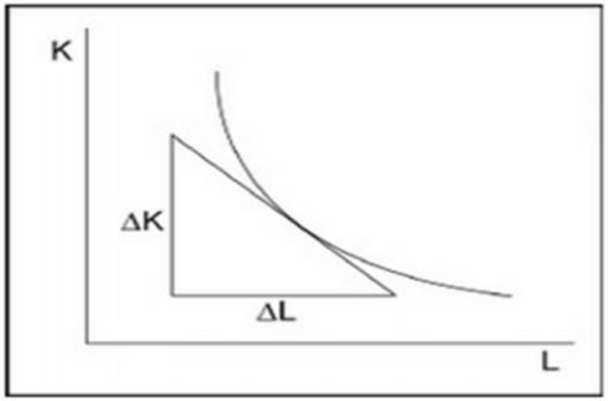
Appendix 4

Marginal rate of technical substitution (MRTS) is the rate where an input can be substituted with other inputs while total output remains unchanged.

When production only involves the use of labour and capital, MRTS $_{LK}$ is the marginal rate of technical substitution of capital to labour, that is, the rate in which capital is substituted with labour without any change in output.

Figure 1. MRTS

$$MRTS_{LK} = -K/L$$



Appendix 5

The **Cobb–Douglas** functional form of production function is widely used to represent the relationship of output and two inputs. The Cobb-Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglas during 1900–1947.

The functional form of Cobb-Douglas production function

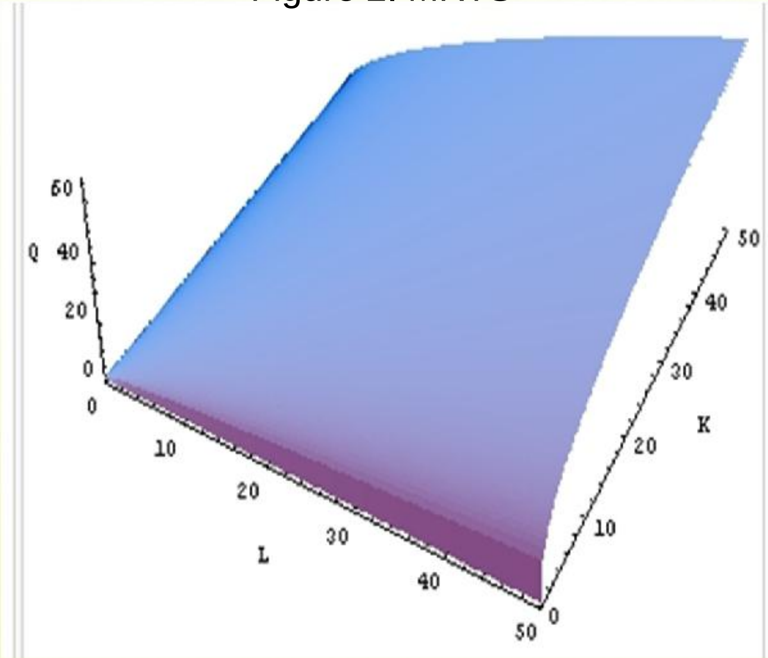
$$Q = F(K, L) = AK^{b}L^{1-b}$$

Where A>0 and 0<b<1**.**

where:

Y = total production (the monetary value of all goods produced in a year)
L = labor input
K = capital
A =total factor productivity
α and β are the output elasticity of capital and labor, respectively. Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus. For example if α = 0.15, a 1% increase in labor would lead to approximately a 0.15% increase in output.

Figure 2. MRTS



A two-input Cobb-Douglas production function

Appendix 6

The term returns to scale arises in the context of a firm's production function. It refers to changes in output resulting from a proportional change in all inputs (where all inputs increase by a constant factor). If output increases by that same proportional change then there are constant returns to scale (CRS).

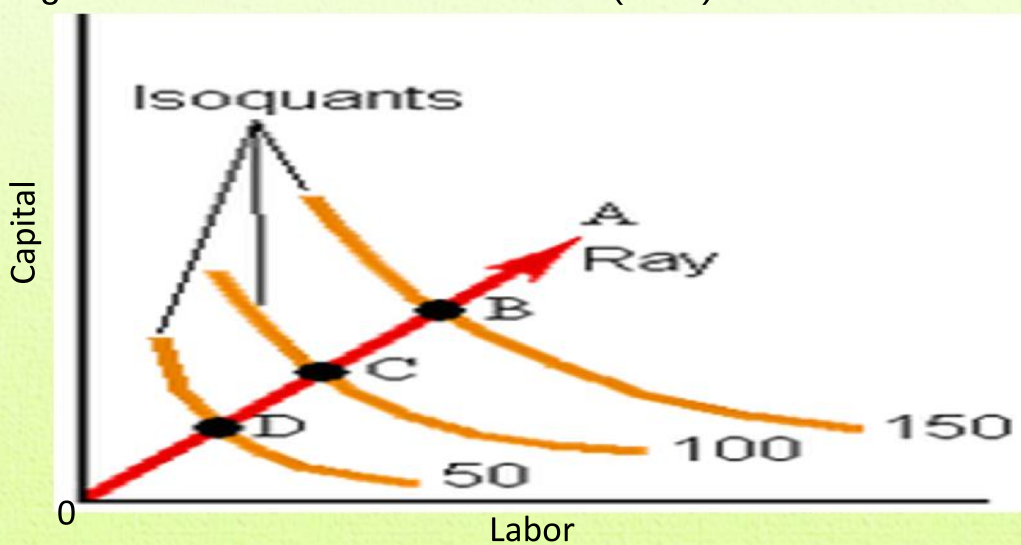
The Cobb-Douglas functional form has constant returns to scale when the sum of the exponents adds up to one. The function is:

$$F(K,L) = AK^bL^{1-b}$$

Where A>0 and 0<b<1. Thus

$$F(aK,aL) = A(aK)^b(aL)^{1-b} = Aa^ba^{1-b}K^bL^{1-b} = aAK^bL^{1-b} = aF(K,L).$$

Figure 3. Constant Returns to Scale (CRS)



Dependent Variable: LNAUS (Salt free Aus model)
Method: Least Squares
Date: 03/13/13 Time: 08:21
Sample: 1 129
Included observations: 129
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.740641	0.942454	2.907986	0.0043
LNFER	1.286970	0.356948	3.605487	0.0005
LNLAB	0.373434	0.445640	0.837973	0.4037
LNFER^2	-0.196472	0.042669	-4.604536	0.0000
LNLAB^2	-0.238071	0.080361	-2.962509	0.0037
LNFER*LNLAB	0.315852	0.060264	5.241145	0.0000

R-squared	0.795560	Mean dependent var	7.418439
Adjusted R-squared	0.787249	S.D. dependent var	0.486678
S.E. of regression	0.224480	Akaike info criterion	-0.104668
Sum squared resid	6.198110	Schwarz criterion	0.028347
Log likelihood	12.75106	Hannan-Quinn criter.	-0.050621
F-statistic	95.72860	Durbin-Watson stat	1.790584
Prob(F-statistic)	0.000000		

Dependent Variable: LNAUS (Salt affected Aus model)
Method: Least Squares
Date: 03/07/13 Time: 09:40
Sample: 1 103
Included observations: 103
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.053447	0.988806	2.076694	0.0405
LNFER	0.186934	0.837031	0.223330	0.8238
LNLAB	2.278422	0.746285	3.053020	0.0029
LNSAL	-0.937969	0.182660	-2.153037	0.0338
LNFER^2	0.716530			

Appendix 8

Table 14. Trans-log Non-salinity Aman Model

$$\ln(\frac{Y}{A}) = {}_{0} + {}_{F}\ln(\frac{F}{A}) + {}_{L}\ln(\frac{L}{A}) + \frac{1}{2}{}_{FF}\ln(\frac{F}{A})^{2} + {}_{FL}\ln(\frac{FL}{A}) + \frac{1}{2}{}_{LL}\ln(\frac{L}{A})^{2} + {}_{LF}\ln(\frac{LF}{A}) + u_i;\ u_i \quad N(0,\pm^{2})$$

Table 15. Trans-log Salinity Aman model

$$\ln(\frac{Y}{A}) = {}_{0} + {}_{F}\ln(\frac{F}{A}) + {}_{L}\ln(\frac{L}{A}) + {}_{S}\ln(\frac{S}{A}) + \frac{1}{2}{}_{FF}\ln(\frac{F}{A})^{2} + {}_{FL}\ln(\frac{FL}{A}) + \frac{1}{2}{}_{LL}\ln(\frac{L}{A})^{2} + {}_{LF}\ln(\frac{LF}{A}) + u_i;\ u_i \quad N(0,\pm^{2})$$

Dependent Variable: LNAMAN (salt free Aman model)
Method: Least Squares
Date: 02/25/13 Time: 18:06
Sample: 1 129
Included observations: 129
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.070112	1.776682	2.290850	0.0237
LNFER	0.730715	0.480856	1.519615	0.1312
LNLAB	0.255481	0.984153	0.259594	0.7956
LNFER^2	-0.212304	0.067722	-3.134952	0.0021
LNLAB^2	-0.325787	0.164621	-1.979010	0.0500
LNFER*LNLAB	0.502500	0.150978	3.328308	0.0012

R-squared	0.696476	Mean dependent var	7.462799
Adjusted R-squared	0.684138	S.D. dependent var	0.494387
S.E. of regression	0.277854	Akaike info criterion	0.321951
Sum squared resid	9.495928	Schwarz criterion	0.454966
Log likelihood	-14.76584	Hannan-Quinn criter.	0.375997
F-statistic	56.44806	Durbin-Watson stat	1.300045
Prob(F-statistic)	0.000000		

Dependent Variable: LNAMAN (salt affected Aman) model)
Method: Least Squares
Date: 03/07/13 Time: 13:20
Sample: 1 183
Included observations: 183
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.430944	0.717125	7.573215	0.0000
LNFER	1.588820	0.407571	3.898264	0.0001
LNLAB	2.610615	0.399540	6.534057	0.0000
LNSAL	-0.489350	0.413457	-2.746408	0.0067
LNFER^2	0.720296	0.137515	5.237961	0.0000
LNLAB^2	0.283231	0.127115	2.228145	0.0271
LNFER*LNLAB	-1.127158	0.268243	-4.202004	0.0000

R-squared	0.348232	Mean dependent var	7.459163
Adjusted R-squared	0.326012	S.D. dependent var	0.348843
S.E. of regression	0.286389	Akaike info criterion	0.374570
Sum squared resid	14.43530	Schwarz criterion	0.497337
Log likelihood	-27.27315	Hannan-Quinn criter.	0.424334
F-statistic	15.67244	Durbin-Watson stat	2.169278
Prob(F-statistic)	0.000000		

Appendix 9

Table 16. Trans-log Non-salinity Boro Model

$$\ln(\frac{Y}{A}) = {}_0 + {}_F \ln(\frac{F}{A}) + {}_L \ln(\frac{L}{A}) + \frac{1}{2} {}_{FF} \ln(\frac{F}{A})^2 + {}_{FL} \ln(\frac{FL}{A}) + \frac{1}{2} {}_{LL} \ln(\frac{L}{A})^2 + {}_{LF} \ln(\frac{LF}{A}) + u_i;\ u_i \quad N(0, \pm^2)$$

Table 17. Trans-log Salinity Boro model

$$\ln(\frac{Y}{A}) = {}_0 + {}_F \ln(\frac{F}{A}) + {}_L \ln(\frac{L}{A}) + {}_S \ln(\frac{S}{A}) + \frac{1}{2} {}_{FF} \ln(\frac{F}{A})^2 + {}_{FL} \ln(\frac{FL}{A}) + \frac{1}{2} {}_{LL} \ln(\frac{L}{A})^2 + {}_{LF} \ln(\frac{LF}{A}) + u_i;\ u_i \quad N(0, \pm^2)$$

Dependent Variable: LNBORO (salt free Boro model)
Method: Least Squares
Date: 03/07/13 Time: 11:33
Sample: 1 121
Included observations: 121
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.723095	1.353556	3.489398	0.0006
LNFER	0.659621	0.464042	2.330947	0.0209
LNLAB	0.192029	0.585969	0.327712	0.1834
LNFER^2	-0.119393	0.047247	-2.526999	0.0126
LNLAB^2	-0.179976	0.085413	-2.107134	0.0369
LNFER*LNLAB	0.270109	0.099429	2.716606	0.0074

R-squared	0.656856	Mean dependent var	7.593060
Adjusted R-squared	0.644688	S.D. dependent var	0.394854
S.E. of regression	0.235365	Akaike info criterion	0.024798
Sum squared resid	7.810917	Schwarz criterion	0.076658
Log likelihood	7.131934	Hannan-Quinn criter.	0.044193
F-statistic	53.98129	Durbin-Watson stat	1.589941
Prob(F-statistic)	0.000000		

Dependent Variable: LNBORO (salt affected Boro model)
Method: Least Squares
Date: 03/07/13 Time: 13:55
Sample: 1 152
Included observations: 152
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.521592	0.614751	2.475135	0.0145
LNFER	0.141213	0.512753	0.275402	0.7834
LNLAB	2.676098	0.450816	5.936117	0.0000
LNSAL	-0.785946	0.150791	-0.707719	0.0648
LNFER^2	0.892015	0.170433	5.233833	0.0000
LNLAB^2	0.823177	0.164953	4.990376	0.0000
LNFER*LNLAB	-2.027354	0.312432	-6.488944	0.0000

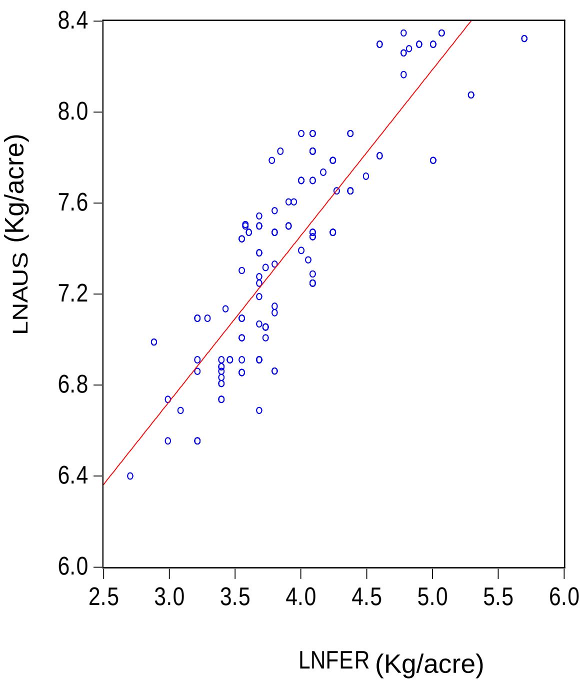
R-squared	0.694099	Mean dependent var	7.106456
Adjusted R-squared	0.681441	S.D. dependent var	0.585126
S.E. of regression	0.330251	Akaike info criterion	0.667034
Sum squared resid	15.81457	Schwarz criterion	0.806291
Log likelihood	-43.69456	Hannan-Quinn criter.	0.723605
F-statistic	54.83483	Durbin-Watson stat	2.543540
Prob(F-statistic)	0.000000		

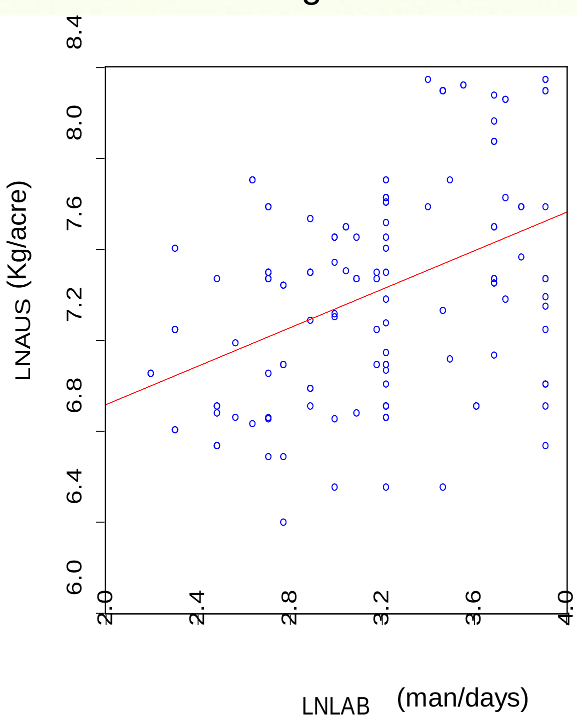
Appendix 10

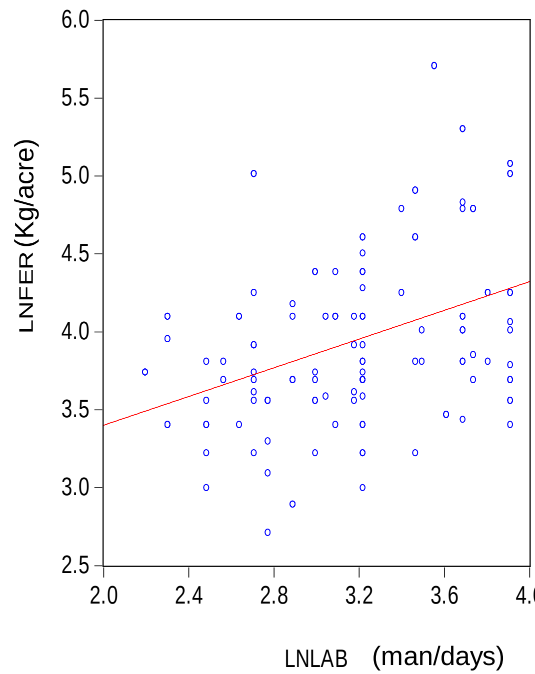
Table 18. Correlation Matrix of Aus rice for normal soil

	LNAUS	LNFER	LNLAB
LNAUS	1		
LNFER	0.869429	1	
LNLAB	0.411324	0.375942	1

Scatter diagram





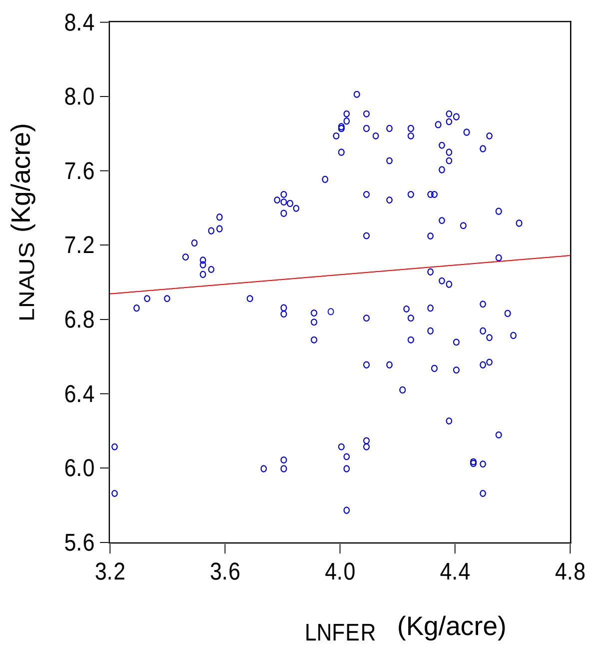


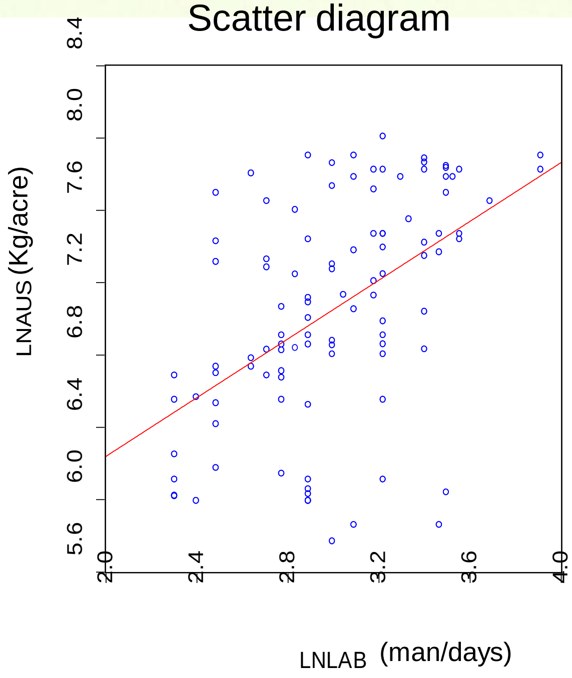
Appendix 11

Table 19. Correlation Matrix for Saline affected Aus rice

	LNAUS	LNFER	LNLAB	LNSAL
LNAUS	1			
LNFER	0.073222	1		
LNLAB	0.498293	-0.178648	1	
LNSAL	-0.116021	0.048517	0.055353	1

Scatter diagram





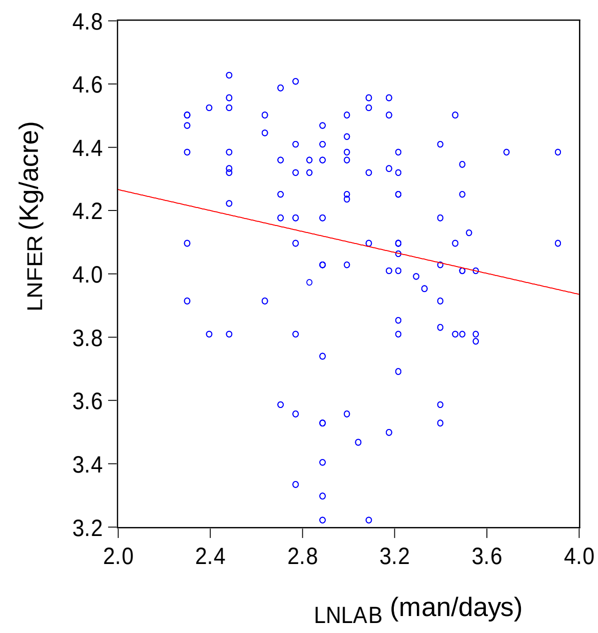
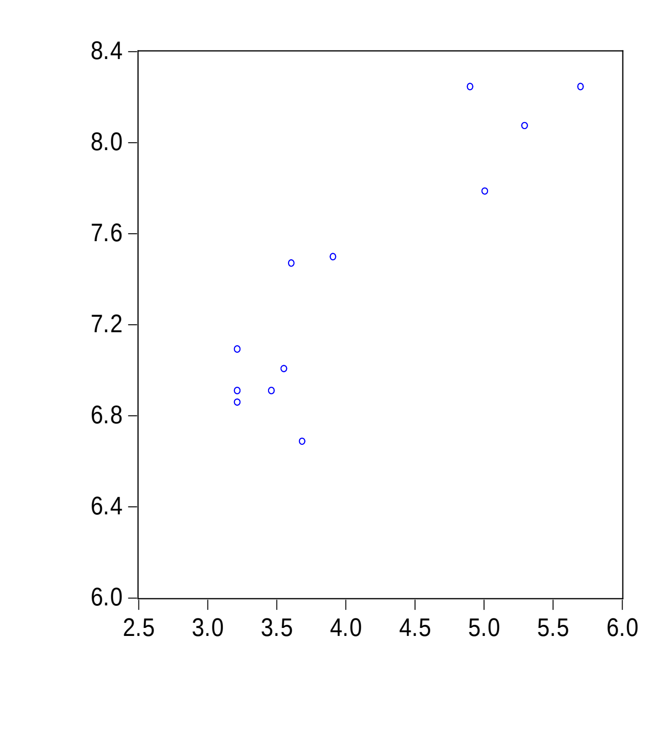


Table 20.Correlation Matrix of Aman rice for normal soil

	LNAMAN	LNFER	LNLAB
LNAMAN	1		
LNFER	0.809831	1	
LNLAB	0.408413	0.408954	1

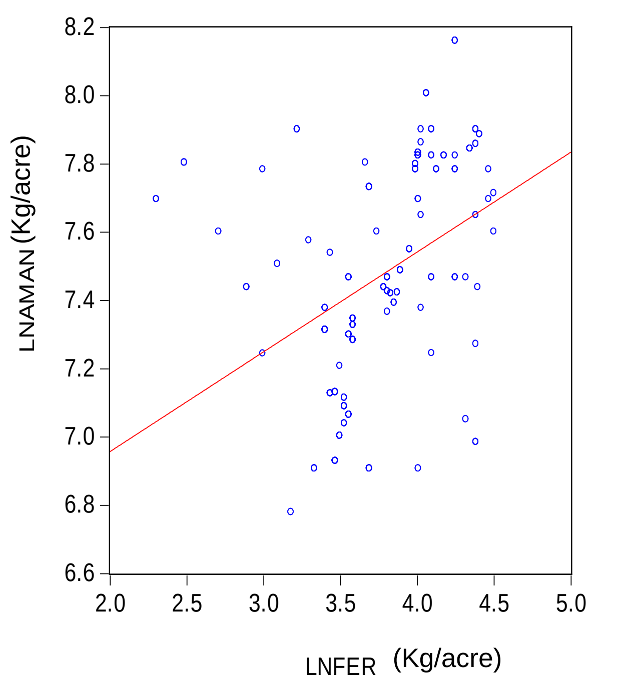


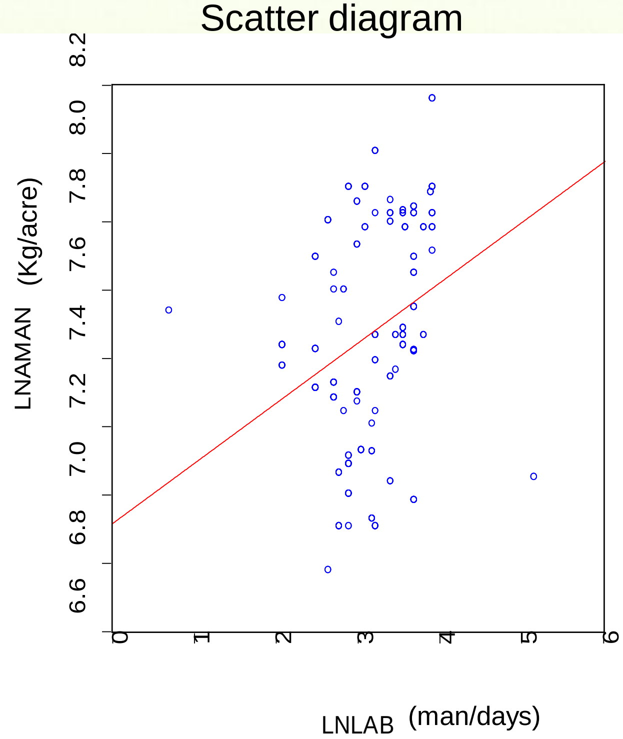
Appendix 13

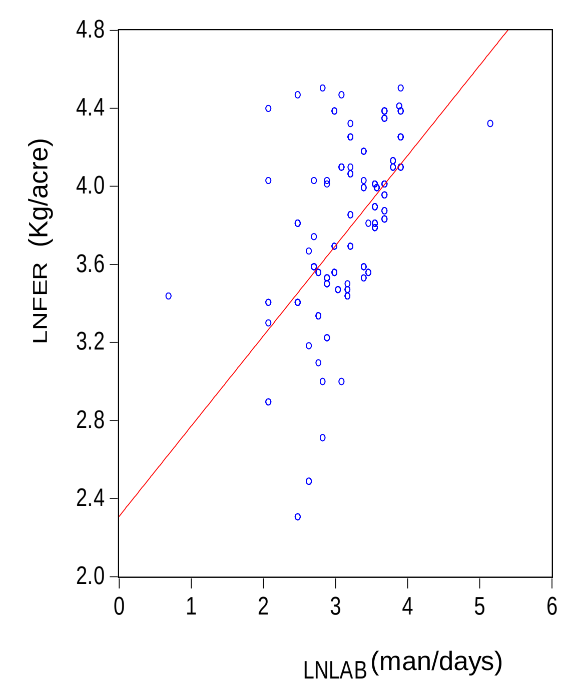
Table 21. Correlation Matrix of Salt affected Aman rice

	LNAMAN	LNFER	LNLAB	LNSAL
LNAMAN	1			
LNFER	0.392659	1		
LNLAB	0.294249	0.575139	1	
LNSAL	-0.118556	0.013658	0.106998	1

Scatter diagram





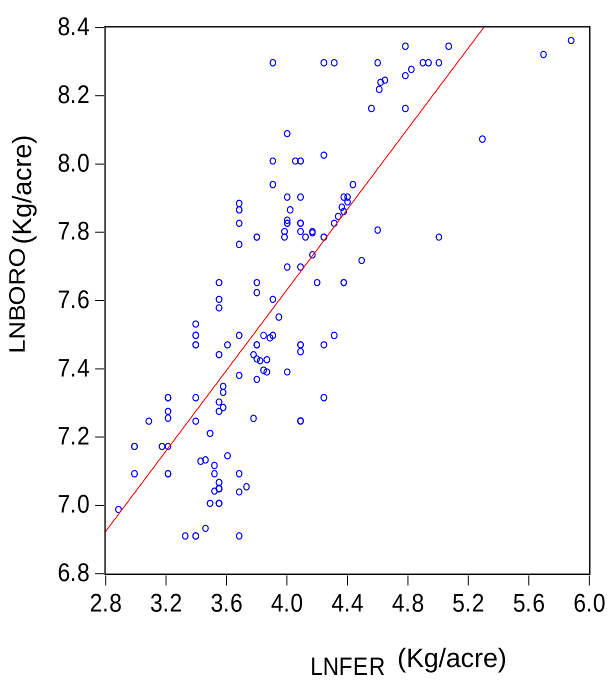


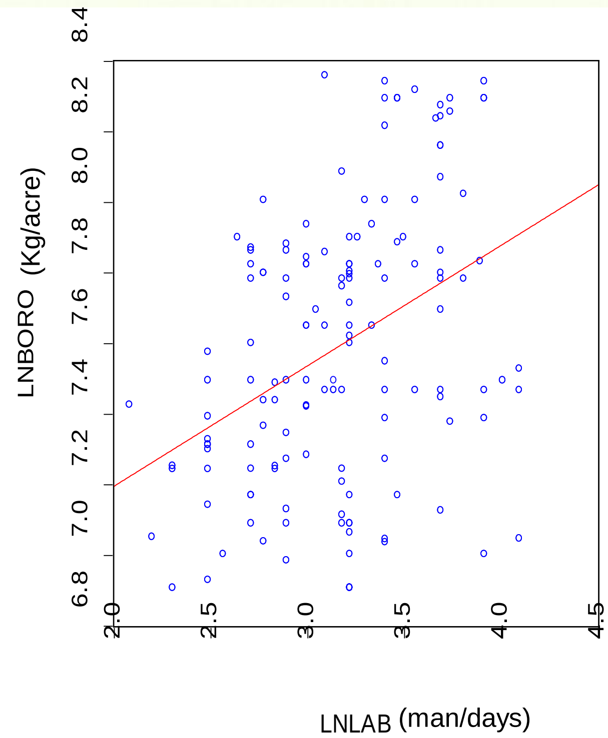
Appendix 14

Table 22. Correlation Matrix of Boro rice for normal soil

	LNBORO	LNFER	LNLAB
LNBORO	1		
LNFER	0.783680	1	
LNLAB	0.387077	0.367684	1

Scatter diagram





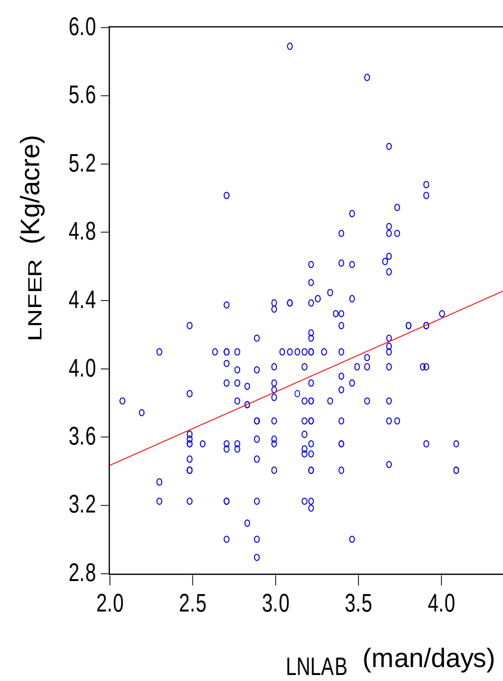
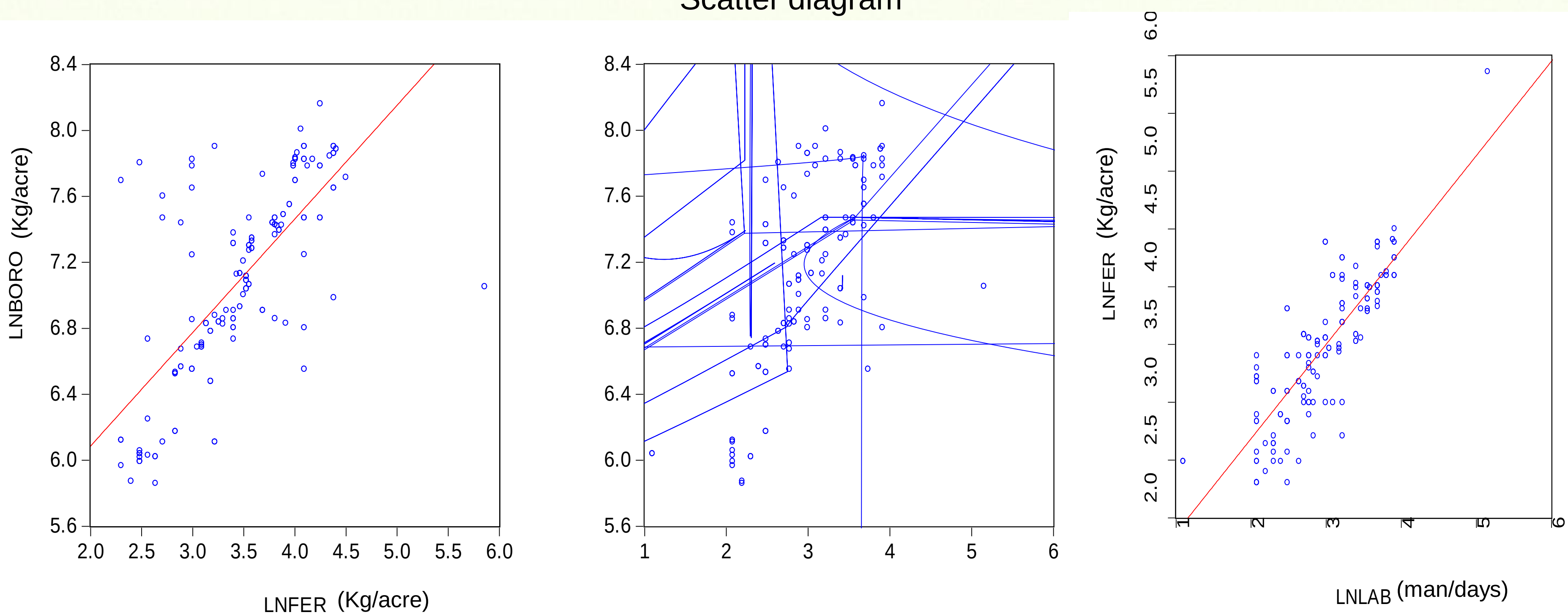


Table 23. Correlation Matrix of Salt affected Boro rice

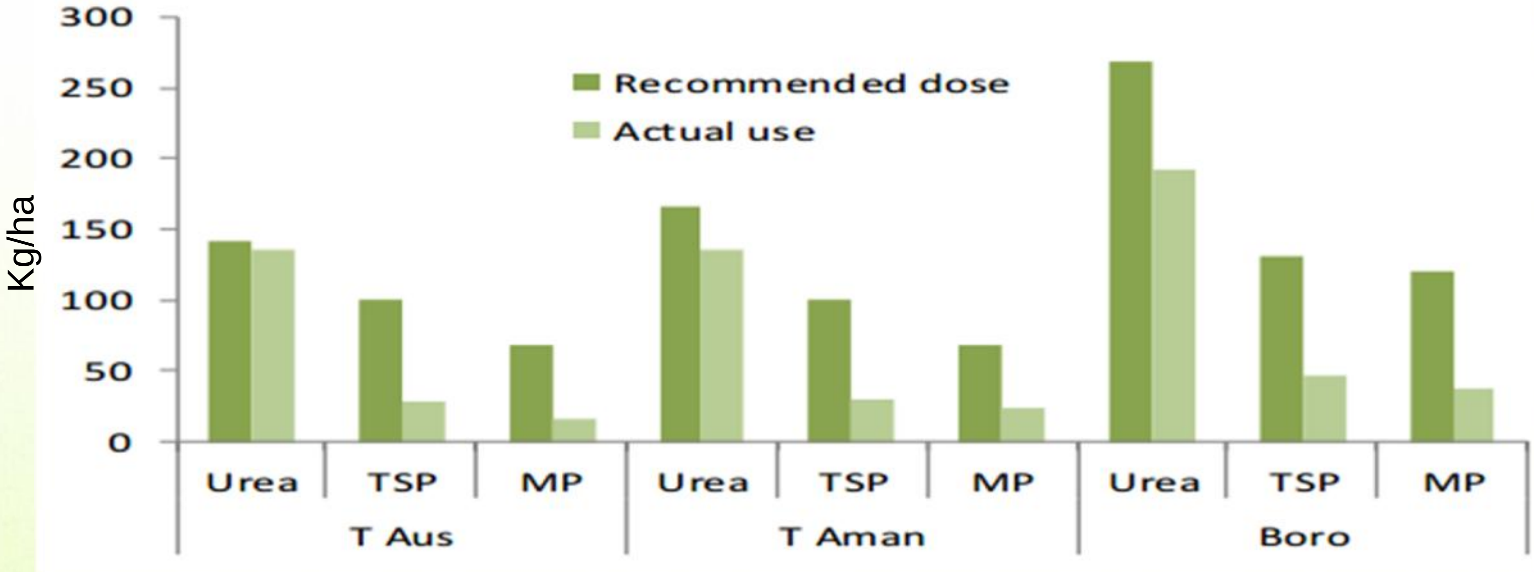
	LNBORO	LNFER	LNLAB	LNSAL
LNBORO	1			
LNFER	0.713471	1		
LNLAB	0.710223	0.841077	1	
LNSAL	-0.004253	0.0125907	0.049537	1

Scatter diagram



Appendix 16

Figure 4. Recommended and actual use of UREA, TSP, and Mop in Bangladesh, 2004



(Source: Jaim & Akter, 2012)

Tabl 24. Recommended and actual use of UREA, TSP, and Mop in Bangladesh, 2004

Name of the Input/Output	Price per kg & wage per day (09:00 am to 17:00 pm)
Labor (man/day)	**৳ 300.00**
Urea	**৳ 15.00**
Triple Super Phosphate (TSP)	**৳ 28.00**
Murite of Potash (MOP)	**৳ 22.00**
Zinc Sulphate	**৳ 10.00**
Gypsum	**৳ 20.00**
Aus/Aman/Boro	**৳ 18.00**

Source: Bith & Khan (2013)

Appendix 17

Table 25. Used fertilizer status by the rice produce farmer

Name of the Fertilizer	Aus		Aman		Boro	
	NS	SAS	NS	SAS	NS	SAS
Nitrogen (kg)/acre	50.60	75.47	82.21	77.04	72.81	65.02
Phosphorus (kg)/acre	38.42	19.87	10.74	13.39	15.74	27.53
Potassium (kg)/acre	10.98	4.66	7.05	9.57	11.45	7.45

NS=normal soil; SAS=salt affected soil

Source: Calculated by the author based on his collected household micro-cross section data

dS/m=deciSiemen/metre in S.I. units (equivalent to 1 mmho/cm=1 milimmho/centi-metre

Appendix 18

Table 26. Site no. 17A, Soil series: Bajoa, MHL, Location: Fultala, Batiaghata (Soil Salinity(ECe: dS/m))

Year	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
2004	5.2	**4.0**	**12.4**	**5.3**	**22.3**	**10.9**	-	-	-	6.1	5.2	13.2
2005	5.0	**4.4**	**17.2**	**11.0**	**15.7**	**5.6**	6.0	2.5	-	-	5.6	2.5
2006	4.3	**25.8**	**28.7**	**21.9**	**18.4**	**5.3**	5.1	2.4	1.8	2.5	1.2	2.4
2007	4.7	**5.5**	**12.8**	**5.8**	**17.5**	**11.7**	5.3	1.4	2.0	4.4	1.5	5.3
2008	6.7	**4.8**	**5.5**	**10.4**	**10.9**	**7.2**	4.1	1.5	1.4	1.7	1.9	1.8
2009	1.9	**3.8**	**4.8**	**7.7**	**13.5**	**8.5**	2.2	8.6	2.3	2.6	1.2	1.5
2010	1.4	**2.5**	**5.7**	**8.0**	**5.3**	**4.9**	1.9	5.4	1.3	2.2	1.2	1.4
2011	1.6	**1.6**	**5.8**	**10.6**	**9.6**	**1.4**	1.6	1.7	1.2	2.0	1.8	3.8
2012	2.5	**4.8**	**6.3**	**7.6**	**10.2**	**3.8**	2.1	1.7				

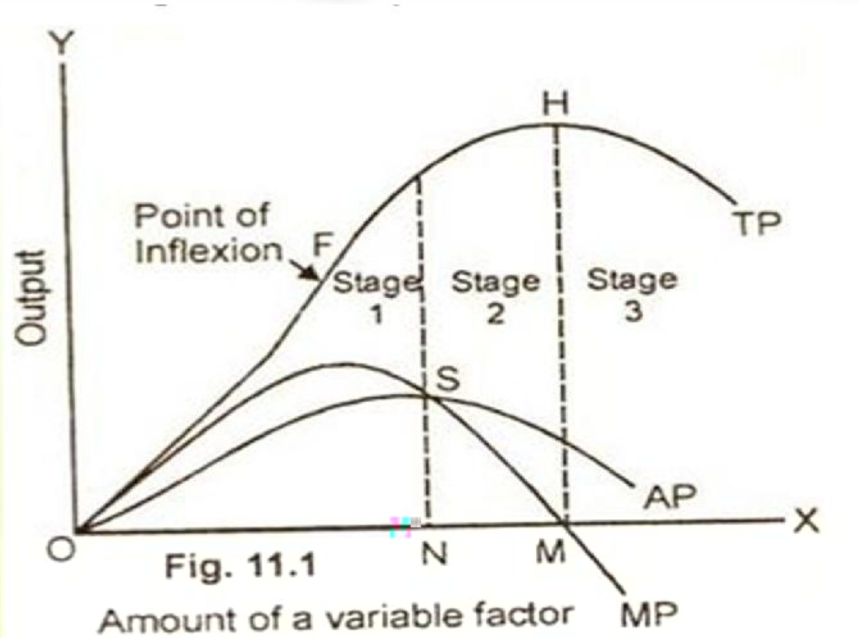
Table 27. Site no. 15. Rupsa river,Rupsa Ferryghat, Khulna(Water Salinity(Ecw: (dS/m))

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	0.4	**2.9**	**11.3**	**16.4**	**25.5**	**0.6**	-	-	-	0.3	0.4	0.5
2005	0.6	**3.2**	**9.0**	**13.5**	**21.8**	**14.0**	0.32	0.39	-	-	0.45	0.53
2006	0.8	**3.9**	**14.7**	**23.3**	**24.9**	**0.4**	0.4	0.3	0.6	0.4	0.5	0.6
2007	1.0	**4.6**	**15.5**	**22.2**	**27.7**	**4.9**	0.3	0.5	0.2	0.4	0.5	0.8
2008	1.7	**7.9**	**13.1**	**17.0**	**22.0**	**0.7**	0.3	0.3	0.4	0.4	0.5	0.5
2009	1.5	**6.0**	**12.5**	**21.1**	**24.3**	**27.0**	0.6	0.5	0.3	0.3	0.4	0.5
2010	1.6	**9.1**	**17.1**	**27.0**	**27.6**	**2.8**	0.3	0.3	0.4	0.4	0.4	0.5
2011	2.6	**10.0**	**12.3**	**18.4**	**22.0**	**6.4**	0.3	0.3	0.2	0.3	0.6	0.6
2012	0.6	**1.0**	**6.0**	**17.0**	**6.0**	**0.4**	0.5	0.4				

Source: SRDI, Botyaghata, Khulna

Appendix 19

Figure 5. Law of variable proportions



Boarder Hessian Determinant (BHD) is the Second-order conditions for constrained Optimization problems

The <u>second-order conditions</u> can be expressed in terms of the following **"bordered" Hessian** - where λ is taken as the first variable in L =L(λ, x_1,x_2).

$$|\overline{H}| = \begin{vmatrix} 0 & g_1 & g_2 \\ g_1 & f_{11} + \lambda g_{11} & f_{12} + \lambda g_{12} \\ g_2 & f_{21} + \lambda g_{21} & f_{22} + \lambda g_{22} \end{vmatrix}$$

Local constrained <u>maximum</u> if $|\overline{H}| > 0$

Local constrained <u>minimum</u> if $|\overline{H}| < 0$

NOTES

[1] If g is a linear function of x_1,x_2 then g_{11}, g_{12}, g_{21}, g_{22} will all be 0 so the bottom four right hand side elements will just be f_{11}, f_{12}, f_{21}, f_{22} .

[2] These conditions can be extended if the number of choice variables increases from 2 to n. They can also be extended to cover problems with more than one constraint. For the details refer to Chiang.

Appendix 20

Problem of salinity tolerance rice?

1. Immature grain fall. (Rahman,2012)
2. Immature rice grain. (Rahman, 2012)
3. Rice is tasteless. (Gani, 2012)
4. Not cover the total cost (TC) because of low production and low market price compare to those of other common rice of Bangladesh (Gani,2012).
5. Bangladesh introduced some salinity tolerance rice like BRRI dhan-28, BRRI dhan-47 and BRRI dhan-55. They can with stand 12-14 dS/m of salinity on land and while they are tender, the entire lifespan of 152-155 days (The Daily Star, July 3, 2012).
6. The representative part of southwest coastal region possess the salinity level at >16 dS/m. (SRDI Report, 2010).
7. Salinity varies from time to time and from location to location (field visit observation).

Thank You