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Saline Soils of Bangladesh

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Saline Soils of Bangladesh

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Author

PREFACE

'Soil Salinity in Bangladesh' is the third documentation of Soil Resource Development Institute (SRDI) on coastal soil salinity. The previous two reports were published in 1997 in Bengali and in 2003 in English. The coastal areas of Bangladesh has less cropping intensity due to dry season salinity of soil and water along with other severe constraints due to certain unfavourable soil and land characteristics like river band erosion, flood, late draining condition, heavy clay basin, poor quality of draught animal, scarcity of irrigation water, acidity, low fertility status, exposure to cyclonic storm surges risk of early and late rainfall, difficult communication and remoteness of urban market etc. Special attention is needed for the development to mitigate constraints by using potentials of the coastal areas.

The primary objective of this report is to provide a general reference work for soil salinity problem in these areas. Until now the salinity problem received very little attention, but due to effect of climate change and to increase the demand for growing more food to feed the booming population of the country it has become imperative to explore the potentials of these lands. For this reason SRDI took necessary steps with its limited resources to conduct special salinity survey at reconnaissance level in May, 2009 following standard procedure to generate data on soil and water salinity status. Using all the generated field level information a revised 'Soil **Salinity map'** of Bangladesh is prepared and enclosed herewith as an integral part of this brief report.

The present report analyzes the soil salinity intensity and extent, constraints as well as possible soil management practices to be followed in coastal areas of Bangladesh. This report also provides information on land characteristics, salt characteristics, present land cropping pattern and major constraints of the area. From the survey findings, it is revealed that total saline area has increased to about 1.056 million hectares from 0.833 million hectares in about the last four decades. This type of data base may be very helpful for intensifying crop diversification activities and designing future research programme of ameliorative measures to minimize soil problems such as salinity, toxicity, drainage impedance as well as soil management packages in the coastal areas of Bangladesh.

I am confident enough that this brief publication will make an opportunity to evaluate the land and soil quality on the basis of salinity for improvement in agricultural planning and crop production by the extension personnel, researchers, policy makers, planners, NGO's at national and local levels.

I congratulate the author, members of the survey team for their sincere effort and hard toiling. I would also like to extend my thanks to the officers involved in analyzing soil and water samples as well as to the persons involved in preparing this report for their test efforts to accomplish the task assigned to them.

Any comment or constructive criticism for its development will be highly appreciated.

(MAINUL AHSAN)
Director

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CHAPTER-I

Introduction

Bangladesh, a deltaic plain, has a very flat and low topography except in the northeast and south-east region. About 10% of the country is hardly 1m above the mean sea level and one-third is under tidal excursions. It has 710 km long coastline running parallel to the Bay of Bengal.

Climate change due to global warming and its negative consequence on environment and agro ecosystem is a serious concern of global community of recent age. It is considered as one of the most serious threats to the environment with its potential negative impacts on food security, agriculture, fisheries, human health, biodiversity, water and other natural resources. In Bangladesh, we have evidences of increased frequency of floods, changing rainfall patterns, more frequent droughts and salinity intrusion. An increasing number of evidence in recent years has clearly established the fact that anthropogenic climate change is a reality. Many of the projected impacts of climate change will reinforce the baseline environmental, socio-economic and demographic stresses already faced by Bangladesh.

The coastal and off-shore area of Bangladesh include tidal, estuarine and meander floodplains. The tidal floodplain land occurs mainly in the south of the Ganges floodplain and also on large part of Chittagong coastal plains. The Ganges tidal floodplains constitute about 49% of the coastal areas. The tidal lands on the coastal plain including the Chittagong coastal floodplain and the Matamuhuri tidal floodplain occupy less than 6%. Estuarine floodplains occupy about 18% of the total coastal area located in greater Noakhali, Barisal, Patuakhali and a smaller area of Chittagong districts (Karim *et al*, 1982).

Agriculture is a major sector of Bangladesh's economy and the coastal area of Bangladesh is suitable for growing rice. More than 30% of the cultivable land in Bangladesh is in the coastal area. Out of 2.86 million hectares of coastal and off-shore lands about 1.056 million ha of arable lands are affected by varying degrees of salinity. Farmers mostly cultivate low yielding, traditional rice varieties during wet season. Most of the land remains fallow in the dry season (January- May) because of soil salinity, lack of good quality irrigation water and late draining condition (Karim *et al*., 1990; Mondal, 1997 and SRDI, 2001). Crop production of the salt affected areas in the coastal regions differs considerably from non saline areas. Because of salinity, special environmental and hydrological situation exists, that restrict the normal crop production throughout the year. In the recent past, with the changing degree of salinity of some areas due to further intrusion of saline water, normal crop production becomes very risky. Crop yields, cropping intensity, production levels and people's quality of livelihood are much lower than that in other parts of the country, which have enjoyed the fruits of modern agriculture technologies based on high-yielding varieties, improved fertilizer and water management and improved pest and disease control measures (BBS, 2001). At the same time food demand in the area is increasing with the steady increase in human population. The present paper analyze the soil and water salinity intensity, extent, constraints and possible soil and water management practices to be followed in coastal areas of Bangladesh for the betterment of the country .

2. Objectives :

The broad spectrum objectives are

a) updating the soil salinity map and total saline area in coastal areas of Bangladesh.

b) identification of agricultural constraints and present land use patterns in coastal areas.

3.0 Methodology

A special field survey was carried out in the south-western part of the coastal arable land excluding Sunderbans by several soil survey team of SRDI in May, 2009. During field survey Soil association maps (1:125,000) of reconnaissance soil survey reports, Upazila Land and Soil Resource Utilization Guides (Upazila Nirdeshika), topo-map (1:50,000), aerial photographs (1:30,000/1:50,000), Upazila Soil and land form maps (1:50,000), published Soil salinity map (2000) with pre-selected traverse lines were used as base materials. Selected traverse lines were changed or modified according to necessity during field survey. The traverse lines a parted 3-4 kilometers from each other. Along the traverse lines a total of 2500 soil samples were collected. During field survey soil samples were collected from both outside and inside the polder. Traverse routes followed the catena, from the bank of the river to the centre of the polders using river transports. From each catena 6 soil samples (topsoil, subsoil and substratum) from ridges and basins were collected by auger. Surface salt crust was also collected separately. Number of spots varied according to complexity of the soil were shown on Soil Salinity map 2009. Horizon wise soil samples were also collected from 20 representative soil pedons and 91 micropedons from 18 districts (Cox's Bazar, Chittagong, Noakhali, Feni, Laxmipur, Bhola, Barisal, Jhalakathi, Pirojpur, Patuakhali, Borguna, Bagerhat, Khulna, Satkhira, Jessore, Narail, Gopalganj, Madaripur).

Profile descriptions were done according to Soil Survey Manual. Detailed land use data were recorded. Electrical conductivity and pH of the soil samples were determined from 1:5 and 1:2.5 soil-water extract, respectively. N was determined by Kjeldhal method, P by revised Olsen, Bray & Cartz method, organic carbon by dry combustion method, S and B by calcium biphosphate extraction method, Cu, Mn, Fe and Zn by DTPA extraction method. $CaCO_3$ were determined by rapid titration method. Soluble salts of 74 profile samples were analyzed. Cl^- was determined by 0.01N $AgNO_3$ titration method, $SO_4^=$ by turbidimetric method, $CO_3^=$ and HCO_3^- by 0.01N H_2SO_4 titration method. CEC was determined by $BaCl_2$ method. On the basis of the soil survey information, a Soil Salinity map (1:2.8) million) is prepared delineating 5 mapping units. Soil salinity boundary of 1973 and 2000 is shown on present Salinity map, 2009 (1:2.8 million). Coastal boundary is also shown on salinity map. Using the salinity map, present extent of saline soils was calculated cartographically.

4.0 Description of the area

The study area lies between 20º25´ and 23 º20´ N latitude and between 88 º25´ and 92 º24´ E longitude. The area is bounded by Kushtia, Chuadanga, Faridpur, Sariatpur, Chandpur and Comilla district on the north, Rangamati, Bandarban districts and Naf River on the east, Bay of Bengal and the Sundarbans on the south and India on the west. Within the study area, 93 Upazilas under 18 districts are found affected by different degrees of salinity. The total rainfall ranges from 1682 mm to 3627 mm, mostly received during the later part of the summer, increasing from the north-west to the south-east.

CHAPTER-II

5. 0 Land characteristics

The areas are subjected to flooding in the monsoon season and water logging in parts of basin areas in most parts of the dry season. Tidal flooding through a network of tidal creeks and drainage channels connected to the main river system inundates the soil and impregnates them with soluble salts thereby rendering the topsoil and subsoil salinity. After the construction of polders, the daily inflow of tidal water reduced and consequently the active sedimentation and erosion process has almost ceased except in brackish water shrimp cultivation area. Within the polders, sedimentation and inundation process are still active with saline water in brackish water shrimp cultivation area. At present, northern part of the area within the polder is flooded mainly with rain water. The most significant feature of hydrology in relation to agricultural development is the seasonal shallow flooding. Highland, medium highland, medium lowland, lowland and very lowland occupies about 5%, 50%, 10%, 4% and 1% land respectively, in coastal areas (Table 1). In these areas, flood water recedes from about 20% area within October, from 30% area in November to mid December and from 20% area in late December or in early January.

Table 1: Land types and water receding time from cultivated area in coastal zone

District	Land types					Flood water receding time from cultivated land			Soils having >40-80% clay content (%)
	Highland	Medium highland	Medium lowland	Lowland	Very lowland	Within Oct.	Nov. – mid. Dec.	Late Dec.	
	Area in percent								
Satkhira	17	62	3	0	0	27	34	21	49
Khulna	4	62	9	2	0	11	31	35	52
Bagerhat	5	61	7	2	0	15	31	29	35
Pirojpur	4	56	6	3	0	13	21	36	29
Jhalakathi	5	54	17	0	0	11	55	10	28
Barisal	3	56	9	3	0	19	26	22	16
Bhola	2	43	2	0	0	24	20	4	0
Patuakhali	1	57	4	0	0	15	41	7	19
Borguna	2	61	3	0	0	19	31	15	32
Narail	14	31	23	11	0	37	10	32	48
Jessore	31	33	11	3	0	55	9	13	47
Madaripur	3	32	30	11	2	47	20	10	14
Gopalganj	3	10	32	27	13	13	30	42	27
Laxmipur	3	62	7	0	0	12	58	2	01
Noakhali	1	51	11	1	0	24	27	13	Minor
Feni	3*	72	0	0	0	10	64	11	05
Chittagong	8*	31	3	0	0	22	17	3	10
Cox's Bazar	10*	31	1	2	0	36	8	Minor	06
Average	5	50	10	4	1	20	30	20	-

* Except hill area

5.1 Soil salinity

All soils contain some water soluble salts. Plants absorb essential plant nutrients in the form of soluble salts, but excessive accumulation of soluble salts, called soil salinity, suppresses plant growth. Saline or salt affected soils are common in coastal area in tropical regions, arid and semi-arid regions. Salts in the soils occur as ions. Ions are released from weathering minerals in the soil. Soil may be saturated with soluble salts due to sea water flooding. They may also be applied in irrigation water or as fertilizers, or migrate upward in the soil from shallow ground water. When precipitation is insufficient (December-June) to leach ions from the soil profile, salts accumulate in the soil and soil salinity can result in Bangladesh.

Poor drainage and/or poor irrigation water often contribute to soil salinity. As plants absorb soil water or as water evaporates, salts from the water remain in the soil. For this reason, soil salinity will usually be greater than the salinity of the irrigation water used. Improper irrigation management increases the risk of developing soil salinity. To prevent salt buildup, enough water must be passed through the root zone to leach salts from the soil. Keep in mind that some of these salts are also essential plant nutrients.

5.1.1. Diagnostic criteria

Soil reaction (pH), electrical conductance of saturated extract (ECe), exchangeable sodium percentage (ESP) and sodium adsorption ratio (SAR) have been used as parameters for assessing the nature and severity of salinity problem in coastal areas.

5.1.2 Present soil salinity status in coastal areas

It is anticipated that withdrawal of fresh river water from upstream, irregular rainfall, introduction of brackish water for shrimp cultivation, faulty management of the sluice gates and polders, regular saline tidal water flooding in unprotected area, capillary rise of soluble salts etc. are the main causes of increased soil salinity in the top soils of the coastal region.

The present spatial distribution of saline soils was assessed in 2009 through ground survey following reconnaissance soil survey technique using different base materials such as aerial photographs, toposheet, Upazila Soil and Land form map, previous published Soil salinity map etc. Distribution of soils with different degrees of salinity is shown on Soil Salinity map, 2009. Out of about 1.689 million hectares of coastal land 1.056 million hectares are affected by soil salinity of various degrees. About 0.328, 0.274, 0.189, 0.161 and 0.101 million hectares of land are affected by very slight (S_1), slight (S_2), moderate (S_3), strong (S_4) and very strong salinity (S_5) respectively. Some of the new land of Satkhira, Patuakhali, Borguna, Barisal, Jhalakathi, Pirojpur, Jessore, Narail, Gopalganj and Madaripur districts are affected by different degrees of salinity, which reduces agricultural productivity remarkably. A comparative study of soil salinity during last four decades (1973-2009) in coastal areas is shown in table 2. About 50% of the coastal lands face different degrees of inundation, thus limiting their effective use. This situation is expected to become worse further because of the effects of climate change (Islam, 2006). Cropping intensity may be increased in very and slightly saline areas by adopting proper soil and water management practices with the introduction of different salt tolerant varieties of crops.

Table 2: Extent of soil salinity during the last four decades (1973-2009) in coastal areas.

Salt affected area (000'ha)			Salinity class and area (000'ha)											
			S1 2.0-4.0 dS/m			**S2** 4.1-8.0 dS/m			**S3** 8.1-16.0 dS/m			**S4** >16.0 dS/m		
1973	2000	2009	1973	2000	2009	1973	2000	2009	1973	2000	2009	1973	2000	2009
833.45	1020.75	1056.26	287.37	289.76	328.43	426.43	307.20	274.22	79.75	336.58	351.69	39.90	87.14	101.92

* S_3 = 8.1-12.0 dS/m, S_4 = 12.1-16.0 dS/m.

A comparative study of the salt affected area between 1973 to 2009 showed that about 0.223 million ha (26.7%) new land is effected by various degrees of salinity during about the last four decades (Table-3). It was also found that about 35,440 hectares of new land is affected by various degrees of salinity during last 9 years only (2000-2009). Upazila wise soil salinity class and district wise mapping unit of Soil salinity map, 2009 are given in appendix 1 and 2.

Table 3: A comparative study of the salt affected area between 1973 to 2009 in coastal areas.

Salt affected area (000'ha)			Salt affected area increased during last 9 years (000'ha) (2000-2009)	Salt affected area increased during last 36 years (000'ha) (1973-2009)
1973	2000	2009		
833.45	1020.75	1056.26	35.51 (3.5%)	222.81 (26.7%)

5.1.3 Salt characteristics

Highest salt accumulation is observed in Ganges tidal floodplain. In this physiographic unit maximum electrical conductivity is recorded as 49.5 ds/m. In top soil it varies from 0.3 to 70.0 dS/m. The amount of accumulated salt is found higher at the surface horizon. It decreases with depth and then increases again in all the pedons. The highest total soluble salts (3122 mg/L) are found under brackish water shrimp cultivation. Among the four physiographic units, the amount of accumulated salts preponderance decrease in the order Ganges tidal floodplain > Lower Meghna estuarine floodplain > Ganges river meander floodplain > Peat basin. Electrical conductivity (EC_e) of almost all the soils decreases with depth and then increases again due to influence of saline ground water. The higher ECe value at the surface horizon followed by lower value with depth is due to flooding with saline water or accumulation of salts through upward capillary movement of saline ground water. In shrimp cultivated areas, flooding with high saline water for a considerable time in each year causing higher soil salinity in all the horizons.

It is observed that Na^+, Ca^{2+}, Mg^{2+} and K^+ ions are the dominant cations in different saline areas. On the other hand $SO_4^=$ and Cl^- ions are the dominant anions. In most of the saline soils the ionic preponderance decreased in the order of $Na^+ > Ca^{2+} > Mg^{2+} > K^+$. But in the soils under prolonged brackish water shrimp cultivated areas, ionic preponderance decreased in the order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$.

In most of the pedons and mini pits the ionic preponderance decreased in the order of $SO_4^= > Cl^- > HCO_3^-$ and in some pedons and mini pits the ionic preponderance decreased in the order of $Cl^- > SO_4^=$

> HCO_3^- . Soluble $CO_3^=$ is found nil or trace in all the pedons. Sodium chloride salts were found more toxic than sodium sulphate in most of the cases.

As salt concentration increases, water becomes increasingly difficult for the plant to absorb. A plant can actually die from water stress or drought in a moist soil if the salt concentration becomes high enough. Other effects of salts on plants are toxicities of specific salts and nutritional imbalances. Some elements, such as sodium, chlorine, and boron have specific toxic effects on plants. Plants sensitive to these elements may be affected at relatively low salt levels in the soil can upset the nutrient balance in the plant or interfere with the uptake of some nutrients.

6.0 Water quality

6.1 Criteria for evaluating water quality

The amount and kind of salts determine the evaluation of water for irrigation. With poor water quality, various soil and water problems may arise. Special management practices may then be necessary to maintains sustainable crop productivity. Salt concentration of water having EC of 12 dS/m can be used for growing salt tolerant and semi-tolerant crops in coarse textured soils, provided the annual rainfall is not less than 400 mm. But in fine textured soils, water with EC of more than 2 dS/m often creates salinity problems.

The important parameters that determine water quality are :

i) *Total salt concentration:* It is measured by the electrical conductivity (EC) of water, expressed as dS/m or mmhos/cm. The major cations in water include sodium, magnesium and calcium and the anions include of chloride, sulphate and bicarbonate. Other ions that may be present, but usually in low concentration are carbonate, nitrate, slica or boron.

ii) *Sodium hazard:* The sodium hazard is denoted by the residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) of the water which are defined by the relation-

RSC= (carbonate+bicarbonate)-(calcium+magnesium)
SAR= (sodium)/(calcium+magnesium)/2)$^{1/2}$
Where all the concentrations are me/l.

Water quality ratings

Water quality rating	ECw dS/m	SAR (m mole/l)$^{1/2}$	RSC (me/L)
Good quality water	<2.0	<10	nil
Marginal quality water	2.0-4.0	<10	<2.5
Poor quality water	>4.0	<10	nil

Source: Irrigation and crop management with brackish water, CSSRI Bull.no.12, 1989.

6.2 Water salinity

District wise water salinity (ECw), pH, B, Ca and Mg data of different water sources such as river, canal, pond, gher, sea, Hand tubewell, STW, DTW etc. are presented in appendix-4.

Surface water

The surface water mainly comprise i) river and canal water, and ii) water in shrimp cultivation field or locally called 'Gher'. In general almost all the river/canal water in south-western part are extremely saline in dry season and not suitable for irrigation.

River water

From south-west and southern part of the coastal saline area 80 water samples are collected from 11 districts The EC range is also very wide varying from 0.16 to 36.0 dS/m. Highest EC value was observed in Maheskhali canal in Maheskhali Upazila of Chittagong district and lowest EC value is observed in Tetulia river in Bhola Sadar Upasila of Bhola district. About 35% river water possess EC<2.0 ds/m, 6% river water possess 2.0-5.0 ds/m and 59% river water possess >5.0 ds/m in dry season.

Except Telutia, Meghna, Kakdon, Subidkhali, Lebukhali, Laukathi, Kukua, Gopaldi, Kajal, Tajumuddin canal under Noakhali, Bhola, Patuakhali, Barisal, Jhalakathi districts almost all the rivers remain highly saline in dry season. In Jessore district almost all the rivers remain saline. Almost all the rivers in Jhenaidaha, Magura, Barisal and Jhalakathi are found non-saline. In Pirojpur district Patharghata canal and Baleswar River near Nazirpur upazila are found highly saline. Tikikata River in Mathbaria is found marginally saline. In Patuakhali district Tetulia, Patuakhali and Pandob riers are found marginally saline and these may be considered as marginally suitable for irrigation. Most of the rivers and canals in northern part of Patuakhali and Borguna districts may be considered as suitable or marginally suitable for irrigation. All the rivers in northern part of Bhola district may be considered as suitable or marginally suitable. Most of the canals within the polder are found marginally suitable for irrigation. All the rivers and canals in southern part of Bhola district is found highly saline.

Gher water (water within shrimp cultivation)

From south-west part of the coastal saline area 8 water samples were collected under 4 districts. The EC ranges varies from 10.0 to 35.0 dS/m. Highest EC value is observed in Koyra upazila under Khulna district and lowest EC value is observed in Dumuria upazila of Khulna district. All the gher water possesses EC > 10.0 dS/m.

Ground water (Shallow tube well)

35 water samples were collected from 6 districts in south-west part of the coastal saline and non-saline area. The EC ranges is also very wide varying from 0.39 to 19.8 dS/m. Highest EC value is observed in S hyamnagar upazila of Satkhira district. This water is used for brackish water shrimp cultivation. About 83% tube well water possesses EC <2.0 dS/m and rest 17% tube well water possess > 2.0 dS/m.

Ground water (Deep tube well)

23 water samples were collected from 5 districts in south-west part of the coastal saline and non saline area. The EC range is also very wide varying from 0.55 to 7.8 dS/m. Highest EC value is observed in Paikgachha upazila of Khulna district. About 50 % tube well water possesses EC < 2.0 dS/m and rest 50% tube well possess > 2.0 dS/m.

7.0 Present cropping pattern

Present cropping pattern is mainly determined by the depth, duration and recession time of seasonal flood water, dry season salinity of soil and availability of fresh irrigation water in the dry season. During field survey 60 different cropping patterns have been identified in these areas. It is evident that a considerable change in land use during this period has been occurred. During field survey 9 modern transplanted aman and 7 modern boro varieties were identified in the farmer's field. Presently, cropping intensity has increased. Early winter vegetables are intensively cultivated through relay cropping with Transplanted aus along with the cultivation of hybrid cowpeas, hybrid tomato, hybrid khirai, hybrid chilli, hybrid raddish, hybrid watermelon in south east and southern part, particularly in Cox's Bazar sadar, Chakaria, Maheshkhali, Kalapara upazilas. Among several production problems, soil salinity in the major constraints. The problem is particularly acute in that area where soil salinity is relatively high. Moreover, most of the vegetable crops are said to be very sensitive to saline condition and their yield decreased from 6-19% with each unit increase in salinity. Due to high soil and water salinity cropping intensity reduced considerably. Farmer's ignorance and less initiativeness are also partly responsible for less cropping intensity in this region. Mapping unit wise major present cropping pattern with area is shown in Table 4. The main reason of changing crops/cropping patterns are-

- Climatic variability.
- Increased salinity and tidal surges.
- Increasing demand of early winter vegetables in the market.
- Increased demand of cash/high value crop.
- Changed/increased demand of food grains.
- Intrusion of saline water/pushing saline water in a confined areas (Gher areas) for brackish water shrimp cultivation.
- Introduction of salt tolerant rice varieties.

Table 4: District wise major cropping patterns under different soil salinity mapping units.

Districts	Mapping units	Cropping patterns	Percent
Patuakhali	1	➢ Chilli/Mung/Til- fallow/broadcast aus (local)-transplanted aman (LIV/BR11/BR22/BR23)	40
		➢ Fallow-broadcasted/transplanted aus (LIV/Brridhan 27/ BR14 /Mala)-transplanted aman (LIV/BR11/ BR22/ BR23)	30
		➢ Ground nut/Sweet potato/Grasspea/Sunflower/Watermelon-Fallow -transplanted aman (LIV/BR11/ BR22/ BR23)	10
		➢ Fallow-fallow-transplanted aman (LIV/BR11/BR22/BR23)	5
		➢ Chickpea/Mustard/Felon- broadcast/transplanted aus (LIV/ Brridhan 27/ BR14/ mala) – transplanted aman (LIV/BR11/ BR22/ BR23)	5
		➢ Rabi vegetables-Kharif vegetables	5
		➢ Boro (Brridhan-29)-fallow-fallow	5

Districts	Mapping units	Cropping patterns	Percent
Patuakhali	2	➢ Fallow/sesame-broadcast /transplanted aus (LIV/Brridhan27/ BR14 /Mala)-)-transplanted aman (LIV/BR11/BR22/BR23) ➢ Chickpea/Mustard/Felon/watermelon- broadcast aus (LIV/ Brridhan 27/ BR14/ mala) – transplanted aman (LIV/BR11/ BR22/ BR23) ➢ Fallow-fallow-transplanted aman (LIV/BR11/BR22/BR23) ➢ Lentil/sweet potato-Sesame -transplanted aman (LIV/BR11/ BR22/ BR23) ➢ Boro (Brridhan-29)-fallow-transplanted aman (LIV/BR11/ BR22/ BR23)	45 30 10 10 5
	3	➢ Fallow-transplanted aus (local)-transplanted aman (LIV/BR11/ BR22/ BR23) ➢ Fallow-fallow-transplanted aman (LIV/BR11/BR22/BR23) ➢ Mung/felon/grasspea-broadcast aus/fallow-transplanted aman (LIV/ BR11/BR22/BR23/Brridhan-47) ➢ Sesame-fallow-transplanted aman (LIV/BR11 /BR22/ BR23) ➢ Watermelon/sunflower/groundnut-fallow-transplanted aman (LIV/ BR11/ BR22/ BR23/Brridhan-47) ➢ Maize-fallow-transplanted aman (LIV/BR11/ BR22/ BR23/Birridhan-47)	40 20 15 10 10 5
	4	➢ Fallow-fallow-transplanted aman (LIV/BR11/BR22/BR23) ➢ Watermelon/mung-broadcast aus (local)-transplanted aman (LIV/ BR11/ BR22/ BR23) ➢ Mung/felon/groundnut-fallow-transplanted aman (LIV/ BR11/ BR22/ BR23/Birridhan-47) ➢ Shrimp -fallow ➢ Planted mangrove vegetation ➢ Fallow-fallow	50 25 10 5 5 5
	5	➢ Fallow-fallow-transplanted aman (LIV/BR11/BR22/BR23) ➢ Mung/felon/watermelon/grasspea/groundnut-fallow-transplanted aman (LIV/ BR11/ BR22/ BR23) ➢ Fallow/watermelon-broadcast aus-transplanted aman (LIV/ BR11/ BR22/ BR23) ➢ Shrimp -fallow ➢ Planted mangrove vegetation ➢ Fallow-fallow	60 15 5 5 5 10
Noakhali	1	➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-fallow ➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables	55 30 10 5

Districts	Mapping units	Cropping patterns	Percent
Noakhali	2	➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Khesari/mung/soyabean/felon/watermelon-fallow-transplanted aman (LIV/MV) ➢ Khesari/chilli/felon/soyabean-dibbling aus/broadcast aus-transplanted aman (LIV/MV) ➢ Fallow-dibbling aus/broadcast aus-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables	50 20 10 10 5 5
	3	➢ Groundnut/khesari/mung/soyabean/felon/watermelon-fallow-transplanted aman (LIV/MV) ➢ Fallow-dibbling aus/broadcast aus-transplanted aman (LIV/MV) ➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Khesari/chilli/felon/soyabean-dibbling aus/broadcast aus-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables ➢ Sugarcane and others	30 20 20 10 10 5 5
	4	➢ Khesari/mung/soyabean/felon/watermelon-fallow-transplanted aman (LIV/MV) ➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables	20 65 10 5
	5	➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Khesari/methi-fallow-transplanted aman (LIV/MV) ➢ Mangrove forest ➢ Fallow-fallow	70 10 10 10
Barisal	1	➢ Fallow- transplanted aus (LIV/MV) -transplanted aman (LIV/MV) ➢ Khesari/mung/chilli/sweet potato) -fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Khesari/mung- mixed broadcast aus & aman ➢ Khesari-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Khesari/cowpea-broadcast aus-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables ➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Boro-fallow-fallow	30 20 20 5 5 5 5 5 5

Districts	Mapping units	Cropping patterns	Percent
Barisal	2	➢ Fallow- transplanted aus (LIV/MV) -transplanted aman (LIV/MV) ➢ Fallow-fallow-transplanted aman (LIV/MV) ➢ Khesari/mung/chilli -fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Khesari/mung-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables	35 30 20 5 5 5
	3	➢ Fallow- fallow -transplanted aman (LIV/MV) ➢ Fallow-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Khesari/mung/chilli/cowpea/groundnut -fallow-transplanted aman (LIV/MV) ➢ Boro (LIV/MV)-fallow-transplanted aman (LIV/MV) ➢ Khesari/mung-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Rabi vegetables-kharif vegetables	40 25 15 10 5 5
	4	➢ Fallow- fallow -transplanted aman (LIV/MV) ➢ Fallow-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Khesari/mung/chilli/cowpea/groundnut -fallow-transplanted aman (LIV/MV) ➢ Khesari/mung-transplanted aus (LIV/MV)-transplanted aman (LIV/MV)	50 30 15 5
	5	➢ Fallow- fallow -transplanted aman (LIV/MV) ➢ Fallow-transplanted aus (LIV/MV)-transplanted aman (LIV/MV) ➢ Khesari -fallow-transplanted aman (LIV/MV) ➢ Khesari-transplanted aus (LIV/MV)-transplanted aman (LIV/MV)	50 30 15 5
Chittagong	1	➢ Boro (Burming/Binni/Birridhan-29)-fallow-transplanted aman (Lembu/Shaheb/Chikon/Birridhan-28,40,41,47) ➢ Fallow- transplanted aus (LIV/MV) -transplanted aman (Lembu/Shaheb/Chikon/Brridhan-28,40,41,47) ➢ Khesari/mung/chilli -fallow-transplanted aman (Lembu/ Shaheb/Chikon/Brridhan-28,40,41,47) ➢ Fallow-fallow-transplanted aman (Lembu/Shaheb/ Chikon/ Brridhan-28,40,41,47)	40 10 30 20

Districts	Mapping units	Cropping patterns	Percent
Chittagong	2	➢ Boro (Burming/Binni/Birridhan-29)-fallow-transplanted aman (Lembu/Shaheb/Chikon/Brridhan-28,40,41,47) ➢ Fallow- transplanted aus (LIV/MV) -transplanted aman (Lembu/Shaheb/Chikon/Brridhan-28,40,41,47) ➢ Khesari/mung/chilli -fallow-transplanted aman (Lembu/ Shaheb/Chikon/Brridhan-28,40,41) ➢ Fallow-fallow-transplanted aman (Lembu/Shaheb/ Chikon/ Brridhan-28,40,41,47)	25 10 35 30
	3	➢ Khesari/mung/chilli /felon-fallow-transplanted aman(Lembu/ Shaheb/Chikon/Brridhan-28,40,41,47) ➢ Fallow- transplanted aus (LIV/MV) -transplanted aman (Lembu/Shaheb/Chikon/Brridhan-28,40,41) ➢ Saltbed-fallow ➢ Shrimp-transplanted aman ➢ Shrimp –fallow-fallow ➢ Fallow-fallow-transplanted aman (Lembu/Shaheb/ Chikon/ Brridhan-28,40,41) ➢ Planted and natural mangrove vegetation	30 15 15 15 5 10 10
	4	➢ Saltbed-fallow ➢ Saltbed-Shrimp/transplanted aman ➢ Shrimp –fallow-fallow ➢ Shrimp-transplanted aman(Lembu/Shaheb/ Chikon/ Brridhan-28,40,41) ➢ Fallow-fallow-transplanted aman (Lembu/Shaheb/ Chikon/ Brridhan-28,40,41) ➢ Planted and natural mangrove vegetation	30 20 10 10 20 10
	5	➢ Saltbed-fallow ➢ Saltbed-Shrimp ➢ Shrimp –fallow-fallow ➢ Fallow-fallow-transplanted aman (Lembu/Shaheb/ Chikon/ Brridhan-28,40,41) ➢ Planted and natural mangrove vegetation	45 30 10 5 15
Khulna	1	➢ Boro (Brridhan-28,29,47,Hybrid [Hira],Ratna,GS, Miniket)-fallow-transplanted aman (BR-10,11,23,Brridhan-27,30, 39, 41, 47, Shawarna,Ranjit, Ranisalut, Dudkumar, Sadamota, Kachra, Bashful, Benapol, Dudkumar) ➢ Rabi crops (Mustard/Lentil/wheat/mungbean, sesame) –jute (O-9897 and Bangkim)/aus-transplanted aman ➢ Boro-Fallow ➢ Boro-shrimp ➢ Rabi vegetables-jute-transplanted aman	60 20 5 5 10

Districts	Mapping units	Cropping patterns	Percent
Khulna	2	➢ Boro (Brridhan-28,29,47,Hybrid [Hira],Ratna,GS, Minikit)-fallow-transplanted aman (BR-10,11,23,Brridhan-27,30, 39,41, 47,Shawarna,Ranjit, Ranisalut, Dudkumar, Sadamota, Kachra, Bashful, Benapol, Dudkumar)	50
		➢ Rabi crops (Mustard/Lentil/wheat/mungbean, sesame) –jute (O-9897 and Bangkim)/aus-transplanted aman	15
		➢ Boro-shrimp	15
		➢ Boro-UBA	5
		➢ Shrimp-transplanted aman	5
		➢ Rabi vegetables-jute-transplanted aman	10
	3	➢ Boro (Brridhan-28,29,47,Hybrid [Hira], Ratna,GS, Miniket)-fallow-transplanted aman (Br-10,11,23, Brridhan-27,30, 39,41, 47, Shawarna,Ranjit, Ranisalut, Dudkumar, Sadamota, Kachra, Bashful, Benapol, Dudkumar)	20
		➢ Shrimp-transplanted aman	10
		➢ Fallow-fallow-transplanted man	40
		➢ Boro-shrimp	10
		➢ Fallow-Sesame –transplanted aman	10
	4	➢ Boro (Brridhan-28,29,47,Hybrid [Hira],Ratna,GS, Miniket)-fallow-transplanted aman (BR-10,11,23,Brridhan-27,30, 39, 41, 47,Shawarna,Ranjit, Ranisalut, Dudkumar, Sadamota, Kachra, Bashful, Benapol)	5
		➢ Shrimp-transplanted aman	20
		➢ Fallow-fallow-transplanted man	35
		➢ Boro-shrimp	15
		➢ Shrimp-fallow	25
	5	➢ Boro (Brridhan-28,29,47,Hybrid [Hira],Ratna,GS, Miniket)-fallow-transplanted aman (BR-10,11,23,Brridhan-27,30, 39,41, 47, Shawarna,Ranjit, Ranisalut, Dudkumar, Sadamota, Kachra, Bashful, Benapol, Dudkumar)	5
		➢ Shrimp-transplanted aman	15
		➢ Fallow-fallow-transplanted man	40
		➢ Boro-shrimp	10
		➢ Shrimp-fallow	30
Jessore	1	➢ Boro (MV/Hybrid)-transplanted aman(MV)	75
		➢ Rabi crops(Mustard/Lentil/wheat/mungbean/ sesame) –jute / aus-transplanted aman	10
		➢ Boro-jute/aus-transplanted aman	5
		➢ Rabi vegetables-kharif vegetables	5
		➢ Banana,Sugarcane, Nursery	5

Districts	Mapping units	Cropping patterns	Percent
Jessore	2	➢ Boro (MV/Hybrid)-transplanted aman (MV)	65
		➢ Rabi crops (Mustard/Lentil/wheat/mungbean, sesame) –jute/ aus-transplanted aman	15
		➢ Boro-jute/aus-transplanted aman	5
		➢ Rabi vegetables-kharif vegetables	5
		➢ Boro-Deep water transplanted aman	5
		➢ Banana, Sugarcane, Nursery	5
	3	➢ Boro (MV/Hybrid)-transplanted aman (MV)	40
		➢ Fallow-fallow-transplanted aman	20
		➢ Rabi crops (Mustard/Lentil/wheat/mungbean,sesame) –jute/ aus-transplanted aman	10
		➢ Boro-jute/aus- transplanted aman	15
		➢ Rabi vegetables-kharif vegetables	5
		➢ Boro-Deep water transplanted aman	5
		➢ Boro-shrimp	5

8.0 Plant responses

Symptoms of salt injury in plants resemble drought. Both conditions are characterized by water stress (wilting) and reduced growth. Severe injury caused by prolonged exposure or high salinity results in stunted plants and tissue death. Reduced growth caused by salinity is a progressive condition that increases as salinity increases above a plant's tolerance threshold.

Plants vary in their response to soil salinity. Salt tolerant plants are better able to adjust internally to the osmotic effects of high salt concentrations than salt-sensitive plants. Salt- tolerant plants are more able to absorb water from saline soils. Salt-sensitive plants have a limited ability to adjust and are injured at relatively low salt concentrations. Many horticultural and landscape (field) plants are classified as sensitive or moderately sensitive to soil salinity. Relative salt-tolerance classifications of some of these plants are given in Table 5. The plants listed are offered as representative of a salt tolerance group. The plants listed can be used to determine the salt tolerance of closely related plants or plants adapted to similar sites. The tolerance rating in Table 5 are to be interpreted only as a guide in making comparisons among plants and supply generally from late seedling stage to maturity.
Specific plant tolerances are affected by climate (rainfall and temperature), soil conditions, cultural practices, and variety selection. During cool and wet weather when plant transpiration demands are low and leaching is much higher than capillary upward movement, salt injury will be less than during hot, dry weather. There is a wide variation in salt tolerance among varieties or root stocks of some species.

Table 5: Relative salt tolerance of horticultural and landscape plants*

Woody fruits and trees`		Ornamentals, grasses and groundcovers		Herbaceous fruits, vegetables, field crops, and flowers	
Highly sensitive ECe: <1.3 dS/m	**Moderately sensitive** EC: < 3.0 dS/m	**Highly sensitive** ECe: <1.3 dS/m	**Moderately sensitive** EC: < 3.0 dS/m	**Highly sensitive** ECe: <1.3 dS/m	**Moderately sensitive** EC: < 3.0 dS/m
Apple	Aspen	American linden	Clematis	Beans	Aster
Cherry & Prunus spp.	Black locust	Cotoneaster	Common snowball	Carrot	Broccoli
Chokecherry	Cottonwood	Mock orange	English Ivy	Onion	Cabbage
Currant	Grape	Oregon grape	Honeysuckle	Parsnip	Cauliflower
Gooseberry	Fir	Rose	Lilac	Strawberry	Celery
Pear	Green ash		Orchardgrass	Lentil	Corn (Maize)
Plum	Honey locust		Privet	Mash kalai	Cucumber
Raspberry	Poplar		Service berry	Chickpea	Flowers,general
Lemon	Siberian elm		Yellow sage	Beans	Gladiolus
Orange	Spruce			Groundnut	Kale
Peach	Willow			Berseem	Lettuce
	Maples				Pea
					Pepper
					Potato
					Pumpkin
					Radish
					Spinach
					Squash,scallop
					Cowpea
					Broadbean
					Vetch
					Bajra
					Grasspea
					Gourds
					Sweet potato
					Sorghum
					Millets
					Clover, berseem
					Tomato
					Turnip
					Watermelon

Moderately Tolerant ECe: <6.0 dS/m	**Tolerant** ECe:<10.0dS/m	**Moderately Tolerant** ECe: <6.0 dS/m	**Tolerant** ECe:<10.0dS/m	**Moderately Tolerant** ECe: <6.0 dS/m	**Tolerant** ECe:<10.0dS/m
Autumn Olive	Tamarix	Blue Grama	Alkali grass	Spinach	Barley
Evergreen,general	Date palm	Karnal grass	Creeping bentgrass	Sugarcane	-
Juniper	Tamaria	Buffalo grass	Iceplant	Raya	Cotton
Russian olive	Salvadora	Caragana		Rice (direct	Sugar beet
Hackberry		Oleander		sowing)	Turnip
Pine		Crested wheatgrass		Rice (Trans. BR-23,	Tobacco
Guava		Perennial ryegrass		Brridhan-47)	Safflower
Pomegranate		Tall fescue		Mustard	Ber
Desi babul (Accasia)		Fine fescue		Safflower, Soyabean	Mesquite
Casuarina		Potentilla		Wheat	
Grape		Wing euonymous		Pearl millet	
		Blue panic grass		Sesame	
		Para grass		Oats	
		Rhode grass		Alfalfa	
		Sudan grass			

Source: Technical Bulletin-1, Hisar Agricultural University, 1992, Blaylock A.D., 1994 and SRDI

*This list is only an indication of the salt tolerances of major plant groups. These "indicator' plants can be used in determining the salt tolerances of closely related plats or plants adapted to similar sites

9.0 Effect of salinity on growth, development and yield on vegetables

The general effect of soil salinity on plants is called an osmotic effect. This means that salts increase the energy with which water is held in the soil. In other words, the soil must be kept wetter to supply the same amount of plant-available water as would be present within the salts. Plants then must increase the energy they expand to obtain water from the soil. The must use energy to get water that would otherwise be used for growth, flowering, or fruiting. When the soil salinity exceeds a plant's tolerance, growth reductions occur. Salinity tolerance of a crop not only varies among crops/varieties but depends upon environment and cultural practices also. Therefore, to have more realistic assessment of salinity tolerance of a given crop, the value of soil salinity at which initial yield decline begins and percentage yield decline with per unit increase in salinity in given in Table 6 for different vegetable crops only.

Table 6: Soil salinity (dS/m) at which initial yield decline begins and percent yield increase in salinity.

Name of the crop	Soil salinity at which initial yield decline begins	Percent yield decline with per unit increase in salinity
Bean	1.0	19.0
Broad bean	1.6	9.6
Broccoli	2.8	9.2
Cabbage	1.8	6.2
Carrot	1.0	14.0
Celery	1.8	6.2
Cucumber	2.5	13.0
Lettuce	1.3	13.0
Onion	1.2	16.0
Pepper	1.5	14.0
Potato	1.7	12.0
Radish	1.2	13.0
Spinach	2.0	7.6
Sweet corn	1.7	12.0
Squash	3.2	16.0
Tomato	2.5	9.9
Turnip	0.9	9.0

Source: Technical Bulletin-1, Hisar Agricultural University.

9.1 Induction to salt tolerance

Several methods like prolonged cultivation in increasingly saline soils, presowing soaking treatment in salt, growth substance, micronutrients and other chemicals, spraying with various regulator solutions, dipping the intact flowering or fruiting branches in salt solution and grafting on salt tolerant root stocks have been used to induce salt tolerance in different crops (Technical Bulletin-1). Very little efforts have been made on different crops including vegetables in this connection in Bangladesh. Some successful efforts have been made in case of onion, tomato, okra, cauliflower and potato crops in different countries and the results are summarized in Table 7.

Table 7: Salt tolerance induction in some vegetable crops.

Name of the crop	Name of the chemical/growth substance	Concentration	Method of treatment	Time for treatment (Hours)
Cauliflower	Cycocel	250ppm	Root dipping for transplants	2.0
Okra	Cycocel	500ppm	Seed soaking	6.0
Onion	Cycocel	1.0%	Root dipping for transplants	8.0
Potato	Sodium salt solution or Cycocel	6.0 dS/m EC or 250ppm	Tuber soaking	2.0
Tomato	Sodium salt solution	8.0 dS/m EC	Root dipping for transplants	2.0

Source: Technical Bulletin-1, Hisar Agricultural University.

10.0 Major agricultural constraints

Higher cropping intensity is observed in mapping unit 1 to 3 and in mapping unit 4 and 5 it is considerably less due to higher soil and water salinity in dry season. Several agricultural constraints are identified in coastal saline area. The dominant soil, land and water related constraints are mentioned below.

- Strong to very strong soil salinity.
- No scope of ground water and river water upliftment for irrigation.
- Severe scarcity of quality irrigation water during dry season.
- Late draining condition in early dry season in considerable areas.
- Prolonged artificial water logging with saline water for aquaculture.
- Cyclone and tidal bore.
- Heavy soil consistency.
- Presence of toxic potential acid sulphate soil in some areas.
- Relatively high flooding depth during monsoon season for HYV transplanted aman crop.
- Presence of peat soils having low bearing capacity and very late draining condition.

Mapping unit wise major constraints on agricultural productivity is presented below in Table 8.

Table 8: Mapping unit wise major constraints on agricultural productivity.

Mapping unit no	Major agricultural constraints on agricultural productivity
1 Non saline with some very slightly saline	• Very slight to slight soil salinity. • Perennial water logging due to inadequate drainage facilities.
2 Very slightly saline with some slightly saline	• Very slight to moderate soil salinity. • Scarcity of quality irrigation water during dry season. • Moderately deep flooding in monsoon season and flush flood. • Existence of peat soil with low bearing capacity. • Perennial water logging due to inadequate drainage facilities.
3 Slightly saline with some moderately saline	• Very slight to strong soil salinity. • Scarcity of quality irrigation water during dry season. • Scope of ground and river water upliftment for irrigation is limited. • Perennial water logging due to inadequate drainage facilities. • Prolonged artificial water logging with saline water for aquaculture. • Existence of toxic buried potential acid sulphate layer. • Flush flood.
4 & 5 Strongly saline with some moderately saline & Very strongly saline with some strongly saline	• Slight to very strong soil salinity. • Severe scarcity of quality irrigation water during dry season. • No scope of ground and river water upliftment for irrigation. • Prolonged artificial water logging with saline water for aquaculture. • Existence of toxic potential acid sulphate soil. • Cyclone and tidal bore.

CHAPTER-III

11.0 Constraints and management

11.1 Major constraints for agricultural development.

Common constraints

Several common and location specific agricultural constraints have been identified in the field through field investigation/observation, farmer's interview and literature review. It is found that constraints increased with increasing salinity intensity. Some common identified constraints on climate, natural and social aspects are a) Soil and water salinity, b) late draining condition, c) presence of saline ground water table almost throughout the year within 1.0 meter depth, d) poor nutrient status, e) high flooding depth in monsoon at the time of transplantation, f) late transplantation and harvesting of aman rice, g) poor polder management, h) shorter winter period, i) heavy soil consistency, j) narrow technological and germ plasm bases for salt tolerant crops, k) uncertain climate, i) unfavorable land tenure system, m) difficult communication and n) poor marketing facility.

Local constraints:

Permanent water logging

Human induced land degradation like localized water logging has developed an adverse affect on the environment and socio-economic condition of the people. In the present days, due to siltation in the intake channels, excessive losses from neighboring irrigation channels, poor management practices, ill planned infrastructural development, lack of proper maintenance and initiative for any effective amelioration measure caused perennial water logging in certain pockets of the area which restricted crop production. Bil Dakatia depressions in Khula-Jessore districts covering 0.02 m. ha is an example of such consequences (Saheed, 1998). Recently localized water logging has developed due to river bed siltation of Kobatak River in Kesabpur upazila in Jessore district. Government has taken some important steps to improve the situation.

Problem soils

The peat basins of about 0.09 m ha occupy extensive deep basin areas occurring in the central east part of the southern coastal saline area of Bangladesh. The peaty or rather mucky materials having low bearing capacity, moderately deep to deeply flooded, very poorly drained, locally contained pyritic sulphides which may develop extreme acidity on drying. About 0.1 m ha of active and potential acid sulphate soil occurs locally in the east and south-western part of the tidal floodplain (SRDI, 1998).

11.2 Reclamatory management practices for coastal saline soils

Besides adopting various methods for inducing salt tolerance in different crops including vegetables. It is important to adopt various land and soil management practices including agronomical techniques for reducing the adverse effect of salts.

Protective embankment

Land may be protected from inundation by saline water through establishment of earthen embankment of suitable size. The recommended size is of free breadth with 1 meter high above the high tide level. The side slope of the embankment should be of 2:1 ratio. The top width of the embankment may range from 1 to 3 m (ICAR Bull no.7).

Provision of sluice gate on the protective embankment

There should be provision of one way manually operated sluice gate in the embankment system to remove excess rain water and also to prevent ingression of saline water inward during high tide in dry season.

Leveling of land

Land should be properly leveled to prevent accumulation of water in the low-lying patches and to facilitate uniform drainage of excess water. It will also help to apply irrigation water uniformly in the field during rabi season.

Control of water through field bunds

About 25 cm high bunds are to be made demarcating the catchments and the field plots, so that the flow of excess water from outside the area and from one plot to another can be regulated. This will also help in retaining about 20 cm standing water to meet the water requirement during the subsequent dry period.

Draining of the catchments

Main and secondary drains are to be provided to directly let the excess rain water to move from different areas towards the sluice gate.

Operation of sluice gate frequently

In coastal area, heaviest showers are received in the month of July and August when most of the land operations are done. During this period, the sluice gate is to be opened more frequently and if necessary for longer periods to maintain desired water levels for optimum crop growth.

Storing of excess rain water for irrigation

After meeting the crop requirement, evaporation and seepage losses in kharif season, about 500 mm of rain water remain in excess. A part of this excess water may be stored in the dugout pond at the farm level for subsequent utilization as irrigation water during the dry period for rabi crops. This excess rain water can also be stored in the main drainage channel and re-excavated the derelict natural channels and closed minor tidal rivers/creeks.

Selection of kharif rice variety

Even though the coastal area is relatively flat, there exist elevational differences between higher and lower part of the catena, which cause different depths of standing water in the fields. The depths of standing water in medium highland ranges from 15 cm to about 90 cm and major portion of the area has the higher depths of water. At present, a number of high yielding rice varieties are available in the country. The selection of the kharif rice varieties may be as such they can overcome the flooding depth of the respective land situations. According to the depth of standing water and soil salinity of the field, suitable rice varieties can be selected

for maximum production according to the available guidelines. Brridhan 23, 30, 40 and 41 are now practiced in the coastal area, particularly in the south-west and southern part in kharif-2 season.

Introduction of a second crop in rabi season

Cropping intensity may be increased in about 0.602 million hectares of very slight (S_1) and slightly saline (S_2) areas by adopting proper soil and water management practices with the introduction of salt tolerant varieties of different crops. If sufficient irrigation water of good quality is available, introduction to a second rabi crop and even rice crop in winter is possible resulting additional production of grain yield. Since certain depth of irrigation water is kept in the field for growing successful rice crop, this practice simultaneously helps in leaching of soluble salts consequently reducing soil salinity. Leaching of salts in this period is facilitated because of relatively lower water table. However, it is the fact that availability of good quality irrigation water is a serious limiting factor for growing rice crop in winter season in the area.

Keeping land covered in winter and summer months

As the ground water is saline and is present at a shallow depth (about 1.0 meter), keeping fallow leads to high salinity in the soil due to excessive soil moisture evaporation. Growing cover crop or mulching is expected to mitigate this problem. Amongst the various materials which can be used as mulch, application of rice straw, rice husk and water hyacinth after harvest of transplanted aman and mixing it partially or wholly with topsoil by ploughing to improve the soil physical condition as well. It will enhance in leaching of soluble salts and increase rice yield in subsequent kharif season.

Introduction of winter rice and shrimp (Lobster) cultivation

In slightly saline (S_2) and moderately saline (S_3) areas cultivation of boro and sweet water shrimp (Lobster) will help in reclaiming soil salinity. In Khulna-Bagerhat region it is called "*Lockpur model".* It is one kind of fish cultivation where both crops and fishes are cultivated on the same piece of land. A dyke/ail/bund is to be built along the boundary of the plot by digging ditch inside the dyke. The length, breadth and height of the dyke will depend upon the flooding depth in the monsoon season. The ditch will be used as water reservoir for fish culture and small scale irrigation. For boro cultivation good quality of ground water may be available in this ditch. By adopting this type of land use soluble salts will be leached out easily within short time.

Introduction of Sharjan technique

Generally Sharjan technique is practiced in the south and south-west part of coastal saline areas where land type ranges from shallowly flooded medium highland to moderately to deeply flooded medium lowland having late draining condition. This facilitates to grow different dryland crops on beds and accumulated water in the furrows during monsoon that can be utilized to irrigate the bed crops during winter months. In this technique land is divided in to several raised subplots. Taking soil from the adjacent site each subplot is raised. Between two raised subplots there should be a ditch for keeping water permanently. Optimum size of the raised subplots is 10 m × 1.5 m. It may be changed depending on the local condition. Water present in the ditches can be used as irrigation source for dry land crops. The land is irrigated with good quality water from the ditch and this practice will help in leaching of soluble salts vertically and laterally and finally in reducing soil salinity.

Provision of sub-surface drainage

In many parts of the coastal area, the soil salinity is quite high and in order to grow a successful crop, it is essential to bring down the salinity to a considerable level by leaching the salts. It is also necessary to lower the water table that is shallow and enriched with salts and maintaining it below the critical depth to prevent salinization. To achieve the above objectives, a proper sub-surface drainage is to be provided. The sub-surface drainage has to be as such to keep the ground water at least 1 meter below the soil surface. This technology is very effective but in our socio-economic condition it is rather expensive.

Raising of vegetable nursery beds in weakly saline beds of transplanted crops

It has been observed that raising vegetable nursery in weakly saline soils develops a certain amount of adoption to saline soils and when such seedlings are transplanted in more saline fields, they perform better and avoid initial salt injury.

Addition of organic matter and chemical fertilizers

Addition of extra amount of organic matter improves soil physical and biological properties of soil and thus helps in better plant growth. Beneficial effort of higher doses of fertilization with N, P and K has been reported in potato, tomato, brinjal and okra under saline soils. As the problem of nutrient unavailability exists in salt affected soils, either due to fixation or competition in uptake, it is advantageous to supply them through foliage.

Keeping soil always moist

Frequent and light irrigation are essential for growing vegetable crops under saline soils. Provision of adequate drainage is also necessary. Sprinkler and drip irrigations are better as they keep the surface layer wet near the root zone and also increases humidity near he plant atmosphere, thus lowering the evapotranspirational rate of water.

Biological method

Very few efforts have been made to use biological methods for avoiding salt hazards. Some plants like *Chenopodium spp.* Absorb large amount of salts which can be grown and latter on removed after complete growth to minimize the salt concentrations from the fields. Vesicular-arbusecular mycorrhizal funjai (VAM) are known to increase plant growth and yield in saline soils.

12.0 Recommendations

12.1 Research aspects

- Development of appropriate soil and water management technologies for irrigated rice, dry land crops and aquaculture on moderately fine to fine textured soils.
- Development of high yielding varieties for tidal submerged tolerant crops in aus and aman season as well as salt tolerant dryland rabi crops.
- Study on salt balance and the natural features affecting the salt regime to understand the process of salinization in order to device prevention/reclamation.
- Monitoring of coastal river water salinity to find out safe period of water to be used for irrigation of specific crops.

- Characterization of soil and water salinity and determination of the nature and amounts of salt present in different salinity levels and their relative effects on plant growth.
- Studies on low cost reclamation measures including specific agronomic practices, flashing/leaching/washing of salts, drainage and control of water table.
- Flash out the topsoil salinity with good quality water after ploughing to decrease soil salinity and thereby reducing negative impact on brackish water aquaculture and on germination and crop seedlings.
- Special crop and soil management practices should be developed for saline water irrigated agriculture.
- Studies on feasibility of water quality for irrigation in dry season.
- Crop screening/selection for salt tolerance.
- Pre-sowing irrigation can be adopted. Early sowing just after the ceasing of monsoon rainfall is advantageous because it does not allow sufficient time for salt accumulation.
- Plasmid construction for enhancing salinity tolerance of rice.
- Enhancing coordinated inter-institutional monitoring of soil and water salinity and resource degradation for helping mitigation of problems and better resource management.
- Appropriate studies on land zoning for developing specific land utilization types.
- Study on nutrient interaction such as P-K interaction, pH Vs uptake of N, Na & Ca, salinity Vs oxygen stress or oxygen supply to the plants.
- Study on mechanism of K/Na selectivity.
- Study on changes in the soil and ground water salinity under brackish water aquaculture.

12.2 Development aspects

- Expansion of non-conventional salt resistant crop and adoption of planned agro- fisheries in low lying coastal areas.
- Conservation/storage of rain water in the re-excavated dead/dying river channels for more efficient water harvest.
- Study on development of 'Farm pond technology' through minimizing flooding depth, improving drainage condition and providing fresh water source for crop production.
- Peat soil should not be drained in order to avoid shrinkage and cracking and subsistence of ground level.
- Ground water abstraction should be limited to the extent to avoid abnormal sinking of ground water table which may cause deep cracking of heavy clays, probable ground subsistence and inland ingression of fresh water - salt water interface, and salinity up coning.

Since large proportion of the cultivable land in coastal saline area has become saline, it is not possible to abandon all the area. The efforts made by scientists towards reclaiming such lands has met with only partial success, as reclamation methods are costly and time taking. Since we cannot completely do away with this problem, we have to coexist and depend on plant manipulations, select the relative tolerant crops including vegetables and their varieties and try to further build up tolerance in them through physiological and breeding methods. Various agronomical techniques may also be great help to avoid salt effects. However, there is enough to do in this new area as very little efforts are being made so far.

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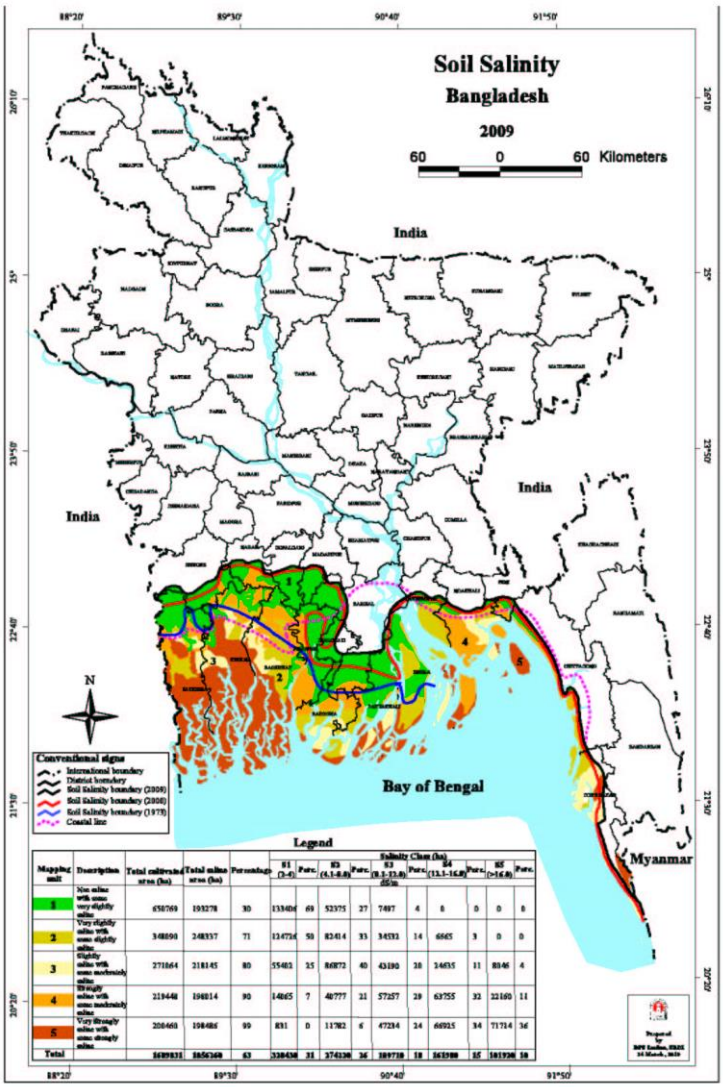
Soil Salinity
Bangladesh
2009
60 0 60 Kilometers
India
India
India
Bay of Bengal
Myanmar
N
Conventional signs
International boundary
District boundary
Soil Salinity boundary (2009)
Soil Salinity boundary (2000)
Soil Salinity boundary (1973)
Coastal line
Legend

Fig-1

Legend

Mapping unit	Description	Total cultivated area (ha)	Total saline area (ha)	%	Salinity class and area (ha)									
					S1 2.0- 4.0	**%**	**S2 4.1-8.0**	**%**	**S3 8.1-12.0**	**%**	**S4 12.1-16.0**	**%**	**S5 >16.0**	**%**
					dS/m									
1	Non saline with some very slightly saline	650769	193278	30	133406	69	52375	27	7497	4	0	0	0	0
2	Very slightly saline with some slightly saline	348090	248337	71	124726	50	82414	33	34532	14	6665	3	0	0
3	Slightly saline with some moderately saline	271064	218145	80	55402	25	86872	40	43190	20	24635	11	8046	4
4	Strongly saline with some moderately saline	219448	198014	90	14065	7	40777	21	57257	29	63755	32	22160	11
5	Very strongly saline with some strongly saline	200460	198486	99	831	0	11782	6	47234	24	66925	34	71714	36
Total		**1689831**	**1056260**	**63**	**328430**	**31**	**274220**	**26**	**189710**	**18**	**161980**	**15**	**101920**	**10**

Appendix -1: Upazila wise soil salinity mapping unit area in coastal saline belt

(Area in hectares)

District	Upazila	Total area (ha)	Uncultivated area (ha)	Cultivated area (ha)	Mapping unit area	Mapping Unit-1	Mapping Unit-2	Mapping Unit-3	Mapping Unit-4	Mapping Unit-5
Khulna	Fultala	7438	2291	5147	5147	3285	1862	-	-	-
	Digholia	6872	2365	4507	4507	3205	1302	-	-	-
	Metro	7013	4679	2334	2334	-	2334	-	-	-
	Terokhada	18769	2625	16144	16144	4403	11741	-	-	-
	Rupsa	12025	3199	8826	8826	2977	3355	2304	190	-
	Dumuria	44797	9919	34878	34878	4946	11161	3805	8244	6722
	Batiaghata	23622	6282	17340	17340	-	4735	8295	4310	-
	Dacope	28557	5800	22757	22757	-	-	-	-	22757
	Paikgacha	38404	5961	32443	32443	4645	1200	524	6593	19481
	Koyra	26323	4910	21413	21413	-	-	-	4840	16573
	Total	**213820**	**48031**	**165789**	**165789**	**23461**	**37690**	**14928**	**24177**	**65533**
Bagerhat	Mollahat	17687	3666	14021	14021	7016	7005	-	-	-
	Fakirhat	15883	5145	10738	10738	-	7999	548	2191	-
	Chitalmari	19039	4450	14589	14589	6284	8305	-	-	-
	B. Sadar	26950	8254	18696	18696	-	10509	7454	733	-
	Kachua	12351	3650	8701	8701	-	7747	954		-
	Rampal	32088	7087	25001	25001	-	3514	8919	9460	3108
	Mongla	18242	3659	14583	14583	-	1716	286	7863	4718
	Morrellgonj	43962	9916	34046	34046	6732	3366	18123	5825	-
	Sarankhola	15129	4760	10369	10369	1499	-	8870	-	-
	Total	**201331**	**50587**	**150744**	**150744**	**21531**	**50161**	**45154**	**26072**	**7826**
Satkhira	Kalaroa	23153	5732	13111	13111	13111	0	0	0	0
	S. Sadar	36609	7290	29319	29319	19152	7861	1250	1056	0
	Tala	33713	4943	28770	28770	17341	11035	-	394	0
	Debhata	17107	2346	14761	14761	1185	4409	2084	3423	3660
	Ashashuni	40982	6526	34456	34456	1636	1565	782	16213	14260
	Kaligonj	32434	5681	26753	26753	0	3176	15091	0	8486
	Shyamnagar	45609	8463	37146	37146	0	1323	1157	0	34666
	Total	**229607**	**40981**	**184316**	**184316**	**52425**	**29369**	**20364**	**21086**	**61072**

(Area in hectares)

District	Upazila	Total area (ha)	Uncultivated area (ha)	Cultivated area (ha)	Mapping unit area	Mapping Unit-1	Mapping Unit-2	Mapping Unit-3	Mapping Unit-4	Mapping Unit-5
Jessore	Abhoynagar	24719	6958	17136	17136	14566	2570	0	0	0
	Monirampur	44499	11473	15025	15025	13900	500	625	0	0
	Keshobpur	25853	6445	19408	19408	17488	1200	720	0	0
	Sharsha	33634	5328	630	630	630	0	0	0	0
	Jhikargacha	30760	5729	1050	1050	1050	0	0	0	0
	Total	**159465**	**35933**	**53249**	**53249**	**47634**	**4270**	**1345**	**0**	**0**
Narail	Narail sadar	37226	9121	24197	24197	23567	630	0	0	0
	Lohagara	28789	5335	2100	2100	1550	550	0	0	0
	Kalia	31042	5570	25472	25472	7642	17830	0	0	0
	Total	**97057**	**20026**	**51769**	**51769**	**32759**	**19010**	**0**	**0**	**0**
Barisal	Agailjhara	15780	7093	8687	3040	2432	608	0	0	0
	Babuganj	15247	11047	4200	1470	1029	368	73	0	0
	Banaripara	12977	2719	10258	3590	2872	718	0	0	0
	Bakerganj	40496	21526	18970	6640	5312	1328	0	0	0
	Gournadi	14417	7542	6875	2406	1925	481	0	0	0
	Wazirpur	24841	4900	19941	6979	5583	1396	0	0	0
	Mehindigang	41615	40340	1275	446	357	89	0	0	0
	Sadar	30335	29460	875	306	245	61	0	0	0
	Total	**195708**	**124627**	**71081**	**24877**	**19755**	**5049**	**73**	**0**	**0**
Jhalakhati	Rajapur	16433	12058	4375	1531	1225	306	0	0	0
	Kathalia	15747	3568	12179	4724	3697	1027	0	0	0
	Nalchiti	20443	19518	925	324	259	65	0	0	0
	Sadar	22304	14837	7467	2613	2090	523	0	0	0
	Total	**74927**	**49981**	**24946**	**9192**	**7271**	**1921**	**0**	**0**	**0**
Pirojpur	Bhandaria	15443	6000	9443	5502	4090	1204	208	0	0
	Kaukhali	7956	4978	2978	1042	834	208	0	0	0
	Mathbaria	35324	11515	23809	19047	12381	4762	1904	0	0
	Nazirpur	22897	5886	17011	9052	6415	2086	551	0	0
	Nesarabad	18343	6013	12330	4316	3453	863	0	0	0
	Zianagar	10358	3737	6621	5061	3317	1256	488	0	0
	Sadar	17487	4397	13090	6213	4535	1388	290	0	0
	Total	**127808**	**42526**	**85282**	**50233**	**35025**	**11767**	**3441**	**0**	**0**

(Area in hectares)

District	Upazila	Total area (ha)	Uncultivated area (ha)	Cultivated area (ha)	Mapping unit area	Mapping Unit-1	Mapping Unit-2	Mapping Unit-3	Mapping Unit-4	Mapping Unit-5
Bhola	Borhanuddin	27713	5594	22119	17943	11998	4374	1571	0	0
	Charfeshion	92595	47446	45149	45149	19403	10934	6788	4911	3113
	Daulatkhan	29056	20406	8650	6066	1814	2148	1169	701	234
	Lalmohan	37773	15678	22095	10593	5537	2999	946	814	297
	Manpura	45020	29609	15411	15411	1418	5675	2557	3975	1786
	Tajumuddin	34828	24332	10496	6631	2310	2236	1063	757	265
	Sadar	41314	17125	24189	10920	8154	2378	388		
	Total	**308299**	**160190**	**148109**	**112713**	**50634**	**30744**	**14482**	**11158**	**5695**
Patuakhali	Dumki	9513	2941	6572	6572	6572	0	0	0	0
	Bauphal	48185	12960	35225	35225	33725	1500	0	0	0
	Dashmina	30287	13202	17085	17085	11614	4690	0	781	0
	Galachipa *	119130	58948	71589	66196	14394	6771	2558	22160	20313
	Kalapara *	47194	11795	45204	40843	0	0	22125	13629	5089
	Mirjaganj	17552	5159	12393	12393	9416	2977	0	0	0
	Sadar	36014	8322	27692	27692	8605	19087	0	0	0
	Total	**307875**	**113327**	**215760**	**206006**	**84326**	**35025**	**24683**	**36570**	**25402**
Borguna	Amtali *	69478	24966	60246	53124	0	16145	12527	20110	4342
	Bamna	10105	2633	7472	7472	7317	155	0	0	0
	Betagi	16771	5284	11487	11487	11253	234	0	0	0
	Patharghara*	32500	12158	23095	21986	653	7171	11443	0	2719
	Sadar *	38833	12509	33034	30024	0	13436	10650	4974	964
	Total	**167687**	**57550**	**135334**	**124093**	**19223**	**37141**	**34620**	**25084**	**8025**
Gopalgonj	Tungipara	12724	1788	7468	4800	4800	0	0	0	0
	Kotalipara	36206	3524	22341	6820	6820	0	0	0	0
	Sadar	38142	5246	21745	8780	8780	0	0	0	0
	Total	**87072**	**10558**	**51554**	**20400**	**20400**	**0**	**0**	**0**	**0**
Madaripur	Rajoir	22928	2855	12037	2380	2380	0	0	0	0
	Total	**22928**	**2855**	**12037**	**2380**	**2380**	**0**	**0**	**0**	**0**
Laxmipur	Raypur	18650	7935	6429	6429	6429	0	0	0	0
	Laxmipur sadar	45664	12813	19711	19711	13798	0	5913	0	0
	Komalnagar	19600	5737	13863	13863	0	2773	10397	0	693
	Ramgati	28758	8417	20341	20341	0	1017	14239	4068	1017
	Total	**112672**	**34902**	**60344**	**60344**	**20227**	**3790**	**30549**	**4068**	**1710**

(Area in hectares)

District	Upazila	Total area (ha)	Uncultivated area (ha)	Cultivated area (ha)	Mapping unit area	Mapping Unit-1	Mapping Unit-2	Mapping Unit-3	Mapping Unit-4	Mapping Unit-5
Noakhali	Sudharam	33267	9231	20430	20430	7556	6976	1394	4504	0
	Kabirhat	16107	4469	9892	9892	3924	0	4397	1571	0
	Subarnachar	45421	12605	32816	32816	0	16737	0	16079	0
	Companiganj	40125	12549	27576	27576	4345	0	10427	10450	2354
	Hatiya	87655	51229	36426	36426	0	20751	0	0	15675
	Total	**222575**	**90083**	**127140**	**127140**	**15825**	**44464**	**16218**	**32604**	**18029**
Feni	Sonagazi	23508	6291	15495	15495	8437	0	860	6198	0
	Daganbhuiyan	16583	3872	1906	1906	1906	0	0	0	0
	Total	**40091**	**10163**	**17401**	**17401**	**10343**	**0**	**860**	**6198**	**0**
Chittagang	Mirsharai	48288	1618	14557	14557	10190	4367	0	0	0
	Sitakundu	48398	126	1131	1131	0	1131	0	0	0
	Sadar	2699	106	971	971	49	923	0	0	0
	Anowara	17353	866	7797	7797	0	7017	780	0	0
	Bashkhali	37690	1600	14398	14398	0	12238	2159	0	0
	Patia	31647	1265	11382	11382	11382	0	0	0	0
	Sandip	76242	2791	25115	25115	0	13813	0	11302	0
	Total	**262317**	**8372**	**75351**	**75351**	**21621**	**39489**	**2939**	**11302**	**0**
Cox's bazar	Chakaria	46483	1574	14168	14169	0	708	3542	7084	2834
	Pekua	13968	1033	9293	9293	0	1859	7434	0	0
	Sadar	19904	739	6651	6651	0	0	0	6651	0
	Ramu	38587	196	1762	1762	0	0	0	1762	0
	Ukhiya	25259	171	1542	1542	0	0	0	1542	0
	Teknaf	38868	748	6728	6728	0	0	0	504Su6	1682
	Kutubdia	21580	660	5942	5941	0	0	5942	0	0
	Moheshkhali	36218	1504	13539	13539	0	0	4062	9477	0
	Total	**240867**	**6625**	**59625**	**59625**	**0**	**2567**	**20980**	**31562**	**4516**
	G. Total	**3072106**	**907317**	**1689831**	**1495622**	**484840**	**352457**	**230636**	**229881**	**197808**

Appendix -2: Upazila wise Soil salinity class and area in coastal saline belt

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Khulna	Fultala	7438	2291	5147	3230	1700	1130	320	80	0
	Dighalia	6872	2365	4507	2720	1460	950	250	60	0
	Metro	7013	4679	2334	1980	890	690	300	100	0
	Terokhada	18769	2625	16144	12180	5810	4260	1610	500	0
	Rupsha	12025	3199	8826	6770	2410	2540	1140	540	140
	Dumuria	44797	9919	34878	30610	6530	7010	7110	5850	4110
	Batiaghata	23622	6282	17340	16380	2830	5460	4340	2700	1050
	Dacope	28557	5800	22757	22760	0	1140	4550	7970	9100
	Paikgacha	38404	5961	32443	29920	2230	3030	6930	8920	8810
	Koyra	26323	4910	21413	21410	240	1310	5250	7250	7360
	Total	**213820**	**48031**	**165789**	**147960**	**24100**	**27520**	**31800**	**33970**	**30570**
Bagerhat	Mollahat	17687	3666	14021	9460	4780	3310	1070	300	0
	Fakirhat	15883	5145	10738	9530	3220	2840	2030	1080	360
	Chitalmari	19039	4450	14589	10200	5060	3570	1220	350	0
	B. Sadar	26950	8254	18696	16890	4780	6450	3440	1750	470
	Kachua	12351	3650	8701	7520	3060	2720	1220	470	50
	Rampal	32088	7087	25001	24210	2680	6040	7020	5370	3100
	Mongla	18242	3659	14583	14330	1080	1660	4380	4130	3080
	Morrellganj	43962	9916	34046	29630	5360	10670	7320	4530	1750
	Sharankhola	15129	4760	10369	9350	1310	4130	2190	1290	430
	Total	**201331**	**50587**	**150744**	**131120**	**31330**	**41390**	**29890**	**19270**	**9240**

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Satkhira	Kalaroa	23153	5732	13111	6550	3930	2290	330	0	0
	S. Sadar	36609	7290	29319	18530	8930	6340	2210	830	220
	Tala	33713	4943	28770	18450	9440	6360	2000	590	60
	Debhata	17107	2346	14761	13450	2420	2950	3200	2800	2080
	Ashashuni	40982	6526	34456	33390	1980	3430	9770	10040	8170
	Kaliganj	32434	5681	26753	25830	2680	7960	5760	5300	4130
	Shyamnagar	45609	8463	37146	36910	620	2630	7380	12360	13920
	Total	**229607**	**40981**	**184316**	**153110**	**30000**	**31960**	**30650**	**31920**	**28580**
Jessore	Abhoynagar	24719	6958	17136	4930	3450	1170	310	0	0
	Monirampur	44499	11473	15025	4160	2700	1180	260	20	0
	Keshabpur	25853	6445	19408	5480	3580	1520	350	30	0
	Sharsha	33634	5328	630	160	110	40	10	0	0
	Jhikargacha	30760	5729	1050	260	180	70	10	0	0
	Total	**159465**	**35933**	**53249**	**14990**	**10020**	**3980**	**940**	**50**	**0**
Narail	Narail Sadar	37226	9121	24197	6220	4350	1540	330	0	0
	Lohagara	28789	5335	2100	660	460	150	50	0	0
	Kalia	31042	5570	25472	10830	7580	2260	990	0	0
	Total	**97057**	**20026**	**51769**	**17710**	**12390**	**3950**	**1370**	**0**	**0**

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Barisal	Agailjhara	15,780	7,093	8,687	1050	840	210	0	0	0
	Babuganj	15,247	11,047	4200	1470	1030	370	70	0	0
	Banaripara	12,977	2,719	10,258	820	660	160	0	0	0
	Bakerganj	40496	21,526	18970	3850	3080	770	0	0	0
	Gournadi	14,417	7,542	6875	2410	1930	480	0	0	0
	Wazirpur	24,841	4,900	19,941	2000	1600	400	0	0	0
	Mehindigang	41,615	40,340	1,275	450	360	90	0	0	0
	Sadar	30,335	29,460	875	310	250	60	0	0	0
	Total	**195,708**	**124,627**	**71,081**	**12360**	**9,750**	**2,540**	**70**	**0**	**0**
Jhalakathi	Rajapur	16,433	12,058	4375	500	400	100	0	0	0
	Kathalia	15,747	3,568	12,179	2190	1750	440	0	0	0
	Nalchiti	20,443	19,518	925	310	250	60	0	0	0
	Sadar	22,304	14,837	7467	1620	1300	320	0	0	0
	Total	**74,927**	**49,981**	**24,946**	**4620**	**3,700**	**920**	**0**	**0**	**0**
Pirojpur	Bhandaria	15,443	6,000	9443	3220	2210	830	180	0	0
	Kaukhali	7,956	4,978	2978	250	200	50	0	0	0
	Mathbaria	35,324	11,515	23809	19050	11430	5710	1910	0	0
	Nazirpur	22,897	5,886	17011	6800	4620	1770	410	0	0
	Nesarabad	18,343	6,013	12330	1240	990	250	0	0	0
	Zianagar	10,358	3,737	6621	2650	1620	780	250	0	0
	Sadar	17,487	4,397	13090	2620	2040	550	30	0	0
	Total	**127,808**	**42,526**	**85,282**	**35830**	**23,110**	**9,940**	**2,780**	**0**	**0**

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Bhola	Borhanuddin	27,713	5,594	22119	17950	9890	6570	1490	0	0
	Charfeshion	92,595	47,446	45149	36130	12810	8920	5640	6950	1810
	Daulatkhan	29,056	20,406	8650	6080	4110	1400	190	190	190
	Lalmohan	37,773	15,678	22095	13260	9220	3230	350	270	190
	Manpura	45,020	29,609	15411	15410	2710	6970	2680	2280	770
	Tajumuddin	34,828	24,332	10496	2110	1080	720	190	80	40
	B. Sadar	41,314	17,125	24189	3630	2290	1030	310	0	0
	Total	**308,299**	**160,190**	**148,109**	**94570**	**42,110**	**28,840**	**10,850**	**9,770**	**3,000**
Patuakhali	Dumki	9513	2941	6572	3950	2760	990	200	0	0
	Bauphal	48185	12960	35225	21530	14810	5510	1210	0	0
	Dashmina	30287	13202	17085	11780	6930	3310	1150	310	80
	Galachipa	119130	58948	71589	53390	10400	9860	9170	12340	11620
	Kalapara	47194	11795	45204	34730	4770	10680	7240	7970	4070
	Mirjaganj	17552	5159	12393	8220	5240	2310	670	0	0
	P. Sadar	36014	8322	27692	21580	11820	7040	2720	0	0
	Total	**307875**	**113327**	**215760**	**155180**	**56730**	**39700**	**22360**	**20620**	**15770**
Barguna	Amtali	69478	24966	60246	41880	10040	12520	8230	7790	3300
	Bamna	10105	2633	7472	4520	3140	1140	240	0	0
	Betagi	16771	5284	11487	6390	4430	1620	340	0	0
	Patharghara	32500	12158	23095	18710	5560	6740	3330	1930	1150
	B. Sadar	38833	12509	33034	24120	7940	8580	4330	2410	860
	Total	**167687**	**57550**	**135334**	**95620**	**31110**	**30600**	**16470**	**12130**	**5310**

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Gopalgonj	Tungipara	12724	1788	7468	2550	1530	890	130	0	0
	Kotalipara	36206	3524	22341	3510	2100	1230	180	0	0
	G. Sadar	38142	5246	21745	4400	2640	1540	220	0	0
	Total	**87072**	**10558**	**51554**	**10460**	**6270**	**3660**	**530**	0	0
Madaripur	Rajoir	22928	2855	12037	1200	720	420	60	0	0
	Total	**22928**	**2855**	**12037**	**1200**	**720**	**420**	**60**	0	0
Laxmipur	Raipur	18650	7935	6429	640	580	60	0	0	0
	L. Sadar	45664	12813	19711	3450	2380	660	310	100	0
	Kamalnagar	19600	5737	13863	4950	2450	1080	990	370	60
	Ramgati	28758	8417	20341	8390	3350	2430	1770	750	90
	Total	**112672**	**34902**	**60344**	**17430**	**8760**	**4230**	**3070**	**1220**	**150**
Noakhali	Shudharam	33267	9231	20430	5460	2580	1870	740	270	0
	Kabirhat	16107	4469	9892	2790	1370	860	400	160	0
	Subarnachar	45421	12605	32816	13030	4490	5470	2190	880	0
	Companiganj	40125	12549	27576	11950	3550	3830	2970	1390	210
	Hatiya	87655	51229	36426	19290	3370	1300	8980	4230	1410
	Total	**222575**	**90083**	**127140**	**52520**	**15360**	**13330**	**15280**	**6930**	**1620**
Feni	Sonagazi	23508	6291	15495	4560	1610	1860	730	360	0
	Daganbhuiya	16583	3872	1906	190	170	20	0	0	0
	Total	**40091**	**10163**	**17401**	**4750**	**1780**	**1880**	**730**	**360**	**0**

District	Upazila	Total area (ha)	Uncultivated area(ha)	Cultivated area(ha)	Total saline area(ha)	Salinity Class and area (ha)				
						S1 2.0-4.0 dS/m	S2 4.1-8.0 dS/m	S3 8.1-12.0 dS/m	S4 12.1-16.0 dS/m	S5 >16.0 dS/m
Chittagong	Mirsharai	48288	1618	14557	6560	3410	2290	680	180	0
	Sitakundu	48398	125	1131	920	410	320	140	50	0
	C. Sadar	2699	108	971	750	340	260	110	40	0
	Anwara	17353	866	7797	6320	2600	2320	1050	350	0
	Bashkhali	37690	1600	14398	11730	4600	4400	2050	680	0
	Patia	31647	1265	11382	3420	2050	1200	170	0	0
	Sandip	76242	2790	25115	21780	4970	4940	4340	5920	1610
	Total	**262317**	**8372**	**75351**	**51480**	**18380**	**15730**	**8540**	**7220**	**1610**
Cox's bazar	Chakaria	46483	1574	14168	13190	570	2750	3230	4650	1990
	Pekua	13968	1033	9293	8180	1330	3880	2230	740	0
	C. Sadar	19904	739	6651	6320	0	630	1580	3160	950
	Ramu	38587	196	1762	1680	0	170	420	840	250
	Ukhiya	25259	171	1542	1470	0	150	370	730	220
	Tecknaf	38868	748	6728	6490	0	650	1540	2990	1310
	Kutubdia	21580	660	5942	5350	540	2670	1600	540	0
	Moheshkhali	36218	1504	13539	12670	370	2730	3350	4870	1350
	Total	**240867**	**6625**	**59625**	**55350**	**2810**	**13630**	**14320**	**18520**	**6070**
	G. total	**3072106**	**907317**	**1689831**	**1056260**	**328430**	**274220**	**189710**	**161980**	**101920**

Appendix-3: Comparison of soil salinity status between 1973, 2000 and 2009 in coastal area.

District	Salt affected area (000'ha)			Salinity class and area (000'ha)												Salinity increase over 4 decades	
				S_1 2.0-4.0 dS/m			S_2 4.1-8.0 dS/m			S_3* 8.1-16.0 dS/m			S_4 >16 dS/m			Area (000'ha)	%
	1973	**2000**	**2009**	**1973**	**2000**	**2009**	**1973**	**2000**	**2009**	**1973**	**2000**	**2009**	**1973**	**2000**	**2009**		
Khulna	120.04	145.25	147.96	13.90	29.04	24.64	92.54	38.32	26.88	13.95	59.49	47.78	9.80	19.61	30.57	27.92	23.3
Bagerhat	107.98	125.13	131.12	8.30	35.66	32.33	77.08	42.56	42.48	3.60	41.23	52.96	0	6.74	9.24	23.14	21.42
Satkhira	146.35	147.08	153.11	26.50	29.03	31.00	85.60	39.01	32.96	34.50	60.55	69.72	10.90	22.01	28.58	6.76	4.62
Total	**374.37**	**417.46**	**432.19**	**48.70**	**93.73**	**87.97**	**255.22**	**119.89**	**102.32**	**52.05**	**161.27**	**169.37**	**20.70**	**48.36**	**68.39**	**57.82**	**15.44**
Jessore	0	10.86	14.99	0	0	10.02	0	0	4.98	0	0	0.99	0	0	0	14.99	100.0
Narail	0	16.05	18.71	0	7.21	12.39	0	5.30	3.95	0	1.08	1.37	0	0	0	18.71	100.0
Total	**0**	**26.91**	**33.70**	**0**	**10.67**	**22.41**	**0**	**5.30**	**8.93**	**0**	**1.08**	**2.36**	**0**	**0**	**0**	**33.70**	**100.0**
Pirojpur	21.30	28.64	35.83	20.40	22.93	23.11	1.90	6.05	9.94	0	2.43	2.78	0	0		15.83	76.5
Jhalakati	0	3.52	4.69	0	2.35	3.70	0	1.17	0.92	0	0	0	0	0	0	4.69	100.0
Barisal	0	10.82	13.96	0	2.35	8.12	0	2.70	2.54	0	0	0.70	0	0	0	13.96	100.0
Bhola	40.33	93.64	94.57	9.18	32.44	42.11	30.81	33.70	28.84	0	26.13	20.62	0	5.27	3.00	54.24	134.5
Total	**61.63**	**136.62**	**149.05**	**29.58**	**60.07**	**77.04**	**32.71**	**43.62**	**42.24**	**0**	**28.56**	**24.10**	**0**	**5.27**	**3.00**	**87.42**	**143.57**
Patuakhali	115.40	139.35	155.18	68.50	41.11	57.73	46.60	43.62	39.90	**0**	46.10	44.98	0	9.52	15.77	40.08	34.82
Borguna	103.55	104.22	95.62	96.39	37.22	32.11	7.20	30.77	30.90	0	33.47	32.60	0	3.77	5.31	-7.93	-
Total	**218.95**	**243.57**	**250.80**	**164.89**	**78.33**	**89.84**	**53.80**	**74.39**	**70.80**	0	**79.57**	**76.58**	**0**	**13.29**	21.08	**32.15**	**11.4**
Gopalganj	0	10.20	6.27	0	5.76	3.66	0	3.12	0.53	0	1.32	0	0	0	0	6.27	100
Madaripur	0	1.19	0.72	0	0.79	0.42	0	0.40	0.60	0	0	0	0	0	0	0.72	100.0
Total	**0**	**11.39**	**6.99**	**0**	**6.55**	**4.08**	**0**	**3.52**	**1.13**	**0**	**1.32**	**0**	**0**	**0**	**0**	**6.99**	**100.0**
Laxmipur	19.30	17.50	18.43	10.90	8.55	8.76	6.80	6.10	4.23	**0**	2.93	4.29	0	0	0.15	-0.87	-
Feni	9.50	7.30	5.75	1.60	2.61	1.78	6.7	4.29	1.88	1.60	0.40	1.09	0	0	0	-3.75	-
Noakhali	49.60	53.54	52.52	6.30	13.04	15.36	39.90	16.93	13.33	1.80	15.83	22.21	0	7.75	1.62	2.92	5.88
Total	**78.40**	**78.34**	**76.70**	**18.80**	**24.20**	**25.90**	**53.40**	**27.32**	**19.44**	**3.40**	**19.16**	**27.59**	**0**	**7.75**	**1.77**	**-3.2**	**-**
Chittagong	45.70	46.50	51.48	18.20	13.38	18.38	15.10	22.08	15.73	5.70	10.07	16.76	5.20	1.97	1.61	5.41	12.65
Cox's Bazar	54.40	59.96	55.35	7.20	2.83	2.81	16.20	11.08	13.63	17.30	35.55	33.84	14.00	10.50	6.07	0.65	1.19
Total	**100.10**	**106.46**	**106.83**	**25.60**	**16.21**	**21.19**	**31.30**	**33.16**	**29.36**	**24.30**	**45.62**	**50.60**	**19.20**	**72.47**	**7.68**	**6.06**	**6.03**
G. Total	**833.45**	**1020.75**	**1056.26**	**287.37**	**289.76**	**328.43**	**426.43**	**307.20**	**274.22**	**79.75**	**336.58**	**351.69**	**39.90**	**87.14**	**101.92**	**222.81**	**26.7**

*$S_{3=}$ S_3+ S_4; S_3 = 8.1- 12.0 dS/m , S_4 = 12.1-16.0 dS/m

Appendix-4 District wise water salinity data in coastal saline area.

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
1.	Khulna	Kaiya Bazar, Dumuria	Shailmari river	N22^{0}47′22.4″ E 89^{0}29’08.4″	7.9	17.0	3.67	1.1	2.1
2.		Kharnia bridge, Kharnia	Vadra river	N22^{0}49′20.4″ E 89^{0}21’13.9″	7.6	20.5	4.64	1.1	2.3
4.		Boalia, Gadaipur, Paikgacha	Shibsa river	N22^{0}37′03.3″ E 89^{0}1’33.6″	8.0	24.8	2.56	0.6	2.4
5.		Antabunia, Maharajpur, Koyra	Shakbaria canal	N22^{0}23′25.4″ E 89^{0}17’15.1″	7.7	35.5	3.42	1.5	2.6
6.		Koyra HQ	Kapotakya river	N22^{0}21′04.0″ E 89^{0}16’44.9″	7.8	34.1	1.31	0.8	0.5
7.		SMRC, Batiaghata	Kazibacha river	N22^{0}41′36.1″ E 89^{0}31’56.0″	7.8	26.6	2.13	1.0	2.4
8.		SMRC, Batiaghata	Kazibacha river	-	8.9	28.4	4.13	1.8	2.6
9.		Rupsa bridge, Khulna	Rupsa river	-	8.0	28.5	0.89	1.8	2.7
10.		Alamtala, Laskar, Paikgacha	Gher	N22^{0}33′51.4″ E 89^{0}17’29.0″	7.7	22.8	1.86	1.8	0.6
11.		Amadi bazaar, Amadi, Koyra	Gher	N22^{0}27′50.9″ E 89^{0}17’15.5″	7.8	12.9	2.57	0.6	1.8
12.		Koyra HQ	Gher	-	7.8	35.0	6.32	1.0	2.6
13.	Satkhira	Kashimnagar, Khalilnagar, Tala	Kapotakya river	N22^{0}42′08.9″ E 89^{0}18’27.3″	7.6	17.5	3.38	0.8	1.6
14.		Binerpota, Satkhira	Betna river	N22^{0}45′03.0″ E 89^{0}06’25.3″	7.8	25.5	3.57	0.6	2.1
15.		Town sreepur, Debhata	Isamati river	N22^{0}35′00.0″ E 89^{0}56’57.7″	7.5	25.8	4.13	1.4	2.5
16.		Kaligonj bridge, Kaligonj	Kakshiali river	N22^{0}27′25.7″ E 89^{0}02’11.0″	7.4	26.1	2.1	1.6	2.4

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
17.	Satkhira	Munshigonj, Shyamnagar	Malancha river	N22^{0}16′08.7″ E 89^{0}11’56.9″	7.8	35.9	6.93	1.2	2.6
18.		Pirojur, Kushulia, Kaligonj	Pond	-	8.0	2.3	0.25	0.11	0.12
19.	Bagerhat	Mongla ferryghat	Pasur river	N22^{0}28′21.3″ E 89^{0}36’04.2″	7.6	25.3	1.98	1.0	2.4
20.		Joymonirghol, Chila, Mongla	Chechang river	N22^{0}21′57.1″ E 89^{0}38’34.1″	7.8	19.4	2.72	0.8	2.1
21.		Mollahat HQ	Madhumati river	N22^{0}55′45.2″ E 89^{0}48’39.4″	8.1	4.5	0.65	0.4	0.7
22.		Daratana bridge, Bagerhat	Daratana river	N22^{0}38′37.1″ E 89^{0}48’14.1″	7.2	15.5	2.26	0.9	1.7
23.		Morelgonj ferryghat	Panguchi river	N22^{0}27′58.0″ E 89^{0}51’46.5″	8.0	9.1	-	0.6	1.4
24.		Rayenda HQ, Shawrankhola	Baleswar river	N22^{0}18′46.8″ E 89^{0}51’24.2″	8.1	4.3	0.87	0.3	0.7
25.		Bisherighata, Morelgonj	Canal	N22^{0}26′16.5″ E 89^{0}50’09.7″	8.4	4.9	0.72	0.4	0.7
26.		Dansagar, Khaolia, Morelgonj	Canal	N22^{0}23′27.3″ E 89^{0}48’58.8″	7.9	8.2	-	0.6	0.7
27.		Nalbunia, Dansagar, Shwarankhola	Canal	N22^{0}20′30.3″ E 89^{0}49’01.6″	8.2	6.5	0.91	0.5	1.0
28.		Digraj, Burridanga, Mongla	Gher	-	7.9	26.0	1.25	0.98	0.2
29.		Kistmat Janjania (Rampal)	Gher	N22^{0}36′22.3″ E 89^{0}38’59.4″	7.9	33.1	3.75	2.1	2.6
30.		SMRC, Batiaghata	Pond	-	7.9	2.7	0.42	0.70	0.40
31.		South kayenmari, Chila, Mongla	Pond	N22^{0}25′51.8″ E 89^{0}36’51.2″	8.1	5.4	0.98	0.3	0.70

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
32.	Satkhira	Munshigonj, Shyamnagar	Malancha river	N22^{0}16′08.7″ E 89^{0}11’56.9″	7.8	35.9	6.93	1.2	2.6
33.		Pirojur, Kushulia, Kaligonj	Pond	-	8.0	2.3	0.25	0.11	0.12
34.	Bagerhat	Mongla ferryghat	Pasur river	N22^{0}28′21.3″ E 89^{0}36’04.2″	7.6	25.3	1.98	1.0	2.4
35.	Chittagong	Muhari Project, Mirsarai	Cannel	22^{0}50′04.1″ 91^{0}27’26.4″	7.6	1.32	1.11	-	1.1
36.		Ishakhali	Cannel	22^{0}48′07.9″ 91^{0}26’56.2″	7.7	3.29	1.35	0.5	0.3
37.		Barabkund	Cannel	22^{0}33′59.6″ 91^{0}39’54.2″	7.9	4.45	1.25	0.3	1.8
38.		Banskhali	Cannel	22^{0}04′49.4″ 91^{0}53’11.8″	7.8	5.95	0.98	0.4	2.0
39.		Banskhali	Sea water	22^{0}04′45.9″ 91^{0}52’02.9″	7.4	29.1	1.76	0.9	8.0
40.		Anwara	Karnafully River	22^{0}19′16.3″ 91^{0}51’20.7″	7.5	4.55	0.82	0.3	2.2
41.		Mognama	Kutubdia Channel	-	7.5	31.2	0.56	0.1	0.5
42.		Pekua	Mathamuhari khal	21^{047}′44.9″ 91^{0}59’23.8″	8.4	2.2	0.45	1.6	4.0
43.		Patia	Surface water	22^{0}17′14.5″ 91^{0}52’15.9″	7.9	1.63	0.48	0.2	0.3
44.		Anwara	Gher Water	22^{0}12′20.4″ 91^{0}49’44.7″	7.7	28.0	5.48	1.0	6.0
45.		Anwara	Sea Water	22^{0}11′34.8″ 91^{0}49’03.4″	7.6	27.2	0.89	1.3	5.0
46.		Chakaria	Saltbed water	-	7.6	33.8	7.81	1.4	3.0
47.		Chakaria	Surface water	-	7.4	32.3	2.15	18.0	5.0

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
48.	Chittagong	Chakaria	Mahaskhali, Channel	-	7.6	36.0	-	1.4	7.0
49.	Cox's Bazar	Cox's Bazar	Sea Water	$21^0$23′34.5″ $92^0$00'01.0″	7.5	39.2	9.2	18.0	5.0
50.	Narail	Kalna ghat, Lohagara, Narail	Modumoti river	N$23^0$11′36.8″ E $89^0$41'31.9″	8.6	2.68	0.37	0.01	0.5
51.		Baraipara, Kalia, Narail	Nabaganga river	N$23^0$02′24.8″ E $89^0$36'05.8″	7.8	15.25	0.60	-	-
52.		Auria, Narail Sadar, Narail	Chittra river	N$23^0$09′25.0″ E $89^0$30'43.2″	8.3	2.05	0.78	0.07	0.55
53.		Tularampur, Narail Sadar, Narail	Afra river	N$23^0$09′56.1″ E $89^0$26'44.5″	8.9	3.85	0.58	0.10	1.06
54.	Pirojpur	Sriramkhati, Nazirpur	Kaligonga river	N$22^0$41′ E 89.59'	8.2	1.26	0.97	-	-
55.		Char Roghunathpur, Nazirpur	Baleswar river	N$223^0$42′ E $89^0$53'	8.2	12.48	1.68	0.14	0.92
56.		Tushkhali, Mothbaria	Tushkhali khal	N$22^0$21′E $89^0$56'	8.0	2.21	2.54	0.11	0.56
57.		Shapleja, Mothbaria	Baleswar river	N$22^0$08′ E $89^0$54'	8.3	2.70	0.43	0.11	0.67
58.	Bhola	Fakirhat, Tojumoddin	Tojumoddin khal	N$22^0$25′ E $90^0$47'	8.4	0.91	1.17	0.05	0.28
59.		Betua, Charfession	Shabajpur river	N$22^0$11′ E $90^0$49'	8.0	4.76	0.07	0.09	0.78
60.		Aslampur, Charfession	Aslampur khal	N$22^0$19′ E $90^0$40'	8.1	2.33	4.61	0.08	0.65
61.		Vekutia Ferry ghat, Bhola	Tatulia river	-	8.9	0.16	3.09	-	-

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
62.	Borguna	Khathaltali,Patharghata	Baleswar river	-	7.8	2.39	0.21	0.07	0.53
63.		Chardowni,Patharghata	Bondho khal	-	7.8	1.76	0.75	0.06	0.03
64.		Pourasova,Patharghata	Biskhali river	-	7.9	1.33	0.18	0.04	0.01
65.		Kismot Volanathpur, Betagi	Jhopkhali khal	-	8.4	0.23	1.59	0.03	0.001
66.		Gourichanna bazaar, Sadar	Khal	-	7.7	3.97	0.89	0.11	0.03
67.		Powrosova,Sadar	Khakdon river	-	8.5	0.36	0.90	0.03	0.003
68.		Choto taltoli, Sadar	Pond	-	7.9	3.23	1.20	0.08	0.03
69.		Choto Gowrichanna, Sadar	Pond	-	8.5	3.77	2.45	0.03	0.02
70.		Baliatoli, Sadar	Paira river	-	7.8	1.76	-	0.06	0.02
71.	Patuakhali	Subidkhali,Mirzaganj	Subidkhali river	-	8.6	0.30	3.21	0.03	0.003
72.		Labukhali Feryghat, Dumki	Labukhali river	-	8.4	0.16	0.28	0.02	0.002
73.		Laukati Bridge, Sadar	Laukhati river	-	8.5	0.27	0.99	0.03	0.002
74.		Kolipura,Sadar	Kukuya river water	-	8.2	0.39	0.86	0.3	0.004
75.		Kolapara ferryghat, Kalapara	Andarmanik river	-	7.5	19.9	2.46	0.13	4.09

Sl no	District	Location	Type of water	Surface Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
76.	Patuakhali	Hazikhali feryghat, Kalapara	Sonatala river	-	7.6	28.9	5.61	0.14	5.29
77.		Puran Mohipur, Kalapara	Pond	-	8.4	1.1	0.89	0.06	0.57
78.		Mohipur Ghat, Kalapara	Khapra Bhanga don river	-	7.7	29.4	5.13	0.15	5.88
79.		Kuakata,Kalapara	Sea water	-	7.5	26.0	6.33	0.14	5.25
80.		Awoliapur,Dashmina	Arojbegi khal	-	8.3	0.71	1.13	0.03	0.003
81.		Pachkhali Char, Dashmina	Tetulia river	-	8.1	0.26	0.98	0.03	0.002
82.		Ranagopaldi,Dashmina	Gopaldi river	-	8.0	0.30	0.77	0.03	0.003
83.		Amkhola, Galachipa	Golachipa river	-	7.8	1.24	0.67	0.07	0.02
84.		Agunmukho, Galachipa	Kajol river	-	8.1	0.28	0.05	0.03	0.002
85.		Khathaltali, Patharghata	Baleswar river		7.8	2.39	0.21	0.07	0.03
	Khulna			Ground Water					
86.		Moukhali, Chandkhali, Paikgachha	DTW	N22^{0}30′37.8″ E 89^{0}17’52.7″	8.1	7.8	1.7	0.7	0.9
87.		Harinagar, Amadi, Koyra	HTW	N22^{0}30′16.2″ E 89^{0}18’20.3″	8.8	3.8	0.69	0.1	0.4
88.		Harinagar, Amadi, Koyra	DTW	N22^{0}30′15.8″ E 89^{0}18’19.2″	8.1	4.7	1.86	1.8	0.6
89.		Chandipur, Amadi, Koyra	STW	N22^{0}28′54.7″ E 89^{0}29’09.8″	8.1	6.7	3.13	0.1	2.1
90.		Batbunia bazaar, Tildanga, Dacope	HTW	N22^{0}34′07.6″ E 89^{0}27’42.3″	9.3	4.5	2.69	0.1	0.3

Sl no	District	Location	Type of water	Ground Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
91.	Khulna	Batbunia bazar, Tildanga, Dacope	HTW	N22^{0}33′42.4″ E 89^{0}27’29.7″	9.0	9.4	2.5	0.1	0.4
92.		SMRC, Batiaghata	DTW	-	8.6	1.5	0.33	0.02	0.6
93.		Sreepur, Asagara, Terokhada	DTW	N22^{0}52′43.2″ E 89^{0}38’28.8″	8.2	4.8	0.66	0.3	0.9
94.		Gajalia, Chandkhali, Paikgacha	HTW	N22^{0}32′37.8″ E 89^{0}17’49.8″	8.4	5.7	0.58	0.2	0.5
95.		Gutudia, Dumuria	STW	N22^{0}47′32.0″ E 89^{0}27’44.5″	8.2	3.3	0.13	0.3	0.5
96.	Satkhira	Town Sreepur, Debhata	HTW	N22^{0}35′02.7″ E 89^{0}27’42.3″	8.6	2.4	0.11	0.04	0.3
97.		Sreefalkathi, Ishwaripur, Shyamnagar	STW	N22^{0}17′31.4″ E 89^{0}07’35.7″	8.1	13.2	1.55	0.3	1.7
98.		Sreefalkathi, Ishuripur, Shyamnagar	HTW	N22^{0}16′37.8″ E 89^{0}08’52.8″	7.8	19.8	2.2	1.3	2.3
99.		Sreefalkathi, Ishuripur, Shyamnagar	STW	-	8.0	5.1	2.4	0.6	0.7
100.		Agardari, Satkhira Sadar	STW	N22^{0}45′20.6″ E 89^{0}03’15.2″	8.2	0.7	0.9	0.07	0.1
101.	Bagerhat	Khajura, Lockpur, Fakirhat	STW	N22^{0}46′08.2″ E 89^{0}37’12.9″	8.3	2.4	0.24	0.2	0.4
102.	Jessore	Madhyakul, Keshabpur	STW	N22^{0}55′45.5″ E 89^{0}13’23.2″	8.5	0.7	0.14	0.07	0.09
103.	Gopalganj	Balagati, Patgati, Tungipara	DTW	N22^{0}55′43.1″ E 89^{0}54’40.2″	8.3	3.7	3.91	0.2	0.3
104.		Hiran, Kotwalipara	STW	-	8.8	2.6	1.02	0.2	0.2
105.	Barisal	Chadpasa, Babugonj	DTW	N22^{0}47′ E 90^{0}20’	8.8	0.91	0.43	0.003	0.01
106.		Kazirchar, Muladi	STW	N22^{0}52′ E 90^{0}23’	8.6	0.69	0.11	0.01	0.25

Sl no	District	Location	Type of water	Ground Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
107.	Barisal	Charkalekha, Muladi	STW	N22^{0}58′ E 89^{0}25’	8.7	0.96	0.78	0.04	0.4
108.		Rakudia, Babuganj	DTW	N22^{0}49′ E 90^{0}16’	9.0	1.3	1.3	0.01	0.13
109.		Barthi, Goarnadi	DTW	N23^{0}02′ E 90^{0}12’	8.5	1.36	1.12	0.01	0.3
110.		Laharhat, Barisal	DTW	N22^{0}41′E 900^{0}29’	8.9	0.55	0.15	-	-
111.	Pirojpur	Bekutia Fery ghat, Pirojpur	STW	N22^{0}34.27′ E 90^{0}02.10’	9.0	1.85	0.25	0.02	0.56
112.		Pachpara, Shikdar Mollik, Pirojpur Sadar	STW	N22^{0}39′ E 89.7’	9.1	3.89	3.51	0.01	0.63
113.		Sriramkhati, Nazirpur	DTW	N22^{0}41′E 89.59’	8.7	2.07	1.0	-	-
114.		Roghunathpur, Nazirpur	STW	N22^{0}43′E 89.54’	8.4	3.34	0.51	0.01	0.7
115.		Charroghunathpur, Nazirpur	STW	N22^{0}42′E 89^{0}53’	8.4	1.82	1.98	0.14	0.64
116.		Sankarpasha, Pirojpur Sadar	DTW	N22^{0}31′E 89^{0}59’	8.9	2.83	4.43	0.01	0.15
117.		Charkhali, Vandaria	STW	N22^{0}29′E 89^{0}59’	8.8	3.98	3.68	0.01	0.28
118.		Tushkhali, Mothbaria	STW	N22^{0}21′ E 89^{0}56’	8.9	3.15	2.54	0.01	0.61
119.		Mothbaria sadar	STW	N22^{0}17′ E 89^{0}57’	9.0	3.33	1.54	0.01	0.49
120.	Jhalakathi	Baghri, Razapur, Jhalakhati	DTW	N22^{0}34′ E 90^{0}08’	9.1	0.95	0.29	-	-
121.		Police line, Jhalakhati	DTW	N22^{0}38′ E 90^{0}13’	8.7	2.11	0.89	0.01	0.16
122.	Bhola	Ilisha Ghat, Bhola sadar	DTW	N22^{0}47′ E 90^{0}39’	8.8	0.80	1.09	0.03	0.06
123.	Patuakhali	Kuakata,Kalapara	DTW	-	8.2	0.62	0.57	0.03	0.77
124.		Bilbilash,Bauphal	DTW	-	8.9	0.78	0.56	0.003	0.003
125.		Darchira, Rangabali, Galachipa	DTW	-	7.9	6.66	1.78	0.13	3.78
126.		Rangabali,Galachipa	DTW	-	7.8	5.3	1.39	0.14	3.15

Sl no	District	Location	Type of water	Ground Water					
				GPS coordinate	pH	ECw (dS/m)	B (ppm)	Ca (meq/L)	Mg (meq/L)
127.	Patuakhali	Arojbegi,Dashmina	DTW	-	8.7	0.60	0.67	0.003	0.003
128.	Borguna	Mirmohon,Betagi	DTW	-	8.9	0.93	0.76	0.001	0.001
129.		Rakhainpara,Betagi	DTW	-	8.9	1.81	2.73	0.003	0.004
130.		Sakharia Bazar,Amtali	DTW	-	8.8	0.76	0.19	0.02	0.001
131.	Noakhali	-	HTW	-	8.0	1.2	1.12	0.002	0.09
132.		-	HTW	-	8.7	1.08	0.46	0.01	0.50
133.		-	HTW	-	8.7	0.48	0.97	0.01	0.29
134.		-	HTW	-	8.9	0.92	0.3	0.003	0.40
135.		-	HTW	-	8.9	1.07	2.10	0.01	0.55
136.		-	HTW	-	8.6	0.39	0.89	0.01	0.10
137.		-	HTW	-	8.6	0.42	0.17	-	-
138.	Chittagong	Barabkund	STW	N22^{0}33′59.6″ E 91^{0}39’ 54.2″	9.2	1.95	1.61	0.05	0.3
139.		Sitakund,	DTW	N22^{0}39′13.4″ E 91^{0}35’ 11.2″	9.1	2.96	1.65	0.09	0.60

Appendix-5: Salt characteristics of different soils in coastal saline areas.

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Bajoa , Medium highland; Location: Jalma, Batiaghata, Khulna										
0-10	6.3	7.3	15.5	10.5	0.50	0.83	275.3	585.8	14.4	0
10-17	7.5	4.4	26.5	6.5	0.40	0.54	150.4	292.8	4.8	0
17-40	7.6	4.2	18.0	10.0	0.30	0.60	202.4	292.8	4.8	0
40-73	7.8	3.7	22.0	5.5	0.25	0.54	133.2	292.8	9.6	0
73-97	7.5	4.7	21.5	7.0	0.33	0.57	234.8	585.6	9.6	0
97-115	4.9	11.6	21.5	10.0	0.40	0.80	375.0	292.8	9.6	0
115-160	4.2	16.0	38.5	25.0	0.45	1.02	390.0	292.8	14.4	0
Soil series: Barisal, Medium highland; Location: Gangarampur, Batiaghata, Khulna										
0-12	4.9	13.4	10.0	10.0	0.49	1.5	480.0	292.8	43.2	0
12-19	6.4	6.5	13.5	10.0	0.44	1.17	212.0	292.8	19.2	0
19-44	6.6	5.9	15.0	10.0	0.44	1.23	228.0	146.0	14.4	0
44-56	6.0	6.4	12.0	10.0	0.45	1.1	304.8	292.8	19.2	0
56-74	6.2	5.9	10.5	20.0	0.40	1.12	405.6	298.8	14.4	0
74-90	5.8	7.3	12.0	15.0	0.43	1.23	192.0	292.8	24.0	0
90-160	3.4	16.7	17.0	20.0	0.05	1.07	75.0	292.8	38.4	0
Soil series: Dacope, Medium highland; Location: Ghutudia, Dumuria, Khulna										
0-9	6.9	6.2	17.5	10.0	0.30	1.08	75.0	292.3	24.0	0
9-13	7.4	4.4	20.0	5.0	0.34	0.94	60.0	292.8	19.2	0
13-20	7.6	3.9	30.5	5.0	0.34	0.84	60.0	293.0	9.6	0
20-23	7.7	2.8	25.5	10.0	0.32	0.80	7.1	292.8	9.6	0
33-80	7.8	3.8	37.5	5.0	0.27	0.75	5.25	292.8	9.6	0
80-95	7.9	2.6	34.0	5.0	0.37	0.76	3.27	292.8	4.8	0
95-120	6.4	11.2	40.5	15.0	0.45	1.03	5.56	292.8	43.2	0
Soil series: Dumuria , Medium highland; Location: Ghutudia, Dumuria, Khulna										
0-7	7.1	23.4	16.0	15.0	0.66	2.4	5.8	380.0	206.4	0
7-12	7.8	8.2	12.5	10.0	0.56	1.4	7.0	292.8	38.4	0
12-32	7.8	5.3	26.5	10.0	0.45	1.36	194.0	292.0	43.2	0
32-48	7.4	7.9	20.5	5.0	0.45	1.48	175.2	292.8	43.2	0
48-90	7.2	7.0	22.5	5.0	0.44	1.6	65.0	292.8	67.2	0
90-120	6.6	8.1	22.5	5.0	0.42	1.6	102.2	292.8	72.0	0
Soil series: Gopalpur, Highland; Location: Khalilnagar, Tala, Satkhira										
0-15	7.8	3.8	23.5	10.0	0.17	0.42	6.25	292.8	4.8	0
15-30	7.6	2.4	23.5	5.0	0.19	0.65	8.45	292.8	9.6	0
30-60	8.0	0.86	24.0	5.0	0.20	0.39	23.10	380.0	9.6	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Barisal, Medium highland; Location: Bastali, Rampal, Bagerhat										
0-15	7.3	24.6	15.5	5.0	0.87	3.15	550.0	292.8	302.4	0
15-30	7.7	6.83	19.0	5.0	0.58	1.44	118.0	263.8	38.4	0
30-60	7.8	8.25	20.0	5.0	0.63	1.56	95.2	292.8	43.2	0
Soil series: Barisal, Medium highland; Location: Chila, Mongla, Bagerhat										
0-15	7.5	29.8	13.5	14.5	0.86	1.96	134.8	292.8	81.6	0
15-30	7.2	10.7	13.5	10.0	0.87	2.11	230.0	146.4	110.4	0
30-60	7.6	9.7	6.5	10.0	0.87	1.88	160.8	292.8	67.2	0
Soil series: Barisal, Medium highland; Location: Kamarkhola, Dacope, Khulna										
0-15	6.9	43.7	17.5	15.0	0.89	2.88	400.2	263.0	177.6	0
15-30	7.8	5.7	22.0	10.0	0.68	1.73	104.1	292.8	48.0	0
30-60	7.7	4.9	12.0	10.0	0.60	1.60	84.0	439.2	38.8	0
Soil series: Gopalpur , Medium highland; Location: Tulshidanga, Kalaroa, Satkhira										
0-15	8.0	1.25	34.0	5.0	0.27	0.64	15.4	292.8	4.8	0
15-30	8.0	0.88	36.0	5.0	0.25	0.49	5.5	292.8	4.8	0
30-60	7.8	0.88	34.0	5.0	0.20	0.44	4.0	380.0	9.6	0
Soil series: Gopalpur , Highland; Location: Keralkata, Kalaroa, Satkhira										
0-15	7.6	1.2	25.5	5.0	0.24	0.42	5.2	292.0	4.8	0
15-30	7.9	0.8	37.5	5.0	0.27	0.45	7.8	292.8	9.8	0
30-60	7.9	0.8	19.5	5.0	0.25	0.48	30.5	292.2	4.8	0
Soil series: Barisal, Medium highland; Location: Jalma, Batiaghata, Khulna										
0-15	7.4	4.1	18.5	5.0	0.37	0.91	103.0	298.0	4.8	0
15-30	7.8	1.3	21.5	5.0	0.38	0.65	73.3	146.4	91.2	0
30-60	7.2	1.0	19.5	7.0	0.39	0.60	70.1	146.4	19.2	0
Soil series: Harta, Low land; Location: Gaola, Mollahat, Bagerhat										
0-15	4.9	17.3	26.5	20.0	0.78	2.38	597.2	292.8	129.6	0
15-30	5.4	14.0	31.5	15.0	0.71	2.37	488.1	292.8	134.4	0
30-60	5.2	20.5	26.0	5.0	0.75	2.40	500.0	292.8	158.4	0
Soil series: Harta, Medium lowland; Location: Kodalia, Mollahat, Bagerhat										
0-15	6.3	8.4	43.5	5.0	0.58	1.2	132.6	322.6	24.0	0
15-30	6.1	8.1	24.0	5.0	0.81	1.23	209.2	292.8	33.6	0
30-60	5.0	8.0	22.5	5.0	0.74	1.37	168.2	322.0	24.0	0
Soil series: Bajoa, Medium highland; Location: Shatgambuz, Sadar, Bagerhat										
0-15	7.2	20.1	19.0	8.0	0.50	2.1	95.7	146.4	197.2	0
15-30	7.7	11.0	22.0	7.0	0.38	1.6	87.4	292.8	72.0	0
30-60	7.8	8.7	12.5	8.0	0.38	1.5	112.8	292.8	24.0	0
Soil series: Jhalakathi, Medium highland; Location: Badal, Kachua, Bagerhat										
0-15	5.4	5.6	5.5	6.0	0.29	1.1	64.5	263.5	52.8	0
15-30	7.2	2.2	7.5	6.0	0.28	0.81	58.0	292.8	14.4	0
30-60	7.5	2.2	7.0	6.0	0.25	0.82	98.0	263.5	4.8	0
Soil series: Jhalakathi, Medium highland; Location: Dhansagar, Sharankhola, Bagerhat										
0-15	5.6	7.0	3.0	6.5	0.37	1.25	10.4	292.8	43.2	0
15-30	6.9	3.9	3.5	6.5	0.40	0.96	61.4	292.8	14.4	0
30-60	7.7	4.0	6.5	7.0	0.40	0.95	13.9	292.8	14.4	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Ghior , Medium highland; Location: Asagara, Terokhada, Khulna										
0-15	7.8	3.3	9.0	6.5	0.34	0.96	12.8	263.5	14.4	0
15-30	7.7	1.6	8.5	6.0	0.34	0.95	14.9	263.5	9.6	0
30-60	6.9	4.6	7.0	6.5	0.32	1.14	169.6	292.8	24.0	0
Soil series: Harta , Medium lowland; Location: Asagara, Terokhada, Khulna										
0-15	5.7	10.3	13.5	8.5	0.48	1.25	100.6	263.5	24.0	0
15-30	6.8	5.6	12.5	6.0	0.45	1.07	123.6	146.4	14.4	0
30-60	6.0	6.0	12.5	5.5	0.48	1.1	28.3	292.8	14.4	0
Soil series: Ghior, Medium high land; Location: Damodar, Fultala, Khulna										
0-15	6.2	5.3	11.0	6.5	0.32	1.07	28.9	322.0	24.0	0
15-30	7.0	4.3	16.0	7.5	0.36	1.05	26.7	292.8	24.0	0
30-60	7.0	4.5	15.0	8.5	0.35	1.01	27.2	292.8	24.0	0
Soil series: Ghior, Medium high land; Location: Sagardari, Keshabpur, Jessore										
0-15	7.6	1.9	22.5	10.0	0.42	1.59	32.1	146.4	14.4	0
15-30	7.5	1.4	38.0	5.0	0.42	0.55	23.2	292.8	4.8	0
30-60	7.8	0.6	24.5	5.0	0.50	0.48	11.1	146.4	4.8	0
Soil series: Ishwardi, Medium high land; Location: Hakoba, Monirampur, Jessore										
0-15	7.4	1.1	18.5	5.0	0.74	0.39	11.4	298.8	9.6	0
15-30	7.8	0.8	33.0	5.0	0.20	0.39	6.0	292.8	4.8	0
30-60	7.5	1.2	17.5	10.0	0.13	0.47	11.7	263.5	4.8	0
Soil series: Ishwardi, Medium high land; Location: Shamlagachi, Sarsha, Jessore										
0-15	7.1	0.7	15.0	5.0	0.27	0.38	62.0	292.8	4.8	0
15-30	7.3	0.8	17.0	5.0	0.29	0.48	63.7	292.8	4.8	0
30-60	7.4	0.4	11.0	10.0	0.28	0.39	19.3	146.4	9.6	0
Soil series: Ishwardi, Medium high land; Location: Kushli, Tongipara, Gopalganj										
0-15	7.0	5.1	17.5	3.0	0.48	1.55	444.2	363.5	24.0	0
15-30	7.9	1.3	27.0	5.0	0.37	0.78	23.8	292.8	9.6	0
30-60	8.0	1.3	23.0	5.0	0.36	0.70	21.3	351.0	9.6	0
Soil series: Paisa , Medium low land; Location: Hiran, Kotwalipara, Gopalganj										
0-15	7.2	1.9	8.0	3.5	0.18	0.63	30.1	292.8	4.8	0
15-30	8.2	1.0	6.0	2.0	0.22	0.33	9.6	322.0	4.8	0
30-60	8.5	1.2	8.5	3.5	0.15	0.62	27.1	292.8	4.8	0
Soil series: Paisa , Medium low land; Location: Ghagor, Kotwalipara, Gopalganj										
0-15	7.0	0.7	8.5	3.0	0.25	0.60	23.7	363.5	4.8	0
15-30	7.3	0.6	10.5	3.5	0.24	0.61	19.8	292.8	4.8	0
30-60	7.4	0.6	6.5	2.5	0.22	0.30	17.5	292.8	4.8	0
Soil series: Paisa , Medium low land; Location: Amtali, Kotwalipara, Gopalganj										
0-15	6.6	0.6	4.0	1.5	0.18	0.34	28.4	292.8	4.8	0
15-30	6.9	0.5	4.0	1.5	0.15	0.31	8.4	322.0	9.6	0
30-60	7.3	0.4	4.5	1.5	0.33	0,26	10.0	409.9	9.6	0
Soil series: Magra , Medium low land; Location: Kajulia, Sadar, Gopalganj										
0-15	6.7	1.5	6.5	2.6	0.38	0.55	31.1	292.8	9.6	0
15-30	6.7	1.7	7.0	2.5	0.21	0.61	31.4	292.8	9.6	0
30-60	7.0	1.7	8.5	2.5	0.30	0.57	31.3	409.9	4.8	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Magra , Medium low land; Location: Majhigati, Sadar, Gopalganj										
0-15	6.4	1.8	7.5	3.5	0.23	0.55	60.8	292.8	9.6	0
15-30	7.5	0.7	11.5	3.5	0.22	0.45	14.2	322.0	4.8	0
30-60	7.7	0.6	11.5	3.5	0.23	0.41	13.8	292.8	4.8	0
Location: Bashkhali,Chittagong; GPS coordinate: N21º55´33.7" E91º56’33.7"										
0-10	6.1	21.8	2.5	15.0	2.25	19.0	172.3	146.2	307.2	0
10-15	6.1	14.7	2.0	9.0	1.75	15.0	141.7	146.4	177.6	0
15-26	6.1	16.6	2.5	9.0	1.6	13.5	147.4	292.8	158.4	0
26-50	6.7	10.9	3.0	9.5	1.55	13.0	121.4	292.8	105.6	0
50-75	6.9	9.2	3.5	10.0	1.6	11.5	108.1	263.5	81.6	0
75-100	7.0	10.3	3.5	12.0	1.5	11.2	105.7	263.5	110.4	0
100+	7.1	12.0	4.0	12.5	1.45	12.5	103.2	292.8	67.2	0
Location: Anwara,Chittagong; GPS coordinate: N22º19’16.3" E91º51’20.7"										
0-15	6.7	26.5	6.0	14.0	1.3	16.5	189.3	292.8	312.0	0
15-45	6.9	4.7	2.5	6.0	0.75	5.5	58.3	292.8	24.0	0
45-60	6.6	5.1	4.0	8.5	0.65	5.0	48.0	146.4	33.6	0
60-80	6.6	6.2	3.5	8.5	0.65	5.5	53.2	146.4	43.2	0
80+	6.8	4.9	2.5	6.5	0.55	3.5	39.3	292.8	24.0	0
Location: Chakaria, Cox’s Bazar (Acid Sulphate soil) GPS coordinate: N21º55’33.7" E91º56’33.7"										
0-10	4.4	11.6	3.5	12.0	0.9	11.0	290.7	380.3	100.8	0
10-15	4.3	7.3	3.0	8.0	0.85	8.0	300.1	292.8	48.0	0
15-35	3.9	7.5	2.0	6.5	0.7	7.5	285.8	322.0	48.0	0
35-50	3.7	10.5	1.5	7.0	0.60	8.5	174.7	292.8	57.6	0
50-75	3.3	14.0	1.5	6.5	0.18	10.0	187.1	146.4	91.2	0
75+	2.8	20.1	1.0	14.0	0.07	7.5	169.0	146.2	259.2	0
Location: Maheskhali, Cox’s Bazar; GPS coordinate: N21º45’39.1" E91º54’57.1"										
0-2	5.9	37.8	10.0	35.0	2.0	30.5	192.5	292.8	364.8	0
0-15	5.2	35.1	4.0	22.5	1.9	21.51	184.4	292.8	120.0	0
15-30	6.6	5.8	1.0	7.0	0.67	10.0	97.3	322.0	115.2	0
30-60	6.7	11.0	1.5	7.5	1.5	12.0	116.5	146.4	33.6	0
60+	6.7	9.9	2.0	8.0	1.65	13.0	110.1	292.8	153.6	0
Location: Pekua, Cox’s Bazar; GPS coordinate: N21º49’35.3" E91º58’08.6"										
0-10	4.7	5.0	3.0	6.0	0.5	4.5	97.1	292.8	38.8	0
10-15	6.0	2.4	2.5	5.5	0.55	3.5	41.7	146.4	19.2	0
15-35	7.5	2.6	3.0	8.0	0.95	4.5	26.4	292.8	33.6	0
35-50	7.6	1.3	3.0	8.5	1.15	5.0	23.6	351.3	33.6	0
50-75	7.6	2.5	2.5	8.0	1.25	5.0	24.1	292.8	4.8	0
75+	7.4	2.3	3.0	8.0	1.3	6.5	24.7	322.0	9.6	0
Medium highland; Location: Dumki, Patuakhali										
0-15	6.3	1.0	9.5	6.0	0.2	0.36	42.2	146.4	28.8	0
15-30	7.4	1.0	10.0	5.5	0.24	0.37	90.0	292.8	134.4	0
30-60	7.9	0.5	11.0	5.5	0.24	0.34	11.2	146.4	14.4	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Medium highland; Location: Dumki, Patuakhali										
0-15	5.4	4.7	8.5	4.5	0.25	0.41	271.3	292.8	19.2	0
15-30	7.0	1.2	11.5	5.0	0.26	0.39	84.3	292.8	9.6	0
30-60	7.2	1.6	11.0	5.5	0.29	0.41	127.4	146.4	19.2	0
Medium highland; Location: Sadar, Patuakhali										
0-15	8.1	4.1	12.0	5.0	0.31	0.33	17.7	146.4	24.0	0
15-30	6.4	4.1	10.5	11.0	0.32	1.45	374.5	146.4	96.0	0
30-60	5.0	4.5	17.5	9.0	0.39	1.85	387.7	439.2	24.0	0
Medium highland; Location: Amatali, Borguna										
0-15	7.4	1.1	21.0	2.5	0.24	0.70	67.5	322.0	19.2	0
15-30	7.9	1.0	23.5	3.0	0.16	0.37	54.3	292.8	14.4	0
30-60	8.2	1.0	16.0	4.5	0.18	0.34	20.1	146.4	9.6	0
Medium highland; Location: Amatali, Borguna										
0-15	4.9	6.6	7.0	5.0	0.21	1.7	374.4	146.4	19.2	0
15-30	6.4	4.8	7.0	7.0	0.30	2.25	319.5	292.8	9.6	0
30-60	6.5	5.4	7.0	8.0	0.55	2.45	379.8	204.9	14.4	0
Medium highland; Location: Kalapara, Patuakhali										
0-15	5.3	3.8	4.0	6.0	0.5	2.3	201.4	292.8	24.0	0
15-30	7.0	2.4	4.9	7.0	0.61	0.66	167.3	439.2	14.4	0
30-60	6.9	4.3	3.5	6.5	0.47	0.78	99.9	292.4	24.0	0
Medium highland; Location: Kalapara, Patuakhali										
0-15	4.8	6.7	2.0	2.0	0.32	2.5	258.9	292.8	33.6	0
15-30	7.1	2.9	2.5	3.0	0.43	2.4	123.8	292.8	24.0	0
30-60	7.5	3.8	2.0	3.0	0.55	2.7	81.7	292.8	14.4	0
Medium highland; Location: Kalapara, Patuakhali										
0-15	6.5	9.1	6.0	5.0	0.87	3.4	124.8	263.8	86.4	0
15-30	7.4	4.3	5.5	4.5	0.34	2.55	50.1	380.3	28.8	0
30-60	7.8	3.9	5.0	5.0	0.44	2.3	35.7	146.4	19.2	0
Medium highland; Location: Sadar, Borguna										
0-15	6.9	3.8	4.0	3.0	0.24	1.85	62.4	322.0	14.4	0
15-30	7.4	1.1	4.0	3.5	0.31	1.65	34.2	292.8	9.6	0
30-60	7.9	1.3	4.5	3.5	0.40	1.85	15.8	322.0	19.2	0
Medium highland; Location: Sadar, Borguna										
0-15	4.9	4.6	8.5	5.0	0.29	1.05	350.1	322.0	9.6	0
15-30	6.0	2.1	10.5	5.0	0.25	0.50	249.8	380.3	14.4	0
30-60	6.4	2.6	10.5	5.5	0.39	1.15	240.9	292.8	19.2	0
Medium highland; Location: Sadar, Borguna										
0-15	5.4	1.1	8.5	3.5	0.17	0.70	61.9	146.4	14.4	0
15-30	6.9	0.6	9.5	4.0	0.23	0.80	21.7	351.3	9.6	0
30-60	7.1	0.9	9.5	5.0	0.43	0.95	20.9	292.8	14.4	0
Medium highland; Location: Sadar, Borguna										
0-15	5.1	1.9	11.0	3.0	0.25	0.70	158.6	380.6	14.4	0
15-30	6.5	1.1	13.5	3.5	0.13	0.75	31.8	292.8	9.6	0
30-60	7.1	1.3	14.5	4.5	0.25	1.0	48.1	292.8	24.0	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Medium highland; Location: Betagi, Borguna										
0-15	5.7	1.5	10.0	2.5	0.29	0.70	99.8	263.8	24.0	0
15-30	7.1	1.0	11.0	3.0	0.20	0.60	23.3	292.8	19.2	0
30-60	6.3	1.1	11.5	3.0	0.24	0.70	54.8	292.8	14.4	0
Medium highland; Location: Betagi, Borguna										
0-15	8.1	1.5	19.5	2.0	0.17	0.85	26.1	292.8	14.0	0
15-30	8.2	1.1	19.5	1.5	0.17	0.60	13.4	146.4	9.6	0
30-60	4.8	1.5	6.0	3.0	0.30	0.55	114.4	146.8	1.4	0
Medium highland; Location: Galachipa, Patuakhali										
0-15	6.2	1.1	7.0	3.0	0.16	1.1	27.7	263.8	9.6	0
15-30	7.7	0.7	8.0	3.5	0.15	0.7	29.6	3292.	14.4	0
30-60	4.6	5.5	5.0	4.5	0.25	1.35	364.7	263.8	9.6	0
Medium highland; Location: Galachipa, Patuakhali										
0-15	7.3	9.9	9.5	4.5	0.38	3.5	201.6	146.4	76.8	0
15-30	8.0	7.1	11.5	5.0	0.26	3.05	131.7	292.8	43.2	0
30-60	7.7	5.0	21.0	3.5	0.26	2.45	80.5	322.0	28.8	0
Medium highland; Location: Galachipa, Patuakhali										
0-15	8.1	5.1	8.0	5.5	0.42	1.75	212.8	146.4	14.4	0
15-30	5.0	4.2	9.0	7.0	0.44	195	139.7	292.8	14.4	0
30-60	6.3	4.2	8.0	6.5	0.45	2.35	216.3	292.8	19.2	0
Medium highland; Location: Patharghata, Borguna										
0-15	5.9	2.8	8.0	3.5	0.29	1.5	90.0	322.0	19.2	0
15-30	7.0	2.5	13.0	3.5	0.29	1.55	40.5	146.4	14.4	0
30-60	8.1	2.6	21.0	3.0	0.34	1.5	46.2	146.4	4.8	0
Medium highland; Location: Patharghata, Borguna										
0-15	5.2	1.1	4.0	1.5	0.14	1.5	17.4	146.4	4.8	0
15-30	7.4	0.5	7.5	4.5	0.13	0.95	6.2	322.0	9.6	0
30-60	7.5	0.6	6.5	4.5	0.15	0.80	4.6	292.8	4.8	0
Medium highland; Location: Dasmina, Patuakhali										
0-15	7.7	2.4	15.0	2.5	0.80	1.45	29.3	292.8	9.6	0
15-30	7.8	3.8	11.5	2.5	0.16	1.3	32.1	292.8	4.8	0
30-60	7.6	1.3	6.0	3.5	0.21	1.25	4.5	146.4	9.6	0
Medium highland; Location: Dasmina, Patuakhali										
0-15	6.8	0.9	7.5	2.5	0.17	0.75	8.7	292.8	4.8	0
15-30	6.9	0.7	10.0	4.5	0.13	0.75	5.3	292.8	4.8	0
30-60	7.1	0.8	7.5	4.5	0.18	0.90	12.0	292.8	9.6	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-15	4.8	9.5	17.5	20.0	0.35	1.22	214.0	292.8	72.0	0
15-30	7.7	5.0	65.0	30.0	0.37	0.93	91.4	585.6	28.8	0
30-60	7.7	5.5	35.0	15.0	0.46	1.02	80.7	292.8	19.2	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-2	5.8	23.1	35.0	50.0	0.44	2.14	372.7	292.8	24.0	0
0-10	5.7	10.2	15.0	25.0	0.38	1.44	276.9	439.0	81.6	0
10-30	7.9	3.8	27.5	25.0	0.37	0.92	71.2	439.2	19.2	0
30-60	8.1	4.4	55.0	20.0	0.37	0.90	49.6	585.6	24.0	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-2	7.1	31.5	32.5	30.0	0.58	4.0	168.0	292.8	523.2	0
0-10	7.5	15.3	10.0	20.0	0.37	1.89	131.6	292.8	177.6	0
10-30	8.2	2.7	20.0	5.0	0.24	0.70	61.0	585.6	14.4	0
30-60	8.2	6.4	22.5	5.0	0.27	0.98	63.3	292.8	33.6	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	7.1	17.2	15.0	50.0	0.57	1.92	138.3	439.2	153.6	0
10-30	8.0	5.1	30.0	5.0	0.50	1.05	93.2	292.8	28.8	0
30-60	8.0	5.1	32.5	30.0	0.59	1.14	89.3	585.6	28.2	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	5.7	0.6	38.0	5.0	0.26	0.19	4.4	585.6	9.6	0
10-30	8.1	0.7	35.0	15.0	0.32	0.24	15.1	292.8	9.6	0
30-60	8.2	1.1	30.0	15.0	0.34	0.32	6.9	585.6	4.8	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	7.0	8.1	12.5	5.0	0.27	1.1	171.0	292.8	52.8	0
10-30	8.0	4.1	22.5	10.0	0.30	0.88	70.6	292.8	19.2	0
30-60	8.2	4.4	37.5	10.0	0.26	0.78	53.2	292.8	24.0	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	7.4	0.6	15.0	5.0	0.12	0.30	12.5	292.8	4.8	0
10-30	7.9	0.6	22.2	5.0	0.14	0.13	5.8	439.2	4.8	0
30-60	8.2	0.7	35.0	10.0	0.19	0.19	8.8	292.8	9.6	0
Soil series: Hatia, Medium highland, Location: Noakhali										
0-10	8.0	0.8	17.0	10.0	0.21	0.54	34.6	292.8	4.8	0
10-30	8.1	0.7	35.5	20.0	0.29	0.49	21.4	263.0	9.6	0
30-60	8.2	0.8	6.5	20.0	0.35	0.47	19.4	292.8	4.8	0
Soil series: Hatia, Medium highland, Location: Noakhali										
0-10	6.9	2.2	40.5	20.0	0.29	0.49	19.7	292.8	9.6	0
10-30	7.8	0.5	39.5	40.0	0.35	0.37	11.1	292.8	9.6	0
30-60	7.8	1.0	8.5	7.5	0.22	0.44	10.6	292.8	19.2	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	5.9	9.5	10.0	11.0	0.31	1.38	210.0	292.8	52.8	0
10-30	7.8	2.7	14.5	14.0	0.38	0.98	46.0	585.6	14.4	0
30-60	7.9	4.2	16.5	10.0	0.45	0.99	44.6	292.8	33.6	0
Soil series: Chandina, Medium highland, Location: Noakhali										
0-10	5.6	1.0	5.0	7.5	0.11	0.44	8.5	292.8	14.4	0
10-30	6.2	0.5	4.5	15.0	0.08	0.34	16.0	292.8	9.6	0
30-60	7.7	0.6	9.5	17.5	0.35	0.57	19.6	585.6	9.6	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-10	5.6	1.2	9.5	15.0	0.36	0.63	27.4	585.6	9.6	0
10-30	7.1	0.7	8.0	20.0	0.33	0.54	10.8	585.6	9.6	0
30-60	7.7	0.7	9.5	17.5	0.35	0.57	19.6	585.6	4.8	0

Depth (cm)	pH	EC (dS/m)	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$SO_4^{=}$	HCO_3^{-}	Cl^{-}	$CO_3^{=}$
			Cmol/kg				ppm		Cmol/l	
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-11	7.8	4.8	17.0	17.5	0.40	1.37	74.0	292.8	43.2	0
11-14	7.9	6.5	16.5	12.5	0.35	1.1	53.4	292.8	19.2	0
14-30	7.8	14.5	17.5	20.0	0.50	2.0	99.0	292.8	48.0	0
30-70	8.1	2.6	20.5	8.5	0.28	0.81	35.1	585.6	14.4	0
70-110	8.0	2.2	26.5	15.0	0.36	0.95	35.4	292.8	9.6	0
110-120	8.4	2.2	24.5	15.0	0.48	0.95	47.4	292.8	9.6	0
Soil series: Ramgati, Medium highland, Location: Noakhali										
0-7	7.5	22.9	17.5	35.0	0.65	3.54	74.0	292.8	484.0	0
7-18	8.0	8.4	23.0	7.5	0.39	1.75	53.4	585.8	86.4	0
18-48	8.0	7.3	20.0	15.0	0.46	1.70	99.4	292.8	38.4	0
48-130	7.9	6.5	22.5	12.5	0.43	1.49	35.1	585.6	115.2	0
130-165	7.8	6.5	18.5	9.0	0.52	1.31	49.4	292.8	33.6	0
Soil series: Silonia, Medium highland, Location: Noakhali										
0-9	5.9	0.5	4.5	3.5	0.22	0.38	32.2	292.8	28.8	0
9-24	7.3	0.4	5.5	5.5	0.21	0.30	9.0	585.6	4.8	0
24-53	7.4	0.4	6.5	6.5	0.32	0.30	6.7	292.8	9.6	0
53-72	7.6	0.3	6.5	7.0	0.37	0.38	5.5	585.6	4.8	0
72-90	7.6	0.4	5.5	5.5	0.36	0.33	10.9	292.8	4.8	0
90-115	7.7	0.4	6.0	8.5	0.41	0.34	10.1	292.8	4.8	0
MHL, Location: Sikder Mallik, Pirojpur Sadar, Pirojpur, GPS coordinate: N21^{o}41’ E89^{o}57’										
0-10	7.7	5.0	-	-	-	-	-	292.8	19.2	0
10-30	7.9	2.0	-	-	-	-	-	409.9	9.6	0
30-60	8.1	3.8	-	-	-	-	-	322.0	9.6	0
MHL, Location: Galua, Rajapur, Jhalakati, GPS coordinate: N22^{o}31’ E90^{o}06’										
0-10	7.6	6.2	-	-	-	-	-	292.8	57.6	0
10-30	8.1	6.0	-	-	-	-	-	292.8	14.4	0
30-60	7.9	3.9	-	-	-	-	-	146.4	19.2	0
MHL, Location: Dhanisafa, Jhalakati, GPS coordinate: N22^{o}21’ E89^{o}57’										
0-10	5.9	6.2	-	-	-	-	-	146.4	24.0	0
10-30	7.4	6.0	-	-	-	-	-	322.0	14.4	0
30-60	7.1	3.9	-	-	-	-	-	146.4	9.6	0
MHL, Location: Tushkhali, Mathbaria, Pirojpur, GPS coordinate: N22^{o}21’ E89^{o}56’										
0-10	6.0	8.0	-	-	-	-	-	380.6	19.2	0
10-30	7.3	4.7	-	-	-	-	-	322.0	38.4	0
30-60	6.2	8.3	-	-	-	-	-	292.8	9.6	0
MHL, Location: Tikikata, Mathbaria,Pirojpur, GPS coordinate: N22^{o}15’ E89^{o}57’										
0-10	5.0	4.8	-	-	-	-	-	263.8	28.8	0
10-30	6.0	4.1	-	-	-	-	-	146.4	14.4	0
30-60	6.2	4.4	-	-	-	-	-	292.8	24.0	0

Appendix 6: General interpretation of ECe values.

Soil salinity class	ECe (dS/m)	Total salt content (%)	Crop reaction
Salt free (Non saline)	0-2	< 0.15	Salinity effects are mostly negligible
Very slightly saline	2-4	< 0.15	Salinity effects are mostly negligible except for the most sensitive plants
Slightly saline	4-8	0.15-0.35	Yields of many crops restricted
Moderately saline	8-15	0.35-0.65	Only tolerant crops yield satisfactorily
Strongly saline	>15	>0.65	Only very tolerant crops yield satisfactorily

Source: Bookers Tropical Soil Manual, 1991