Government of Bangladesh World Food Programme Government of the Netherlands

CHAR DEVELOPMENT & SETTLEMENT PROJECT II

CDSP-II

চর উন্নয়ন ও বসতি স্থাপন প্রকল্প ২

BANGLADESH

Agriculture in Southeastern Coastal Chars of Bangladesh

Technical Report No. 12

Volume 1

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and

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CDP
Consultants for Development Programmes

Haskoning
Royal Dutch Consulting Engineers and Architects

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Sheltech Consultants

Agriculture in southeastern coastal chars of Bangladesh

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Experiences and Guidelines for Development

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LIST OF ABBREVIATIONS/ACRONYMS

BRAC	: Bangladesh Rural Advancement Committee
BT	: Bandertila (Part of Nijhum Dwip)
CDSP	: Char Development and Settlement Project
DAE	: Department of Agricultural Extension
ha	: Hectare
HYV	: High Yielding Variety
IPM	: Integrated Pest Management
kg/ha	: Kilogram per hectare
LRP	: Land Reclamation Project
MAA	: Muhuri Accreted Area (Project site)
MP	: Muriate of Potash
NARS	: National Agricultural Research Stations
ND	: Nijhum Dwip (Project site)
NGO	: Non-Government Organization
CL	: Char Lakshmi (Project site)
MD	: Char Maradona (Project site)
RDC	: Resource Development Centre
SH	: South Hatiya (Project site)
SRDI	: Soil Resource Development Institute
t/ha	: Ton per hectare
GT	: Char Torabali-Gangchil (Project site)
TSP	: Triple Superphosphate

Chapter 1 An overview of Coastal agriculture and CDSP

1.1 Introduction

The coastal zone of Bangladesh is a dynamic and continuously changing environment, both in respect of human, physical and agroecological conditions. As more land accretes, landless people are attracted by newly emerging chars and start growing paddy and build their homesteads where it is only barely possible. With time, continuing accretion and protection of the seashore by mangrove forest plantation gradually make the living conditions safer and the agroecological conditions more favourable. Eventually, once the new land has attained a sufficient elevation, it may be empoldered, which creates a more secure and a more productive environment through protection from saline flooding and improved drainage, presenting new opportunities to farmers.

Polder development as undertaken under Land Reclamation Project (LRP), during the two phases of the Char Development and Settlement Programme (CDSP) and by other projects, has been shown to be reasonably profitable, and its cost efficiency can still be improved (Bol, 1999[4]). But empolderment is an expensive affair for which only limited financing is available. Besides, there are large areas where conditions are not yet favourable for embankment and which will remain partially or unprotected, but which are already inhabited. And finally, with continued accretion and empolderment, the hinterland is increasingly affected by drainage problems.

Because of these different conditions in the coastal zone, all with their specific problems and needs, CDSP, initially a 'polder project', was given the mandate during its second phase to cater, within its ability, for all of them. The overall objectives of CDSP-II were therefore to contribute to: (i) institutional development, (ii) accumulation of knowledge and (iii) direct improvements in the situation of the char population, i.e. in unprotected chars, polders and water-congested hinterland.

During the formulation of CDSP-II the programme's agriculture section argued that the coastal agro-ecological conditions, from the sea board to the hinterland, really form a continuum. The section wanted to contribute to the characterisation of these diverse coastal conditions and, through the Department of Agricultural Extension (DAE), target the most appropriate interventions and technologies for each combination of agroecological conditions (esp. salinity, landclasses, drainage). No *a priori* distinction was made between protected and unprotected areas: their differences would be largely expressed through the differences in these conditions. And finally, in the context of the programme's institutional development objective, the section was expected to assist DAE in the development of its capacities to target the char people.

[4] Bol, D. 1999. The cost and benefits of char development. Technical Report # 26, CDSP.

Because of this much broader mandate, compared to CDSP-I, it was logical that the programme was requested to bring together its findings at the end of CDSP-II in a document about 'Agriculture in the Coastal Areas of Bangladesh', containing its accumulated experience as well as guidelines for future development. The document should have relevance for any agency involving itself in coastal agriculture and can therefore be seen as one of CDSP-II's contributions to 'Integrated Coastal Zone Management'

Like coastal agriculture itself, this document should be 'dynamic'; it should be updated as more experience accumulates. That is especially true for the agroecological characterisations, because they change continuously. It also applies to the technologies which can be disseminated in the coastal area, because old ones will get discarded as new ones are developed. This will be reflected in the format of the final version of this document, once it is completed by the middle of 2005. The chapter about appropriate technologies will also be published as a loose-leaf **Technology Sourcebook**, which can be continuously updated as the need arises.

A number of gaps remain in this preliminary version of the 'Coastal Agriculture' document. Annex-II lists these gaps and recommends the actions to be taken in the coming year to fill them.

1.2 Background of the CDSP programme

Coastal charland is the result of the dynamic phase of land development along the coast (land facing the sea) forming an integral part of the land. This young deposition of alluvial soil is subjected later to natural compaction over time and emerges as specialized habitat for certain halophytic flora and fauna. This is the most vulnerable ecosystem characterized by tidal flooding, salinisation, threat of cyclones and storm surges and a variety of socio-economic imbalances. Development of coastal chars is a dynamic process that leads to considerable variation in the ecosystem in its different stages of development. At a certain point, a stage is reached when it becomes inhabitable and fit for other forms of land use. That is when land-hungry people move in, build their homesteads and start producing paddy.

Out of 2.83m ha land in the 13 coastal districts of Bangladesh, about 0.84m ha are affected by varying degrees of soil salinity (Karim & Iqbal, 2001[5]). Factors contributing to continued soil salinity, even after the land has risen above the average high tide level, are: (a) tidal flooding during spring tides, (b) direct inundation by saline or brackish water after storm surge, (c) wilful inundation with saline and brackish water for shrimp farming, and (d) possible intrusion of saline sea water in the groundwater which comes up on the soil surface due to capillary pull. Some preliminary investigation by BRRI and SRDI indicates that the saline groundwater front may be moving further from the coast inland due to over-extraction of groundwater for boro cultivation in the hinterland.

Agriculture remains the principal sources of income of the farmers of these areas. About 90% of the households are directly or indirectly dependent on agriculture for

[5] Karim, Z. and A. Iqbal (ed.). 2001. Impact of land degradation in Bangladesh: Changing scenario in agricultural land use. Bangladesh Agricultural Research Council, Farmgate, Dhaka. 106p.

their livelihood. The physical, biological and social vulnerabilities limit the development of agriculture and the livelihood of coastal communities presents a great challenge for the development effort in the char areas.

Since its inception in 1995 the agricultural section of the CDSP-I project concentrated on the provision of extension services, as well as monitoring of salinity conditions and land use in three polders. CDSP was preceded by the Land Reclamation Project (LRP) which spent about 14 years to generate useful information related to soil salinity and production potential of crops in the coastal area through research carried out in a 40-ha research farm located in their polder CBD-I close to the river Baggar Dona in Noakhali sadar (see Fig.1). CDSP tried to extrapolate their findings to three newly empoldered areas, CBD-II, CBT and CM, of the Noakhali main land. In its second phase (1999 to 2004), the project (called CDSP-II) extended from the protected to a number of unprotected areas scattered over the region.

1.3 The Programme area

CDSP-II extended its operations from the three char areas protected under CDSP-I to the protection of another two areas as well as activities in a number of already protected and unprotected sites in the coastal region of Noakhali, Feni and Chittagong districts (see Fig. 1 and Table 1). CDSP-II started its activities in 13 project sites in between the Meghna and Feni rivers that cover around 27,000 ha in the districts of Chittagong, Feni, Noakhali and Lakshmipur (Fig. 1). Of the 13 areas mentioned, six are protected and the rests are unprotected (outside the polder). CDSP-II concentrated its efforts to improve agricultural production in only seven out of these 13 project sites. These areas are Mora Dona (MD), Char Lakshmi (CL) and Char Gangchil-Torabali (GT) under Sadar and Companiganj, South Hatiya (SH), Bandartila/Nijhum Dwip (BT) and Char Osman/Nijhum Dwip (CO) under Hatiya upazila of Noakhali district; and Muhuri Accreted Area (MAA) that covers part of Sonagazi upazila of Feni and Mirsharai upazila of Chittagong district (yellow colored areas in Fig. 1). The location and some information about the areas of each project site are shown in Table 1.

1.4 The CDSP-II agriculture programme

1.4.1 Goal and objectives

During the initial stage of CDSP-II more attention was given to characterize the ecosystem of the new areas together with collection of baseline information on various factors related to agricultural development. Subsequent activities were focussed to improve agricultural production through agricultural extension activities of various forms. More specifically studies were undertaken to:

- understand the situation of agriculture in the study areas with respect to agriculture, water management, land use and socio-economic conditions;
- characterize the ecosystem in terms of soil, climate, crops and other environmental parameters;
- prepare a document about Coastal Agriculture which will be of wider interest for other agencies and projects

- generation, acquisition, testing and tailoring of potential agricultural technologies;
- develop of an adoptable system of crop production; and
- improve socio-economic condition of the people of the coastal char areas in a sustainable way.

Table 1. Project locations, area and population

Project area	District & Upazila	Union	Mouza	Area (ha)		Popul-ation
				Total	Cultiv-ated	
MD	Noakhali, Sadar	Char Bata Char Jubilee	Char Majid Paschim Char Bata Purba Char Bata Dakshin Char Majid Char Mohiuddin Kachhyapia Char Ziauddin	1729	1120	15,652
CL	Noakhali, Sadar	Char Amanulla Char Clerk	Keramatpur Char Torabali Char Lakshmi Dakshin Char Clerk Hazipur Char Langulia	1128	606.7	5,978
GT	Noakhali, Sadar Companiganj	Char Clerk Char Elahi	Char Torabali Gangchil Char Elahi	743	725	1,831
SH	Noakhali, Hatiya	Sonadia Burirchar Jahajmara	Sonadia Bordail Natun Sukchar Mecpharsion Purbo Char Birbiri Muktaria Mohammadpur	2755	1460	18,307
CO	Noakhali, Hatiya	Jahajmara	Char Osman	520	449	4,742
BT	Noakhali, Hatiya	Jahajmara	Bandertila (unsurveyed)	652	561	5,961
MAA	Chittagong, Mirsharai Feni, Sonagazi	Ichakhali Osmanpur Sonagazi	Paschim Ichakhali Uttar Ichakhali Companinagar Banskhali Thak Khoajer-lamsi	1919	1765	3,150

Sources of data: 1) Total area : Scanned from map
2) Cultivated area & population : RDC

Map of the CDSP II Project Area

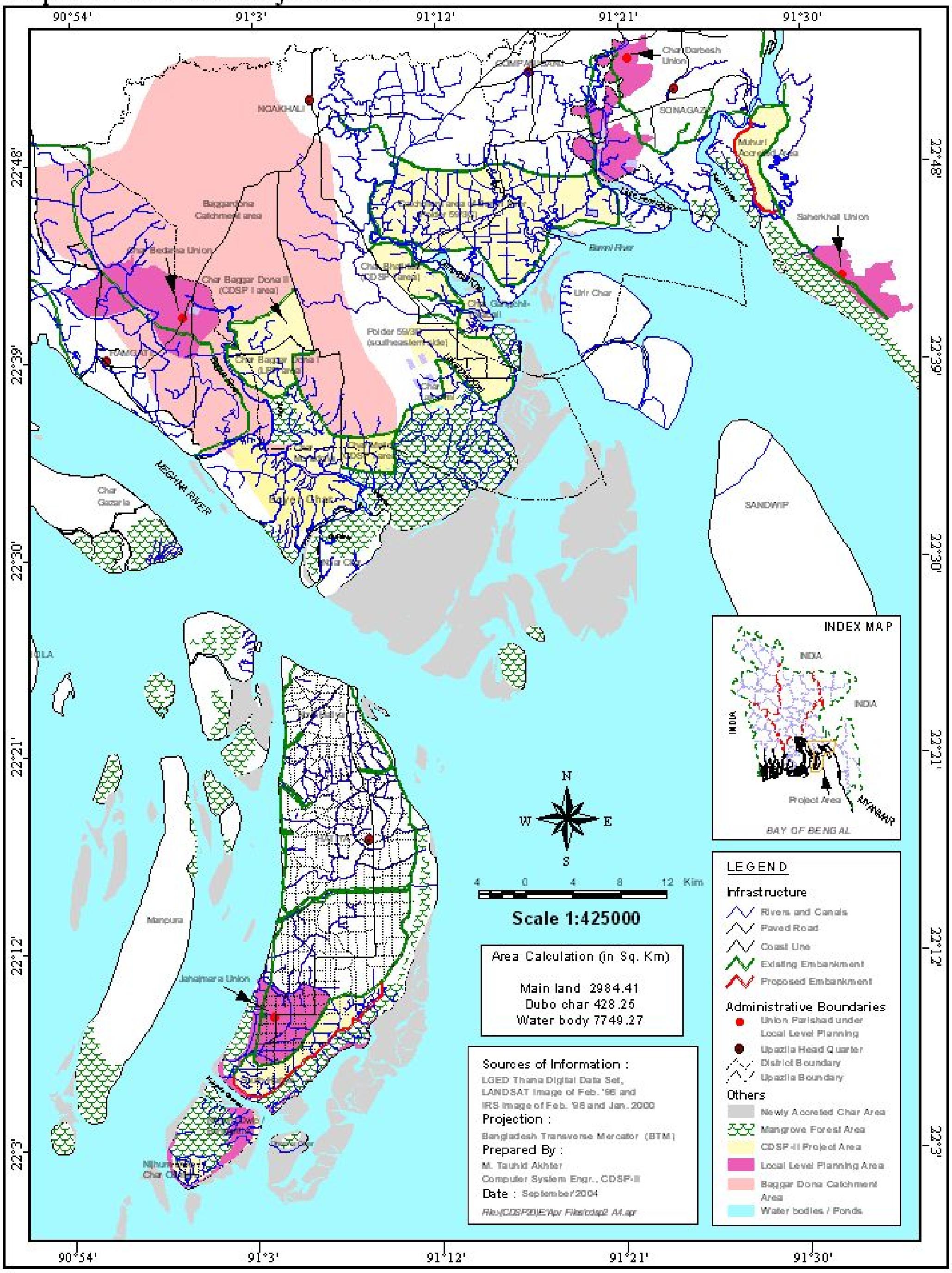

Fig. 1. Map showing CDSP-II project areas.

1.4.2 Approaches

The Char Development and Settlement Project -II (CDSP-II) started working in the project areas to improve the economic life of the char people. In the absence of various types of entrepreneurs in the coastal char areas, especially in the early phases, the direct economic development here solely depends on the development of agricultural production. Agricultural production, in turn, is related to a number of factors -- physical, biological and socio-economic-- that interplay and generate a possible output. In order to understand this complex relationship of the environment CDSP-II spent sufficient time during its early phase to analyse the agro-ecological environment of the newly expanded project sites, which was discussed at length by Sattar (2002)[6]. These analyses provided the department of agricultural extension (DAE) with a starting point and guided them for targeting technologies for a particular agro-ecological zone so as to achieve the maximum possible farm output.

DAE started massive agricultural extension work during the second half of the project period, which strengthened the extension activity already started by the project staff in collaboration with the DAE field staff since the year 2000. Moreover, they continued with the activities related to identification, testing and demonstration of proven technologies to the farmers of the project areas.

The project also continued its effort to seek answers to the various problems related to dynamics of soil salinity and aspects of management of water and soil salinity vis-à-vis for better understanding of crop-soil-water management in the saline coastal ecosystems.

This report elaborates the agricultural development that took place in the project areas as a result of the CDSP-II interventions. The report also brings together the key findings of CDSP on agriculture in the coastal char areas since the programme's inception in 1995 and elaborates guidelines for future agricultural development from a technical and an institutional perspective. Therefore, this report takes the shape of a final report combining relevant issues presented in all the previous interim technical reports. The document targets audiences at three levels:

- local development workers, in particular DAE and agriculturally oriented NGOs who need recommendations on appropriate technology for dissemination in the area;
- research institutes who will find ideas and recommendations for on-farm testing of improved technology for these ecosystems;
- decision makers at regional and national levels as well as donors who should take into account the lessons learned by CDSP about the necessity of an effective institutional cooperation.

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[6] Sattar, S. A. 2002. Agriculture in CDSP-II project areas. Technical Report No. 5 (Vol. 1 & 2). CDSP-II.

Chapter 2 Agro-ecological Environment

2.1 Introduction

The physical features that interact and support crop growth as well as promote agricultural growth is regarded as the agro-ecological environment. The physical features include abiotic factors like land type, properties of soil and climate, and biotic factors such as flora and fauna of the area. However, land type and climate largely determine the type of biotic compositions of an area. Since the variation in climatic parameters over the broader areas covering all project sites is small, the discussion will apply for all project sites. On the other hand, significant variations in other ecological parameters are observed among the project sites, and thus, are discussed at length in the relevant sections.

2.2 Climate

While climatic conditions determine the dominance of certain plant species in a given area, the weather conditions largely determine the performance of a crop. Weather also dictates the type of management to be given to a specific crop and or a variety for better exploitation of its genetic yield potential.

Among the weather elements, solar radiation in the tropical country is not considered as limiting although occasionally it comes down to as low as 100 kcal/day during a heavy overcast day in the rainy season. Therefore, the choice of a crop/variety and its associated management practices, such as time of planting, fertilization, pest control and water management, is very much dependent on rainfall and temperature (minimum and maximum) even within the same cropping season. Daily weather data obtained from the nearby meteorology stations for the period 1953 to 2002 are used to characterize climatic conditions of the project areas. Data of other locations along the coast are also presented for showing regional variations, if any, in the coastal region. Seasonal variation in the depth of groundwater table in CDSP-I areas have also been used to visualize the crop water management for the new project sites.

2.2.1 Temperature

There are two distinct thermal zones, cool winter and high temperature summer, prevailing in the country and the coastal region is not an exception in this regard. Monthly mean maximum and minimum temperatures of the two locations in the northeastern coastal region are in Table 2. Mean monthly temperatures do not vary much between the locations. But annual variations exist both in the maximum and minimum temperatures; the magnitude being much higher at Hatiya, which is more close to the main sea, than at Maijdee court as is evidenced from the higher standard deviations. Unlike other parts of the country, coastal region in general experiences relatively higher night temperature during the winter months (Fig. 2), which is above the critical level (10^{o} C) of plant growth. However, southwestern coastal region (Khulna) is hotter during the summer and also cooler in the winter than the southeastern coast (Maijdee and Sonagazi). The average day temperature during summer is more or less the same (around 33° C) throughout the country. The hottest months are April and May and the temperature never exceeded 35° C as is observed elsewhere in the country. The influence of these climatic parameters on productive potential of crops has been discussed in Chapter 4.

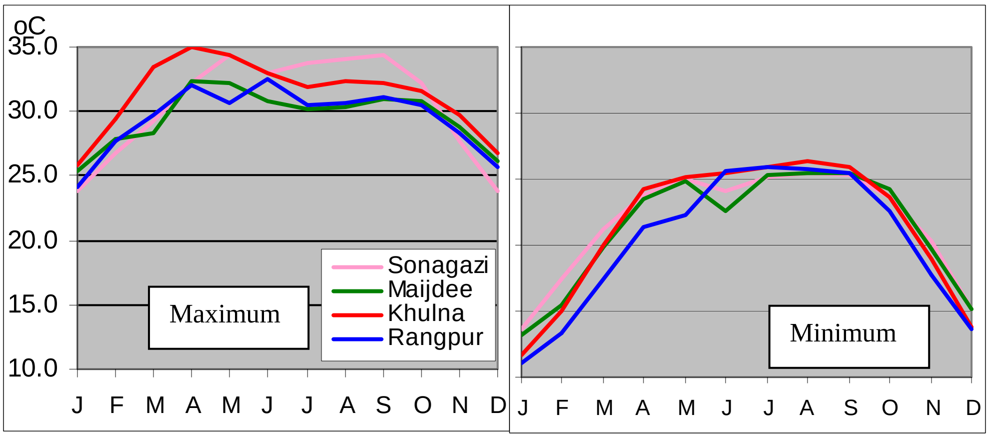

Fig. 2. Monthly mean temperatures at the northern (Rangpur) and three southern coastal locations.

2.2.2 Rainfall

The distribution pattern of monthly total rainfall of regions does not vary much (Fig. 3) but the southeastern coastal region (Sonagazi and Maijdee) receives much higher rain than the southern (Barisal) and south-western (Khulna) regions. The distribution, in most cases, is unimodal with a peak in July. Most rainfall occurs during monsoon (June to September) all over the country but late rain (until October & November) is a common feature of the coastal region. The total amount of annual rainfall is high in the southeastern coastal region, usually it exceeds 3000 mm while in the western region it is below 3000 mm (Table 3). The cropping seasons are largely determined by the pattern of rainfall distribution and have been clearly shown in Fig. 3. A frequency analysis of rainfall using historical weather data for Noakhali and Hatiya (between 1953 to 2003) has also been carried out. The implications of these rainfall patterns on crops and cropping practices have been dealt with in Chapter 4

2.3 Soils of the coastal chars

Soil is the storehouse of plant nutrients. Plants have to extract these continually but they cannot be taken up in the form they are normally present in the soil. They have to undergo natural transformation, which occurs under the influence of certain physical, chemical and biological characteristics of the soil. In order to assess the productive potential of soils, these characteristics have to be clearly understood.

One of the major characteristics of coastal soils is salinity, its annual cycle, spatial variation and long-term trends. Because of the importance of soil salinity, a detailed discussion is needed and thus a separate section has been devoted to it.

Table 2. Monthly mean temperatures (^{o}C) of Maijdee court and Hatiya (mean of 1953 to 2002)

Month	Maijdee court						Hatiya					
	Maximum			Minimum			Maximum			Minimum		
	Range	Mean	σ	Range	Mean	σ	Range	Mean	σ	Range	Mean	σ
Jan	23.1-27.3	25.3	0.82	10.7-15.2	13.2	1.02	23.8-26.7	25.2	0.72	11.7-16.7	14.5	1.24
Feb	25.4-30.3	27.9	1.18	12.4-18.5	15.5	1.36	25.4-29.3	27.5	0.97	12.1-19.0	16.8	1.40
Mar	23.1-32.9	28.4	2.60	16.0-22.8	19.9	1.49	28.8-32.1	30.6	0.86	19.6-25.5	21.4	1.19
Apr	29.5-34.8	32.4	0.95	21.0-25.8	23.5	1.04	30.0-33.6	31.8	0.91	23.0-27.6	24.1	0.97
May	30.2-34.5	32.3	0.91	23.2-26.6	24.9	0.84	30.1-33.6	31.8	0.80	22.9-26.7	25.0	0.98
June	28.7-33.5	30.8	0.98	23.8-27.4	22.5	0.70	28.5-32.0	30.3	0.76	24.1-28.3	25.6	0.84
July	28.7-31.4	30.2	0.70	23.9-26.2	25.4	0.54	28.9-30.5	29.9	0.38	23.5-26.2	25.4	0.58
Aug	28.5-32.4	30.4	0.74	23.5-26.3	25.4	0.61	28.9-31.5	30.0	0.62	23.4-26.7	25.4	0.64
Sep	29.4-32.6	30.9	0.76	23.9-26.4	25.4	0.50	28.6-31.5	30.4	0.69	22.6-26.2	25.1	0.79
Oct	29.1-32.5	30.8	0.83	22.9-25.8	24.3	0.65	28.6-31.7	30.6	0.69	21.1-25.5	24.2	1.02
Nov	26.7-31.0	28.8	0.91	16.8-23.9	19.8	1.70	27.5-30.8	28.9	0.76	18.4-25.5	20.8	1.68
Dec	24.5-27.7	26.1	0.82	11.6-23.9	15.1	1.79	24.3-27.2	25.8	0.87	14.2-25.5	16.2	2.11

2.3.1 Sampling and analyses

Soil samples were collected in the project areas for initial site characterisation from each intersection of 500x400m grid during 2000 and 2001. All samples were analysed for soil salinity while every tenth sample was analysed for pH, organic matter and nutrient content. Since the entire region appears to be uniform with regard to soil texture, the textural analyses were done on one sample each from GT, CO, BT, CBT and CBD-II. Collection and analysis of soil samples were carried out by the SRDI, Gazipur. Since the soils have pH higher than 7, Olsen's method was followed to determine available phosphorus. For all other analyses standard laboratory procedures were used. For sampling procedures and salinity measurements, see Annex I.

Table 3. Total annual rainfall at three locations in the coastal chars of Noakhali and at Maijdee (mean of 1999 to 2003 data)

Location	Rainfall (mm)
CBT	3516
CBD-II	3260
CM	3688
Maijdee court	3005
Khulna	2234

2.3.2 Soil morphology, texture and structure

The physiography of the Noakhali coastal region is estuarine floodplain, which is part of the Young Meghna Estuarine Floodplain (AEZ 18). The land is almost level with very large basins. The soils are stratified grey and calcareous. Coastal chars are formed as a result of alluvial deposition of silt and clays. The soils are young without differentiated horizons. Mechanical analyses of the coastal soils show that they are mostly heavy textured varying from silty clay loam to silty clay (Table 4). In general, coastal soils are almost devoid of sand.

Such soil texture is characterized by high moisture retention capacity and low permeability. An analysis carried out by LRP in CBD-I (Groot, 1995[7]) showed that soil moisture is at 50 volume% up to pF 2 (pF 2 corresponds with a groundwater table at 1m). Further downward movement of the water table to 3 m (pF 2.5) only results in a decrease of equilibrium moisture retention to 30 – 40%. Upward movement due to evaporation will usually exceed downward movement due to a decreasing water table. This results in salt accumulation in the topsoil in the dry season unless evaporation is reduced by special measures, such as tillage and/or a soil cover.

2.3.3 Organic matter

After deposition coastal soils undergo gradual development through the addition of organic matter that comes from droppings of grazing animals, natural vegetation and/or crop residues. Indiscriminate removal of these materials renders the soils of Noakhali low in organic matter (OM). The situation is further aggravated by the collection of droppings of the grazing animals by the char people who use them as fuel (Fig. 5). As a result, organic matter (OM) content of soils is low, ranging from

[7] Groot, J.M., 1995. Mission Report No. 12, Land and Water Engineering, CDSP, Noakhali.

0.86 to 2.44% in the topsoil and from 0.93 to 2.02% in the subsoil (Table 5). No major differences in OM content are observed among the sites. Successful crop production would require judicious application of OM, to raise the OM content up to at least 2.5%.

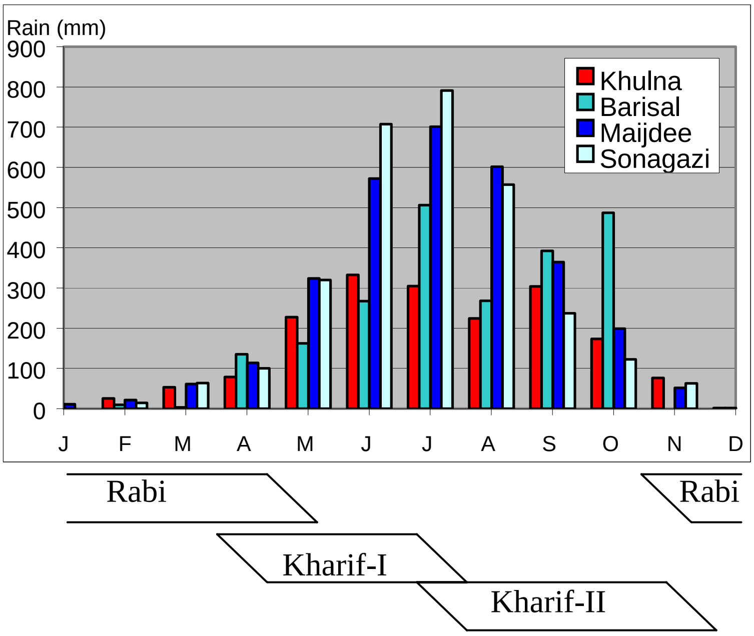

Fig. 3. Monthly total rainfall at four locations in the coastal region and its relation with the cropping seasons.

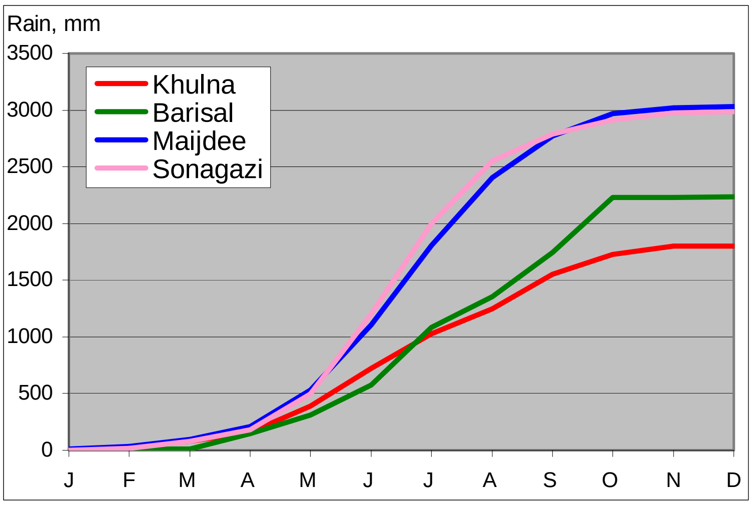

Fig. 4. Cumulative rainfall at four locations in the coastal region

2.3.4 Soil reaction

Topsoil of Muhuri Accreted Area, South Hatiya, Bandartila and Gangchil-Torabali is mostly near neutral to slightly alkaline while sub-soils are mostly alkaline, with only few samples having values below 8.0 (Table 5).

Table 4. Average textural classes of the Noakhali coastal soils

Name of char	Percent of			Textural class
	Sand	Silt	Clay	
CBT	2	73	25	Silt Loam
CBD-II	1	78	21	Silt Loam
BT	4	73	23	Silt Loam
CO	2	69	29	Silty Clay Loam
GT	1	67	32	Silty Clay Loam

Fig. 5. Cowdung prepared for use as kitchen fuel

Among the sites of Noakhali mainland, soils of MD and CL are mostly alkaline; the topsoils are more alkaline (pH ranging from 8.0-8.7 at MD and from 7.8-8.5 at CL) than the subsoils. Induced nutritional imbalances often occur in such soils, particularly of zinc and phosphorus, due to their binding into an unavailable form.

Table 5. pH and organic matter (OM) content of soils of the project sites

	Topsoil				Subsoil			
Sites	pH		OM (%)		pH		OM (%)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
MAA	7.0-8.6	7.60	1.35-2.44	1.80	7.5-8.8	8.20	0.95-2.02	1.54
MD	8.0-8.7	8.26	1.01-1.55	1.39	7.5-8.5	8.32	0.94-1.52	1.27
CL	7.8-8.5	8.26	1.25-1.94	1.50	8.1-8.7	8.52	1.00-1.75	1.33
SH	7.1-8.8	8.11	0.86-1.68	1.36	7.5-8.8	8.36	0.93-1.45	1.20
GT	7.1-7.9	7.60	0.98-1.17	1.07	7.7-8.0	7.80	1.00-1.12	1.04
CO	7.5-7.7	7.60	1.23-1.63	1.39	7.7-7.9	7.80	1.08-1.44	1.29
BT	7.5-8.0	7.70	0.95-1.25	1.09	8.0-8.1	8.03	0.96-1.35	1.12

2.3.5 Soil fertility

Mean nutrient contents in the soils of seven chars are shown in Table 6 (more detail in Annex-3), together with the levels considered as critical, optimum and high with respect to normal plant growth (BARC, 1997[8]). The P-figures look suspiciously low, which may be related to the analytical methods used. We will accept, however, that P-content is generally very low.

Table 6. Mean nutrient concentration in soils of the CDSP chars

Char	OM	TN	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
	(%)	(%)	ppm	----meq/100 g--------			------------------- ppm ----------------------------------					
	Topsoil											
MD	1.38	0.08	5.65	0.33	12.44	7.50	228.3	1.09	3.92	78.1	69.9	5.87
CL	1.50	0.05	5.16	1.83	11.33	8.08	309.4	1.10	5.39	70.0	67.5	1.74
GT	1.07	0.05	0.16	0.72	11.25	12.30	238.6		2.97	19.4	5.12	0.20
SH	1.36	0.11	6.78	0.52	14.06	13.71	214.4	0.99	4.53	65.9	140.0	6.22
CO	1.39	0.07	0.81	0.43	9.83	9.08	226.4		3.89	17.2	2.7	0.17
BT	1.09	0.05	2.79	0.69	10.58	12.00	197.7		2.37	23.7	5.9	0.14
MAA	1.80	0.04	11.09	0.52	9.40	7.33	110.7	1.07	5.78	93.0	146.7	1.74
CM				0.32	7.4	9.35	230.5		3.95	46.2	7.4	0.31
CBT				0.41	7.55	11.13	207.1		3.78	28.4	5.9	0.19
CBD-II				0.29	8.28	9.68	186.7		2.83	22.1	4.0	0.11
	Subsoil											
MD	1.27	0.06	5.44	0.36	12.43	7.93	239.7	0.84	3.04	46.7	58.7	10.32
CL	1.33	0.03	5.16	0.38	12.20	6.90	212.8	0.82	3.46	47.8	78.0	1.59
GT	1.04	0.05	0.27	0.62	10.80	11.40	198.7		2.32	15.3	6.12	0.11
SH	1.20	0.09	6.40	0.53	16.00	12.55	151.0	0.76	3.49	47.4	67.1	4.55
CO	1.29	0.07	0.35	0.36	9.50	9.25	167.3		3.89	33.0	4.73	0.28
BT	1.12	0.05	0.02	0.50	15.08	9.75	132.9		7.62	20.4	8.20	0.10
MAA	1.54	0.05	10.79	0.55	9.53	8.98	128.6	0.89	5.61	87.5	156.9	1.81
Critical		**0.12**	**10**	**0.12**	**2**	**0.5**	**10**	**0.10**	**0.2**	**4**	**1**	**0.6**
Optimum		**0.27**	**22.5**	**0.27**	**4.51**	**1.13**	**22.5**	**0.45**	**0.45**	**9.1**	**2.26**	**1.35**

Results indicate widespread deficiency of nitrogen and phosphorus in these soils. Phosphorus deficiency is especially severe in GT and CO. Many soils in GT, BT and CO also show a deficiency of zinc.

All other nutrients are in excess of plant requirements. Soils of char Lakshmi are very high in potassium and sulphur, soils of SH are very rich in magnesium, calcium and zinc and high zinc content is also found in MD. Manganese, iron and boron contents are high everywhere.

Therefore, soils of the Noakhali coastal region have widespread deficiency of nitrogen and phosphorus and localised zinc deficiency. No other nutritional imbalances are apparent. Sulphur and zinc, even when present in large quantities, may exhibit induced deficiency due to the alkaline soil reaction. Abundance of soil boron may not interfere with plant growth but is likely to become a threat to human health if present in such quantities in drinking water.

[8] BARC, 1997. Fertilizer recommendation guide. Bangladesh Agricultural Research Council.

2.4 Soil salinity

2.4.1 Measurement and interpretation of salinity data

Soil salinity is one of the major factors determining land use and land productivity in the coastal areas. Large spatial variation in soil salinity occurs, both in the top and the subsoil, even within the same plot; the magnitude being higher in the top. The level of soil salinity is dynamic and shows an annual cycle, changing with the seasonal wetting and drying process of the soil. The maximum salinity occurs when the soil becomes dry in the month of March and or April. The salt comes up along with the rising capillary water that is evaporated leaving behind the salt on the soil surface. This continuous pulling up of water increases the salinity in the topsoil and this process continues until monsoon rain starts. In addition to the annual cycle, in protected chars there is expected to a long term, downward, trend in soil salinity, as the salt is gradually washed out of the profile.

There are many different methods to measure soil salinity, the most common being measurement of electrical conductivity (EC) in a soil extract. The commonly published values are for saturated extract, EC_e, but its direct measurement is laborious. Which is why simpler methods are used for routine monitoring, like direct measurement in a 1:1 soil-water suspension, which has been used by CDSP. Conversion factors were determined to convert EC(1:1) to EC_e (Annex-I). In this document only the EC_e values are presented.

We like to caution future workers about the importance of consistency and transparency of salinity data. Too often data are published with no indication of the way they were measured or how the actual raw data were converted to EC_e. CDSP-II have had to spend an inordinate amount of time checking and rechecking results published by its predecessors and even those reported by renowned institutions.

Information about soil salinity must be related to the sensitivity of crops to saline conditions. Table 7 shows the usual classification of saline soils, but we are not dealing with constant salinity and the pronounced seasonal changes must be taken into account when looking at crop suitability. That will be taken up in sections 2.4.6 and 4.6.

Table 7. Classification of saline soils for crop production purposes[1]

EC_e (dS/cm)	Descriptive name	Characteristics
0 - 2	Non-saline	Salinity effects mostly negligible
2 - 4	Slightly saline	Yields of very sensitive crops may be restricted
4 - 8	Saline	Yields of many crops restricted
8 - 16	Strongly saline	Only tolerant crops yield satisfactorily
> 16	Extremely saline	Only a few very tolerant crops yield satisfactorily

[1] *US Salinity Laboratory, 1969.* Saline and Alkaline Soils. Agricultural Handbook No. 60, USDA. Also used by *Ritzema H.P., 1994.* Drainage Principles and Applications. ILRI Publ. 16. ILRI, Wageningen.

2.4.2 Spatial variation of soil salinity

Table 8 gives a first hand idea about the salinity conditions in the coastal areas of Noakhali region, measured in the CDSP-II chars when salinity was maximum in 2000-2001. Later it was found that in some pockets the salinity values do not represent the actual field conditions and therefore the sampling and analysis are repeated once again in February and March 2003-2004. The results are more representative and will be used here for all other interpretations and mapping.

Because of the high degree of spatial variation (Fig. 6 and Table 8), averages and ranges of soil salinity will give only a preliminary idea about the soil salinity of an area. Especially the occurrence of patterns is most important, because that would allow identifying areas within chars with aptitude for certain crops and crop sequences. Grid-based baseline data on soil salinity were collected in all chars. With these data spatial salinity patterns are presented graphically in Fig. 7 & 8.

Table 8. Soil salinity (ECe, dS/m) in the top-soils (0-10cm layer) of seven CDSP-II chars

Char	March-April, 2000-2001				February/March, 2003-2004			
	No. of sample	Range	Mean	σ	No. of sample	Range	Mean	σ
MD	69	2.9-60.7	31.0	17.0	356	0.7-60.7	14.3	12.0
CL	50	12.4-60.9	37.8	15.8	185	0.9-40.4	13.7	8.3
SH	124	0.7-60.9	27.2	17.3	570	2.1-32.0	10.8	5.0
MAA	96	4.2-60.9	22.9	12.9	368	1.2-48.5	10.7	8.1
GT	44	4.5-59.8	31.3	14.7	151	0.9-39.9	11.7	7.7
BT	33	19.5-60.8	43.8	12.9	144	0.2-44.8	18.6	8.3
CO	26	3.8-60.7	42.3	16.9	123	1.6-25.6	11.3	4.5

Mapping was done by interpolation between the measured data at the sampling grid points, using GIS software. We complete this section with a brief characterisation of soil salinity in each of the seven chars.

Fig. 6. Spatial variation of soil salinity in a field at Char Majid.

Muhuri Accreted Area

Prior to construction of the embankment the area was flooded with saline water during the spring tide. Soil salinity varied from 1.2 to 48.5 with a mean salinity of 10.7 dS/m. The spatial variability is high (Table 8). About 47% of the total area is non-saline or slightly saline (ECe up to 8 dS/m during peak dry season). Saline to strongly saline soils covers about 32% area where soil salinity never exceeds 16 dS/m in the peak dry season. Rest (about 21%) of the areas are extremely saline (Table 9).

Table 9. Percent area under each salinity class

Char	ECe, dS/m		
	0-8	>8-16	>16
MD	41.0	21.6	37.4
CL	24.9	46.5	28.6
GT	40.4	41.1	18.5
SH	36.2	48.4	15.4
BT	7.6	33.4	59.0
CO	25.2	62.6	12.2
MAA	46.8	32.3	20.9

South Hatiya

The project area has different land types. Prior to embankment medium high lands were often salinized during normal high tide while high lands were occasionally flooded. Soil salinity varied from 2.1 to 32.0 with a mean of 10.8 dS/m (Table 8). Though the mean soil salinity level is almost similar to that of MAA, SH appears relatively less saline with smaller spatial variability than MAA. About 36% of the total area is non-saline to slightly saline where soil salinity varies from <1 to 8 dS/m (Table 9). Saline soil covers about 48% area while only 15.4% areas are extremely saline.

Char Mora Dona

The area is naturally protected from saline flooding, even during high tide, except for a small area along the bigger canals that overflow to a certain extent. Salinity in the top soil layer varies from 0.7 to 60.7 with a mean of 14.3 dS/m. Spatial variability, as indicated by the high standard deviation, seems very high (Table 8). About 41% area is non-saline to slightly saline (ECe = 0-8 dS/m). Saline soils covers about 22% of the area where soil salinity does not exceed 16 dS/m. About 37% area is extremely saline (Table 9).

Char Lakshmi

The whole area is flooded with saline water almost every year and thus highly saline. Soil salinity varies from 0.9 to 40.4 with a mean of 13.7 dS/m (Table 8). Non-saline to slightly saline soils having salinity not exceeding 8 dS/m covers only about 25% of the area. About 47% area is saline to strongly saline and the rest (about 29%) is extremely saline (Table 9).

Char Gangchil-Torabali

This is an unprotected area, which is flooded every year, mostly in every October when the outside water salinity is started rising. Soil salinity varies from 0.9 to 39.9 with an average of 11.7 dS/m. Spatial variability of soil salinity is relatively low (Table 8). About 40% areas have non-saline to slightly saline soils where salinity does

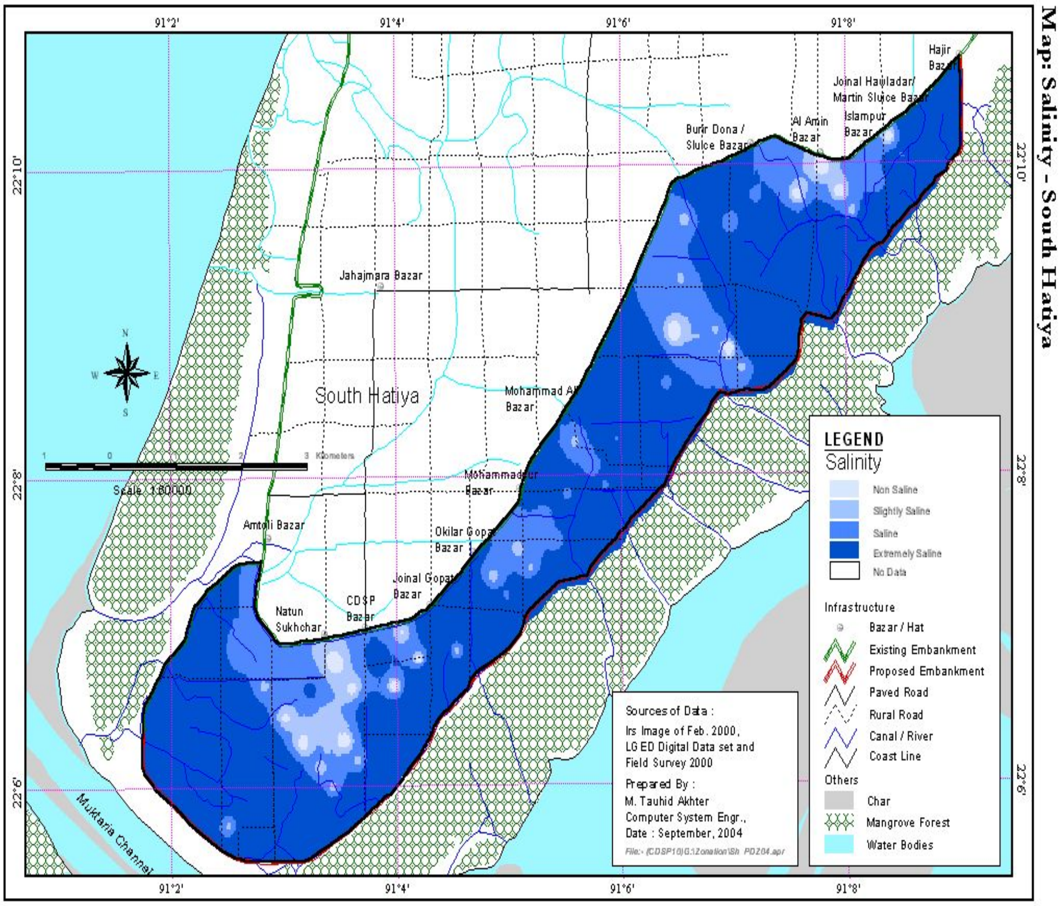

Fig. 7. Map showing top soil salinity of south Hatiya analysed in 2004

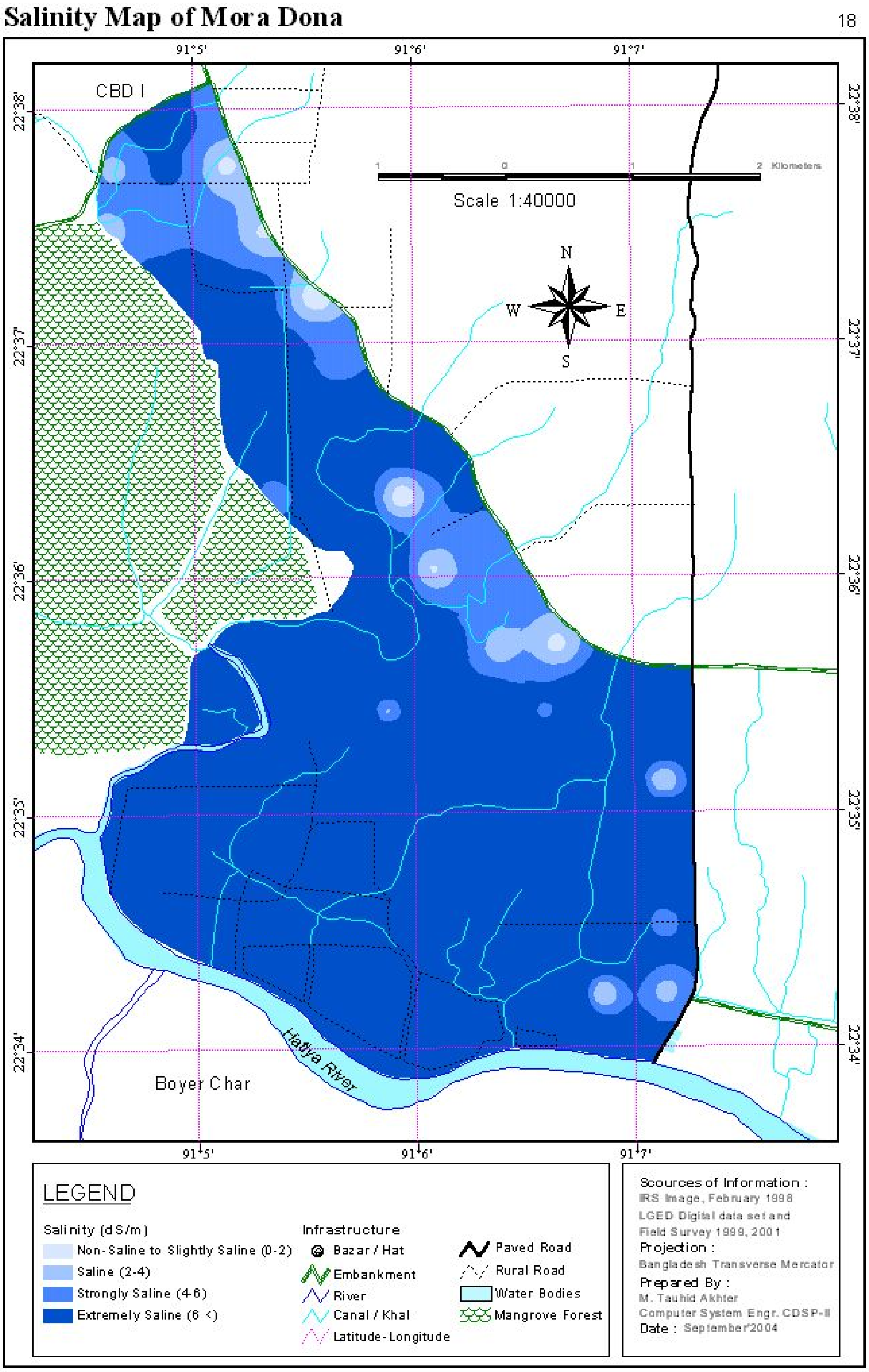

Fig. 8. Map showing top soil salinity of Mora Dona analysed in 2004

not exceed 8 dS/m (Table 9). Saline to strongly saline (ECe 8-16 dS/m) soil covers about 41% of the area and the rest (about 19%) area is extremely saline.

Bandartila/Nijhum Dwip

This area has a physical resemblance to GT with respect to saline flooding and is highly saline. The soil salinity varies from 0.2 to 44.8 with a mean of 18.6 dS/m. The spatial variability of soil salinity is high but slightly lower than at GT (Table 8). Only 7.6% area close to the forest is non-saline to slightly saline where soil salinity does not exceed 8 dS/m. About 33% area is saline to strongly saline and the rest (59%) area is extremely saline.

Char Osman/Nijhum Dwip

Though this area is unprotected and close to the main sea, it is almost protected from normal tidal flooding due to its elevated foreshore. Soil salinity ranged from 1.6 to 25.6 with a mean of 11.3 dS/m. However, the spatial variability of soil salinity is the lowest of all chars (σ = 4.5 dS/m) in the topsoil (Table 8). Though the maximum soil salinity value is much lower than other chars, higher mean value indicates that the non saline area is less. Only about 25% area is non-saline to slightly saline (ECe 0-8 dS/m). Most part (about 63%) of the area is saline to strongly saline while the rest 12% is extremely saline.

2.4.3 Seasonal trends of soil salinity

Soil salinity shows a pronounced annual cycle. During the monsoon the rainwater infiltrates into the dry soil and takes the salts down, creating a non-saline upper layer where paddy can be grown. After the monsoon the soil dries and capillary rise from the groundwater resalinises the upper soil layers. Fig. 9 illustrates this annual trend. It has a strong influence on farmers' cropping options, as will be seen later on.

2.4.4 Variation of soil salinity with depth

The trends in salinity at two depths are illustrated for 1.5 years in one plot in MD (Fig. 9). During the dry season soil salinity is higher in the top 10 cm (upper curve) than in the subsoil (10-30 cm), while during the monsoon subsoil salinity tends to be somewhat higher. This pattern is generally found in all the chars.

2.4.5 Long-term soil salinity trends

There has been and there continues to be uncertainty about the rate of salinity decline, once an area is no longer exposed to saline flooding. LRP had observed a decrease in maximum topsoil salinity in its experimental plots in CBD-I from about EC_e 30 dS/m in the late 1970s to about 10-12, 5 years later. At the start of CDSP-II it was hypothesised, on the basis of the available records, that soil salinity in new polders would indeed decrease during the first 6 years after protection to reach an average pre-monsoon (April) EC_e of about 8-10, after which further decline would be very slow. The evolution of soil salinity in protected and unprotected chars was therefore monitored by seasonal measurements in a number of fixed representative locations in each of the chars, including the older polders, created during CDSP-I. The latter have served as monitoring sites with sufficiently long records to assess longer-term salinity trends.

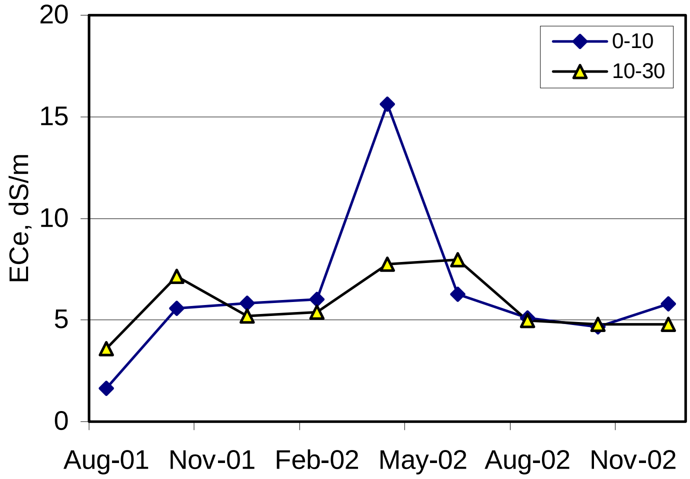

Fig. 9. Seasonal change of soil salinity at two depths at Mora Dona

The next four figures (Fig. 10) show the trends in the three old polders and in three of the new unprotected areas.

The figure for CBD-II shows indeed that the maximum April salinity has stabilised at an EC_e of about 10. This polder was embanked around the same time as CBD-I, but some saline flooding continued until the main sluice was closed in 1987. No salinity data are available before 1995, but there is no reason to assume that initial salinity was less than that of CBD-I in the late 1970s. Hence, the change in salinity in CBD-II is consistent with the expected trend.

CBT and CM were embanked under CDSP-I, in 1995 and 1996. They were not fully protected, however, until 1998 when the sluices were completed. If the hypothesis about salinity decline were correct, it should now also have reached the 10-12 dS/m threshold. The figures up to 2003 suggested that that was the case, but in April 2004 there was a surge in salinity again. The lower April figures for 2002 and 2003 may have been caused by early rain in that month, before the samples were taken. Similar lower peaks in the data from the new areas (shown for Mora Dona and Lakshmi) give further support to that possibility. For that reason in 2004 samples were taken late March and will be in the future.

So, even now, it is not clear from the available data whether indeed soil salinity has been declining significantly, with the notable exception of CBD-II. That polder, however, borders the Baggar Dona river, which may have contributed to a lateral flow of groundwater towards the river in one hand and flashing of the area with fresh water from upstream areas after embankment-cut every year, gradually removing the salt from the profile. The data on the shift in rabi crops, presented in Chapter 4, does lend some support to the assumption that even in CM and CBT salinity is decreasing, however slowly.

The data series for the new chars are too short to draw conclusions and monitoring has to continue. The location of the sampling sites, however, may have to be reconsidered once the PDZ mapping of all the areas is complete. The existing locations should be continued but some additional ones may have to be chosen to get a more representative data set.

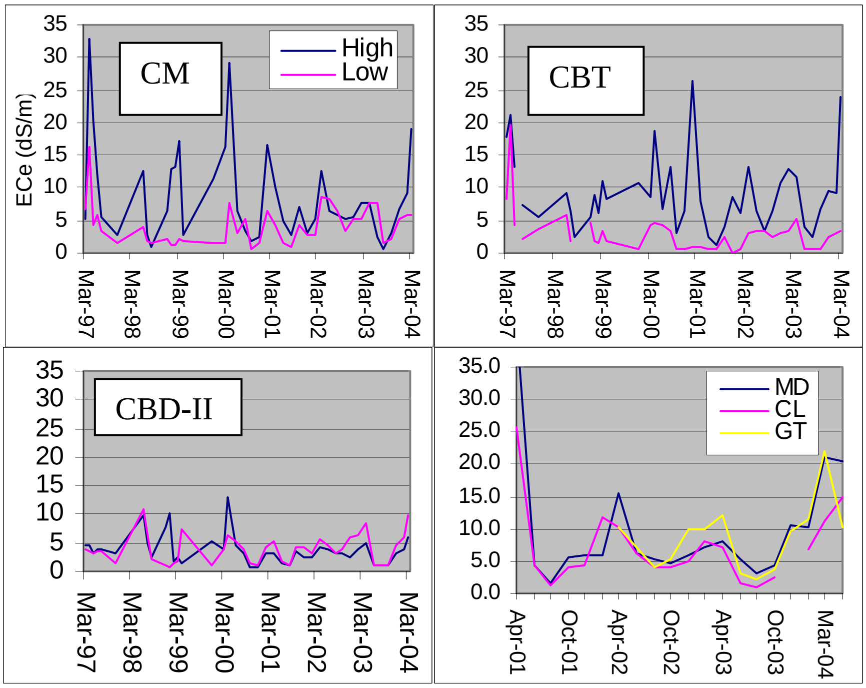

Fig. 10. Long-term trend of topsoil salinity in 3 old polders (CBD-1I, CM, CBT) and 3 new chars (MD, CL and GT). In polders both high and low saline plots and only highly saline plots in new chars are shown.

2.4.6 Crop adaptation to soil salinity

Most published information about salt tolerance of crops is not directly applicable to the char areas because of the cyclic nature of soil salinity in the coastal zone. If a crop is reported to be tolerant to salinity of up to, say, EC_e10 dS/m and salinity in a field at the end of the Rabi season is 15, that does not necessarily mean that field is not suitable, because salinity would be below the tolerance level for most of the growing cycle. It is very important to keep that in mind. It would not be practical to measure the seasonal salinity trend in each area, nor is it necessary, because once the peak salinity is known the seasonal pattern can be predicted with reasonable accuracy for practical purposes. Fig. 11 shows the schematic patterns for three salinity levels (compare with the measured data of Figs. 9 & 10). They should be taken as approximate and used only for the purpose they are meant for: to estimate the seasonal trend when only maximum values are available. With this information we can now interpret the findings by LRP, CDSP-I and CDSP-II about the tolerance of species and varieties to soil salinity.

Kharif-I (pre-monsoon) crops

Farmers sow or plant aus paddy with the first rains, which means just after soil salinity has passed its peak. Since aus is sensitive to salinity, the extent of aus growing in an area is a good indicator for the salinity conditions. During CDSP-I aus grown in the oldest polder, CBD-II with lower salinity, out-yielded that in the younger ones. The latter also showed more crop failures due to salinity. An indication of the salinity threshold for successful aus growing can be gleaned from Fig. 12, which shows the response of two aus varieties to April salinity in 1997 in the three CDSP-I polders. In all plots the rice was deep dibbled to put the seed below the level of the highest salinity. The wide scatter of the points is because of the differences in

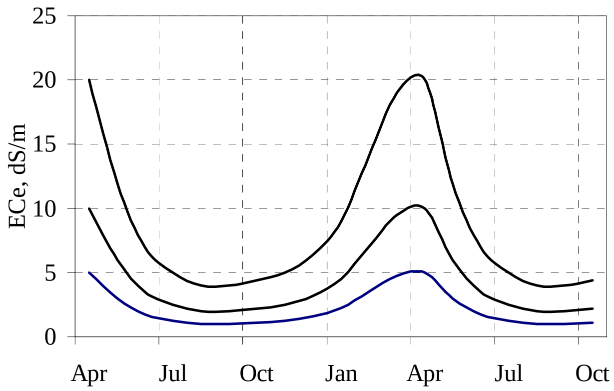

Fig. 11. Approximate seasonal trends of soil salinity at three levels

management among farmers and the differences between the polders. Unfortunately, it is not known how many plots failed completely, but some certainly did. The data suggest that up to an EC_e of at least 10 dS/m there was no yield effect, while yields declined from about 15 or 16 dS/m. Pot trials during CDSP-II showed good growth of young rice plants (up to 30 days) when the initial EC_e was 16 or less. We conclude that the threshold for aus growing is at an April salinity of 15 dS/m EC_e.

Deep dibbling is practised by farmers at the higher salinity range, while they will shift to broadcasting when it becomes safe to do so.

Kharif-II (*Aman season*) *crops*

Data from CDSP-I showed a somewhat lower t-aman yield in CBT and CM than in CBD-II, especially for the improved varieties. This may have been due to the higher salinity in the former (younger) polders. LRP could not establish a clear relationship between salinity and aman paddy yield in the experimental farm (with large differences in salinity).

It seems safe to assume that under monsoon conditions yield depression of t-aman because of salinity will be minimal, except when there is a surge in salinity due to a dry spell during the monsoon, as is sometimes observed.

Rabi season crops

Studies about crop suitability for the Rabi season in the coastal zone have been carried out by LRP, CDSP-I, CDSP-II and MCC. Details may be found in the publications by these agencies. Here, their major findings are synthesised, supplemented with observations of what farmers actually grow. Crop species which have been shown to have some promise for the chars, as far as tolerance to soil salinity is concerned are the following:

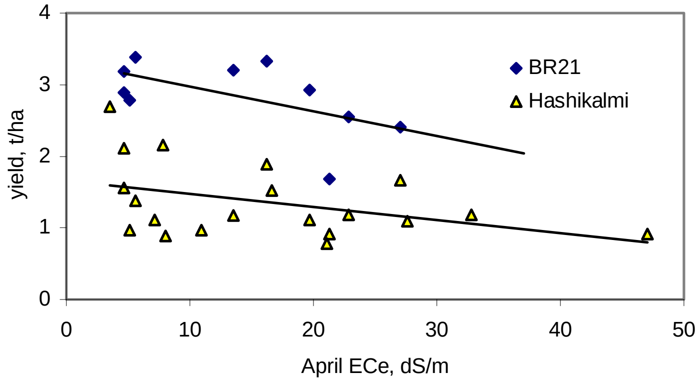

Fig. 12. Effect of top soil salinity on aus yield, CDSP-I, 1997

oilcrops	**cereals**	**pulses**	**vegetables**	**other**
soybeans	wheat	greengram	chilli	sweet potato
sunflower	maize	groundnuts	garlic	
	triticale?	cowpeas	onion	
		mungbean	tomato	

The tolerance of Rabi field crops to salinity, inferred from the published sources, is approximately as follows:

sweet potato>greengram>linseed>groundnut > millet > sunflower>soybean>triticale> wheat>cowpea>mungbean>>mustard

For vegetables, spices and fruits the ranking would look like this:
batisak > chilli > spinach > kangkong > garlic? > chinasak > Indian spinach > okra > water melon > red amaranth

It is not possible to give precise tolerance figures for all the species, but the following indicative figures can be used with some confidence.

An EC_e of more than 16 dS/m, measured in early April (which is equivalent to about 8 dS/m around January, would have a depressing effect on growth and yield of all crops, with the exception of chilli, sweet potato and greengram, which may tolerate somewhat higher levels. An April EC_e of >30 would be prohibitive for all rabi crops.

On the basis of the published data, tolerance of some common rabi crops in the coastal areas given in Table 10. For most of the vegetables there is not enough information yet to indicate tolerance levels. The table suggests that, as the land becomes desalinised below an April EC_e of 30, some rabi cropping becomes possible, but at that level the risk of crop failure is considerable. Only when salinity decreases below 20 dS/m do the chances at success improve. Chilli, sweet potato and greengram can already be grown before the land becomes suitable for aus, as is commonly observed.

Some crops have to be planted early in the rabi season and they therefore may escape the period of maximum salinity. Examples are greengram, linseed, garlic, wheat, sunflower and soybean. The next table shows recommended planting dates in the char areas for some potential rabi crops. These dates are the same as those given for these crops in the technology packages in volume 2 of this report where many more species are presented.

Table 10. Tentative tolerance of field crops to top soil salinity, measured during the Rabi season

range of EC_e				
January value	< 4	4 - 8	8 - 15	> 15
April value	< 8	8 - 16	16 - 30	> 30
	sunflower	aus	chilli	no aus, no rabi
	soybean	groundnut	sweet potato	
	wheat	linseed	greengram	
	cowpea	garlic?		
	mungbean			
	okra			
	water melon			

Crop	Recommended planting dates
Green gram	before 15 Nov
Linseed	before 15 Nov
Wheat	1 – 20 Nov
Tomato	Sep -Nov (seedbed); Oct - Dec (transplanted)
Chilli	1 Nov. – 10 Dec
Garlic	15 Nov - 15 Dec
Onion	Oct (seedbed); 15 Nov - 15 Dec (transplanted)
Groundnut	15 Nov – 15 Jan (?)
Soybean	November
Sunflower	November
Sweet potato	mid January
Cowpea	before 15 Jan
Mung bean	before 31 Jan

As will be seen later on, however, early rabi planting is often not possible in the char areas because of late aman harvest. The opportunity for escaping salinity by early planting is therefore small.

With the salinity maps for the CDSP chars which are now being prepared these indicative crop tolerances will enable us to predict crop suitability for the rabi season, as far as soil salinity is concerned. As we will see presently, however, monsoon flooding depth will also have a strong effect on land suitability for rabi cropping, because of persistence of flooded conditions after the monsoon as well the risk of early inundation at the beginning of the next pre-monsoon.

2.5 Availability of water and its quality

Unlike other parts of the country, coastal region is not normally flooded due to overflowing of the rivers rather is flooded with monsoon rain. Among the other physical vulnerabilities of the coastal region, tidal flooding, storm surges and cyclones are the common. These vulnerabilities directly affect crops, lives and properties of the coastal region.

Agriculture in the coastal area is essentially rainfed and provides no options for the use of groundwater (irrigation) due to the probable intrusion of saline sea-water in the aquifer. Only transplanted aman rice is grown in the monsoon season. Growing dry season crops becomes risky in most of these areas because of two major constraints such as (1) either excess water in the field during crop establishment stage or shortage of water required for normal crop growth in the early growth stage, and (2) drought related development of soil salinity up to the level that is very toxic for most crop plants. Often the aman rice crop suffers from drought during either tillering or ripening stage reducing yield to a great extent; modern varieties suffer more than the local varieties. One supplemental irrigation at this stage would save the crop from such disaster. As mentioned earlier, the amount of annual total rainfall in the coastal region is high, and the seepage and percolation are slower than in other types of soil (personal observation) while the drainage in some cases is poor during the late monsoon period. These leave the entire zone in a too wet condition during the transition period of Kharif-II and Rabi seasons. This happens particularly after heavy rainfall in the late monsoon season, making it difficult to plant rabi crops in some areas or delaying sowing of seeds in general.

2.5.1 Flooding characteristics

Noakhali coastal region is an accreted area having almost flat land, depending on locations, just 2.2 to 5.0 m above the mean sea level. Although the northern parts of the country are higher than the southern areas allowing easy drainage of the main rivers, many of the southeastern areas of the country closer to the coast have serious problem of water congestion. This is mainly due to the impeded drainage as a result of siltation of the canals, particularly of the secondary and tertiary ones. All these processes have resulted in an elevated foreshore and the effect of the general slope of the country becomes almost obsolete in the immediate vicinity of the coast. Although flat lands dominate the region, localized depressed areas are common. Because of these depressed areas there are variations in the microenvironment of the specific sites which is important for designing a cropping scheme for the area.

Except south Hatiya and Muhuri accreted area all other five chars covered by the agricultural programme under CDSP-II are unprotected. However, among the three sites of Noakhali sadar MD is almost protected naturally from saline flooding in one hand, and has a slower drainage during monsoon on the other, due to its elevated foreshore close to the Hatiya river to which it drains. CL has some gentle depressed areas where water remains stagnated up to a height (0.4 to 0.9m) that makes introduction of improved crops very difficult. GT and BT are newly accreted areas having ramified river creeks all over the area and a gentle slope in the north-south (GT) and west-east (BT) directions until ends up with the rivers. There are some pockets of depressed areas in its slightly elevated north and north-western areas of

GT. CO though it is almost protected from tidal flooding due to its elevated southern boarders tidal water enters into the creeks which normally do not flood the area unless there is tidal surge.

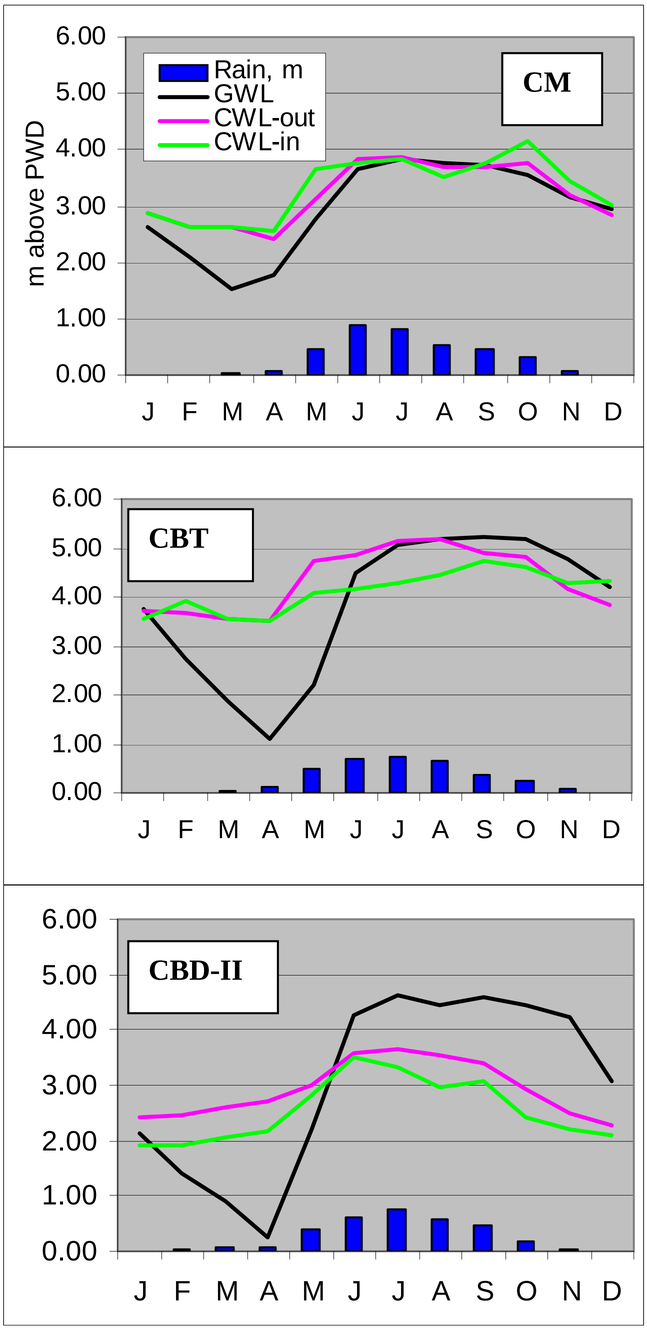

Fig. 13. Groundwater level (GWL), canal water level outside (CWL-out) and inside (CWL-in) sluices and rainfall (m) in the three polders of Noakhali.

There are two types of flood occur here - (a) the normal flooding caused by accumulation of monsoon rain which cannot drain into the rivers or takes longer time to drain due to impeded drainage canals, and (b) the damaging flood during tidal or storm surges associated with cyclones. However, normal floods are also damaging when it prolongs or comes untimely.

Monsoon flooding

Seasonal flash flood occurs after heavy downpour during the monsoon. The depth of flooding varies with location (Table 11), even within a particular area. There are many locally depressed areas where rainwater accumulates up to a maximum depth of 90 to 180cm. In the higher lands flooding depth does not exceed 15 cm. It is quite common that aman crop in the medium highland to lowland is flooded up to a depth of 0.5-1.5m almost every year. Crop loss due to monsoon flooding varies with locations depending on the speed of drainage. During monsoon the canals in and around some of the project sites usually remain filled up with rainwater that cannot recede because of raised water level in the nearby larger water bodies (Fig 13) together with very low seepage and percolation rate. This figure also indicates that this is particularly true in case of CBD-II where groundwater level reaches the ground surface while the water level in the nearby canal remains above that during the monsoon. This, together with elevated foreshore of some of the areas, impedes rapid drainage and prolongs the duration of water stagnation until late December.

Because of the higher monsoon rain (Fig. 3 and Table 3) fields in the coast remain flooded with rainwater up to a depth, on an average, of 30cm in the early monsoon period. But most farmers keep their levee height much higher thereby increasing the flooding level up to 50 cm or more. Drainage congestion often occurs in most of the areas due to wanton mechanical obstructions by the influential people and other vested interest groups in the internal drainage canals behind the sluices. All these contributed to the poor drainage conditions of the areas thereby making introduction of the high yielding varieties of aman rice difficult. The water management committees formed by CDSP-II tried to improve the situation. Nevertheless, these committees in some cases are not actually free from the clutches of the influential and thus could not function properly. They have to be empowered fully through real people's participation as has been envisaged in the national policy.

Table 11. Monsoon flooding depth reported by farmers of the areas during plot-to-plot survey.

Location	Peak monsoon flooding depth (cm)	
	Minimum	Maximum
Mora Dona	12	90
Char Lakshmi	12	122
Gangchil-Torabali	15	183
South Hatiya	15	107
Bandartila	15	167
Nijhum Dwip	15	122
Muhuri Accreted Area	10	152

Tidal flooding

Coastal areas experiences a daily cycle of low and high tide and the medium to lowlands of the unprotected areas are occasionally flooded with tidal water, particularly during the Kharif-II season. Depth of such flooding normally varies from 3 to 4m above the mean sea level during monsoon in the Noakhali coastal region (Fig. 13). Although such flooding occurs twice a day, the frequency of devastating tidal flooding of the crop fields varies considerably with the land type and proximity of the areas to the coast. Devastating tidal flooding comes in south Hatiya once in every 8-10 years while Mora Dona area of Noakhali sadar did not experience such flooding during the last 20 years. Crops in areas close to the coast are affected by tidal flooding almost every year; the damage is more particularly when flooded during the later part of October to November when concentration of salts in the river water started increasing (Fig. 17).

Storm-surge and cyclone

The storm surge or the raising of the sea level during the passage of the cyclone is another source of damaging flood and is a characteristic of the coastal region. However, not all cyclones are accompanied by storm surge. Again, storm surges may affect some areas and not others during the passage of cyclone, particularly when comes during the low tide.

The height of the storm-surge has so far been officially estimated to be about 7m although the theoretical possibility of a height up to as high as 13m (Brammer, 1999[9]). Records of the cyclonic storms and cyclones show that these can occur both during pre and post monsoon period covering almost all coastal districts (Table 12).

Table 12. Frequency of cyclonic storms and cyclones occurred during 1795-1991 (from Brammer, 1999)

Pre-monsoon		Post-monsoon		District	No
Month	No	Month	No		
April	4	September	2	Chittagong	40
May	18	October	20	Noakhali	14
June	1	November	9	Barisal	11
		December	4	Patuakhali	10
		January	1	Khulna	16
Total	23	Total	36	Some affected more than one district at a time	

Storm surge damages crops by strong force of water flow, flooding, salt and burial of land by sediments. Damage to crops by storm surge is usually very severe.

Potential for irrigation

As mentioned earlier most of the fields along the coast drain very late and paddy fields remain muddy which delays harvesting of the aman rice as well as planting of the next rabi crops. Soils remain wet for quite a longer time and do not dry faster in the dry season; top-soils remain wet than the sub-soils (Fig. 14). Rabi crops grown in these soils seldom die but have restricted growth due to drought even though the top-soils contain enough moisture. Therefore, rabi crops are generally planted late in the costal region which grow normally using the residual soil moisture during their early phase. Only a few irrigations are needed during March and April before the rain starts for optimum performance of the rabi crops in the coastal region.

[9] Brammer, H. 1999. Agricultural disaster management in Bangladesh. Univ. Press Ltd. Dhaka. p.291-301

Normally there are two sources of irrigation water, surface water stored in open water bodies such as ponds, ditches, borrow-pits and canals, and sub-surface or groundwater. The potential for irrigation has to be judged for three attributes: the quantity of water available, quality of water, and the relative cost of extraction or acquisition of water.

The surface water study (Latif, 2001[10]) shows that the average size of the seasonal ponds is about 0.08 ha. Generally, farmers dug these ponds mainly for their domestic uses. Apart from domestic uses, water stored in these ponds is used for irrigating rabi crops grown in fields near the pond and in homestead areas. In addition to the ponds, limited amount of water from borrow pits and canals are also available for the irrigation of small vegetable fields and seedbeds only. The scope for such irrigation is small as these storages devices can store water up to January and dry out between February and May, a period when there is an urgent need for the irrigation water. While the percolation rate at the bottom of the ponds are assumed to be minimum in these alluvial virgin soils having fairly uniform texture (silty loam to silty clay loam) throughout the deeper layers, the causes of disappearing a huge amount of water (1.5m) from the open water bodies after discounting all usage and evaporation could not be accounted for (Mutsaers, 2000[11]). Many of these pits and canals cannot store enough water due to either siltation or probable leakage in the sluices. Moreover, use of pond water is restricted to the pond-owner only and the neighbouring farmers have no or limited access to it.

There is scope for increasing the volume of fresh-water storage in the coastal region by (a) increasing the depth of the ponds owned by the farmers, (b) stopping leakages of the sluices and maintaining these properly, (c) keeping the main canals of the area with regulatory devices filled up with fresh water during the post-monsoon period, and by (d) promoting more number of community-based multipurpose larger ponds on the *khas* lands. However, storing more water in the canals may have limited scope for two reasons. Firstly, the sluices have to be kept open until early October to allow drainage that facilitates harvesting of the standing aman crop. Secondly, the outside canal or river water starts becoming saline in October (Fig. 18) thereby reducing the chances of in-taking fresh water in the canal. Growing high value crops that do not need flood irrigation could increase irrigation coverage further. Adopting the concept of drip irrigation only and not the costly devices can do this.

Besides increasing the storage capacity of water in ponds, canals and borrow-pits, the quality of water should be assessed, particularly before using for irrigation. Water of most ponds of the Noakhali coastal areas appear to be sweet, the water salinity ranges from 0.18 to 2.18 dS/m (Table 13). Though the permissible limit of salinity of the irrigation water is less than one (Panaullah, 1993[12]), BRRI demonstrated a successful production of rabi crops by irrigating with saline (EC=1.60 - 2.04) groundwater at

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[10] Latif, M. A. 2001. Report on fresh water in char areas. Technical report No. 4. CDSP-II. p.12

[11] Mutsaers, H.J.W. 2000. Mission report No. 9. Report on consultancy visit. (Nov. 10-17, 2000)

[12] Panaullah. G.M. 1993. Soil salinity and associated problems in connection with crop production in the coastal region of Bangladesh. Paper presented at the Workshop on *Soil salinity and crop production in Bangladesh.* BRRI, Joydebpur, Gazipur. Feb. 17. 18p

Barisal region (Mondal *et al*, 2001[13]). However, the long-term effect of such irrigation on building up of top soil salinity has yet to be assessed.

The possibility of extracting groundwater for irrigation has been reviewed (Sheltech, 2000[14]). The report shows that there is possibility of extracting water from shallow aquifers but these are so scattered that doubt shrouds the exact volume of available water. Moreover, water quality is not suitable for irrigation. More potential aquifer can be seen in a deeper layer (215 to 375m) but extraction of water from such a deep layer is likely to favour intrusion of saline seawater.

Table 13. Salinity of water from ponds and borrow-pits in and around char Majid and Maradona during April

Type of reservoir	Location	Salinity, dS/m
Pond	1. CM polder pond -1	0.67
	2. CM polder pond -2	0.55
	3. CM polder, near Jaker's house	0.56
	4. Tota Miar Bazar (East)	0.46
	5. Maradona near Tota Miar hat	0.31
	6. Maradona, after Tota Miar hat	1.02
	7. Maradona near Janata Bazar	2.18
	8. Maradona, Globe fish farm	1.86
	9. Maradona, near Globe fish farm	0.72
	10. Maradona, near Mohiuddin bazar	1.29
	11. Near Mohiuddin Cyclone shelter (east)	0.74
	12. Near Mohiuddin Cyclone shelter (west)	0.66
	14. Mohiuddin Asrayan (west pond)	1.15
	15. Mohiuddin Asrayan (east pond)	0.98
	16. Near Shibcharan Cyclone shelter	0.18
Borrow-pit	1. After Tota Miar hat	0.31
	2. Near Bhuiyar hat	1.02

Moreover, the huge cost involved in extraction of water from such a depth may make it economically less sustainable. The report also hinted that water from deeper layer contains boron in little higher concentration. This can also be visualized from the high concentration of boron in the soils of Noakhali region.

[13] Mondal, M.K., S.I. Bhuiyan and D.T. Franco. 2001. Soil salinity reduction and prediction of salt dynamics in the coastal rice lands of Bangladesh. Agric. Water Mgt. 47: 9-23

[14] Report on groundwater survey & secondary data in the districts of Lakshmipur, Noakhali, Feni and Mirsarai thana of Chittagong district. Technical Report (Final) by Sheltech Consultants (Pvt.) Ltd. 2000

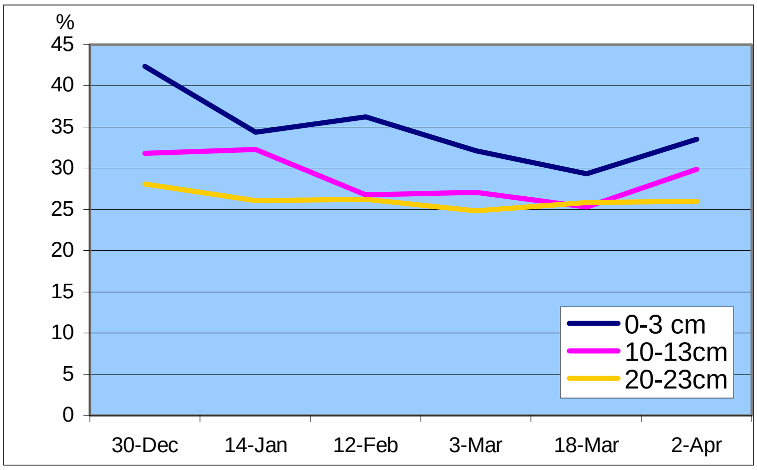


Fig. 14. Changes in soil moisture (%) in three layers after the harvest of aman rice at CM & MD (mean of six fields).

Chapter 3 The Institutional Environment

3.1 Introduction

In long-established agricultural areas farmers can, in principle, make use of many services available to them, both from government and non-government institutions and from the private sector. In newly settled areas like the coastal chars, however, the installation of such services lags considerably behind settlement, which seriously hampers development. CDSP is a temporary facility, which assists line agencies and NGOs to get involved in the char areas and work for the improvement of living conditions of the char population. One of the most challenging tasks of CDSP's Agriculture Unit is to mobilise all the important actors to work in a co-ordinated way towards improvement of productive conditions in the protected and unprotected coastal areas. In this chapter we review CDSP-II's record in promoting the establishment of important agencies for service delivery to agriculture in the coastal chars.

3.2 What institutional support is needed for agriculture?

Farming in the chars is to a large extent concerned with subsistence production, but not exclusively so. Several crops, in particular those produced in the Rabi season, and even part of the paddy, are also marketed. Char agriculture is therefore partially integrated in the money economy and exposed to market forces. Farmers are interested in improving their productivity by using modern productive inputs and growing high value crops for the market. This means that char farmers need the kind of services which are available elsewhere and which have helped farmers in some mainland areas to become quite successful entrepreneurs. The most important services are the following:

1. *Information* on more productive technology, such as better crop varieties, new crops, fertiliser requirements, pest and disease control
2. *Access to inputs* needed to apply the improved technology, i.e. seed, fertiliser, small tools, pesticides, sprayers, processing equipment
3. *Access to markets* for agricultural surpluses
4. *Organisational support*, to help farmers form groups of sufficient size to organise their collective needs and improve their bargaining powers

Information on available technology is usually provided by the government extension service or by extension services of other organisations, in the case of Bangladesh including NGOs. Research institutes are the major source of new technology, but not much research has been done specifically for the actual coastal ecosystem.

Provision of inputs to farmers is now considered as outside the task of government, although in Bangladesh government continues to provide inputs, especially seed of improved varieties, through the extension service. The private sector and specialised NGOs are expected to play this role.

Producers can sell their goods at different levels: by selling small amounts at local markets or to local traders, selling larger quantities in larger markets and in urban centres, through contracts with larger operators, etcetera. Better prices can be obtained by selling as close as possible to the final users and by pooling the produce of several producers. That requires organisation on the part of the producers. When a new crop is grown for which there is as yet no local outlet, there is a high chance of failure, unless the producers, perhaps assisted by some agency, organise themselves to pool their production and take it to where demand exists.

In the protected areas there is a need for close co-operation among the inhabitants for managing the water infrastructure, taking into account the sometimes conflicting interests of different groups. Water management organisations are therefore needed at the grassroots level, scaled up to the level of the polder as a whole.

The bargaining power of individual small farmers is very limited and they will benefit from organising themselves, for example in producer groups, to collectively procure inputs or sell their produce. In Bangladesh there are several large NGOs with experience in helping farmers organise themselves.

3.3 Agencies supporting agriculture in the coastal zone

3.3.1 Government agencies

The government institutions most immediately concerned with agricultural development are:

– The Department of Agricultural Extension (DAE) of the Ministry of Agriculture is primarily vested with imparting agricultural extension services in the country. This organization serves as the recipient of the support by a number of organizations, particularly for generation of location specific technologies and input supply. DAE has offices up to the Thana level but its wings are spread over the grassroot level where field level extension workers designated as Block Supervisor (BS) are the vital actors. The Deputy Director, DAE Noakhali is the CDSP Agricultural Programme's Director. DAE has transfered some BSs to the CDSP mandated areas, but no new staff have been recruited. The coastal upazilas (sadar and Hatiya) remaining understaffed.

– The Bangladesh Agricultural Research Institute (BARI), with the national mandate for generation of technologies for crops other than rice, jute, sugarane and tea. The BARI's On-Farm Research Division (OFRD) has a farming systems research site at Atkapalia under Noakhali sadar upazila. The OFRD has mandate for on-farm testing, tailoring and validation of technologies generated by the various research stations of the country leading to formulation of appropriate package of technologies suitable for a particular location. Therefore, the OFRD of Noakhali is expected to carry out development-relevant applied research for the coastal zone in particular. Shifting of the OFRD site would be needed to a location which is more representative for the coastal ecosystem.

– The Bangladesh Rice Research Institute (BRRI) is the source of new paddy varieties in the country. It also generates technologies for rice based farming systems. Unlike BARI, BRRI has another important mandate of imparting training to the extension workers of the DAE, other organizations involved in rice cultivation and the farmers. Its sub-station at Sonagazi no longer represents the coastal ecosystem and should be transfered to a more representative site, preferably in the Noakhali District, close to the coast.

– The Soil Resource Development Institute (SRDI), which provides specialised skills in characterizing soil resources and deals with soil-related problems in the country. The institute has a group of staff and a basic laboratory at Dhaka and at Comila, a place closest to the project, where soil and water salinity can be measured. It has an office without a laboratory at Noakhali and with a small group of staff. The local office gets soil samples analysed by their central and or regional laboratories whichever is nearer, but they do carry out soil and water salinity measurements.

– The Bangladesh Agriculture Development Corporation (BADC), formerly a large institution with many commercial roles, is now involved only in the production and distribution of certified seed. They have no network below the District level, but they can licence local private seed supply operators. BADC with its limited resource can supply only a small fraction, not more than 5%, of the national demand for seeds of improed varieties of various crops.

– Bangladesh Rural Development Board (BRDB) is a large organization with offices up to the upazila level. They are involved in a number of activities like (a) poverty alleviation programmes implemented through various cooperative societies formed with the targetted group of people such as landless, small and marginal farmers, (b) motivation and formation of groups for deep tubewell irrigation scheme, (c) promotion of marketing of agricultural produces through temporary storage facilities, and (d) training and motivation of women for family planning, health care, etcetera.

3.3.2 Non-Government Organisations

Supposedly, the NGOs' strength is in people's mobilisation and group formation at the village level. The aim is to strengthen the people's capability to deal collectively with their problems through self-help activities and by obtaining services from different institutions. Usually some small credit scheme is part of an NGO's package. Most or all of them get their funding from international NGOs or donors.

There are a good many NGOs established in the south-eastern coastal zone, including in recently settled chars, but none of them have an exclusive agricultural development signature. The NGOs working in the areas covered by the CDSP programme are:

N-RAS (Noakhali Rural Action Society). This is a local NGO, established in 1989 and working in the greater Noakhali district. It has 34 permanent staff including five positions of Programme Coordinator to undertake as many as 20 programmes including agriculture, forestry and fishery. It clearly indicates that the programme leaders are heavily overburdened.

SSUS (Sagorika Samaj Unnayan Sangstha). This local NGO, much known as Sagorika, was established in 1986 to work in the greater Noakhlai district covering four coastal thanas. It has 58 permanent staff on board including programme leaders to undertake seven programmes including agriculture.

UPOMA (Unnayan Parikalpanay Manush). This is also a local NGO established in 1990, working in the coastal char areas covering three Upazilas of Noakhali and one Upazila of Lakshmipur district. It has 67 permanent staff including 15 programme leaders and co-leaders to look after 16 programmes including agricultural development, homestead gardening and afforestation.

DUS (Dwip Unnayan Sangstha). Established in 1982 this NGO has been working mainly in Hatiya but its wings are spread over two more upazilas of Noakhali, four upazilas of Lakshmipur and in Monpura of Bhola district. It has seven block offices distributed over the entire working area at Hatiya. There are 45 permanent staffs on board of which 3 are programme leaders and co-leaders to implement 13 various sectoral programmes including homestead agriculture.

YPSA (Young Power in Social Action). It was established in 1985 to work in three upazilas of Chittagong and one Upazila of Feni district with an estimated beneficiaries of over 50,000. There are 95 permanent staff including 17 programme leaders to support 17 programmes including homestead production in the Muhuri accreted area.

CARE Bangladesh (Coordinated Assistance for Relief Everywhere). CARE has a agricultural programme, particularly on homestead production designed for women folk only, in sadar and Hatiya upazilas of Noakhali and Ramgati Upazila of Lakshmipur district implemented through its LIFT project. There are 11 technical staff to coordinate the programme including 35 field level workers to assist the technical coordinators. Prior to implement the programme these technical coordinators have undergone short to medium term training in the relevant fields.

MCC (Mennonite Central Committee) is one of the oldest local NGOs working at Noakhali since 1974. It started to improve the livelihood of the marginal farmers who have food reserve for only 8 months a year through the introduction of rape seed, sorghum, and protein-rich crops like pulses, soybean and sunflower under a crop diversification programme. Sunflower suffered a lot due to high sterility and farmers adopted only soybean. Introduction and promotion of soybean cultivation in the country is one of their most tangible achievements so far. The NGO has eight skilled technical personnel to coordinate all activities mostly in the field of on-farm research on crops and crop management, livestock, fish culture and their integrations in a whole farm approach.

BRAC (Bangladesh Rural Advancement Committee), a large national NGO with strong links with international donors, has established partnerships with five of these NGOs (Sagorika, Upoma, N-RAS, DUS and YPSA) under a special grant from the Netherlands Embassy. With technical and financial support from BRAC the NGOs promote homestead production and other programmes in the CDSP-II mandated areas.

Towards the end of CDSP-I the Productive Development section linked up with Sagorika and N-RAS to form farmer extension groups in the three polders as a new medium for extension, in replacement of the more 'elitist' demonstration-extended farmer approach. During CDSP-II, the five NGOs mentioned above, have given some organisational support to agricultural extension in the new areas, through the formation of Farmer Forums, which are the successors to the earlier farmer extension groups. BRAC has played a (small) role in assisting the local NGOs in this effort.

3.4. Peoples' organisations

There is some degree of coherence among char dwellers, because people from the same provenance tend to settle in the same area, if possible, but there are no real organisational structures among them. Since collective responsibility-taking and joint actions are essential for water management and economic development, several actors, including the CDSP programme, have intervened in the promotion of different kinds of groups. This has led to a plethora of groups with little functional linkage among them, even though there is usually a lot of overlap in leadership.

- Polder Committees, Sub-Polder Committees, Local area development committee (in the unprotected areas) and Water Management Committees have been formed by the BWDB/LGED facilitated by CDSP consultant staff (the only case of direct intervention) for operation and maintenance of local water management infrastructure and as communication channels between char inhabitants and the BWDB
- Tubewell User Groups (TUG) have been formed to manage drinking water pumps and tube wells installed under the Programme and to promote hygiene, including the installation of latrines
- The five partner NGOs of BRAC have formed groups, which are involved in the development of homestead horticulture and in small credit schemes, with support from BRAC.
- DAE has adopted a Farmer Group approach and, since the start of CDSP-II so-called Farmer Forums have been formed, which are now DAE/CDSP's major extension mechanism. The Farmer Forums are to some extent animated by NGOs which work with BRAC for the promotion of homestead horticulture. All extension messages from DAE are now being delivered to the farmers through these Farmer Forums.
- *Shakhi samity* (Friends' Society). All women members of three or four PCs and SPCs were extracted to form a separate society in the name of *Shakhi Samity* at South Hatiya, Muhuri Accreted Area and Boyer char during the later part of the CDSP-II. These societies try to motivate and organize women to overcome gender disparities in all wakes of their social livelihoods.

There have been suggestions to convert the WMC into multi-functional committee which would also involve themselves in agricultural production, or at least establish some functional links between them and the Farmer Forums, but steps are yet to be taken. However, there are informal linkages, considering the fact that some of the members of the WMCs are also the members of a Farmer Forum.

3.5 The private sector

The private sector is poorly developed in the coastal zone, especially in the recently settled char areas. There are small rural markets where produce can be sold piecemeal and some seed and planting material can be purchased. Small shopkeepers sometimes sell other agricultural inputs like fertiliser and small tools. Traders from Noakhali will only come and buy produce if they can be assured of sufficient volume, like in the case of the recent expansion of watermelon, okra and sweet potato growing in Char Mara Dona.

Eighty percent of the farmers' needs as expressed by the Farmer Forum members were related to the kind of services which the private sector would be expected to provide: seed of paddy HYV and rabi crops, bins for seed storage, knapsack sprayers, rice threshers, market outlets and fertiliser (least mentioned!). During CDSP-I DAE identified and licensed 5 dealers in agricultural inputs but they do not seem to have gone off to a successful start, reputedly because the demand was too weak. The situation may be more favourable now, however, but no documented information is available at present about the current input supply situation in the zone.

3.6 Strengthening service delivery; the CDSP experience

This section reviews the achievements and the remaining challenges in mobilising agencies to deliver the services in the char areas and organising farmers to obtain the services they need.

3.6.1 DAE

In the early years of CDSP-I, project staff intervened directly in agricultural extension, although always in close co-operation with the DAE staff. A network of demonstration- and 'extended' farmers was established who were provided with the necessary inputs to apply a variety of technologies, ranging from paddy HYV and rabi crop varieties to Integrated Pest Management and green manuring. The CDSP-I agricultural advisor exploited his own informal network to obtain information, seed and planting material, from BARI, BRRI, SRDI, BADC and others, which were purchased directly with CDSP funds.

At the inception of CDSP-II it was decided that consultant staff would henceforth play a less direct role and emphasise facilitation and co-ordination of local actors. For agriculture this meant that CDSP-sponsored activities would be integrated into DAE's regular programme. A budget was provided directly to DAE for that purpose and DAE posted additional field staff to the char areas. The 'demonstration-extended farmer' approach was abandoned, however, and replaced by a group approach through 'Farmer Forum' (FF). The FF is further discussed in Chapter 5.

As from late 2002, during CDSP-II, things improved and DAE managed to carry out most of the agreed programme of crop demonstrations, farmer forum meetings, farmer training, on-farm seed multiplication, monitoring of land use changes, etcetera. The programme was quite successful in several respects, as described elsewhere. One of the early weaknesses was the absence of systematic programme planning taking into account the specific conditions in the coastal zone and previous results. The consultant staff, therefore, started developing the Productivity Zone (PDZ) concept and assembling a technology sourcebook, as discussed in Chapter 5. These will then increasingly form the basis for more systematic planning of DAE's extension programme.

3.6.2 The Research Institutes

An important question for any agricultural extension service is where and how to get new ideas and new technologies, and how to test them prior to their dissemination. Research institutes are expected to generate new technology and propose them for extension, after due testing under farmer conditions. That is particularly important for the coastal zone, because of its peculiar agro-ecological conditions, which means that results obtained elsewhere do not necessarily apply here. The knowledge base about agro-ecological conditions in the char areas surprisingly weak and there is a lack of new technologies developed specifically for those conditions. CDSP-II therefore had a provision to contract research services with three research institutes, with BARI and to a lesser extent BRRI for on-farm research, and with SRDI for soil related surveys and analyses, all to be funded through the DAE budget. Only a minor part of the funds for on-farm testing could be spent because of administrative difficulties: BARI and BRRI are not permitted to draw treasury funds at the District level and there is no separate project agreement with the institutes at the central level, as is the case with DAE and other line agencies. The co-operation with SRDI, which is part of the same administrative structure as DAE, has been much more favourable. Their District staff has carried out all baseline salinity and soil fertility sampling in the char areas covered by CDSP, under an allocation from the DAE-CDSP budget, drawn directly from the treasury.

In CDSP's daily practice, innovative approaches came largely from the consultant team rather than from research. That is the case with the development of the PDZ and the assembly of a technology sourcebook (vol.2 of this report), which ideally should have been done by or in close co-operation with BARI. Furthermore, the agricultural advisor has been the main source of new ideas on crops and cropping practices and in most cases the CDSP team has been obliged to do its own screening and on-farm testing. It will be important to thoroughly discuss the PDZ concept and the sourcebook with the research community and have them formally accepted. The ICZM project should be asked to initiate that discussion, because the tools should be of costal zone-wide interest.

3.6.3 Other agencies and projects

Only one other agency, MCC, is directly active in the promotion of agriculture in the coastal zone. Over the years they have carried out a massive and quite successful soybean promotion programme. MCC carries out mostly on-farm testing of crops and production technologies generated elsewhere and more recently they have started a modest research programme on the integration of crop livestock and fish at their Mannan nagar research station although some trials are being carried out under actual field conditions within this region. However, being a private organization, MCC has little or no access to the policy makers like BARC and the Ministry of Agriculture although they share their experiences with farmers, extension workers, other NGOs, some academicians and other Government bodies. However, a change in the policy of the organisation is imminent. Its role is changed from being a direct actor to a supportive one who supports other NGOs with technical advice only. There has been no direct co-operation between CDSP and MCC, beyond the exchange of information.

There have been several, mostly donor-funded projects within DAE and BARI with activities in the coastal areas. Examples are:

- Crop Diversification Programme, funded by Danida and carried out by DAE
- On-Farm Seed Multiplication programme, funded by Danida through DAE
- The integrated soil fertility and fertiliser programme (SFFP), funded by World Bank at BARI
- Poverty Elimination through Rice Research Assistance (PETRRA), funded by DfID and carried out by BRRI and BARI with scientific support from IRRI.

These programmes are (or were) all implemented nation-wide and they are centrally planned, in theory with some, but in practice probably with very little influence of the local staff on programme content.

3.6.4 BRAC, homestead production and Farmer Forums

Since 2000 BRAC intervenes in the CDSP mandated areas under a separate contract with the Netherlands Embassy. The objective is the promotion of intensive horticultural production only in the homesteads, carried out by local NGOs with BRAC support. There has been little or no co-ordination between this horticulture programme and CDSP-II's field crops programme, although both work in the same areas and often with the same households.

Earlier CDSP-II's Agriculture Unit requested BRAC and its associated NGOs to help out in organising the Farmer Forums. Since this role was not part of their original programme agreement with the RNE it was looked at as an additional burden and did not take off well.

3.6.5 Input delivery and marketing

There have so far been no systematic efforts to promote input delivery through the private sector. In the context of the DAE extension programme inputs have been made available to a limited extent for demonstration purposes by CDSP/DAE, in particular seed of new paddy varieties and new crops. The Farmer Forums have been stimulated to practise on-farm seed production, for sale to its members and outside clients. This is further discussed in Chapter 4.

Marketing of agricultural produce is another area where little programme activity has so far taken place. Farmers sell their produce through existing channels, which normally does not pose major problems, except for unusual products, like sunflower and to a lesser extent soybeans. In the future more attention should be paid to marketing bottlenecks and possible price advantages accruing from pooling of produce by farmer groups and collective transport to larger markets.

3.7 The institutional context must be reformed

Over viewing the institutional landscape relating to agricultural development in the coastal zone, the most striking features are fragmentation and lack of focus.

First there is extension, which is mainly provided by a public organisation, DAE. Other, non-government organisations play a role as well, but a fairly small and specialised one: MCC for some specialty crops, soybeans in particular, and BRAC for homestead horticulture. DAE is CDSP's primary partner for agricultural development. Its major role is to provide information to farmers about appropriate production technology and demonstrate the technology in their fields. DAE decides what technology it will demonstrate or recommend and should therefore have some priorities in mind. Ideally, they would be based on farmers' own priorities, the agro-ecological conditions under which they work and what technologies are within their means to use. In everyday practice that kind of analysis barely takes place. A lot of extension is routine demonstration of so-called improved varieties and cropping practices which are defined somewhere else in the system, mostly at central level. Internationally funded projects are superimposed on the DAE programme, to promote specific technologies, like IPM or integrated fertility management. Also, there is no system in place which allows DAE to find out how successful the innovations are when used by farmers and whether they are used at all, or to what extent.

This suggests that three things are needed to make extension more effective:

1. An effective extension approach.

A mechanism is needed to find out what farmers really need, not what somebody in the organisation thinks they may need. The farmer group approach which is being adopted by DAE is meant to sharpen the organisation's sense for real farmer needs, but it is doubtful that DAE has the attitude to make the groups into a real participatory medium where dialogue takes place, rather than the one way 'teaching' which is most common now. While more will be said about this in Chapter 5, here we want to suggest that in order to make the participatory process more effective what is required first is a change in the attitude of the DAE personnel so that the concept of the new agricultural extension policy (NAEP) is fully understood and implemented.

2. Better tools for choosing appropriate technology

The organisation needs better tools to choose those technologies which are best adapted to coastal conditions. CDSP consultants completed coastal land zoning based on salinity and flooding depth and on a technology sourcebook which brings together all the technologies deemed suitable for each Productivity Zone (PDZ). This is taken up further in Chapter 4.

3. Better integration of different 'vertical' projects within DAE

Several 'vertical' projects, usually donor-funded, have worked through DAE. Such projects could be useful, provided they are an integrated part of the overall programme planning at the level of the coastal zone. As it is, they are usually run entirely as small stand-alone projects and it is doubtful that much if any of the results eventually find their way into farmers' practices. An example is the PETRRA project, which was recently evaluated and will probably be extended under the label "Managing Water and Land Research for Sustainable Livelihoods at the Interface between Saline and Fresh Water Environments in Vietnam and Bangladesh". The project (PETRRA) would benefit much had the activities of CDSP been reviewed during the evaluation of or formulation of their follow-up projects. Therefore, it shows the urgent need for much stronger co-ordination among the different projects working in an area with common goals. A suitable coordinating body would be either ICZM or DAE who could take up the task of coordination in close collaboration with CDSP in future.

There are two other things, which are important for agricultural development, but which DAE cannot do, or only to a very limited extent. The first is providing the inputs which are needed for boosting production, including seeds, fertiliser, insecticides and small equipment. The second is generating new technologies which may do better job for farmers.

For input supply there is only one public institution, BADC, but its size and role have been severely reduced during the last decade. In Bangladesh, as in most other countries, input supply is no longer seen as a task for government but should be taken care of by the private sector, including farmer co-operatives and perhaps NGOs. In the new chars the private sector is practically non-existent and farmers who want to buy fertiliser, HYV seed, equipment, etcetera, have to travel out of the area to find them. Under those circumstances some organisation, whether government or non-government, should provide assistance, on a non-profit basis, to the emerging private sector in the chars to establish themselves as dealers. Some unsuccessful attempts were made during CDSP-I, and this issue should be addressed in a more systematic manner in the future. A first step would be to assess the current demand and explore how farmers at present obtain their inputs. Based on that information a strategy for input supply should be developed.

In Bangladesh the tasks of generating new technology and testing them under farmers' conditions are assigned to publicly funded national research institutes. Technology is developed for broadly defined ecologies, including coastal conditions with saline soils. Crop breeding particularly has met with significant success and good high yielding varieties are available, especially for paddy, some of which perform well under coastal conditions. The public institutes will remain the only source of improved varieties in the foreseeable future. Research work on crop production practices has been much less successful. As a result, technologies that are thought to be feasible for saline conditions have not yet been extensively tested under farmer conditions. CDSP has done some on-farm testing itself, but that is obviously not its task. BARI is the most indicated institute because of its national on-farm research mandate, but there have been problems with contracting the institute for 'demand-driven' on-farm testing, apart from its evident staff weakness. Once the Technology Sourcebook is ready and the technology gaps have become clear, a way must be found to carry out on-farm testing with appropriate technologies to fill the gaps. The possibility should be explored to contract a non-government or private organisation with strong capabilities in applied research to carry out à la carte on-farm testing according to the priorities formulated by DAE with support from CDSP Agriculture experts.

Chapter 4 Agricultural production

4.1 Introduction

The principal land use in the coastal region is crop production, although a section of char people earn their livelihood mainly from selling labour; the fraction of the latter being about 0.27. About 40% of the household heads are directly involved in crop production while fishermen comprises only 1 to 8% of the char people. Therefore, crop production remains as the principal sources of livelihood.

Three cropping seasons, Kharif-I, Kharif-II and Rabi, classified based on mainly the rainfall and temperature, are distinguished (Fig. 3). In the coastal region, however, soil salinity is an additional factor that determines which crops and cropping practices to be followed under a particular soil condition. The characteristics of each of the seasons are discussed below; while our activities related to the improvement of the cropping practices during these seasons are elaborated and discussed in section 4.7 of this chapter.

Besides the physical determinants a number of socio-economic factors directly affects cropping practices in the country and the coastal region is not an exception. However, some of the socio-economic elements are the characteristics of the coastal regions and strongly influence all farm activities. These are discussed below before we go for describing the actual cropping practices.

4.2 Land use, farm size and major cropping patterns

Agriculture Unit conducted a sample survey in two chars, MD and SH, during January and February 2004. During this survey 241 farmers of MD and 169 farmers of SH were interviewed and recorded farm size, land use and year-round cropping practice of each of the plots he cultivated. These findings are summarized below but the vivid analyses of these findings are offered in section 4.7 and 4.8 by assessing the impact of the project interventions on farming practices, particularly their influences on land use and adoption of modern agricultural technologies, by comparing with those of the baseline survey.

4.2.1 Land use

The principal land use in the coastal area is crop production. Although there are potentials for other forms of land use such as livestock farming and fishery the existing Government policy does not support these interventions, either in the Govt. or in the private sector, except the last one. On the other hand the resource poor farmers of the region cannot adopt large-scale fishery programme and as a result absentee vested interest groups are more active in grabbing land for fishery project making the poor farmers poorer. Recently GNAEP, a DANIDA-funded project, is trying to bring these displaced farmers back to a modified system of land use – the rice-cum-fish culture in the greater Noakhali district. However, it is still in its infant stage.

Since fishery is not included in the CDSP programme, the latter tried to improve the economic condition of the char farmers by improving agricultural crop production. This was achieved by in three ways: (a) increasing adoption of more productive high value crops, (b) increasing area under the more productive crops, and (c) increasing cropping intensity. These are discussed in greater detail in section 4.7.

4.2.2 Farm size distribution

Farm size varies from 0.08 to 10.68 ha at MD and from 0.20 to 7.77 ha at SH (Table 14). Most of the farmers rented in land irrespective of the farmer category; larger farmers rented in more land than the smaller ones. Most of the farmers of MD belong to small farmer category while those of SH belong to mostly medium farmer category and there is no landless farmer in this char. About 18% farmers of each of the two chars are large farmer.

Table 14. Farm size distribution (%) in two chars of CDSP-II as of 2004

Char	Farm size (ha)		Farm size distribution	
	Minimum	Maximum	Farmer category	% farmer
MD	0.08	10.68	Landless (0-0.2 ha)	2.5
			Small (>0.2-1.0 ha)	41.1
			Medium (>1.0-3 ha)	38.6
			Large (>3 ha)	17.8
SH	0.20	7.77	Landless (0-0.2 ha)	0.0
			Small (>0.2-1.0 ha)	22.5
			Medium (>1.0-3 ha)	59.8
			Large (>3 ha)	17.8

4.2.3 Cropping patterns

The changes in cropping pattern and intensity after the project interventions in two chars are in Table 15. Single cropped areas covered about 58 and 41% of the cultivable areas of MD and SH respectively. There was no plot planted with only aus while only rabi crops covered less than 1% areas. Therefore, transplanted aman rice was the dominant single crop that covered 57.4 and 40.1% of the total areas of these chars. Likewise, about 34 and 37% areas of MD and SH, respectively, were double cropped. Transplanted aman followed by rabi was the dominant cropping pattern in the doubled cropped areas. Triple cropping of aus, aman and rabi covered only about 9 and 22% of the cultivated land of these two chars. The overall cropping intensities are about 151 and 180 at MD and SH respectively. There are several factors contribute to the changes in cropping patterns which have been taken up in section 4.7.

4.3. Cropping seasons, production practices and crop yield

Reviewing all the prospects and problems enumerated below and above, CDSP-II started with analysing the present situation of agro-ecology, crops and cropping patterns and the constraints for adoption of modern technologies in the coastal char areas. The search for better technologies continued through screening of crops against various levels of soil salinity.

4.3.1 Kharif-I season

This season starts from March/April and ends in June overlapping dry and monsoon seasons and is characterized by high temperature as well as scanty rainfall during the crop establishment stage (Fig. 3). Often crops suffer from drought at the establishment and or early stage and submergence at the later stage, particularly in low-lying areas.

Table 15. Percent of land under each cropping pattern in two chars of CDSP-II.

Cropping pattern	Chars	
	MD	SH
Aus	0.0	0.0
Aman	57.4	40.1
Rabi	0.2	0.4
Total	57.6	40.5
Aus-aman	3.0	4.6
Aus-rabi	0.1	0.1
Aman-rabi	30.6	32.2
Total	33.7	36.9
Aus-aman-rabi	8.7	22.2
Cropping intensity	151.1	180.9

Climatically this season has the least productive potential. High diurnal fluctuation in temperature during the vegetative stage not only favours profuse vegetative growth but also encourages growth of weeds and other pests and diseases. On the other hand, narrow fluctuation in air temperature at the ripening or later growth stages of the crops lowers the net assimilation rate resulting in lower yield of grain crops. These make the season somewhat risky for crop production and therefore successful crop production in most cases depends on supplemental irrigation and proper control of pests and diseases.

Total amount of rainfall required to produce crops successfully is about 800-1000 mm for aus. Farmers start preparing their fields after one or two showers. After the dry season at least 150 mm rain is required to begin land preparation and a total of about 200 mm rainfall needed for proper stand establishment of aus crop. Low probability (0.09-0.17) of optimum rainfall indicated higher chances of failure to establish aus crop in optimum time (April) and other kharif-I crops (Table 16) and therefore, a satisfactory production of kharif-I crops in all the years would depend on supplemental irrigation. This table also shows that high (>500 mm per month) rainfall starts soon, which often (probability 0.66 - 1.00) damages standing kharif-I crops.

Crops grown

Only aus rice and some summer vegetables are grown in this season. Since the physical conditions of the coastal chars, particularly the unfavourable soil moisture status and soil salinity, do not permit normal growth and performance of the summer vegetables, the char farmers usually grow aus rice during this season. The most favourable areas for this crop are those with low to moderate soil salinity. The practices required for successful culture of aus rice in the coastal region are described below.

Table 16. Probability of rainfall at Maijdee court (calculated from 48 years data).

Month	Total rainfall, mm				Season	Seasonal rainfall, mm	Probability
	>=200	>=300	>=400	>=500			
Jan	0.00	0.00	0.00	0.00	Rabi (Nov-Apr)	>=120	0.72
Feb	0.00	0.00	0.00	0.00		>=220	0.38
Mar	0.09	0.02	0.00	0.00		>=320	0.19
Apr	0.17	0.04	0.02	0.00		>=400	0.09
May	0.77	0.49	0.36	0.13		>=500	0.06
Jun	0.96	0.87	0.81	0.66	Kharif-I (Mar-June)	>=500	1.00
Jul	1.00	1.00	0.96	0.94		>=800	0.79
Aug	0.98	0.96	0.85	0.72		>=900	0.71
Sept	0.94	0.68	0.45	0.23		>=1000	0.50
Oct	0.40	0.26	0.15	0.04			
Nov	0.04	0.00	0.00	0.00			
Dec	0.00	0.00	0.00	0.00			

The choice of a variety depends on a number of factors such as (1) growth duration, (2) tolerance to drought and soil salinity, (3) grain quality, and (4) demand in the local market. During mid-eighties several HYVs were introduced in this region. Among these only BR1, BR3, BR9, BR14, BR20 and BR21 became popular but only beyond the saline belt while the traditional varieties like Hashikolmi, Boilam, Kerandol, Binnatoa thrived well in the saline ecosystems. Baseline survey done in seven chars during 2000 indicates that the traditional varieties were predominant in the coastal region although some farmers were just found flexible to grow some HYVs until mid-nineties. The changes in adoption of varieties are discussed in greater detail in Section 4.7.

Planting method

There are two types of aus rice culture: direct-seeding and transplanting. In the former method, farmers generally sow the dry seeds by broadcast or dibble the seeds directly into the sub-soil layer just after the first shower in late March or early April and are grown under rainfed conditions until the crop is harvested in July/August.

Rainfall pattern also dictates the choice of planting methods as it also regulates soil salinity. If monsoon starts early, direct-seeding, particularly dibbling is beneficial otherwise transplanting is an easy tool to avoid salt injury since planting of rice can be done in late April to early May. Transplanted culture is not very popular in the Noakhali coastal chars mainly because of the non-availability of suitable land and sufficient water for preparation of the nursery beds and raising seedling. Dry seedbed are prepared elsewhere but it is not possible in the coastal region due to the unfavourable soil texture and risk of aggravated drought-related soil salinity problem.

The choice of planting method also depends on the types of variety and the agro-ecological conditions; generally the HYVs are transplanted while the LVs are sown directly in the field. Direct seeding can, depending on the land type and rainfall pattern, be done on the dry or on a puddled seedbed after adequate rainfall.

Fig.15. Dry seeds of aus rice are dibbled to about 5-cm deep to avoid salt injury to the germinating seeds. Similar technique is used to prepare seedbed for transplanted aus rice.

Farmers of the coastal saline belt started experimenting by themselves and eventually discovered that deep dibbling is an effective method to avoid salt injury to the germinating seeds (Fig. 15). Since then they started growing HYVs like BR20 and BR21 under dibbled conditions. Being impressed by the higher yields of these varieties farmers gradually moved to transplant the other HYVs mentioned above. All of these varieties performed satisfactorily only in years when early monsoon set it. Failure of crops, particularly the direct-seeded ones, often occurred due to the development of drought-related high soil salinity during the seedling stage.

Rice yield

The various climatic features (as discussed earlier in this section) restricts yield of aus rice even when the crop is grown with utmost care and maximum level of management. Nevertheless, farmers, particularly the poor ones with extreme vulnerabilities, cannot avoid growing this crop. In Bangladesh, aus rice is a crop that brings life for the poor people in particular since it is harvested in such a time of the year when usually the farmers have no food to eat.

A series of crop-cut were done in the farmer-managed crop fields to assess the trend of rice yield in all the project sites. The crop from $10m^2$ area selected at random in a plot was cut, processed and weighed in the field. Grain moisture content was measured using a portable grain moisture meter and the weight was adjusted for 14% moisture content before converted to yield in ton per hectare. The results in Table 17 show that HYVs gave 1.21 t/ha (about 75%) higher yield than the local varieties. The average yield of these HYVs achieved is much lower than their potential yields which is an indication of applying inadequate management required for these varieties.

4.3.2 Kharif-II season

The season covers the full monsoon period from July to December when more than 2000 mm rainfall (about 60% of the total annual rainfall) is received (Fig. 3). Besides high rainfall the season is characterized by high humidity and high temperature with a minimum diurnal fluctuation in the air temperature until later part of September and increases thereafter. During the flowering time of the aman rice (October-November) night temperature remains fairly above the critical level (19^{o} C) for the existing varieties (BRRI, 1987[15]), which are also moderately suited to this ecology. This kind of thermal regime of the south-eastern coastal region during the late reproductive phase favours higher grain production of aman rice.

Soil salinity normally remains at its minimum level due to washing away with rainwater and is not a major problem in this season. Since the total amount of rainfall required to produce crops successfully is about 1200 mm is almost evenly distributed over the time in Kharif-II (for aman rice) season, normally this kind of rainfall distribution in the coastal region is good for kharif-II crops. However, occasional short drought spell (usually not lasting for more than 10 days) may occur during both the early and later parts of the season when the crops may suffer from both drought and drought-related soil salinity.

Table 17. Grain yield (t/ha) of aus rice (mean of all char)

HYVs		Local	
Variety	Yield	Variety	Yield
BR1	2.96	Bhatraj	1.76
BR2	2.90	Bhaturi	1.64
BR3	2.86	Binnatoa	180
BR12	2.76	Boilam	1.63
BR14	3.01	Chabakhoi	1.76
BR20	2.85	Chinal	1.24
BR21	2.41	Hashikolmi	1.46
BR24	3.11	Kerandol	1.70
BR26	2.40		
BRRI Dhan27	3.15		
Chandina (?)	2.95		
Dayal iri (BR9)	2.60		
Purbachi	2.75		
Sonali	2.89		
Mean	2.83	Mean	1.62

[15] BRRI, 1987. Internal Review of Plant Physiology Division, Bangladesh Rice Research Institute.

Planting method

Transplanted aman rice, the main crop of the country, is the only crop grown in the season extensively and it is very hard to find a fallow plot unless the area is too low for this crop. Transplanted rice culture requires raising of seedlings in especially cared seedbed. Depending on the cropping pattern, Since the rain starts earlier in the coastal region, farmers of Noakhali region start preparing seedbed in June, about a month ahead of the season, in the mono-crop areas and transplantation is completed within the first half of August. In the double-cropped (aus followed by aman) areas aman rice is normally transplanted up to the end of August. However, transplanting of aman rice often (2 to 3 years in every ten years) becomes late due to delayed rainfall that also delayed the establishment of the aus crop.

Rice variety

The type of rice varieties to be grown depends on the time of planting and depth of flooding. Varieties not sensitive to photoperiod have a limited span of time within which they have to be planted for getting optimum yield. Since transplanting time is more flexible for the varieties having sensitivity to photoperiod, transplanting can be extended, depending on the degree of sensitivity, up to the first week of September. However, not all the strongly sensitive varieties can give optimum yield unless they have at least moderate thermosensitivity so as to avoid low temperature stress during the reproductive stage and some adjustment in planting practices are made.

Kajalsail and Rajasail, the two varieties strongly sensitive to photoperiod, are being grown traditionally in the Noakhali coastal region and still cover the largest area. Planting of some HYVs (BR22, BR23, BRRIDhan31, BRRIDhan39, BRRIDhan40 and BRRIDhan41) has increased considerably during the last five years as discussed in sections 4.7.2.

Rice yield

Following the method mentioned in the previous sub-section 155 crop-cuts were done in the aman season. The results (Table 18) show that yield of HYVs varied from 2.5 to 5.5 t/ha with a mean of 3.98 and that of local varieties varied from 1.45 to 3.50 t/ha with a mean of 2.06. High yielding varieties, on an average, gave 1.92 t/ha more yield than the local ones. Among the HYVs, BR23, BRRIDhan40 and BRRIDhan41 are more productive yielding more than 4 t/ha; others yielded less than this. Large variations in the yield of rice, both high and low yielding, are mainly due to difference in the level of managements employed by the farmers.

4.3.3 Rabi season

In Bangladesh rabi season starts as soon as the rain stops in October and covers the period up to mid-May (Fig. 3). But in the coastal region activities on rabi crops cannot be started until December or even early January in some areas. This is mainly because many fields remain under water or the soil moisture remains at or near saturation (Fig. 13). Late rain often occurs during October to December making seedbed preparation for rabi crops difficult. Damage to greengram (*Khesari*) relayed in preceding aman due to late rain appears to be a common feature in the recent years. Crops can normally be established in most plots using the residual soil moisture but a success of normal crop production depends on irrigation (Table 16). Production of rabi crops in the coastal region faces two major constraints; drought in the crop establishment phase and high soil salinity throughout the season.

Table 18. Grain yield (t/ha) of aman rice (mean of all chars)

Variety	Yield, t/ha		Variety	Yield, t/ha	
	Range	Mean		Range	Mean
BR11	2.87-4.60	3.61	Kajalsail	1.90-2.80	2.23
BR22	2.71-4.75	3.75	Rajasail	1.58-3.50	2.09
BR23	3.03-5.50	4.39	Betichikon	1.45-2.80	2.13
BRRIDhan30	3.19-4.50	3.98	Binni	1.59-1.80	1.72
BRRIDhan31	2.68-4.80	3.74	Gigaj	1.75-2.70	2.23
BRRIDhan32	2.60-5.20	3.71			
BRRIDhan39	2.50-5.10	4.18			
BRRIDhan40	4.40-5.45	4.93			
BRRIDhan41	3.00-4.40	3.55			
Mean		3.98			2.06

Total amount of rainfall required to produce crops successfully is about 250-450mm in rabi (for non-rice crops only). With regard to availability of moisture the rainfall pattern during the last 48 years at Noakhali shows that rabi crops can successfully be grown only in three of every 10 years with supplemental irrigation and only one of every 10 years under rainfed conditions. However, there are chances when rainfall exceeds this amount (only one of every ten years) and some crops may suffer from water congestion (Table 16).

Low temperature is another characteristic of this season which restricts growth and performance of certain crops. However, in the coastal region mean night temperature remains above 13^o C which is about 3 to 4 degrees higher than elsewhere in the country.

Crops grown

There are a host of crops belonging to vegetables, spices, oil crops, cereals and pulses grown in this season throughout the country. These are mostly irrigated crops and thus cannot be grown in the coastal region where there is limited scope for irrigation. Table 19 lists ten dominant rabi crops grown in the coastal chars of Noakhali. Moreover, after the harvest of aman crops the entire coastal areas becomes grazing ground for the cattle (Fig. 16). Because of these limitations a large area remains fallow in this season.

The coastal region is characterized by a range of maximum and minimum temperatures that are favourable for most field crops grown in the country except wheat. Wheat, the next important cereal crop after rice, needs prolonged duration of low temperature, particularly during grain filling stage, for satisfactory yield. This crop requires at least 25^{o} C average (mean of day and night) temperature for satisfactory grain filling while 20^{o} C is needed for getting optimum sized grain.

Table 19. Dominant rabi crops in two chars of CDSP-II as of Rabi 2004.

South Hatiya			Mora Dona		
Rank	Crop	% rabi area covered	Rank	Crop	% rabi area covered
1	Mungbean	23.1	1	Mungbean	37.3
2	Linseed	17.5	2	Chili	13.4
3	Greengram	16.8	3	Water melon	10.4
4	Groundnut	13.8	4	Groundnut	9.3
5	Felon	11.2	5	Felon	8.5
6	Sweet potato	7.0	6	Sweet potato	5.5
7	Chili	6.6	7	Soybean	4.2
8	Water melon	1.4	8	Greengram	3.0
9	Soybean	0.9	9	Okra	2.9
10	Tomato	0.2	10	Linseed	1.0

Therefore, wheat may have limited prospect of growing in the coastal region in view of the fact that during the grain filling stage (February-March) average temperature remains moderately favourable only in five or six of every ten years. In other years low yield of wheat is expected due to higher temperature that results in shrivelled grains. High minimum temperature (>12^{o} C) in the coastal region compared to other parts of the country during January provides flexibility in establishment of some rabi crops, particularly boro (irrigated winter crop) rice. Diurnal fluctuation in temperatures during the vegetative phase of favours higher production of winter vegetables in south-eastern coastal region.

Greengram relayed into transplanted aman rice, chilli, groundnut and sweet potato are predominantly grown in most chars. In addition to this, linseed is also popularly grown in some chars, particularly at south Hatiya and Gangchil-Torabali.

Farmers of the coastal chars of Noakahli had been growing groundnut for long but recently its popularity has been reduced due to the problem of harvesting and post harvest processing. In the recent years coastal region receives high rainfall during early monsoon and groundnut fields remain under water at the time of harvest. The wet nuts are difficult to separate from plants and also drying of nuts becomes impossible due to frequent rains and non-availability of drying space.

The changes in crops which are grown in the rabi season is discussed in section 4.7.

4.3.4 Homestead crop production

BRAC-CDSP initiated this programme in the Noakhali coastal chars with a separate arrangement with the Netherlands Embassy. BRAC executed the programme in the CDSP areas through a partner NGO of the locality. The programme is coordinated by the BRAC sector specialist. It is expected that BRAC will be able to contribute to this document with a brief technical report in later time.

4.4 Input supply

Modern agricultural technologies are high-input based. These inputs include seed, fertilizers, pesticides and farm implements and machinery. Currently BADC is the lone national organization that bears the responsibility of production, processing and distribution of seeds to the farmers of the country. But using the available resources, hardly it could satisfy 5% of the total national requirements. Rest of the demands are being met up through local production and farmer-to-farmer distribution of seeds. BADC had also been supplying other inputs like fertilizers, pesticides and some farm implements, particularly irrigation equipments until supply of these was privatised in phases during eighties. Since then though the availability of these inputs to farmers have been increased all over the country, their availability to farmers of the coastal

Fig.16. Grazing animals are the threat to rabi crop production in coastal chars

chars is not satisfactory. We tried to motivate some farmers to put up business in agricultural inputs but failed. All of them opined that there is no demand for these commodities in the chars. We found three main reasons for this. Firstly, since the farmers traditionally grow some local varieties of rice having high demand in the local market, the cropping intensity in the chars is low. Secondly, a few farmers showed interest in growing HYV aman rice but did not come forward due to the unavailability of fertilizers in the local market. Thirdly, the development of the local markets is not satisfactory due to the poorly developed infrastructure and communications systems, which is a pre-requisite for market development.

The project started intervening to improve agricultural production through introducing HYVs of various crops. But in the initial stage the rate of adoption of these crops was very slow and was even negative in some cases. While the negative adoption was found to be due to the unfavourable water conditions in some chars, the main causes of low adoption of HYV of rice and other modern agricultural technologies in the coastal chars of Noakhali are the non-availability of seeds and fertilizers and lack of marketing facility.

Considering the limitation of BADC the project supported the programme with some inputs and supplied about 56 tons of fertilizers and about 23 tons of seeds (Table 20), which motivated the farmers to grow HYVs of aman rice and rabi crops. In order to make the farmers self-sustaining with regard to seed production, the project tried to improve the production, processing, storing and distribution of seeds of suitable varieties of rice in four project areas. During a farmer group discussion it came out that farmers could not maintain the quality of seed due to lack of knowledge of seed production and lack of proper storage facilities. As a pilot programme, 25 farmers (12 of MD, 5 each of CL and SH and 3 of GT) were selected on conditions that they would produce seed not only for their own use but for selling to the neighbouring farmers also. Thus each of the farmers would be the centre of technology dissemination. They were specially trained in production, processing and storing of rice seeds under char situation. Each farmer was given a plastic seed-bin to store seed.

Table 20. Supply of agricultural inputs (kg/no.) in the project areas

Inputs	Year				
	2000	2001	2002	2003	Total
Urea	0	0	6393	17043	23436
TSP	0	0	3487	18356	21843
MP	0	0	1746	9272	11018
Seed	350	1610	2692	18618	23270
Seedlings (No.)	4500	8000	0	0	12500

During the last three consecutive crop seasons these 25 farmers produced 6330 kg seeds of 11 varieties of rice out of which they sold 3940 kg to 554 farmers of the areas after meeting their personal requirement (Table 21). Follow-up casual interview with the farmers who bought seeds from the piloted producers revealed that on an average 3 other farmers purchased seeds from them. This means that multiplication of seed proceeded further thereby increasing the area under HYVs and overall cropping intensity (Tables 15 & 36).

Table 21. Quantity of rice seeds produced and distributed by the farmers of four chars

Char	Produced, kg	Distributed, kg	# farmer bought seed	Variety	Quantity (kg)
CL	1050	615	99	BR11	350
GT	630	390	42	BR22	100
MD	2470	1500	154	BR23	2250
SH	2180	1435	259	BRRI Dhan27	1150
				BRRI Dhan30	190
				BRRI Dhan31	590
				BRRI Dhan32	150
				BRRI Dhan39	240
				BRRI Dhan40	420
				BRRI Dhan41	890
	6330	3940	554	Total	6330

4.5 Livestock

Though livestock has not been a component of CDSP-II, the latter could not ignore the contribution of this sector to the livelihood of the char people. As such some observations made in this regard is presented below with the hope that this will draw necessary attention of the concerned authorities and eventually a pragmatic programme will evolve.

1. A coastal char land initially emerges as a mud-flat which gradually turns to be a grassland. Upon maturity, the unauthorized char dwellers convert this

grassland into a crop field that usually begins with a small homestead. This country having the highest population density of 840 per square kilometre is trying hard to accommodate this booming population on its ever-decreasing landmass. As a result there is no space available in the country to take up another essential enterprise like livestock, particularly dairy farming. Coastal chars offer the Government an opportunity to meet up the space problem without displacement of the people from their permanent parental abode. Moreover, this would create more job opportunities for the char people.

2. At present a large flock of cattle, mainly water buffaloes, cows and rams owned by some influential absentee landlords are found in almost all chars. These cattle take shelter in the forests of the coastal shoreline during monsoon when fields remain flooded and come out of the forest during dry season for which cultivation of rabi crops in some char becomes impossible.
3. There are serious crisis of draft animals in the chars for which farmers use power tiller to do the primary tillage. This lowers the quality of soil tilth and eventually satisfactory performance of various crops, particularly the rabi crops, is not achieved. In absence of a disk plough, animal drawn plough is more efficient during primary tillage. Therefore, much scope exists in promoting small-scale livestock farming in the chars provided freshwater availability is ensured which is a problem in most chars. This not only would solve the crisis of draught animals but also would bring more cash earning to the poor people.

4.6 Productivity Zones (PDZ) and technology targeting

4.6.1 The PDZ concept

Soil and water conditions in the coastal char areas are far from uniform. There are considerable differences, even over fairly short distances, in depth of flooding during the monsoon and soil salinity during the rabi season. Agricultural extension must formulate suitable packages of recommendations which take those differences into account. They determine the options farmers have for land use and the kind of technology they need. The PDZ have been mapped for several char and polder areas with two purposes in mind:

- Prediction of the options farmers have for land use in a particular location; If the prediction is different from what farmers actually do this means either that our understanding is incorrect or that there are other more important factors affecting land use (e.g. land tenure relationships!)

- Targeting of technologies by the extension service to those PDZ for which they are most suitable. This is a very important objective which so far has not been attained.

4.6.2 Mapping of PDZ

CDSP-II has, therefore, identified four PDZ with different combinations of field water conditions and soil salinity.

Field water conditions

During plot-to-plot surveys farmers were asked about the maximum flooding depth in a particular field or location. These maxima were used as a single factor characterising overall field water conditions in that location. That is justified because monsoon flooding depth has implications for both monsoon and for rabi cropping.

Soil salinity

Our database on soil salinity consists of grid-based data measured in early April, i.e. when salinity is maximum. In order to interpret these data the response of crops to soil salinity must be known. Field trials were carried out with a range of potential rabi crops to observe their performance under different salinity conditions in the rabi season (Technical Report 5, Vol. 2, table 5). They show that growth reduction for all crops was minimal as long as EC_e of the topsoil (0-10 cm) measured in April was below 8 dS/cm. Above this level different crops reacted differently, according to their tolerance. In view of these results and earlier data (Mission Report 14, 'Out of the Periphery'), four salinity classes (Table 22) are used.

Table 22. Maximum flooding depths and their implications on crop production.

maximum flooding depth (cm)	**Implications for cropping**
0 - 20	Suitable for HYV Aman, but drought risk during and late in the monsoon when rains are insufficient. No limitation for Aus or rabi cropping. When growing Aus, HYV-Aman transplanting may be too late for a secure Aman crop
20 - 45	Suitable for some HYV Aman varieties, but timely transplanting may be difficult when water logging occurs. Drying of the fields may be late in wet years, causing delays in rabi planting. No limitation for Aus
45 - 100	Unsuitable for current HYV Aman, suitable for local tall Aman varieties; some new tall HYV may be suitable. In wet years late drying of the fields, restricting rabi cropping. No limitations for Aus
> 100	Only suitable for local tall Aman varieties with early transplanting. Drying of the fields usually late. Very limited Rabi cropping. Lowest areas are only suitable for boro provided surface water is available.

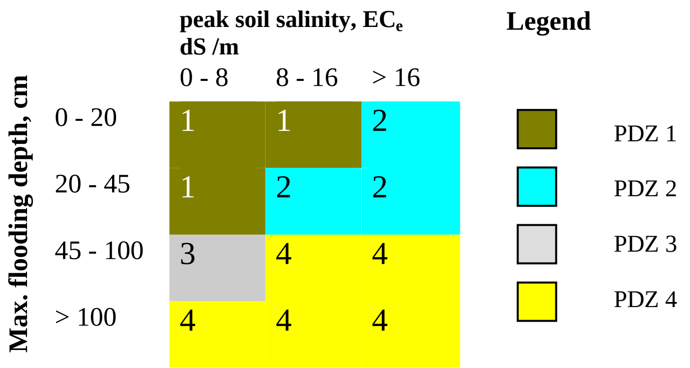
peak EC_e, dS/m in topsoil (0-10 cm)	**suitability for cropping**
0-8	non- to slightly saline; no growth reduction of most crops
8-16	slightly to moderately saline; no growth reduction for highly tolerant crops, light to medium reduction for other crops (see table 5 in Technical Report No. 5); Aus may be grown
16-30	moderately to strongly saline; medium to severe growth reduction for most crops; chilli and sweet potatoes may be grown at moderate salinity; stubble-planted keshari and linseed escape late season salinity
> 30	strongly saline; all current crops die or suffer severe stunting; not suitable for Aus; some indigenous and exotic salt tolerant crop and fodder species may be suitable

It must be kept in mind that salinity in the coastal chars is different from that in arid climates where the soil is permanently saline. In the coastal zone salinity builds up gradually after cessation of the rains, so a soil which has the fairly high salinity figure of, say, 12 dS/m would be unsuitable for most crops in arid lands, while in the coastal chars of Bangladesh several crop species can still be profitably grown when 12 dS/m is the peak salinity, measured in April.

Factor combinations

We defined four PDZ for the coastal char and polder areas, with different combinations of flooding depth and soil salinity which determine the land's suitability for monsoon and rabi cropping. The classes are shown in the next illustration.

Flooding depth is the major factor for Kharif-II (monsoon) cropping. Soil salinity has only a minor effect on aman paddy because the salt is pushed down below the rooting zone by the fresh water layer. For kharif-I the major factor is salinity at crop establishment, i.e. in April, when salinity is most severe. For rabi cropping the important factors are both salinity and water logging in early and late rabi season. Delayed drainage of deeply flooded fields delays rabi planting, while in the next pre-monsoon water from early rains may accumulate in low lying fields, damaging standing rabi crops.



The characteristics of each PDZ are as follows:

Productivity Zone (PDZ)	**Characteristics**
PDZ 1	**"Shallow flooding, low to medium salinity". Favourable conditions in all seasons** - High ('Uchu') to medium high ('Majori') land that may get temporarily inundated to a maximum depth of 45 cm; after rain the highlands drain fast, within a few hours to 3 days. The land starts drying during mid-October to mid-November, sometimes later. The Zone is relatively risk-free where all types of crops can be grown. - Direct-seeded dibbled aus rice can be grown successfully. - HYV Aman varieties have potential, but late transplanted Aman may suffer from drought during the reproductive stage in the high land, unless there is late rain. - Different Aman varieties may be needed for high and medium land - In highland Rabi crops can be planted early, which allows them to escape salinity in soils with April salinity up to 6 dS/m. They may suffer from water scarcity during establishment, particularly in years with a minimum of late rain.

Productivity Zone (PDZ)	Characteristics
PDZ 2	**"Shallow flooding , medium to high salinity". Favourable Aman season conditions, limitations for Aus and rabi due to salinity** - High land flooded up to 20 cm depth with high soil salinity and medium land flooded between 20 to 45 cm with medium salinity. Shallow flooded areas drain fast, usually within a few hours to 3 days after each rain and the medium flooded areas become dry in mid-November. - Transplanted aus rice can be grown in the medium land in this zone. - HYV Aman varieties have potential, but late transplanted Aman may suffer from drought during the reproductive stage in the high land, unless there is late rain. - Different Aman varieties may be needed for high and medium land - Rabi crops tolerant to moderate soil salinity can be grown early in the high lands and less tolerant ones adapted to late planting in the medium lands.
PDZ 3	**"Medium to deep flooding, low salinity". Flooding depth limits options in all seasons, suitable for short season rabi crops** - Medium-low to low areas ('Nichu') with low salinity. Fields do not drain out until late November or early December. In the lowest fields water logging may extend to January when there is late rain, which is a common in the southeastern coastal belt - Transplanted aus rice is suitable if monsoon flooding is not too deep, otherwise Aman transplanting will be hampered. - Currently available Aman HYV are not suitable - Late planted Rabi crops can be grown but there is risk of water congestion at maturation - High and low beds ('Sarjan') can be tried with crops like summer and winter vegetables.
PDZ 4	**"Deep to very deep flooding". Only suitable for long straw Aman varieties, boro if water is available** - Low to very low lying areas; similar hydrological conditions as PDZ 3, but longer period of water logging after the monsoon - Long straw varieties of transplanted Aman rice is the only crop suited for this zone. In very deeply flooded areas even that may not be possible. Boro can be grown if surface water is available

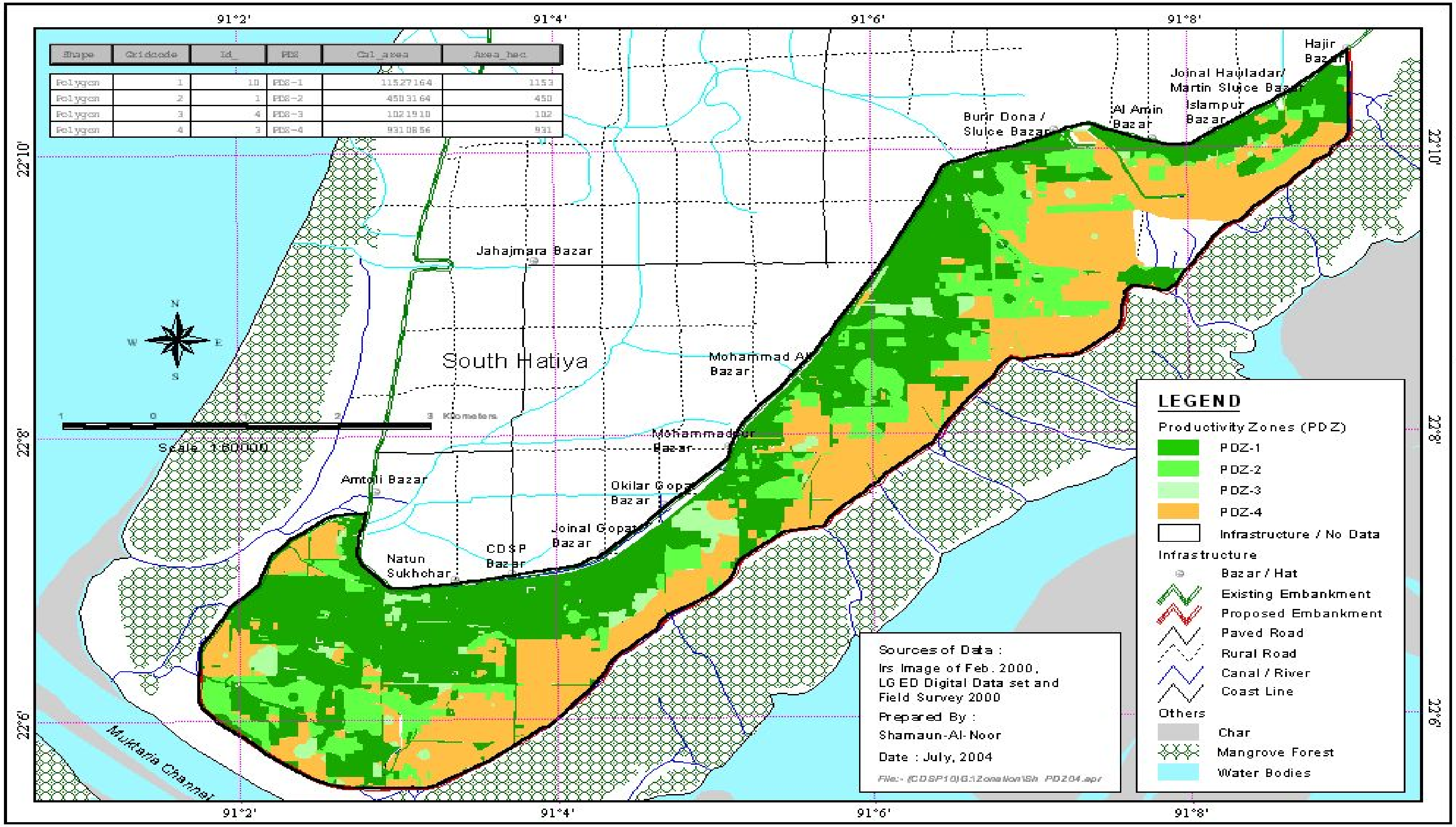
4.6.3 Status of the PDZ maps

A first series of maps has been prepared for the CDSP-II areas, but later on it was found that the baseline data for soil salinity had to be reanalysed. The analysis is now complete and the new set of the final maps is prepared. The map of south Hatiya is shown here as an example. The extent of area under each PDZ of the seven chars is in Table 23.

Under the dynamic conditions of the coastal chars the character of the land changes continuously. After having been protected from saline intrusions the soil may become less saline, drainage may be improved, or it may deteriorate as more land is accreted on the sea board. The PDZ classification of a particular area is therefore necessarily temporary and has to be updated as conditions change. One of its advantages, however, is precisely that it permits changes which occur in a systematic way. After the initial conditions have been mapped in terms of PDZ, changes can be monitored separately for each PDZ.

4.7. Changes in landuse and adoption of improved technology

CDSP has regularly monitored changes in land use during CDSP-I in land use since the first plot-to-plot survey carried out in 1995/96. Plot-to-plot surveys, however, are



Productivity Zones - South Hatiya 2004

very time consuming and therefore not practical for routine monitoring. Therefore, a transect survey method was used instead during the CDSP-II which, while less precise than the plot-to-plot surveys, has the advantage of being easy and fast. The method is outlined in Annex 1.

During CDSP-II, RDC undertook baseline survey during 2000 to 2001 in all but one chars. In about the same time Agriculture Unit of the project also conducted plot-to-plot survey during 2000 to 2001 (pre-project period) to collect information about ecosystem, land use and crops and cropping patterns. The latter also conducted a follow-up sample survey in two chars, MD and SH, during January and February 2004 (Post-project period). During this survey 241 farmers of MD and 169 farmers of SH were interviewed and recorded year-round cropping practice of each of the plots he cultivated. These findings are used to assess the impact of the project interventions by comparing with those of the plot-to-plot survey of CDSP-I and baseline survey of CDSP-II.

Table 23. Areas under each PDZ of the CDSP-II chars. Figures in parenthesis are percent of cultivable land.

Char	PDZ-1	PDZ-2	PDZ-3	PDZ-4
MD				
CL	29.0 (3.8)	39.3 (5.2)	51.2 (6.8)	633.2 (84.1)
GT	143.0 (20.4)	2.0 (0.3)	101.0 (14.4)	455.0 (64.9)
SH	1153 (43.7)	450 (17.1)	102 (3.9)	931 (35.3)
BT	22.6 (3.4)	131.4 (19.8)	0.0 (0.0)	508.3 (76.7)
CO	92.0 (20.0)	95.0 (20.7)	22.0 (4.8)	251.0 (54.6)
MAA	233.3 (15.1)	141.4 (9.1)	88.7 (5.7)	1085.0 (70.1)

4.7.1 The changes in landuse

In CDSP-I polders

Three important expectations about the effects of improved water management and decreasing soil salinity are that:

1. adoption of HYV rice during the aman season should steadily increase because of better regulation of flooding depth in the paddy fields throughout the monsoon
2. the conditions should become more favourable for aus because of lower salinity at the end of the dry season
3. the land should gradually become more suitable for rabi cropping because of decreasing salinity, early evacuation of water after the monsoon and lower risk of inundation at the beginning of the next monsoon

Adoption of the technologies introduced were monitored regularly to see whether these expectations achieved. The longest series of data is available for the so-called 'old polders', i.e. those protected during CDSP-I: CBD-II, CM and CBT. The CBD-II embankment was completed in 1990, those of CM and CBT in 1996. Continued monitoring of changes in those polders was one of the objectives of CDSP-II. The information on land use, collected from 1995 through 2003, is shown in Table 24.

Adoption of HYV-Aman

There are major differences among the three old polders. In CBD-II and CBT the percentage of HYV seems to converge on 20% of the total Aman area (which is practically 100% of total cultivable area), while in CM it is only half of that. Furthermore, between 1996 and 2000 adoption in CBD-II even *declined* steeply, to pick up again afterwards. Those are disappointing figures, which need explanation. The fact that the trends are different in the three areas hold promise that such explanation may be found.

First, workshops were held in 2001 with the Water Management Committees (WMC) to get the farmers' own opinions. After filtering out the usual, largely ritualistic complaints of the type 'we have no money' and 'we are ignorant about HYV', the following significant farmer observations emerged:

- water levels are often too high for HYV seedlings at time of transplanting
- HYV is more prone to risk because of damage by sudden flash floods and slow drainage of excess water
- draining excess water from lower land leads to drying out of higher lying land
- HYV are more sensitive to late monsoon drought
- there are conflicts between landlords and sharecroppers about payment for inputs

As expected, soil salinity was not mentioned, although there may sometimes be an upsurge of salinity during extended dry spells in the monsoon.

Next, a joint field assessment was held by agriculture and water management experts in June and July 2001 after exceptionally high June rainfall, to verify the influence of monsoon water congestion. Problems with water logging due to drainage problems had already been observed in CBD-II earlier on. They were caused by reduced flow through the Baggar Dona river, due to siltation and by public cuts in the northern embankment to decongest the adjacent upper area. The field assessment was meant to verify these observations (Mutsaers *et al*, 2001[25]).

At the time of visit the water level in practically all of CBD-II was very high and a considerable part of the Aus crop was under water. Water conditions were most favourable in the 'old land' in the extreme south-eastern part which has the highest altitude and appears to be drained more or less adequately. In most of the polder water control during the high monsoon had declined to insignificance. The major cause was the failure of the Bagar Dona river to drain the area due to siltation, which resulted in insufficient water head for adequate drainage. This has also provoked the people in the adjacent area to cut the northern embankment and offload part of their own water congestion on CBD-II. Since then the Baggar Donna river has been re-excavated and drainage has improved and the adoption of HYV-Aman has increased again to about 20%, the same level as in CBT, where no conspicuous water logging was observed during the field assessment.

[25] Mutsaers, H.J.W., S.A. Sattar and M.A. Sekendar. 2001. Agriculture: Mission Report No. 14. CDSP-II.

In CM, adoption of HYV has remained low, in spite of good overall drainage and field conditions which are favourable for Aman production. Some other factors must therefore cause the much lower adoption compared with CBD-II and CBT. It has been suspected for some time that different land ownership conditions are at least part of the explanation. CM has the highest percentage of land 'owned' by landlords and let to tenants under different kinds of sharecropping arrangements. These arrangements are a strong disincentive for growing high input crops like HYV paddy, because the landowners take a high percentage of the crop but usually do not contribute to production costs (Latif, 2003[26]). That was also one of the reasons given by farmers during the WMC workshops.

Even under more favourable land tenure conditions, however, the adoption of HYV-Aman remains relatively low. That is at least partly explained by ineffective water management inside the polders. Even though overall drainage may look adequate, the conditions at critical times may not be conducive to HYV growing. For example, evacuation of excess water at the time of transplanting Aman seedlings may be too slow, resulting in submergence and damage to short HYV seedlings and young plants. Conversely, adequate drainage for one area may result in too much drainage in another and damage to standing crops because of drought. These factors were all mentioned by farmers during the WMC Workshops. During the field assessments it was observed that many khals were blocked by local cross dams, resulting in slow drainage and that sluice management was not optimal for agriculture

Aus paddy production

Again, the differences among the three polders are considerable. In the oldest polder, CBD-II, Aus coverage has declined from about 40% in 1995 to about 25% in 2003, while in CBT it increased from only 7% to about 45% (the 2003 figure in the table looks inflated, eyeball estimation suggested something between 40 and 50%). In CM it has fluctuated around a low 5% throughout.

The trend in CBT most probably reflects the gradual decrease in soil salinity after protection, as shown in section 2.4, Chapter 2. Aus is planted (usually dibbled) at the beginning of the Kharif-I season when topsoil salinity is at its highest and as the salinity level decreases the conditions become more favourable for Aus paddy. In CBD-II soil salinity had already attained a favourable level in 1995, which explains why Aus coverage in that year was similar to that in CBT in 2003. Two things remain to be explained then:

1. why did aus coverage go down to 25% in CBD-II after 1996, and
2. why did it remain very low throughout in CM?

The decrease in CBD-II of both aus and rabi cropping between 1995 and 2003 could be an indication that there has been an increase in soil salinity again, after the initial decrease since protection. There is, however, no indication for such a resurge in the salinity monitoring data (Fig. 10, Chapter 2). So, the causes remain unclear. The very low aus incidence in CM must be related to the land tenure situation, as was the low adoption rate of HYV-Aman.

[26] Latif, M.A. 2003. Report on land monitoring survey 2003: Internal Resource Report. CDSP-II

Table 24. Changes in land use in CBD-II, CM and CBT in terms of percentages of plots planted in the rabi season and percentages planted to HYV during the Kharif seasons

	BaggarDonna-II				Char Majid				Char Bhatirtek			
	Rabi	Aus		Aman	Rabi	Aus		Aman	Rabi	Aus		Aman
Year	% plots	HYV %	% plots	HYV %	% plots	HYV %	% plots	HYV %	% plots	HYV %	% plots	HYV %
1995			42.4	5.2			4.2	0.3			7.7	0.6
1996	47.7		40.0	13.6	51.0		4.7	1.1	49.3		6.6	1.1
1997	45.1				56.0				47.6			
1999			22.4	6.7			9.9	suspect			16.1	20.2
1999[a]	*51.0*		*33.5*	*5.9*	*38.8*		*5.8*	*4.2*	*41.8*		*13.2*	*6.3*
2000	63.4			2.0	47.0			6.9	48.2			
2001	44.8	8.3	23.4	17.9	25.8	3.1	3.6	9.5	46.6	17.4	48.3	18.7
2002	36.2	10.1	26.7	22.7	26.3	4.6	5.0	6.4	32.0	16.8	42.5	27.8
2003	34.2	10.7	26.2	17.9	25.2	4.4	4.9	12.1	[63.9?]	35.8	[62.9?]	19.8
2004	57.2	27.3	51.0	-	33.2	2.5	9.2	-	57.1	25.3	58.5	-

[a] baseline survey; percentage of the *area*

In CBT aus paddy appears to have expanded considerably this year and planting has continued up to very recently. This suggests that salinity has further declined and water control is good. There are some major pockets in the central and eastern part, however, where mainly T-Aman is grown with little Rabi and Aus cropping. These are relatively low-lying areas according to the recent elevation map (although the overall elevation in CBT is considerably higher than in both the other polders), with impeded drainage. Limited extension of the khals draining those areas is one of the causes. Farmers also mentioned high salinity as a reason for not growing aus. This may be related to high groundwater levels in the low-lying areas at the beginning of the dry season and more upward capillary movement carrying salt to the surface, like in CM. Poor gate management at the Nabagram sluice on several occasions in August and September 1999 and 2000 led to continued high water levels within the sluice, probably resulting in water logging in the low-lying areas.

Rabi cropping

The current situation as regards rabi cropping is similar in the three polders, as far as total area is concerned, with roughly 25-35% of the area being used for rabi crops. The area has somewhat decreased since 1995 in CBD-II and CM and less so in CBT.

Overall, chilli has been the most important rabi crop throughout the recorded period, followed by greengram and sweet potatoes. These are the crops which are best adapted to medium soil salinity conditions. They are the first crops farmers can grow with confidence once the salinity falls below the EC_e threshold of about 20 dS/m (measured in April).

The importance of groundnut fluctuates strongly which probably has to do with the post-harvest loss and price developments for the crop. Groundnuts are at risk from flooding at the time of harvest for which the post-harvest loss is the maximum. These seem to make farmers hesitant to grow it unless the price expectation is good.

The increase in cowpea and mungbean cultivation in all three polders, but especially in CBD-II and CM lends support to the assumption that there has been an overall, though small, decrease in topsoil salinity. The fluctuation in rabi cropping in CBT is probably due to the fact that farmers grow a lot of aus, which limits the range of choices for rabi crops. That also points to a lowering of salinity levels.

In CDSP-II areas

The areas catered for by CDSP-II include both protected and unprotected areas with very different conditions. The trends in landuse will be briefly described for each area separately, followed by an attempt to synthesise the findings. The data on land use are presented in Table 25.

Mora Dona

MD in many respects resembles a protected area as explained elsewhere in this document. It is evolving in the same direction as CBT, with gradually increasing HYVs of aman and aus, and rabi cropping.

Char Lakshmi

This area is a typically unprotected char, strongly exposed to inundations from the sea side. Cropping is essentially limited to Aman paddy during the monsoon with very low adoption of HYV. There is limited Rabi cropping, consisting of salinity tolerant chilli, khesari and sweet potatoes, with some garlic in higher locations.

Table 25. Changes in land use in CDSP-II areas.

Year	**Mora Dona**				**Char Lakshmi**			
	Rabi	Aus		Aman	Rabi	Aus		Aman
	% plot	Total	%HYV	%HYV	% plot	Total	%HYV	%HYV
baseline	17.3	0.2	0	0	0.3	0	0	0
2000		1.5	0.7	0				
2001	17.3	6.6	4.2	8.4	1.5	0	0	0.5
2002	24.9	9.9	6.2	14.0	10.3	2.3	2.3	6.7
2003	28.8	6.9	4.2	24.6	12.1	5.1	2.1	4.0
2004	35.9	4.4	2.6		8.6	5.5	2.3	

Year	**Gangchil-Torabali**				**South Hatiya**			
	Rabi	Aus		Aman	Rabi	Aus		Aman
	% plot	Total	%HYV	%HYV	% plot	Total	%HYV	%HYV
baseline	8.1	0	0	0	22.3	4	0	0
2000		0	0	0				
2001		0	0	0			9.3	1.7
2002	34.9	2.3	2.3	6.7	[30][a/]	[10]	[5]	16.4
2003	77.9	5.2	2.1	4.0	[30]	[10]	[5]	10.8
2004	24.7	6.6	2.5		[40]			

Year	**Bandartila/Nijhum Dwip**				**Char Osman/Nijhum Dwip**			
	Rabi	Aus		Aman	Rabi	Aus		Aman
	% plot	Total	%HYV	%HYV	% plot	Total	%HYV	%HYV
baseline	0	19	0	0	4.5	0	0	0
2000								
2001	0	30	0	0.3	4.5	3.6	0	0.9
2002	0	8.3	8.3	14.5	23.4	1.3	1.0	9.9
2003	22.5?	42.6	21.7		21.7			
2004	17.9?				30.3			

Year	**Muhuri AA**			
	Rabi	Aus		Aman
	% plot	Total	%HYV	%HYV
baseline	21.7	3.3	2	0
2000				
2001		[4]	[3]	5.6
2002	57.9	[4]	[3]	13.7
2003	59.2	[4]	[3]	4.0
2004				

[a/] figures in square brackets are estimates by SAA & not from survey

Gangchil Torabali

Conditions here are also not favourable for intensive crop production, although a little better than in Lakshmi. There is practically no HYV Aman. The 2002 and 2003 figures for the extent of Rabi cropping are probably strongly inflated. Most of it is 'salinity escaping' greengram and linseed, as well as small areas of chilli and sweet potatoes.

South Hatiya

South Hatiya was embanked in 2002 and its land use pattern is significantly increasing. In particular there has been and increase in Aus and Rabi growing, but so far only a modest increase in HYV-Aman.

Bandartila/Nijhum Dwip and *Char Osman/Nijhum Dwip*

Both these unprotected chars are on the Nijhum Dwip island and very exposed to the bay of Bengal. The figures in Table 24 for these chars are not reliable. The high percentages for rabi and aus are not relative to the entire land area, but to the immediate vicinity of the settlements.[27] The conditions are similar to other unprotected areas on the mainland.

Muhuri AA

The embankment of Muhuri was completed in 2003 and the sluice has recently been closed. The landuse situation is peculiar. There is very little HYV, although some parts of the polder would definitely be suitable. Also, the high incidence of rabi cropping consists almost entirely of greengram, a good animal fodder. Large herds of cattle graze the area during the Rabi season. There has been very little settlement and most of the land is controlled by people living elsewhere. The peculiar land use pattern probably bears a relationship with that situation

Overall cropping intensities

As a summary of the information presented above, the next table gives the changes in overall land use intensities of all the protected and protected areas (Table 26). They are calculated simply by adding up the percentages of the plots occupied by aman (assumed 100% everywhere), aus and rabi, and are therefore the intensities for the

Table 26. Overall cropping intensities in the protected and unprotected areas

Char	Survey year				
	1996	Baseline	2001	2002	2003
CBD-II	188	185	168	163	170
CM	156	145	129	121	130
CBT	156	155	196	174	Unreliable
MD		119	124	135	136
CL		100	102	113	117
GT		108		137	Unreliable
SH		122		140	140[1]
BT		119			
ND		105			
MAA		125		162	163

[1] estimated by SAA; because the survey data are not reliable

[27] The enumerators and supervisors will need to be retrained to get better data in the future

chars as a whole. The figures give a somewhat inflated picture, because the 'percentages of plots' with Rabi crops is higher than the 'percentage area', as explained in Annex 1.

4.7.2 Technology adoption

The coastal farmers were completely in dark about the modern crop production practices until the CDSP-I, using the limited amount of information generated by the Land Reclamation Project (LRP) during 1980-1990, started massive agricultural extension activities in mid-nineties in three polders under Noakhali sadar upazila. The efforts were made to increase productivity of the cropped area by replacing the existing low yielding traditional varieties (LVs) with the high yielding modern ones (HYVs) of different crops as well as by converting mono-crop area to double- or even triple-crop areas. Some efforts were also made to improve crop yield further through employing better management in crop production.

After a series of tests and demonstrations CDSP-I confirmed the LRP findings indicating superiority of the modern rice varieties over the existing traditional ones, when grown under favourable conditions. Modern varieties, in both the aus and aman seasons, out yielded the LVs by about 50 to 100%. HYVs, in general, responded better to fertilizer application although the response varied considerably among the HYVs. Besides rice varieties and fertilizer management, the benefits of using other technologies like green manuring and integrated pest management were also demonstrated to the farmers. Nevertheless the benefits of all these technologies could not encourage most farmers of the three polders to adopt these. This was revealed in a follow up adoption study made during 1998. Subsequent studies identified a variety of constraints for adoption of modern technologies, which are related mainly to the physical conditions of the chars, particularly unfavourable water conditions and soil salinity, as well as other socio-economic conditions of the char dwellers.

Kharif-I season

The results of a sample survey done during 1998 to evaluate adoption of HYV in three old polders are also used to trace out of the evolution of agricultural technologies in the coastal char areas. A large number of demonstration plots (158 demonstration plots) were established throughout the coastal region of Noakhali and Mirsharai during 2002 to 2004 to popularise modern varieties of aus rice in the region (Table 27). Adoption of these varieties were evaluated through survey along the pre-

Table 27. Results of demonstration of aus varieties (summary of all chars)

Variety	# of demo	Grain yield, t/ha)			
		Minimum	Maximum	Mean	STD
BR9	2	2.98	3.01	2.99	
BR12	2	1.75	2.82	2.79	
BR14	20	2.40	4.00	3.41	0.44
BR21	1			3.10	
BR26	2	3.97	4.00	3.99	
BRRI Dhan27	131	2.03	5.81	3.60	0.71
Hashikolmi*	41	0.68	2.45	1.49	0.37
Binnatoa*	12	1.54	2.01	1.80	0.15

* Not a demo but crop-cut made in the farmer’s field to record yield.

Table 28. Ranking of the aus rice varieties grown in the southeastern coastal region of Bangladesh.

Area	Position in the rank					
	1996	1998	2000	2001	2002	2003
Sadar, Noakhali	Hashikolmi IR8 BR3 BR14 BR1	Hashikolmi Kerandol BR14 BR26 BR21	Hashikolmi Kerandol BR21 BR14	Hashikolmi BR21 BR14 BR3	Hashikolmi Kerandol BR21 BR14 BRRI Dhan27	Hashikolmi BRRI Dhan27 BR21
Hatiya, Noakhali			Hashikolmi BR3 BR21	Hashikolmi BR9 (Dayal iri) BR21	Hashikolmi BRRI Dhan27 BR9 Purbachi	Hashikolmi BRRI Dhan27 BR9 Purbachi
Muhuri, Chittagong			Binnatoa Bhaturi Chabakhoi BR12	Binnatoa Bhaturi BR3 BR12	Binnatoa Bhaturi BRRI Dhan27	Binnatoa Bhaturi BRRI Dhan27

determined transect lines across each of the ten project sites. Though the adoption of a variety varied considerably among farmers, the actual popularity can be judged by the overall conditions of a region. As such ranking of the varieties according to their popularity has been done for each of the three upazilas (Table 28).

Farmers of Noakhali sadar had been growing some local varieties of aus rice such as Hashikolmi, Kerandol and Boilam of which Hashikolmi, locally known as *Satia,* is the most popular one until now. Among the HYVs, IR8 was the most popular one and was second to Hashikolmi until 1996 (pre-CDSP-I period) followed by BR3 and BR14. But when the shorter duration varieties became available in this region, the farmers shifted from the long-duration variety like IR8 and BR3 to the short duration ones such as BR21 (some farmers call it *Chandina*) and BR14. BRRI Dhan27, a short duration variety with taller seedlings and moderate yield, started to become popular after its introduction during 2002 and onward. Besides these there are a few exotic HYVs whose identity cannot be known are also grown in the area.

Hashikolmi also tops the list of the varieties of aus rice grown in the offshore island, Hatiya. Among the HYVs, BR3 was the second most popular variety during 2000 but in the following year it was almost replaced by BR9, locally known as *Dayal iri*. When BRRI Dhan27 was demonstrated to the farmers in 2001, the farmers because of its long straw and shorter growth duration readily adopted it. This variety occupies the second and BR9 the third position until last year.

The farmers of Muhuri accreted area persistently grow Binnatoa, a traditional variety, while another local variety, Bhaturi occupies the second position. Pre-germinated seeds of these varieties are sown either on dry or on puddled fields. Among the HYVs, BR3 and BR12 were grown as transplanted rice securing third and fourth positions, respectively, until the year 2001 when BRRI Dhan27 was demonstrated. Another HYV whose identity is not known but locally known as Biplob (not BR3 which has the official name Biplob) is also grown. During the last two years Binnatoa, Bhaturi and BRRI Dhan27 seem to become stable in the area.

BRRI Dhan27 became available in the country in1994 and was recommended for the non-saline tidal ecosystems. But it remained unknown to the farmers of the Noakhali coastal region until late nineties. This is a tall (140 cm) variety having medium coarse grain and matures in only 115 days from seed to seed. Farmers are becoming familiar with this variety since it was demonstrated during 2001& 2002 at seven chars of Noakhali. Now it appears to have gained popularity as is revealed during the transect survey done in last year.

Kharif-II season

Modern high yielding varieties (HYVs) were demonstrated in the CDSP-I polders during mid-nineties but the farmers could not retain those and are almost lost from this area. CDSP-II once again started introducing some HYVs in five of its project sites during 2000 and 2001 but was successful only in two locations. The main constraint was the deteriorating drainage conditions in some polders and some other socio-economic imbalances in general. As mentioned earlier (section 2.4) depth of impounded water in the field plots did not encourage transplanting of HYVs due to their shorter seedlings. Subsequently, 208 demonstration plots were established with nine HYVs (Table 29) in the more favourable ecosystem (PDZ1 and PDZ-2), arranged field days to show other farmers the performance of the crop. During field days demo farmers shared their experiences with the fellow farmers which helped the farmers of the areas to gain confidence in HYVs. Later on these farmers tried some of these varieties in the similar ecosystems with success. This led to adoption of HYVs in these area but the rate varies considerably among the project sites; it was the highest in MD (ca 25%) followed by SH (ca 11%). Adoption of HYVs in CL, GT and MAA all having almost the similar ecosystems is around 4% (Table 25).

Kajalsail and Rajasail, the two local varieties are extensively grown in the coastal areas (Table 30). Among the HYVs, BR22 and BR23, the two varieties strongly sensitive to photoperiod, perform best in the coastal chars and are most popular. BRRI Dhan30 and BRRI Dhan31 are becoming popular in some areas but farmers find it difficult to adjust the plating time for these varieties so as to avoid problem of high spikelet sterility due to gusty winds normally that prevails during the flowering time in the char areas. BRRI Dhan32 is a lodging-prone and is rejected by the farmers mainly due to its finer grain. Among the three newly released varieties, BRRI Dhan39, BRRI Dhan40 and BRRI Dhan41, the latter two are said to be tolerant to soil salinity up to 12 dS/m, appeared promising in these areas. However, we cannot expect good yield from these varieties always as is indicated by higher variability in yield (Table 29).

Table 29. Results of demonstration of aman varieties (summary of all chars).

Variety	# of Demo	Grain yield (t/ha)		
		Range	Mean	STD
BR11	3	4.20-4.50	4.33	0.15
BR22	6	3.50-4.00	3.73	0.25
BR23	47	3.50-5.50	4.45	0.53
BRRI Dhan30	13	2.60-4.50	3.68	0.72
BRRI Dhan31	34	2.40-5.00	4.00	0.69
BRRI Dhan32	20	2.80-5.20	3.98	0.60
BRRI Dhan39	43	2.50-5.10	4.06	0.52
BRRI Dhan40	12	3.75-4.80	4.32	0.30
BRRI Dhan41	30	2.00-5.30	4.25	0.78
Total Demo	208			

While search for a variety with tall seedlings continuing, one of the four advanced breeding lines, BR4974-23-1-6-1, with about 60 cm tall seedlings appeared promising in a test at MD. This is a low tillering genotype with tall (141cm) plants. BRRI dhan27 also has taller seedlings and was tried in aman season but could not be popularised due to lower yield.

Rabi season

It was very hard to convince the farmers of the areas to diversify the cropping mainly for two reasons; lack of irrigation facility and high soil salinity. None in the country systematically studied the tolerance of these crops to the levels of soil salinity, rather a preliminary scrapping during LRP generated some good information in a limited scale that served as the basis of demonstration of some crops in CDSP-II chars. Testing of crops against soil salinity is being done just by growing them directly in fields with different levels of salinity along with the demonstration plots in all chars.

Table 30. Changes in the adoption of aman varieties in coastal region of Noakhali.

Char name	Arranged in order of popularity		
	2001	2002	2003
CM	Kajalsail Rajasail BR22 BR23 Betichikon	Kajalsail BR23 Rajasail BR222 Gigaj	Kajalsail BR23 BR22 Rajasail BR11
CBT	Kajalsail BR23 Rajasail BR22 BRRI Dhan30	Kajalsail BR23 Gigaj BR11 Betichikon Rajasail	Kajalsail BR23 Gigaj Betichikon BR22
CBD-II	Kajalsail Rajasail Betichikon Gigaj BR23 BR22	Kajalsail Gigaj Betichikon BR22 BR23 Rajasail	Kajalsail Betichikon Gigaj BR23 BRRI Dhan31
CM	Kajalsail Rajasail BR22 BR23 Betichikon	Kajalsail BR23 Rajasail BR22 Gigaj	Kajalsail BR23 BR22 Rajasail BR11 BRRI dhan31
MD	Kajalsail Rajasail Betichikon Gigaj	Kajalsail BR23 BR11 Betichikon Gigaj BR22 BRRI dhan31 Rajasail	Kajalsail BR23 BR11 BRRI Dhan31
GT	Rajasail Other LVs Betichikon	Rajasail BR11	Rajasail BR23
CL	Kajalsail Rajasail Betichikon	Kajalsail Rajasail Betichikon BR23	Kajalsail Rajasail Betichikon BR23 BRRI dhan31
SH	Rajasail Kajalsail Other locals	Rajasail Kajalsail Other local BRRI Dhan32	Rajasail Kajalsail BR23 BRRI Dhan32
BT	Rajasail Kajalsail	Rajasail Kajalsail	No valid data
CO	Rajasail Kajalsail	Rajasail Kajalsail BRRI Dhan32	No valid data
MAA	Agnail Kajalsail Rajasail BR11 Binni	Agnail Kajalsail BR11 Rajasail Guar	Kajalsail Agnail BR22

The results of tests and demonstrations are summarized in Table 31 and 32, respectively. Production of crops in some test plots could not be recorded but the overall performance of the crops was visually observed only.

Table 31. Results of tests of rabi crops in the coastal char (mean of five chars)

Crops	Yield, t/ha		Remarks
	Range	Mean	
Batisak			Good growth & salt tolerant
Brinjal	5.99-17.8	14.63	
Chilli	0.93-1.63	1.38	
Cabbage			Good yield in non-saline soils
Garlic	3.65-5.02	4.22	
Groundnut	1.08-1.99	1.42	
Knolkhol			Good yield in non-saline soils
Maize	1.14-3.00	1.97	
Okra		7.77	
Onion	0.82-4.72	3.24	
Potato		21.00	
Sweet gourd	3.81-8.55	6.18	
Soybean	1.42-1.63	1.53	
Spinach	1.60-11.65	4.49	Leaf only
Sunflower	0.83-1.19	0.99	Severe bird damage
Tomato	6.88-18.56	14.63	
Watermelon	19.02-27.38	23.70	
Wheat	0.81-1.72	1.27	

Table 32. Results of demonstration of rabi crops in coastal chars

Char	Crop	Variety	Yield, t/ha	
			Range	Mean
SH	Water melon	Glory	25.0-33.0	29.3
	Soybean	Sohag	1.6-2.2	1.9
	Mungbean	BARI-5	0.6-1.30	1.0
	Okra	BARI-1	5.0-5.20	5.1
	Felon (Cowpea)	Local	0.95-1.20	1.0
MD	Soybean	PB-1	1.4-1.7	1.5
	Water melon	Glory	33.0-44.0	38.8
	Maize	Bornali	2.88-3.0	2.99
	Okra	BARI-1	6.0-8.5	7.1
	Sweet gourd	Local	12.0-19.0	15.8
	Field cucumber	Local	19.0-26.0	22.0
	Garlic	Local	3.5-5.4	3.3
	Onion	Local	4.2-8.2	6.5
	Potato	Cardinal	12.4-23.0	19.2
	Cowpea	Local	0.85-1.10	0.98
CL	Soybean	PB-1	1.20-1.90	1.36
	Maize	Bornali	1.8-2.1	2.0
	Field cucumber	Local	Damaged	-
GT	Water melon	Glory	0.0-30.0	25.0
	Sweet gourd	Local	0.0-5.0	4.0

A massive demonstration programme started with different crops since the year 2002 which resulted in adoption of several new crops. Batisak, completely a new crop performed very well in the chars and found to be highly tolerant to soil salinity, could not be promoted further for problem of marketing. Considering its tolerance to soil salinity and having good and acceptable taste (farmer's opinion) it has potential to be a cash crop also whenever marketing can be possible.

Since 2003 watermelon and okra are being commercially grown in the chars, particularly Mora Dona, Gangchil-Torabali and south Hatiya. Very recently field cucumber, soybean, cowpea, sweet gourd and mungbean are also becoming commercial crops. The changes in adoption of rabi crops are in Table 33.

Table 33. Dominant rabi crops grown in CDSP-II areas. The crops are arranged in order of the farmer's preference.

Char	2002	2003	2004
MD	Chili Mungbean Greengram Sweet potato Cowpea	Chili Mungbean Cowpea Sweet potato Watermelon	
CL	Chili Garlic Sweet potato	Chili Greengram Sweet potato	
GT	Linseed Greengram Chili Sweet potato	Linseed Greengram Chili Sweet potato	
SH	Greengram Linseed Cowpea Chili Mungbean Sweet potato	Mungbean Cowpea Greengram Sweet potato Chili Groundnut	Mungbean Greengram Chili Sweet potato Cowpea Groundnut
BT		Chili Spinach Mustard Linseed	Chili Linseed Greengram
CO	Greengram Chili Sweet gourd Sweet potato	Chili Sweet potato Cowpea Spinach	Chili Sweet potato Greengram Cowpea
MAA	Greengram	Greengram Groundnut	

4.8 Summing up: the prospects for intensified land use

From the above discussions, it is clear that significant improvement took place in the agricultural production raising the cropping intensity from about 118-126 in the pre-project period to about 160-216 during the post-project period (see Section 4.2). Likewise, use of high yielding varieties of aus and aman rice increased from 0-0.6% in the pre-project period to about 5.8-32.6% during the post-project period. The question is now: what will be an attainable target for HYV adoption under these (protected) char conditions and what needs to be done to reach it? At the end of CDSP-I it was assumed, unrealistically, that after 7-10 years about 75% of the cultivable area would be planted to HYV Aman. Obviously that did not happen. However, several possibilities of further improvement in the agricultural production can be envisaged. These are discussed in the light of the constraints limiting improvement and thus different mitigation options are suggested to address these in the following paragraphs.

4.8.1 Can some socio-economic constraints be removed?

The results of three surveys (section 4.7) are used here to analyse the existing situations. These analyses clearly indicated two important factors that directly or indirectly influence adoption of improved agricultural technologies are farm-size and land tenure system in particular in the coastal region. The following paragraphs will elaborate the changes in cropping practices and adoption of crops, if any, and how these are influenced by the farm size and land tenure system.

During the pre-project period single transplanted aman rice pattern dominated covering about 83 and 75% of the cultivated areas of MD and SH respectively followed by double cropping of transplanted aman, aus and rabi that covered only 15.1 and 23.2% area of MD and SH respectively. Triple cropped area in these two chars was below 2%. After 3 years of interventions by CDSP single cropped areas decreased by about 31-46% with the concomitant increase in the double and or triple cropped areas (Table 34). The double-cropped areas increased from 15.1 to 33.7% at MD and from 23.2 to 36.9% at SH. Triple cropped areas increased from 1.4 to 8.7% at MD and from 1.9 to 22.2% at SH. Among the double crop patterns, transplanted aman followed by rabi was dominant in both the chars covering about 30.6% area of

Table 34. Percent of land under each cropping pattern in two chars of CDSP-II.

Cropping pattern	MD		SH	
	Pre	Post	Pre	Post
Aus	0.0	0.0	0.1	0.0
Aman	83.3	57.4	74.8	40.1
Rabi	0.0	0.2	0.0	0.4
Total	83.5	57.6	74.9	40.5
Aus-aman	1.4	3.0	1.6	4.6
Aus-rabi	0.0	0.1	0.1	0.1
Aman-rabi	13.7	30.6	21.5	32.2
Total	15.1	33.7	23.2	36.9
Aus-aman-rabi	1.4	8.7	1.9	22.2
Cropping intensity	117.9	151.1	127.0	180.9

MD and 32.2% area of SH. Cropping intensity increased from 116.3 to 151.1 at MD and from 127.0 to 180.9 at SH.

Farm size distribution has been presented in section 4.2.2. Although cropping intensity is not influenced significantly by the farm sizes, a negative trend is observed at SH indicating that small farmers cultivate their lands more intensively and the large farmers do not exploit the full potential of their land (Table 35). At MD, although the adoption of HYVs of aus and aman is negatively related to the farm size, their relationship is stronger only in case of adoption of HYV aus. Rabi cropping is not influenced by farm size in this char. At SH, adoption of HYVs of aus and aman and rabi cropping is negatively related to farm size; their relationships being stronger.

Further analyses of the data of Table 34 have been provided in Table 36 relating the farming practices with the land tenure system. Farmers invest more in their own land than in lands rented in. Farmers of SH, particularly the smaller ones (as explained by the negative correlation coefficient in Table 35), cultivate their own land more intensively (cropping intensity 216%) than the land rented in (cropping intensity 161%). Table 36 also shows that most farmers of the coastal chars prefer to grow more HYVs in own land. Cropping intensity is also much higher in own land than the land rented in. The reason for this as expressed by the farmers is an unbalanced cost and crop sharing with the landlords.

4.8.2 Improvement of water conditions

Soil salinity of CBD-II has been reduced sufficiently (Fig. 10) due to flashing away of salts by the on-rushing monsoon water from the upstream areas almost every year after the embankment cut. This, however, did not help increasing the cropping intensity because of the deep flooding. To improve this situation the Baggar Donna Khal and the Jabbar Khal as the main drainage arteries for CBD-II and the northern adjacent area, respectively, must be sufficiently dimensioned to evacuate the water from the adjacent area fast enough to satisfy the riverines, otherwise they will continue cutting through the embankment. The Baggar Donna Khal will probably have to be re-excavated to increase the flow.

Excess water in the crop establishment stage restricts introduction of HYVs and drought in the reproductive stage reduces yield of rice (see Section 2.5). During the rabi season, too much soil moisture due to the impeded drainage conditions hampers establishment of rabi crops in most fields in one hand and drought during active growth phases of the rabi crops on the other serve as the major constraints to promotion of rabi crops in the char areas. Any attempt that resolves this water related problem would promote the agricultural development further. There are several ways to overcome these problem and these are:

Solving excess water problem

a) All the canals within and around the polders or areas should drain the areas up to the desired level within three days after each flooding. Canals have to be dimensioned accordingly through routine excavation and or repair works. Presently, the WMCs of CDSP-II (analogous to the WMOs of the national water policy) are trying to remove the wanton blockages made in the canals by the vested interest groups but are not fully capable to do this. Support from BWDB, as has been said in the national water policy, is urgently needed.

b) Farmers prefer to raise their levee height up to abut 40cm so that enough rain water can be stored in the plots during the reproductive stage when water may be a limiting factor in some cases. This practice might not be a problem to regulate water level in the field according to the crop-water requirement provided field to field draining of excess water would be possible. But field to field draining becomes impossible due to lack of cooperation among the farming community. Thus the problem could be solved by lowering the levee height up to a maximum of 20-25cm which would allow water to drain freely in excess of this height. The farmers have to be motivated to conserve water in the late monsoon rather than storing water in the field early in the season. However, a strong committed extension programme is required, perhaps for an extended period.

c) Two types of varieties of rice would be best fitted in to the local system; HYVs having submergence tolerance in the early stage or having taller seedlings. The national agricultural research station (NARS) could not achieve the former as yet while they have not yet considered the latter one. However, development of HYVs of rice having taller seedlings is needed. Test of two advanced breeding lines of rice with seedlings taller than 50cm in the coastal chars clearly indicated that there are possibilities of developing varieties with taller seedlings (60-65cm). Demand for such technologies has to be placed to the NARS by DAE.

Table 35. Coefficients showing relationship of farm size and cropping practices at two chars of CDSP-II

Cropping practices	MD (df=239)	SH (df=169)
Cropping intensity	.090ns	-.126ns
HYV aus	-.170*	-.325**
HYV aman	-.113ns	-.165*
Rabi	.001ns	-.392**

ns=non-significant; * &** significant at .05 & 0.1 levels of probability, respectively.

Solving drought problem during monsoon

Farmers of this country generally do not irrigate monsoon rice and more so the char farmers even when facilities for this practice exist, perhaps due to some socio-economic factors. In the coastal chars drought related development of soil salinity is another factor sometimes poses threat to monsoon rice production. Only one or two supplemental irrigation can save the crop from these disasters (as suggested in Section 2.5). There are two options available for applying supplemental irrigation in the coastal chars; irrigating the field using surface water wherever available and in absence of this facility use of field-ditch method developed by the BRRI would be the best option. In this method, a small temporary (seasonal) ditch (dimension depends on the size of the field plot) can be dug in a corner of the plot wherein rainwater is stored. The amount of water stored should be enough to provide at least one supplem-

Table 36. Changes in crops in two CDSP-II chars as influenced by land tenure system.

Project	Crops	Own land			Land rented in			Total		
		HYV	Local	Total	HYV	Local	Total	HYV	Local	Total
MD	Aus	16.7	6.6	23.4	4.3	1.8	6.1	8.5	3.4	11.9
	Aman	45.4	54.6	100.0	26.1	73.9	100.0	32.6	67.4	100
	Rabi	-	-	49.6	-	-	34.6	-	-	39.6
	Total	-	-	172.6	-	-	160.8	-	-	151.1
SH	Aus	25.2	17.6	42.9	10.9	6.9	17.9	16.1	10.8	26.9
	Aman	24.2	75.8	100.0	15.0	85.0	100.0	18.4	81.6	100.0
	Rabi	-	-	73.5	-	-	44.1	-	-	54.9
	Total	-	-	216.0	-	-	160.8	-	-	180.8

ental irrigation, if needed. This technique is being used by the farmers elsewhere in the country and could be practiced here. DAE field staffs have to be trained in this line who, in turn, will motivate the char farmers.

Means of promoting rabi crops

As discussed earlier and in Section 2.5 potential of increasing rabi area in the coastal chars is limited at the present char situations. Further intensification of rabi cropping depends on two factors; increase of irrigated area using surface water and reduction of soil salinity. The possibility of increasing irrigated area is discussed in the foregoing paragraphs while the phenomenon of soil salinity is discussed in the next sub-section. There are numerous canals and creeks in the char areas. The polders are protected from flooding during the spring tide of October/November through the regulatory device (sluice) in the main canal. These canals are thought to be the potential storage devices for surface water in the area. It was suggested earlier that let these canals be filled in with tidal water during the spring tide of September/October. This water would be used to increase the coverage of the rabi crops. The potential maximum storage capacity of the canals of some chars was calculated using the available data (baseline survey by RDC) on canals. The results (Table 37) do not encourage going for this option for two reasons. Firstly, the area that could be irrigated with this limited amount of water per char is very small ranging from 0.8 to 8.3% of the total cultivable area of all but Gangchil-Torabali chars; it is about 23% in the latter char. Secondly, the water of the river outside the sluices becomes saline during the rabi season making the water unsuitable for irrigation (Fig. 17).

Table 37. The extent of area that can be irrigated using water stored in the canals of CDSP chars (potential condition), calculated from baseline survey data.

Char	Total length of canal, km	Total volume of canal, m^3	Effective water level, mm-ha[a]	Areas can be irrigated[b]	
				(ha)	% of cultivated
CBD-II	33.3	519927	43634	124.67	7.9
CM	18.0	224072	16034	45.81	5.1
CBT	27.8	429309	31310	89.46	6.7
GT	17.4	706263	57508	164.31	22.7
MD	33.5	423272	32473	92.78	8.3
SH	27.9	244859	11857	33.88	2.3
BT	10.2	188994	12450	35.57	6.3
CO	5.4	42270	1259	3.60	0.8
MAA	9.8	296774	26317	75.19	4.3

[a] After subtracting loss of 840mm due to evaporation and expected S &P for four months (November to February).

[b] Assuming a rabi crop would require 350mm water for full irrigation (at least twice).

4.8.3 Improvement of soil salinity

It was assumed in the first phase of CDSP that soil salinity in the polders will be reduced to a level tolerable to most crop plants within five years after protection. However, the data on the dynamics of soil salinity in the CDSP polders available so far do not follow a definite pattern (Fig. 10) making it difficult to draw a valid conclusion. Further investigation is being carried out by measuring soil salinity along two transects from the hinterland to the coast. In order to supplement these measurements historical information on changes of soil salinity as perceived by the local old farmers are being recorded. The preliminary findings indicate that a significant reduction of soil salinity cannot be achieved within five years of empolderment rather it may take, depending on the distance from sea, at least 15 to 25 years. According to them, the speed of desalinisation depends on several factors such as closeness to the sea, drainage characteristics of the area, intensity of land use and use of manures. A report on the detailed study will be available next year.

4.8.3 Scope of increasing rabi area

Expansion of rabi area requires solving of three major problems of the char areas; lack of irrigation facility, reduction of soil salinity and marketing. Apparently it seems there is no possibility of increasing irrigated area in the chars for rabi production as has been discussed in section 2.2 and the previous sub-section.

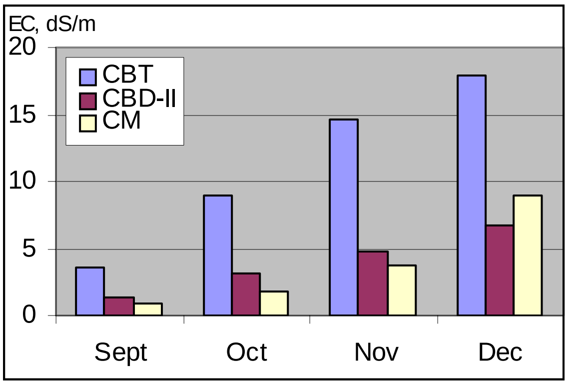


Fig.17. Maximum salinity of canal water in the month outside sluices (sea side) of three polders of CDSP (Data from Engineering Section).

Presently, some farmers use water from dug-well and hand tube well to irrigate their okra and watermelon fields. Quality of this water, particularly of the dug well, was never checked. If the water of the dug well is non-saline then the practice could be extrapolated to other areas.

Salt tolerant new crops may be available. Results of field-testing of rabi crops indicate that some leafy vegetables like batisak and spinach can be grown in moderately saline soils, provided at least one irrigation can be given. This opens a possibility of growing these crops in PDZ-2 or even PDZ-3 using the residual soil moisture after the harvest of aman rice as these fields dry up very slowly. However, to grow these crops in this situations some special management of the field and or seedlings have to be made. These managements are:

1. Seedlings raised in nursery beds around the homestead well advance of drying of the fields to be planted when field conditions permit.

2. A semi permanent high and low beds to be prepared in the field. Soil salinity of the high beds will be washed away during monsoon and will support growth of all types of vegetable crops (Fig. 18). Vegetables and other rabi crops can be grown on the high beds while transplanted rice with or without fish can be produced in the low beds.

3. BARI in collaboration with ICBA and CDSP-II succeeded in growing crops like chilli and tomato in highly saline soils [ECe 21.7 and 29.4 dS/m in February (flowering) and March (fruits matured) respectively] using drip irrigation at MD (Fig. 19). A low-cost local alternative device can be developed for the drip irrigation system which would enable the farmers to use saline soils for rabi crop production.

Fig. 18. Pulse crop on raised beds (roadside) around paddy fields at char Mora Dona.

Fig. 19. Chili grown on highly saline soil of MD with drip irrigation being tested by BARI in collaboration with ICBA and CDSP-II.

4.8.4 Development of marketing

Only a few rabi crops (greengram, chilli, sweet potato, groundnut and linseed) had been traditionally growing in the coastal chars of Noakhali. Among the various constraints limiting expansion of rabi area, lack of marketing facility for crops other than the traditional ones, is important. Lack of marketing facility again is due to poor development of communication systems as well as the limited exposure of the farmers to the more profitable and potential crops that would attract buyers. Recent development of the network of rural roads in the char areas promoted marketing of some high value crops such as okra, watermelon and sweet gourd introduced in the areas.

Chapter 5 In search of effective extension approaches

5.1. Introduction and background

5.1.1 Reform of national agricultural extension

The country has a long history of public sector agricultural extension services, which dates back to the colonial period even before the birth of India and Pakistan in 1947. The Department of Agricultural Extension (DAE) is the largest public sector organization with about 25,000 members of staff delivering extension services to farmers throughout the country at present. Nevertheless, it remains a relatively small player of information dissemination. Farmers' demands for information exchange are mostly met through meeting friends, relatives, neighbours and observation made during tours outside their region.

To improve this situation a reformation of the extension methodology started at least two decades back through the introduction of a system called *Training and Visit* (T&V). This is a system of continuous training and field visits in which a Block Supervisor (BS) of DAE was supposed to make direct face-to-face contact with 10% of the farmers (contact farmers) of his block, delineated by an area inhabited by about 800 farm families, during field visits. Each fortnight a BS was given 2-3 impact points (recommendations) prepared on the basis of the field problems observed and reported by the BS during the previous fortnight. Although this programme brought some good results yet it suffered a lot from the BS not making frequent field visits due to poor logistic and financial support. Moreover, farmers found only 30% of the impact points useful and the rest were more of a traditional type and could not fulfil farmer's needs.

A second reform started after a few years of T&V when the system of *meeting individual farmer* was changed to *meeting a group of farmers* thereby introducing a **group approach** in the mid-nineties. Concomitantly the approach was turned to bottom-up planning, farmer participation and decentralisation. With this sort of changes in the approach, a new policy document bearing the title **New Agricultural Extension Policy (NAEP)** was formulated in 1996. Essential features of NAEP are:

a) extension support to all categories of farmers
b) decentralisation
- collect information about local resources
- local level planning (bottom-up approach)
- training based on local needs
- use of mass media (radio, television, bulletins, leaflets, posters, folders)

c) demand-led extension
- identify key problems at farm level through participatory process
- on-farm participatory research

d) working with groups of all kinds
- contact with more farmers
- provide forum for farmers for participatory programme planning and action

e) strengthened extension-research linkage
- national technical committee
- agricultural technical committee
- research-extension review workshop

f) coordinated extension activities
- local level coordination under the chairmanship of Union Parisad Chairman
- thana level through the Upazila Agricultural Development Committee (UADC)
- district level through District Development Co-ordination Committee (DDCC)
- regional level through Agricultural Technical Committee (ATC)
- national level through National Technical committee (NTC)

Subsequently in 1997 the Government prepared another document on the Strategy for Implementing NAEP. More committees at various levels were proposed to coordinate the implementation processes. Terms of References for the coordination committees at all levels were set out in detail. These coordination committees are:

1. NATC [National Agricultural Technical Co-ordination Committee] at the national level
2. ATC [Agricultural Technical Committee] at the regional level
3. DEPC [District Extension Planning Committee] at the district level
4. UAECC [Upazila Agricultural Extension Co-ordination Committee] at the upazila level
5. DAE/NGO Liaison Committee for homestead production.

5.1.2 Implementation of NAEP

With the implementation of NAEP in 1997 the conditions of service delivery of the DAE improved to some extent but the overall performance has been disappointing, irrespective of the service providers and the clients. Among the success stories about implementation of NAEP in its initial phase, the followings are worth mentioning.

- Bottom up planning is being practiced but a full-scale autonomy of the local offices has not been achieved.
- Working with farmer groups, taking into account the gender issues
- DAE developed strategic planning mechanisms in response to NAEP
- Need based extension getting underway
- Promotion of eco-friendly technology such as integrated pest management (IPM) is trudging at the closer of the donor-funded project.

There exist a number of weaknesses in the NAEP for which it failed to bring about an expected breakthrough in the quality of extension services. These weaknesses can be classified into two; one at management level and the other at technical level. The weaknesses at the technical level has never been perceived by the policy makers and planners (see Section 1.3) and those at managerial level as recorded in a national workshop are:

- limited responsibility and autonomy of the DEPC
- other extension service providers are less responsive to NAEP strategy

- more cross-sectoral collaboration, particularly at the national level needed
- linkages with various committees are weak
- strong partnerships are often ignored
- most collaborating partners perceived NAEP as a policy of DAE and not as a strategy.

5.1.3 Present status and scope of improving extension service

At the bottom level, NAEP seems to be non-functioning mainly because of non-availability of the operational fund. Meetings are not regularly held, at least at the Upazila level, and the decisions taken in earlier meetings are just documented and no action plan has been taken thereon. There is no or very limited participation of other service providers. NAEP, also being a donor-funded programme, seems to have the same fate as other donor-funded programmes such as T&V, which died upon discontinuation of the external funding. Therefore, considering there are many effective guidelines, the government and policy makers need to overcome weaknesses in the NAEP and find means of sustainability of this system so that a national policy on the agricultural extension service delivery can be evolved.

Careful analyses of the above successes and failure reveal the major sources of weaknesses that are deeply seated in the whole system and almost always escape the attention of the planners. CDSP's experiences at the grass roots, Thana and District levels outlined in this chapter provide some food for thought of the planners and policy makers to overcome the situation at least in part if not fully. Moreover, suggestions to improve field activities based on the experiences gained during the CDSP-II project interventions are also enumerated below.

In fact NAEP has given priority to the management aspect, particularly at higher levels. Solving managerial problems is a pre-requisite for a successful extension service delivery but problems of field level activities along with problems faced by the grass root level workers are almost ignored. As a result an important chapter is overlooked while making this strategic plan. These have to be considered at each level of field activities.

5.2 New extension approaches and CDSP's experience

5.2.1 Group approach and Farmer Forums

NAEP offers a unique system of bottom-up planning which starts with problem census in the name of FINA (farmers information need assessment) by the DAE grassroot level workers. DAE field workers deal with farmers. Farmers and extension workers are not merely that, they are human beings and should be dealt with accordingly. Face to face dialogue between a farmer and a BS is the most efficient way of extension service delivery. To facilitate this a BS is supposed to reside in his block but that never happened, especially in the char areas where the living conditions are harsher than elsewhere. Therefore, delivering effective extension services becomes an impossible task for a BS in the absence of required logistic support, particularly if he is working in an area not easily accessible. Group approach as suggested in the NAEP is a partial solution to this problem. Under the present system the BS are working with groups of 20-30 farmers. A group has farmers with varying needs, mental attitude, social status, education, skill, hope and aspiration. Dealing with a group with such a heterogeneous farmers is not an easy task and often brings up a variety of complexities. The policy document (NAEP) failed to offer appropriate direction in this regard.

DAE is presently working with farmer groups. Because of the problems discussed in the foregoing paragraph, these groups lack coherence of farmers and thus could not emerge as a self-sustaining farmer group. To avoid this, DAE field workers should classify the farmers according to their farm sizes, levels of education and skill and farmer groups be formed accordingly. Farmer groups should exclude farmers with multiple non-farm business unless otherwise he is very keen to agricultural development. Moreover, a farmer group should be looked at as an organisation with realistic functional modalities and hence the name Farmer Forum (FF) is proposed. A guideline for formation and operation of a farmer forum, as developed by CDSP-II is given below.

Farmer Forums are meant as a mechanism for dialogue and cooperation between agricultural producers in the coastal areas and 'service providers' in agriculture, in particular DAE. They are not essentially different from the extension groups DAE is expected to set up according to its own extension policy. In fact the Forums should strengthen extension efforts by encouraging farmers to articulate their own needs for interventions to improve production.

Formation of farmer forums

The DAE's BS, being a grassroot level worker should be able to form a group, if not he may do so in collaboration with an NGO of the area. The number of farmers in a group should not exceed 25-30. In case there are already groups formed by an NGO they can also be used for strengthening agricultural extension services provided the group is formed with real farmers homogeneous in characteristics. However, the existing groups of the NGOs are formed mostly with land less people, engaged in activities covered in their micro-credit saving programs and not necessarily in field crop production. Therefore, members of the farmer forum should be selected per farmer-classes mentioned earlier. They should meet the criteria of (a) having at least 20 decimal of cultivable land, either of their own or rented in, (b) reside in or around the area and are socially accepted in the locality, and (c) should be willing to participate in all group activities.

Objectives and activities of the Farmer Forums

The specific objectives and activities of the FF are as follows:

1. *Assessment of need, scope and opportunities for technologies*

This should not be a one-way process with extensionists telling farmers what is good for them. Rather it should be the farmers themselves who analyse their situation, assisted by NGO or extension personnel, and come up with major constraints to be addressed. Well-established simple participatory methods may be used. The constraints and opportunities should relate to agricultural production, not just any constraint. Shopping lists are not useful.

2. *Discuss options for improvement.*

This may be as simple as a new variety or as complex as an entirely new crop. Other options may be the use of simple equipment such as weeder and threshers, improved storage, marketing or processing. The external people (DAE) bring in their specific knowledge about the potential of the area, using the zonal maps and present ideas they have about possible technologies and other innovations (e.g. farmer seed production, marketing, processing). They do not 'teach' the farmers but dialogue with them about possible options.

3. *Test and demonstrate possible innovations*

Members of the Forum may volunteer to locate test or demonstration plots in their fields or store seed of improved varieties for later sale to other members. DAE/CDSP may assist in identifying possibilities for crop marketing, processing, procurement of equipment, etc.

4. *The dialogue should be continuous*

As their name implies the Forums should be a meeting place where a dialogue goes on continuously. They are expected to meet bi-monthly. During some meetings, especially after each crop season, much attention would be given to the (renewed) analysis of constraints and proposals for new activities. These meetings may be termed 'Review and Planning Meetings'. During the cropping seasons the emphasis would be more on on-going activities and problems encountered. Elements from the Farmer Field School Approach could be useful here to structure those meetings.

Roles and responsibilities

The roles and responsibilities of all the actors in the process are as follows:

The Farmer Forum

They are informal groups of producers, linked with DAE and local NGOs. They meet bi-monthly, not necessarily with all members present. Non-members who are interested in a particular technology are welcomed. The BS, and a representative of all parties including the NGO are in attendance as facilitators, not as teachers. At least one meeting to be held beginning of each crop-season as the Review and Planning meeting. Forum's secretary will take minutes of all meetings, assisted by the BS and or NGO representative. The minutes are also forwarded to Upazila agricultural office of DAE for inclusion of the important issues as an agendum for the next TAECC meeting. The topics for discussion depend on the season.

DAE

All extension activities of DAE will be channelled through the FF. For DAE the FFs satisfy the requirements of extension groups as specified by the national extension policy. The BS attends all meetings. The officers of the Upazila Agriculture Office attends the review and planning meetings of each season and adjusts the extension program according to the priorities identified by the Forums. DAE will provide training to the farmers on specific technologies if and when needed and facilitate access to inputs, processing facilities and markets through local traders and manufacturers in collaboration with the private sector or NGOs wherever possible. DAE will also produce periodic reports on the discussions, activities and results of the Forums.

NGOs

The participating NGO is the 'guardian' of the participatory process. Their role is to facilitate dialogue and learning. They will ensure that the members' concerns and priorities come out loud and clear and that the meetings do not turn into conventional promotion of extension messages and packages. They will introduce participatory methodology when appropriate. They have no technical responsibilities for the technologies being introduced but they will help the FF to assess the technologies' performance and express their opinions. The NGOs will ensure timely holding of meetings of the FF, processing of minutes of the meetings and will submit the minutes to DAE.

Field activities

There are a number of conventional activities adopted by the DAE to disseminate suitable technologies among the farmers. These are establishment of demonstration plots, holding field days and farmer motivational tours. A variety of training programmes (farmer training, IPM training, DAE staff training) were arranged under CDSP-II to educate the farmers about the new technologies and to improve the skill of DAE officers and staff. Bi-monthly routine sessions of non-formal farmer group discussions were held where farmers spoke of their field problems and ventilated their ideas for further development. Our observations made on these DAE field activities identified a lot of loopholes which merit rethinking leading to formulation of guidelines more appropriate for the char farmers. The following paragraphs will discuss each of these field activities with suggestions to improve the service.

Demonstrations plots

Often we found DAE demonstration plots established at a field not easily accessible and far away from the main public thoroughfare in the area. Also the plots are too small to attract attention of the farmers. The reasons for this are as follows:

- the characteristics of the technology is often ignored while selecting a field and preference goes more in favour of the BS rather than the ecological conditions required for the technology;
- it is almost conventional that all extension messages are channelled through some pre-selected farmers only; and
- the activity is not demand-driven and is imposed upon the farmer in many cases.

The demonstration plots are established entirely with full support from the DAE leaving no room for the farmer’s participation. Consequently the farmer does not have a sense of owning the demonstration plot and he assumes that since it is the business of DAE, he has no responsibility for the activity whatsoever. Therefore, to make the demonstration more effective, the following guidelines should be followed.

1. The details of the technology have to be discussed in the meeting of the farmer forum. The demonstration should be based on the demand of the farmers and the farmer should be selected through dialogue in the meeting.
2. Select field for the demonstration meeting the ecological requirements for the technology, preferably in a place close to a public thoroughfare.
3. Size of the demonstration should be prominent enough to attract the attention of the passers-by.
4. Farmer owning the demonstration plot should be motivated to test the technology by himself. This means that he should invest his labour and, if possible, other required inputs. However, depending on the type of technology, DAE can help the farmer with some support for inputs.

Field days

Field days are an effective tool for dissemination of technology. This event should be an integral part of any demonstration programme. But DAE is often found to ignore this event in most cases. Even when the event is arranged, the attending farmers have very little time to have a glance at the technology since the venue of the function is usually far away from the field in a secluded area. Therefore, field day can only be effective when:

- it is arranged directly at or near the field with demonstration;
- the attending farmers have a chance to see the demonstration;
- there is real discussion around the technology being tested, rather than the usual speeches delivered by extension staff; and
- farmers can exchange views with the one in whose plot demonstration was established.

Motivational tours by farmer

When ranking extension activities with respect to their impacts or motivation, motivational tours by farmers would be the second, after demonstration plots; this is true particularly in case of the coastal char areas. Coastal char dwellers are mostly poor and illiterate and never move out of the region, unless as migrant labour, and thus have little or no exposure to the development in the field of agriculture. As a result, they remain contented with whatever little they earn from using the traditional cropping practices and are often sceptical about any modern agricultural technologies. Therefore, motivational tours are a unique tool to expose them to the modern agriculture and have proved to be effective in creating awareness about the modern technologies. This can be clarified by citing a practical example presented in the box below.

Training

Farmer training plays a crucial role in motivation and technology adoption and is an essential event in all development activities. DAE conducts two types of formal training, farmer training and staff training. The following discussion will be based on the experiences learnt from the farmer's training programme of DAE as well as from two mini workshops with the farmers of CDSP-I areas organised by CDSP-II. Our observations on this event are as follows:

Motivational tours, an effective extension tool

Farmers from Noakhali chars who never visited conditions outside the district have been given training on modern rice varieties for two years. But many of them failed to appreciate the varieties so far. This group was taken to BRRI Gazipur and Comilla and to farmer fields at Bogra on a trip set out in motivational tours during the last season. The farmers were surprised to see the performance of the different rice varieties and since then they are placing demand for seeds of some varieties of aman rice in the coming season. Likewise in another motivational tour during the rabi season farmers observed how the farmers of Comilla are managing their vegetable field and many of them expressed to adopt those in their farms. Therefore, it is evident that we are able to do in one motivational tour what we could not do through the long-term farmer training.

Lack of attention of the farmers to the speaker in a farmer's training programme is found to be a common feature. There are several reasons for this such as:

1. the training programmes are not demand-driven;
2. the training curricula were of more conventional type and not based on the felt needs of the farmers;
3. one way exposés by the speaker on a pre-fixed topic offered no scope for farmer's participation;
4. though the training programme was intended for the members of he Farmer Forum, a lot of people with farming as a secondary profession were invited just to fill up the vacancies of the absentee forum members so that DAE can complete the list of the required number of trainees. These trainees had less interest in the subject offered than in other forms of incentives usually given to the attending farmers.
5. the trainers of DAE were never found to use any training materials such as posters, flip charts, live samples of pests and diseases etc. in the training class.
6. it appears that farmer's training means only the classroom lectures and there is no need for a follow up practical orientation.

Here are some reports on case studies to clarify some of the facts mentioned above. These are clear indications that there was no real demand for the services requested for. However, farmers may not be blamed for not responding to the promised services since it is their perception that they should be getting free services and even inputs, particularly from the DAE, as a prerogative of the clients (farmers) in this country. Unless this preception is changed, no real participation of the farmers can be expected and a slower progress in agricultural development will tend to persist in the country.

Case Study 1

The project consultant staff organized mini workshops with the farmers of two chars to get their views about the constraints for adoption of modern varieties of rice in the chars. All of the participating farmers identified four major constraints for agricultural development in the coastal chars. These are (1) lack of knowledge about modern agricultural technologies, (2) unavailability of seeds of the modern varieties in the areas, (3) high soil salinity, and (4) unfavourable moisture conditions. They prioritised two events such as farmer training and making seeds available as the primary steps for solving these problems. When we promised to arrange such training we found none interested to participate the training programme unless they get some financial support.

Case Study 2

There was a serious demand for seeds of improved rice varieties. Interested farmers were asked to prepare a list of farmers indicating name of variety and the quantity of seed they need and to submit to us along with the price as per BADC rate. A list of interested farmers with requirement of seed was submitted but without money. Subsequently none of these farmers came to us for any service.

Case Study 3

We tried to assess the impact of classroom lecture on the farmer's perception at the end of some classroom lectures on important topics. Individual farmers in presence of the speaker were asked to mention at least one message that he got from the just-concluded lecture. Most of the farmers except a few very young farmers (actually not true farmer but student-cum- farmers) could not mention a single body of knowledge he gained from this class lecture.

Therefore, considering all the facts stated above, the following suggestions could be made in order to make the existing training programme for the farmers more effective.

1. Identify a problem on which training is needed, primarily based on dialogue with the farmers in a forum meeting. The problem should preferably be very specific and based on field problems farmers faced during the previous season. Examples may be - use of a completely new crop or variety in the area, use and maintenance of certain implements, importance and methods of fitting green manuring crops in the cropping system, uses and abuses of pesticides, various usage of certain crops like soybean, maize, batisak etc. etc.
2. With the help of BS and or Upazila level extension officers the farmer forums should organize the training programme by themselves and should invite speakers identified by the DAE local offices. However, this is contrary to the present system in DAE. Therefore, DAE itself has to be motivated first before they start motivating farmers to be vocal about their problems and training requirements.
3. More emphasis should be given to informal and on-the-job practical trainings with minimum classroom lectures. Even in the classroom the speaker should initiate

discussions among the farmers first and he should take the role of simply a observer. Let the farmers share their own experiences on a particular issue. In the process speaker should try to identify knowledge gaps in the farmers and subsequent discussion should focus on the identified problems or knowledge gaps.

Group discussions

Discussion with the members of the farmer fora should be held regularly where contemporary field problems can be discussed. The Chair person of the farmer forum should organize the meeting in consultation with BS, who in turn will invite other field level extension workers, if any, of various sectors. An officer at least in the rank of Agricultural Extension Officer (AEO) from upazila should attend the meeting. BS or any other field level extension workers should take the minutes of the meeting and important problems and issues have to be forwarded to the Upazila Agricultural Officer who will include these as agenda for the forthcoming meeting of the UAECC.

Farmer field school

In early eighties, BRRI introduced a system of mobile school in the name of *Rice School* which hepled faster expansion of HYV rices in the country. A similar programme called *Strengtheing Plant Protection Services (SPPS)* of the DAE/UNDP/FAO was launched by the DAE with funding from DANIDA since late nineties. In this programme,7800 farmer field schools (FFS) with 25 farmers in each school are formed. Eventually these FFSs will be converted to self sustaining rural institutions in the name of IPM Club. It is expected that each of the members of the club would take the role of local teacher for the farmers of the area. These clubs will sustain through some income genmerating activities. Perhaps it is too early to assess the impact of this system.

Monitoring and evaluation

There is a provision of monitoring and evaluation of the programmes at the top or national level but its objectives are somewhat different from what is required for the DAE field activities. Monitoring and evaluation of the field activities has never been considered by the DAE to be an activity required for effective programme implementation. Also NAEP failed to identify this as an essential tool for successful implementation of any field programme of DAE. This activity is essential for effective field programme management, particularly for:

a) identifying various shortcomings in the programme and to suggest possible solutions thereof; and
b) assessing impact of all field level interventions on the targeted groups or phenomena.

5.2.2 Input supply

Coastal farmers, particularly of the southeastern region, have no or very limited access to required agricultural inputs. The reasons are: (a) farmers are not aware of the high input-based modern agricultural technologies, (b) non adoption of modern crops and crop varieties due to a host of socio-economic and coastal vulnerabilities, and (c) poor development of infrastructure in the coastal region impedes people's mobility and so marketing of agricultural inputs as well as of the products did not develop. All these led to no or poor demand for all agricultural inputs and so there is no market developed for these.

CDSP in its first phase tried to motivate some farmers and helped them to get government licence to put up shops at the doorsteps of the char farmers for the supply of fertilizers and pesticides. Initially there was some demand, particularly of pesticides and less of fertilizers and other inputs, after the introduction of high yielding varieties (HYVs) of rice. But within a few years agro-ecological conditions in some areas became unfavourable for the HYVs due to severe water congestions and farmers switched back to traditional local varieties of rice, which are usually grown without added fertilizers and pesticides. Soon the shopkeepers found this business less profitable and then discontinued. Attempts were also made to popularise other inputs like a simple weeder for use in the rice paddies and pedal threshers in the CDSP-I areas. Use of weeder requires to transplant rice in rows which the farmers of the char areas do not do as they have been growing traditional varieties only. So, there was no demand for weeder. Threshing rice is a labour intensive operation and farmers would be benefited if this would be made available to them.

During CDSP-II the problems of water congestion at CBD-II and CM have been improved to some extent and the farmers have started to adopt more HYV rice again after massive promotional activities by DAE with the technical support from CDSP-II. Faster promotion of HYVs would be possible with the improvement of input delivery system. The matter was discussed with the farmers in several meetings of the farmers during CDSP-II but farmers' response was negative considering the limited volume of business. However, there exists scope for improvement of input delivery in the coastal char areas of this region, which is expected to happen albeit slowly, for the following reasons:

1. With the improvement of agro-ecology, adoption of HYV is increasing in the areas thereby creating more demand for inputs in the local market.
2. Improvement of infrastructure due to intervention by CDSP offered a better road communication with most of the project sites, which is a pre-requisite for development of local market.
3. BADC, the only national organization, with a mandate to produce and supply seeds of improved crops in the country is capable of meeting only 5% of the national demand.

Any external effort to strengthen input supply would take the whole extension effort one step further. Keeping this in view CDSP-II supported the char farmers, who were willing to produce and store HYV rice seed for selling among their neighbouring farmers, with seed bins and hand-on training on production, processing and storing of HYV rice seeds. These farmers contributed significantly towards dissemination of HYV rice in the char areas.

DAE established horticultural nurseries at the upazila level only. These nurseries are good and reliable sources of saplings and seedlings for promoting social afforestation and homestead gardening. However, farmers of char areas are seldom benefited from these since these are located far away from them. Therefore, for the greater benefit of the char farmers, DAE should consider supporting establishment of horticultural nurseries directly at the farmer's homesteads.

5.2.3 Production Credit

Our agriculture is at the subsistence level. Often poor farmers have no food to eat during the lean period of the year. Therefore, usually they have no other options but to purchase food for the family at the cost of whatever assets (like loaned money, seeds and other family assets) they have. Farmers, particularly of the char areas, feel insecure to invest borrowed money in crop production since a good harvest is not always ensured. Moreover, the tenant farmers loose interest in heavy investment in crop production because the landowner never shares the cost of production. Use of credit faces multifarious problems in our country and the situation in the coastal char areas is even the worse. Char dwellers are mostly poor and there is high demand for credit both for productive and unproductive purposes. More than 63 to about 74% of the household are found to be indebted with an average loan size of Tk. 8,314.00 in the CDSP-I polders (Latif, 2003).

Sources of credit

Formal production credits are available to support both small and large farmers from various nationalized banks in the country. Although many of the nationalized banks have credit programme, Bangladesh Krishi Bank (BKB) has the mandate to give credit exclusively for the development of agricultural sectors. Sonali Bank, another nationalized bank, also provides agricultural credit to farmers. These banks provide credit with an annual interest rate of 12%. Most char dwellers do not possess valid title on their land which is the prerequisite for getting credit from the nationalized credit giving institutions. Moreover, it becomes very difficult for the farmers to satisfy banks with all other requirements. As a result the lowest interest rate of these institutions could not encourage farmers to get credit from them. Moreover, processing of the loan takes so long time that hardly it becomes available in time. If the money becomes available after the crops season, the farmers usually spend the money in unproductive rather than in productive purposes. Farmers once took loan from a bank, usually do not visit the bank any more and tend to remain as a loan defaulter.

In absence of sufficient number of formal institutions closer to char lands and because of the difficulty in processing of the loan cases, farmers depend on the private moneylenders (landlords, relatives and neighbours) for credit. They follow two different systems of credit management. In most cases the farmer will get the money at the beginning of the crop season and will pay it back not in cash but in kind at the end of the season (within four months) which is five *maunds* (1 *maund* = 37.3 kg) of paddy for each Tk. 1000.00 loan. Some moneylenders charge one *maund* paddy for each Tk. 1000.00 loan plus the principal amount of money. Using the farm gate price of one *maund* paddy at Tk. 270, the farmers paying five *maunds* of paddy are really paying 105% interest and the latter category of farmers are paying 81% interest on an annual basis. Nevertheless the high rate of interest did not repel the farmers from going to a local moneylender as they can be easily reached at any time and does not involve any formalities as with the formal institutions. Farmers found it easier for them to repay the money in kind. Furthermore, farmers can maintain a good relation with the moneylender and so not only he can get the money whenever he needs it, he enjoys other social gains out of it.

When the NGOs became functional in char areas, gradually more and more farmers started approaching them for credit. NGOs in general do not give agricultural credit and have different system of credit management what they call it micro-credit system. In this system, a farmer gets small amount, usually not exceeding 5000.00 taka, and are payable in 46 to 52 weekly instalments beginning the following week the loan is disbursed. They do not charge any interest rather than what they call it service charge at the rate of 12 to 15% on the principal amount which remains fixed throughout the recovery period. Therefore, the rate of interest on credits given by NGOs is very difficult to ascertain although they show it as 12-15% in books only but the actual rate will be in the neighbourhood of 28%. However, farmers prefer to go the NGO for credit for several reasons and these are:

a) farmers can get the loan exactly in time when they need it;
b) they can pay it back in instalments of smaller amount since the size of loan is small;
c) farmers found it more convenient since they need not to go to the NGO rather the NGOs come to them to collect the instalments and so the farmers have no chance to be loan defaulters.
d) since the women can approach an NGO very easily the male members have enough time to take up other important jobs.

Usage of credit

Direct investment of the loaned money in field crop production is almost absent except on a special case for purchasing some fertilizers and pesticides, particularly when cultivating high-input based modern varieties of crops. Mostly credits are being used for purchasing food for the family followed by investing in their small businesses and permanent assets like purchase of land, ricksaw or ricksaw van, pond digging, fish farms, purchase of fishing nets, boats and cows etc. About 15-20% of the loanees use credit to meet up family needs (purchase of food during distress period) and other social events such as marriage, dowry, social festivals etc. At least 10% of the loanees use this credit for repayment of their previous loans.

Scope for improving credit facility

Attempts could be made to come up with a practical solution for these constraints after analysing the following facts.

1. Considering the limitations of the formal credit giving institutions to ramify their offices at the grassroot level, the government should encourage private sector to come forward and necessary guidelines could be prepared.
2. In many cases the illiterate farmers fall prey of the local cunning, both of their locality or at the bank, and are cheated while processing the loan cases. The formal institutions could improve their service by opening a help desk for the farmers, especially for the illiterate ones, and assisting them to process the loan cases.
3. The government should have some guidelines for the private credit giving institutions/persons with a pragmatic implementation scheme.

ANNEX I
Methodological notes

Transect surveys

Plot-to-plot surveys or other types of comprehensive surveys are useful to collect baseline data against which to measure change or progress. For regular monitoring, however, they are too cumbersome and expensive. CDSP has therefore promoted rapid transect surveys to monitor landuse changes. During CDSP-II the surveys were carried out by DAE Block Supervisors. The procedure was as follows:

1. Two representative transects were chosen which covered all the variation occurring in a char or polder in terms of land types and salinity conditions, according to the plot-to-plot surveys and later according to the soil and land type surveys carried out by SRDI
2. The location of the transects were marked in the GIS map
3. During each cropping season the crops or cropvarieties grown in the plots bordering on the transect lines were recorded
4. For each crop or variety the percentage of plots along each of the transect lines where it was grown was calculated

The outcome of the transect surveys must be treated with caution, because of some inherent biases:

- The quality of the observations, now carried out by DAE field personnel, has not always been adequate and regular supervision is needed
- The representativenes of the transects is sometimes questionable
- Some crops are grown in smaller fields than others and the formers' importance will then be overestimated

The representativeness of the transects can be improved once the Productivity Zone (PDZ) maps are ready. The transects should then be re-aligned so that each PDZ is represented in proportion to the area it actually occupies. This can be done as follows. First a number of transects is drawn visually on the PDZ map such that the representation of each zone along the transects is roughly the same as their actual area in the char. The transects are then transfered to the GIS which calculates the exact percentage of the transect line lengths in each zone. The deviation realtive to the real area of each PDZ is then corrected by adjusting the alignment until the percentages exactly match. This was done for S. Hatiya without any problem and should be done for all chars.

Better allignment of the transects will result in better data on overall crop incidence, but not on their distribution according to PDZ, unless the surveyer can record his exact position while carrying out the survey. That can be done by using a GPS device. In that way the crops occurring in each zone can be calculated. We have not done this so far.

Soil salinity measurements and conversion

Sampling

For initial baseline data collection a grid-based sampling procedure for soil salinity was used, initially with the gridlines spaced 500 by 400 m. Later the spacing was reduced to 300 x 200m in some chars and to 250x 200m in others. Hence the sampling density was 1 per 20 ha at first and 6 or 5 ha later. Around each intersection point four samples were collected and bulked for each of the two depths. In the first year sampling depth was 0-20 (topsoil) and 20-40cm (sub-soil). The following year sampling depth was changed to 0-10 and 10-30 cm, which are the usual depths for salinity measurement and which were also used by LRP and CDSP-I. Ten percent of the samples colected from top layer only are analyzed or nutrient content. The earlier data therefore had to be converted for consistency. Conversion factors were derived from a set of samples from 30 representative locations, taken at 10 cm depth intervals. The following relations were found:

for conversion from 0-20 (x) *to 0-10 cm* (y)*:*

$y = 1.502\,x$ R^2 of the linear relationship: 0.973

for conversion from 20-40 (x) *to 10-30 cm* (y)*:*

$y = 1.260\,x$ R^2 of the linear relationship: 0.931

All data presented in this document are for 0-10 and 10-30 cm sampling depth, after conversion of those early cases where the different sampling depth was used.

When sampling soils repeatedly over a long period to follow trends in salinity the samples should be taken strictly in the same location. Otherwise the strong micro-variation even over short distances will result in wildly fluctuating results which make it difficult to discover trends.

Measurement and conversion

Because of the large number of samples and the limited facilities at the SRDI laboratory at Noakhali, a rapid measurement method was used. The added advantage is that the reported values can be easily checked by CDSP-II staff. Soil and water were mixed in 1:1 ratio and stirred in a shaker for about an hour. The suspension was allowed to stand overnight and re-stirred just before taking the measurement the next day. Electric conductivity (EC) of the suspension was measured directly using a pre-calibrated EC meter. SRDI uses standard conversion factors to covert EC(1:1) to EC_e, but data from LRP and from a study by Mizuochi and Khanam[19] showed that these were not applicable to the char soils. Better conversion parameters were therefore derived from a set of 55 samples. EC_e values were determined by the BRRI laboratory in Gazipur and the EC(1:1) values were measured by SRDI Noakali. Fig. 21 shows the quadratic relation between EC(1:1) and EC_e satisfying the following equation:

$$EC_e = 2.37\,EC(1{:}1) - 0.02\,EC^2(1{:}1), \text{ with } R^2 = 0.95$$

[19] Mizuochi, T., M. Khanam and S. A. Sattar. 2000. Report on a field trip to CDSP sites and proposal of a practical method for salinity evaluation in Meghna Charland. BRRI, Dhaka.

This equation was used to convert all data to EC_e.

Some of the early data by LRP and CDSP-I were measured in 1:2.5 soil-water extract. LRP Technical Report No. 26 and the Mizouchi and Khanam study show that the data must be multiplied by 2 in order to convert them to 1:1 suspension. This was done for some of the early CDSP-I monitoring data, before conversion to EC_e..

Measurement in the field

We have been looking for a simple and rapid field method for measuring soil salinity. That would be useful to (i) choose suitable plots` for particular (rabi) crops and (ii) examine the effect of local salinity on crop growth in tests and demonstrations.

The simplest and most rapid method is using an auger-type probe which is pushed into the soil for direct measurement (e.g. the probe marketed by Eijkelkamp). The conductivity measured by the electrodes in the probe will be very sensitive to the contact between probe and soil and to the soil's moisture content. It will be especially unreliable for measurement in the top 10 cm under dry season conditions. Field probes are therefore only suitable to obtain relative figures, comparing two fields with the same conditions, not for absolute figures such as we need. Another option would be to use a hand-held refractometer. That method has been applied successfully for testing saline water by Prof. Helmut Lieth, of the Institute for Environmental Systems Research, University of Osnabrück. The measurements are calibrated with a standard laboratory salinity test. The method may be used in the field by preparing a small amount

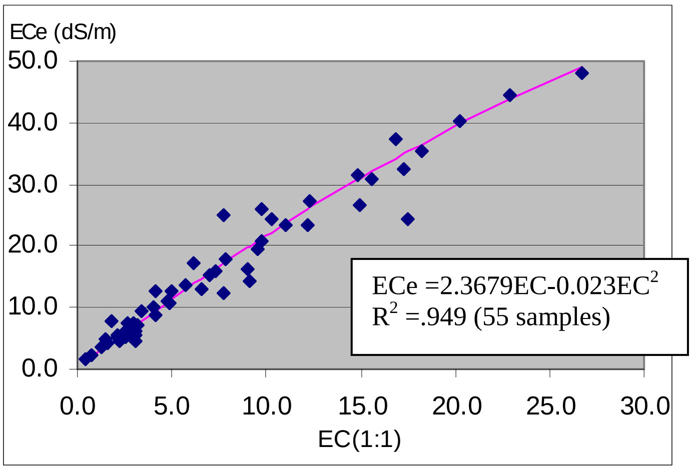


Fig. 21. Measured and fitted relationship between EC(1:1) and EC_e, (55 samples)

of 1:1 soil suspension (assuming the field water content may be estimated) and measuring refraction in a drop of the suspension. A refractometer is needed which should be sensitive in a (very) low refraction range.

ANNEX II
Outstanding issues

This Annex enumerates some gaps in our information about agriculture in the coastal char and in our methodology, which can be filled during the remainder of the present programme phase.

1. Study on input supply and marketing

Input supply is an important area where our information remains mainly anecdotal. Earlier attempts to promote a mini-network of input stockists in the char came to nothing, but demand may be greater now and the next programme may want to do something about it. Prior to that, it would be useful if the Monitoring and Evaluation specialist could conduct a study on the input supply situation in the char areas: fertiliser, pesticides, sprayers, seed, etc. and how farmers obtain them.

For marketing of crop produce little concrete information exists also. Information may be collected in combination with the study on inputs supply.

2. Baseline data CDSP-I polders

Post-project monitoring of the three CDSP-I polders has turned out to be very useful for our understanding of agricultural evolution in protected areas. We should also have collected baseline data on salinity and flooding depth long ago, in order to map the PDZ in the polders. For some reason this has not been done till today. It is strongly advised to collect these data in March 2005 (the earliest possible date) and carry out the PDZ mapping immediately afterwards. This will still leave some time to use the maps as a possible tool in water management.

3. Transect surveying and salinity monitoring

The results of some of the transects appear to be erratic. Likewise, some of the soil salinity monitoring data do not represent the real situation.

To overcome these transect lines have to be realigned based on the PDZ and the CDSP field agriculturists should monitor the survey done by DAE. The realigned transect lines should be identified using GPS initially and the suitable land marks to be fixed. Similarly, the points for soil collection by SRDI have to be refixed after identifying appropriate salinity levels during the dry season of 2004. These points have to be identified in maps using GPS initially followed by fixing these with suitable landmarks.

4. Field measurement of soil salinity

We have been looking for a field method for salinity measurement, so far unsuccessfully. Prof. Leith of the University of Osnabruck recommends to use a hand-held refractometer. We will look for a suitable type with the right sensitivity for soil suspension, if such exists at all.

5. Potential technologies

Some more information may be collected about the potential technologies generated by other organizations, in particular the PETRRA project, which has worked in the coastal area. Furthermore, some thoughts have to be given to options for green manures species or multipurpose species which can be grown on the levees and paths in the chars.

6. Historical perspective of the dynamics of soil salinity in coastal area

It was assumed that soil salinity would reduce to a level tolerable by most crops after five years of empolderment. This is somewhat against our field observations after five years. In order to assess precisely the field measurements have to be supplemented with historical information on the changes in soil salinity along transects perpendicular to the coast covering both the saline and non-saline phases. The information have to be collected from the aged people living in the areas since accretion through a questionnaire survey.

ANNEX III

Nutrient status of soils of the coastal chars

Analysed in 2000-2001

Analyses	MD		CL		GT		SH		BT		CO		MAA	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
OM(%)	1.0-1.6	1.4	1.3-1.9	1.5	1.0-1.17	1.07	0.9-1.7	1.4	1.0-1.3	1.1	1.2-1.6	1.4	1.4-2.4	1.8
N(%)	.05-.09	.08	0.04-0.07	0.05	0.05-0.06	0.05	0.06-0.14	0.11	0.04-0.07	0.05	0.06-0.08	0.07	0.01-0.11	0.04
P (ppm)	3.8-8.9	5.7	3.3-9.0	5.2	0-0.8	0.16	3.9-15.1	6.8	1.4-3.8	2.8	0-2	0.8	5.9-15.8	11.1
K (me/100g)	.20-.05	0.33	0.29-8.6	1.83	0.6-0.9	072	0.03-1.0	0.52	0.6-0.8	0.69	0.28-0.52	0.43	0.19-0.91	052
Ca (me/100g)	10.8-13.0	12.4	10.2-13	11.3	10-12.8	11.3	1.6-20.3	14.1	3-16.5	10.6	7.8-13	9.8	8.5-10.5	9.4
Mg (me/100g)	5.5-14.0	7.5	5.5-14	8.1	9-17.3	12.3	1.0-18	13.7	7.5-16.5	12.0	8.3-10	9.1	1.0-9.5	7.3
S (ppm)	39-461	228	137-411	309	150-274	239	10-390	214	94-262	198	196-251	226	30-186	110.7
Zn (ppm)	0.6-18	5.9	0.9-3.8	17	0.12-0.3	0.20	0.8-22.7	6.2	0.06-0.22	0.14	0.1-0.24	0.17	0.9-4.0	1.7
Fe (ppm)	32-196	78	58-82	70	17.6-23	19.4	6-162	65.9	20.8-29.0	23.7	0-29.2	17.2	54-166	93
Mn (ppm)	27.6-106	70	40-97	68	4.4-6.2	5.1	10-982	140	3.8-8.8	5.9	0-4.8	2.7	40-230	146.7
Cu (ppm)	2.0-6.5	3.9	4.0-6.4	5.4	2.5-4.3	3.0	2.5-7.6	4.5	2.0-3.0	2.4	3.2-4.6	3.9	4.1-7.7	5.8
B (ppm)	0.3-1.8	1.1	0.76-1.65	1.1	-	-	0.23-1.77	0.99	-	-	-	-	0.75-1.71	1.07

Analysed in 2003

Analyses	MD		CL		GT		SH		BT		CO		MAA	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
OM(%)	0.3-2.7	1.2	0.19-2.38	0.72									0.17-2.38	1.31
N(%)	0.02-0.16	0.07	0.02-0.14	0.05									0.01-0.14	0.08
P (ppm)	0.12-8.3	3.5	0.45-10.3	3.72									0.02-9.8	2.8
K (me/100g)	0.11-0.68	0.44	0.31-0.84	0.54									0.34-1.78	0.61
Ca (me/100g)	3.4-10.6	5.9	4.3-7.6	5.72									3.4-12.5	5.1
Mg (me/100g)	2.8-10.1	6.1	5.4-8.5	6.70									4.93-8.55	5.9
S (ppm)	17.3-130.6	62.2	53-211	92.6									36.7-186.2	80.6
Zn (ppm)	0.74-1.46	0.94	0.53-2.12	1.00									0.67-2.02	1.12
Fe (ppm)	22.0-170.0	86.0	34-180	99.3									32-380	103.5
Mn (ppm)	1.0-24.0	9.5	11-76	24.2									6-56	20.2
Cu (ppm)	1.21-6.44	2.96	2.8-9.3	5.2									2.7-9	5.3
B (ppm)	0.29-1.42	0.6	0.11-2.45	0.85									0.23-1.26	0.63