PART - C

PRELIMINARY DEVELOPMENT PLAN OF CARING CHAR

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PRELIMINARY DEVELOPMENT PLAN OF CARING CHAR

CHAPTER-1: INTRODUCTION

1.1 Background

Caring Char is a developing new char at the south-ward extension of accreting new char lands in Southern Noakhali in the vicinity of Boyer Char. Major part of land is still at formation stage and yet to be matured for empoldering and as such a preliminary development plan needs to be prepared indicating a time frame of reaching the char land to the maturing level for empoldering.

Char Development and Settlement Project (CDSP) came in 1994, with Dutch Technical Assistance, for implementation of Baggardona-II, Char Batir Teck, Char Majid, Char Maradona, Muhuri Char and Boyer Char under CDSP-I & II. Present Preliminary Development Plan preparation of Caring Char is a part of support of the Feasibility Study on the Development of New Chars in the Vicinity of Boyer Char under CDSP-III.

1.2 Preliminary Plan Area

The Preliminary Development Plan area of Caring Char falls in Hatiya Upazila of Noakhali District.

It has a total land area of 6852 ha and is at initial stage of settlement. The area is mainly covered by grazing land and forest. Agriculture is there but not extensive. The area is criss-crossed by numerous tidal khals and creeks.

1.3 Objective of Preliminary Development

The main objective of the Preliminary Development Plan is to address present water management problems - delineation of hydrological units, assessment of accretion rate with a possible time frame for empoldering and immediate measures like water supply and sanitation and multipurpose cyclone shelter for the present households

CHAPTER- 2 : PRESENT SITUATION

2.1 Location

Caring char is located on the southern side of Char Nangulia and south-eastern side of Noler Char. It is bounded by Mamur khal on the north, Caring khal on Meghna River on the south-west and Hatiya channel on the south and south-east. The preliminary plan area falls within the BTM co-ordinates of about 482,000 - 491,000 Northings and 6125,000 - 625,500 Eastings. Location of Plan Area is shown in Fig. G 1.2.

2.2 Physical Condition

The area is comparatively a new emerging char as the south-most extension of the mainland of Southern Noakhali. It gets saline tidal inundation from the Meghna River and Hatiya channel through the tidal khals and creeks. Large area on the south is a "Leski area" a sloping area that goes under water during normal tide which is a new grazing land for cattle with saline grass all over.

2.3 Topography

The char area is on an average about 13 km long northeast - southwest and average 5 km wide northwest -southeast. Land lével has a gentle slope from the central part towards south and southwest. Average land elevation is about 3.0m (PWD). Maximum land of the area is within the elevation of 2.00m and 4.00 m(PWD) covering about 77% of the Char Area (Fig. C 2.3). A rough area elevation relation found from 500m grid survey is as below :

Elevation (mPWD)	Area(ha)
<2.00	634
2.00 - 2.50	1052
2.50 - 3.00	1463
3.00 - 3.50	1438
3.50 - 4.00	1371
4.00>	894
Total :	6852

Flood depth map of existing condition : 10 year return period monsoon (Fig. C 2.3) gives present flooding condition of the char.

Figure : C2.3 Flood Depth Map (Existing Condition: 10 year return period - Monsoon)

2.4 Hydro-morphology

The hydraulic and morphological conditions in the estuarine river and channels are quite complex and very dynamic in nature. The behavior of the estuary is influenced by the circulation of water and solids in the bay as well as by the whole tidal part of the river system. The boundary shape of the estuarine system is determined by the geomorphology of the land and the properties of all alluvial materials that form the bed and banks of the channels. Usually, the overall boundary shape changes only slowly, though there may be rapid local or short term adjustments. The flow pattern in estuaries is unsteady, not only because of the tidal rise and fall at the mouth but also there are large scale eddies that vary in size and location. The complicated inter-play between the forces of the river, tide and wave is causing continuous redistribution of sediment by erosion and sedimentation, which is striving to achieve a dynamic equilibrium between the morphological form and discharge

The tides, fluvial discharges, waves and storm surges are mainly responsible for the morphological changes in the estuary. The cumulative effect of retardation of flow velocity accelerates sedimentation. As a part of hydro-morphological investigation the consultant has collected the available satellite images from CEGIS. Surveys of khals have been carried out by the consultants. The tide in the estuary, water levels of the rivers in and around the project area have been analyzed with the help of secondary data available from different sources.

Long-term Development

A caparison of the 1999 satellite image with the 1779 map of J. Ronnel shows a completely changed system of channels and river courses but a more or less stable coastline west of the Tetulia River. East of the Tetulia river a general tendency of seaward growth of the coastline can be recognized, particularly in the region Bhola Island, Hatiya Island, and in Southern Noakhali.

Several studies have examined the rates of change in area for coastal Bangladesh (Table-2.4) where the net changes studied over a period ranging for 23 to 220 years, and there was a net increase of land. The range of net land gain over the periods varies from 4.4 km^2/y to 18.8 km^2/y (MES-II). Comparison of erosion and accretion rates from different studies are presented in Table 2.4/1.

Table 2-4/1: Comparison of erosion and accretion rates from different studies

(Source : MES-II Study)

Length of Study period (Year)	Period of Study	Net change for period (km^2)	Rate of change (km^2)/y	Reference
220	1976-1996	+ 2,187	9.9	EGIS (1997)
192	1972-1984	+ 1,346	7.0	Allison (1998)
144	1840-1984	+ 638	4.4	Allison (1998)
23	1940-1963	+ 279	12.1	Eysink (1983)
27	1973-2000	+ 508	18.8	MES – II (2001)
7	1972-1979	+ 213	30.4 [1)]	SPARRSO & ERIM (1981)

1) *Areas described as mud flat was considered as accreted. Therefore, rate of change is not comparable to the present study.*

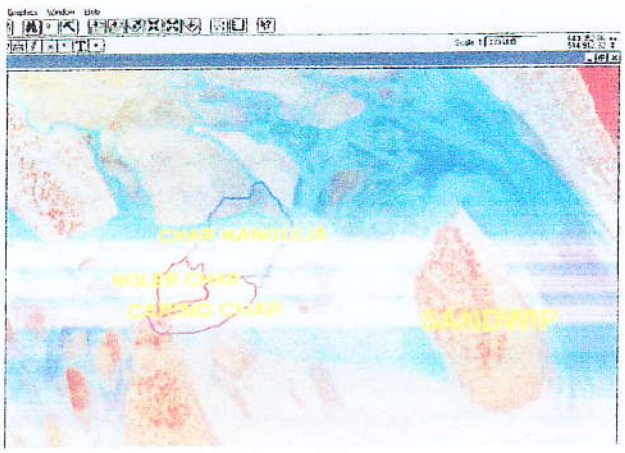
Mid-term Development

Construction of Noakhali cross-dams in late 1950s and early 1960, triggered the process of land formation at the southern part of Noakhali main land. Study area has also been developed during this period.

Development of the study area has been studied using time series-satellite images of 1973, 1984, 1996 and 2005 (Figure C 2.4/1). In satellite images land mass is considered as land when sign of vegetation is there and visible in the image. Mud-flat was not considered as a part of land during the analysis. Analysis of these images provides a reliable information about the lateral accretion/erosion of the study area and its surroundings. In 1973, a small part of the main land was present in the boundary of the Char Nangulia, Size of the then Char Nangulia was 1,590 ha. (Figure C 2.4/2). Noler Char and Caring Char did not exist at that time. The northern tip of Hatiya was within the present boundary the Caring Char.

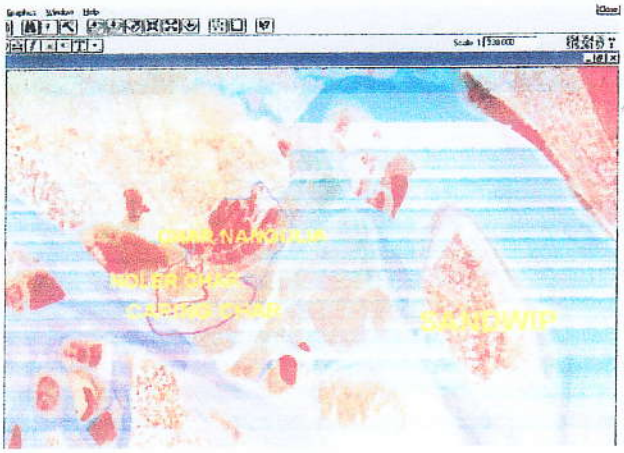
In 1984, size of the Char Nangulia was increased from 1,590 ha to 3,510 ha (Table 2.4/2). Rate of increase of the char during the period 1973-84 was 180 ha/year. Noler Char and Caring Char did not emerge although main land of Noakhali migrated towards south. Northern part of Hatiya had been eroding.

In 1996, a vast land and mudflat at the southeast part of the study area were emerged. Char Nangulia increased its size from 3,510 ha to 8,580 ha and rate of increase in size is 425 ha/year during the period 1984-96. During this period Noler



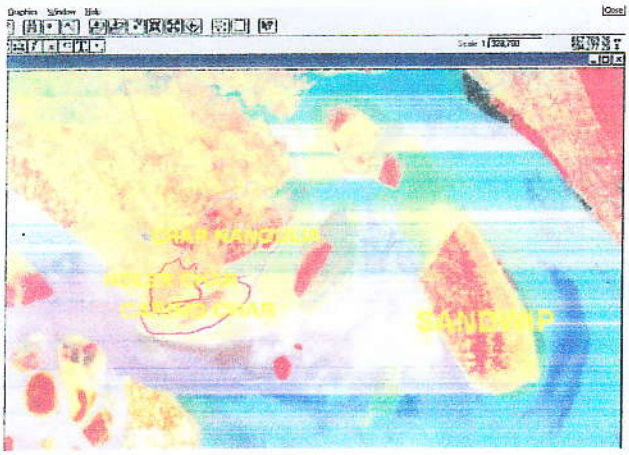
1973

1984



1996

2001



2003

2005

Figure C 2.4/1: Time-series satellite images showing the study area

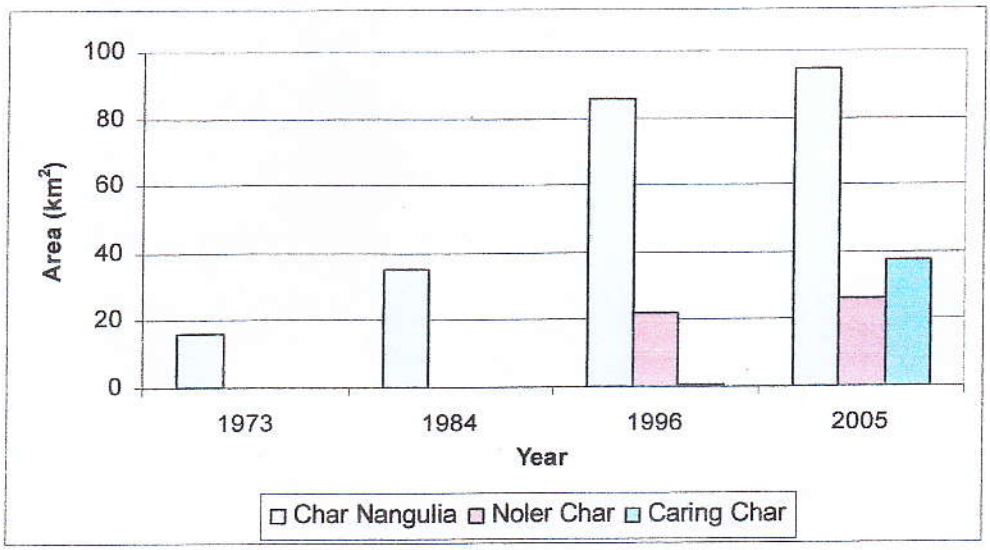


Figure C 2.4/2: Changes in area of study area during the period 1973-2005

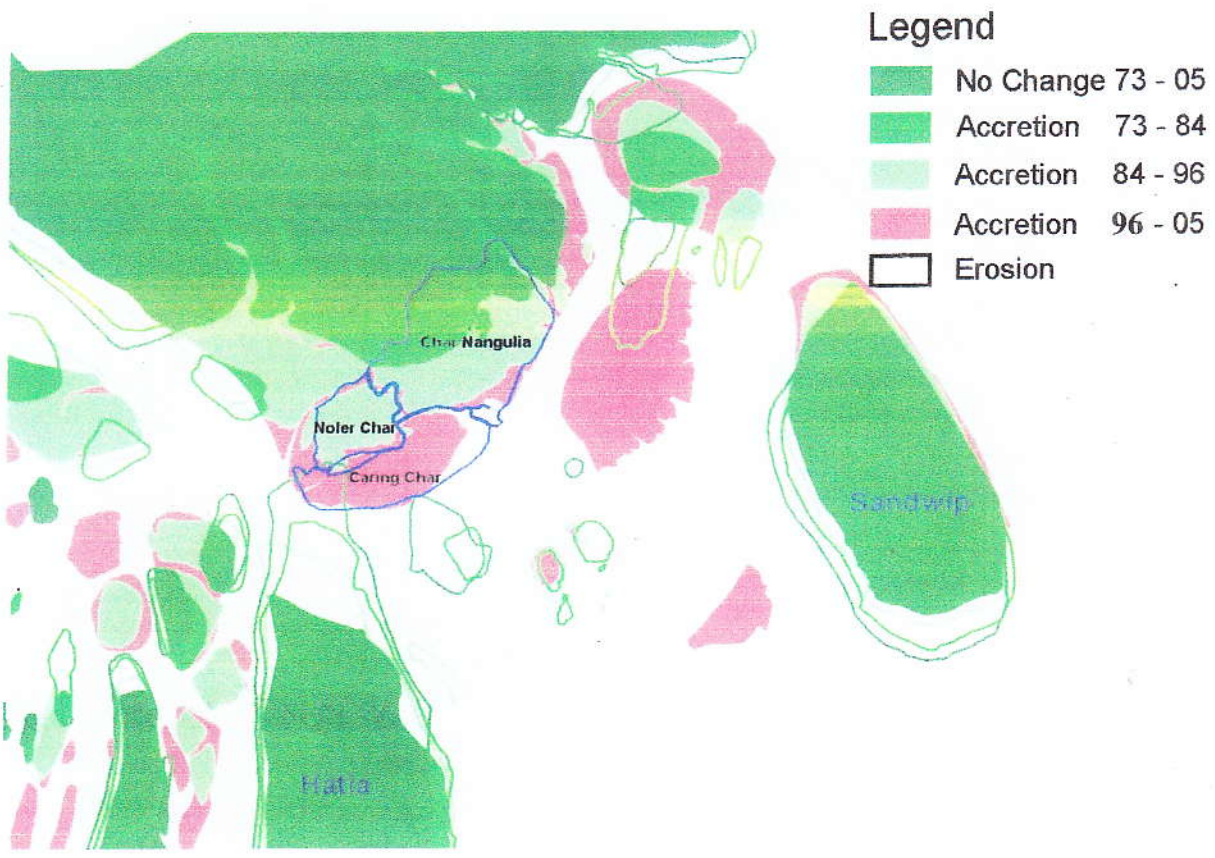


Figure C 2.4/3: Accretion and erosion pattern (1973-2005) in the study area

Char came into visible and its size was 2,173 ha. Growth rate of the char was at least 180 ha/year. Caring Char also came into the scene, but it was tiny. Northern part of Hatiya continued to erode.

In 2005, the main land of Noakhali continued to develop towards south during the period 1996-2005, but at a slower rate. Growth rate of Char Nangulia decreased to 100 ha/year. During this period this char increased its size only by 860 ha. Similar is the case for Noler Char, rate of growth was only 50 ha/year. But the growth rate of the Caring Char was very high, 410 ha/year.

Table 2.4/2: Changes in area of the chars during 1973-2005

Year	Area of the chars (ha)		
	Char Nangulia	Noler Char	Caring char
1973	1,590	0	
1984	3,510	0	
1996	8,580	2,173	70
2005	9,440	2,620	3,740

During the last 32 years (1973-2005), the southern part of Noakhali continued to develop southward (Figure C 2.4/3). This trend is continuing. At the same time, northern part of Hatiya Island gradually eroded and continuing to erode till now. Study area was about 1,590 ha. in 1973 and it became 15,800 ha in 2005, increase is about 10 folds. Average growth rate of the study area is about 450 ha/year. Growth rate during the last decade was 560 ha/year. The present growth rate may continue in the coming decade also. Considering the average growth rate of 560 ha per year Caring Char present area comes to 4860 ha, but the area determined from topographic survey is 6852 ha. Major reason for the difference is that topographic survey area included mud-flats.

Increasing of area of Char Nangulia and Noler Char was attributed to the sedimentation in the internal tidal channels (Figure D 2.3.3/2). Only Caring Char developed southward. It appears that Char Nangulia and Noler Char have reached a stable size, while the size of Caring Char has been increasing.

Rainfall Analysis

Considering the different catchments area, data of the rainfall gauge station Ramgati (Station Id 375) from 1961 to 2002 have been analysis A 5-day duration rainfall with 10-years recurrence interval will be appropriate as the design rainfall for computation of drainage modulus. Results of 5-day duration rainfall of different

return periods, which present the results of the frequency analysis of 5-days accumulated rainfall of the project area in monsoon periods, are presented in the Table 5.2.2a

Table 5.2.2a Frequency Analysis of 5-day Accumulated Rainfall (Monsoon)

Return Period / Station	2.33 Year Rainfall (mm)	10 Year Rainfall (mm)	20 Year Rainfall (mm)	25 Year Rainfall (mm)
Ramgati	340.65	591.61	699.67	733.94

Wind

The wind regime along the Bay of Bengal shows a typically seasonal variation between the dry season (November-March) and the monsoon season (June-September). During the dry season the prevailing winds are calm and offshore. The prevailing winds during the monsoon season are from the South-Southeast direction, with an average velocity of about 8-12m/s. During severe storms and cyclones, very high wind velocities can occur. The highest wind speed, reported during the April 1991 cyclone (CERP-II, 2000), is 62.5m/s, corresponding to 225 km/h. Most cyclones occur during April-May and October-November, which are the transitional periods between the dry season and the monsoon season.

Tides

Tides in the sea results from the gravitational pull of the moon, the sun and the planets and from local meteorological disturbances. Two tides will occur during each rotation of the earth, and that the spring tide will occur when the forces due to the sun and the moon appears to be in opposition to each other. Tidal rise and fall of the water surface at the entrance of an estuary causes surface gradients which results in the propagation of a gravity wave into the estuary. The rate of propagation depends primarily on the depth of water and, in consequence, on the tidal range at the mouth. The tidal wave travels more slowly as the depth decreases and, consequently, the wave form becomes distorted as it travels inland.

According to the classification of tides proposed by Devies (1964) the tidal range in the study area can be classified as follows:

- South Bhola – Hatiya North : Meso-tidal – tidal range 2-4 m
- East Hatiya – sandwip :Macro small – tidal – tidal range > 4 m

The study area is still information stage and unprotected and completely subject to tidal movement of the coastal waters. Coastal water at this location are mainly saline i.e. about eight months a year. The maximum high-tide water level is about 6.5m above PWD during cyclone surges. The maximum current velocities vary from 0.1-4.0 m/s in the tidal channels to about 0.2 – 0.5 m/s in the shallow areas on the mudflats and chars. During spring tide the flow velocities are normally higher than during neap conditions (MES II, June 2001).

The high water levels at spring tide outside the Char Majid Polder are 3.5m PWD and at neap tide 2 to 2.75m PWD (Polder Design and Development, Technical Report No. 13, 2004) during monsoon season. In dry season, water levels outside the Char Majid Polder are about 1.5m lower, as compared to the monsoon.

Waves

No wave heights have been recorded during severe storms until now. Wave models indicate that under the prevailing S – SE winds (with an average wind speed of about 8 m /s), the average significant wave height varies 0.6 – 1.5 m in the near shore zone to 0.1 – 0.6 m in the landward part of the project area. In the dry season the waves are generally less than 0.6 m with peak periods of 3 – 4 seconds. During the monsoon season wave heights exceed 2 m with periods greater than 6 seconds.

Higher waves may occur mainly in the pre and post monsoon periods during cyclones. In a study carried out under Second Coastal Embankment Rehabilitation Project (CERP-II, 2000) estimates of significant wave height were done which are given below for the offshore wave heights.

Offshore Significant Wave Height and Wave Periods

Return Period (Years)	2.5	5	10	20	50	100
Offshore Significant Wave Height Hs(m)	6.9	7.6	8.2	8.8	9.6	10.2
Offshore Significant Wave Period Ts(m)	11.1	11.7	12.2	12.5	13.1	13.6

Cyclonic Storm Surges

The coastal areas of Bangladesh are occasionally struck by severe topical cyclones which generally originate in the form of a low pressure depression out at sea. They move northwards with well-defined circular wind fields which rotate in an anti-clockwise direction.

The cyclonic storm surge is a gradually varying and unsteady flow. The amplitude of cyclonic storm surge wave amplifies during its progression towards the coast of Bangladesh due to long shallow continental shelf. The height of the surge at a point depends on the origin, track, forward speed and strength of the wind field associated with each particular cyclone event. Because of the large length of the cyclonic storm surge wave, it is accompanied by movement of huge mass of water. When a cyclonic storm surge reaches the coast, the adjacent area is flooded by the surge water.

Flooding of coastal areas and offshore Island by storm surge during a cyclone causes loss of lives and damages to properties. Available data on cyclonic storm surge height is very scanty. The displacement of water surface during a cyclonic storm surge also depends on tide. The displacement of water surface is the largest when the cyclonic storm surge reaches the coast during the time of spring tides. Such coincidence occurred during cyclones of November 12, 1970, December 10, 1981 and April 29, 1991.

The Multi-purpose Cyclone Shelter Preparatory Study (MCSP, 1993) has made a very thorough analysis of various aspects of the generation of cyclones surges and its penetration in-land. The yearly maximum wind speed (anywhere in the Bay of Bengal) was analyzed statistically revealing a relationship between return period and wind speed and is reproduced below :

Cyclone Wind Speeds (source MCSP, 1993)

Return Period (Year)	5	10	20	250	50	100
Wind Speed (km/h)	165	195	223	233	261	289

The storm surge height in the Meghna delta entrance is generally larger due to shoaling condition. Storm surge heights have been computed using a mathematical model in cyclone protection Project-II (1992). Estimated surge heights at the Chittagong to Noakhali sea coast for 20 years, 50 years and 100 years return periods with 90% confidence limits is presented below :

Estimated Surge Heights at Chittagong to Noakhali Coast with 90% Confidence Limits

Region	Surge Height (m)		
	20 years	50 years	100 years
Chittagong to Noakhali Coast	4.8 ± 1.0	6.5 ± 1.4	7.8 ± 1.8

The design surge height corresponding to given return period has been used for design of proposed infrastructure.

2.5 Salinity

Salinity intrusion is caused by the inflow of sea water during cyclones and lunar high tides and is the major constraint to agriculture development in the study area. The construction of embankments with adequate drainage facilities and adequate water management can reduce this problem. Serious crop damage occurs when standing crops are flooded by saline water.

Salinity data from LRP and MES indicate an enormous seasonal effect due to the influence of huge fresh water discharge from the lower Meghna River on the horizontal distribution of salinity in the estuary. During monsoon (June-September), nearly the whole estuary is filled with fresh water (salinity lower than 2 ppt (part per thousand).

Salinity level of water within the unprotected project area varies with the seasons; maximum values are reached in the pre-monsoon (April, May) and vary between 20-30m S/m (12-19 ppt) (CDSP-II, Technical Report No. 13, May, 2004).

As per classification by MES, the land in this area is surrounded too long, more than three months, by saline water intrusion and harmful to agriculture. Soil salinity levels in the area fluctuates considerably within a year. During the monsoon (July – October) soils of the project area are slightly saline but remain below 5 to 10 dS/m. After the monsoon, from November onwards, soil salinity levels increase and reach a peak in March and April.

2.6 Drainage and Drainage Units

The general drainage pattern of the area is towards the south and south-east, and the land of the area slopes also to south and south-east. Since the construction of the two Meghna cross-dams (1957 and 1964) in the old course of the Lower

Meghna, a vast area has been added and is still being added with the main land, with Caring Char as the latest one. Being at not fully developed stage there exists no drainage problem now for Caring Char.

Drainage Units

Natural drainage exists through the tidal creeks. Though the char land is in formation and developing stage, depending on the present topography four Drainage Units have been identified – Eastern, Southern, Western and Northern Drainage Units. (Fig. C 3.2, Annexure, Enclosure-1)

Eastern Drainage Unit : The unit has an area of about 2123 ha with khal-6, khal-4 and khal-5 forming the draining network draining towards Hatiya channel.

Southern Drainage Unit : This drainage unit having an area of 2125 ha drains to also Hatiya Channel with khal-1 and khal-2 as main drainage khals.

Western Drainage Unit : The unit has an area of 1669 ha and drains through Batenkhali and Mohiuddin khals to Meghna River and through Dakatia khal to Caring khal.

Northern Drainage Unit : This unit is a long strip along Caring khal with an area of about 863 ha. The area drains to Caring khal through Boater khal and other small creeks.

As the char is still developing the drainage units may change their area identification depending on developed land levels and likely changed drainage networks.

2.7 Present Land Use

Caring Char is a new emerging char and has a present land area of about 6852 ha as found from the survey. Forests are being cleared, settlement started and agriculture not extensive. Most of the area is grazing land and includes Leski areas. Land under agriculture is only about 26%, grazing land about 55% and forest 9%. Present land use as per field survey is presented below :

Caring Char

Project Area	:	6852 ha
Cultivated Areas	:	1788 ha
Grazing/Leski Areas	:	3795 ha
Forest Areas	:	584 ha
Khals	:	605 ha
Rest (Homestead – 533 nos. Bazars – 2 Nos. Religious places, etc.)	:	80 ha

2.8 Agriculture

Caring Char is an extended Char area which is recently formed and seems yet not ready for empoldering. Caring Char is separated by Caring khal from Noler Char and Char Nangulia. It has an area of about 6852 ha having 533 homesteads.

Objectives

- to determine land types and land use
- to identify major crops, area under each crops, cropping pattern, intensity and yield
- to identify constraints of crop production
- to develop future preliminary land use plan

Scope

The study made preliminary investigation on land types and land use and presented future plan. The report covers present crops grown, area, cropping intensity, yield and constraints of crop production, socio-economic situation and support services.

The future potentials of land use for crop production were also investigated.

Method and Approach

In order to collect relevant information on land types, land use and constraints of production, primary data was collected from group discussion with the farmers

using a checklist. The group discussion was held at one market place having 6-10 farmers with a leader.

The Agriculture Expert conducted the group discussion. He explained the purpose of discussion and a rapport was built up with the farmers and they became interested and agreed to provide relevant information. From the group discussion, information on flooding depth, crops grown in different seasons, area of each crop, yield, constraints of production and their perception on the solution of problems were collected.

Present Agricultural Situation

Present crop production in Caring Char suffers during Kharif-I and Rabi seasons from salinity and abnormal flooding in Kharif-II season. Besides, Caring Char lacks all kinds of support services including land settlement.

Land use

Present land use for different crops is determined by dry/Rabi season salinity, soil moisture condition, monsoon rain, tidal flood, land and soil types. Caring Char has 6780 ha, net cultivated area (NCA) is 1788 ha (26.3%), 3723 (54.9) grazing, 584 ha (8.6%) forest, 55% single, 60% double and 5% triple crops areas (Table 2.8.2).

Land and Soil Types for Crop Production

The land and soil types of Caring Char are briefly described below,

Land Types. The flood plain lands are classified by MPO and FAO on the basis of flood regime. During group discussion, information on depth of flooding was collected. Some of the lands (29%) in Caring Char fall within F1 which is flooded between 30-90 cm depth during the peak monsoon followed by F2 (27%) and F3 (4.0%). Fo land is 40%. (Table 2.8.1).

Soil Types and Salinity. Caring Char is adjacent to Boyer Char. Land topography and soil types are very close to Boyer Char. Soils of Fo lands are loam to silty loam and slightly saline. Soils of F1 lands are silty clay loam to clay loam and moderately saline. Soils of F2 lands are silty clay to clay usually strongly saline and single T. Aman crop is grown during the Kharif-II season.

Present Crops Production

The major crops grown in Caring Char are similar to Char Nangulia and Noler Char. The production in Caring Char mainly suffers from soil salinity during Kharif-I/Aus season and Rabi/Boro season. A farmer's decision to select a crop depends on his resources and his requirements. Food security is the prime concern to a farmer. Once food is secured, economics and environment determine his choice of crops. Caring Char is dominated by T. Aman crop (90%), followed by Rabi crops (30%) and Aus rice (10%), (Table 2.8.3). The major crops grown in Caring Char are as follows.

Boro/Rabi Season :

Pulse : Most common is khesari (40%) of Rabi Crops
Oilseeds : Ground nut, Mustard and Linseed
Spices : Chillis, Onion and Garlic

Aus/Kharif-I :

Aus – Local rice varieties are saita, Boilam and HYV rices are China IRRI (Purbachi) and BR-I (Chandina).

Kharif-II/T. Aman :

Local rice varieties are Rajasail, Kajolsail, Gieig, etc. The areas of major crops and yields are shown in Table 2.8.4

Present Cropping Pattern and Intensity in Caring Char

The major cropping patterns are also similar to Char Nangulia and Noler Char. Three cropping patterns are usually observed. These are single cropping pattern is Fallow-Fallow-T. Aman (55%). There are two double cropping patterns, Fallow-Aus- T. Aman (5%) and Rabi-Fallow-T. Aman (25%). The triple cropping pattern is Rabi-Aus-T. Aman (5%). The total cropping intensity is 130%, far below the national average of about 180%. (Table 2.8.3).

Constraints of Crop Production

The constraints of crop production in Caring Char are similar to any newly settled coastal char. During group discussion, the farmers reported that crop production suffers mainly from soil salinity during Aus and Rabi season. There is no flooding and drainage congestion yet in Caring Char. The farmers also reported that crop production situation in Caring Char may be better than Noler Char. Their major problems are lack of drinking water, communication and shelter from cyclone.

Table 2.8.1 : Land types of the Gross Area (ha) in Caring Char

Land Type	Present Condition			Remarks
	Flooding depth (cm)	Area (ha)	(%)	
Fo (High Land	0-30	2740	40	Infrastructures, etc.
F1 (Medium High Land)	30-90	1944	28.4	
F2 (Medium Low Land)	90-180	1870	27.3	
F3 (Low Land)	> 180	298	4.3	Khals, etc.
Total	-	6852	100	

Source : Group Discussion

Table 2.8.2 Present Land use for Crop Production in Caring Char

Sl. No.	Name of the Char	Total Area (ha)	Area under Settlement, Water bodies, Infrastructure, Forest, etc. (ha), (%)	Grazing Land (ha) and (%)	Net Cultivated Area (ha) and %	Single Crop Area (ha) and %	Double Crop Area (ha) and %	Tripple Crop Area (ha) and %
1	2	3	4	5	6	7	8	9
	Caring Char	6852	1269 (18.5%) Forest 584 ha (8.6%)	3795 (55.4%)	1788 (26.1%)	983.4 55	536 30	89.4 5

Source : Topo Survey and Group Discussion.

Table 2.8.3 : Present Cropping Pattern and Intensity in Caring Char

Cropping Pattern	Net Cultivated Area (NCA) and %	Cropped Area (ha)	Cropping Intensity
Single Crop			
Fallow–Fallow -T. Aman 0 - 0 - 55	983.4 (55%)	983.4	55
Double Crop			
Fallow-Aus-T. Aman 0 - 5 - 5 Rabi - Fallow – T. Aman 25 - 0 - 25	89.4 (5%) 447 (25%)	1073	60
Tripple Crop			
Rabi-Aus-T. Aman 5 - 5 - 5	89.4 (5%)	268.2	15
30 - 10 - 90	1609 (90%)	2324.4	130

Source : Study Calculation

Table 2.8.4 : Present Area (ha) and Yield(t/ha) of different Crops in Caring Char.

Crops	Present		
	Crops Name	Area (ha)	Yield (T/ha)
Rice	Aus Local (8%)	143	1.3
	Aus (HYV) (2%)	36	2.5
	T. Aman Local (87%)	1555	1.8
	T. Aman HYV (3%)	54	3.0
	Rice Total:	1788	-
Pulses	Khesari (40%)	214	1.0
Oil Seeds	Ground Nut (5%)	27	1.5
	Mustard (5%)	27	0.8
	Linseed (5%)	27	0.7
Spices	Chillies (20%)	107	0.8
	Onion (8%)	43	0.8
	Garlic (7%)	37	0.7
Tubers	S. Potato (10%)	53	8.0
Total :			

Source : Study Calculation and Group Discussion, NCA = 1788 ha, CI = 130%, Rabi Crop = 536 ha.

2.9 Livestock

Caring Char is a new emerging char in the Meghna estuarine area in southern Noakhali. As the soil is yet to be very suitable for field crop production the inhabitants use the fallow grazing land as good opportunity for livestock production. In a country where more land is going under plough and other non agricultural purposes the open grazing field that exists in the Char is unique situation for cattle raising. The inhabitants have adapted with the soil condition and pasture facilities and foraging in the forests. The area is sparsely populated but, livestock raising, mainly, Indian water buffalo and local 'deshi' cattle is the main occupation of the herdsmen. The exact livestock population and their production parameters are not known.

The preliminary findings indicate that the large farmer in the main land hire the herdsmen and put them in the new chars along with herds for cattle raising. As the land become more suitable for crop production it goes under agriculture.

There is no reliable data on the livestock population, per capita availability and their contribution to household economy. Study on livestock may be taken up when the development plan will be taken up for Caring Char. Information on livestock that is

available with the Hatiya Thana Livestock Office and Noakhali District Livestock Office is not enough to contribute to make a comprehensive livestock plan. The private sector also appears to be non-existent.

With organized project interventions in future the Caring Char can also be developed in livestock resources.

CHAPTER – 3: ENGINEERING SURVEY

Engineering Surveys include Bench Mark Survey, Topographical Survey and Khal Survey.

3.1 Bench Mark Survey

Bench Mark (BM) values have been carried to the permanent objects (Tube-well platforms) within the project area from the nearest available permanent Bench Mark (PWD).

One permanent BM has been set up by CDSP/BWDB at the Bashkhali sluice site in Polder Char Majid having a value of 5.479 (mPWD). BM and TBM values of the study area are presented in Map (Fig. G 2.1.1 in Enclosure-1, Annexure).

3. 2 Topographical Survey

BM set up by CDSP at the Bashkhali sluice in Char Majid Polder were connected by GPS measurement, with an accuracy below 5-10 cm per 100 km (both horizontally and vertically) to get the horizontal co-ordinates for accurate positioning in the study area and are used as control points for carrying survey for producing correct topographical maps of Caring Char.

Existing features such as rivers/khals, ponds, houses, forest areas, bazaars, tube-wells etc. have been taken by offset method.

500m X 500m size grid surveys have been carried out in Caring Char. In forest area where sights were obstructed grids could not be maintained. Land levels related to PWD levels at each grid have been taken. Topographical map of Caring Char is presented in Fig. C 3.2 (Annexure, Enclosure-1). Area determined from the Map is 6852 ha.

3. 3 Khal Survey

Longitudinal and cross-section surveys were conducted for existing drainage channels/khals.

For longitudinal profile, the spot levels of the existing channel beds and banks have been taken at 500m interval in the case of main channel and 100m intervals in the case of branch or small channels. The survey started from the outfall of the channel proceeding towards upstream.

The cross-section of existing channels has been taken at 500m and 100m intervals or closer depending on ground conditions in the main and branch channels. All cross-sections were made perpendicular to the longitudinal alignment of the channel at point of survey. The khals surveyed are given in Table 3.3.

Table 3. 3 : List of khals Surveyed

Sl. No.	Name of drainage channels (Khals)	Length (km)
1	Boater khal	4+000 km
2	Dakatia khal	1+800 km
3	Khal-1	2+500 km
4	Khal-2	4+650 km
5	Khal-3	2+000 km
6	Khal-4	2+750 km
7	Khal-6	3+500 km

Presentation of Survey Data

Field survey data have been processed by using the computer packages. The survey data have been presented as below:

- Existing channels and khals, profiles of bed along with design bed were drawn.
- The profiles also show the locations of all the existing roads, khals and structures with the individual chainages in km.
- Cross-sections were plotted to the scales of 1:200 vertically and 1:500 horizontally.

Survey results are presented in Enclosure-1, Annexure.

CHAPTER 4 : PRELIMINARY DEVELOPMENT PLAN

4.1 General

The preliminary development plan of Caring Char will discuss the issues related to accretion process, present land formation stage, emplolering land level, time frame to conduct feasibility study for development plan and possible immediate actions.

4.2 Accretion Process

Caring Char is a developing char, developing both in area and in land elevation due to the sedimentation process in the Hatiya Channel of Meghna estuary. Sedimentation rate adjacent to the extended southern main land char areas of Noakhali has been very high due to the impacts of X-Dams No. 1 & 2 constructed in 1957 & 1964 and the high rate of sedimentation still continuing.

Sedimentation rate is higher because depth averaged sediment concentration is 1.30-2.20 gm/l. (Ref. P-29) Fig. 14 (31). Rate of sedimentation is directly related to sediment concentration and inversely with local flow/field. With the higher sediment concentration and lower flow velocity nearer to the flatly sloping accreting shore of the Hatiya channel comparatively heavier sedimentation takes place in the area. The rate is faster below the level of MLW and then continues at a diminishing scale of rate to reach higher levels taking more time span. In this process the char area is getting enlarged south-east ward with gradual increase of land level.

4.3 Land Formation Stage

As stated, land formation of Caring Char is continuing and will take time to reach at a maturing stage of development. From topographic survey it is seen that the present char area is about 6852 ha and land level varies between 4.426m to 1.502 m (PWD) with more than 50% below 3.00m (PWD) land level.

From the recent satellite image superimposed with previous shore lines (1996-2005) it is seen that the char has increased in width by about 5.00 km, i.e. shore line increased on an average by about 0.56 km/yr. But at what rate the land level has developed is difficult to assess. The siltation process itself follows a logarithmic scale

over time; as land elevation rises due to the continuous siltation, the frequency (or duration) of the inundation reduces and the siltation process slows down. Furthermore, sedimentation depend on the depth of the silt laden water layer over the deposit area. With the land elevation rising, the volume of sediment also reduces, again slowing down the sediment action process. At present no land level or bathymetry monitoring data in and around the area is available from which an assessment can be made for the rate of increase of land level. However, discussion with the knowledgeable local persons give that "Leski" area i.e. submergible char area increase in land level by about 3" to 4" an year on an average. In absence of any bathymetric monitoring data of the study area, the land level monitoring data of Muhuri Accreted Area may be referred to. Feasibility Study of Muhuri Accreted Area Final Report, Table 2.3, P 2-6, (Main Report) (15) gives that after initial year of construction (1985 -86) of the closure land level at location D rose from 1.85m to 3.00m (SOB) and between 1989 to 1990 from 4.15m to 4.60m (SOB) i.e. .45m in one year. The report also stated that for 9 years (1990-1999) on an average the rate of land level increase of the Muhuri Accreted Area was 4 cm per year.

4.4 Empoldering Land Level

Empoldering land level is a critical issue for polder development. The average land level at which empoldering against peripheral inundating water for an accreted char area can be done depends on number of factors such as drainage environment, sedimentation rate, empoldering effects, socio-economic factors etc. Land elevations of the major area of Char Nangulia varies between elevation 3.00m to 4.50 mPWD, average about 3.70m, and of Noler Char between 2.50m to 4.00 mPWD, average about 3.00 mPWD.

Present land level of Caring Char varies from 1.502m to 4.426m with majority area between 2.00m to 4.00 mPWD. These show that empoldering of the Char should be awaited till its land level improves. However, comparing to Noler Char level Caring Char may be considered to have reached near-empolderable land levels. But as the area is larger and newer, average land level needs to be developed further for better drainage environment . It is suggested to monitor yearly rise of land levels and Feasibility study for preparation of development plan might be delayed by 5 to 7 years to have better empolderable land levels.

4.5 Possible Immediate Works and Costs

For the existing and present population some immediate actions in the form of providing water supply, sanitation, roads and also multipurpose cyclone shelters need to be provided. The facilities and estimated costs are given in the Tables C 4.5a and C 4.5.b.

Table C 4.5a : Details of Internal Intervention of Caring Char

Sl. No.	Infrasturcture	Length /No.	Unit
1.0	Rural Roads (Type R-2)	10.00	km
2.0	4.1 Multipurpose Cyclone Shelter	2	Each
3.0	Community Ponds	5	Each
4.0	Deep Tube-well	38	Each
5.0	Latrines	586	Each
6.0	Social Afforestation	Item	LS

Table C 4.5b : Cost Estimate of Internal Intervention of Caring Char

Sl. No.	Project Infrastructure	Length/ No	Unit	Rate (Tk)	Amount as per schedule of 2006-07 (Tk. '000)	Expected escalated amount for the year 2009 (Tk. '000)
1.0	Rural Roads (Type R-2)	10.00	Km	4,90,000	4900	6522
2.0	Multipurpose Cyclone Shelter	2	Nos.	64,66,000	12,932	17,212
3.0	Community Pond	5	Each	3,00,000	1,500	1,997
4.0	DTW	38	Each	60,000	2,280	3,035
5.0	Latrine	586	Each	2,000	1172	1,560
6.0	Social Afforestation	Item		LS	100	133
				Total :	**22,884**	**30,459**

Adding 10% physical contingency total cost in base year comes as Tk. 25.172 million and escalated cost in 2009 comes as Tk. 33.505 million.

Yearly O & M Costs based on 2009 cost is given in Table C 4.5c

Table C 4.5c : Yearly O & M Cost Estimate of Internal Inventions of Caring Char

Sl. No.	Item of works	Quantity	Unit	Item Cost at 2009 year	Yearly O & M	
					% on 2009 cost	Estimated Cost (Tk. '000)
1.0	Rural Roads (Type R-2)	10	Km	6,522	2	130
2.0	Multipurpose Cyclone Shelter	2	No.	17,212	2	344
3.0	Community Pond	5	No.	1,997	2	40
4.0	DTW	38	No.	3,035	2	61
5.0	Latrine	586	No.	1,560	2	31
6.0	Social Afforestation	Item	LS	133	2	3
			Total:	30,459		609

CHAPTER - 5 : FUTURE DEVELOPMENT

Caring Char needs to be empoldered in future for CDSP type development and to protect agriculture from mainly saline inundation/flood and soil salinity for optimum crop production.

Future Agriculture (Crop Production)

The future agriculture will depend on the solution of problem of saline inundation/flood and soil salinity and on the policy of distribution of lands for different components such as crop production, forestry, fishery and livestock. Caring Char is newly settled, the population is low, only 533 households and net cultivated area is only 26.3%. (Table 2.8.2). In future 50% of the lands should be allotted to agriculture (crop production, 25% for the protective forest belt and the rests for fishery and livestock. At present, there is no plan of embankment to protect the area from salinity but with some support services the cropping intensity and yield can be increased by at-least 25%.

Table 3.8 Cost estimate of internal infrastructure of Caring Char

Sl. No.	Item of works	Quantity	Unit	Item Cost at 2009 year (Tk. '000)	Yearly O & M	
					% on 2009 cost	Estimated Cost (Tk. '000)
1.0	Rural Roads (Type R-2)	10	Km	6,522	2	130
2.0	Multipurpose Cyclone Shelter	7	No.	60,248	2	1,208
3.0	Community Pond	5	No.	1,997	2	40
4.0	DTW	230	No.	18,368	2	367
5.0	Latrine	586	No.	1,560	2	31
			Total:	88,695		1,776

The total investment costs for internal infrastructure other than BWDB for all three chars combined amount to Taka 57,44,54,000 (Taka 574.6 million) with annual O&M costs of Taka 1,12,96,000 (Taka 11.3 million).

- The estimated amounts of internal infrastructures have been checked with the cost of ongoing CDSP-III related structures and found justified considering required cost escalation.

C/C 18/3/09
PD, CDSP-III
BWDB, Dhaka

for TL, CDSP-III
12.03.09
QCE, CDSP-III

Recommendation of "Report Review Committee" on the Final Report of Feasibility Study on the Development and Settlement of new Chars; Char Nangulia, Noler char and Caring char, November 2008 for approval of the Board.

1. Background Information

1.1 Bangladesh Water Development Board (BWDB), by an Office order (Memo No-35/WDB (Sec)/Planning-1/Misc-3/2002 dated 03-07-2006; copy enclosed, **Annex-A**), formed a committee headed by the Chief Engineer, Design, BWDB, Dhaka to review and recommend about the Study Reports prepared by Consultants. The Terms of Reference (ToR) of the Committee may be seen in **Annex-A**.

1.2 Final Report was forwarded to the member-secretary of the committee by Chief Planning, BWDB, Dhaka vide U.O.no. 1025 dated 24 November 2008.

1.3 The report was prepared by Euroconsult Mott MacDonald, Dhaka.

1.4 Project Director, CDSP-III, BWDB, Dhaka under administrative control of ADG (Planning), BWDB, Dhaka represented the Board (the client) for conducting the study.

1.5 The Draft Final Report was discussed in a workshop on 14 January 2008, held at the BWDB conference room, Dhaka.

2. Activities of the Committee

2.1 The member-secretary received the Report on 26 November 2008.

2.2 (a) The member-secretary of the committee, being requested by the convener of the committee, communicated vide memo no. 1c-5/2006 (part-2)/366 dated 14 December 2008 the notice of meeting of the committee to discuss the report on 23 December 2008.

(b) Accordingly, the committee met on 23 December 2008 in the office room of the Chief Engineer, Design, BWDB, Dhaka & concerned Project Director, Executive Engineer from the field division were present in the meeting.

3. Observations of the Committee

3.1 The Committee observed that the comments, suggestions & recommendations made by the participants on the Draft Final Report of Feasibility Study on the Development and Settlement of new Chars; Char Nangulia, Noler char and Caring char, November 2008 in the meeting of 14 January 2008 have been properly addressed by the Consultants & concerned officials and incorporated in the final version of the Report.

3.2 The Committee discussed the report in the meeting (held on 23 December 2008) and the observation is presented in Annex-B.

4. Recommendations:

4.1 The Committee as per ToR opines that:

- প্রকল্পের মূল উদ্দেশ্যের সাথে সামঞ্জস্যতা ঃ The Final Report is consistent with the Objectives of the study (which is presented in the report).
- প্রদত্ত সুপারিশসমূহের বাস্তব ভিত্তি সমন্ধে ঃ The recommendations made in the study are realistic and implementable in the field.
- সমীক্ষা প্রতিবেদনের গুণগত মান প্রসঙ্গে ঃ The quality of the report is acceptable.

4.2 Under the above circumstances the Committee is recommending to accept the Final Report.

23/12/08

(Md. Fazlur Rahman)
Director, Planning-II
BWDB, Dhaka.
(Member-Secretary of the Committee).

23/12/08

(Md. Naushad Ali)
Chief Engineer, Design
BWDB, Dhaka.
(Convenor of the Committee).

বোর্ড সচিবালয়
ওয়াপদা ভবন (৩য় তলা)
মতিঝিল বাণিজ্যিক এলাকা,
ঢাকা-১০০০।

[illegible]
[illegible]-১৩৩ (অফিস)

Annex-A

একই স্মারক নং ও তারিখে প্রতিস্থাপিত

স্মারক নং-৩৫/পাউবো (সচি)/পরি-১/বিবিধ-৩/[illegible]

তারিখঃ ০৩-০৭-২০০৬ ইং

দপ্তরাদেশ

পরিকল্পনা-১ পরিদপ্তরাধীন [illegible] বিদেশী ও দেশীয় পরামর্শক প্রতিষ্ঠান, ইনডিভিজুয়াল পরামর্শক, আই ডাব্লিউ এম এবং সি ই জি আই এস কর্তৃক সম্পাদিত সমীক্ষা কাজ সমূহের চূড়ান্ত প্রতিবেদন অনুমোদনকল্পে [illegible] সমন্বয়ে একটি কমিটি গঠন করা হইলঃ-

১। প্রধান প্রকৌশলী, নকশা, বাপাউবো, ঢাকা। : আহ্বায়ক
২। পরিচালক, পরিকল্পনা-২ পরিদপ্তর, বাপাউবো, ঢাকা। : সদস্য-সচিব
৩। প্রকল্প এলাকার সংশ্লিষ্ট নির্বাহী প্রকৌশলী, বাপাউবো : সদস্য

কমিটির কার্যপরিধিঃ

ক) সমীক্ষা প্রতিবেদনের [illegible] সুপারিশ সমূহ বাস্তব সম্মত ও প্রকল্পের মূল উদ্দেশ্যের [illegible] সে ব্যাপারে স্পষ্ট মতামত প্রদান।
খ) সমীক্ষার চূড়ান্ত প্রতিবেদন [illegible] পরীক্ষা ও নিরীক্ষা পূর্বক সর্বোচ্চ ৭(সাত) দিনের ভিতর বোর্ডের অনুমোদনের জন্য সুপারিশ প্রদান।
গ) বিবিধ।

বোর্ডের আদেশক্রমে

(স্বাক্ষরিত)
৩.৭.০৬

(সামসুননেহা)
সচিব, বাপাউবো
ঢাকা।

স্মারক নং-৩৫/১(৮) পাউবো (সচি)/পরি-১/বিবিধ-৩/[illegible]

তারিখঃ ০৩-০৭-২০০৬ ইং

অবগতি ও প্রয়োজনীয় ব্যবস্থা গ্রহণের জন্য অনুলিপি প্রেরণ করা হইল।

১) প্রধান পরিকল্পনা, বাপাউবো, ঢাকা।
২) প্রধান প্রকৌশলী, নকশা, বাপাউবো, ঢাকা।
৩) প্রধান প্রকৌশলী, বাপাউবো [illegible]
৪) তত্ত্বাবধায়ক প্রকৌশলী, বাপাউবো [illegible]
৫) পরিচালক, পরিকল্পনা-১, বাপাউবো, ঢাকা।
৬) পরিচালক, পরিকল্পনা-২, বাপাউবো, ঢাকা।
৭) সি এস ও টু মহাপরিচালক, বাপাউবো, ঢাকা।
৮) পি এ টু অতিরিক্ত মহাপরিচালক-পরিকল্পনা, পওম-১, পওম-২, বাপাউবো, ঢাকা।

(স্বাক্ষরিত)

(এ টি এম আবদুল বারী)
উপ-সচিব (পরিকল্পনা)
বাপাউবো, ঢাকা।

Annex-B

Feasibility Study on the Development and Settlement of new Chars; Char Nangulia, Noler char & Caring char: Final Report November 2008, done by Euroconsult Mott MacDonald, Dhaka

Compliance Report on the Objectives of the Study

Sl. No.	Objectives (as required in the ToR)	Compliance (as reported in the Report)
A.	**Comprehensive development plan for Nangulia Char & Noler Char**	
	1. Establishing baseline conditions	
	► **Water management & Land suitability :**	
	➢ Basic topographic map of present situation	Chapter-1, Fig-1.1, Page- 4
	➢ Basic drainage map of present situation	Chapter-2, Fig-2.1, Page- 8
	➢ Map of present salinity situation	Page-75
	➢ Flood map	Page-74
	➢ Identify bottlenecks & develop interventions	
	• Design of optimal internal drainage system to avoid bottlenecks	Chapter-2, Article-2.4.3, Page-14
	• Embankment heights	Chapter-2, Article- 2.4.2, Page-13
	➢ Drainage, salinity & flood maps with interventions	Chapter-3, Fig-3.1, Page-18
	➢ Land suitability map	Page-75
	►Population and settlements :	
	➢ Household Census	Chapter- 1, Article-1.4.2, Page-5
	➢ Occupation	Chapter- 1, Article- 1.4.3, Page-5
	➢ Migration Pattern	Chapter- 1, Article-1.4.5, Page-6
	➢ Income	Chapter- 1, Article- 1.4.6, Page-6

	➢ Food situation ➢ Land titles ➢ Tenancy ➢ Existing level of services ➢ Desired level of services	Chapter- 1, Article- 1.4.6, Page-6 Chapter- 4, Article-4.4, Page-27 Chapter- 4, Article-4.4, Page-27 Chapter- 3, Article- 3.2, Page-17 Chapter- 3, Article-3.3, Page-17
	►Land allocation : ➢ GOB policy on land distribution & existing claims on land	Chapter- 4, Article- 4.3, Page-26
	►Agriculture and livestock : ➢ Existing cropping pattern and yields ➢ Existing livestock situation ➢ Analyze agricultural practices ➢ Identify main bottlenecks	Chapter-5, Article- 5.3.2, Page-31 Chapter- 5, Article-5.5.1, Page-34 Chapter- 5, Article- 5.3.3, Page-32 Chapter- 5, Article- 5.3.4-5.3.5, Page-32
	► Aquaculture and Fisheries : ➢ Map of existing actual activities with special focus on regional aquaculture ➢ Identify possibilities for small scale aquaculture ➢ Identify constraints for small scale aquaculture	Chapter- 6, Figure-6.1, Page-39 Chapter- 6, Article- 6.3.1, Page-40 Chapter- 6, Article-6.2.4, Page-40
	2. Identification of possible interventions	Chapter-3, Article- 3.3, Page-17
	3. Analysis of costs & impacts of interventions ➢ Costs and benefits of proposed interventions ➢ Costs and benefits of proposed land settlement ➢ Costs and benefits of agriculture and livestock development ➢ Costs and benefits of aquaculture and fisheries development ➢ Costs and benefits of forestry development ➢ Costs and benefits of institutional development ➢ Social impacts ➢ Environmental impacts	Chapter-3, Article- 3.4, Page-21 Chapter-4, Article- 4.5, Page-28 Chapter-5, Article- 5.7, Page-37 Chapter-6, Article- 6.4, Page-43 Chapter-7, Article- 7.5, Page-48 Chapter-8, Article- 8.5, Page-55 Chapter-9 , Article-9.3, Page-59 Chapter-9 , Article-9.4, Page-60

	4. Formulating the development plan, setting priorities & timetables & making an overall assessment of the impacts (feasibility study)	
	➢ Land distribution plan	Chapter- 4, Article- 4.4, Page-27
	➢ Development plan for infrastructures	Chapter-3, Article- 3.3.2, Page-21
	➢ Development plan for agriculture and livestock	Chapter-5, Article- 5.4.1 & 5.6, Page-33 & 36
	➢ Development plan for aquaculture & fisheries	Chapter-6, Article-6.3, Page-40
	➢ Plan for social forestry on roads, embankments etc.	Chapter-7, Article-7.4.1, Page- 47
	➢ Development plans and management system for shore and social mangrove forestry for applying public participation and process	Chapter-7, Article-7.4.1 & 7..4.2, Page-47 & 48
	➢ Support the delineation of administrative bodies and their involvement in the implementation of the development plan	Chapter- 8, Article- 8.2.2, Page-51
	➢ Plan for involvement of NGO's/LGI's	Chapter- 8, Article- 8.3, Page-53 & Page-76
	➢ Outline of sustainable structure of local committees for land and water management	Chapter- 8, Article- 8.4, Page-53 & Page-76
	➢ Overall costs and impacts	Chapter-9, Article- 9.1, Page-56
	➢ Priorities and timetables	Page-78
B.	Preliminary development plan for Caring Char	
	1.Topography & Water management :	
	➢ Basic topographic map of present situation	Chapter-1, Fig-1.1, Page- 4 ,
	➢ Basic drainage map of present situation	Chapter-2, Fig-2.1, Page- 8
	➢ Map of present salinity situation	Page-75
	➢ Flood map	Page-74. Data are shown in article 5.2.1 (page-29)
	➢ Assessment of accretion rate	Page-79
	2. Further reconnaissance on living conditions	Chapter-5, Article- 5.3.3, Page-32 Chapter-6, Article- 6.2.3, Page-40 Chapter-7, Article- 7.2, Page-46

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	3. Forestry : ➢ Development of plan for establishment and management of a forestry	Chapter- 7, Article- 7.5.1, Page-49
	4. Interventions : ➢ Identify and plan for immediate interventions	Chapter-3, Article- 3.3.2, Table-3.5, Page-21
	5. Environmental impacts	Chapter-9, Article-9.4, Page-60
	6. Social impacts	Chapter-9, Article-9.3, Page-59
C.	**External drainage situation :** ➢ Identify all possible interventions ➢ Make a screening and selection of most promising ones ➢ Further analyze the selected promising solutions ➢ Make a comparison between these promising solutions in support of decision making by the BWDB	Chapter-2, Article-2.3.2, Page-11 & Page-80 Chapter-2, Article-2.3.3, Page-11 & Page-80 Chapter-2, Article-2.3.3, Page-11 & Page-80 Chapter-2, Article-2.3.3, Page-11 & Page-80

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G M Shamsur Rahman
Project Director
CDSP-III
BWDB, Dhaka.

Sediment Management Plan for Hoar Khal and Caring Khal

Sedimentation is likely to occur at the outfall of the Haor Khal and Caring khal during the period from late September to June. The following measures will be followed after implementation of the project.

(i) Initially the depth of sedimentation would not be significant, which can be in the range of 30 to 50 cm. An operation rule for operation of the gate will be followed to generate eroding velocity at the downstream stretch of the Hoar Khal and Caring Khal. In the beginning of October only two gates/one gate of each regulator will remain open instead of all the gates of the regulators to obtain sufficient head difference of water between upstream and downstream. Eventually the stream power will be higher to transport the incoming sediment load further downstream from the outfall of the Khals. Even, if any sedimentation occurs that would be very less. This mechanism of sediment management would be effective from October to November. However, it will reduce the depth of sediment deposition.

(ii) A monitoring system would be followed to find the sedimentation rate and its exact location by cross section survey with 500m spacing in the Haor Khal and Caring Khal. A lead channel having the capacity of 2m X 1.5m would be developed at the silted reach based on monitoring results before the onset of monsoon. At the onset of monsoon the remaining loose/unconsolidated sediment deposition will be removed and required drainage condition would be developed due to huge onrush of fresh water.

01-3-09

Team Leader-Acting
Char Development & Settlement Project
Dhaka.

PART – D
EXTERNAL DRAINAGE SYSTEM STUDY

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EXTERNAL DRAINAGE SYSTEM STUDY

CHAPTER-1: INTRODUCTION

1.1 General

Meghna Estuary and its tidal channels are Morphologically very dynamic. The knowledge about the physical processes and morpho-dynamic behaviour of the lower Meghna Estuary system specially related to Hatiya River and around is still fairly limited. A complicated interplay between the forces of the river, tide and the waves create a complex pattern of sediment displacement in the estuary. Large quantities of sediment are transferred continuously towards the shallow coastal region. Since almost no sediment is exchanged with the deeper part of Bay of Bengal, the overall sediment budget is determined by the process of continuous redistribution of sediment in the river system upstream. The displacement of sediment is a part of a continuous process of the estuarine-landscape striving to achieve dynamic equilibrium between the physical shape (morphology), and the continuously changing river discharge conditions and tidal flows.

Land accretion rates in southern Noakhali has become high after construction of cross dams No. 1 and 2 in fifties and sixties and as a result of which main land in South Noakhali has been extending gradually southward. This phenomenon lengthened the path of drainage of the Hatiya River with outfall to Meghna River. Hatiya River is the main drainage artery of the study area, draining, in addition to some upland area, CDSP completed polders like Char Baggardona I(LRP) and II, Char Moradona and Char Majid, under construction Polder Boyer Char, unembanked area on south of Char Majid and the present study Chars – Char Nangulia, Noler Char and Part of Caring Char.

Drainage diversion plans have been prepared with construction of two planned cross dams on Baggar Dona/Hatiya River for drainage of completed polders with shorter drainage paths towards west to Meghna River (Feasibility Study on the Development of the Catchment area of the Baggardona River, 2001). Under the situation, this External Drainage system Study has been taken up as a part of Support of the Feasibility Study on the Development of New Chars in the Vicinity of

Boyer Char. The Study area falls in Subarno Char and Hatiya Upazilas of Noakhali District.

1.2 Objectives

The objectives of the study are to :

- study the future condition of Hatiya River as the main drainage artery of the area (completed polders and new polders proposed to be undertaken) along with the future of Mamur khal and Caring khal.
- Comment on the 2nd Cross dam Options on locations.

1.3 Scope of Works

The aim of the study is to:

- Generating information and arrive at a solution to create adequate drainage conditions for the drainage units (existing and proposed polders) at minimum investment and maintenance cost.
- Assess the complications stem out from the uncertainties in the trend of morphological changes in Mamur khal and Caring khal.
- Development of alternative solutions to shift the 2nd Cross dam from Ferry Ghat to the alternative locations downstream of Hatiya River :
    - Just down stream of Char Majid outfall (outfall of Banshkhali khal)
    - Down stream of mouth of Mamur khal.
    - As far down stream as possible (near the outfall of Hatiya River to Lower Meghna River.

CHAPTER- 2: EXISTING SITUATION

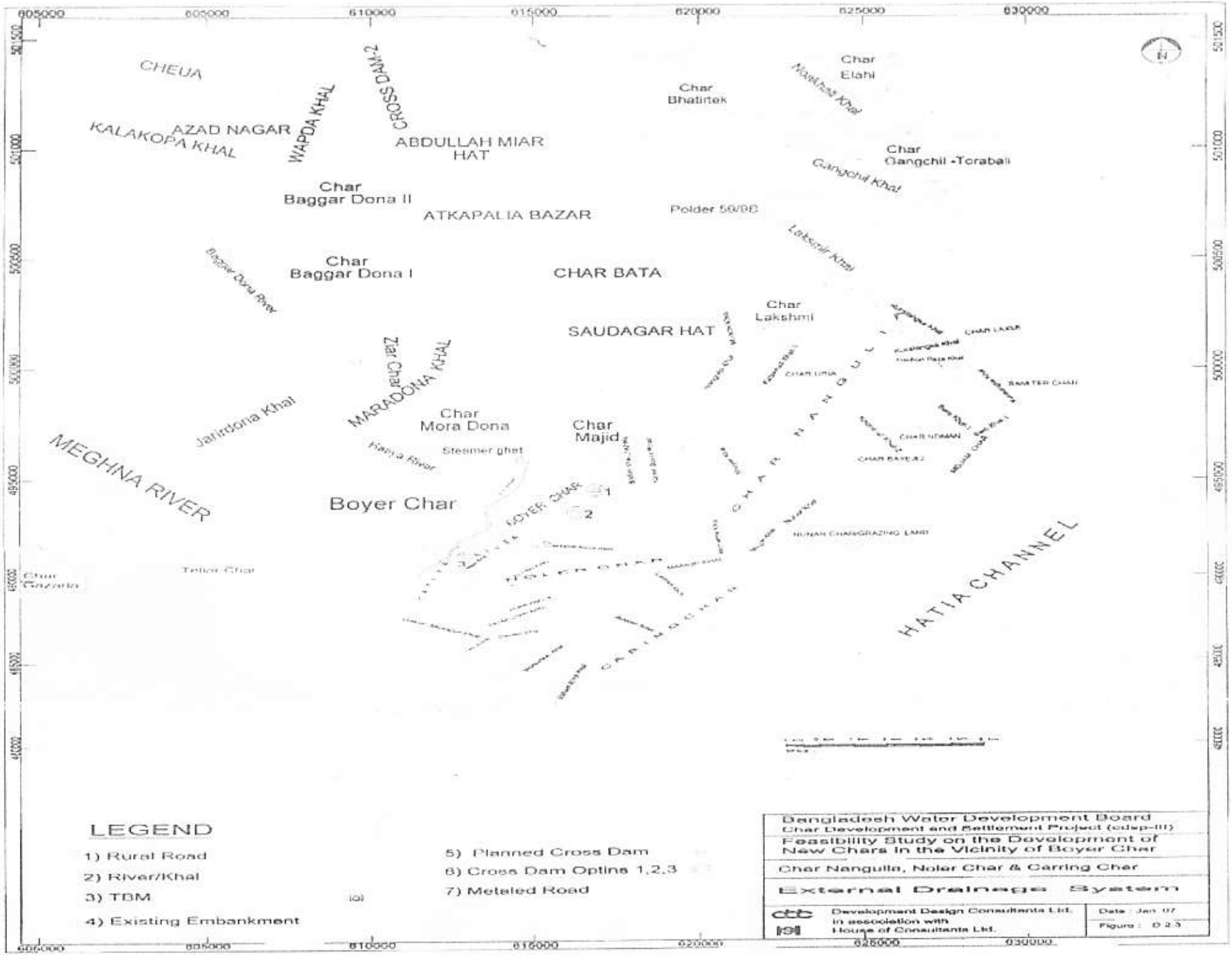
2.1 Drainage Area

Present drainage area of Baggardona/Hatiya River, the main drainage artery includes Char Baggardona I & II, some upland areas, Char Moradona, Char Majid, unembanked area south of Char Majid, part of Boyer Char, Char Nangulia, Noler Char and part of Caring Char. The Baggardona/Hatiya River drains an area of about 79,000 ha. It is about 42 km long in the north-south direction and 16-25 km in the east-west direction. The width is maximum in the middle of the river basin. The average land elevation of the river basin is about 3.8m (PWD). The maximum land of the areas falls within the elevation 3.5 to 4.25m (PWD). Average land elevation in Char Moradona is 3.5m (PWD), Boyer Char 3.25m (PWD), Char Nangulia 3.70 m(PWD) and Noler Char at is 3.0m (PWD). The feasibility study on the Development of the Catchment Area of Baggardona River, November-2001 has planned drainage of the upper areas and Baggardona I & II to be diverted to Meghna River through a shorter drainage path (Jarirdona khal) by the Ist cross dam on Baggardona River near CBD-1 and drainage of Char Moradona, Char Majid and part of Boyer Char to be diverted by a short cut channel through Boyer Char to Meghna River by a 2nd cross dam on Hatiya River at the present Ferry Ghat. The rest catchment area for drainage through Lower Hatiya River stands to be the combined areas of Char Nangulia with part of Char Laxshmi and Char Clarke, Noler Char and part of Caring Char and the unprotected area south of Char Majid.

2.2 Drainage Network

The major drainage network consists of Mamur khal, Caring khal and Hatiya River and finally the Lower Meghna as outfall channel. The general drainage pattern of Hatiya River System is towards south-west. The network of drainage channel of Hatiya River basin is presented in figure D.2.3.

The study area has one main drainage channel, the Baggar Dona/Hatiya river. The Baggar Dona/Hatiya river is a typical coastal river with its saline water intrusion and sedimentation problems up to the far interior of river system. Problem of drainage congestion is acute due to rapid morphological development, siltation of channel bed and lengthening of the flow paths. The Baggar Dona in upstream is


CHEUA
AZAD NAGAR
KALAKOPA KHAL
WAPDA KHAL
CROSS DAM-2
ABDULLAH MIAR HAT
Char Bhatirtek
Char Elahi
Char Gangchil -Torabali
Gangchil Khal
Char Baggar Dona II
ATKAPALIA BAZAR
Polder 59/60
Char Baggar Dona I
CHAR BATA
Char Lakshmi
SAUDAGAR HAT
MARADONA KHAL
Char Mora Dona
Char Majid
Jarirdona Khal
Steamer ghat
MEGHNA RIVER
Boyer Char
HATIA CHANNEL
Char Ganzaria
LEGEND
1) Rural Road
2) River/Khal
3) TBM
4) Existing Embankment
5) Planned Cross Dam
6) Cross Dam Optins 1,2,3
7) Metaled Road
Bangladesh Water Development Board
Char Development and Settlement Project (cdsp-III)
Feasibility Study on the Development of New Chars in the Vicinity of Boyer Char
Char Nangulia, Noler Char & Carring Cher
External Drainage Syatem
Development Design Consultants Ltd. in association with House of Consultants Ltd.
Date : Jan '07
Figure : D 2.3

called Bhulua river and downstream Hatiya river. The upper part of the Hatiya river from coufluence point of Ramgati khal is known as the Baggar Dona River. The project area drains ultimately towards the Lower Meghna river through Baggar Dona/Hatiya river. A network of khals originating from the upper part of the project area extends inside the existing CEP polder, 59/3B and drains towards the Baggar Dona-Hatiya river. The drainage problems are mainly caused by the accretion of the coastal mudflats lengthening the drainage path and silt deposition in the channels. A very little bank erosion has been observed along the outer bend of the river.

Hatiya river has 8 tributaries flowing south-east and crossing the embankment of CEP's polder 59/3B at different locations, of the prominent ones are Banshkhali, Batenkhali, Kawnia and Madadona, Maradona is the main drainage artery for Char Maradona.

Char Bata and Char Majid drain through the 8-vent Char Majid sluice in to the Baggardona/Hatiya river, 2 km east from the Ferry Ghat (Steamer Ghat). Some areas of Char Bata located at eastern side of Sonapur-Steamer Ghat road of RHD drain into the Baggar Dona/Hatiya river through a series of culverts on the road from Atkapalia to Bhuiyer hat.

Boyer Char is an Island situated on the western bank of Hatiya River. A system of creeks has developed on Boyer Char through which drainage water flows to the shore. Northern belt of Boyer Char drains into the Hatiya river through a series of small creeks developed in that part of island.

Noler Char, (including Char Rahman & Pater Char) and Caring Char are situated on the left bank of the Hatiya river, eastern side of Boyer Char.

Mamur khal is an important tidal channel receiving present upland drainage of mainly Char Nangulia, tidal water coming from Hatiya Channel and flowing to Hatiya river due to higher tidal range in eastern Hatiya-Sandwip : micro tidal range and contributing to out-flow of Hatiya river.

The Mamur and Caring khals are highly dynamic, comparatively shallow and unstable. Long section of Mamur khal, 13.7 km long, shows that the bed levels slope from east to west with RL between 1.025 mPWD and -2.359 mPWD with some elevated bed levels in the middle. Local information is that Mamur khal bed

level is getting higher year to year particularly on the eastern part with difficulty to navigation. Caring khal, 9.12 km long, off-taking from Mamur khal slopes from north to south-west with bed level between 1.356 m and -2.630 mPWD. Width of Mamur khal at outfall to Hatiya River (Ch. 0+000 km) is about 160m with lowest bed level -2.33 mPWD, at Ch. 9+000 km is about 200m having lowest bed level 1.219 mPWD and at Ch. 13+000 km is 260m with lowest bed level 1.199 mPWD. Caring khal widths are about 280m at outfall to Hatiya River (Ch. 0+000 km) lowest bed level -2.630 mPWD. At Ch. 5+000 km the widths is about 140m lowest bed level - 1.041 mPWD and at 9+000 km about 110 m with lowest bed level 1.353 mPWD. Widths of Hatiya River at Steamer Ghat is about 120m with lowest bed level -2.498 mPWD. At the D/S of Mamur khal outfall (Ch. 7+750 km) width is about at 250 m with lowest bed level -2.020 mPWD, and at Azim Ghat (Ch. 3+700 km) the width is about 325m with lowest bed level -2.022 mPWD and at outfall (Ch. 0+000) the width is about 650m with lowest bed level – 3.306 mPWD. Fig. D.2.2a/1-4 show cross section of Hatiya River, Fig. D 2.2b long section of Mamur khal, Fig. D 2.2b/1-3 cross section of Mamur khal, Fig. D.2.2c long section of Caring khal and Fig. D.2.2c/1-3 cross section of Caring khal are given in Enclosure-1 of Annexure Volume.

2.3 Hydro-morphology

2.3.1 Tide

The study found that the water level variation of the area is dominated by semi-diurnal tide with a marked seasonal variation of the mean water level. The south Bhola to north Hatiya fell in meso tidal area (tidal range 2-4m) while east Hatiya to Sandwip fell in macro tidal zone (tidal range >4m). In the coastal area variation of amplitude from spring to neap was observed. The seasonal variation of mean water level was observed to be around 0.8m (FAP 4, Final Report, Vol. 2, 1993).

2.3.2 Waves

Waves often have an important influence on the erosion and deposition processes. During the dry season the prevailing winds are calm and off land. The waves then generally are less than 0.5m with periods of 3 to 4 seconds. During the monsoon season wave heights of 2m with a period of about 6 seconds incidentally occurred or were exceeded. Generally wave heights then ranged approximately between 0.5m to 1m. Incidentally, higher waves occur during cyclones. Those, in

combination with a long storm surge wave under extreme conditions may be as high as about 5m. Such conditions are too incidental to be relevant from a morphological point of view.

2.3.3 Morphology

The hydro-morphological conditions in estuarine rivers and channels are highly dynamic as well as complex in nature. Deltas and estuaries are known as areas of net deposition of sediments either carried by rivers or supplied by sea. No sediment exchange with the deeper part of the Bay of Bengal takes place in reality. The Baggardona/Hatiya River is a typical coastal river in which tide causes rapid morphological changes. Accretion of mudflats is lengthening the drainage path. The lengthening of flow path retards the flow velocity. The cumulative effect of retardation of flow velocity as well as lengthening of flow path accelerates sedimentation.

The Baggar Dona/Hatiya River used to have a wide mouth at the outfall. The emergence of Boyer Char initially caused bifurcation of the outfall into eastern and western branches. The western branch known as Jarirdona has silted up at offtake and the eastern branch is falling in to the Meghna as Hatiya River.

Source of Sediment in the Estuary

The major sources of sediments in the estuary is silt carried by the sea water. The study area is situated in the Lower Meghna Estuary and is greatly influenced by the tidal flow. The tides moving up twice a day carry huge quantity of sediment from the sea and play important role in to-and-fro transport of sediment in the project area. The circulation patterns are highly affected by river and tidal dynamics, resulting in characteristic morphological changes.

The reversals in tide that produce bi-directional currents also produce patterns of bi-directional bed load and suspended load transport. Typical current speeds of 1 to 3 m/s of the estuary, are sufficient to keep sediments in motion for much of the tidal cycle, forcing channels to continuously adjust to erosion and deposition. Within the Lower Meghna Estuary, the river borne sediments become trapped by the tidal pumping and residual circulation and mix with material brought in from the sea. Sediment deposited on the shallow shelf just in front of the estuary during the

monsoon season, at least partly, may re-enter the estuary in the next dry season and may contribute to the growth of the delta.

Accretion and Land Formation

The coastal Areas of Noakhali can be termed as fluvio-tidal with a meso-tidal range between 2-4m based on the interaction between river discharges and tidal volume moving through the channels during pre-monsoon, monsoon and post-monsoon periods. Deltas and estuaries generally are known as areas of a net deposition of sediments either carried by the river or supplied from the sea. The growth of the delta and the accretion of land in the estuaries is a continuous and generally very gradual natural process interfered by the dynamics of the ever-changing courses of their channels.

When water and sediments enter the marsh, mostly or totally through the drainage creeks, the extended pathway necessary to pass the water dissipate the energy of the tidal currents and hence act as a mechanism for catching sediment.

New char land continuously emerged or was eroded as the Meghna shifted its main course. Gradually, however the Noakhali distributary branch of the Lower Meghna was abandoned in favour of the present Shahbazpur branch west of Ramgati. This was initiated and or followed by a rapid silting up to the old course. The inland silting up and reclamation of the old Meghna course was completed by the early seventies. The construction of the two cross dams (1959 and 1964) accelerated the ongoing accretion process considerably. FAP-5 reviewing the 1990 aerial photos observed tendency of accretion at the outfall of the Baggar Dona. A time series of geo-referenced satellite images from the period 1973 to 1998 were used by Meghna Estuary Study (MES) to examine and assess the erosion and accretion in the Meghna Estuary area. They also tried to assess the long-term changes in coastal morphology by comparing historic maps with current satellite imagery. The changes for the total period of study, 1973-74 to 1996, showed a vast area of new land off the Noakhali coast and Boyer Char that is associated with an even larger area of mud flat, which appears to be emerging land.

The coastal char land study (1999) observed that Boyer Char accreted very fast during the last 10-years(mid eighties – mid nineties), increasing in size and height. The land accretion process in the neighborhood area of Boyer Char (particularly Caring Char) is continuing without any sign of slowing down. The process is

largely a natural one, but the following human interferences have been of substantial influence:

- the construction of two cross dams; and
- construction of polders and other projects in the area.

Short-term Development

Understanding of the recent development of the study area is important for planning any interventions in such a dynamic environments. For this, analysis of satellite images of 1996, 2001, 2003 and 2005, Figure C 2.4/1and the result of the analysis of bathymetric surveys of MES were used.

During the period 1996-2001 size of Char Nangulia and Noler Char was constant, except the large increase of Caring Char (Figure D 2.3.3/1). Rate of growth was 420 ha/year. During the period 2001 to 2005, sizes of all three chars increased but with a different rate. Growth rate of Char Nangulia was 280 ha/year, that of Noler char was 110 ha/year and rate of Caring Char was very high about 400 ha/year.

Increasing of area of Char Nangulia and Noler Char was attributed to the sedimentation in the internal tidal channels (Figure D 2.3.3/2). Only Caring Char developed southward. It appears that Char Nangulia and Noler Char have reached a stable size, while the size of Caring Char has been increasing. An important phenomenon working here is that average sediment concentration is comparatively higher in Hatiya Channel (1.30-2.20 gm/l) and lower in Meghna River side (0.60-1.30 gm/l) as given in MES Study, P-29. Fig. 14, reproduced.

The bathymetric maps derived from the surveys carried out in 1997 and 2000 have been compared by MES Study Team. It reveals that Morphological change in Southern Noakhali is related to the migration of Hatiya channel. Extensive accretion is observed on the southern side (Noakhali Main land/ Boyer Char, Char Nangulia, Noler Char, Caring Char) reducing the depth of channel and forcing the main water flow towards the northern head of Hatiya. This results in the migration and deepening of the Hatiya channel and large scale-erosion of the head to the Island.

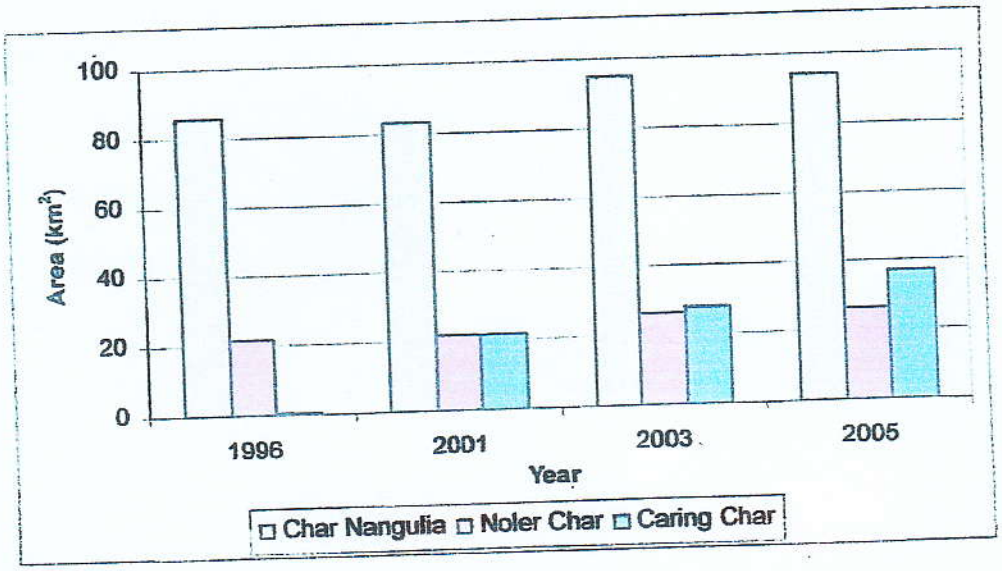


Figure D2.3.3/1: Changes in study area during the period 1996-2005

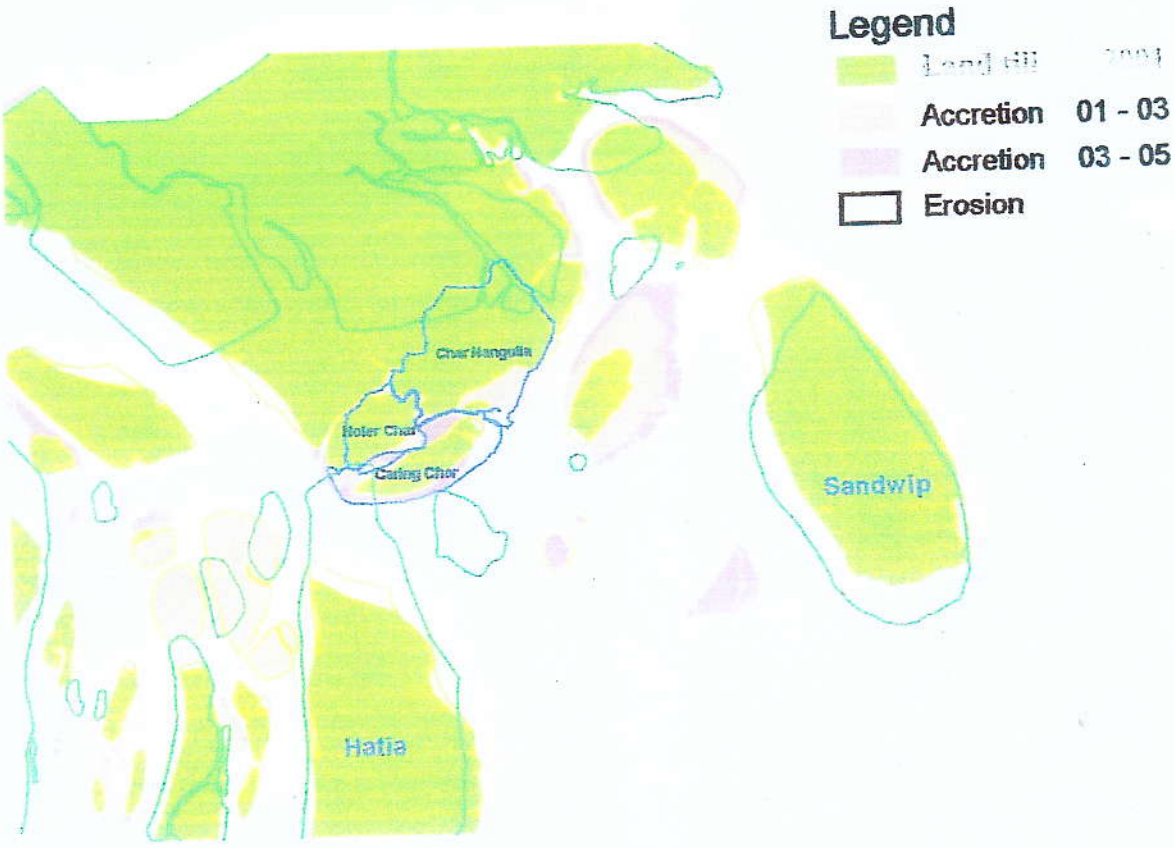


Figure D 2.3.3/2: Accretion and erosion pattern (1996-2005) in the study area

Figure 14: Spatial Variability of Average Sediment Concentration in the Meghna Estuary

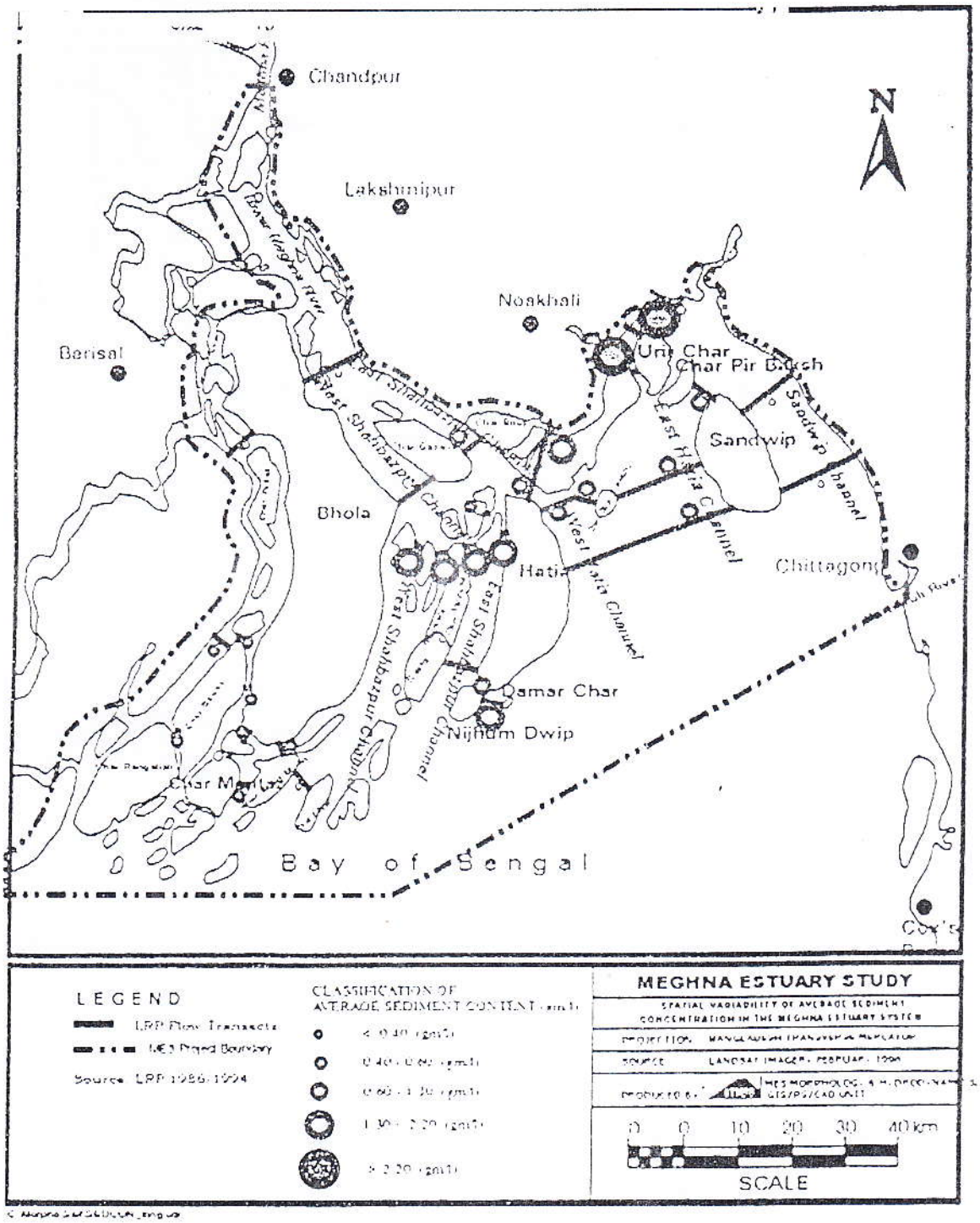
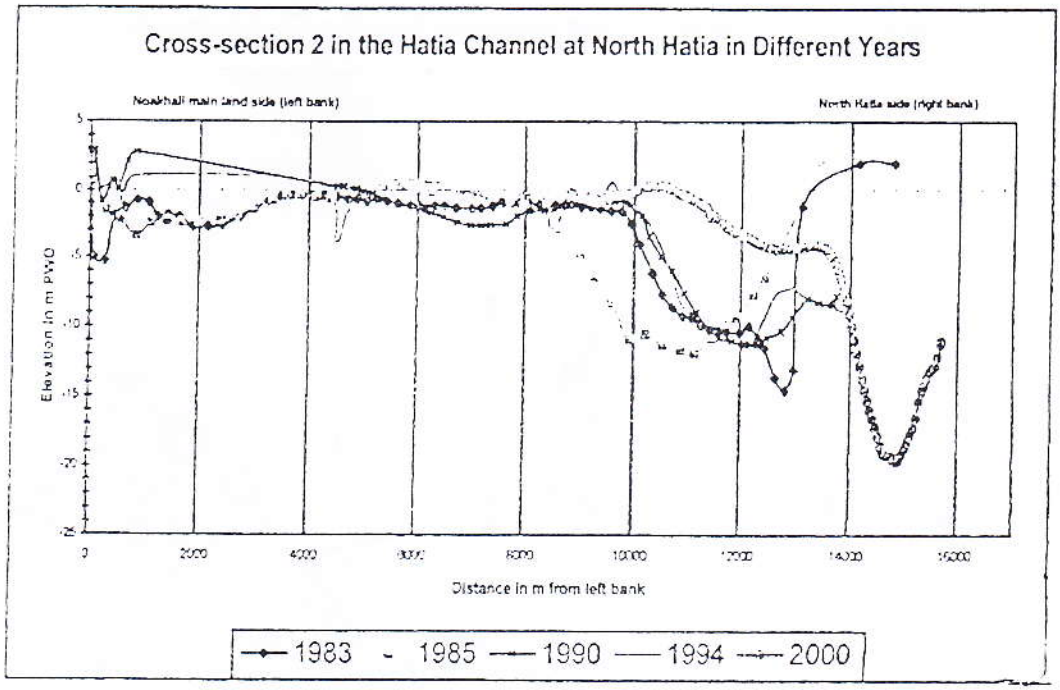


Figure 23: Long term changes in cross-section 2 between North Hatia and Noakhali



'The shape of cross-section 2(Fig. 23), page 45 of MES-II, 2001 in Hatiya channel at North Hatiya with Noakhali Mainland (reproduced below) has changed from 15 km width to 5 km width due to land forming on the Noakhali side. The main conveyance section of Hatiya channel becomes smaller and deeper.

2.3.4 Erosion

The Analysis carried out by MES in 1998 (DHV et. Al. 1998) estimated bank line erosion rate as 100m/year based on analysis of satellite images of 22 years (1974-1996). Near the Baggar Dona/Hatiya River outfall the bank line erosion is reported to be 60m/year. Observations suggest periods of severe erosion succeeded by periods of stable or moderate erosion. No definite cycle could be established.

FAP-5 study predicted that erosion of the northern bank of Hatiya Channel and the western side of Boyer Char to continue in near future.

The coastal char land study estimated annual average erosion of more than 50m/year in the areas south of Ramgati to western side of Boyer Char. LRP expert observed that periods of severe erosion are succeeded by stable periods without erosion or with only moderate erosion. IWM (erstwhile SWMC) analysis of the Meghna bank line movement in the region also predicts continuity of erosion in the future.

2.3.5 Coastline and River Migration

MES analysis done in 1998 (DHV et. Al. 1998) estimated bank line erosion rate as 100 m/year based on analysis of satellite image of 22 years (1974-1996). Near the Baggar Dona/Hatiya River outfall the bank line erosion is reported to be 60 m/year. Various reported erosion rate has to be taken as representative instead of quantitative in terms of value.

Based on the analysis of recent field surveys, investigation results and study of satellite imageries the Study Team found that average rate of erosion is about 100 m per year on the southwest coast of Boyer Char (about 6 km from the outfall of Jarirdona to outfall of Lombakhali khal). From the mouth of Lombakhali khal to outfall to Tankir khal, coastline migration is gradually decreasing. Along the

southeast coast of Boyer Char accretion is very active and a big submerged char has already been formed in the mouth of the Hatiya River. FAP-5 review of 1990 aerial photos also predicted continuity of accretion tendency at the outfall of Hatiya River and on the outside of polder 59/3B. The area is extending on the eastern side largely by coastal accretion. This has resulted in the formation of Boyer Char, Caring Char, Char Yunus etc. Caring Char accreted fast increasing in size and height during the last 10 years.

2.4 Present Drainage

As stated in Para 2.1 (Drainage Area) drainage problem of upper catchment of Baggar Dona/Hatiya River has already been planned to be solved by diverting drainage discharge by the Ist cross-dam on Baggar Dona/Hatiya through Jarirdona khal to Meghna River and that of mid catchment through Boyer Char by the 2nd cross-dam on Hatiya River at Ferry Ghat. (Fig. D 2.3).

Drainage of the lower catchment of the Hatiya River, that is, the study area remains to be discharged through Lower Hatiya River or otherwise after construction of the two planned cross-dams. However, the second cross-dam has alternative locations which needs to be decided.

It is understood from the present study of drainage problems of the study area that the problem exists in Char Nangulia extensively having additional drainage run off from Northern boundary area (Part of Char Laksmi and Char Clarke), due to the fact that internal drainage channels have been blocked at places and got silted up and can not be drained out adequately to Mamur khal. In Noler Char there is no significant drainage problem now. During field visits it could be known from the local people that Char Majid also does not face drainage problem, even with the additional drainage load through the embankment cut from upper Char Nangulia area.

Though the siltation process has been continuing in Hatiya river as perceived from the problem to navigation during low tide the channel section is quite adequate for drainage and seems likely to remain so. Of-course, after the planned drainage diversions are implemented reduction of channel section will happen to accommodate to the changed inflow and out flow discharges.

Present phase of morphological changes of Meghna near the out fall location of Hatiya River show that erosion has been continuing along Boyer Char shore and Hatiya River outfall zone and extending towards Caring Char southern tip. Siltation at the outfall zone is relatively small (Mathematical Modelling, south-west Noakhali P-3) (36). The trend of erosion seems likely to continue as the Gazaria Char near-by on Meghna has been getting stabler deflecting flow towards mainland shore at Boyer Char. This phenomenon has been giving a favourable outfall condition to drainage. However, considering anticipated silting up in the long run Hatiya River has been avoided as drainage outfall channel in Water management Option-4.

CHAPTER-3 : DRAINAGE SYSTEM STUDY

3.1 General

Water management option under this study (Part-A & Part-B) for empoldering of Char Nangulia and Noler Char for preparation of the development plans for the chars has decided for the Option not using Hatiya River as drainage outfall channel and both the chars as separate drainage units (Option 4). Char Nangulia will have one sluice (10V-1.5m x 1.8m) to discharge to Lower Meghna River and another one (5V-1.5m x 1.8m) to Hatiya Channel. Noler Char will have one sluice (7V-1.5m x 1.8m) to discharge also Lower Meghna.

Planned diversions of drainage of upper reaches as discussed in Chapter-2 leaves the drainage of the three chars under this study and an un-embanked small area south of Char Majid to drain presently through Hatiya River. There is no drainage problem of Char Majid now but planned for drainage diversion along with Char Maradona through Boyer Char by the planned 2nd Cross dam at Ferry Ghat.

Present drainage situation study confirms that drainage congestion exists in Char Nangulia due to siltation of internal drainage khals (mainly Nangulia Khal, Katakhali khal and Bhuiyer khal) and not due to external outfall channels condition (Mamur khal and Hatiya River). Noler Char does not face significant drainage problem at present. However, the problem will be solved by re-excavation of silted up existing drainage khals network linked to the proposed drainage sluices with outfalls to Lower Meghna River and Hatiya Channel.

Under this situation it needs to be assessed if the 2nd cross dam at Ferry Ghat, as proposed in the Feasibility Study on the Development of the Catchment Area of Baggar Dona River, 2001, can be shifted to a suitable location further downstream along the Hatiya River.

3.2 2nd Cross Dam Options

The objective of the External Drainage System Study is to create adequate drainage condition for Char Nangulia and Noler Char at minimum investment and maintenance cost and to study different locations for the 2nd Cross dam on Hatiya River along with the planned one at Ferry Ghat.

The three Options for Location of the 2nd Cross-dam on Baggar Dona/Hatiya River as per ToR are :

- At Ferry Ghat, the original one;
- Just downstream of the outfall of Banshkhali khal;
- Just downstream of the mouth of Mamur khal or further.

3.3 Discussion on Cross Dam

Deltas and estuaries are known as areas of net deposition of sediments either carried by rivers or supplied by the sea. The Terms of Reference (ToR) of the study requires establishment of morphological pattern using satellite imageries, River/khal bathymetry and other available hydro-morphological data. The ToR also stresses on synthesisation of observation and experience of local people.

A network of khals originating from the upper part and peripheral areas of the study area carries the runoff to the Baggar Dona in the mid reach portion and to the Hatiya river in the downstream portion. It is a typical coastal river system in which saline water intruding to inland causes rapid morphological changes. Accretion of mud flats is lengthening the drainage path. The lengthening of flow path retards the flow velocity. The cumulative effect of retardation of flow velocity as well as lengthening of flow paths accelerates sedimentation. The satellite images for 1973, 1984, 1996, 2003 & 2005 have been collected and digitized. The digitized images are used to determine he short term series map. Analysis of erosion and accretion has been done based on these time series maps. The consultant has completed survey of Char Nangulia, Noler Char and Caring Char and bathymetric survey of rivers and khals of the Project Area. (Hatiya River, Mamur khal and Caring khal etc.)

In the early nineties the western channel of the Baggar Dona/Hatiya River was silted up and the river now drains via its east course with increasing drainage path. This has led to considerable reduction of discharge of the upstream areas aggravating flooding during monsoon.

Baggar Dona/Hatiya river is a tidal river with tidal peak velocities of more than 1m at places. Shoals are coming up with considerable accretion at the outfall. The

shoaling is reducing the quantity of water flowing in and out during the tidal cycle. Consequently the cross-section of Baggar Dona/Hatiya River is reducing with the passage of time.

The coastal char land study also observed that two of the major khals of Baggar Dona polders are not functioning well due to siltation. It necessitated re-excavation of primary and secondary drainage canals of Baggar Dona/Hatiya River basin.

In the report "Feasibility Study on the Development of the Catchment Area of Baggar Dona River 2001" the Consultant also suggested in their report that the regulator sluice (8-vent) in Banshkhali khal (Char Majid polder) will be inoperative due to closure at Steamer Ghat. This can technically be avoided by planning the closure in the Hatiya River downstream of Banshkhali khal outfall channel (Polder Option 4). In that way a large fresh water basin can be added to the system between the closure and the existing ferry ghat and the regulator sluice can be maintained as an internal water control structure for Char Majid polder.

An application run of erstwhile SWMC (IWM) Mathematical Model for critical design event shows that the planned Cross dam at Ferry Ghat will reduce the tidal prism in the Hatiya River significantly and the lower part of the river will be subject to rapid siltaiton.

Polder Option 4 for the development plans of Char Nangulia and Noler Char, closes Mamur khal and Caring khal and will act as main drainage channels of Char Nangulia with discharge to Lower Meghna. Closure of Mamur khal will further reduce the tidal prism in the Hatiya River resulting in further siltation.

Analysis of satellite images (Fig. C 2.4/1) it shows that prior to 1996 there were no existence of Caring Char. During the period, 2001 to 2005, size of all the three chars increased but with a different rate. Caring Char developed southward, it appears that Char Nangulia and Noler Char have reached a stable size, while the size of Caring Char has been increasing (Fig. D 2.3.3/1). At present Mamur and Caring khals are highly dynamic, comparatively shallow and unstable but Hatiya River is comparatively morphologically stable. Local information is that Mamur khal bed level is getting higher year to year.

Widths of Hatiya river at Steamer Ghat is about 110m with lowest bed level – 2.498m PWD. At the downstream of Mamur khal (Ch 7.75 km) width is about 250m PWD with lowest bed level – 2.020m PWD and at Azim Ghat (Ch. 3.70 km) the width is about 325m with lowest bed level – 2.022 m PWD and at outfall (Ch. 0.00) the width is about 650m with lowest bed level – 3.306m PWD.

The Cross dam in the Hatiya River downstream of the Char Majid outfall will create, a large fresh water basin to the system between the closure and the existing Ferry Ghat. The 8-vent sluice draining Char Majid polder can be maintained as an internal water control structure. Furthermore excavation/ rehabilitation of the existing borrow pit and construction of new culvert as planned in the "F.S. on the development of the Catchment Area of Baggar Dona/ Hatiya River could be avoided along with some reduction of the length of the embankment of Boyer Char at Steamer Ghat end. Cross dam length at the D/S the outfall of Char Majid will be biggar compared to Cross dam at Ferry Ghat in size and will involve additional cost of Tk. 8.0 million more according to Baggar Dona Catchment Study, 2001.

Based on the analysis of previous Study Reports, recent field surveys, investigation results and study of satellite imageries, the study team found that the Cross dam, located near the existing Steamer Ghat or elsewhere down stream, empolderment of Char Nangulia and Noler Char and closing the flow of Mamur khal, will reduce the tidal prism in the Hatiya River significantly, as a result of which the lower part of the river will be subject to rapid siltation.

3.4 Discussions on the 2nd Cross Dam Options

Considering the complex and dynamic situation and existing environment of the area the Consultants carried out detailed hydro-morphological investigation in the Baggar Dona/Hatiya River system and in the Lower Meghna River along the Boyer Char and Caring Char coast. The recent reports and satellite images and the land survey conducted in Char Nangulia, Noler Char and Caring Char are the main tools are used in comparing the Cross dam Options.

2nd Cross Dam Option-1 (Cross Dam at Ferry Ghat) :

The Option includes the construction of Cross dam at existing Ferry Ghat (Steamer Ghat) on Baggar Dona/Hatiya River as proposed in the "Feasibility Study of the Development of the Catchment Area of Baggar Dona River. Under this Option the

proposed closure will reduce the tidal prism in the Hatiya River significantly and lower part of the river will be subjected to rapid siltation causing drainage problem through Banshkhali sluice of Char Majid polder. The study also proposed to divert the drainage flow of the Char Majid polder to the Hatiya River in the upstream of the closure using the existing borrow pit canal of the polder and connecting it with the Batenkhali khal of Char Moradona by constructing a culvert on the existing road. There will be no impact on Boyer Char planned works.

A fresh water reservoir will be created in the upstream of the proposed closure in the Hatiya River.

The negative aspect of this Option is that the existing 8-vent sluice of Char Majid at Banshkhali khal to drain Char Majid Polder will be inoperative due to siltation in the Hatiya River.

2nd Cross Dam Option- 2 (Cross Dam at D/S of Char Majid Outfall) :

By constructing a closure Dam near the outfall of Banshkhali khal;

Positive points of Option-2

(1) A large fresh water basin could be added to the system between the closure and the existing ferry ghat,

(2) The 8-vent sluice of Char Majid Polder can be maintained as an internal water control structure for Char Majid;

(3) Area left out on southern side of Char Majid during the F.S. in 2001 can be protected with the changed condition (existence of no forest).

(4) The excavation/rehabilitation of the existing borrow pit (inside polder) and construction of new culvert could be avoided.

(5) Some length of the embankment empoldering Boyer Char from Ferry Ghat to outfall of Banshkhali khal will be reduced.

The negative points are –

(1) The closure at D/S of the outfall of Banshkhali khal will be bigger in size and costlier than that of the closure at Ferry Ghat. During the study in 2001 it was estimated that an additional amount of Tk. 8.00 milllion will be required present value (2007) of which will be around Tk. 14.00 million.

(2) The lower part of the river will be vulnerable to rapid siltation.

2nd Cross Dam Option – 3 (Cross Dam at D/S of Mamur Khal Mouth) :

This option includes the construction of closure at downstream stream of Mamur khal outfall or further down towards the outfall of Hatiya River. Mamur khal has been proposed to be closed in the development plans for Char Nangulia dnd Noler Char by embankment. Mamur khal has been working as distributory channel for conveyance of tidal water from eastern side of the project area to Hatiya River. The discharge of Mamur khal along with the drainage discharge of Char Majid polder and upland flow of the project area was the main source of upland flow to Hatiya River. Since all these discharge ceases to flow to Hatiya River the tidal prism that will enter through the outfall of the river will meet dead end at closure site and will cause rapid siltation in the lower part of the river.

Positive point of Option 3

1) A large fresh water basin will be added to the system between the closure and the existing Ferry Ghat.

2) The length of embankment of Boyer Char can be reduced from Ferry Ghat to closure site.

3) The excavation and rehabilitation of the existing borrow pit (inside polder) and construction of new culvert could be avoided.

Major negative point is the bigger size of the closure than that at D/S of Char Majid outfall involving higher risks and construction cost of the closure. This will lengthen the flow path and will retard the flow velocity.

Location at further D/S will further increase the risk of construction of closure as well as huge increase in construction cost. It may also create unexpected morphological changes due to faster rate of siltation.

Selected 2nd Cross Dam Option

Considering the discussions above, Option 2 of 2nd Cross Dam on Hatiya River at D/S of Banshkhali khal outfall is the most favourable one and selected for implementation.