

Char Development and Settlement Bridging Project (Phase IV Additional Finance) Bangladesh

**Expert opinion on bank development along CDSP III and IV
chars, and on scope of hydraulic and morphological study.**

Technical Report No. 1

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Government of Bangladesh / IFAD / Government of the Netherlands

Implementing Government Agencies:

- **Bangladesh Water Development Board (BWDB)**
- **Ministry of Land (MoL)**
- **Local Government Engineering Department (LGED)**
- **Department of Public Health Engineering (DPHE)**
- **Forest Department (FD)**

1. Introduction

This expert opinion report on the bank development along the CDSP III and IV chars and on the scope and survey requirements of the hydrodynamical and morphodynamical study that is part of the CDSP Bridging Project (CDSP-B) is prepared by the short-term consultant Ir. Bram Bliëk¹ at the request of the TA team of CDSP-B, following his visit to the site and discussions with several experts and authorities in Dhaka between 17th and 26th August 2019. Terms of Reference for the mission are attached in Appendix 2.

The purpose of this report is to make an assessment of the erosion processes along the river banks of CDSP III and IV and on the options concerning how to develop sustainable infrastructure in these chars during the implementation of CDSP-B.

The scope of CDSP-B also includes a numerical model study on the development of the Meghna estuary, including surveys, aiming at getting a better understanding of areas with safe and unsafe chars for development during CDSP-V that may be planned to take place after CDSP-B.

CDSP-B started in July 2019. The findings of this expert opinion report will be integrated in the Inception Report of CDSP-B submitted in September 2019.

2. Findings of field visit

A field visit to the chars of CDSP III and IV was made on 20th and 21st August 2019. The coastal inspection started at Gabtoli Sluice in Boyer Char and ended at the location of the former Sluice DS2 in Char Nangulia. Inland the locations of the intended retired sluices to replace the lost sluices were visited. A detailed summary of the findings is given in Appendix 1.

It has to be concluded that the whole bank line of CDSP III and IV is eroding. Caring Char on the south corner of the CDSP land is almost completely washed away. Sluice DS2 in Char Nangulia had gone already by the end of 2016. During the visit it appeared that the Sluices DS-1 in Caring Char and Chatla Sluice in Boyer Char are no longer functioning as the polders are partly inundated by breaches in the embankments. The sluices are expected to fall in the river very soon. The same applies to Sluice DS-3 in Noler Char. Two other sluices in Boyer Char (Tankir Sluice and Gabtoli Sluice) are still doing well, but here the river is also coming close to the structures.

In Boyer Char between Tankir Sluice and Chatla Sluice the embankment is washed away over a length of about 1km. Recently a retired embankment was built by BWDB, but this has also breached already over a distance of some 100m. The embankment

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between the entrance of Hatiya River and DS-3 has gone over the full distance of about 1.5km. In Char Nangulia the retired embankment near Janata Bazar that was built some 2 years ago has also eroded over a distance of about 1km.

The tidal water entering the chars through the former khals and borrow pit channels is threatening the box culverts in these khals. In the borrow pit channel near Janata Bazar one box culvert collapsed on 18 August, two days before we came. Also, the embankments of these channels are at risk, as they are not designed to cope with tidal currents.

In general, it can be concluded that Boyer Char, Noler Char and Char Nangulia are no longer fully protected from the river by embankments and sluices. The bank erosion does not only destroy the embankments and sluices at the riverbank, but it is also a threat to the infrastructure (embankments, roads and box culverts) in the polders.

3. Interpretation of existing documents (MES, EDP, BDP)

During the mission only the main report of Estuary Development Project (EDP)²-2011 (without Annexes) and the Bangladesh Delta Plan (BDP)³-2018 Baseline Studies were available. The Meghna Estuary Study (MES)⁴ report (MES-II, 2001) was not available, but was cited in EDP-2011 and BDP-2018.

In BDP-2018 (Baseline Study Report Part 7b) a bank line analysis is made based on satellite images over the period 1973-2015. It appears that over this period both banks of the lower Meghna River have eroded (right bank Bhola and left bank Ramgati), as well as the north bank of Hatiya Island. Between Hatiya and Bhola Island new chars have developed. The same applies to the southern end of the left bank. This is the area of CDSP III and IV.

In EDP-2011 not only the bank line development is analysed, but also the changes in sediment volume. The image below shows this development over the period 1999-2009 (copied from Figure 3.12 of EDP-2011).

In the period 1999-2009 net erosion occurred in the 2 upper left boxes (being the lower Meghna main channel) of an average 71 million m³ per year. In the other 5 boxes on the east and south side sedimentation was dominant, in average totalling 347 million m³/year.

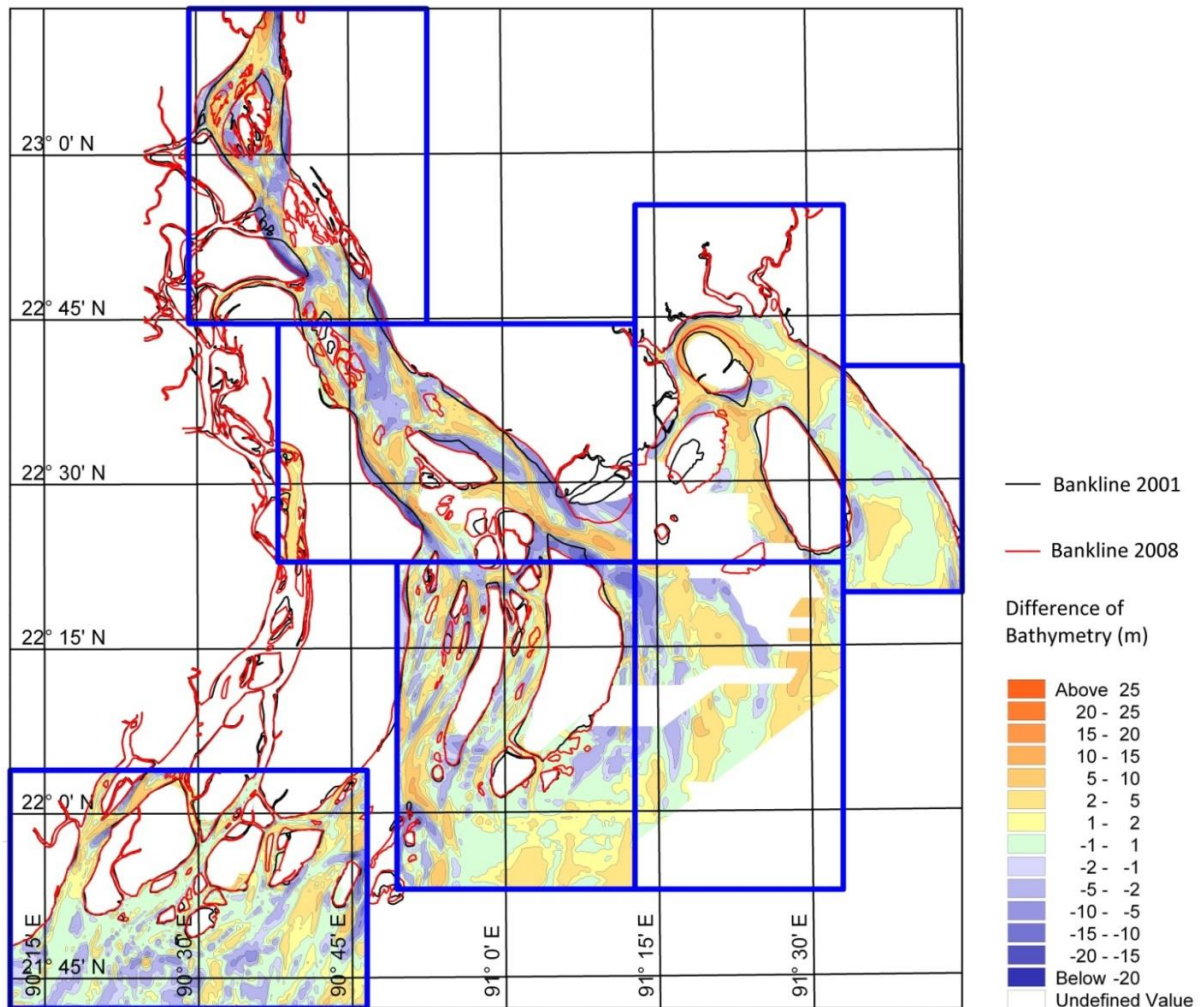
² <http://www.devconbd.com/project/estuary-development-programme-under-dutch-assistance-edp-phase-iii/>

³ <http://www.plancomm.gov.bd/site/files/0adcee77-2db8-41bf-b36b-657b5ee1efb9/Bangladesh-Delta-Plan-2100>

⁴ <https://www.devconbd.com/project/meghna-estuary-study-mes-i/>

The highest rate of accretion occurred in the Urir Char box (136 million m³/year). Also the area between Bhola Island and Hatiya Island received a large amount of sediment, as well as the area East of Hatiya Island.

Looking in detail at the development around the CDSP area it is clear that in this area erosion was present in the period 1999-2009. So even before the start of CDSP IV the first symptoms of the present erosive trend were already visible.



Erosion and sedimentation patterns in Meghna estuary (from EDP-2011)

In EDP-2011 also numerical modelling was applied to make a three year projection of the development of the seabed. Figure 4.3 of EDP-2011 shows the calibration results for the water levels on the SE side of CDSP. It appears that in dry season the model underestimates the tidal range at Char Majid (just East of Char Nangulia) and overestimates the tidal range at Harishpur on the West side of Sandwip Island. The model results indicate that high tide at Char Majid is higher than Harishpur, while the measurements show the opposite.

In the wet season a comparison between measurements and model is only given at Harishpur. It appears that the model is lagging behind the observations by about one hour, and both high tide and low tide levels are low (meaning that Mean Sea Level in the model is too low). As a result of these anomalies the calculation results of the seabed developments in EDP-2011 are not reliable.

The model forecast shows ongoing accretion south of Caring Char and Char Nangulia (Fig. 4.10 of EDP-2011), while reality in 1999-2009 shows an eroding trend here. The same applies to the large scale trend, as shown in Figure 3.11 of EDP-2011. The model shows the development of a large channel between Hatiya Island and Bhola Island, while in reality the trend in 1999-2009 is accretion.

It is not unlikely that the wrong model results have blocked the decision on building cross dams in the Urir Char area. Why build a cross dam if siltation comes naturally without further measures? If cross dams had been built between Char Nangulia and Jajaher Char (or mainland-Urir Char in combination with Urir Char - Sandwip Island), the present erosion process along the riverbank of Char Nangulia would have been avoided. Making a cross dam now will be much more complicated than 10 years ago because of the increased tidal volume and flow velocities.

4. Preliminary analysis of Google Earth pictures

During the mission a preliminary analysis was made of the Google Earth historical satellite images from (approximately) 1985 to 2015. These historical images are freely available in Google Earth Pro.



Satellite image of approximately 2015 showing schematized bank line in red

In the picture above the situation of (approximately) 2015 is given. The year is estimated by approximation as the picture is composed from several images with various dates. The yellow line in the lower right corner has a length of 10km. The red line in the picture indicates the actual bank line as it was around 2015. The red line will be used for comparison with earlier dates, back to approximately 1985.

Because of the interpolation between different images the bank line itself is also determined by approximation only, as different images may have been taken at different water levels, so the analysis can only be used to detect large scale trends.

In the figures below the historical development is presented by going back in time, with five year steps, to 1985.



Comparison 2010-2015



Comparison 2005-2015



Comparison 2000-2015



Comparison 1995-2015



Comparison 1990-2015



Comparison 1985-2015

Some remarkable trends can be derived from this analysis:

- Erosion of the Meghna bank near CSDP has been an ongoing trend since (at least) 1985; the same is the case for the North side of Hatiya Island.
- The Meghna channel between CSDP and Hatiya Island is growing. This is also a trend that has lasted for at least 30 years already.
- The second main channel system of the Meghna River between Hatiya Island and Bhola Island is silting up, resulting in the development of different chars in this area.
- Caring Char has grown up to approximately 2010; from then on it tends to erode.
- Jahazer Char has developed from non-existing and seems still to grow.
- South of Jahazer Char a new char is developing.

Because of the interpolation between different images to get the composite annual pictures it is not possible to draw conclusions on the development of the shortcut channel along the bank of Char Nangulia. Detailed analysis of individual images taking into account the water level of each image is required to make a reliable analysis here.

The interpretation of the existing documents and the recently available historical satellite images (including the baseline study of the BDP) has resulted in new insights in the development of the lower Meghna River and estuary. In the morphological

studies to date the conclusion has always been that the char area to the south of Char Nangulia would continue to grow, without shortcut channel development towards the East and without increasing river discharge through this channel.

The new insights result in a significant change of the forecast of the trends of the riverbank development at the CDSP chars.

5. Expert opinion on bank development in CDSP III and IV

Two main processes are expected to dominate the riverbank development of the CDSP III and IV chars in the coming years:

- a. The widening trend of the Meghna Channel to the west of CDSP. This trend has been taking place for a period of at least 30 years, and there is no sign that it will slow down soon;
- b. The development of the shortcut channel between the Meghna and Sandwip/Chittagong Channels on the SE side of CDSP (Char Nangulia). This development started in the period 1999-2009 and it is expected that it will go on during coming years and slow down in a later phase due to sedimentation in the area North of Sandwip Island.

Both processes have led to severe bank erosion along the CDSP chars over recent years, with Caring Char at the Southern corner almost completely gone as this char is suffering from the combination of both processes.

There is an interference between the continuing widening of the Meghna Channel and the shortcut channel development towards the Sandwip area. It cannot be excluded that this interference will increase over the next few years. In other words not only the tidal flood flow (that triggered the shortcut), but also the river discharge may find its way to the Sandwip region.

As a result of this interference, it is expected that the fast erosion of the South corner of CDSP will not come to an end in the short term.

In the picture below an estimate is presented of where the bank line could be after say 10 years. This estimate implies that part of Boyer Char and almost the whole of Noler Char and Char Nangulia are at risk of being eroded.



Estimated safe bank line in CDSP III and IV area for the coming 10 years

Doing the proposed hydro- and morphodynamical study of the estuary, which is part of the present CDSP-B program is urgently required to get more insight into the development of the estuary and the expected sustainable bank line of the chars in future.

After proper calibration using recent water level and discharge measurements and actual seabed developments (surveys are also part of the CDSP-B programme) the model may also be used to re-investigate the feasibility of a cross dam to Jahazer Char or to Sandwip Island.

The plans of BWDB to implement a bank protection scheme along the Meghna bank of Noler Char may have a positive impact on the development of the bank lines and on the sustainability of existing and new infrastructure in the chars. This impact can be investigated beforehand in the model.

6. Recommendations on actions to be taken in CDSP III - IV areas

From the above it is clear that (at least for the time being) it is not recommended to implement new high cost structures like sluices and retired embankments in Boyer Char, Noler Char and Char Nangulia.

The outcome of the morphological study and the decision of BWDB on implementation of sustainable bank protection at the Meghna side must be awaited before next steps on new infrastructure can be taken.

In the CDSP-B project full attention should be given to emergency actions to minimize the impact of the erosion of primary embankments and sluices for the people living in the chars.

This impact may consist of:

- higher current velocities and erosion in the drainage khals than before because of the tide re-entering them, resulting in erosion of khal embankments and/or collapse of (box) culverts (as happened already near Janata Bazar);
- higher water levels in the khals than before because of the tide, which may go over the crest level of (dwarf) embankments and threaten low lying land behind them.

Regular monitoring of the condition of all existing infrastructure in the chars should be top priority, to be followed by immediate emergency actions if critical levels are exceeded.

All proposed activities of CDSP-B behind the estimated “safe” bank line after 10 years may continue as planned. It may also be considered to build new cyclone shelters in that zone to compensate for shelters that are lost in the eroded chars.

Note that the locations of the new retired sluices as proposed previously in the CDSP-B programme are outside the estimated safe bank line. Therefore these retired sluices should not be built under CDSP-B as long as the uncertainties on future development will remain high in coming years.

7. Objectives of the recommended hydro-morphodynamical study

The proposed objectives of the hydro-morphological study are threefold:

- A. To understand the hydraulic and morphodynamical processes that are going on in the estuary, linked to the findings of previous studies and of new survey results.
- B. To define areas of high risk, medium risk and low risk in the existing CDSP III and IV areas (a) if no further bank erosion control actions are taken, (b) with BWDB bank protection in place and (c) with cross dam to Jajaher Char or Sandwip Island.
- C. To define areas of high risk, medium risk and low risk in the whole estuary as part of an initial study for the selection of chars to be developed under CDSP V.

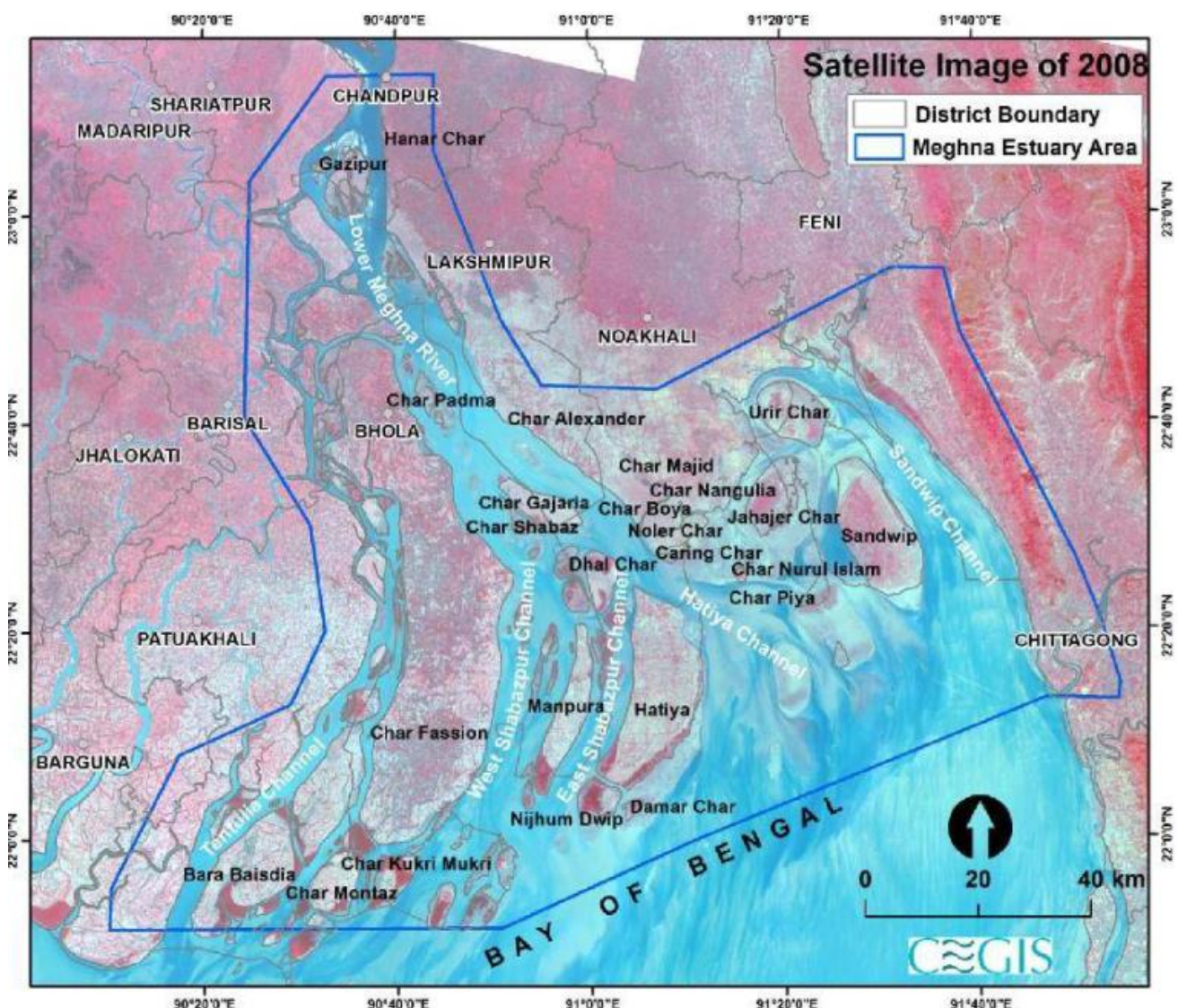
The study area is defined in the picture below and corresponds with the area that was taken up in previous studies like MES II-2001 and EDP-2011.

The channel west of Bhola Island and Char Fasson has to be included in the study only as far as sediment balance and river discharge distribution are concerned. No

new surveys will be done in this area and it will not be included in the numerical model domain.

In the model the historical seabed developments should be reproduced over a period of 10-20 years (depending on availability of bathymetrical surveys). Deviations between model outcome and survey result should be identified and analysed. Sensitivity analyses should be done to minimize the discrepancies between model and reality.

Sensitivity analyses should also be done for different climate change scenarios. These scenarios may include increase of river discharge, sea level rise and/or increased wave climate or cyclone frequency.

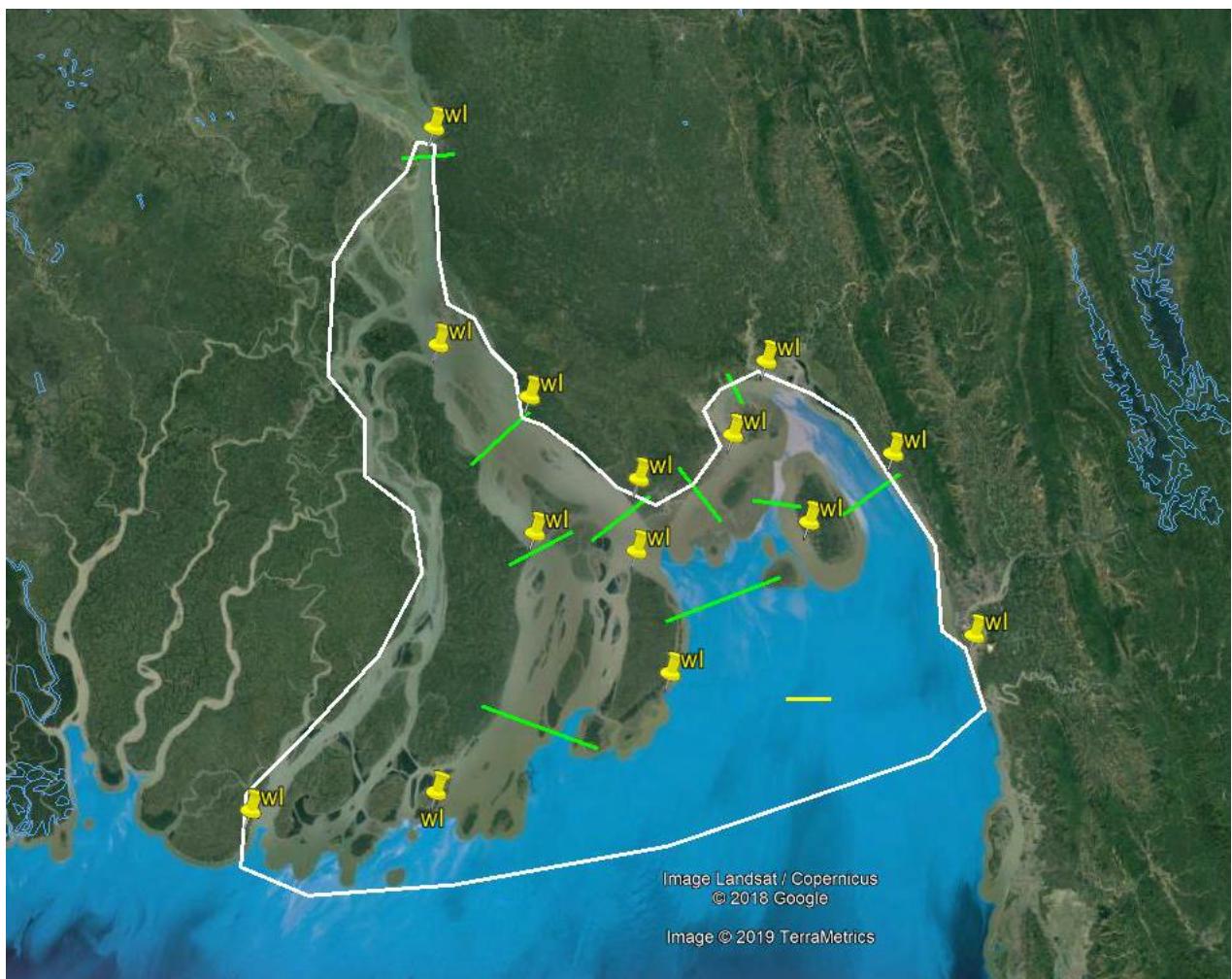


Proposed study area (in line with previous studies)

8. Survey requirements

The figure below presents the survey requirements for the purpose of calibration of the hydraulic and morphodynamical model. The requirement does not necessarily mean that new surveys should be done at all places. If recent surveys are available, the need for new surveys becomes less urgent.

In areas where changes go relatively slowly, like in the open sea South from Sandwip Island, “recent” can be defined as “2015 or later”. In highly dynamic areas “recent” means “2018 or later”, while the channels next to Char Nangulia, around Jajaher Char and Urir Char and west of Sandwip Island should be surveyed in any case.



Definition of survey requirements: white line indicates bathymetrical survey area, green lines indicate discharge measurement sections and yellow markers indicate water level gauges.

The bathymetric surveys should be done once, while discharge and water level measurements should be done twice: in the dry season and in the monsoon. Each discharge measurement should cover the full tide (approx. 13 hours) and should include suspended sediment measurements.

During the bathymetric survey bed surface sediment sampling should be done at regular spacing and analysed for grain size distribution.

The tide gauges should run for at least 28 days in both seasons and should be operational at the time of the discharge measurements. If permanent water level stations are present in the vicinity of the locations proposed in the figure, these stations can be used and the location in the figure can be skipped.

All temporary tide gauges should be properly levelled, because knowledge of any differences in Mean Sea Level (MSL) between stations is very important. The gauges should preferably be automatically recording, as manual reading of gauges may easily include errors. The current velocity recorders for the discharge measurements should be (Acoustic Doppler Current Profiler (ADCP)).

Bathymetric surveys should be done with a suitable echosounder, DGPS or RTK positioning system and suitable processing software.

9. Specifications of hydraulic and morphodynamical model

The numerical model to be applied for the hydro- and morphodynamical study should have the following specifications:

- Flexible grid with a coarse grid in the open sea (grid size 2-5km) and a fine grid in the dynamic char areas (grid size 100-300m).
- Model should update bathymetry online during the calculation to cope with the impact of gradually changing bathymetry on the currents.
- Model should produce proven stable results for calculation periods of at least 20 years.
- Depth averaged flow (2D model) is satisfactory.
- There is probably no need to include sea and swell waves in the model, but the option to interfere online with a wave model like SWAN should be available.
- Sediment transport should be based on characteristics of sand and mud, including sand-mud interaction.
- Model should have the possibility that land is being eroded in the model (no fixed model boundaries at present bank lines and no fixed position of chars).

10. Conclusions

Over the last year the bank erosion problem in the CDSP III and IV chars has further worsened. Large infrastructure objects like sluices and embankments are at increased risk or have collapsed already.

It is likely that more char land will be lost during the next few years, as the erosion process will not stop in the short term. A preliminary “safe” line through the chars is drawn indicating the position of the bank line after 10 years. This line is on a significant distance from the present bank line, and there is no warranty that this line will hold.

It is recommended not to start with construction of new embankments or sluices in CDSP III and IV as long as the uncertainties concerning developments remain so high. By limiting the investments to monitoring of the development and to taking emergency actions to keep the existing infrastructure functioning as long as possible the risks of further losses will be minimized.

The activities of CDSP-B in the other (older) chars may continue as planned.

The urgency of monitoring and modelling of the whole lower Meghna estuary in the short term has increased over the last few years, because the erosion and sedimentation patterns are changing and the erosion at the Meghna side of CDSP is accelerating.