

The Ganges-Brahmaputra Delta in a Changing Climate

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Deltas in Times of Climate
Change, Rotterdam, 2010

Objectives

- We simulated the historical sea margins of the Bengal Delta based on assumed sedimentation rates, subsidence and sea-level rise. The margins were compared with observational evidence, and empirical corrections were made to the sedimentation and subsidence rates.
- Using the publicly available Shuttle Radar Topography Mission data, we have generated different scenarios due to future sea-level rise that will affect the Bengal Delta. The results are limited to the inherent vertical resolution of the SRTM data and only integer meter rise in water levels were considered. Estimated sedimentation and subsidence rates were included in the simulation.

Dataset

- Elevation dataset produced by NASA's Shuttle Radar Topography Mission (SRTM) is the most detailed free-of-cost near-global digital elevation model (DEM) dataset publicly available. The SRTM dataset covers over 80% of the global land area. The data are available as 3 arc second (92 m along the meridians and the equator). The results show that the SRTM data have a vertical root mean square error (RMSE) of 1.3 to 5.2 m. The data are provided with elevations rounded to integer meters.

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Software and Method

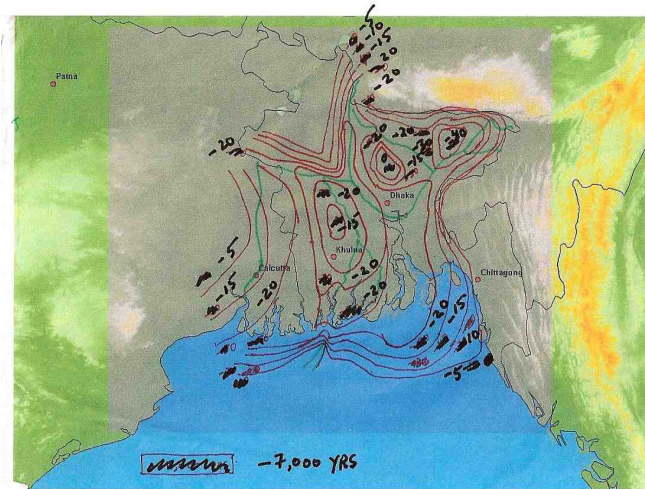
- ESRI's ArcGIS software, with its spatial analyst extension, was used for the processing and analysis of the SRTM data. Because the SRTM data provides elevation information based on tree tops in the areas of dense forest, a method was devised to estimate the ground elevation. A supervised image classification was performed on the Bing data (published by Microsoft) to extract areas of tall and short forests present in the Sundarban area of the Delta. The elevations were extrapolated from the surrounding flat fields resulting in reductions between 5 and 9 m. Some additional elevation outliers (individual outstanding pixels with elevations exceeding the local average by 15 or more meters) were manually corrected based on the analysis of both the satellite imagery and corrected SRTM data.

- Using isopachs for 11 kybp and 7 kybp we established the baseline sedimentation rate. The lowest contour levels are -70 m for 11,000 ybp and -20 m for 7,000 ybp (Goodbred & Kuehl 1999, Goodbred & Kuehl 2000)



Isopachs 11,000 ybp

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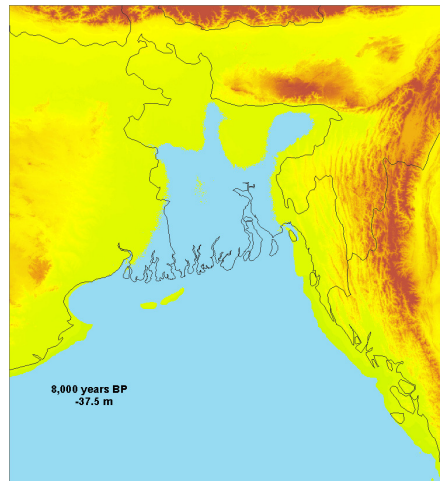
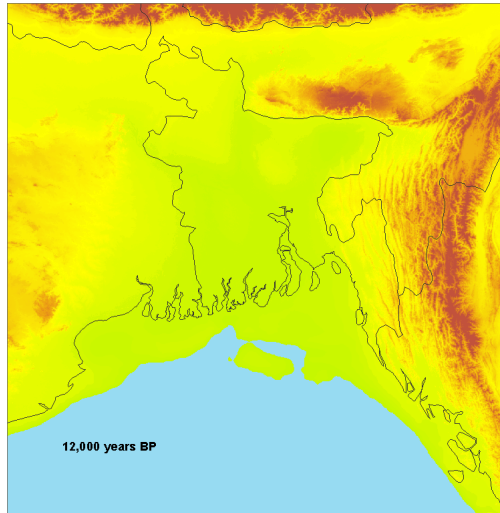
Isopachs 7,000 ybp

The lowest contour levels are -70 m for 11,000 ybp and -20 m for 7,000 ybp.

Sea-Level Data

- Sea-level
- 17,000 yrs BP : -120 m
- 16,000 yrs BP : -115 m
- 14,000 yrs BP : -95 m
- 12,000 yrs BP : -85 m
- 11,000 yrs BP : -60 m
- 10,000 yrs BP : -52 m
- 9,000 yrs BP : -35 m
- 8,000 yrs BP : -18 m
- 7,000 yrs BP : -15 m
- 5,000 yrs BP : -7 m
- Now : 0 m

12,000 years before present.

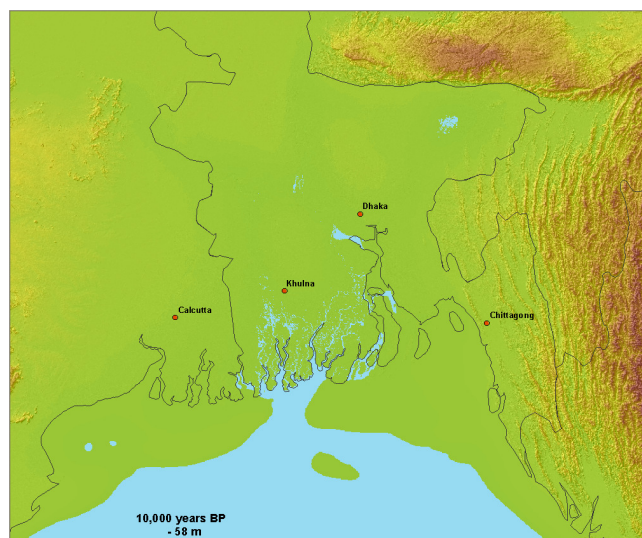


The coastline has retreated since the last glacial maximum (18,000 kybp). However, this simulation shows major inland transgression at 8,000 ybp does not match with the observation (see Goodbred & Kuehl 2000 and references therein).

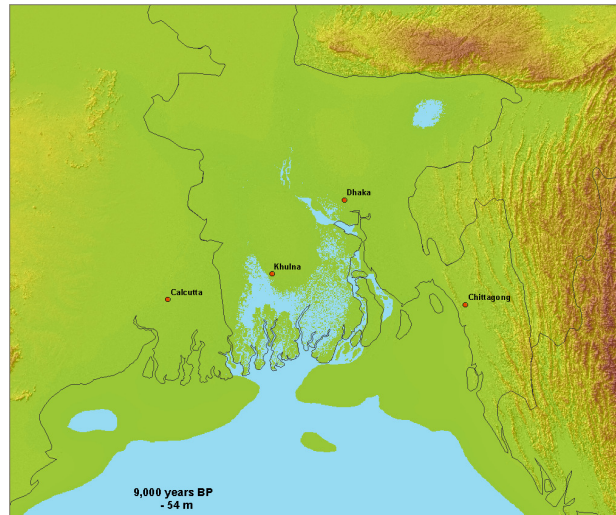
We decided to raise the surface levels until they resembled the observational data. We artificially added 10 m to our previous estimates and also added 4 m of subsidence for every 1000 years. In addition, the anticline just north of Khulna was elevated by 10 meters and the Madhupur highland region was spatially expanded.

• Time	Previous	Sea-level	New Surface Level
• 11 kbp	-70 m	-60 m	-70m
• 10 kbp	-57.5 m	-52 m	-57.5m
• 9 kbp	-47.5 m	-35 m	-33.5m [-47.5 m + 10 m + 4m]
• 8 kbp	-37.5 m	-18 m	-23.5m [-37.5m + 10 m + 4 m]
• 7 kbp	-20 m	-15 m	-6m [-20m + 10m + 4m]

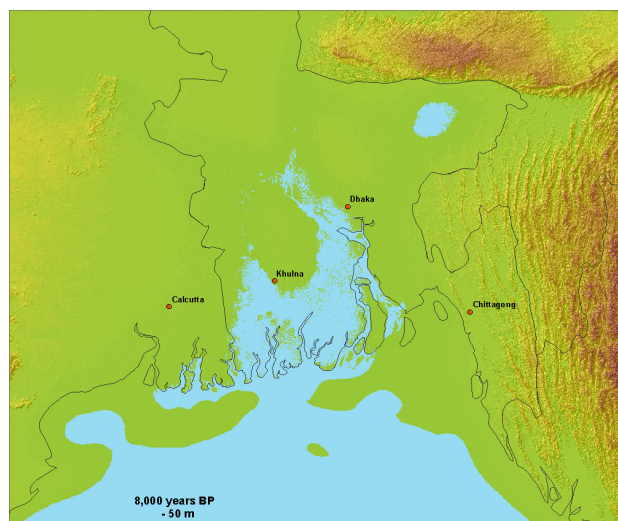
10,000 years before present. Lowest surface level : -57.5 m



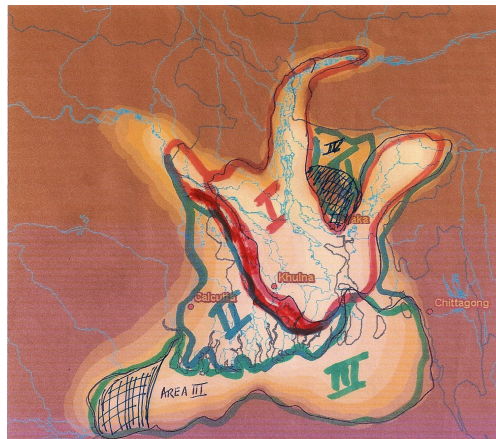
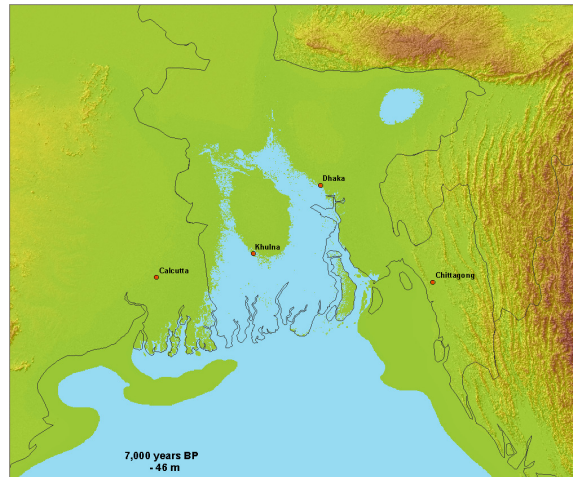
9,000 years before present. Lowest surface level : -33.5 m



8,000 years before present. Lowest surface level : -23.5 m

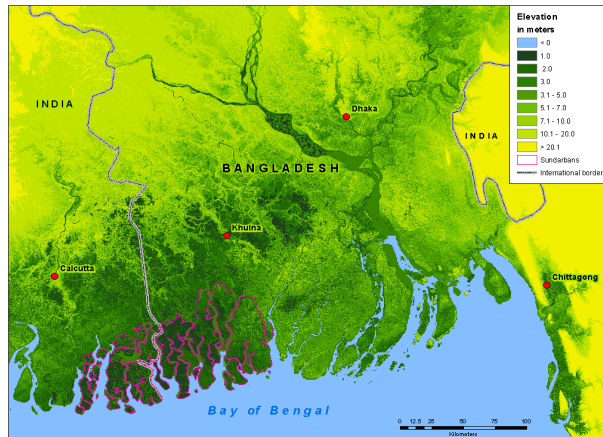


7,000 years before present. Lowest surface level : -6 m

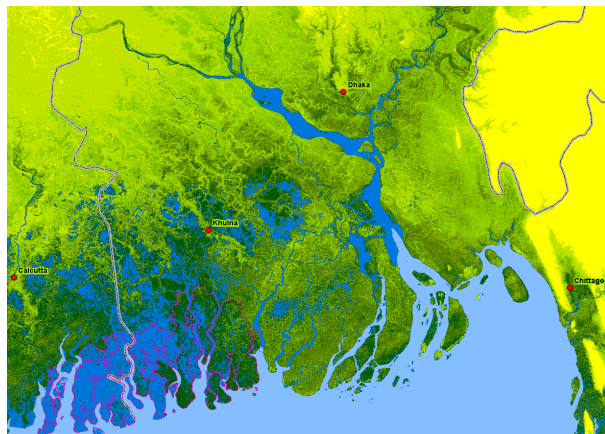


- Next we estimated the current sedimentation rate. Based on an estimate of 10^9 tons of sediment/year flowing through the Bangladesh Delta we derived a spatially differentiated sedimentation rate of 3.1 mm/yr (area III) and 1.5 mm/yr (area I & II). A conservative estimate of 1 mm/yr subsidence was used across all areas.

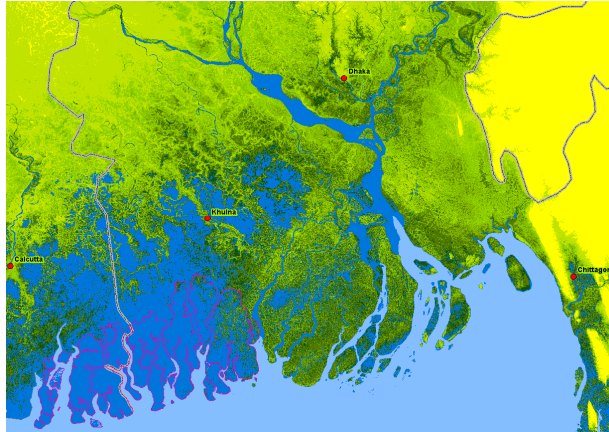
Current cartographic elevations



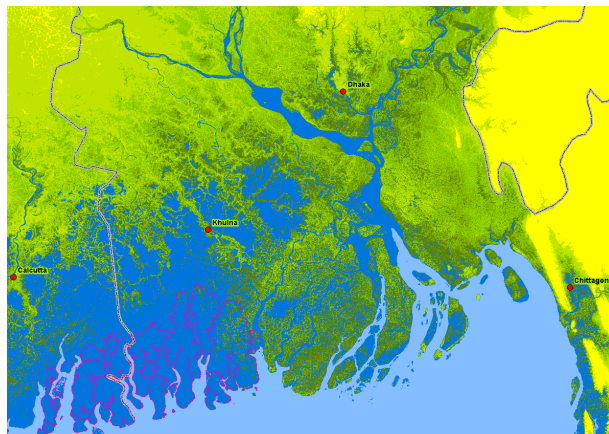
(0 - 1) m rise 6.3%



(1 - 2) m rise 10.9%



(2 - 3) m rise 14.4%



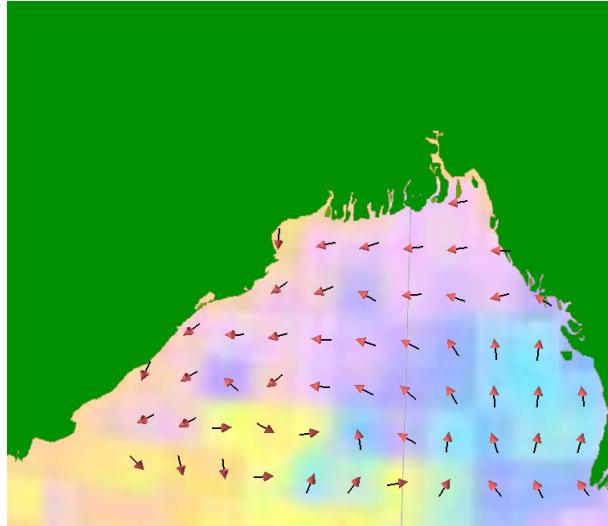
Affected % of Sundarban

Water-level rise	All	Bangladesh	India
0 - 1 m	68%	67%	72%
1 - 2 m	90%	85%	90%
2 - 3 m	91%	94%	99.5%

Coastal bathymetry: white (-1 m), cyan (-2 m), and azure blue (-3 m). The darkest blue indicates waters deeper than 3 meters. This map indicates intense sedimentation process in the white and cyan areas. Notice almost no sedimentation in the western delta. The original bathymetry data has a resolution of 3 km which have been resampled and smoothed to 1 km.



Ocean currents in the Bay of Bengal. The currents transport sediment from east to west.



Conclusion

- The study underscored the need for sum-meter topographic data, reliable sedimentation and subsidence rates, and the local sea-level rise rates.