Paper No. 299-12, T150. Advances in Understanding Processes at or Near the Groundwater–Surface Water Interface
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AN ENGINEERING GEOLOGICAL ANATOMY OF THE PADMA RIVER BANK FAILURE AND EROSION, 2018: A CASE STUDY OF NARIA BANK SECTION, BANGLADESH

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AN ENGINEERING GEOLOGICAL ANATOMY OF THE PADMA RIVER BANK FAILURE AND EROSION, 2018: A CASE STUDY OF NARIA BANK SECTION, BANGLADESH

ABSTRACT : The Naria town of Bangladesh is developed on the right bank of the Padma River. The bank is an old natural levee of Meghna River. The Holocene-Recent geology of Naria is actively dominated by the fluvial processes of Ganges-Brahmaputra-Meghna River system where the deltaic sediments are characterized as unconsolidated fine sand and silt, covered by thin veneer of clayey silt and loam. The annual volume of water discharge and flow dynamics are dependent on the intensity of the rainfall, runoff and the length of dry winter. Excessive river bank erosion, channel avulsion, renewed submergence of floodplains, and formation of natural levees and channel-bars are due to natural geomorphological processes that impact the area by inevitable ground failures. The geological attributes of ground condition and drastic variations in water levels make the area extremely vulnerable to severe bank failures and erosion.

A unique erosion phenomenon prevailing in this part of Bengal delta prompted this study. During Aug-Sept, 2018 a sudden complex attenuation of current, wave and vortex in the Padma water flow caused an extraordinary disaster and made more than 5000 people homeless overnight by devouring away houses including concrete buildings, factories and markets. It is observed that geologically the Padma River remained confined within a width of 5 miles striking NW-SE trend following the margins of older alluvium and Faridpur Trough. The river tends to a meandering pattern consisting of deep vertical trenches along the Naria curvature. The deep trenches form along right bank and render the ground increasingly more vulnerable to subaqueous slope failure due to presence of thick (~200 ft.) alternating cross-bedded silt and micaceous fine sand of very high dilatancy and low angle of friction.

The present study identifies some application of technological advancement for developing real-time engineering geological mapping systems for monitoring and managing complex river bank erosion. Large scale 3D engineering geological map coupled with air-borne photogrammetric and radar inferrometry methods can be applied for real-time monitoring and prediction of differential settlements, subaqueous failures and ground movement. The point cloud maps developed using data from these systems can refine engineering geological maps for decision makers and improve the design of protective measures and sustainable engineering structures.

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T150. Advances in Understanding Processes at or Near the Groundwater–Surface Water Interface
doi: 10.1130/abs/2019AM-335679

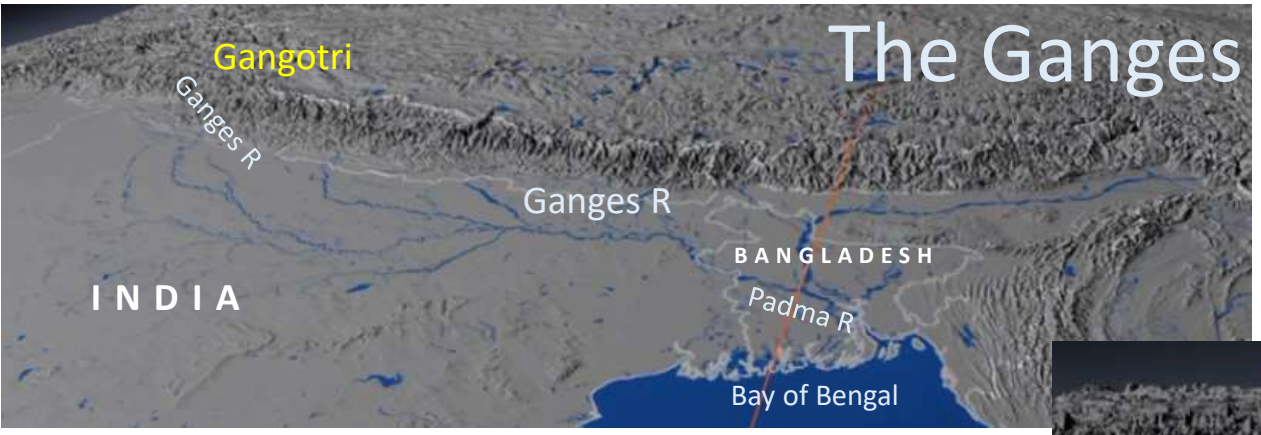
Background and Objectives

This presentation is on last year's (2018) river erosion along Padma R, near Naria with possibilities of preparation of engineering geological maps and database.

The simple geological maps or conventional geotechnical investigations (both field and laboratory) do not provide right directions for river bank hazard prediction or bank failure risk management in the unique fluvial environs of the Bengal delta.

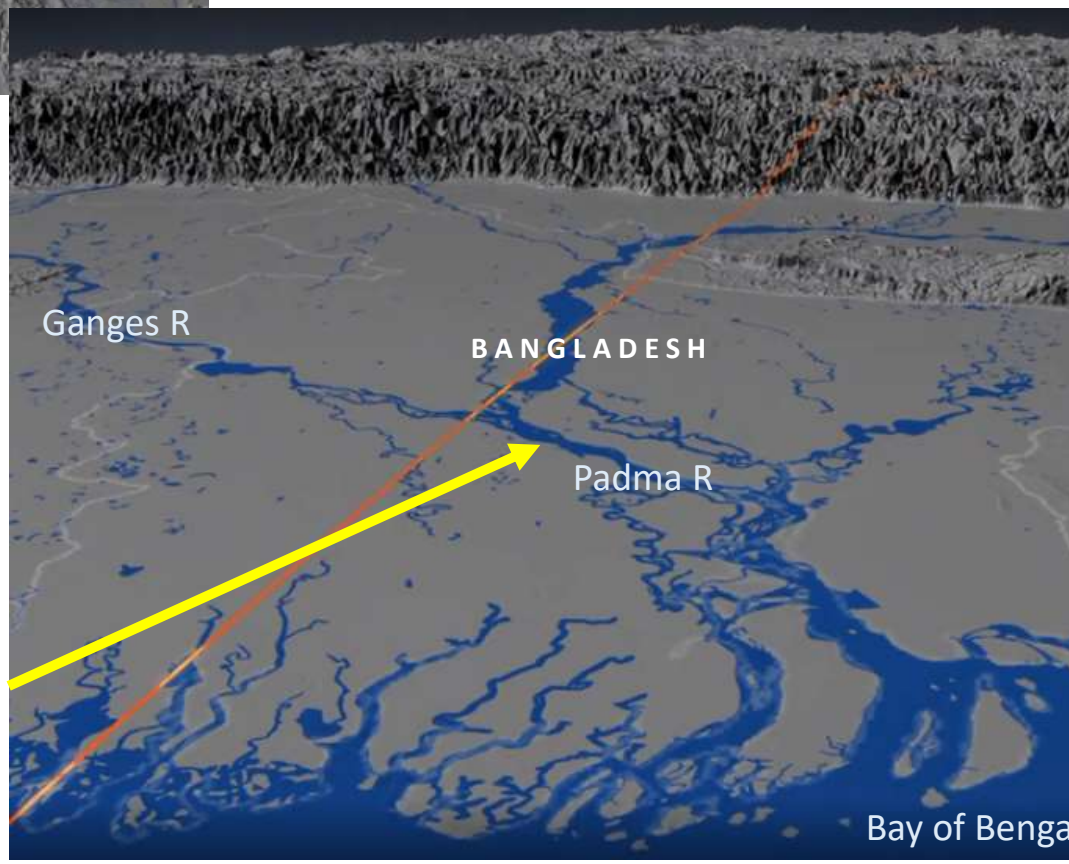
Because geotechnical samples are not truly representative of actual field condition and can be of misleading in the uses.

That is the reason it necessary to illustrate presence and influence of sedimentary structures. It is better if we can investigate and understand bank cliff erosion phenomena in and around Naria for a long-term understanding and design of required geostructures and disaster management plan.



The Ganges Padma River System

Padma River channel is exceptionally young and longest in comparison to any other major rivers of the world.



During Aug-Sept, 2018 a sudden complex attenuation of current, wave and vortex in the Padma water flow caused an extraordinary disaster and made more than 5000 people homeless overnight by devouring away houses including concrete buildings, factories and markets.

A unique erosion phenomenon prevailing in this part of Bengal delta prompted this study.

https://svs.gsfc.nasa.gov/4047

The furious Padma River at her bank full water stage

The furious rivalry between man and the river.

Live River Shifting Observation
for Live Geological Map Update System
discussed later


Temporal Erosion Pattern of Padma River Between Mawa and Chandpur
1984 to 2016
Google Earth Imagery processed
by Mir Fazlul Karim, Geocom
To investigate geological causes of
2018
that made 5000 people homeles
, 2018
There are 32 slides (Time Series) here
Please contact the author
for playable video
mfkarimazad@gmail.com
Naria Upazila
Image Landsat / Copernicus
Mir Fazlul Karim
Google
8.30 mile
Play

The Consequences

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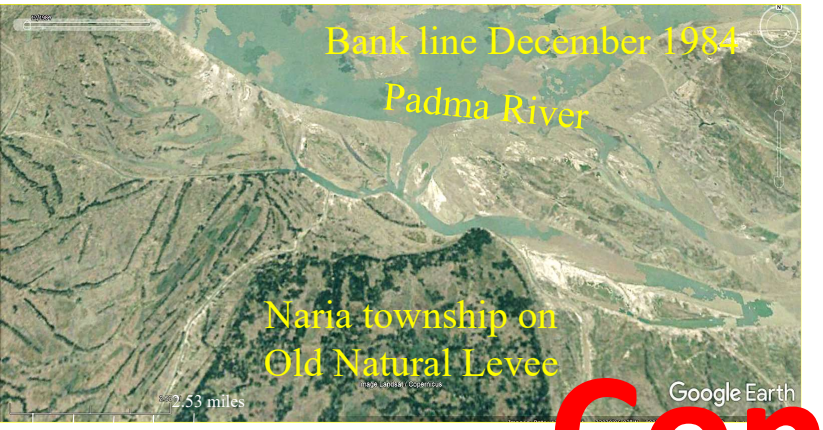
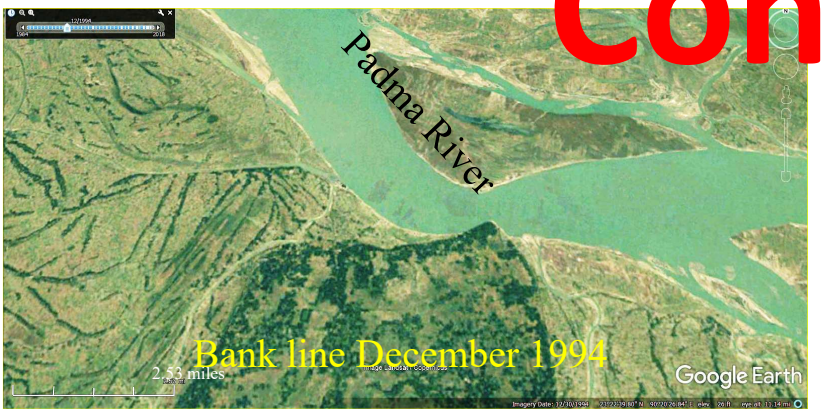
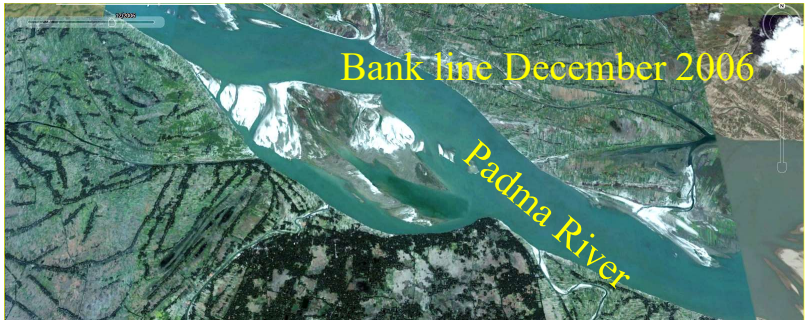
Play Video

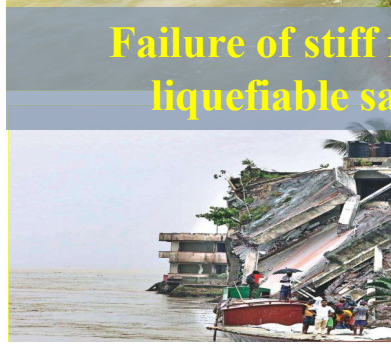
Consequences







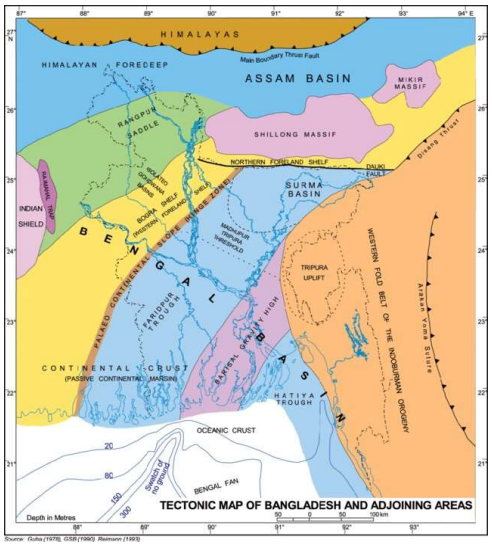
ynamic river bank shifting changes the surface geology every year.

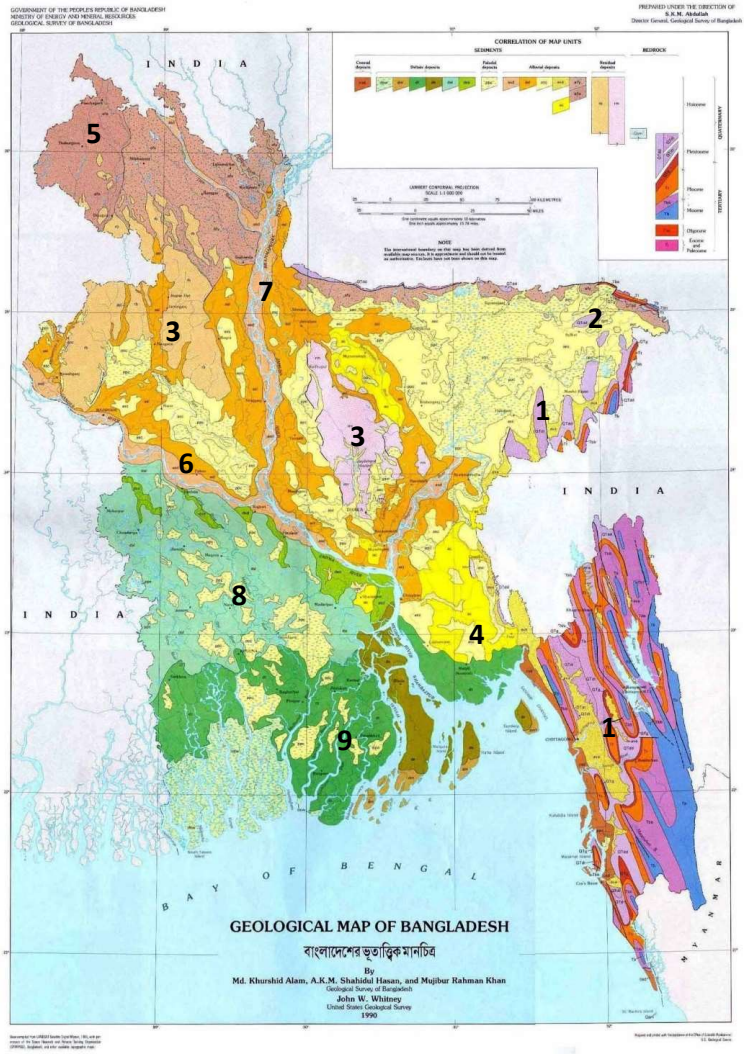


Geology and Tectonics

SURFACE GEOLOGY

Tectonic Map of Bangladesh and surrounding areas





Lithological Units

1 and 2

Folded hills of Tertiary sedimentary rock

3

Pleistocene Terraces
Barind and Madhupur

4

Old Alluvial Deposit (Chandina Alluvium)

5

Alluvial Fan Deposit**6**
Paludal Deposit
Marshy clay & peat

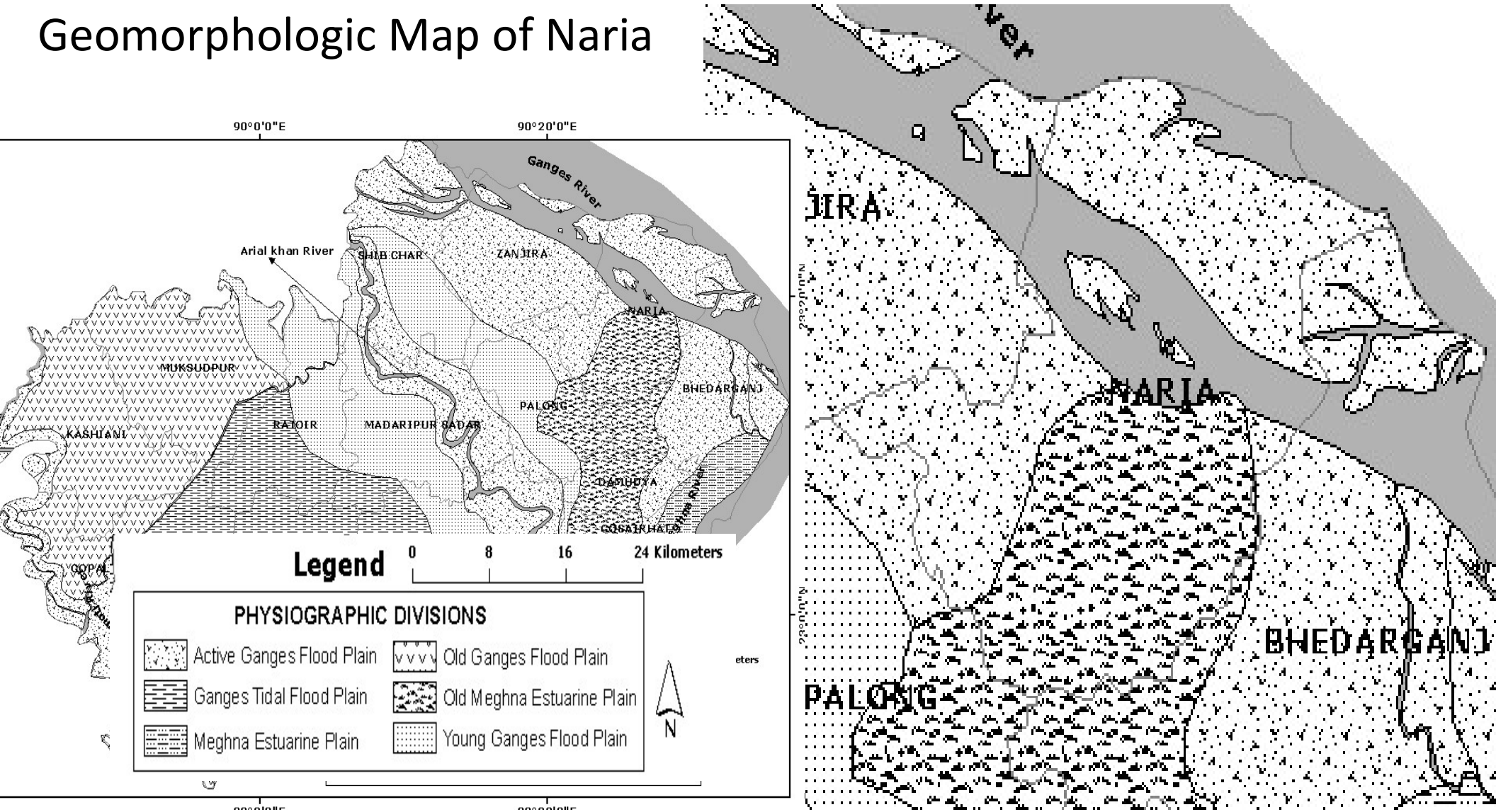
7

Young Alluvial
Deposit (Inter-stream deposit)

8 and 9

Deltaic and Coastal Deposit.
Including Beach, Estuarine and Mangrove swamp deposits.

Geomorphologic Map of Naria



Sub-Surface Geology

The Holocene-Recent geology of Naria is actively dominated by the fluvial processes of Ganges-Brahmaputra-Meghna River system where the deltaic sediments are characterized as unconsolidated fine sand and silt, covered by thin veneer of clayey silt and loam.

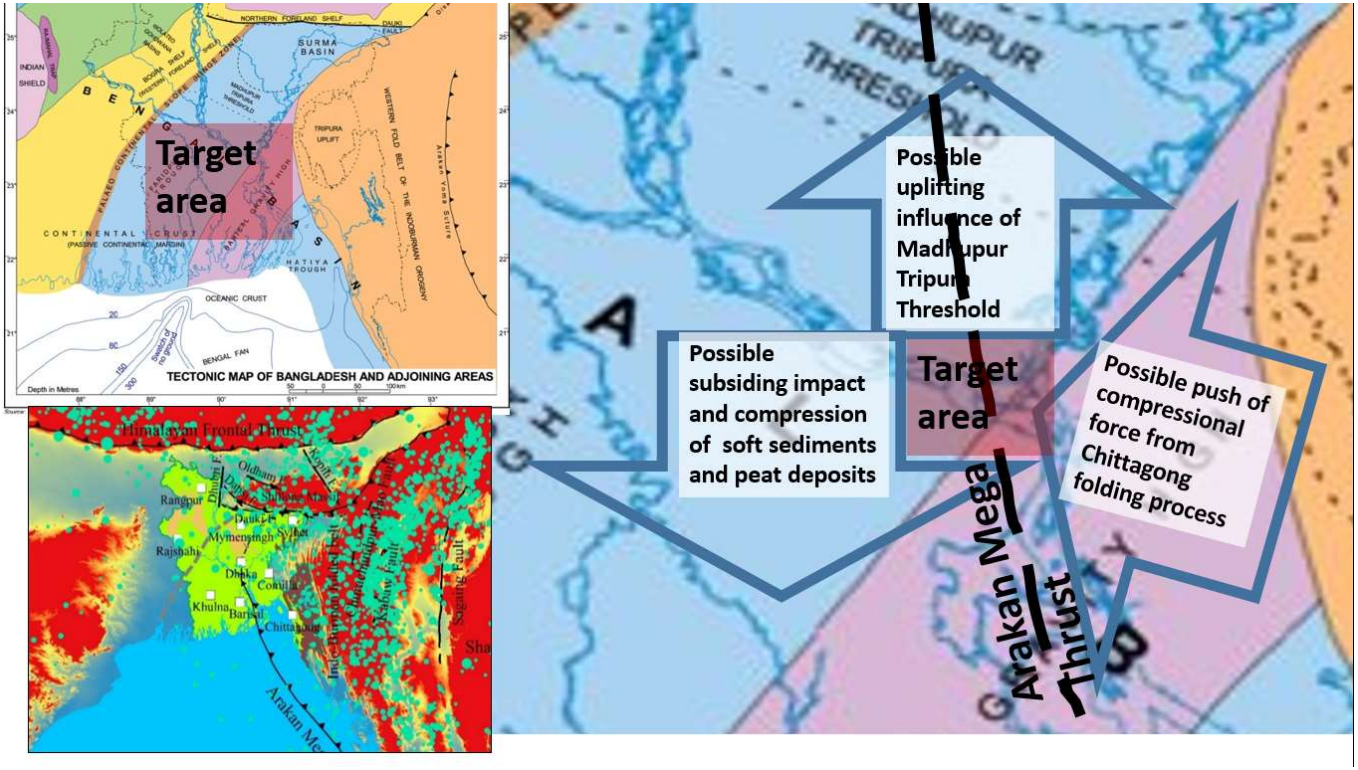
LOCATION (Borehole-14)
Purbanaodoba union,Zazira upazila, Sariatpur District
LATITUDE-23.40978
LONGITUDE-90.28343
TOTAL DEPTH- 57m

op(ft)	Bottom(ft)	Top(m)	Bottom(m)	Lithological Description	Depositional environment
0	3	0	1	**Filling materials**	
3	11	1	3	**Sandy silt:**Light olive grey(5Y6/2) and pale olive(5Y6/3),staining along roottubes which is very dark grey(10YR3/1),yellowish brown(10YR5/6),yellowish brown(10YR5/4) and olive brown(2.5Y4/4),laminated.	Flood basin
11	70	3	21	**Sand**:Grey(7.5YRN7/) and light grey(7.5YRN6/),fine with medium,huge mica, micas are partially decomposed.	Channel
70	90	21	27	**Sand with little silty clay**:Grey(7.5YRN6/),very fine to fine with medium,huge mica,micas are partially decomposed, few large mica flakes,few zill/roottubes, silty clay is grey(5Y5/1),zill/roottubes present,laminated,burrows filled with sand huge wood cut and vegetal matter found(89-90)ft.	Tidal/Bar top
90	187	27	57	**Sand**:Grey(7.5YRN6/), medium to fine,huge mica,micas are partially decomposed interlaminated vegetal matter,wood debris found at 165ft and 185ft,lower part is fine to medium with coarse.	Channel

Sub-Surface Geology

LOCATION (Borehole-11)
Bilashpur mouza,Bilashpur union,Zazira upazila, Sariatpur District
LATITUDE-23.31827
LONGITUDE- 90.37863
TOTAL DEPTH- 72.0m

Top(ft)	Bottom(ft)	Top(m)	Bottom(m)	Lithological Description	Depositional environment
0	5.5	0.0	1.7	**Filling materials**	
5.5	8	1.7	2.4	**Silty clay**:dark grey(N5/) and bluish grey(5B5/1),sticky,soft,vegetal matter partly decomposed,little humic odour and laminated. No vegetal matter at (7ft-8ft).	Flood basin
8	11	2.4	3.4	**Silty clay**:olive grey(5Y5/2) and light olive grey,sticky,soft,laminated,staining along roottubes pale olive(5Y6/3),light olive brown(2.5Y5/6) and brown(7.5YR4/4),few shell present at 10.5ft.	
11	41	3.4	12.5	**Interlayering of silt,silty sand,silty clay and sand:** Silt is grey(5Y5/1),laminated. Silty sand is grey(7.5YR N5/), huge mica micas are partially decomposed, fine to very fine.sand is grey (5YR N5/) and very fine to fine.silty clay is grey(5Y5/1)and light olive grey(5Y6/2),sticky,soft and laminated.	Bar top
41	66	12.5	20.1	**Sand:** Grey (7.5YR N5/), upper cycle is fine to very fine up to 41ft-56ft) lower part is coarse to medium sand,grey(5B5/1) and bluish grey (5B 5/1).huge mica and micas are partially decomposed, wood debris found at 60ft and 63ft.	Channel
66	71	20.1	21.6	**Silt with clayey silt:** Greenish grey(5B5/1), laminated (upper part clayey silt).	Tidal flood
71	76	21.6	23.2	**Sand**: Bluish grey (5B 5/1), medium to coarse,few large mica flakes,huge mica and few vegetal matter.	
76	84	23.2	25.6	**Clayey silt and silt:** Clayey silt is dark grey(N4/),laminated up to 79ft. Silt is bluish grey(5B5/1) and laminated.	
84	97	25.6	29.6	**Interlayering of silty clay and sand:** Grey (2.5Y N5/) and bluish grey(5B5/1) coarse to medium,few mica.(Pektin found at 92ft). Silty clay is dark grey(N4/) and bluish grey(5B5/1),soft,sticky,few vegetal matter and laminated.	Inter tidal
97	130	29.6	39.6	**Sand:**Light bluish grey (5B6/1)upper part is very fine to fine and lower part is fine to medium with little coarse, few vegetal debris	
130	161	39.6	49.1	**Interlayering of sand and Clayey silt:**Sand is bluish grey(5B5/1),dark grey(N4/), fine to medium with coarse,huge mica,micas are partially decomposed,interlaminated vegetal matter.clayey silt is bluish grey(5B5/1),laminated.	
161	232.5	49.1	70.9	**Sand**:Dark grey(N4/),grey(5Y6/1),huge vegetal debris,upper part is very fine to fine with medium and lower part is coarse to medium with pebbles,wood debris.	Channel
232.5	236.0	70.9	72.0	**Silty clay**:Dark grey(2.5YN3/) and bluish grey(5B5/1),sticky,hard,vegetal matter, soapy felling,impregnated lithic granules,compact.	Supratital



Possible impact of tectonic structural elements and dynamic forces rendered by tectonic movement and regional stratigraphic setting.

The Padma River Bank erosion or slope failures in the target area are influenced by complex act of tectonic shift and movement due to the junctural influence of multiple tectonic elements. The river erosion consists of two processes: basal erosion due to fluvial hydraulic force and bank failure under the influence of gravity and tectonic forces.

The exposed bank materials

Top soil: 2-3 ft:
Brownish gray loamy soil or plough soil, mostly moist to dry, moderately permeable, fractured, Contains rootlets and perforations.

Below topsoil:
Sand: Gray and light gray, fine with medium, highly micaceous, laminated with fine silt, cross bedded, mostly rounded quartz, loose sand.

Padma River Bank failure Characteristics

Generally the bank resistance strength varies with the degree of saturation of bank material.

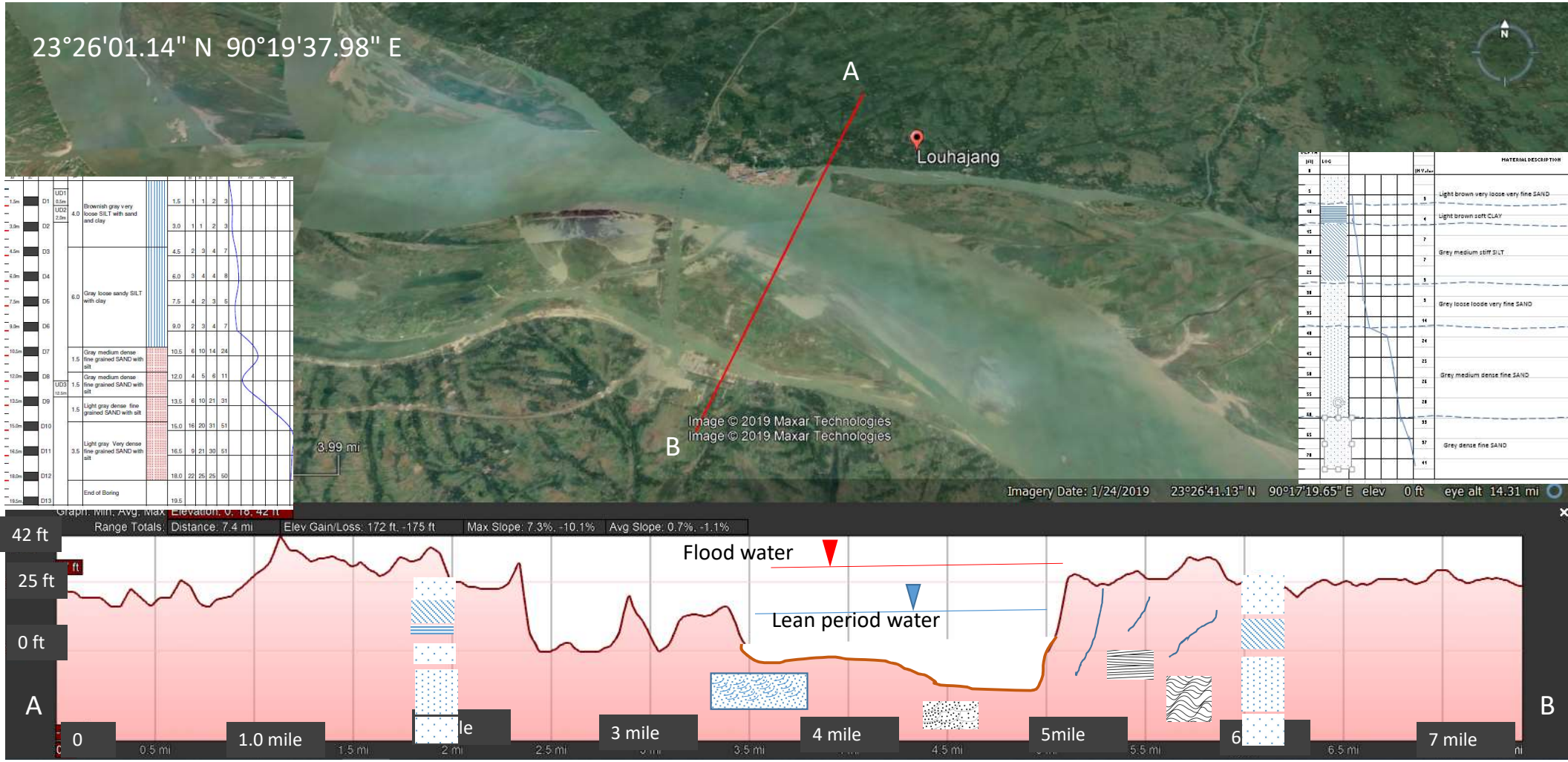
The probability of bank failure is dependent on the stability characteristics of the river bank. (it can be both natural and man-made).

Where the degree of saturation of bank material is directly related to the variations of the river stages.

The magnitude and the frequency of bank failure is always related to the frequency and time span of the flooding.

The rate of bank erosion is related to basal erosion, material consistency, sedimentary structures and their discontinuity or the continuity pattern, and bank failure occurrences..

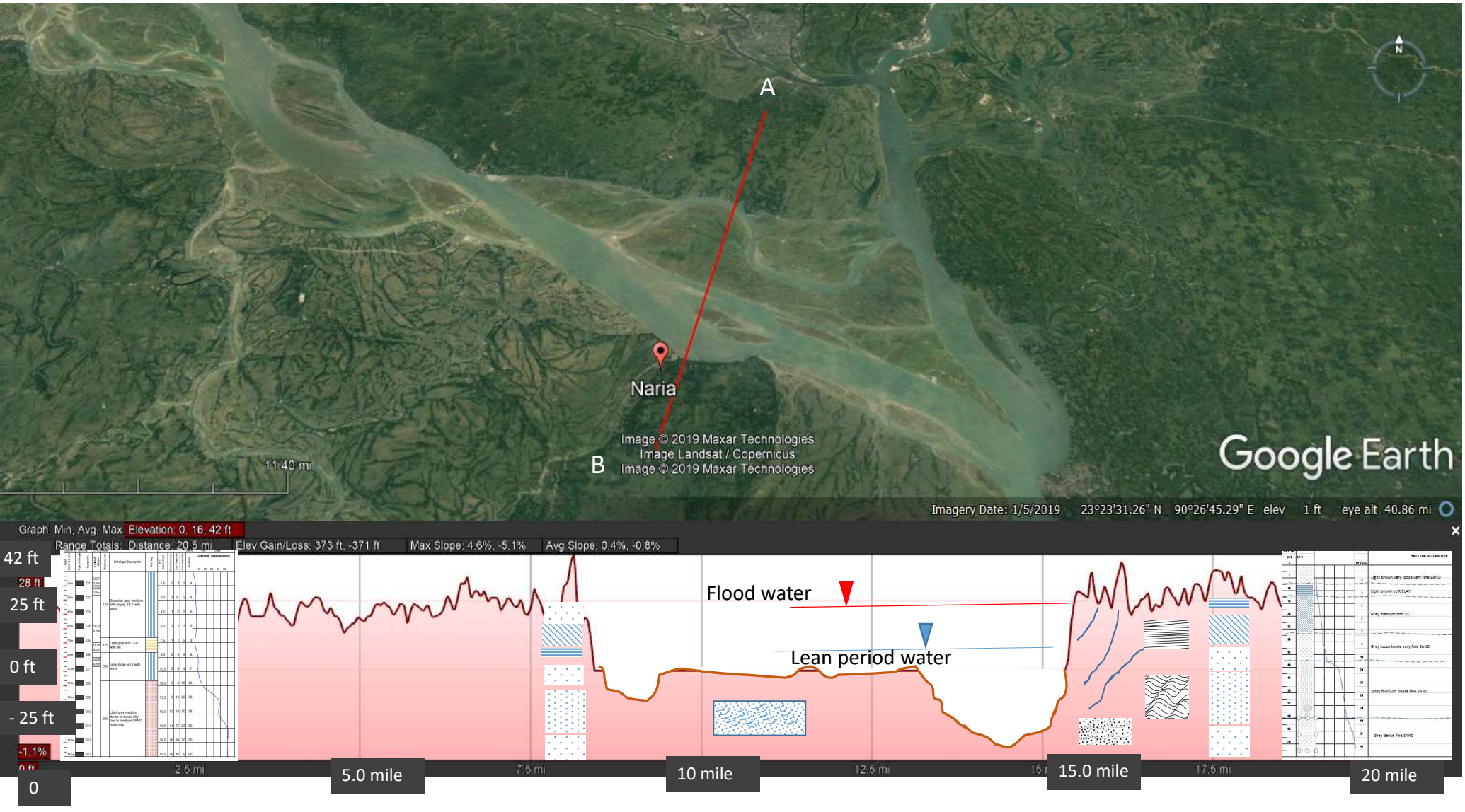
A method for measuring the rate of bank erosion and bank failure processes for the rivers like Padma is not appropriately performed or analyzed. The water discharge and the effects of hydraulic factors, bank geometry, properties are unique and never been modeled or tested.



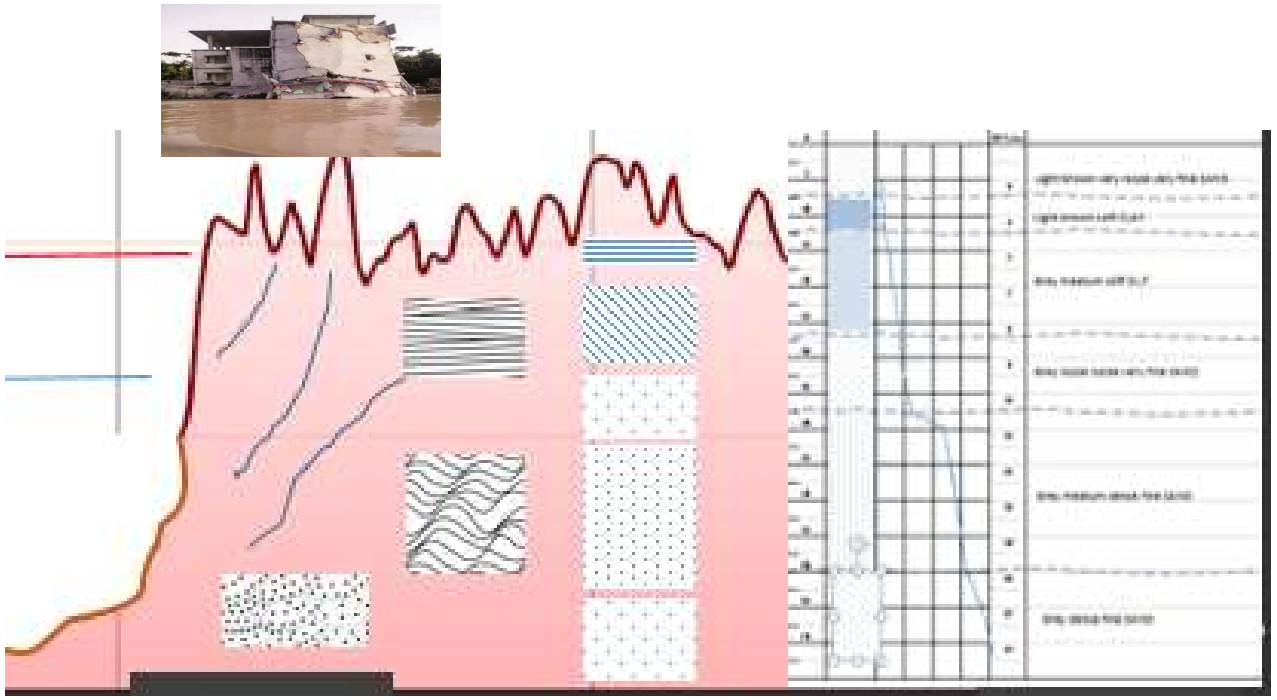
Left Bank

Alternating cross-bedded silt and micaceous fine sand of very high dilatancy and low angle of friction due to presence of micaceous sand.

Right Bank

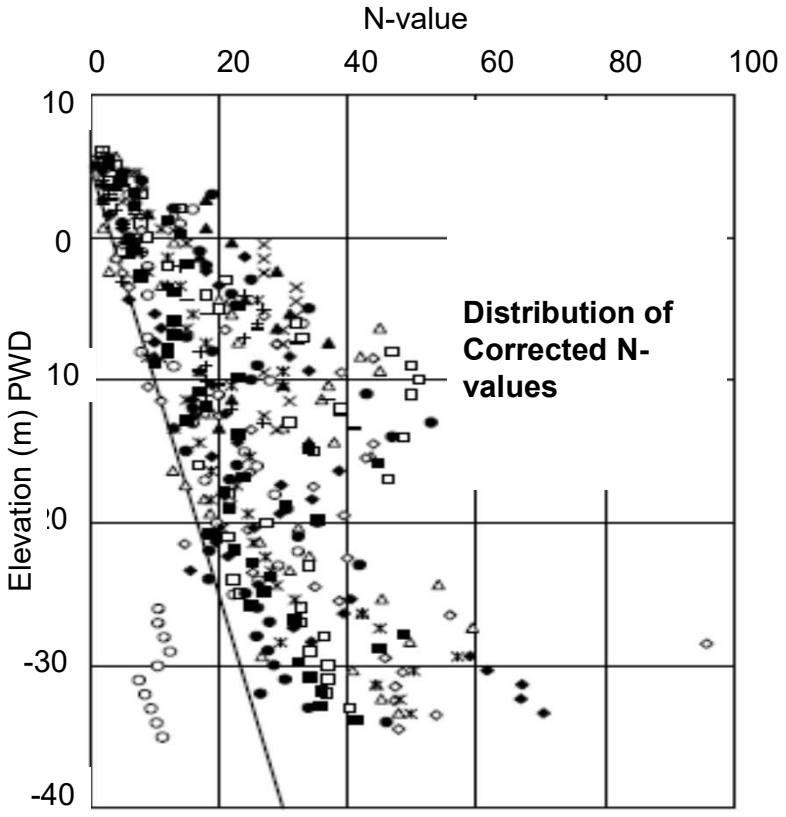

A
B
Naria
11.40 mi
Image © 2019 Maxar Technologies
Image Landsat / Copernicus
Image © 2019 Maxar Technologies
Google Earth
Imagery Date: 1/5/2019 23°23'31.26" N 90°26'45.29" E elev 1 ft eye alt 40.86 mi
Graph: Min, Avg, Max Elevation: 0, 16, 42 ft
Range Totals: Distance: 20.5 mi
Elev Gain/Loss: 373 ft, -371 ft
Max Slope: 4.6%, -5.1%
Avg Slope: 0.4%, -0.8%
42 ft
28 ft
25 ft
0 ft
- 25 ft
-1.1%
Flood water
Lean period water
2.5 mi
5.0 mile
7.5 mi
10 mile
12.5 mi
15.0 mile
17.5 mi
20 mile
0

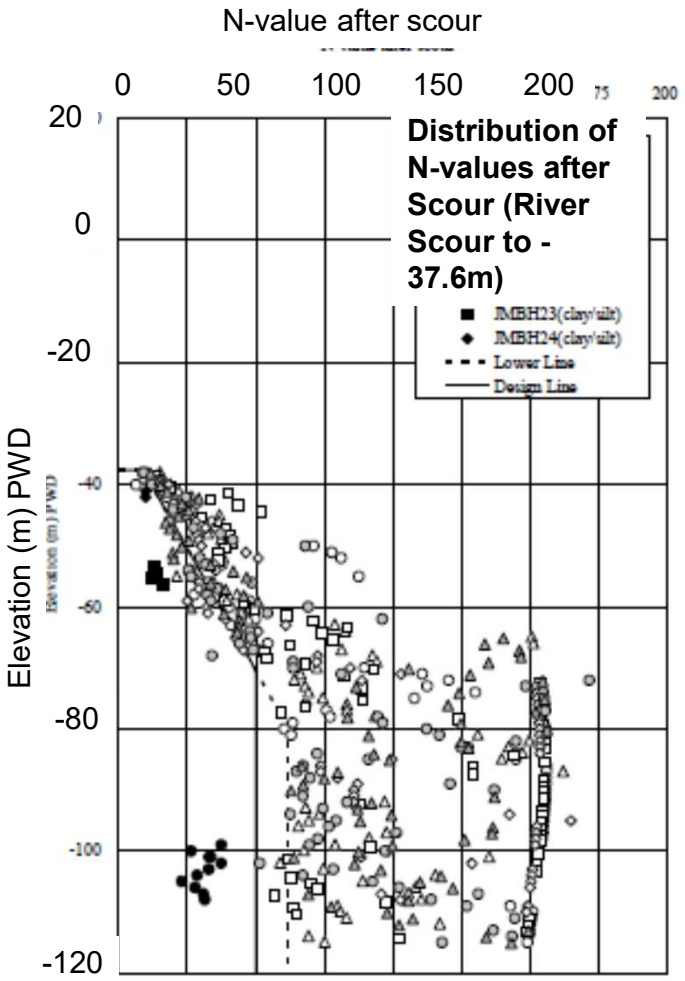
Development of bank failure processes



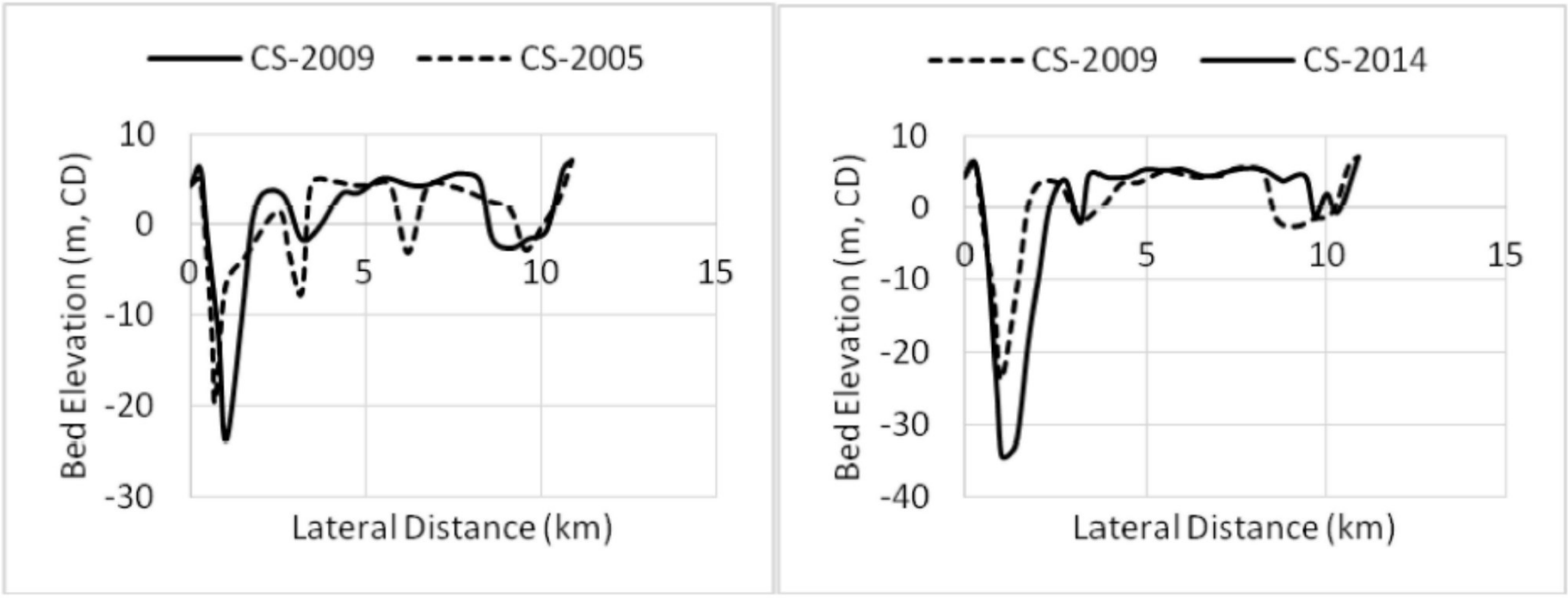
Preexisting fractures, inconsistent lithology, Hydrodynamic characteristics like Permeability and drastic changes in pore water pressure (PWP) including negative PWP, due to agricultural landuse and fall and rise of river water stages bank failure processes are evolved.

Geotechnical Characteristics





RIVER BED CONFIGURATION -The deep trenches form along right bank and render the ground increasingly more vulnerable to subaqueous slope failure due to presence of thick (~200 ft.)



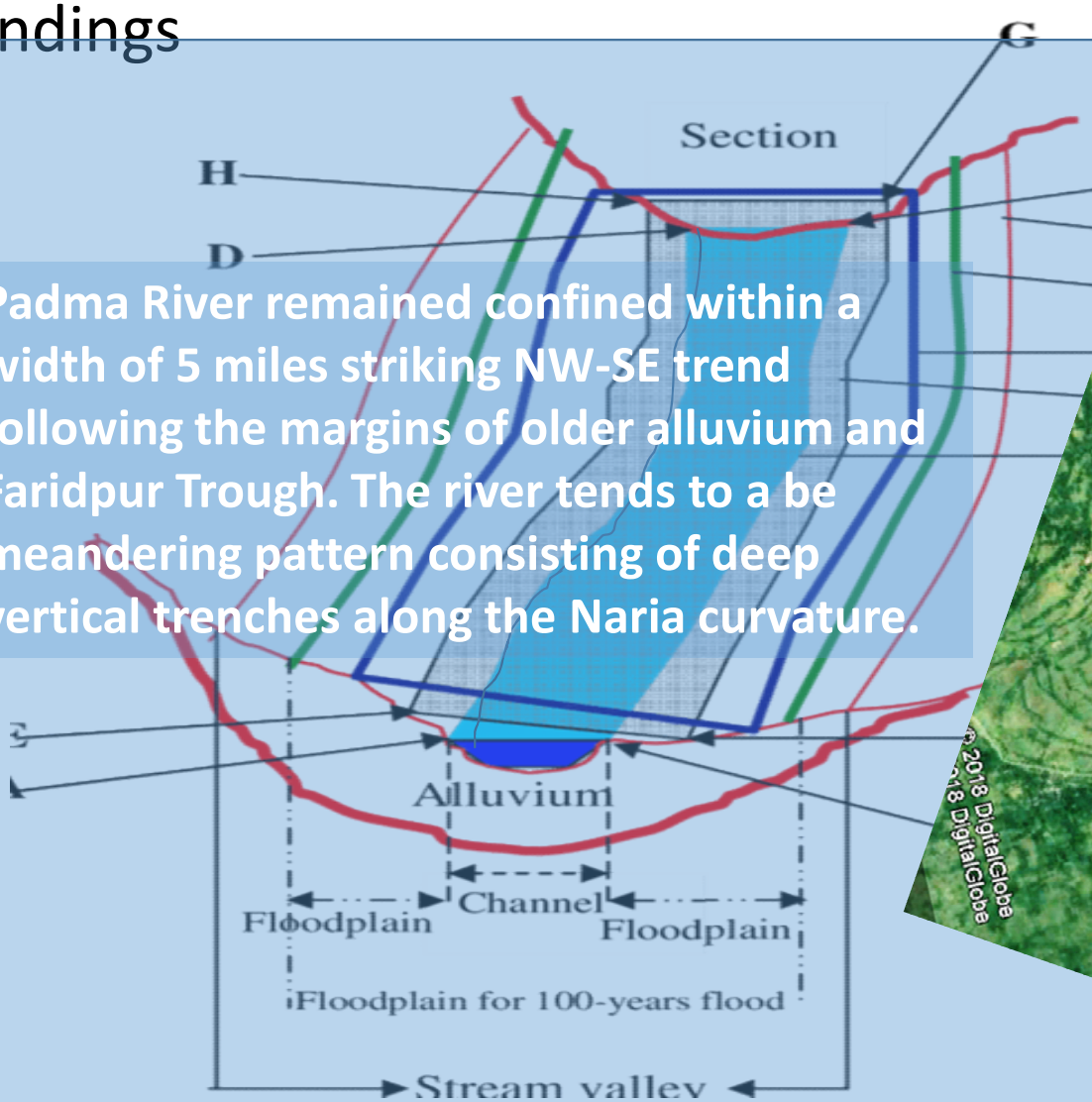
A typical cross sectional variation of Padma River at Bauria BWDB Station between 1996 and 2014

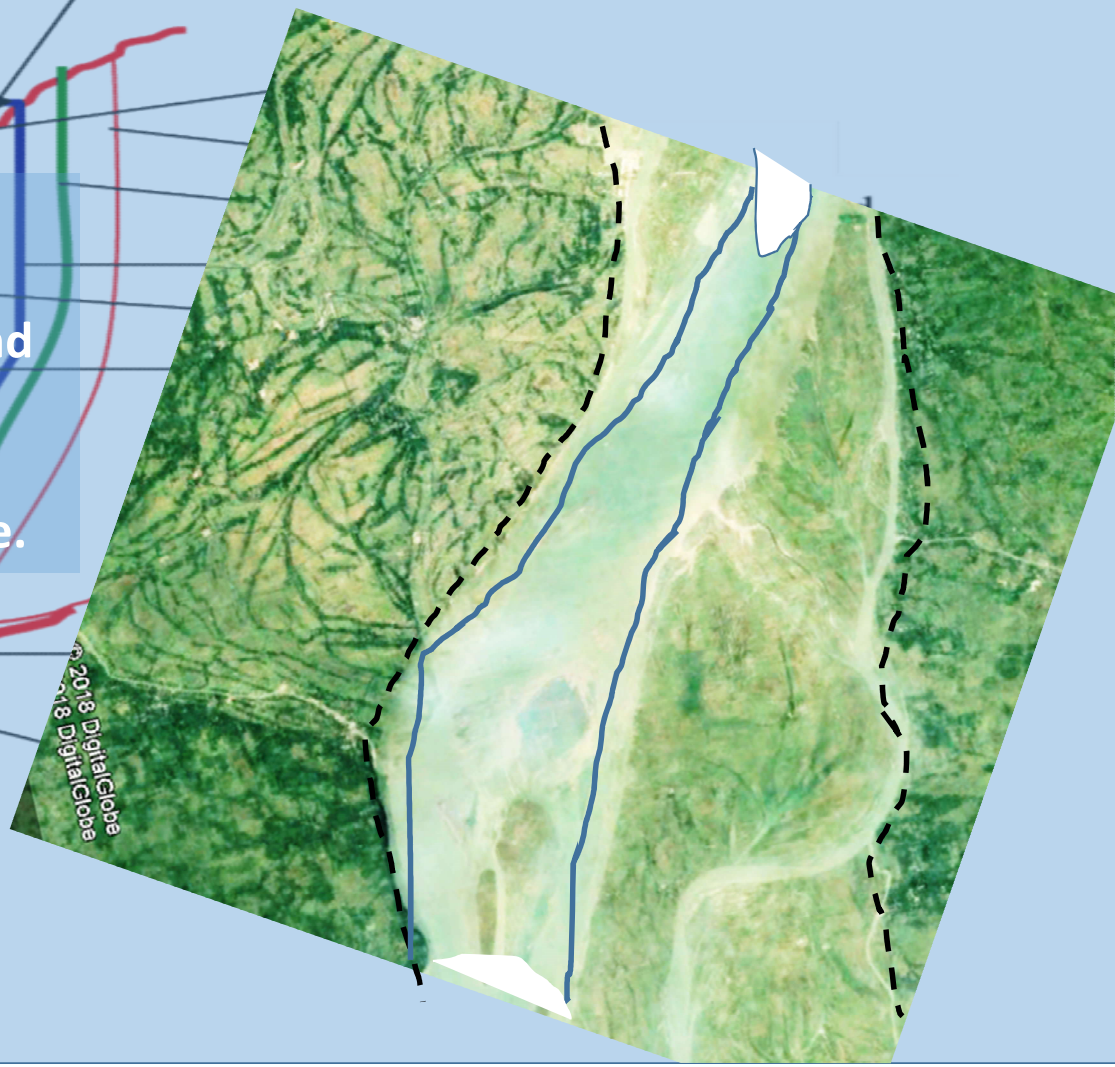
An investigation by Uddin. M J. et al (2017) at Baruria Transit station showed a dynamic behavior and deep bed level variations.

Reference: Md. Jahir Uddin, Prokashon Chakma, S.M.Abdullah Al Faruq STUDY OF WATER AND BED LEVEL VARIATION IN THE GANGES-PADMA RIVER, BANGLADESH Journal of Civil Engineering, Science and Technology 8(2):96-107 · August 2017

Findings

Padma River remained confined within a width of 5 miles striking NW-SE trend following the margins of older alluvium and Faridpur Trough. The river tends to a be meandering pattern consisting of deep vertical trenches along the Naria curvature.



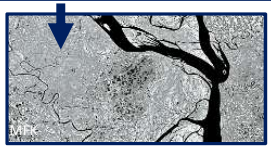


Development of Live Geologic-Map System (LGMS)

Field Observation and Monitoring System Installations by Geology Team

Data Transmission

Data Processing by Geological Mapping Experts and Remote Sensing Laboratory



Data Retrieve and Processing

National Geological Survey Organization and Quality Control

Setting up of applicable dynamic mapping tolls for measuring river erosion, thalweg depth, floodwater and surface runoff, landslides, land degradation, subsidence, slope movements, pre-seismic and pre-volcanic surface creeping and ground deformation at target area/region.

Continuous Live High Resolution and Large Scale Satellite Imagery of the target area/region from image providers and Digital Drone Survey

Real Time Monitoring

LGMS

Data Publishing Processes

Data Distribution

Live Geologic-Map System

Decision makers and / or Response Team

This LGMS flow diagram is created by Mir Fazlul Karim PG (NY). The detail Application Procedure and Installation System may be available from the author. This may be used for the global benefit with the due acknowledgement to geologist.karim@gmail.com

CONCLUSIONS

Padma River remained confined within a width of 5 miles striking NW-SE trend following the margins of older alluvium and Faridpur Trough.

The river tends to a meandering pattern consisting of deep vertical trenches along the Naria curvature.

The deep trenches form along right bank and render the ground increasingly more vulnerable to subaqueous slope failure due to presence of thick (~200 ft.) alternating cross-bedded silt and micaceous fine sand of very high dilatancy and low angle of friction due to the mineralogy.

CONCLUSIONS

The present study identifies some application of technological advancement for developing real-time engineering geological mapping systems for monitoring and managing complex river bank erosion. The authors proposes Development of Live Geologic-Map System (LGMS)

Large scale 3D engineering geological map coupled with air-borne photogrammetric and radar inferrometry methods can be applied for real-time monitoring and prediction of differential settlements, subaqueous failures and ground movement.

The point cloud maps developed using data from these systems can refine engineering geological maps for decision makers and improve the design of protective measures and sustainable engineering structures.

Live Geologic-Map System (LGMS)

The LGMS is designed and created by Mir Fazlul Karim. The authors are interested for development, implementation and execution of the proposed system by the Geological Survey of Bangladesh. A team of geologists leaving in USA is looking forward to explore for funding from any appropriate agencies like USAID, NSF, EU, UNESCO or GoB

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GSA 2019
22–25 September
Phoenix, Arizona, USA

THANK YOU
FOR YOUR KIND PATIENCE

Geocomp

THE CITY UNIVERSITY OF NEW YORK
FOUNDED IN 1847

GeoTesting
EXPRESS