Save Sundarbans from Coal Pollution: Shift Rampal Power Plant to Safe Location

Keynote Paper

By

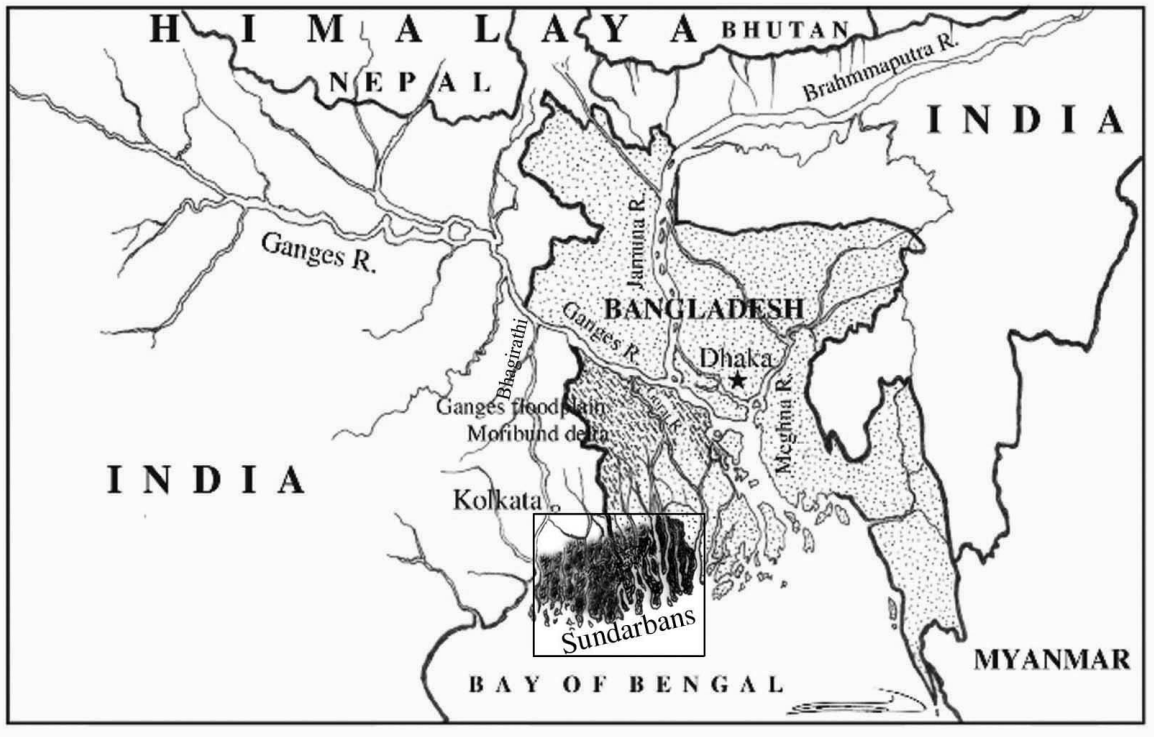
Dr. Abdul Aziz

Professor of Botany

University of Dhaka

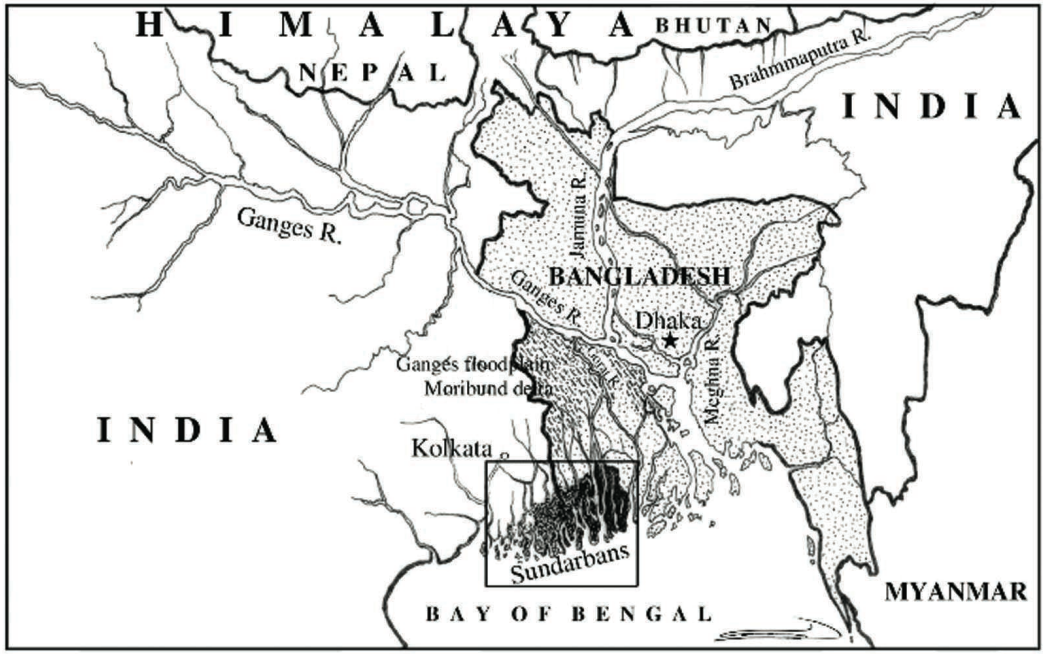
Sundarbans

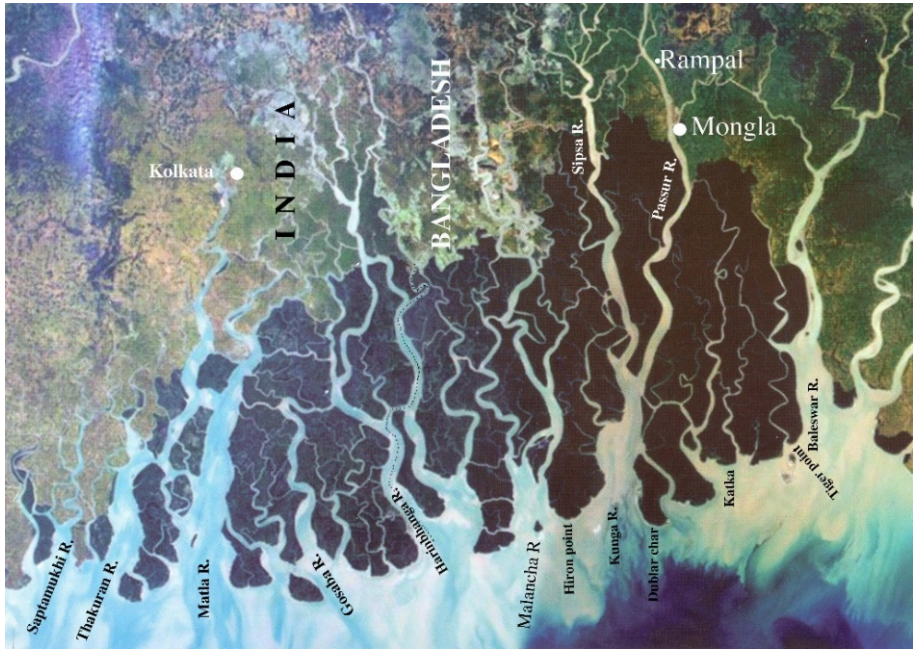
Sundarbans is a deltaic mangrove forest, formed about 7000 years ago by the deposition of sediments from foothills of Himalayas through Ganges river system, West Sundarban by Bhagirati R. and East Sundarbans by Gorai R. **Thus, Sundarbans has had great influence to local freshwater environment, facilitating profuse growth of Sundri, the tallest economically important plant. If any river is cut off from the Ganges or disturbed, Sundri growth/Sundarbans will be affected.**



Natural degradation of Western Sundarbans

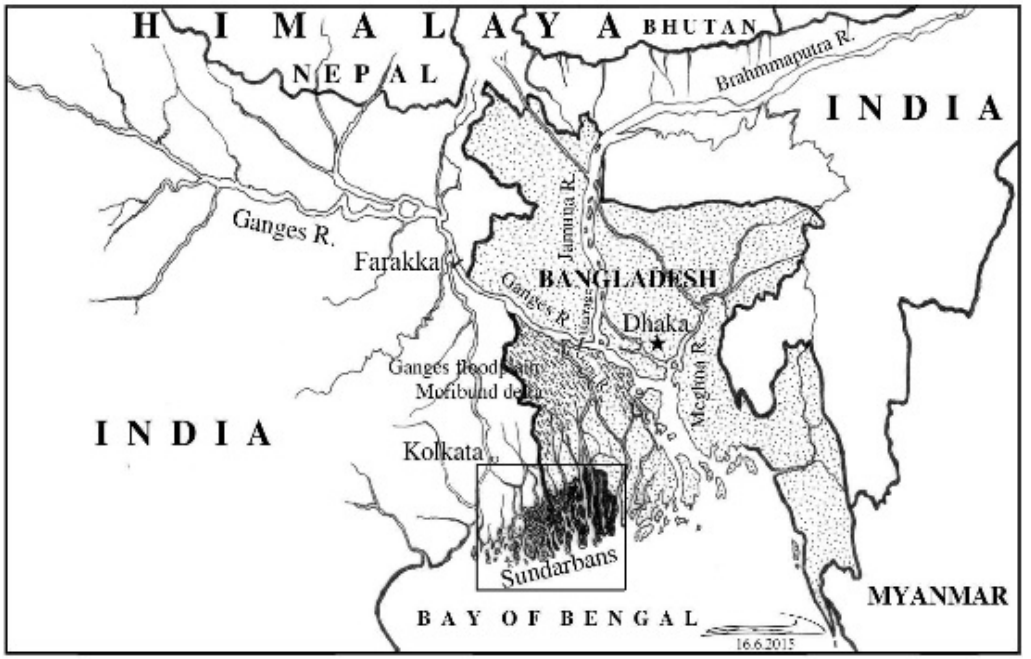
About **1000 years ago** Bengal Basin tilted due to Earthquake resulting dissociation of the Bhagirathi River from the Ganges R. Due to lack of freshwater supply from the Ganges, Western Sundarbans in India degraded, a **"Natural process".**





Manmade degradation of Eastern Sundarbans

Since 21 April 1975 India started operating the Farakka Barrage and freshwater discharge into the Bangladesh territory was limited. For some days during April every year freshwater does not reach up to the Bangladesh Sundarbans and degrading since then, a **"Manmade process".**



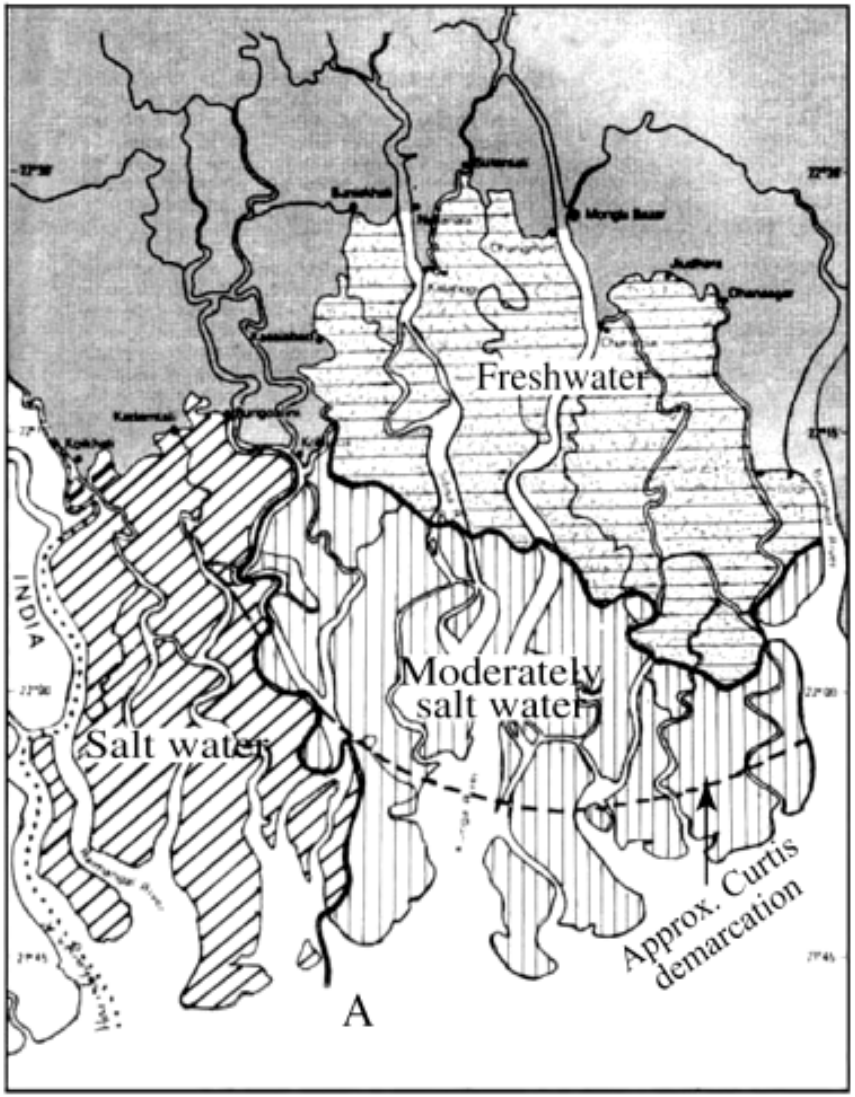
Manmade degradation of Eastern Sundarbans

Due to low discharge of sediment containing water, millions of tons of sediments deposited in the Padma and in Gori R. that obstructed water flow to the Passur R. and Sundarbans.

Low discharge from Farakka inresed Salinity in the Sundarbans

Curtis (1933, dashed line) got freshwater zone in the north and moderately saline zone in the south.

Chaffey (1985) got freshwater zone in the north, moderately saline in the middle and salt water zone in the south after 10 years of Farakka barrage operation.



Dominant vegetation of three ecological zones in the Sundarban Mangrove Forests (Nazrul Islam 2003)

Low saline

1. ***Heritiera fomes*** **(Ab)-Sundri**
2. *Excoecaria agallocha* (Ab)
3. *Porteresia coarctata* (Ab)
4. *Hibiscus tiliaceous* (F)
5. *Avicennia alba* (F)
6. *A. officinalis* (F)
7. *Sonneratia apetala* (F)
8. *S. caseolaris* (F)
9. *Amoora cucullata* (F)
10. *Barringtonia racemosa* (F)
11. *Acanthus ilicifolius* (F)
12. *Derris trifoliate* (F)
13. *Cynometra ramiflora* (Oc)
14. *Sapium indicum* (Oc)
15. *Cerbera manghas* (Oc)
16. *Lumnitzera racemosa* (Oc)
17. *Tamarix indica* (Oc)
18. *Pongamia pinnata* (Oc)
19. *Pandanus foetidus* (Oc)
20. *Pharagmites karka* (Oc)
21. *Nypa fruticans* (Oc)
22. *Typha elephantine* (Oc)
23. *Acrostichum aureum* (Oc)
24. *Clerodendron inerme* (R)
25. *Flagellaria indica* (R)
26. *Caesalpinia cristata* (R)
27. *Dendropthoe falcate* (R)
28. *Mucuna gigantean* (VR)
29. *Tetrastigma bracteolatum* (VR)
30. *Ceriops decandra* (VR)

Medium sline

1. ***Excoecaria agallocha*** **(Ab)- Gewa**
2. *Rhizophora mucronata* (Ab)
3. *R. apiculata* (Ab)
4. *Heritiera fomes* (Ab)
5. *Nypa fruticans* (F)
6. *Kandelia kandel* (F)
7. *Bruguiera sexangula* (F)
8. *Sonneratia apetala* (F)
9. *Ceriops decandra* (F)
10. *Porteresia coarctata* (Oc)
11. *Tamarix indica* (Oc)
12. *Dalbergia spinosa* (Oc)
13. *D. Candenatensis* (Oc)
14. *Petunga roxburghii* (R)
15. *Brownlowia tersa* (R)
16. *Pandanus foetidus* (R)
17. *Phoenix paludosa* (R)
18. *Sarcolobus globosus* (R)
19. *Mucuna gigantea* (VR)
20. *Clerodendron inerme* (VR)
21. *Finlaysonia maritima* (VR)

High saline

1. ***Ceriops decandra*** **(Ab)-Goran**
2. *Aegiceras cornculatum* (Ab)
3. *Bruguiera gymnorhiza* (Ab)
4. *B. sexangula* (F)
5. *Xylocarpus granatum* (F)
6. *X. mekongensis* (F)
7. *Kandelia candel* (F)
8. *Nypa fruticans* (F)
9. *Phoenix paludosa* (F)
10. *Brownlowia tersa* (F)
11. *Acanthus ilicifolius* (F)
12. *Acrostichum aureum* (F)
13. *Microsolen cochinchinensis* (R)

Effects of salinity increase

GROWING STOCKS DECREASING YEAR AFTER YEAR

Table 5. Inventories of Sundarbans forest's growing stocks (no. per ha) and products

Sl. no.	Inventory/trend	Sundri (dbh ≥ 15 cm)	Total trees
1.	1959	211	296
2.	1983	125	180
3.	1996	106	144

- **Salt in the water, salt in the soil - already, the Sundarbans is declining due to rising salinity.**
- **This happened due to manmade Factor, the Farakka Barrage.**

When the Bangladesh Sundarbans is already affected by Farakka barrage another manmade factor is at the door-step that will destroy the forest-

THE COAL FIRED POWER PLANT AT RAMPAL!

It is often said that

"Coal Power Plant at Rampal will not have any bad effects on the Bangladesh Sundarbans".

But official document published as "Bangladesh Sundarban Delta Vision 2050" says different.

It is a Vision Document

Forwarded by the Ministry of Environment and Forests.

Published by IUCN in Nov. 2014.

Let us see, what has been said about the Power Plant (pp. 90-93):

"The potential impact identified in the Environmental Impact Assessment (EIA) study for the proposed power plant includes:

-degradation of air quality,

-surface water quality and quantity,

-degradation of fish habitat and diversity,

-disturbance to migration and breeding grounds of aquatic wild-life and fisheries, etc."

"….. According to EIA report, the Rampal power plant will daily release 142 tons of Sulfur dioxide which will be 2-3 times higher than the standard emissions limit for Environmental conservation Rule 1997, Bangladesh.

…… A typical 600 megawatt coal power plant release hot water by 7.5 to 9.3° C higher than the water receives it, creating "thermal pollution". So, 35° C river water temp. in summer will rise by several degree within hours during 'nip-tide' (stagnant for 2 to 3 hours) causing death of aquatic organisms.

So,

1300 MW Power plant may produce hotter water may be 10 to 15^{o} C higher than the river water temperature at the point of discharge causing disaster to Plants, Animals and Microbes by rising temperature by several degrees in Spring and Summer months, when there will be no freshwater pressure from upstream.

As per EIA report, 10 lakh tones Bottom Ash (containing heavy metals- mercury, Arsenic, etc.) generated annually for 30 years would be initially stored in a 100 acre pond, in addition to filling up the area by fly ash. The effects would be:

(i) Leaching will contaminate groundwater, increasing groundwater arsenic further in addition to other metals.

(ii) Tidal-bore, a frequent phenomenon will wash away the ash jeopardizing the flora and fauna of Sundarbans and surroundings.

Eventually, with the completion of the Rampal Power Plant at the currently proposed site, there will be Fly ash/Carbon Soot in the air, blown over to Sundarbans plant community, coating leaves and flowers in dry seasons.

This will occur despite the usage of Advanced USCT filtration technology that will be used at Rampal which has the efficiency of 40-45%, according to experts.

So, over 50% released finer particles of all pollutants would fly all the way to Sundarbans in Winter and Spring seasons.

Effects of Fly-Ash/Carbon Soot

(i) The fly ash layer may form sticky layer on plant parts will reduce the plant's photosynthesis and flower formation and pollination,

(ii) Increase leaf drop affecting plant growth,

(iii) Grazers and other biota will be affected jeopardizing the food chain and forest ecosystem.

(iv) Fruits and seeds formation will be affected- Sundarmbans degradation will be accelerated manifold. (China facts)

Effects of Fly-Ash/Carbon Soot

The air born particles carried over to the Sundarbans ecosystem will cause heavy-metal pollution in water and soil environment affecting growth of all living components.

Ecosystem services or benefits that we are enjoying will be reduced.

Ecosystem services

Establishing "Coal Power Plant at Rampal" we must not damage the Sundarbans, which provides Ecosystem Services in various ways:

(i) First and foremost is the Carbon sequestration reducing the global warming factor.

Ecosystem services

(ii) The total Carbon stock in Sundarbans was estimated to be 55.8 m metric tones in 2010. By Carbon Trading Bangladesh could earn a minimum of US$ 279 m per year.

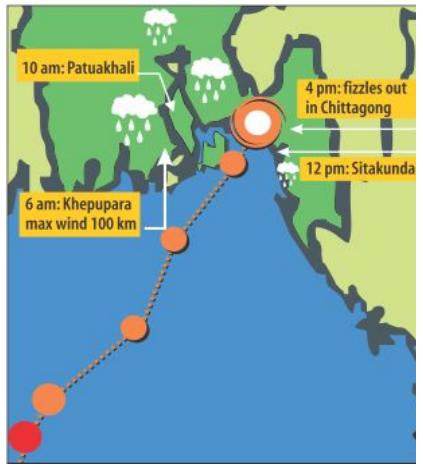
(iii) The carbon deposit would be equivalent to 205 m metric tones Carbon dioxide sequestration. The value is four times the annual carbon dioxide emission rate of Bangladesh fossil fuel consumption.

Sundarban is functioning as a "Natural wall"

It was noted recently that many of the cyclones that were supposed to strike Sundarbans changed their routes towards Chittagong, a feature that is most likely due to buffering of the atmosphere around thousands of square km of the Sundarban Mangrove Forests securing lives and properties value of which is between US$ 273 and 714 million

11 Nov. 1970, wind speed 205 km/h at Bhola.

29 April 1991, wind speed 260 km/h ended at Chittagong.



16 May 2013, "Mahasen" ended at Chittagong.

(Source: The Daily Star)

Bangladesh is a signatory of Copenhagen Accord

Accordingly, we have to save forests, no felling, no damaging of trees.

Establishing Coal Power Plant beside Passur River will obviously damage the Bangladesh Sundarbans.

Shifting to Safe Site

- **Factors of concern that appear to produce from the Coal Power Plant would affect Sundarbans in some way or another.**
- **Considering the present need for power in a developing nation and stance of the govt. regarding the issue, safe locations have been suggested, like shifting to Lobonchora near Khulna town.**
- **However, the proposition of relocation presents a few problems:**

Faults of the proposed relocation

(I) Lobonchora is close to highly populated Khulna City.

(II) Freshwater supply and is limited from Gorai River.

(III) Lack of FW pressure will create Thermal Pollution in the surroundings.

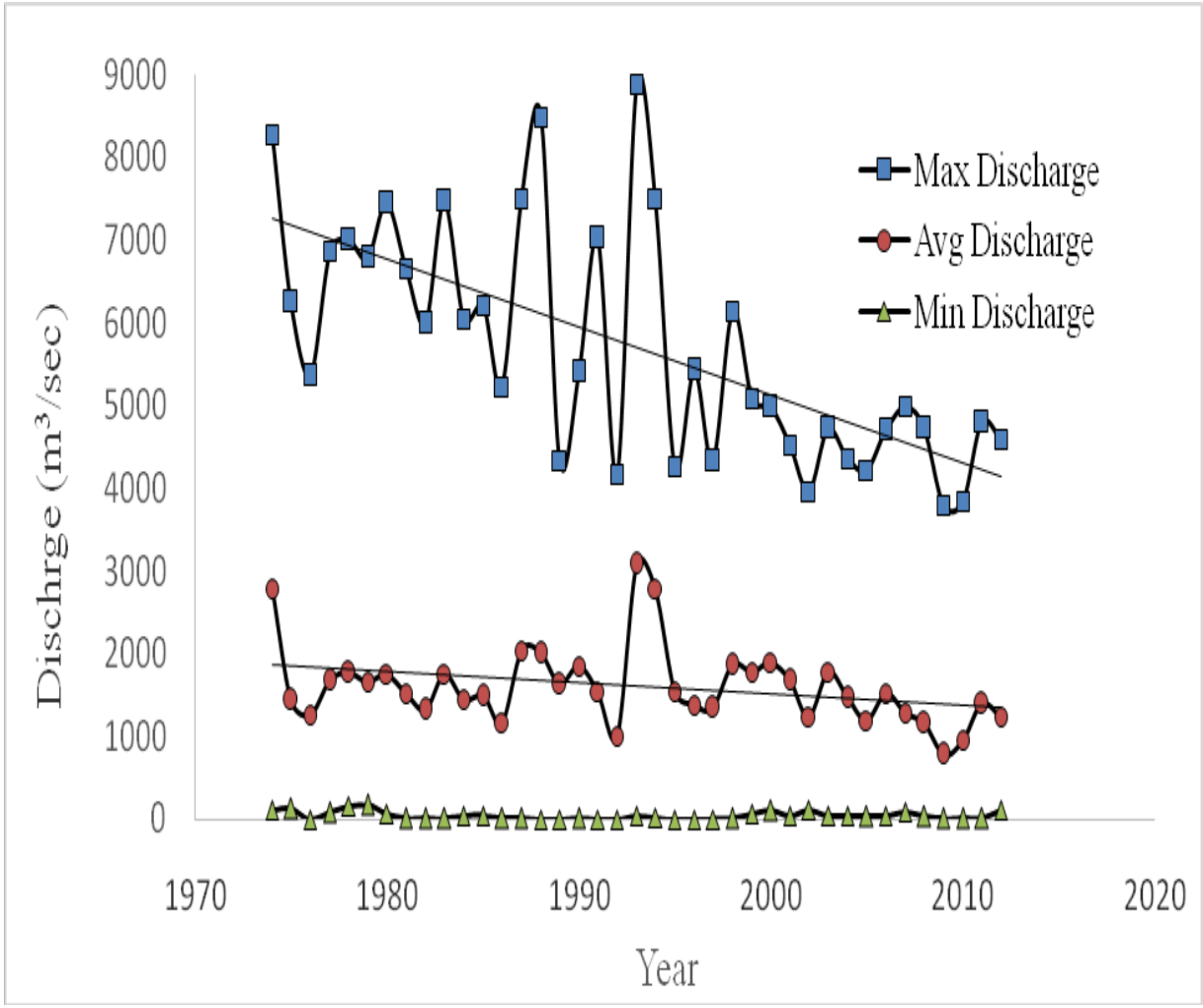
(IV) Passur R. is the life line of Sundarbans. Change even by a single factor will affect the Sundarbans.

Freshwater for the Coal Power Plant is limited

At over 160 km upstream from Sundarbans, monthly minimum discharge varies from 0.00 to 170 cubic meter in summer.

So, no FW supply for some days to weeks in the Gorai R. in dry period.

Obviously, no FW for weeks up to Sundarbans during the period.



Factors to consider a safe site

- **Freshwater pressure from upstream is essential. Lobonchora or Rampal, neither of these locations contain freshwater pressure.**
- **Quick disposal of released 5000 cubic meter hot water to avoid “Thermal Pollution”.**

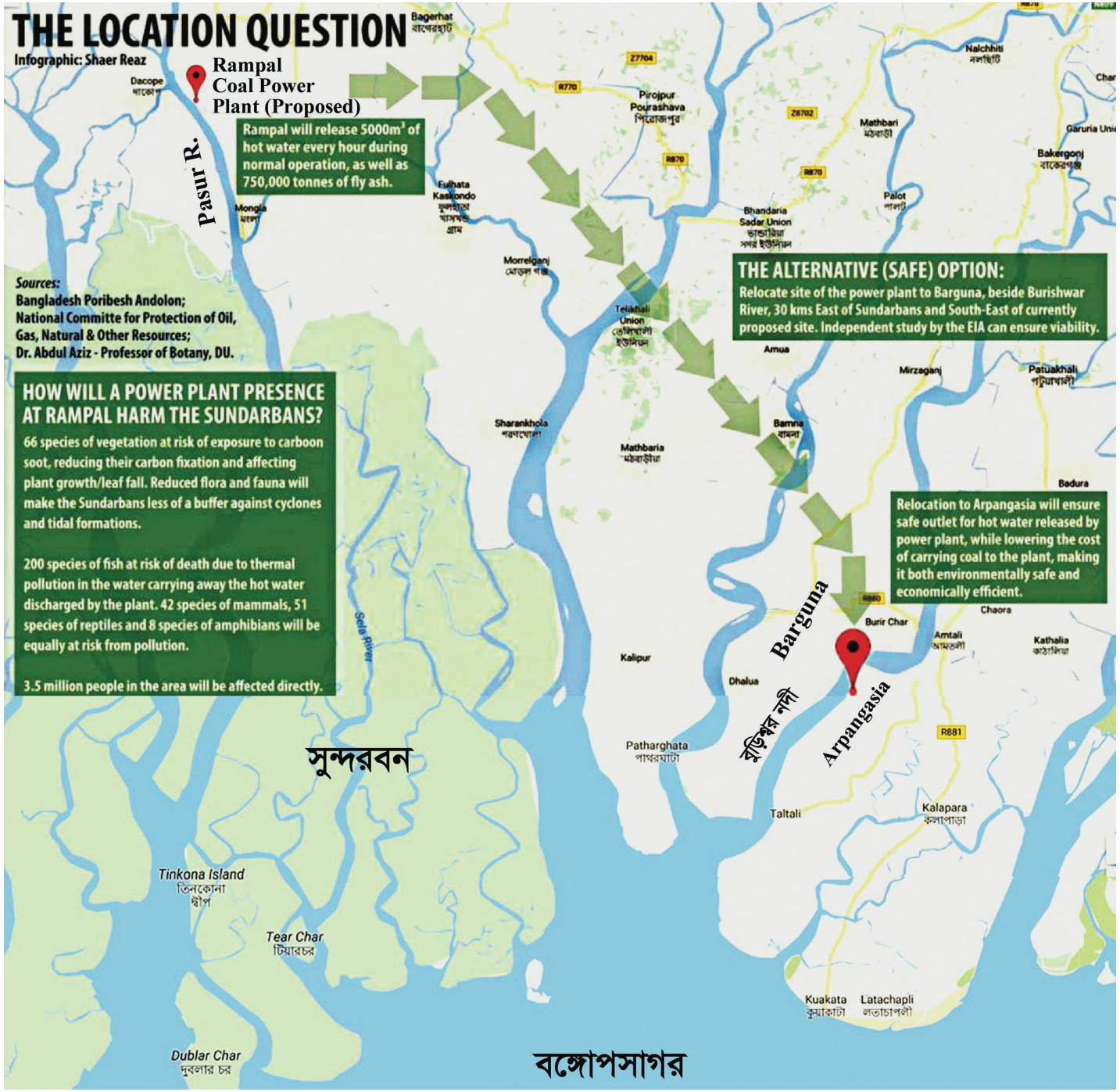
Factors to consider a safe site

- **Transportation of coal through Passur R. must be avoided to safeguard Sundarbans.**
- **Through out the world Coal Fired Power Plant is preferably established near to the coast to avoid above mentioned factors.**
- **Considering the bad impact, Coal Power Pants establishment should be done 50 km away from forests and not in the line of wind directions.**

Proposal

Considering the facts and figures discussed above, a safe area has been identified as shown in the next slide.

Safe site for establishing Coal Power Plant:



Arpangasia beside Buriswar R. appears to be safest place for establishing the Power Plant:

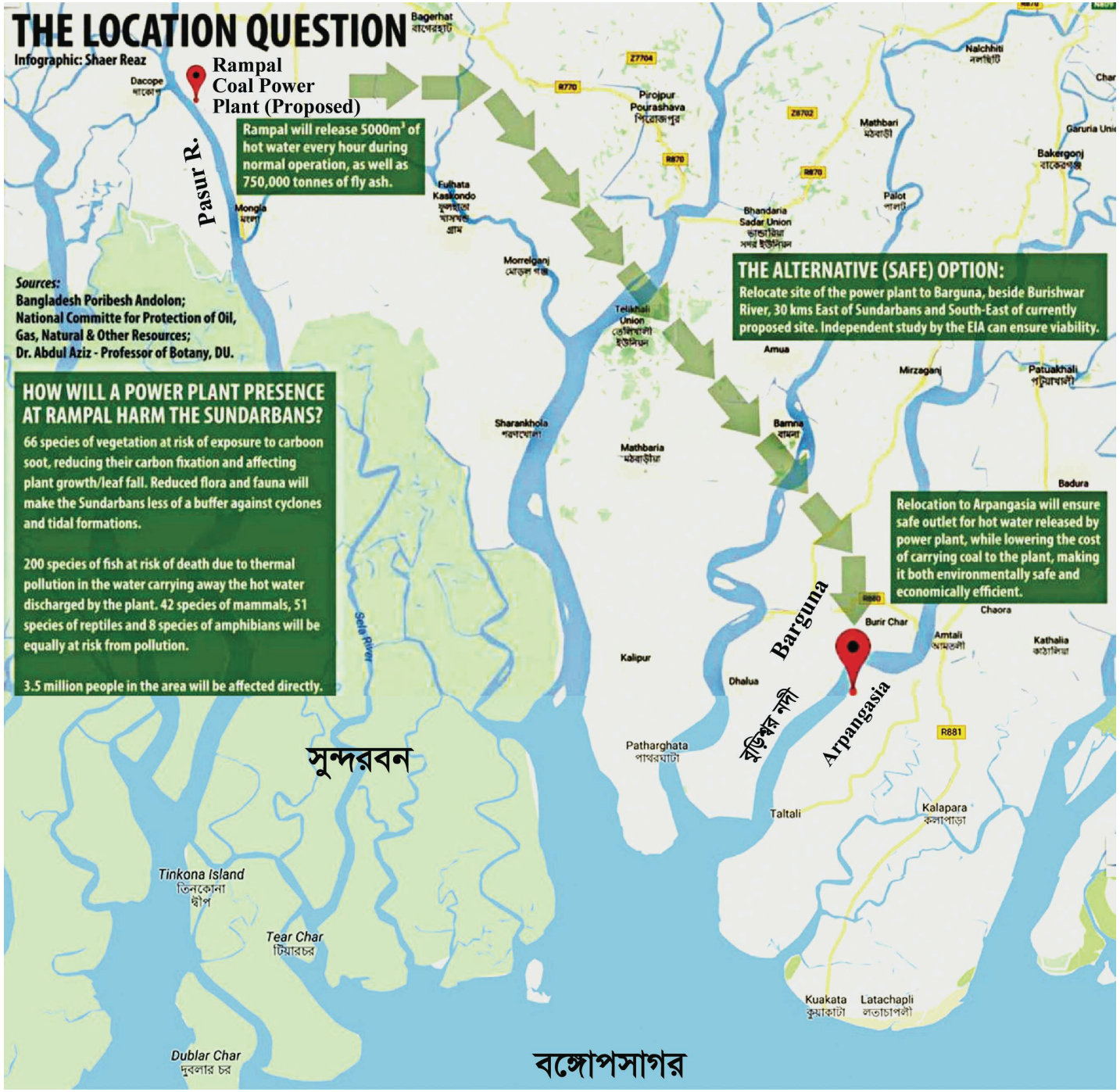
i)The site is 30 km east of Sundarbans, so away from wind directions.

ii)The river is much wider and has regular FW discharge from Meghna- so, no thermal pollution.

iii)The Arpangasia site is close to the coast- so, low carrying cost.

iv) Water pollutants will quickly wash away to the sea.

Safe site for establishing Coal Power Plant.



(v) Arpangasia is thinly populated and relatively remote area.

(vi) For safety reasons instead of dumping bottom and fly Ashes in to open ponds, these may be immediately used up in the production of Portland Cement where 25% Fly Ash is used. So, required number of Cement Industries may be established reallocating transport cost needed for 30 years for the purpose.

Considering the scientific basis provided in the above arguments for relocation of the site, the government should look into doing feasibility study at the suggested location of the east bank of Burishwar River, south-east of the Borguna Sadar, and ensure survival of vital asset to the Nation and the Global climate.

For things created by God

By Mr. Ted Hughes, a poet laureate of Great Britain wrote a remark on 22 Nov. 1989.

For the singers God created
Her voice.
For the poet-
His words.
For Bangladesh-
The Sundarbans.
What happens to the singer-
Who loses her voice.
What happens to the poet-
Who loses his words?
Bangladesh take care
Of the Sundarbans.

An Appeal

Following the feelings of the poet laureate Mr. Ted Hughes

We would like to appeal to our Honourable Prime Minister, please take Arpangasia, at Borguna as safest site for constructing the Coal Powered Power Plant for the sake of SUNDARBANS, the UNESCO heritage.

THANKS

for patience hearing

“An alternative site to the alternative”

As there is no supply of upstream freshwater during summer moths there will be stagnation particularly during “nip-tide” creating “thermal pollution”. Thus both the Rampal and Labanchora sites are not suitable for the power plant.

Site beside Buriswar R. in Borguna has been proposed shown in the next slide.

Why the growing stock decreasing

We are concerned very much with Sundri stock because the plant is tallest quality timber plant storing highest amount of Carbon because:

Seedling survivability rate of *Heritiera fomes* after 33 months of their appearance in the forests of three zones showed that-

6.53% survived in oligohaline,

1.93 and survived in mesohaline and

0.00% survived in polyhaline zones.

Reverse in *Excoecaria agalocha*:

0.391% in oligohaline and

14% in polyhaline zone, indicating salt loving character.

Quality of growing stock deteriorating

Diameter of stems at breast height in *Heritiera fomes* decreases with salinity rise-

0.133 cm/year in oligohaline zone,

0.102 cm/year in mesohaline and

0.062 cm/year in polyhaline zones

Quality of growing stock deteriorating

After about 8 years of Farakka Barrage operation

Height class 1 (plant height is ≥15 m) in the Chandpai Range has fragmented in to:

Height class 2 (plant height 10- <15 m) and

Height class 3 (plant height 3- <10 m making scrubby forests.

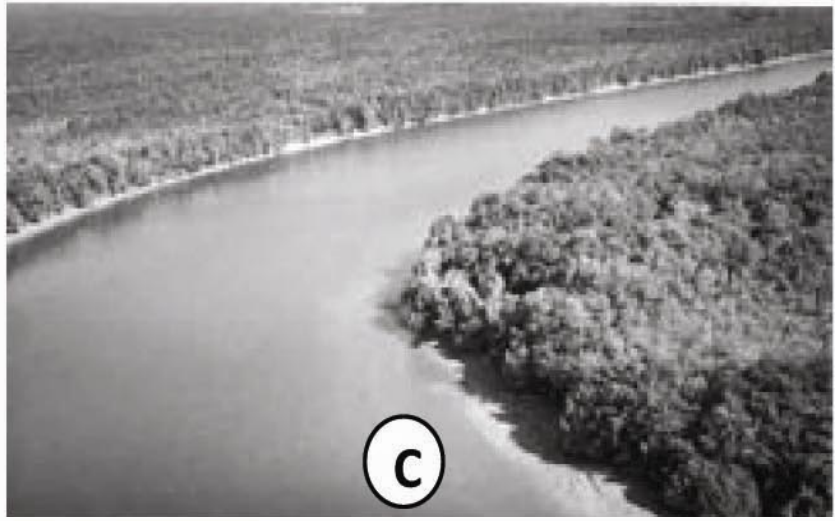
Quality of growing stock deteriorating

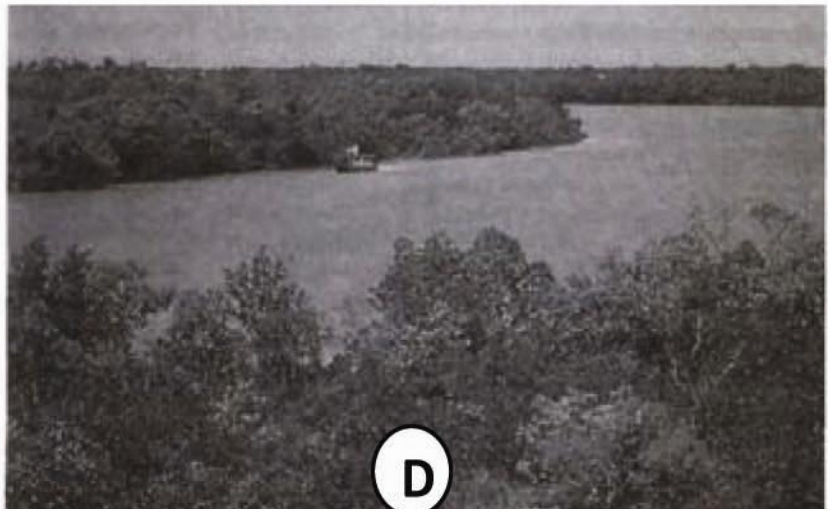
Canopy closure in the three saline zones:

60-100% in oligohaline zone (High Carbon reserve) (C)

40-80% in mesohaline zone

30-70 %, in polyhaline zone (Low Carbon reserve) (D)





Dominant vegetation of three ecological zones in the Sundarban Mangrove Forests (Nazrul Islam 2003)

Oligohaline Zone

1. ***Heritiera fomes* (Ab)**
2. *Excoecaria agallocha* (Ab)
3. *Porteresia coarctata* (Ab)
4. *Hibiscus tiliaceous* (F)
5. *Avicennia alba* (F)
6. *A. officinalis* (F)
7. *Sonneratia apetala* (F)
8. *S. caseolaris* (F)
9. *Amoora cucullata* (F)
10. *Barringtonia racemosa* (F)
11. *Acanthus ilicifolius* (F)
12. *Derris trifoliate* (F)
13. *Cynometra ramiflora* (Oc)
14. *Sapium indicum* (Oc)
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20. *Pharagmites karka* (Oc)
21. *Nypa fruticans* (Oc)
22. *Typha elephantine* (Oc)
23. *Acrostichum aureum* (Oc)
24. *Clerodendron inerme* (R)
25. *Flagellaria indica* (R)
26. *Caesalpinia cristata* (R)
27. *Dendropthoe falcate* (R)
28. *Mucuna gigantean* (VR)
29. *Tetrastigma bracteolatum* (VR)
30. *Ceriops decandra* (VR)

Mesohaline Zone

1. ***Excoecaria agallocha* (Ab)**
2. *Rhizophora mucronata* (Ab)
3. *R. apiculata* (Ab)
4. *Heritiera fomes* (Ab)
5. *Nypa fruticans* (F)
6. *Kandelia kandel* (F)
7. *Bruguiera sexangula* (F)
8. *Sonneratia apetala* (F)
9. *Ceriops decandra* (F)
10. *Porteresia coarctata* (Oc)
11. *Tamarix indica* (Oc)
12. *Dalbergia spinosa* (Oc)
13. *D. Candenatensis* (Oc)
14. *Petunga roxburghii* (R)
15. *Brownlowia tersa* (R)
16. *Pandanus foetidus* (R)
17. *Phoenix paludosa* (R)
18. *Sarcolobus globosus* (R)
19. *Mucuna gigantea* (VR)
20. *Clerodendron inerme* (VR)
21. *Finlaysonia maritima* (VR)

Polyhaline Zone

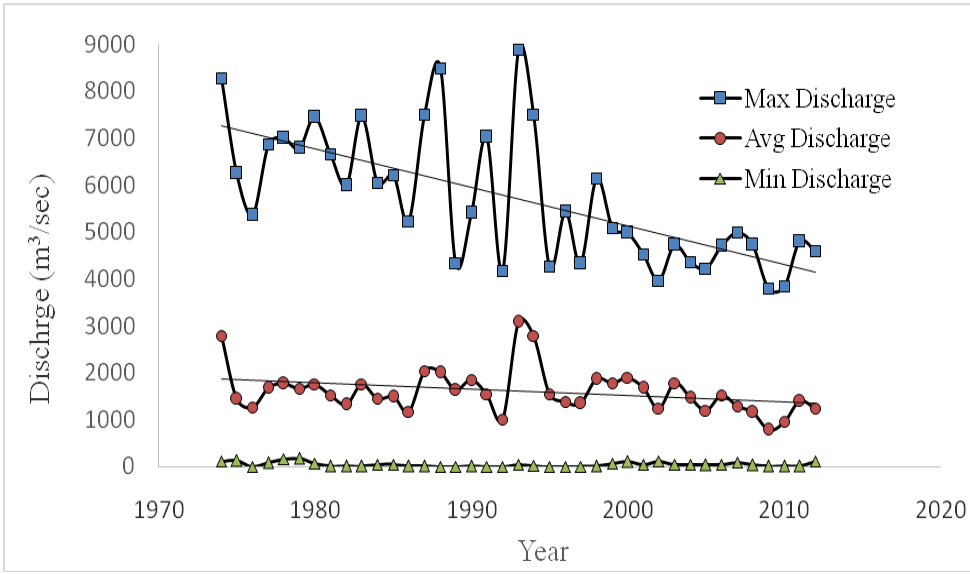
1. ***Ceriops decandra* (Ab)**
2. *Aegiceras cornculatum* (Ab)
3. *Bruguiera gymnorhiza* (Ab)
4. *B. sexangula* (F)
5. *Xylocarpus granatum* (F)
6. *X. mekongensis* (F)
7. *Kandelia candel* (F)
8. *Nypa fruticans* (F)
9. *Phoenix paludosa* (F)
10. *Brownlowia tersa* (F)
11. *Acanthus ilicifolius* (F)
12. *Acrostichum aureum* (F)
13. *Microsolen cochinchinensis* (R)

Conclusion

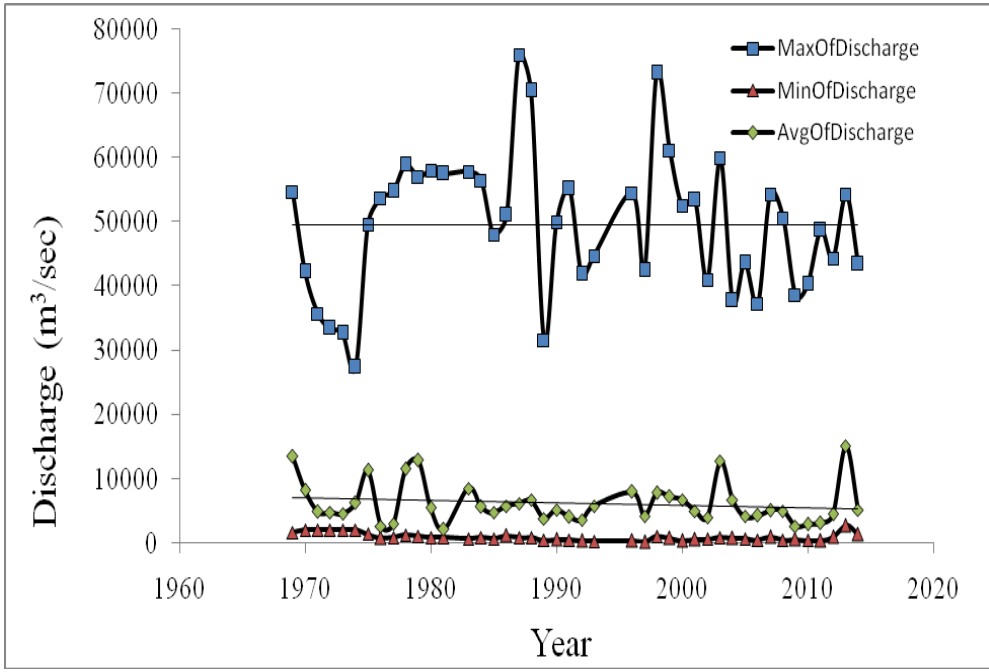
From the previous findings it is clear that salinity increase of above 5‰ is not suitable for Sundri and some other plants reducing mangrove diversity (due to very limited or no freshwater flow in the Gorai R.)

Therefore, we need to discharge at least 194.4 $m^3 s^{-1}$ sediment-laden freshwater deep inside the Sundarbans during dry period to create pre-1975 environment for Sundri plants.

How could we discharge 194.4 $m^3 s^{-1}$ freshwater deep inside the Sundarbans?



Sedimented Gorai R. itself is obstructing the flow, indicated by steep slope of max. water discharge, though at Hardinge bridge max. discharge was similar from 1974 to 2013.



How could we discharge 194.4 $m^3 s^{-1}$ freshwater deep inside the Sundarbans?

The Mega Project may cost over 5 billion $ for a period of 5-10 years. The expenditure may be met through "Carbon Trading" as Bangladesh is a signatory of Copenhagen Accord, UN Framework CCC.

We have to dredge the Gorai R. and push the sand-carrying freshwater towards Sundarbans. Dredging should start from west of Tricon Aila the confluence of Passur and Sipsha rivers where large sediment deposition occurs normally. As soon as it is cleaned the Gorai R. should be divided into 10 segments of 15 km each. 1st segment should be near to northern part of Khulna Range in Passur and dredging should begin as flood period starts for quick disposal. Detail studies of basin morphology and other related issues are needed in a coordinated way

How could we discharge 194.4 $m^3 s^{-1}$ freshwater deep inside the Sundarbans?

Gradually other rivers westwardly like, Shipsa and Arpangasia may be dredged as before.

The whole Ganges floodplain will be reclaimed having salinity free groundwater, with increased agricultural productions and revenue.

Hinterlands like Barendra area will be benefited, reducing desertification.

Water Security: Ganges Barrage

- We should keep in mind that freshwater scarcity will increase in future with little water from transboundaries.
- We have to manage our available water.

- 4,000 to 7,000 m^3 s^{-1} water we receive at Hardinge bridge and we have to hold this water for various uses
- Bangladesh Govt. has developed a Ganges Barrage project.

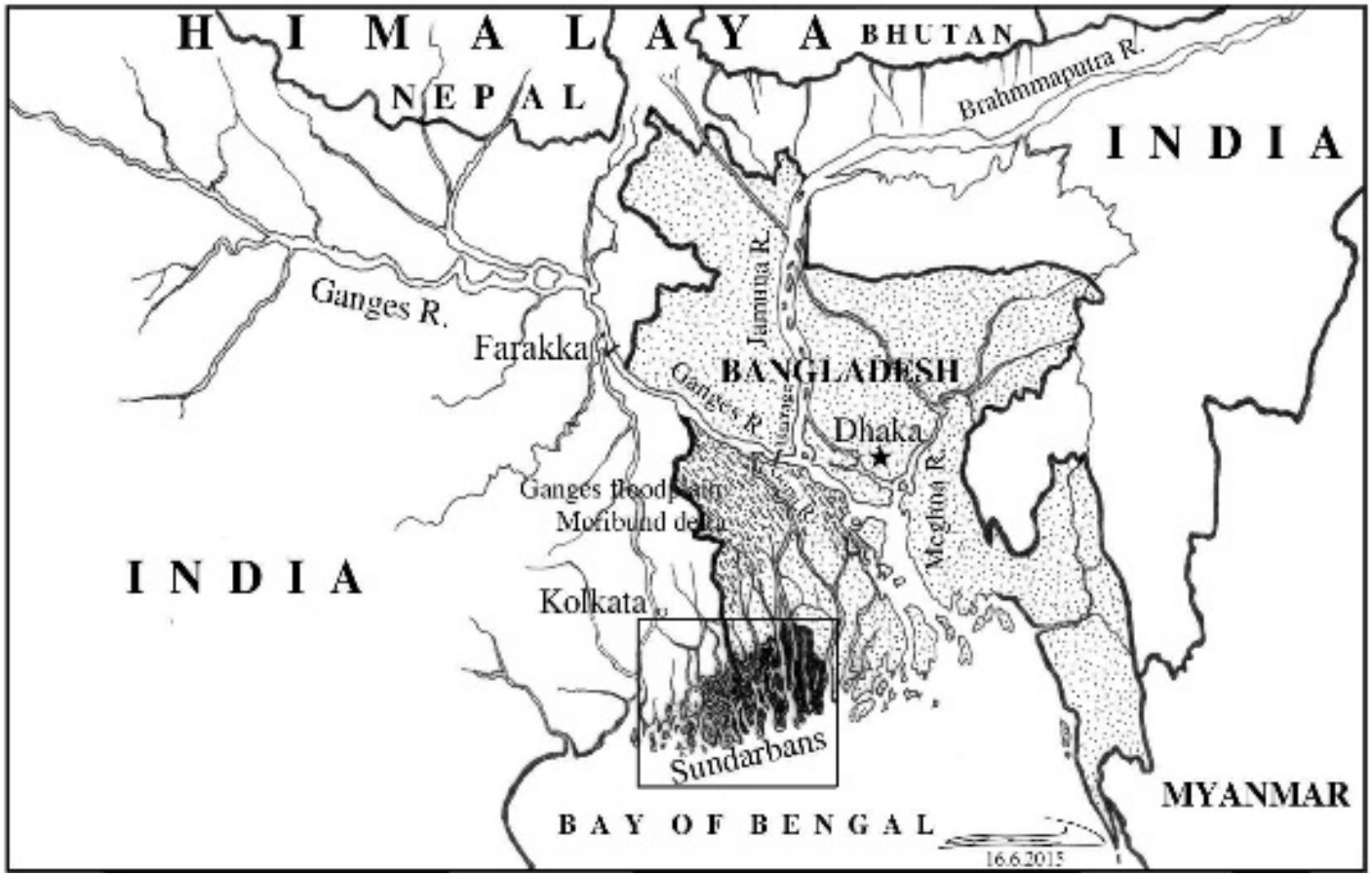
Summery

Farakka Barrage (diverting freshwater needed by India), a manmade factor affected Sudri and other plants of Bangladesh Sundarbans by:

- **No freshwater flow during April in to the Sundarbans through Gorai R.**
- **This caused medium to high salinity which is not suitable for Sundri growth.**
- **Mangrove diversity decreased due to high salinity.**

Water Security: Ganges Barrage

Ganges Barrage Project implementation about 33 km from Gorai R. would ascertain sufficient and uniform freshwater flow for maintining oligohaline environment in the vast Sundarbans Ecosystem.



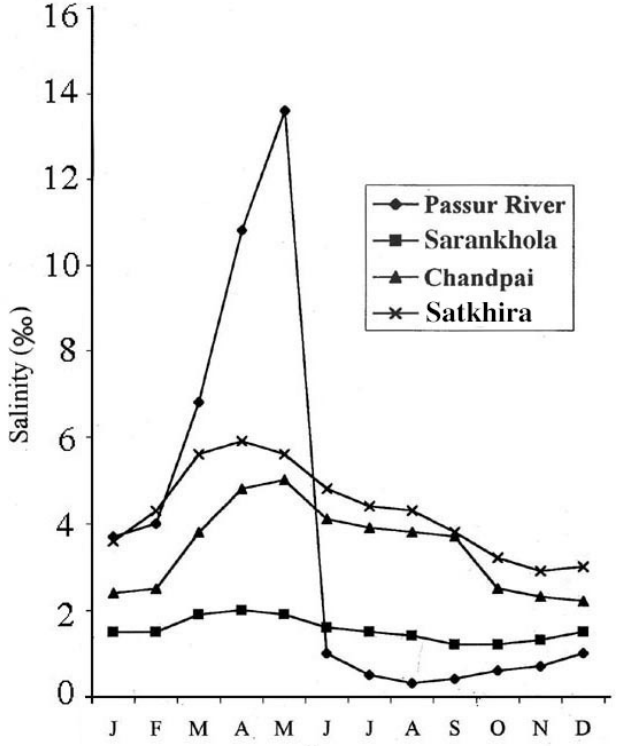
Water Security: Ganges Barrage

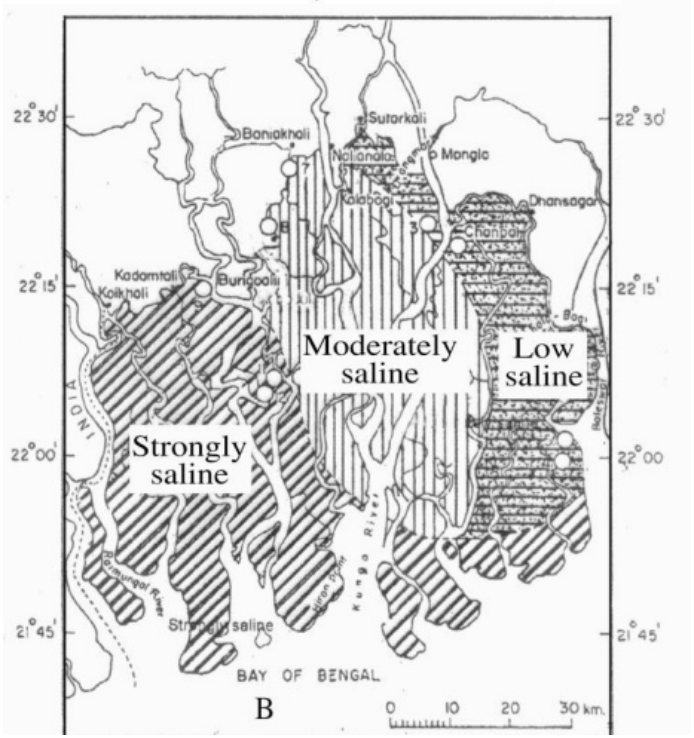
For functioning effectively dredging of Ganges R. basin converting it in to a large water reservoir. Pushing sediment loaded water in to Sundarbans and along the coast of Bay. This will strengthen the forest lands and islands.

Salinity engulfing Sundarbans

As there was no freshwater pressure from upstream, marine water (>30%) intruded easily towards the north through large rivers like Passur and Sipsha increasing the salinity. Other Ranges had lower increase.

Thus, moderately saline zone developed along the two rivers in a north south direction as observes by Siddique (1996).

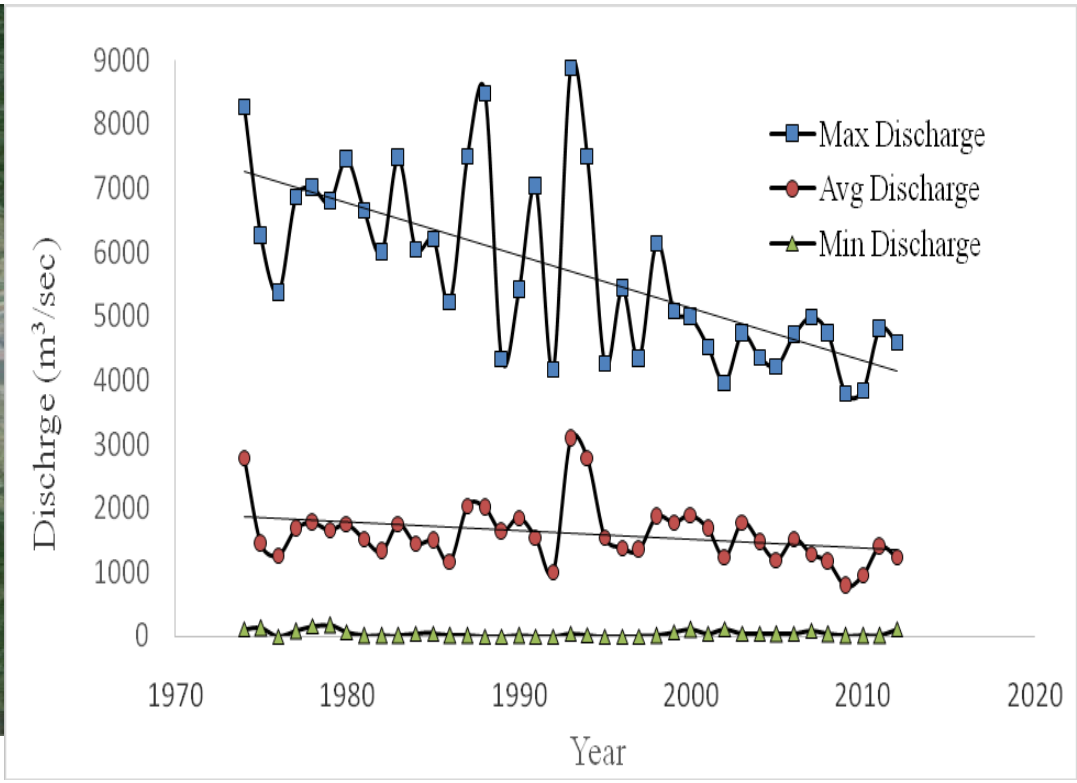




Water security: Consortium for sharing Ganges water

- To ascertain sufficient water from Farakka Barrage, formation of a consortium of India, Nepal, Bhutan and China is essential to contain the vast Sundarbans Ecosystem.

Discharge pattern at Gorai Rl. Bridge



Max. and Average discharges at Gorai Railway bridge formed steep slopes indicating severe sedimentation over the years.

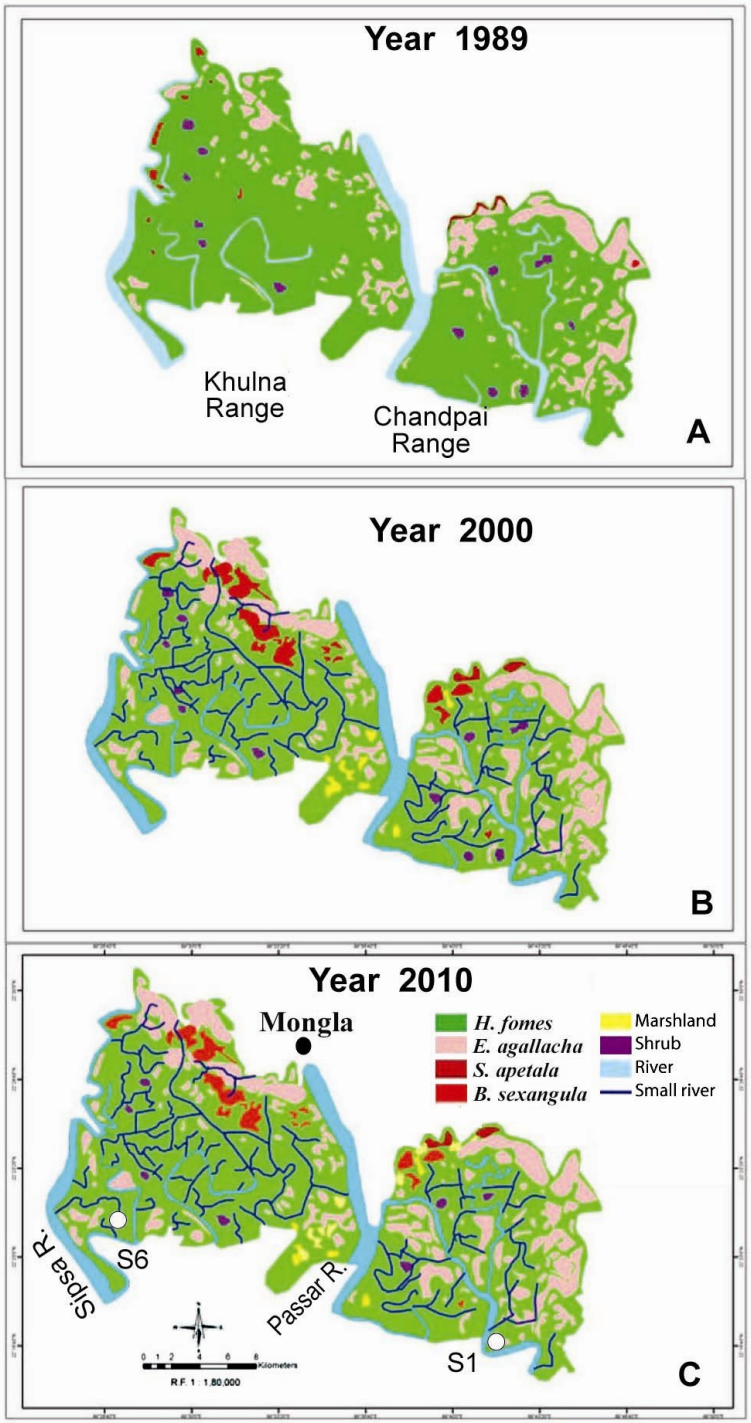
Mean min. discharge at Gorai about 162 km upstream of Sundarbans revealed that on many occasions during April there was no freshwater flow (0.00 to 172 $m^3 s^{-1}$).

Whereas about 194 $m^3 sec^{-1}$ regular flow is needed to keep oligohaline (suitable for Sundri) environment in the SMF.

Changes in forest/water areas northern parts of Khulna and Chandpai ranges.

Giri (2014) estimated that about 66 km^2 Sundarban forests have been washed away mostly from sea facing ones.

A recent study using satellite images we have found that 3.61% forest of Khulna and Chandpai ranges have been lost forming large number of small rivers and creeks some time before 2000. This has happened due to low sediment supply to Sundarbans.



Effects of low or no water-flow on Sundarbans: Forests are washed away

Due to low discharge of freshwater the sediments are deposited on river beds blocking the water flow and depriving Sundarbans with sediments.

The decreased sediment flow into Sundarbans reduces sediment deposition around forests making it vulnerable to wave action and thus forest lands are being washed away. According to Giri et al. 2014 about 66 km^2 forest-lands has been washed away.

Disperse sediments deposited in the Ganges R. bed towards coast

We have lost 66-124 km^2 forestlands already in the last several decades and may be attributed to low sediment deposition.

Similarly Talpotti has been washed away because of lack of sediment supply through Harinbhanga R.

Disperse sediments deposited in the Ganges R. bed towards coast

If deposited sediment of Ganges is not dispersed the coastal lands will remain vulnerable to erosion.

New Islands will not form.

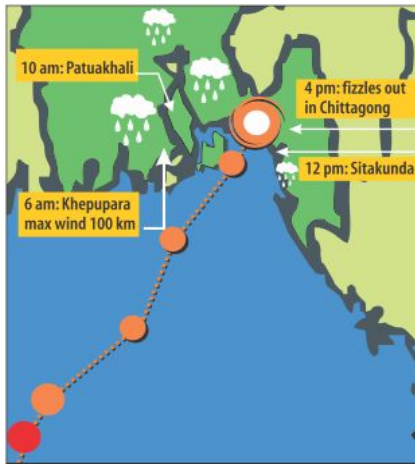
The Climate Change Factors will further aggravate the situation causing destruction of forests and Islands.

Sundarban is functioning as a "Natural wall"

Recently many of the cyclones that were supposed to strike Sundarbans changed their routes towards Chittagong, a feature that is most likely due to buffering of the atmosphere around thousands of square kelometer of the Sundarban Mangrove Forests securing lives and property.

11 Nov. 1970, wind speed 205 km/h at Bhola.

29 April 1991, wind speed 260 km/h ended at Chittagong.



16 May 2013, "Mahasen" ended at Chittagong.

(Source: The Daily Star)

Ecosystem services

- The Bangladesh Sundarbans Mangrove Forests working as a natural wall, saving properties as well as millions of lives from natural disasters, the value of which is between 273 and 714 million US$

Why the growing stock decreasing?

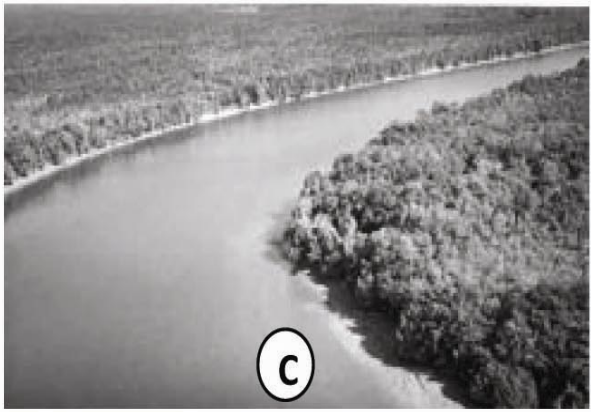
We are concerned very much with Sundri stock because the plant is tallest quality timber plant storing highest amount of Carbon because:

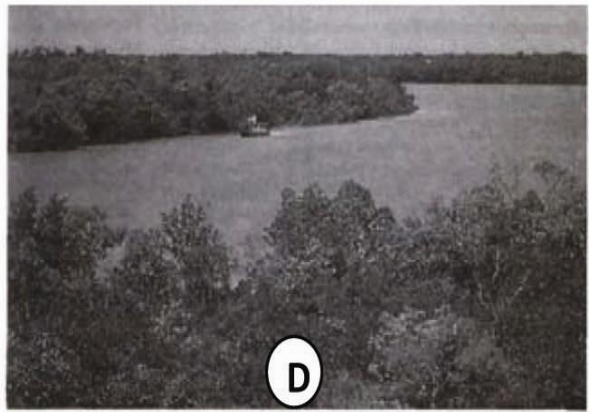
(i) Survivability rate of Sundri seedling after 33 in highly saline soil is 0.00% compared to 6.53% in low saline soil.

(ii) Diameter of stems at breast height

0.062 cm/year in highly saline soil compared to 0.133 cm/year in low saline soil.

(iii) Canopy closure 30-70 %, in highly saline soil but 60-100% in low saline soil.





Why affected?

Decreased discharge or **low flow rate of sediment laden freshwater** has been identified to be **"the main factor"** that affected Sundarbans in two ways:

1st: Due to no or low discharge of freshwater into the SMF, marine water having 33-35‰ salinity gets deep inside increasing the salinity (> 60% is now polyhaline), and

2nd: The decreased flow rate of sediment laden freshwater into SMF resulted low sediment deposition around forests and thus forest lands are being washed away

Why degraded (forests eroding)?

Low sediment-laden freshwater discharged during dry period decreased due to Farakka Barrage compared to Pre-1975.

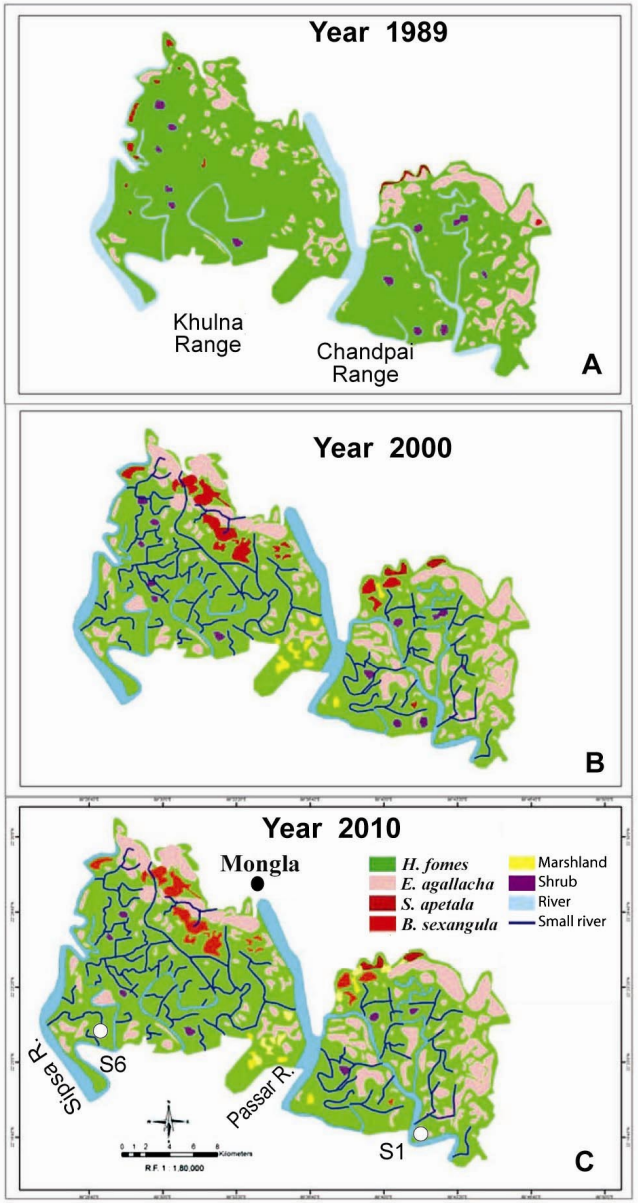
About 262 million ton sediment load/year, but only 7% is discharged into the Bay) and distributeries. So, over 250 million ton sediments are deposited mostly in the Padma, huge amount in Gori the feeding river of Passur.

Sufficient sediment deposition around forest-lands lacking making the forests vulnerable to wave actions and tidal bores. So far 66 or 124 km^2 forests have eroded.

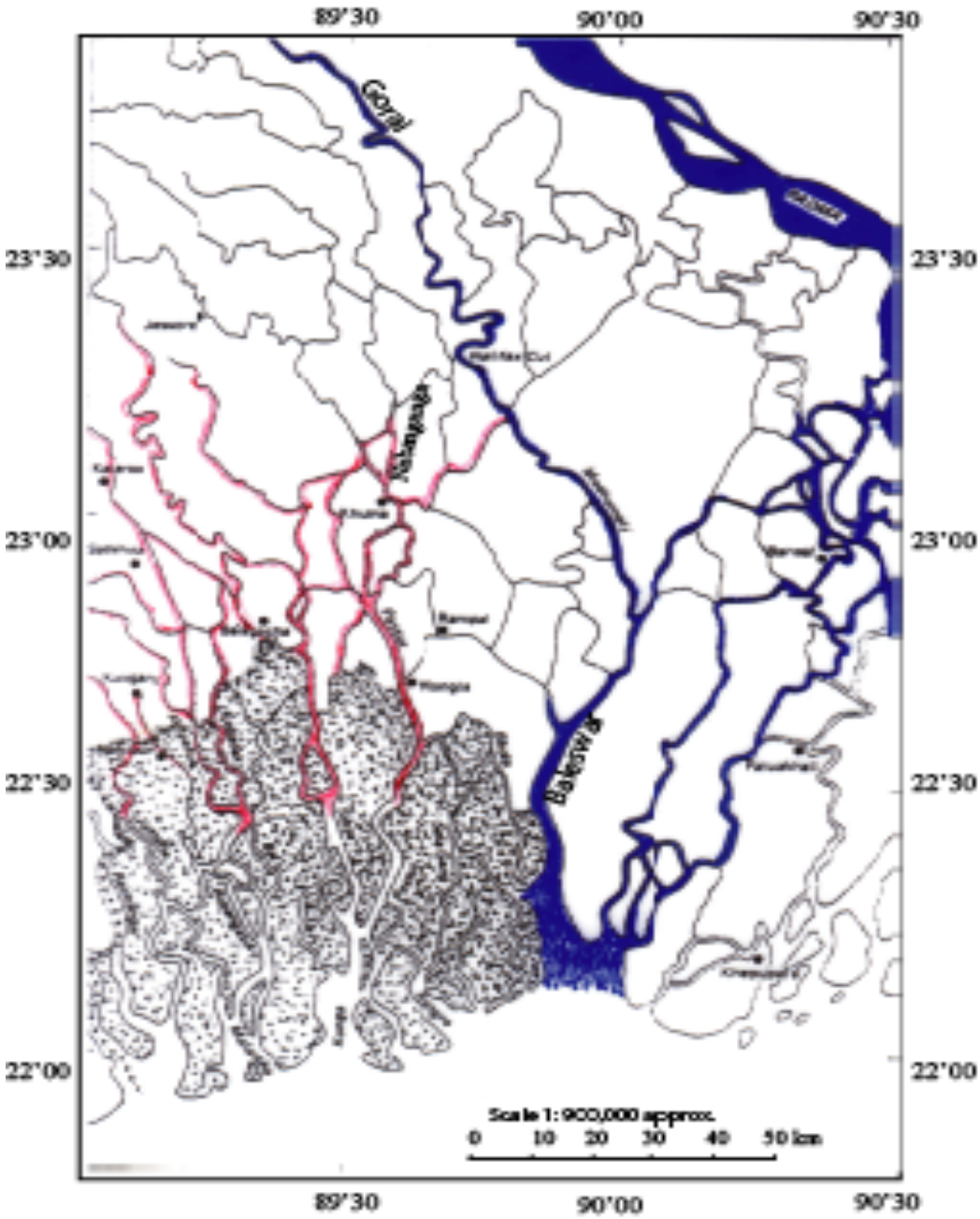
Bangladesh Sundarbans-

Changes in forest/water areas Northern parts of Khulna and Chandpai ranges in 21 years.

- Large number of small rivers and creeks were formed, some time before the year 2000 (Fig. B) reducing forest area of 443 km^2 to 427 km^2 = a total loss of 16 km^2 which is 3.61 % in 20 years (Table next).
- One possibility of the changes is high discharge of 7020 and 8880 $m^3 s^{-1}$ water at Gorai in 1991 and 1993, respectively was followed by tidal surge of the cyclone in April 1991 which forced the huge water-mass to pass across the wet forestlands forming creeks and canals.




Padma R.
GRB
Garai R.
Dhaka
Meghna R.
Khulna
Rampal
Pasur R.
Barguna

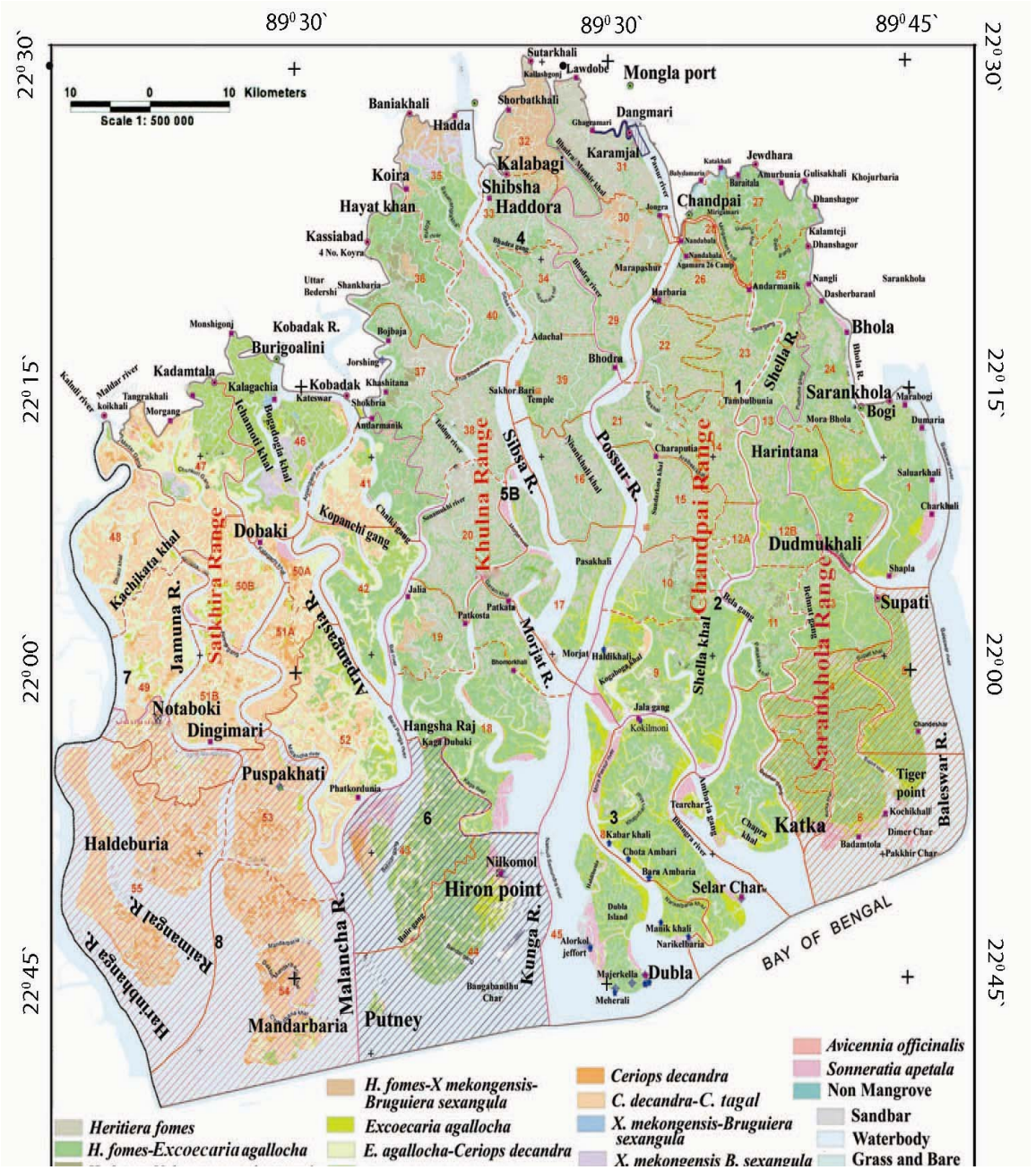

89°30
90°00
90°30
23°30
23°00
22°30
22°00
Gorai
Kobadak
Baleswar
Scale 1:900,000 approx.
0 10 20 30 40 50 km

“Shadow over Sundarbans” –The Daily star, 07 October 2013

SINCE 1975, because of the diversion of fresh-water from Ganges through Farakka Barrage, the salinity of water and in the soil has increased in a large part of Bangladesh. This has already impacted on the growing stocks of the Sundarbans.Inventories of the Department of Forests (1996) showed that there were 144 trees per hectare in 1996 compared to 296 trees per hectare in 1959 (report by Forestal). Trend analysis estimated a further decrease to 109 total trees per hectare in 2020.Now, there is a possibility of “the black carbon” (soot) appearing near Sundarbans. The black Carbon forms a layer on leaves and other parts of a plant and becomes sticky within a few days, resulting in decreased light penetration to the leaves that will obviously reduce photosynthesis and growth of plants. An expert of the CEGIS is trying to justify the building of a power plant by quoting that by buying electricity for Tk.1.00 the people will get benefit between Tk.39 and Tk.45. This may look beneficial in the short run, however, in the long run, the Sundarbans will be destroyed. It is just to mention that at present, the Sundarbans (at least the Bangladesh part) has a carbon reserve of about 120 million tons (an estimate of 2010). The shrinking of the Sundarbans is not mainly due to anthropogenic effects, but the salinity intrusion as mentioned before. The expert also mentioned that the disasters in the region are making people in the area poor, and salinity is hampering the growth of crops. Why have the frequency of disasters and the salinity of soil and water increased? Why have the natural disasters increased? Because of climate change. To my mind, another climate change factor will be introduced by installing a coal-operated power plant near

Sundarbans. **The writer is Chairman, Department of Botany, Dhaka University.**

Map
Hand dawn



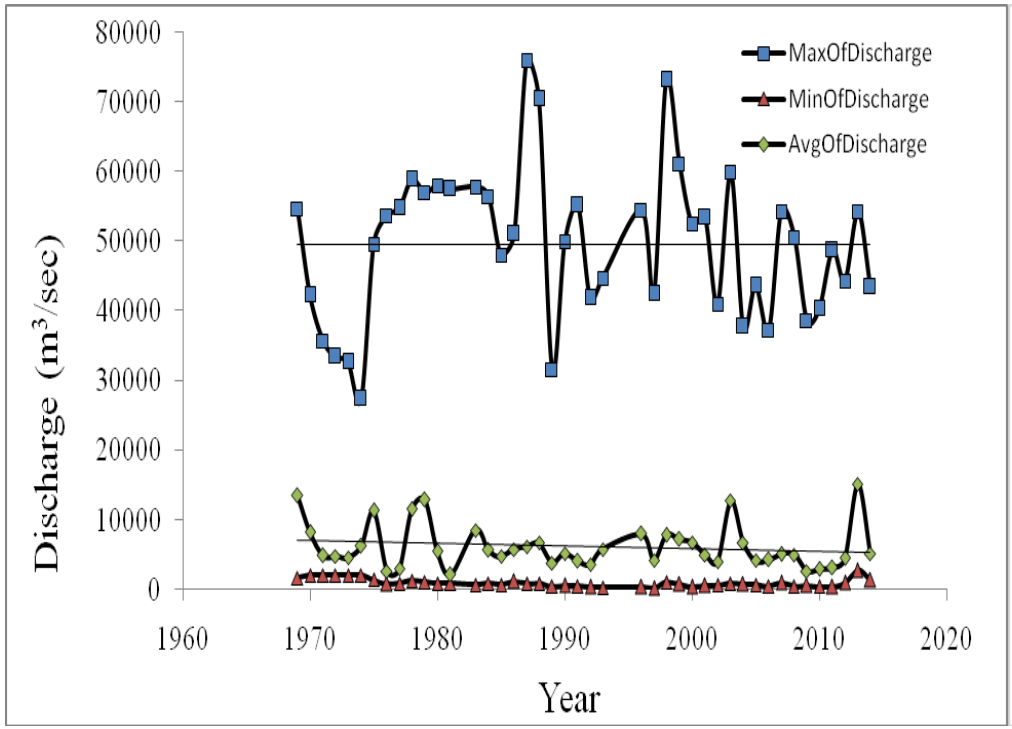
c

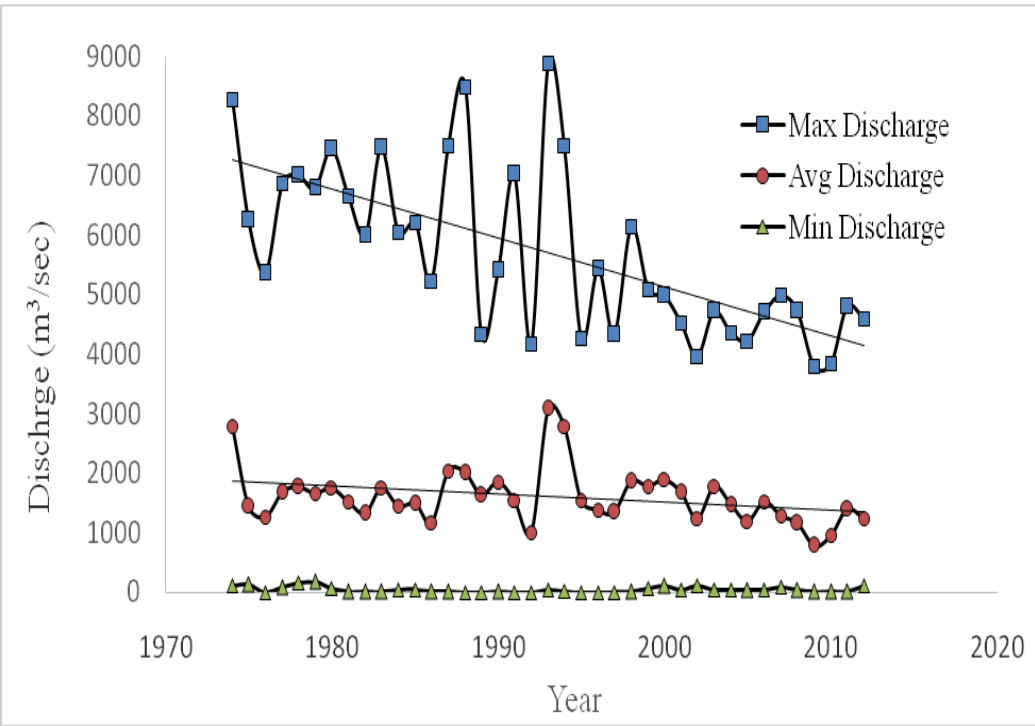
Discharge patterns from Farakka Barrage

Discharges at Hardinge Bridge (about 185 km north of SMF). Max. and average discharges at Hardinge bridge did not form any slope but at Gori discharges formed distinct slopes.

Source: BWDB

Discharges at Gorai Railway Bridge (about 160 km north from the SMF). Max. and Average discharges at Gorai Railway bridge formed steep slopes compared to that at Hardinge bridge. The min. monthly available freshwater flow varies from 0.00 to 170 m^3 sec^{-1} in dry period. Whereas about 194 m^3 sec^{-1} regular flow is needed to keep oligohaline environment in the SMF.





Effect of salinity on plant height

Salinity results stunted growth of trees making scrubby forests.

A comparison of height class in 1959 with 1983 after 25 years or about 10 years of Farakka Barrage operation revealed that the

Height class 1 (plant height is ≥15 m) in the north-east has fragmented in to:

Height class 2 (plant height 10- <15 m) and

Height class 3 (plant height 3- <10 m).

Effect of salinity on canopy cover

- Diameter of stems at breast height is also affected. Annual increase of diameter for *Heritiera fomes* was found to be:

- **0.133 cm/year in oligohaline zone,**
- **0.102 cm/year in meso- and**
- **0.062 cm/year in polyhaline zones**

Effect of salinity on canopy cover

There was a decrease in canopy closure of SMF where 78% forestlands had a canopy closure of 75% or more in 1959.

It was found to decrease to 65% in 1983 and

About nil in 1996.

Canopy closure in the three saline zones decreased to

- 60-100 in oligohaline zone
- 40-80 in mesohaline zone and
- 30-70 %, in polyhaline zone PUT Image of the foresty

Top dying

- **The incidence of *Heritiera fomes* top-dying and increase in soil salinity in the affected sites indicate a strong relationship and suggest that increase in salinity is possibly the predominant factor in the onset of the condition.**
- **Soil pH around 6.5 is generally ideal for PO_4-P absorption. The sundri plant is probably best suited at or just above this pH, above which it showed pathological symptoms like top dying. Subsequently bacteria and saprophytes invade.**
- **It is concluded that much of the Sundarbans no longer provides an environment to which *H. fomes* is ecologically well suited.**

Why

over the last over 40 years

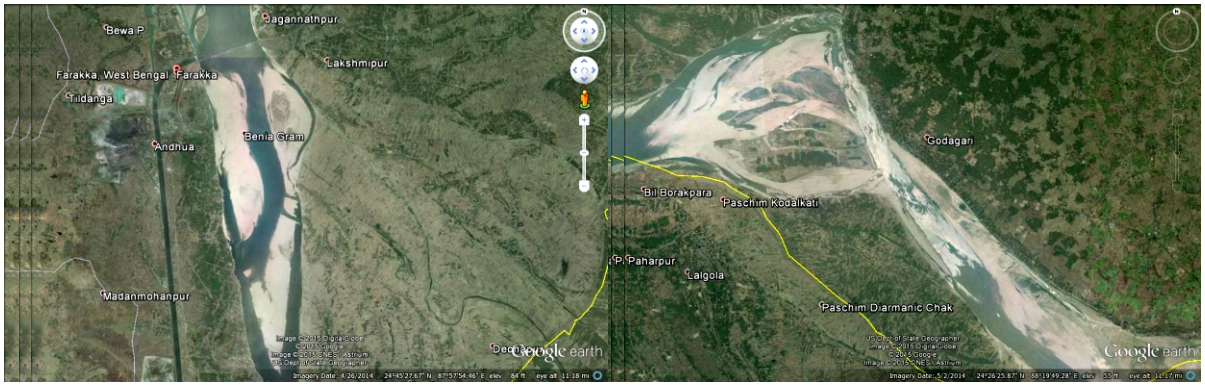
Sundarbans or its Vegetation

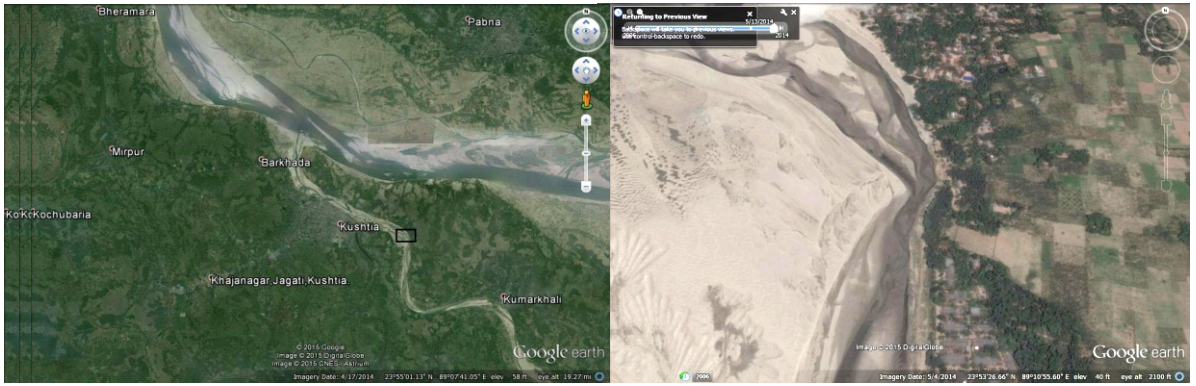
is affected?

Washing away of Talpotti is an example of severety of errosion

How to reclaim the Sundarbans

As shown before low freshwater and sediment discharge in to the Sundarbans from upstreams are causes of degradation.


Bewa P
Jagannathpur
Lakshmipur
Farakka, West Bengal
Farakka
Tildanga
Andhua
Benia Grami
Madanmohanpur
Godagari
Bil Borakpara
Paschim Kodalkati
P. Paharpur
Lalgola
Paschim Diarmanic Chak
Google earth


Bheramara
Pabna
Mirpur
Barkhada
Kushtia
Khajanagar Jagati Kushtia
Kumarkhali
Returning to Previous View
Google earth

What is the fate of the SUNDARBANS?

How to Reclaim the SUNDARBANS?

Why should we save our Sundarbans?

- Nobel Lauret …..

Effect of salinity on plant growth

- **Seedling survivability rate of *Heritiera fomes* after 33 months of their appearance in the forests of three zones showed that-**
  - **6.53% survived in oligohaline**
  - **1.93 and survived in mesohaline and**
  - **0.00% survived in polyhaline zones.**

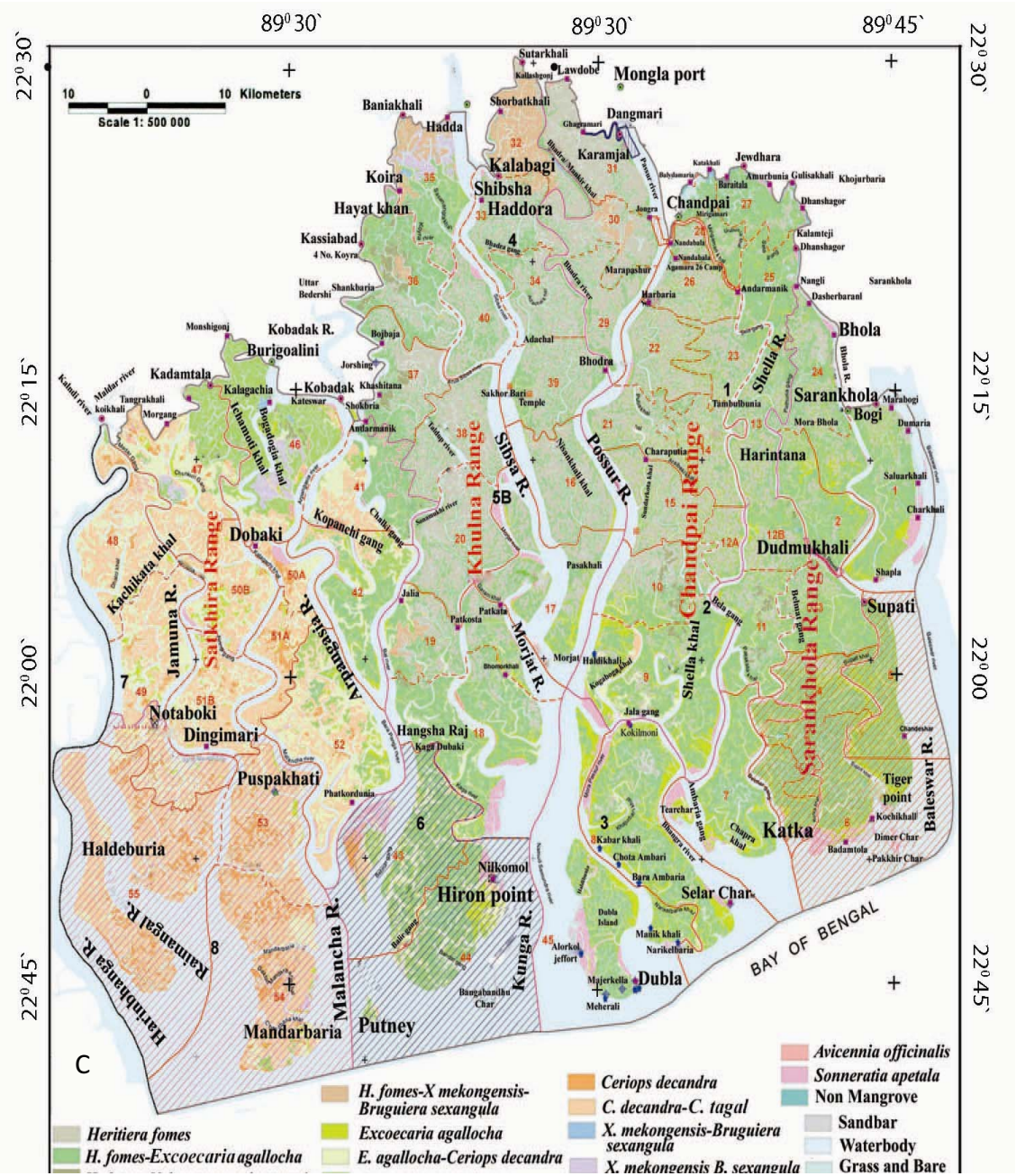
A similar trend was found for other mangroves,

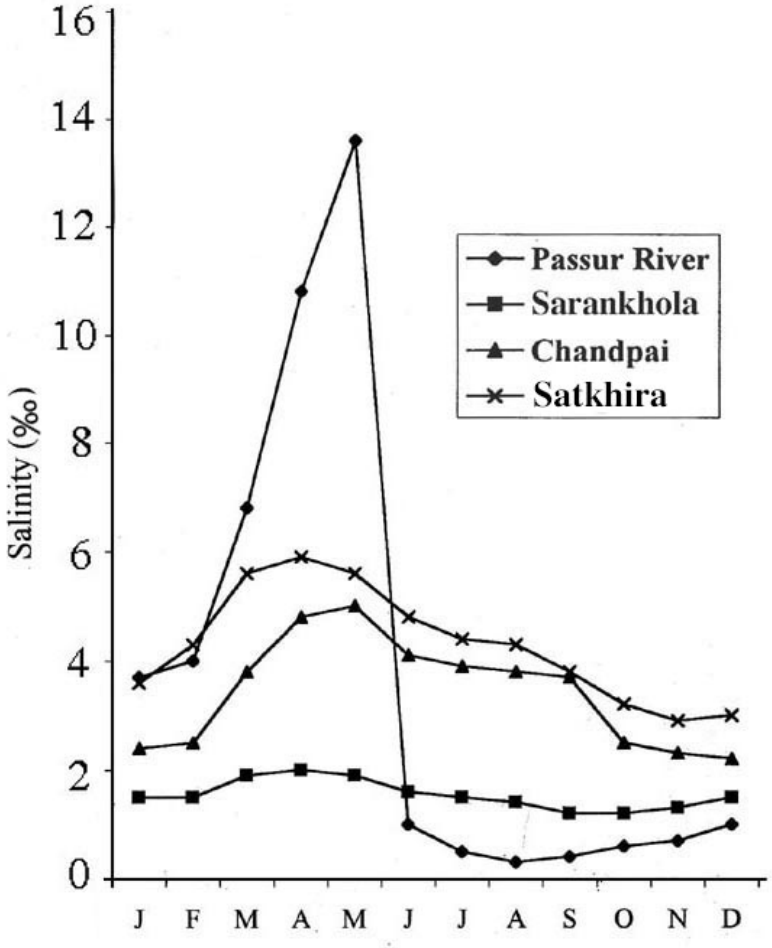
except: *Excoecaria agalocha* which had-

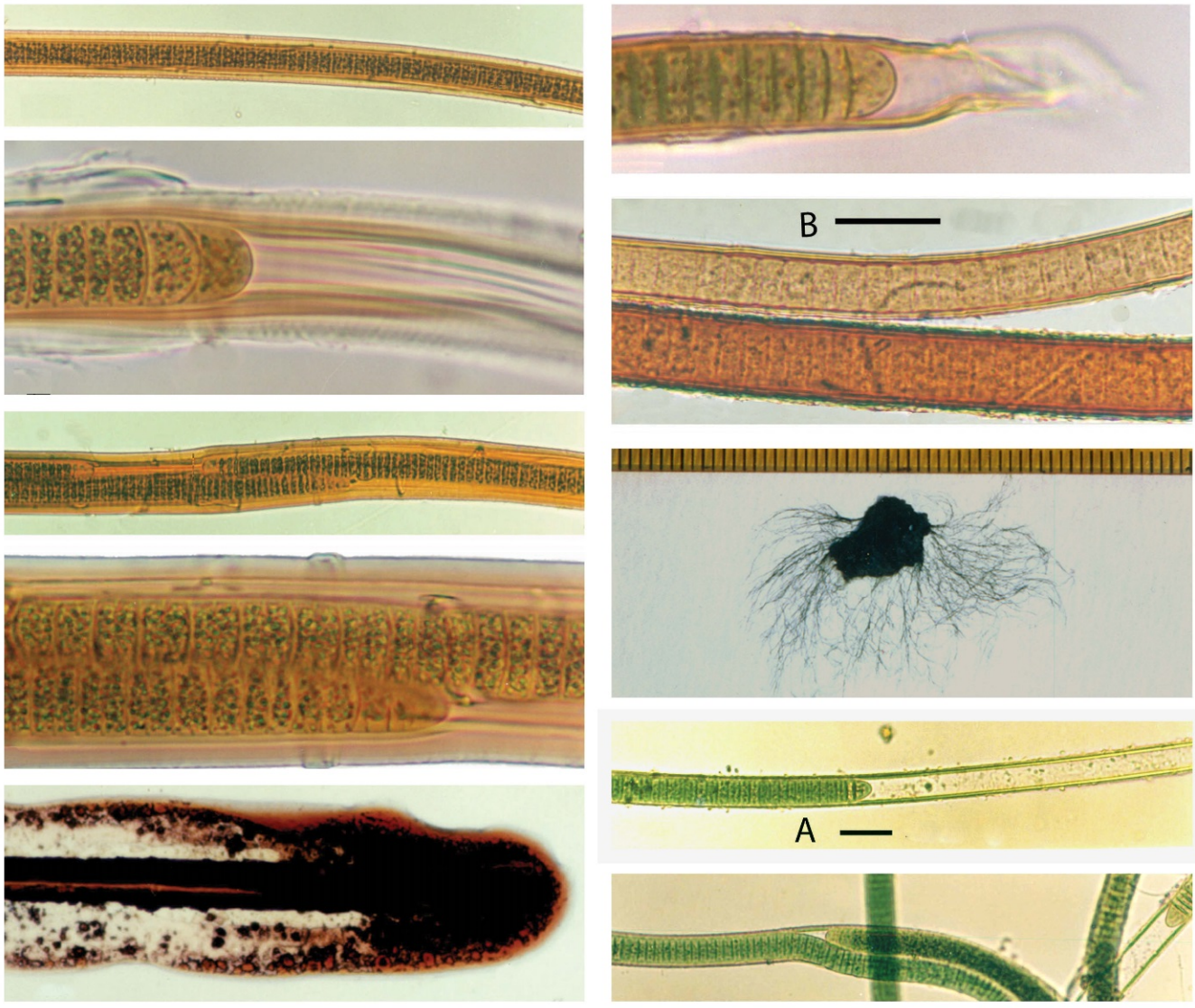
-0.391% in oligohaline and

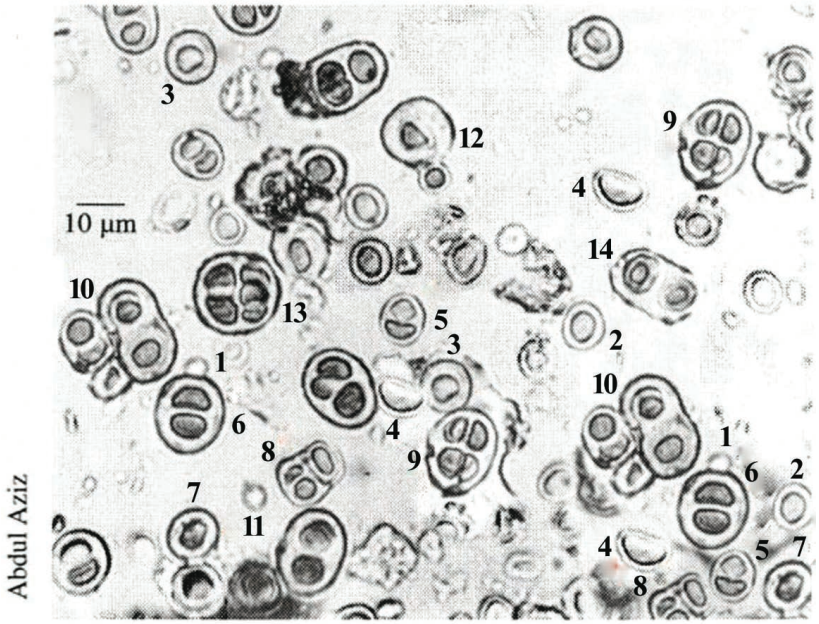
-14% in polyhaline zones indicating salt loving character. These are low quality plants and gradually dominating the Sundarbans.

Salinity in different zones over a year, late 1980's



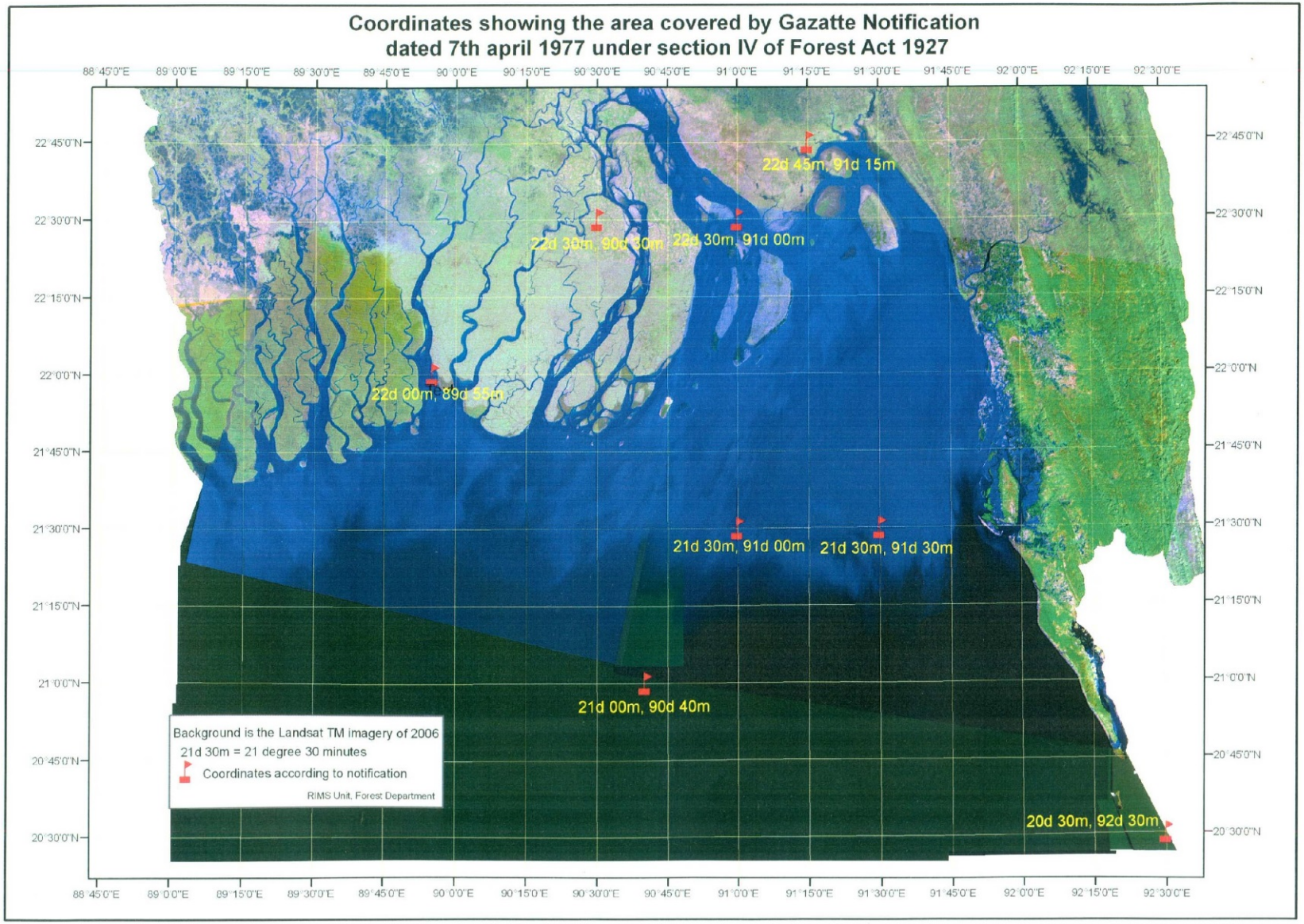



B
A



Myxosarcina burmensis Skuja

Coordinates showing the area covered by Gazatte Notification dated 7th april 1977 under section IV of Forest Act 1927



Water Security and Biodiversity
Diversity of Flora

Bangladesh appears to have good diversity of flora where a total of **>7320 plant species** from all groups have so far been reported. Of these more than 200 species appeared to be threatened.

Groups	No. of species	Groups	No. of species
Bacteria	> 171	Pteridophytes	> 200
Algae	> 2700	Gymnosperms	7
Fungi	> 275	Angiosperms	> 3671
Bryophytes	> 290	Threatened plants:	
		Red Data book (2001)	< 106*
		In Press (2013)	> 200

Bacteria

Fungi

- So far about 100 fungal species have been recorded from Bangladesh

- Three species are new to science:

  Peziza natrophila Khan 1976

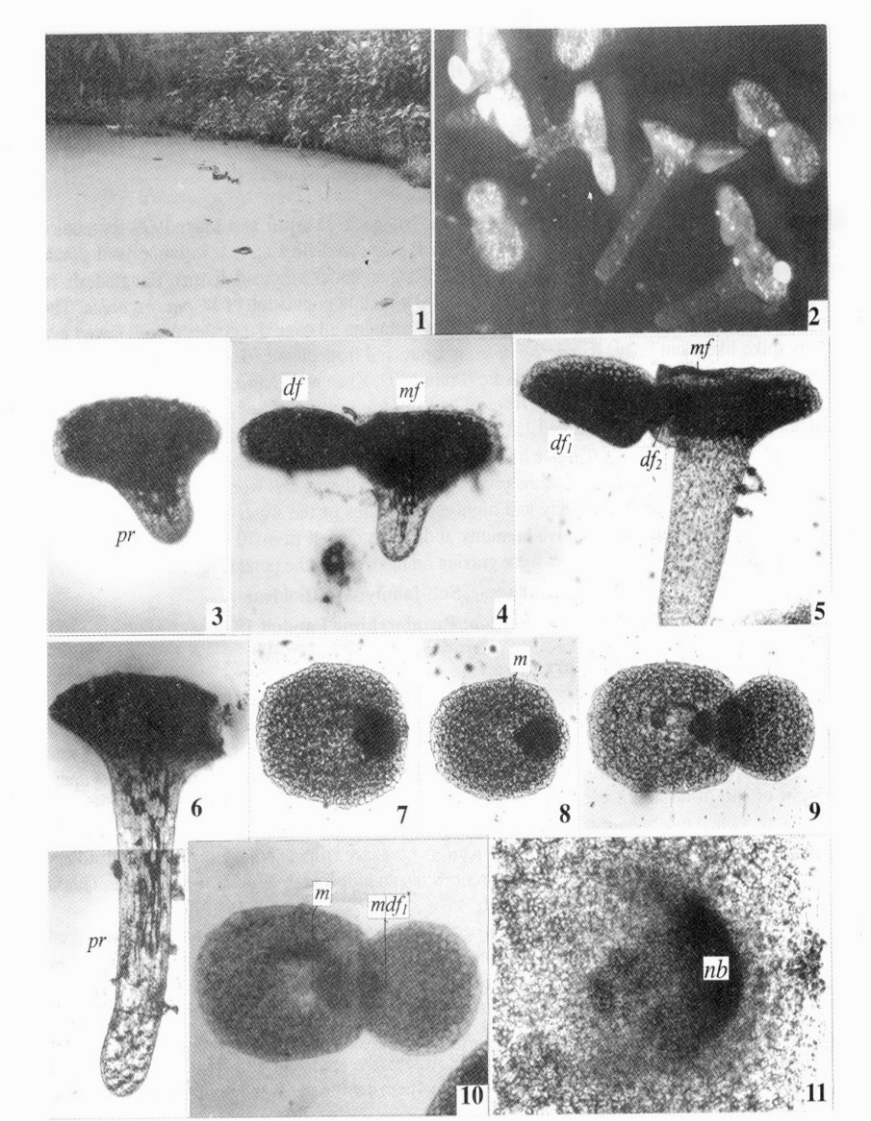
  Chroogomphus britannicus Khan *et* Hora 1978

  Phomopsis corchoricola Khan *et* Das 1980

Four new combinations have been created by Khan and Shamsi

Critically Endangered flowering plant, *Wolffia microscopica* (Griff.) Kurz.,

Due to habitat loss ***Wolffia microscopica*** (Griff.) Kurz. (smallest flowering plant) has been found only in one pond at Jessore out of several hundred ponds searched. At present it does not exist in any part of the world (Appenroth, pers. communication).



Figs. 1-11. *Wolffia microscopica* (Griff.) Kurz. 1. Thick mat in a home-yard pond with ducks grazing on the duckweed. 2. Plants of different ages and views in a dark-field dissecting microscope. 3-6. Plants in lateral view showing different stages of development. 7-11. Plants in top view showing different stages of development; a budding pouch enlarged in fig. 11. *df*, daughter frond, df_1, daughter frond of the first generation, df_2, daughter frond of the second generation; *m*, meristem; *mf*, mother frond; *nb*, new bud. The taxon appears to be extinct (Appenroth, pres. comm.)

Angiosperm species occurring in Bangladesh only

Boesenbergia islamii Yusuf & Rahman
Carex caespititia Nees *ex* Wight,
Curcuma bakerii Rahman & Yusuf,
Curcuma hookerii Rahman & Yusuf
Curcuma roxburghii Rahman & Yusuf,
Curcuma wallichii Rahman & Yusuf
Curcuma wilcockii Rahman & Yusuf
Cuscuta chittagongensis Sen Gupta
Cyperus pilosus Vahl *var.* **polyantha** C. B. Clarke
Dalbergia confertiflora Benth. *var*. **listeri** Thoth.
Flemingia fluminalis C.B. Clarke *ex* Prain
Globba rahmanii Yusuf
Gomphostemma salarkhaniana Khanam & Hassan
Hedyotis thomsoni Hook.f.,
Iodes thomsoniana Baill.
Knema bengalensis W. J. J. O. de Wilde
Lagenandra gomezii (Schott) Bogner & Jacson
Limnophila cana Griff.,
Litsea clarki Prain,
Mantisia salarkhanii Rahman and Yusuf
Nothopegia acuminata J. Sinclair
Periploca acuminata Rahman & Wilcock
Persicaria eciliata Hassan
Rotala simpliciuscula (Kurz) Koehne **Tarenna scandens** (Roxb.) Good
Taxillus thelocarpus (Hook.f.) Alam
Vernonia thomsoni Hook.f.
Zingiber salarkhaneum Rahman & Yusuf

Out of these 15 taxa recorded in the Prain's Bengal flora published in 1903 have not been reported so far from other part of the world.

Algal and Moss taxa reported as new to science from Bangladesh

So far the genus *Kirchnerielosaccus lunatus* Islam and another168 species/var. of algae have been reported as new to science from Bangladesh. Intensive studies may discover dozens of algal species new to science

So far 37 species of *Riccia* (2 by Khan and 35 by Zaman and Hadi) and four species of Mosses (by Banu and Hadi) have been reported as new to science from Bangladesh.

Dominant vegetation of three ecological zones in the Sundarban Mangrove Forests (Nazrul Islam 2003)

Oligohaline Zone

1. *Heritiera fomes* (Ab)
2. *Excoecaria agallocha* (Ab)
3. *Porteresia coarctata* (Ab)
4. *Hibiscus tiliaceous* (F)
5. *Avicennia alba* (F)
6. *A. officinalis* (F)
7. *Sonneratia apetala* (F)
8. *S. caseolaris* (F)
9. *Amoora cucullata* (F)
10. *Barringtonia racemosa* (F)
11. *Acanthus ilicifolius* (F)
12. *Derris trifoliate* (F)
13. *Cynometra ramiflora* (Oc)
14. *Sapium indicum* (Oc)
15. *Cerbera manghas* (Oc)
16. *Lumnitzera racemosa* (Oc)
17. *Tamarix indica* (Oc)
18. *Pongamia pinnata* (Oc)
19. *Pandanus foetidus* (Oc)
20. *Pharagmites karka* (Oc)
21. *Nypa fruticans* (Oc)
22. *Typha elephantine* (Oc)
23. *Acrostichum aureum* (Oc)
24. *Clerodendron inerme* (R)
25. *Flagellaria indica* (R)
26. *Caesalpinia cristata* (R)
27. *Dendropthoe falcate* (R)
28. *Mucuna gigantean* (VR)
29. *Tetrastigma bracteolatum* (VR)
30. *Ceriops decandra* (VR)

Mesohaline Zone

1. *Excoecaria agallocha* (Ab)
2. *Rhizophora mucronata* (Ab)
3. *R. apiculata* (Ab)
4. *Heritiera fomes* (Ab)
5. *Nypa fruticans* (F)
6. *Kandelia kandel* (F)
7. *Bruguiera sexangula* (F)
8. *Sonneratia apetala* (F)
9. *Ceriops decandra* (F)
10. *Porteresia coarctata* (Oc)
11. *Tamarix indica* (Oc)
12. *Dalbergia spinosa* (Oc)
13. *D. Candenatensis* (Oc)
14. *Petunga roxburghii* (R)
15. *Brownlowia tersa* (R)
16. *Pandanus foetidus* (R)
17. *Phoenix paludosa* (R)
18. *Sarcolobus globosus* (R)
19. *Mucuna gigantea* (VR)
20. *Clerodendron inerme* (VR)
21. *Finlaysonia maritima* (VR)

Polyhaline Zone

1. *Ceriops decandra* (Ab)
2. *Aegiceras cornculatum* (Ab)
3. *Bruguiera gymnorhiza* (Ab)
4. *B. sexangula* (F)
5. *Xylocarpus granatum* (F)
6. *X. mekongensis* (F)
7. *Kandelia candel* (F)
8. *Nypa fruticans* (F)
9. *Phoenix paludosa* (F)
10. *Brownlowia tersa* (F)
11. *Acanthus ilicifolius* (F)
12. *Acrostichum aureum* (F)
13. *Microsolen cochinchinensis* (R)

- **Sundarban has rich diversity where a total of 65 species has been recorded by Chaffey et al. (1985) compared to 70 true mangrove worldwide. Recently, increased salinity caused decreased abundance and diversity of flora; some recorded species may not be found any more.**