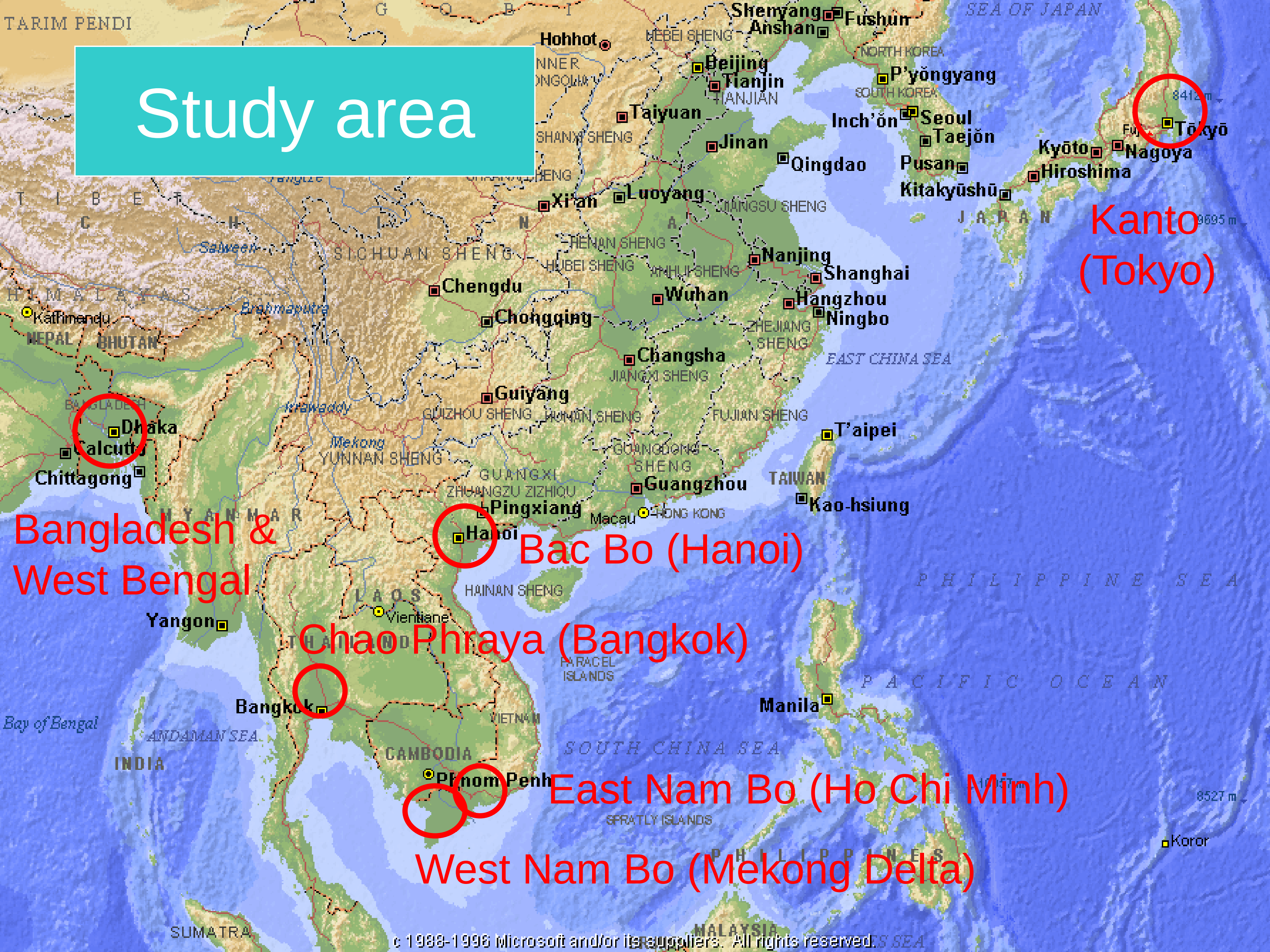
Groundwater contamination in the Padma River and in the lower Ganges Delta in Bangladesh and India

with special reference to sea level change in the late Quaternary

Outline of today's topic

- Background - Hydrogeological location
  - Topographically very low wetland--- flood disaster
  - behind-developed infrastructure for water supply
- Objectives - Why is arsenic contaminated area distributed here in east-westward belt zone of the lower delta ?
- Methodology -Topographical and geological history, specially on the sea level change in the latest Quaternary age
  - Depositional environment of arsenic accumulation
- Outlook - Alternative water source
  - Alleviative tactics for people to survive
  - Policy and legal aspects
- Risk - Risk hiding in the Transboundary Aquifer
- Groundwater and Human Security – United Nations University Workshop

Study area



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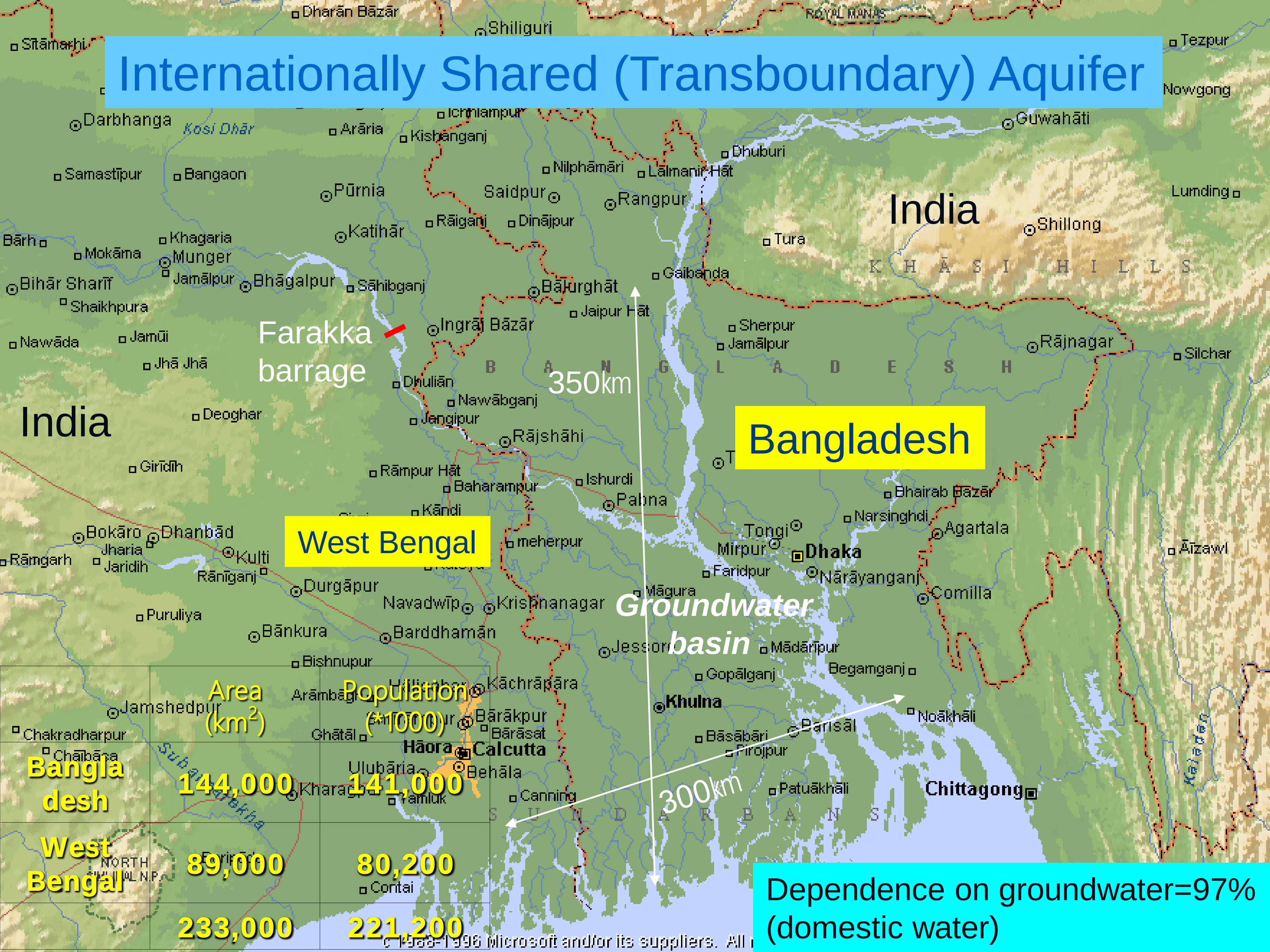
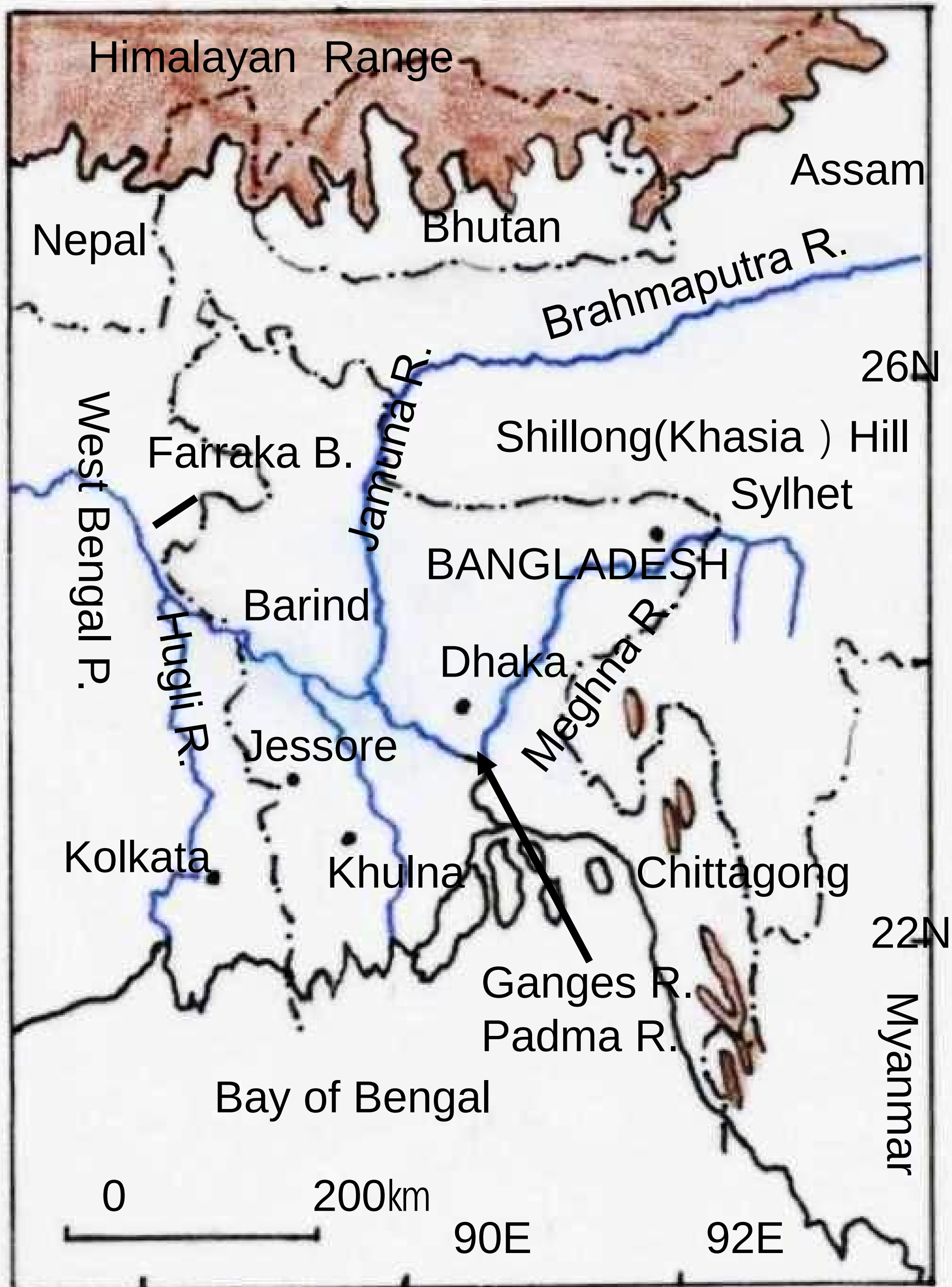
Internationally Shared (Transboundary) Aquifer



	Area (km^2)	Population (*1000)
Bangla desh	144,000	141,000
West Bengal	89,000	80,200
	233,000	221,200

Dependence on groundwater=97% (domestic water)



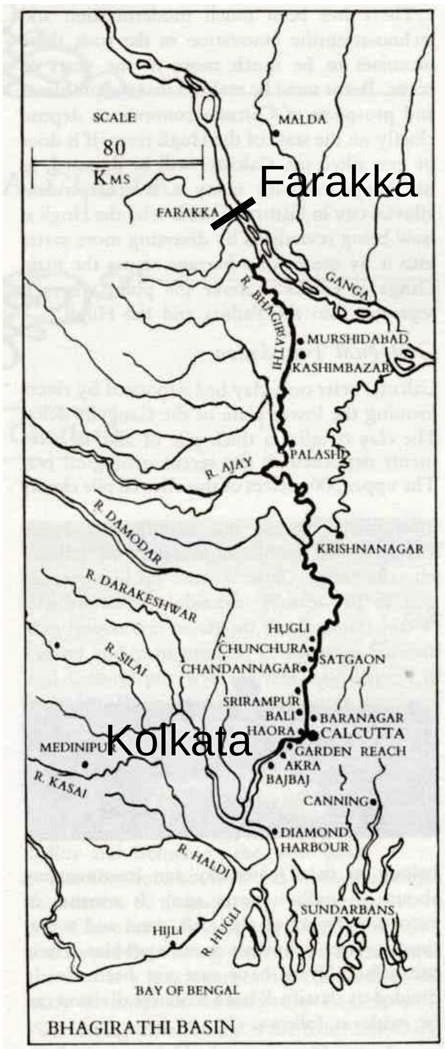
Himalayan Range
Assam
Nepal
Bhutan
Brahmaputra R.
26N
Jamuna R.
Shillong(Khasia）Hill
West Bengal P.
Farraka B.
Sylhet
BANGLADESH
Barind
Hugli R.
Meghna R.
Dhaka
Jessore
Kolkata
Khulna
Chittagong
22N
Ganges R.
Padma R.
Myanmar
Bay of Bengal
0
200㎞
90E
92E

Brief history of groundwater use in rural areas of Bangladesh and West Bengal

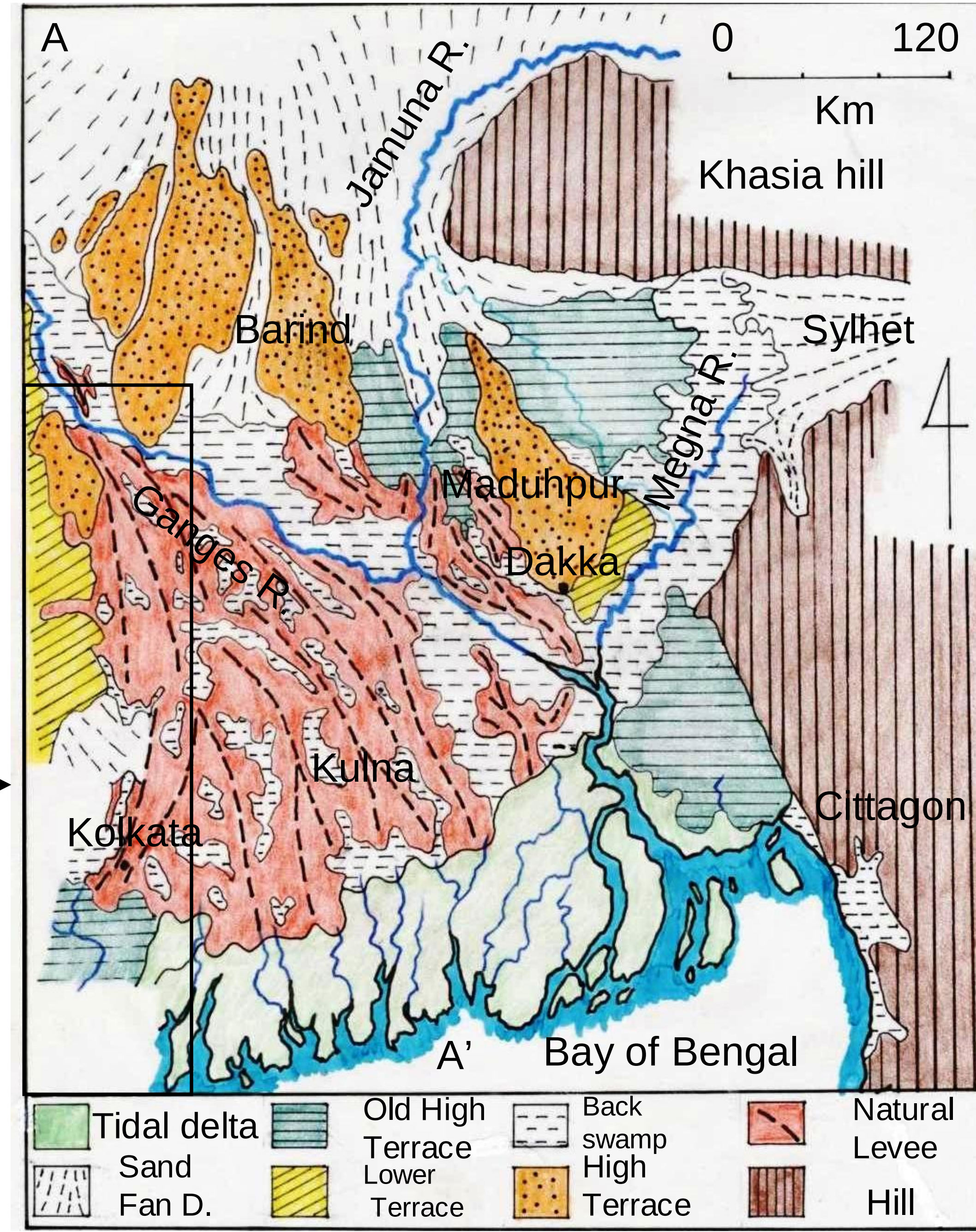
～1960s	Most people used water from dug wells and; ,surface water sources (rivers, pond, lakes etc).
	These water sources transmitted diseases such as diarrhoea, dysentery, typhoid, cholera and hepatitis.
1970s-1980s	UNICEF initiated a tube well campaign as the solution to diesease epidemics, providing materials for tube wells using UNICEF's own design and paying costs to install the wells (1 million or more wells were installed privately).
	At the peak of the program, 90%of the wells were installed within walking distance from a village. It was believed they supplied safe water.
1983	First patient was diagnosed with arsenic poisoning in West Bengal Province, India
late 1980s-early 1990s	Increasing numbers of people began to show signs of arsenic symptom illness.
1993	Bangladesh government firstly admitted arsenic poisoning patients near the western border.
1995	International conference on arsenic contamination in Kolkata. UN, the governments and NGOs joined the conference.
1998	BGS : geohydrological, geochemical and screening of wells contaminated by aresenic surveys (-2001), 1998 : SOES : Jadavpur University,Kolkata screening of wells contaminated by aresenic survey (-present)
1998-2006	Bangladesh Arsenic Mitigation and Water Supply Project (BAMWSP-2006) in nation-wide screening program of the drinking wells.
2004	National Water Management Plan (Approved by the Council, Ministry of Water Resources, Bangladesh)
	National Policy for Arsenic Mitigation 2004 &Implementation Plan for Arsenic Mitigation in Bangladesh (Local Government Division, the Ministry of Local Government, Rural Development &Co-operatives, Bangladesh)
2005	The West Bengal Ground Water Resources Act, West Bengal, India

Topographic features in Ganges Delta Plain

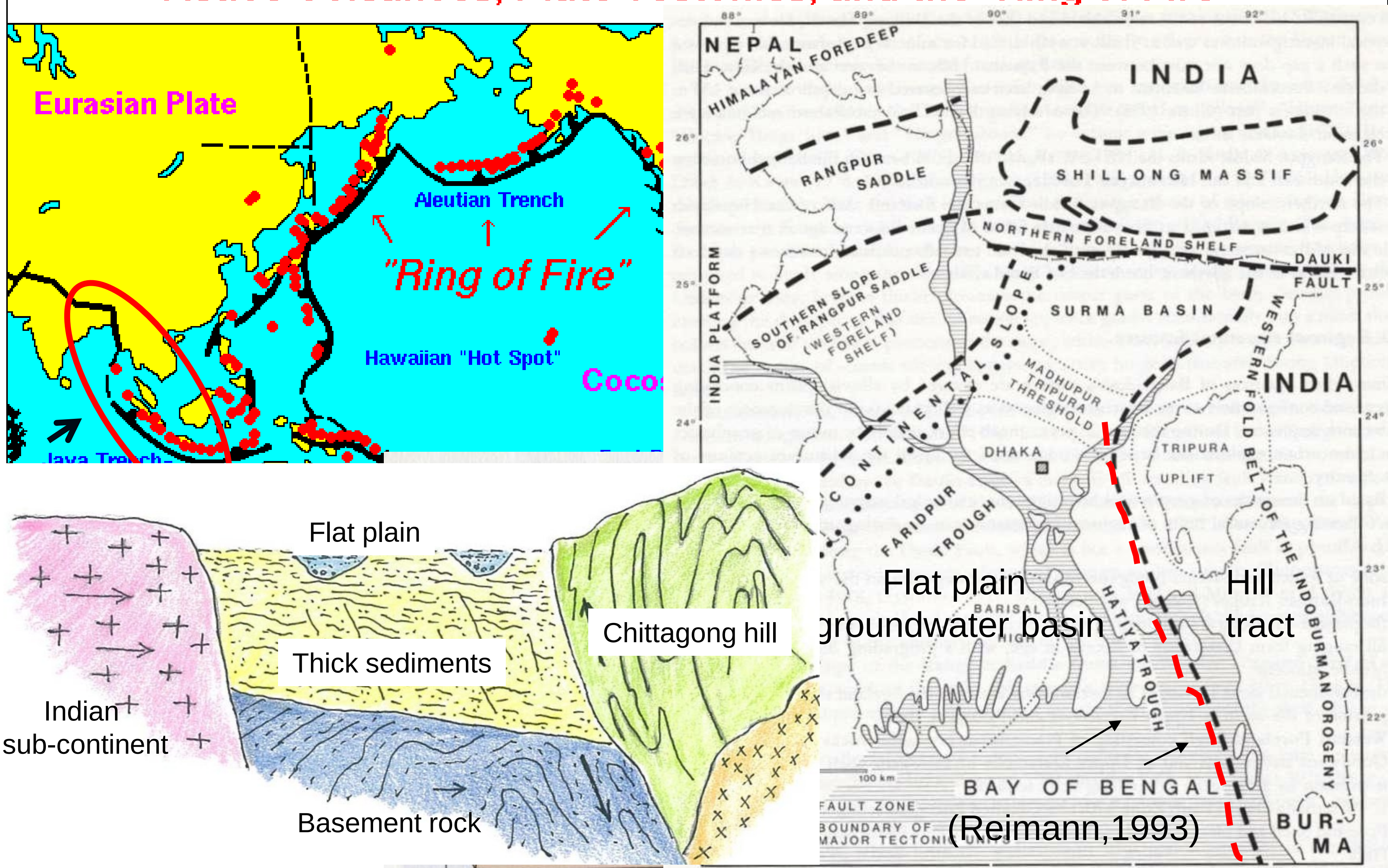
Hugli river



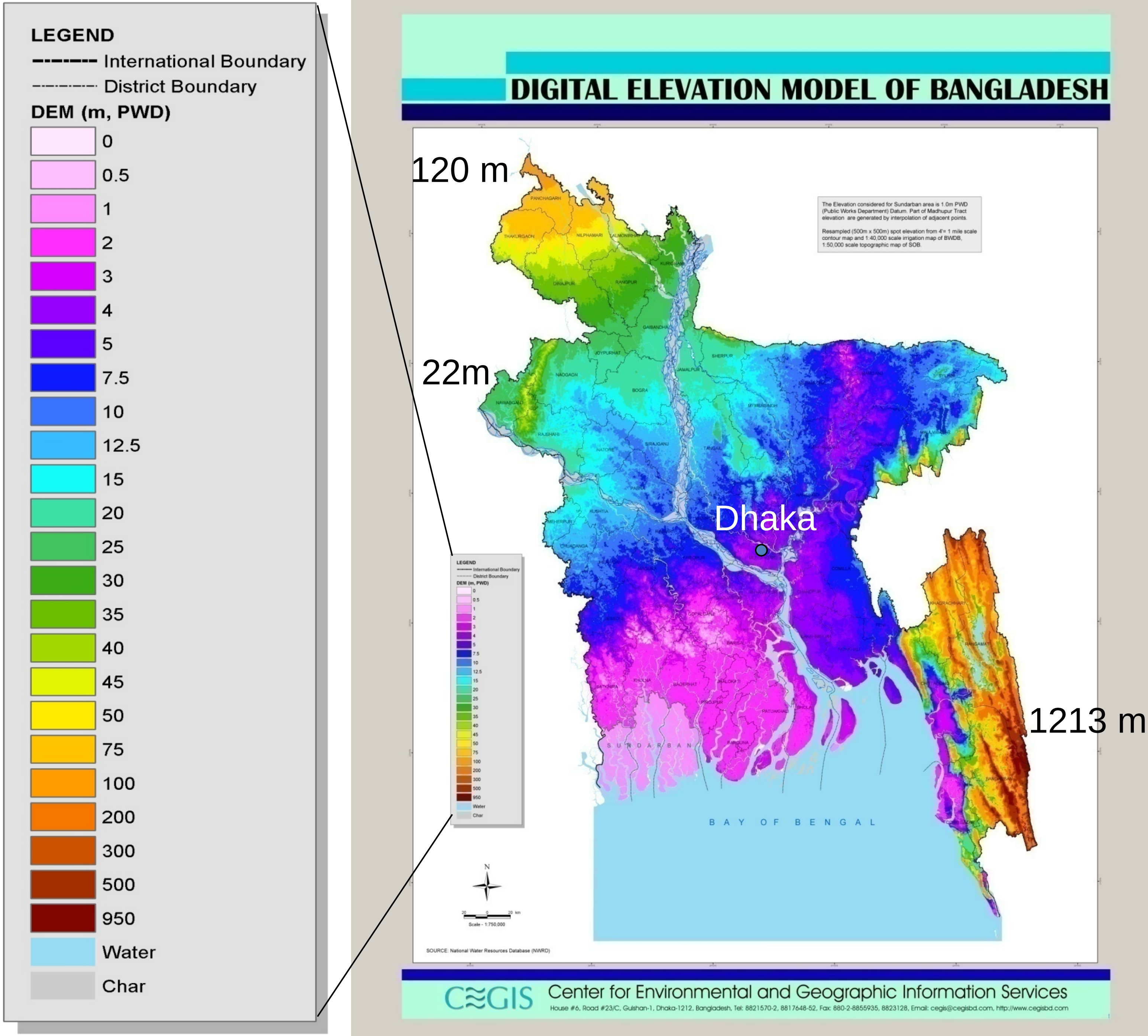
Part of Fig.2



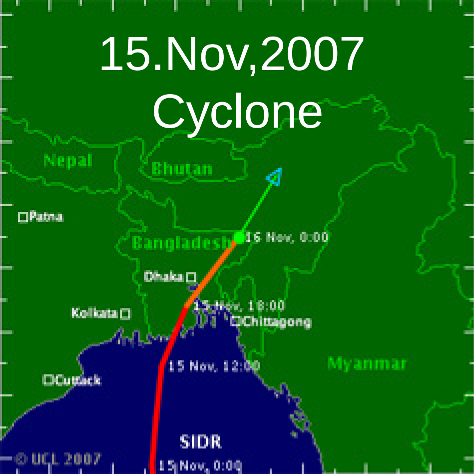
Active Volcanoes, Plate Tectonics, and the "Ring of Fire"



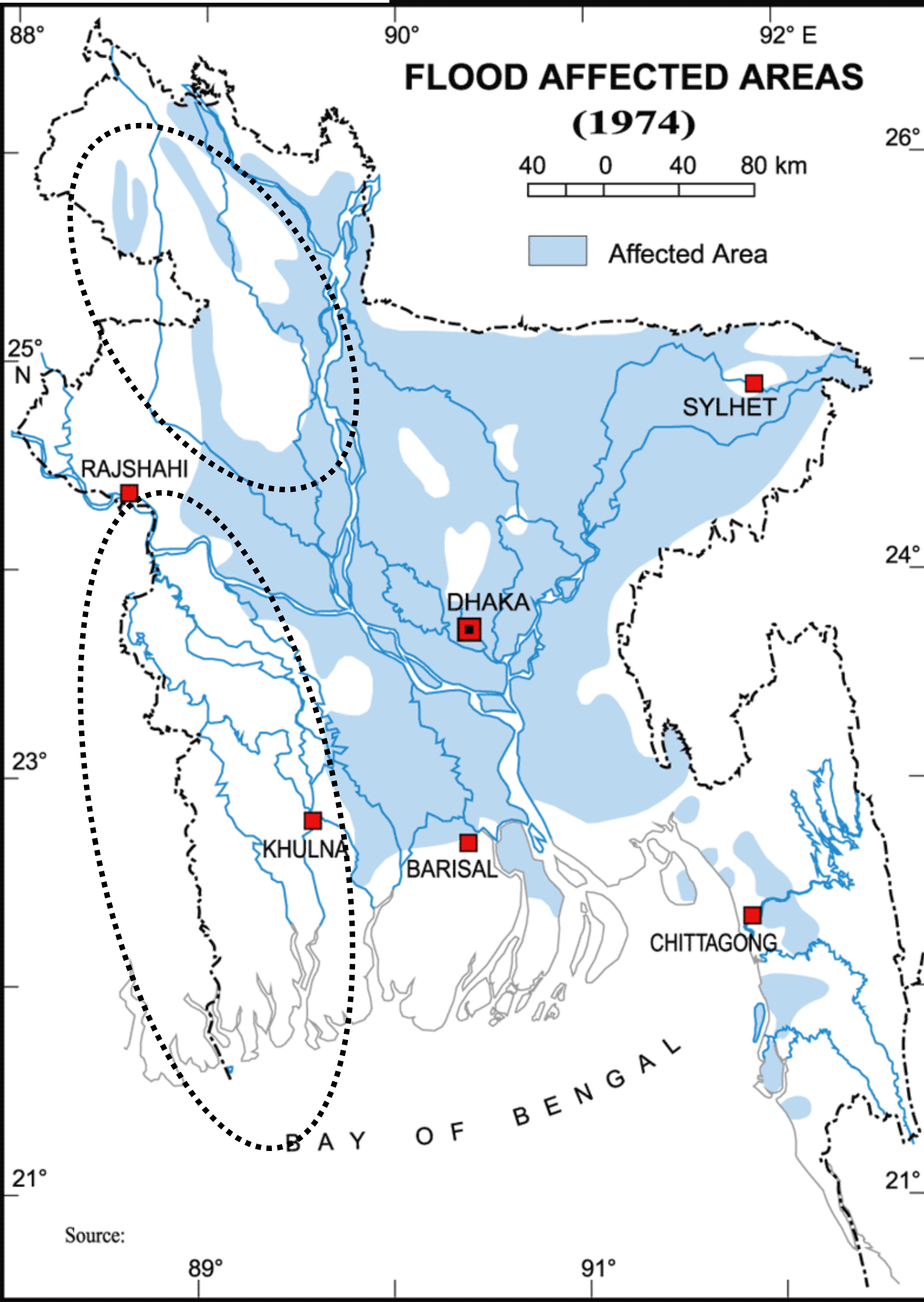
Major tectonic line runs in eastern edge of Bangladesh and hence to the west the basement rocks underlie as deep as ca. 3000m below the Ganges flat plain

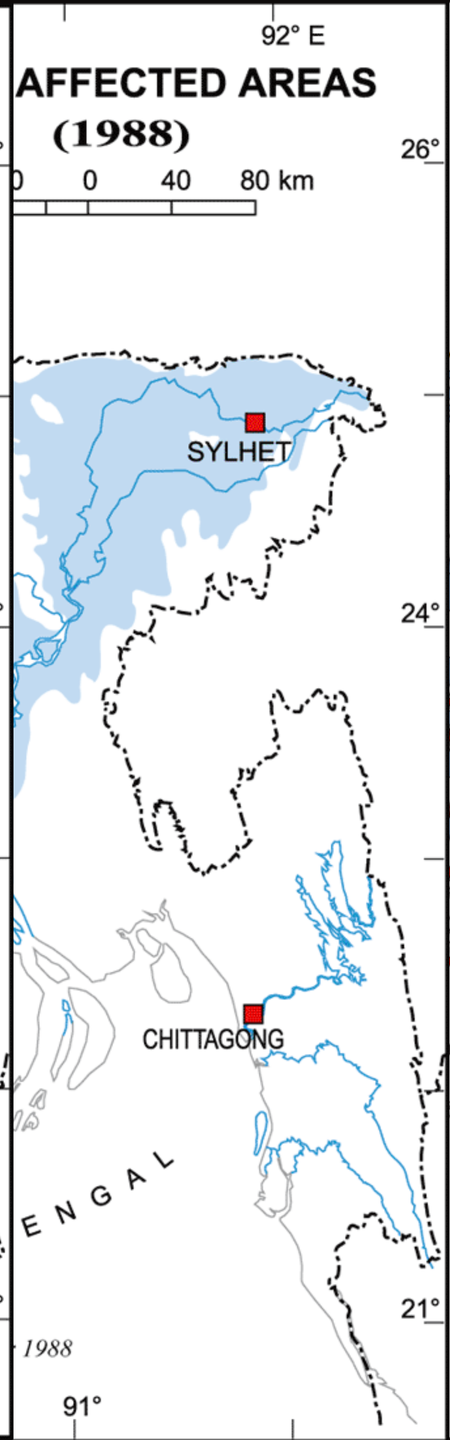

LEGEND
International Boundary
District Boundary
DEM (m, PWD)
0
0.5
1
2
3
4
5
7.5
10
12.5
15
20
25
30
35
40
45
50
75
100
200
300
500
950
Water
Char
DIGITAL ELEVATION MODEL OF BANGLADESH
120 m
22m
Dhaka
1213 m
The Elevation considered for Sundarban area is 1.0m PWD (Public Works Department) Datum. Part of Madhupur Tract elevation are generated by interpolation of adjacent points.
Resampled (500m x 500m) spot elevation from 4"= 1 mile scale contour map and 1:40,000 scale irrigation map of BWDB, 1:50,000 scale topographic map of SOB.
S U N D A R B A N
B A Y O F B E N G A L
SOURCE: National Water Resources Database (NWRD)
CEGIS Center for Environmental and Geographic Information Services
House #6, Road #23/C, Gulshan-1, Dhaka-1212, Bangladesh, Tel: 8821570-2, 8817648-52, Fax: 880-2-8855935, 8823128, Email: cegis@cegisbd.com, http://www.cegisbd.com

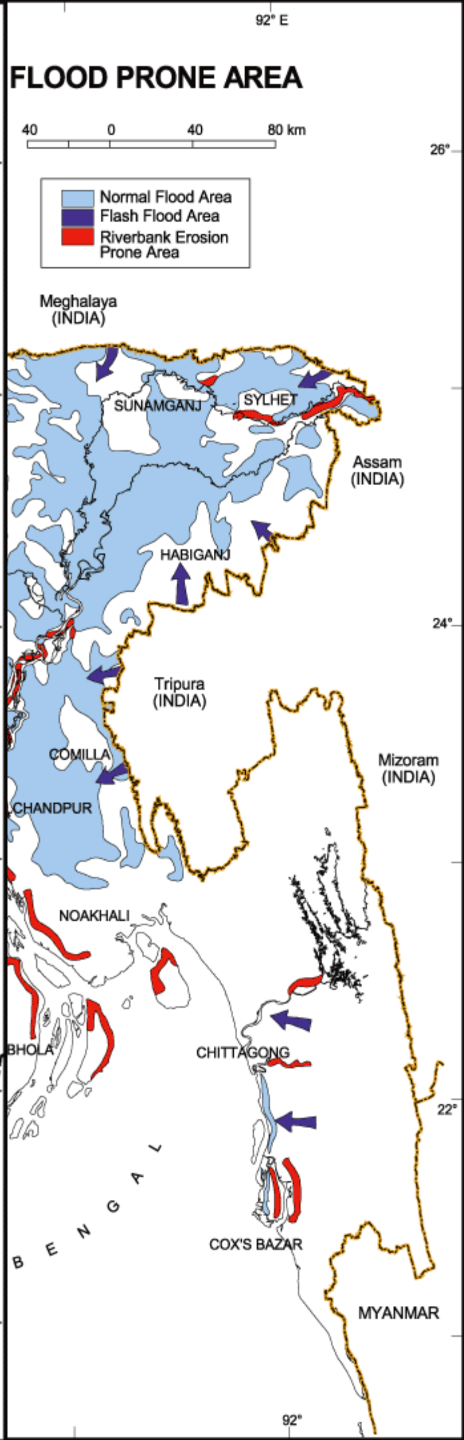
15.Nov,2007
Cyclone

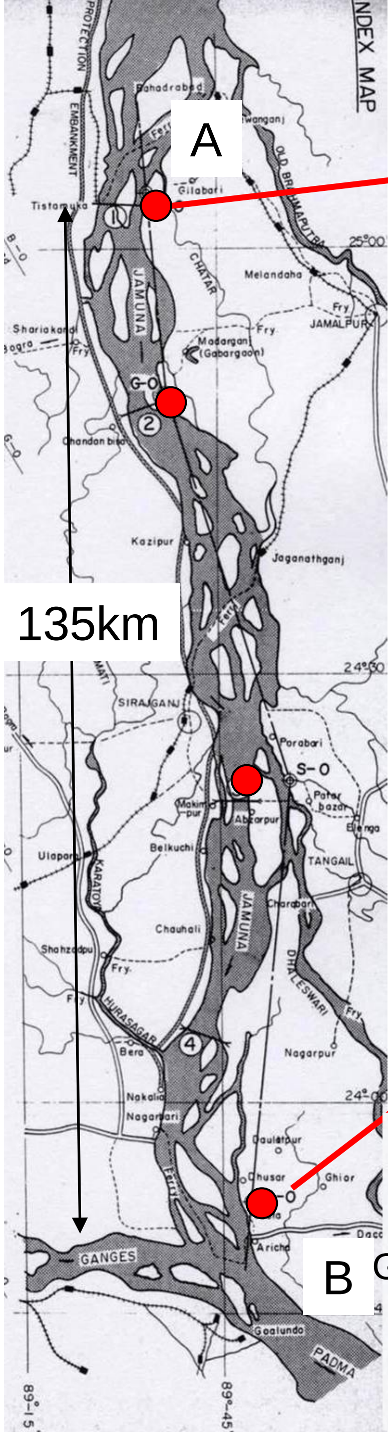


Asahi Newspaper


FLOOD AFFECTED AREAS
(1974)
40 0 40 80 km
Affected Area
88°
90°
92° E
26°
25° N
24°
23°
21°
89°
91°
RAJSHAHI
SYLHET
DHAKA
KHULNA
BARISAL
CHITTAGONG
BAY OF BENGAL
Source:


AFFECTED AREAS
(1988)
0 40 80 km
92° E
26°
24°
21°
91°
SYLHET
CHITTAGONG
ENGAL
1988


FLOOD PRONE AREA
40 0 40 80 km
Normal Flood Area
Flash Flood Area
Riverbank Erosion Prone Area
92° E
26°
24°
22°
92°
Meghalaya (INDIA)
Assam (INDIA)
Tripura (INDIA)
Mizoram (INDIA)
MYANMAR
SUNAMGANJ
SYLHET
HABIGANJ
COMILLA
CHANDPUR
NOAKHALI
BHOLA
CHITTAGONG
COX'S BAZAR
BENGAL



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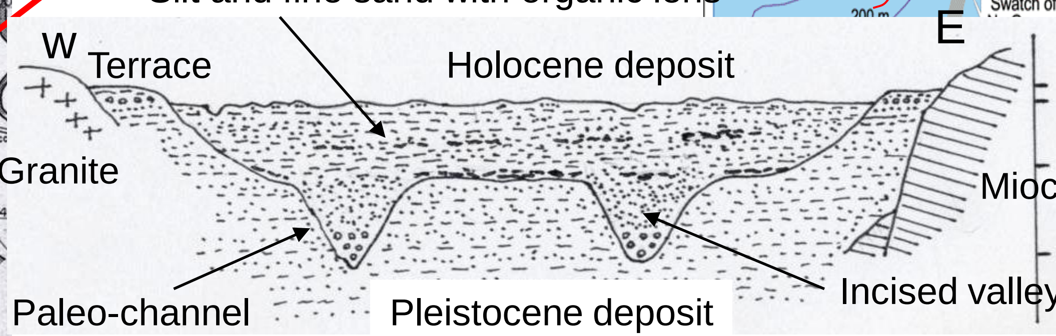
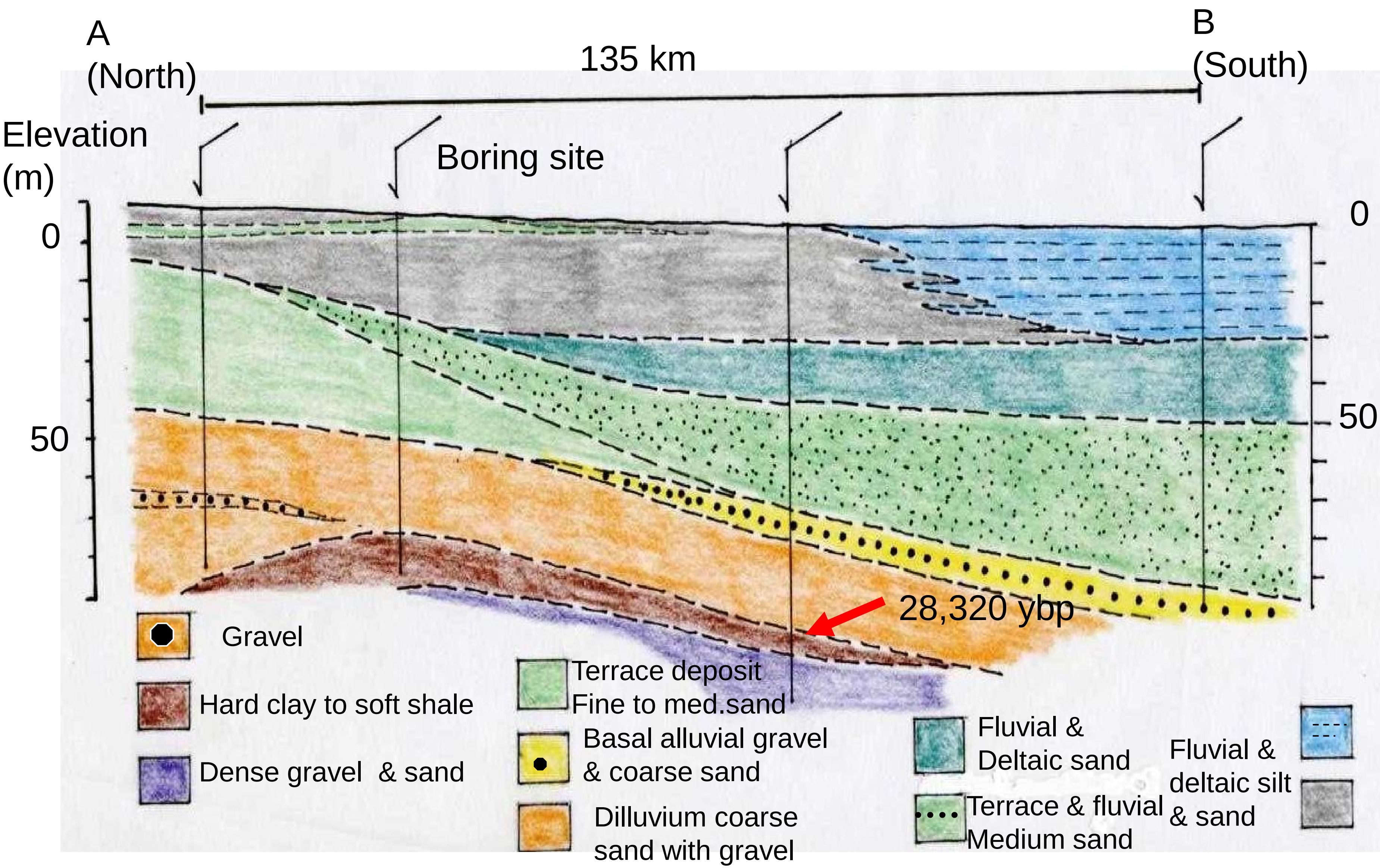
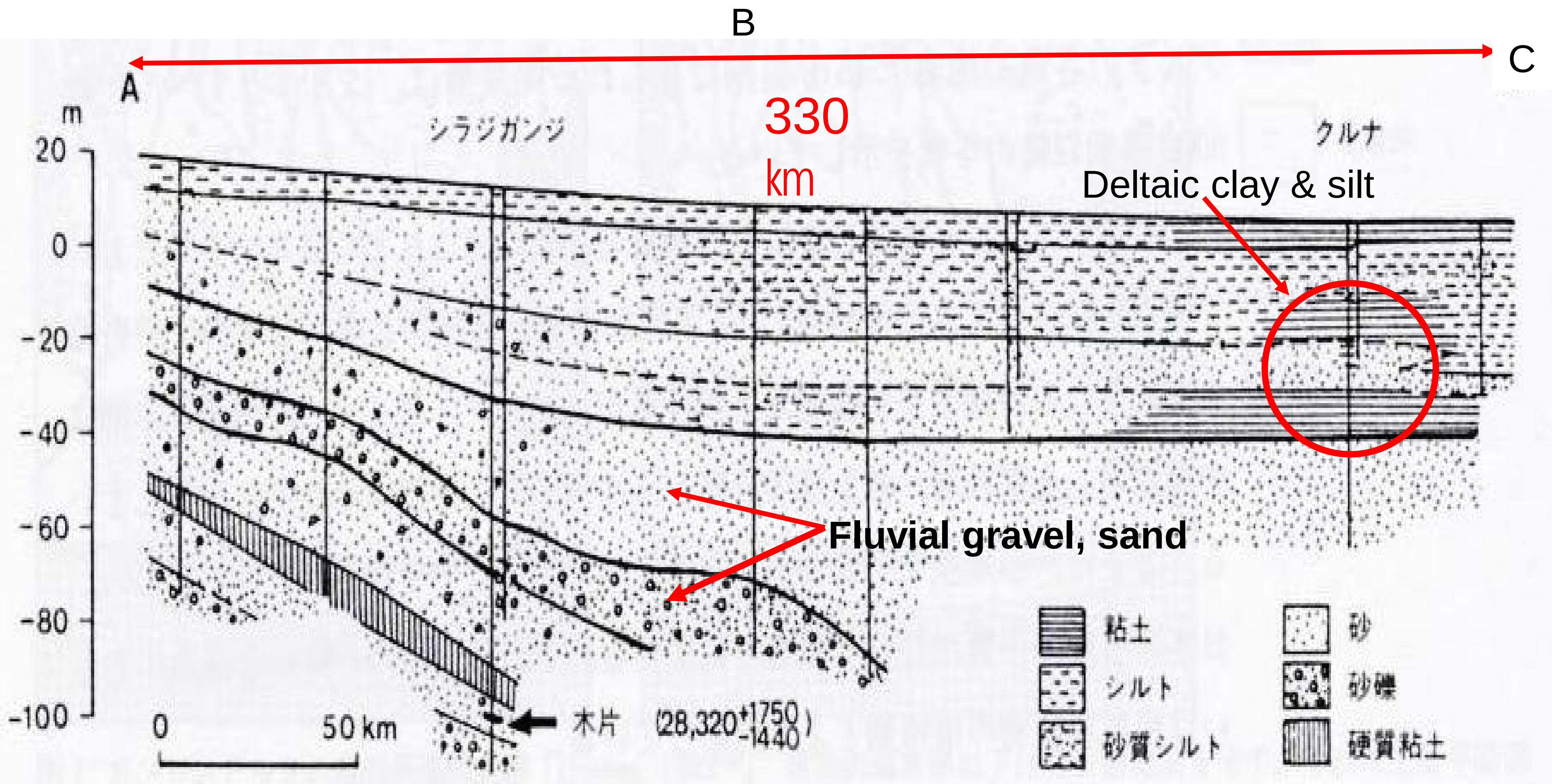


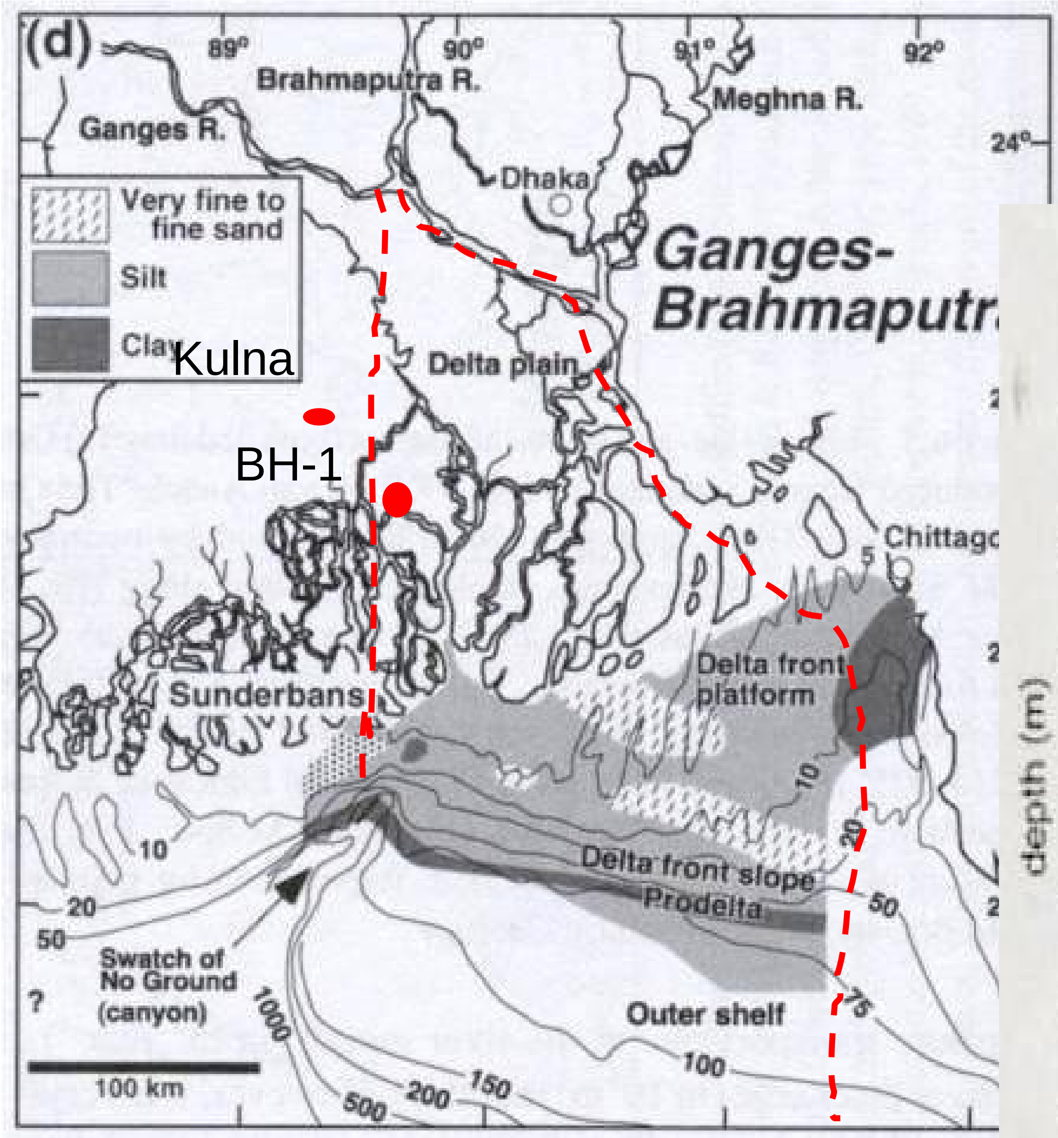
Geological cross section along the Jamuna River

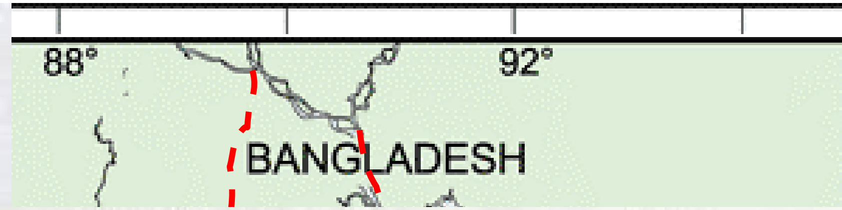


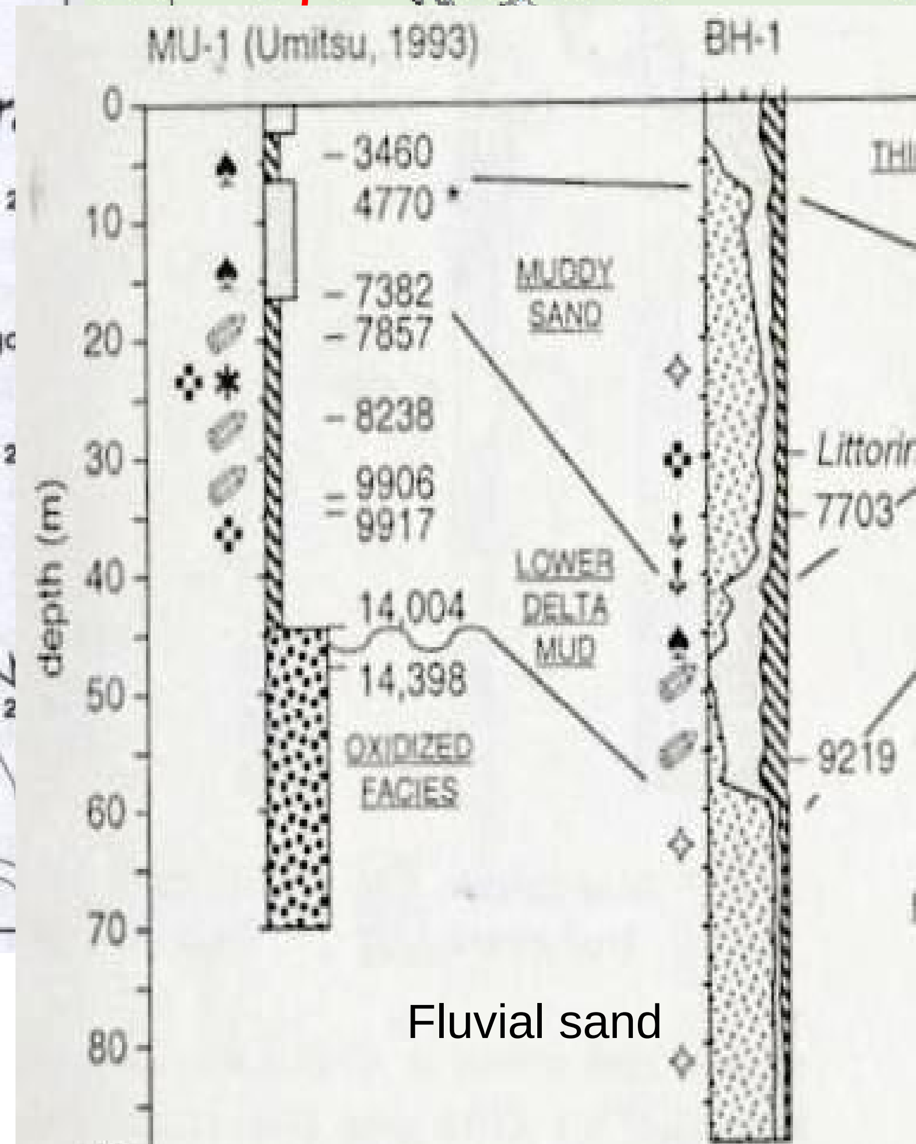
Geological section from Jamuna river to Khulna

（Umitsu,1987）









Goodbred Jr. et al.（2000)

Two incised channels at the time of the glacial maximum

(Bathymetric contours)

Sea-level changes during the last interglacial-glacial transition

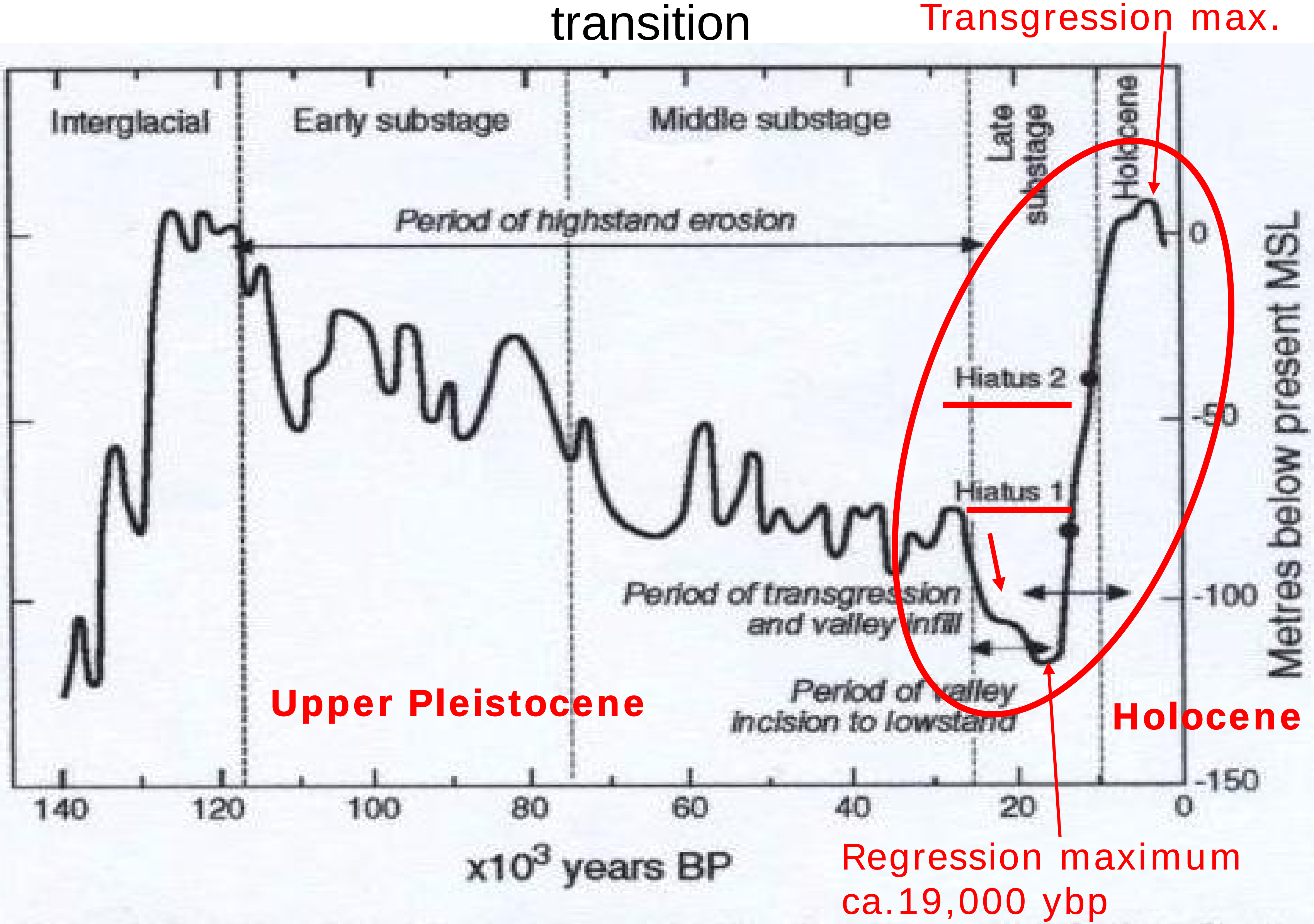
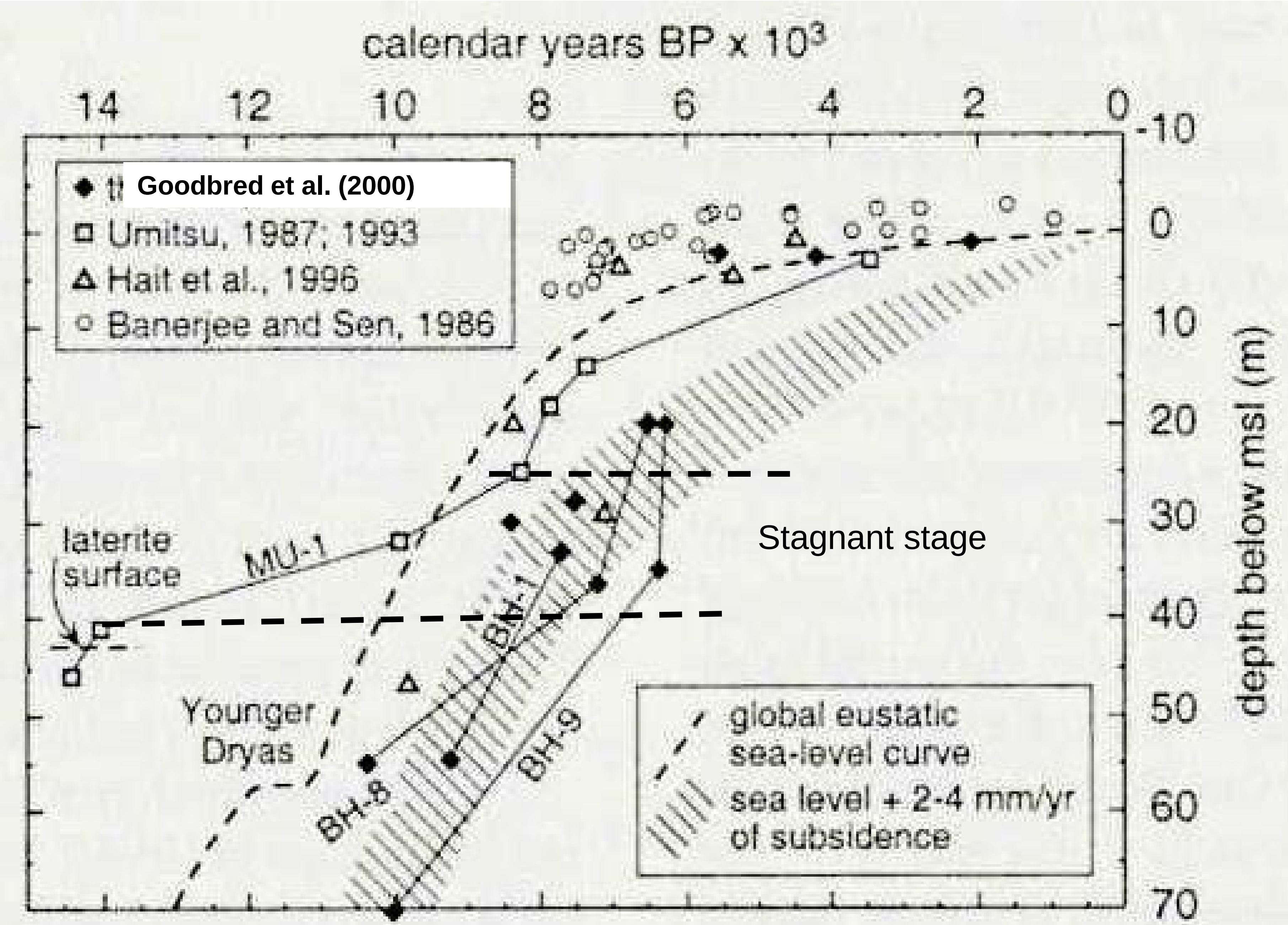


Figure 3.4. Sea-level changes during the last interglacial-glacial transition (after Pirazzoli, 1991).



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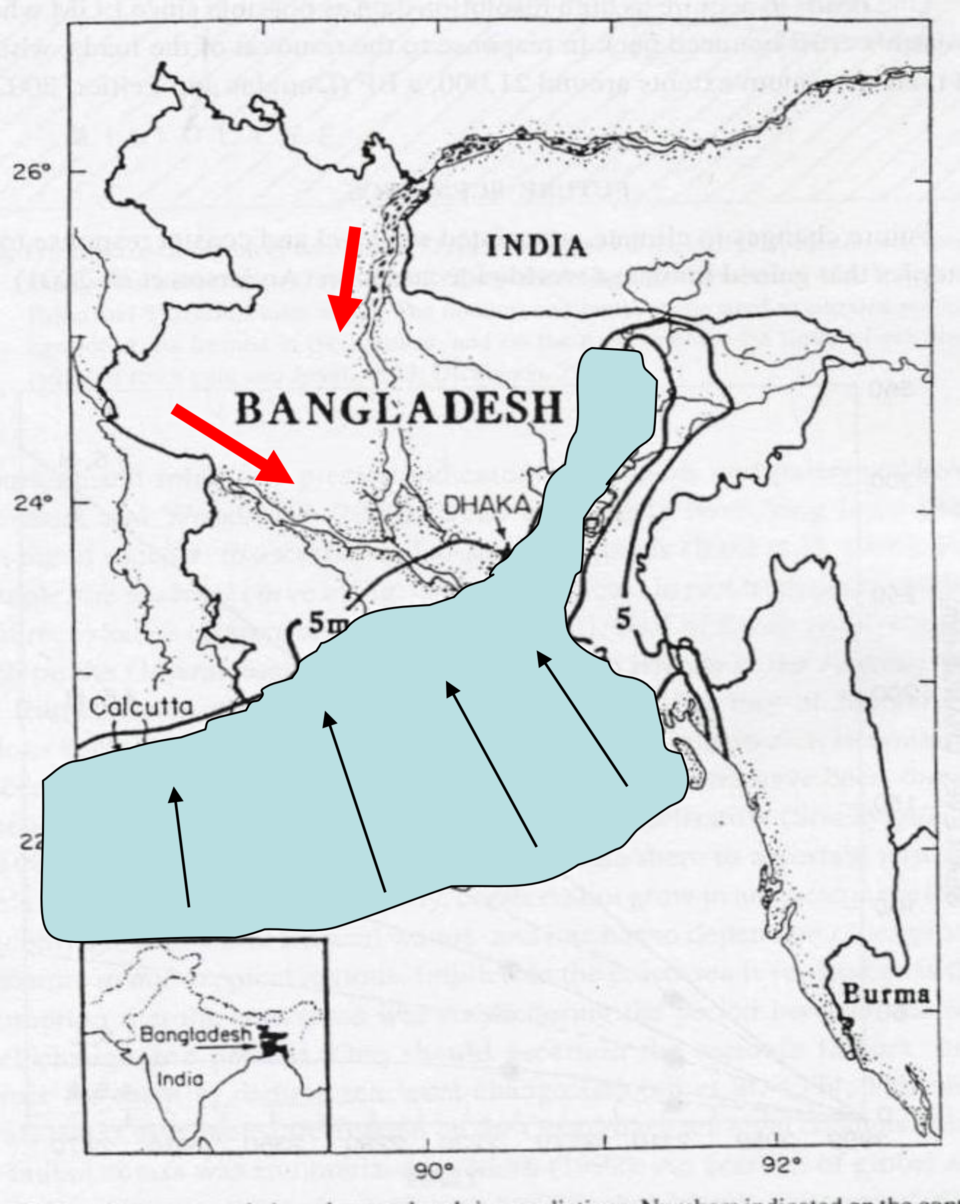
4 meters above sea level nearly equal to the transgression maximum, (7,000 ybp) after last glacial age(ca.19,000 BP)



Sea level change in the past 10,000 years (Holocene)
M.Shahidul Islam (2001)

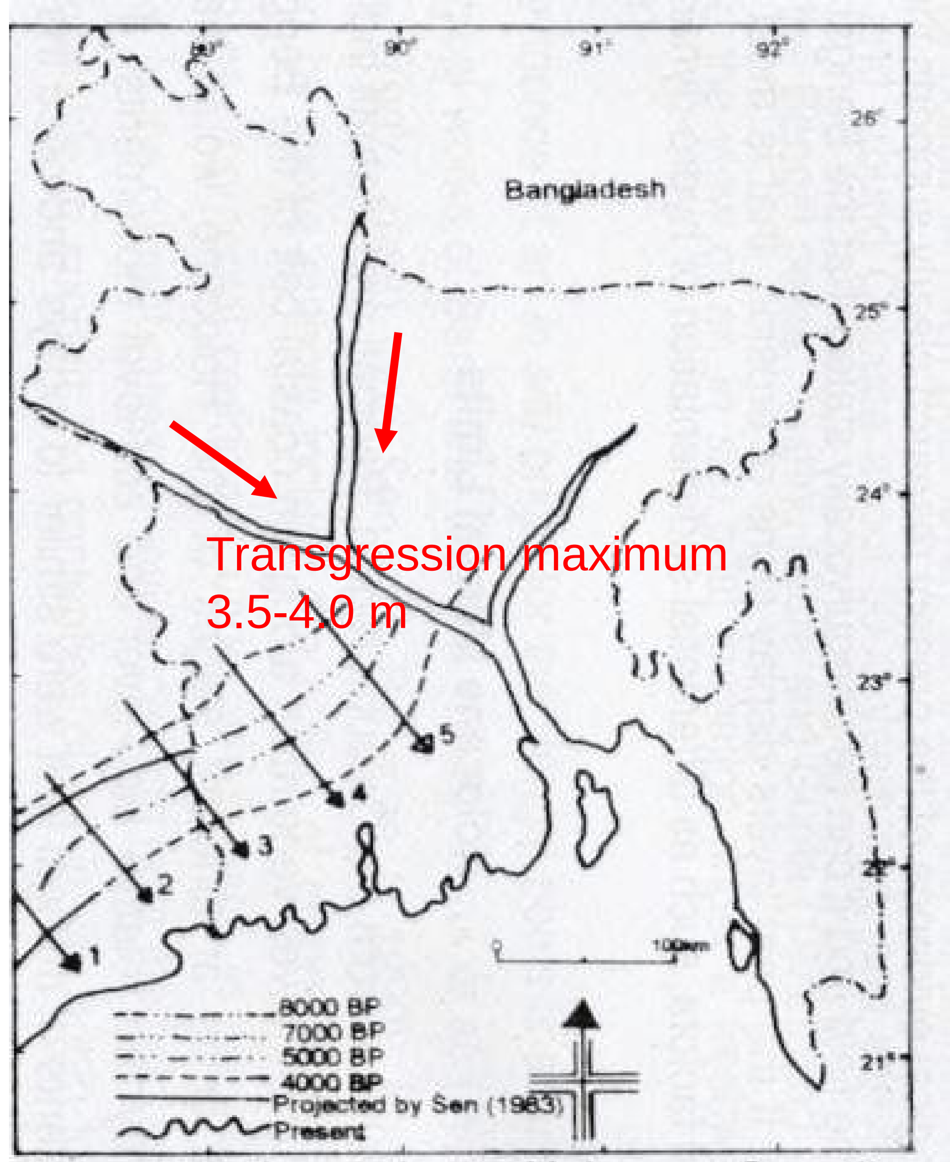
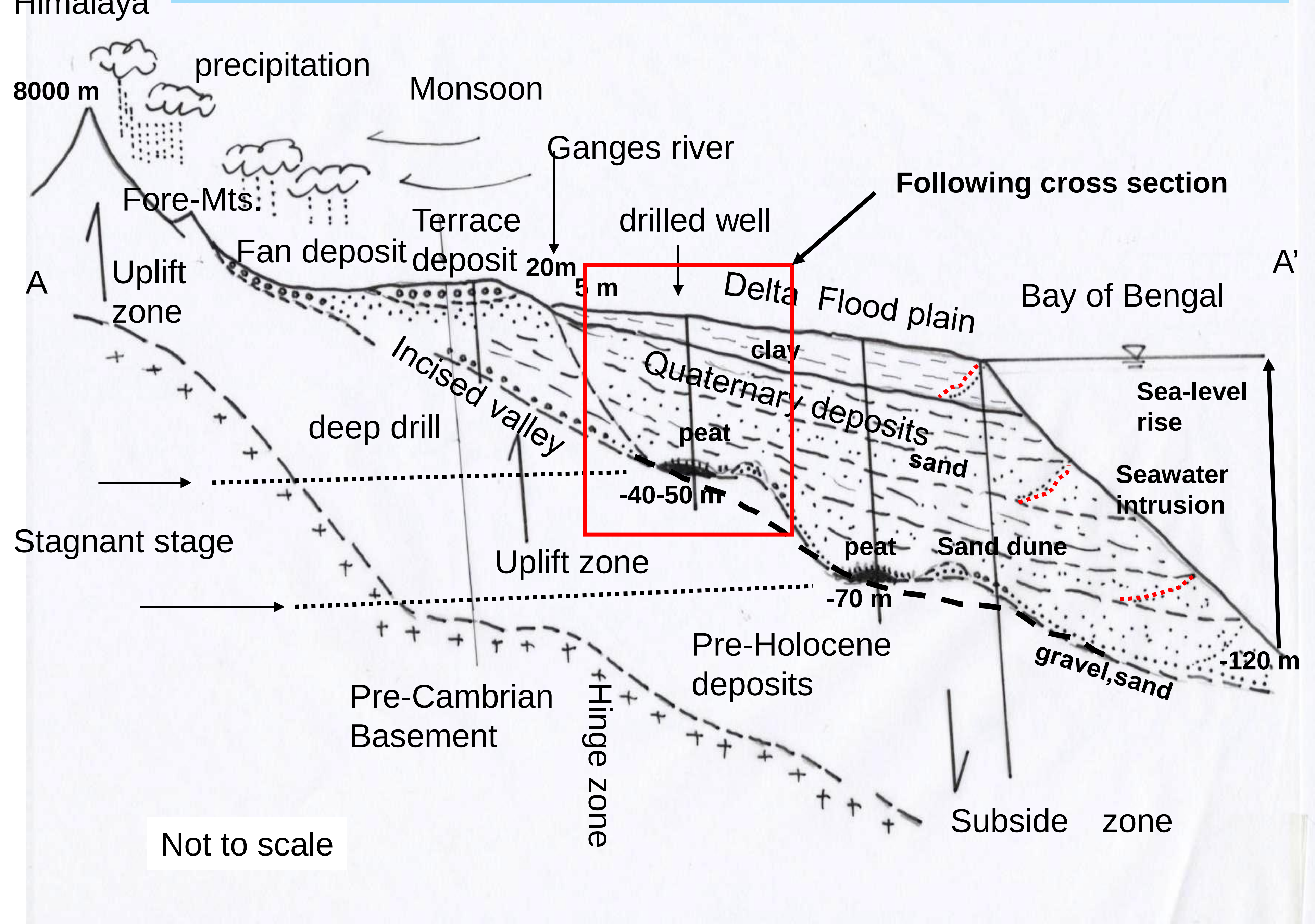
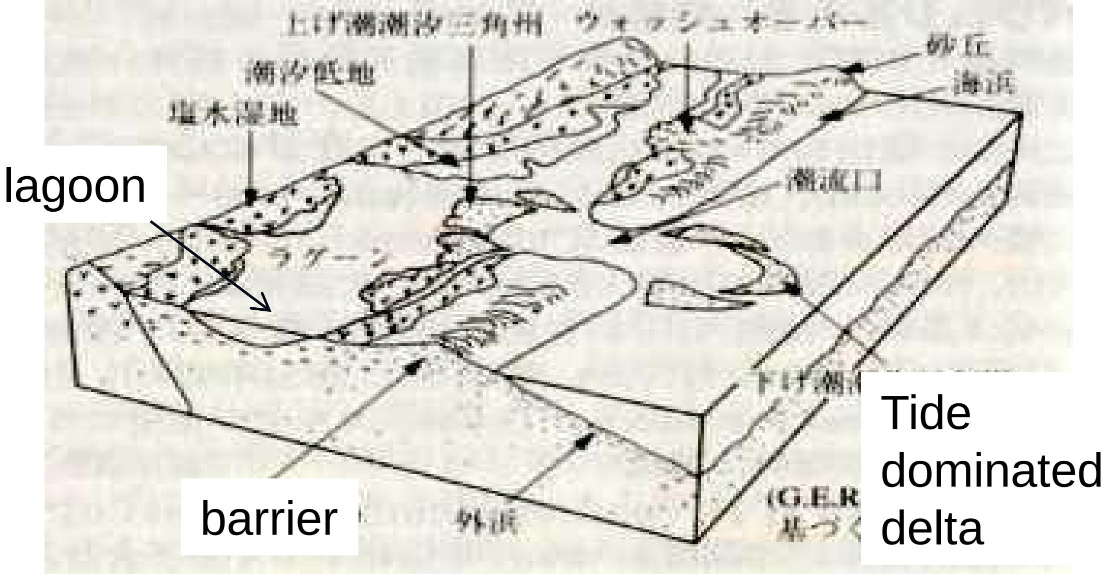


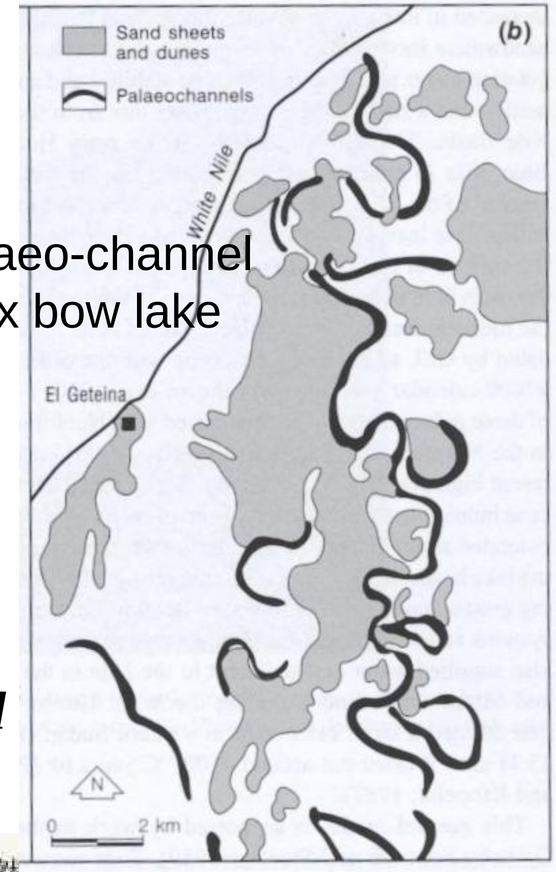
Figure 9.3: Approximate Holocene Coastline

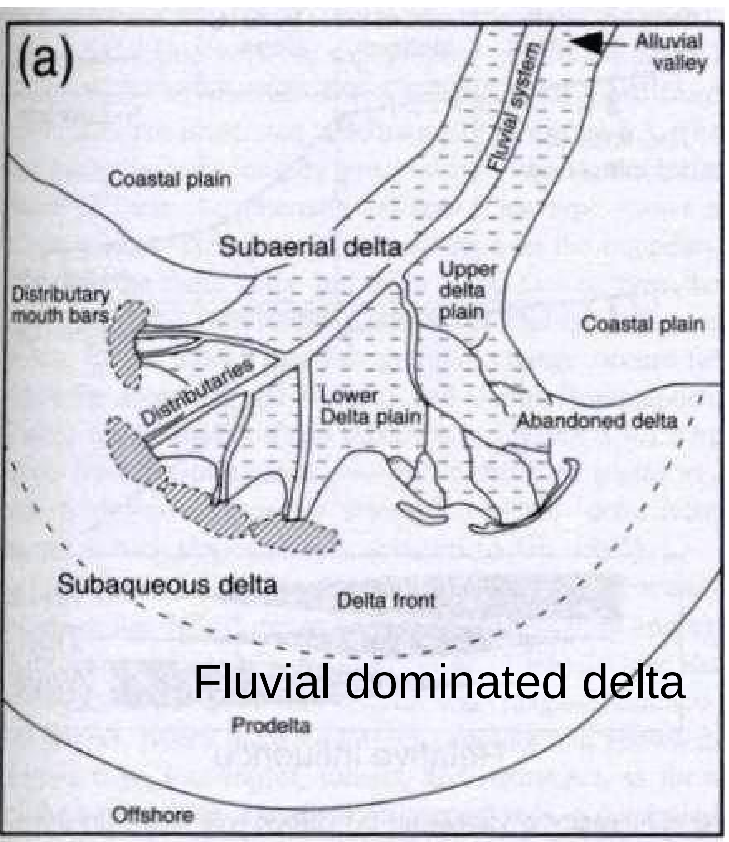
Diagrammatic Geohydrological Section of Ganges Plain

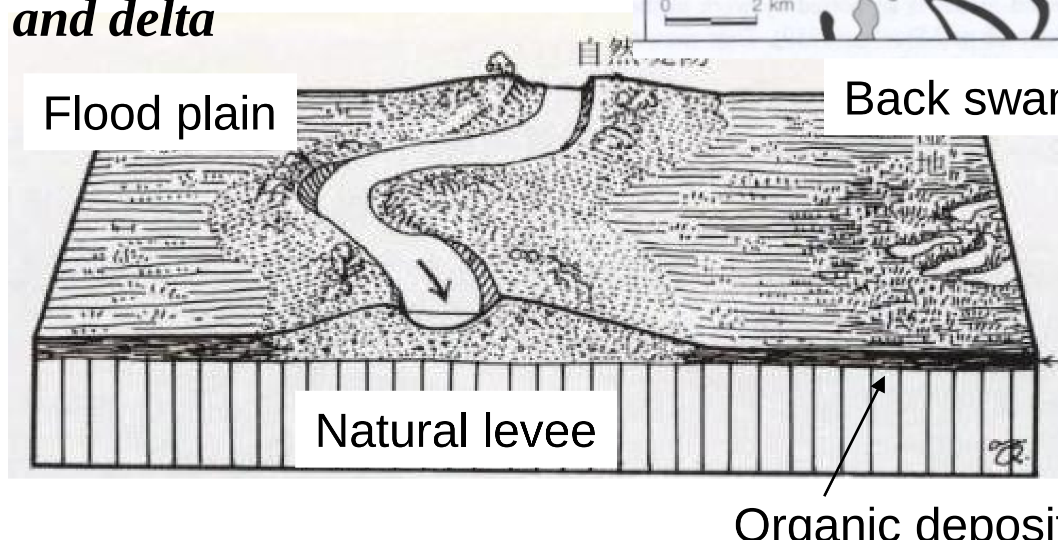


Specific topography formed by river and tide at estuary and delta







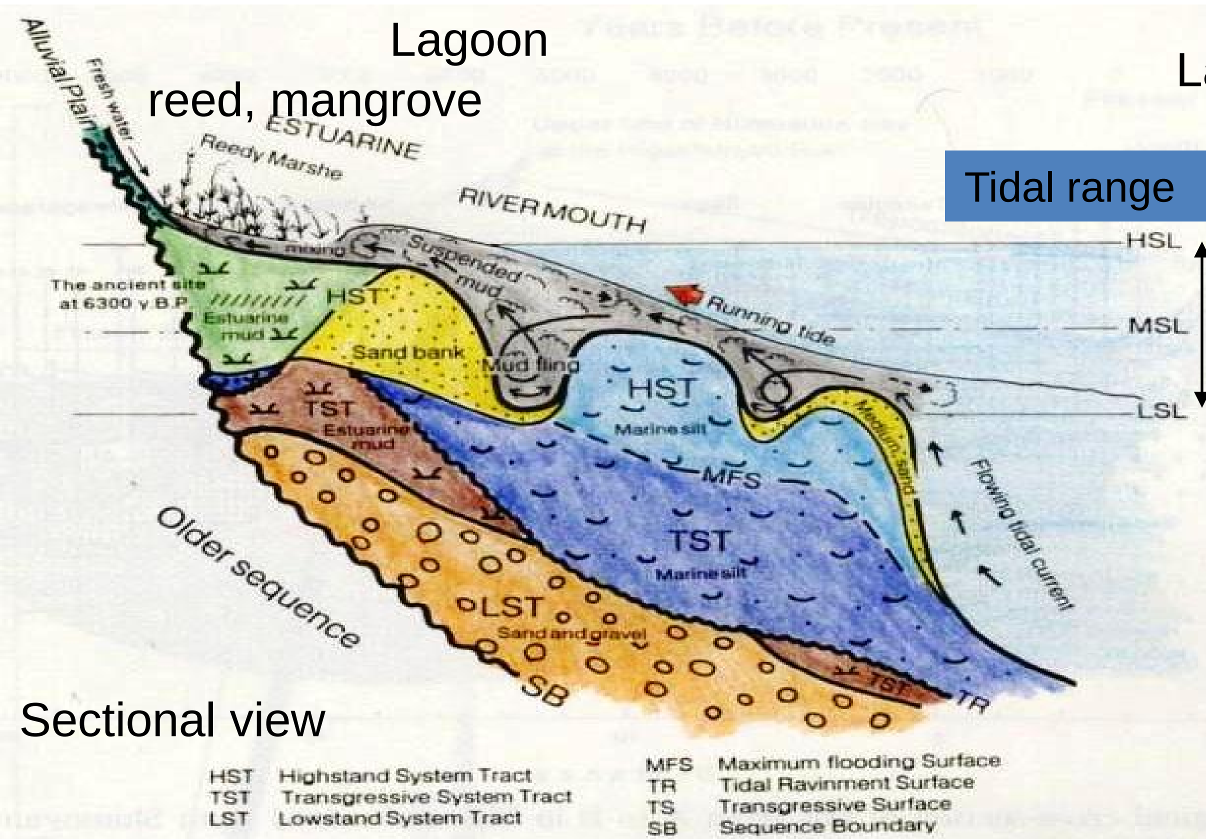


-Origin: Erosion of FeS_2,FeAsS,Geothermal,Mining

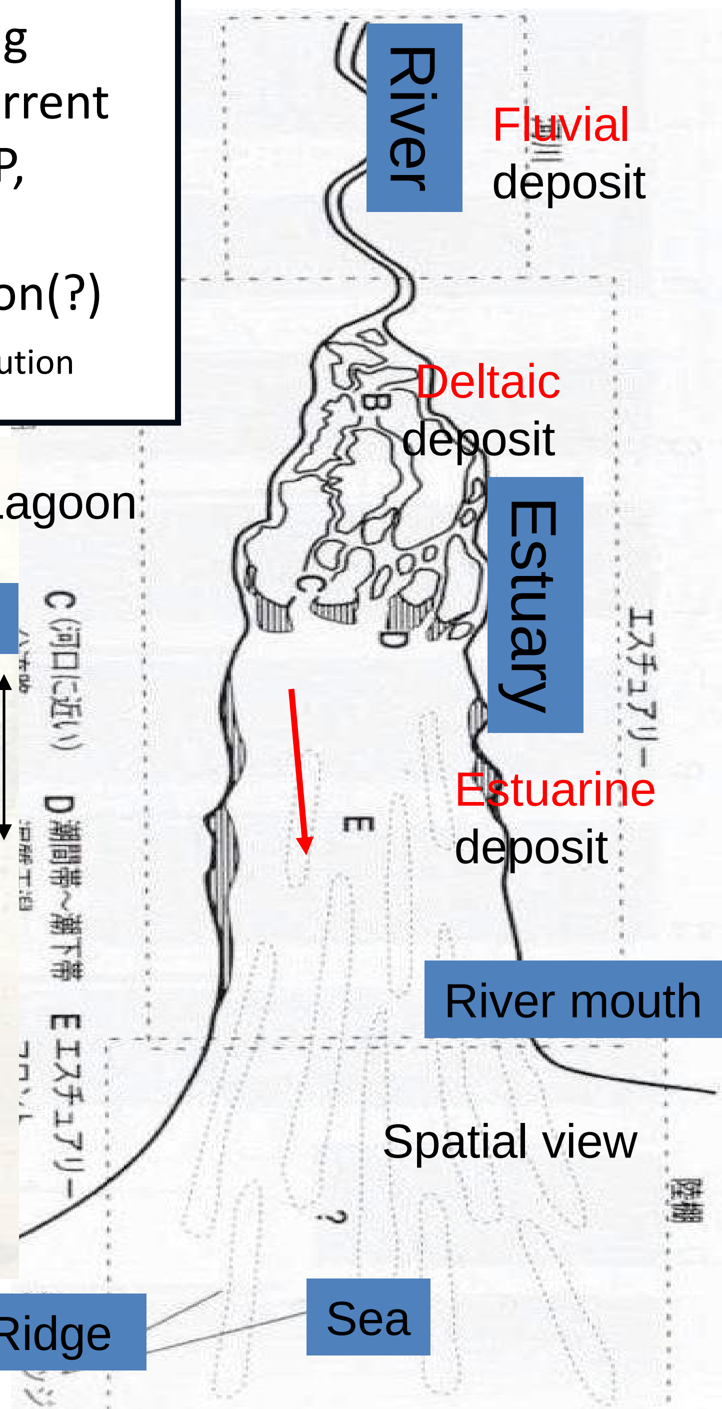
-Transportation :$H_2AsO_3^-$, $H_2AsO_4^-$ etc. in slow current

-Absorb in sediment of fine clay & peat (low ORP, Ph : neutral to weakly alkaline)

-Dissolution in groundwater: oxidation(?) or reduction(?) mechanism:exp.$Fe(OH)_3$ => Bacteria => Reductive => As dissolution

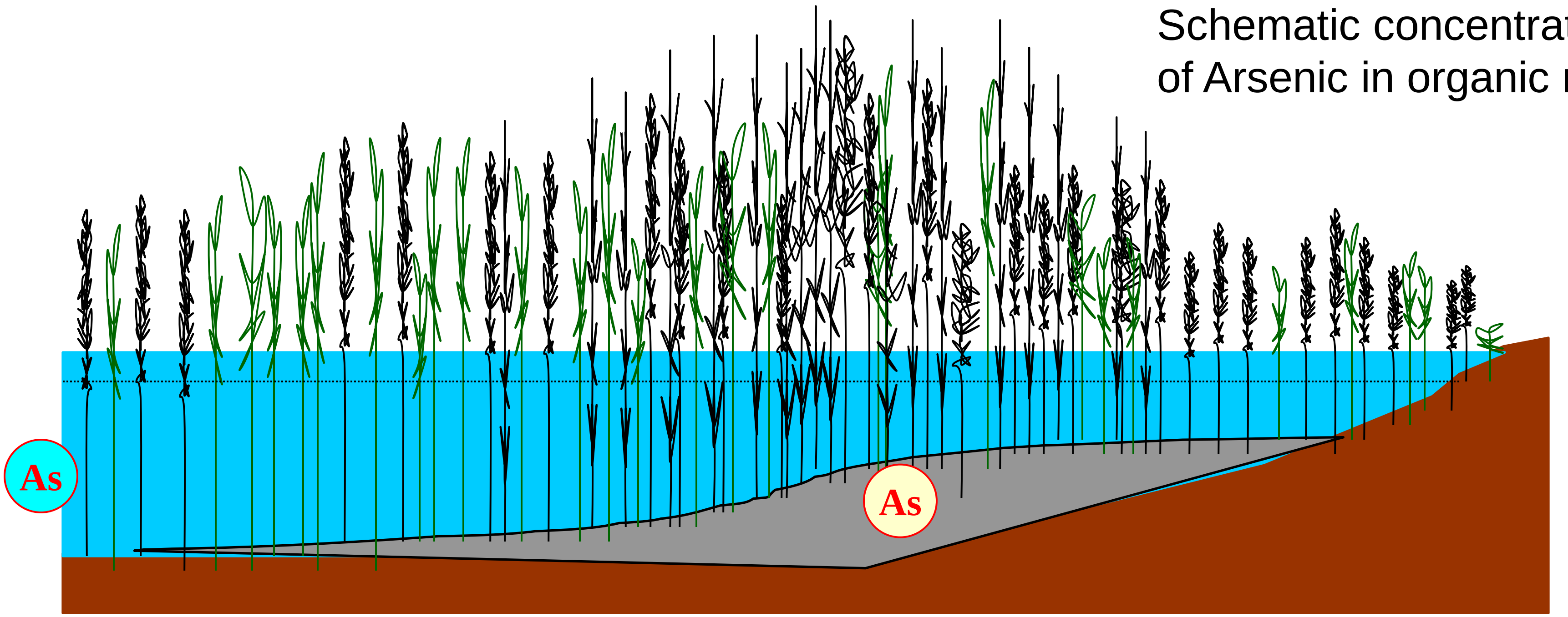


(Shimoyama,1999)



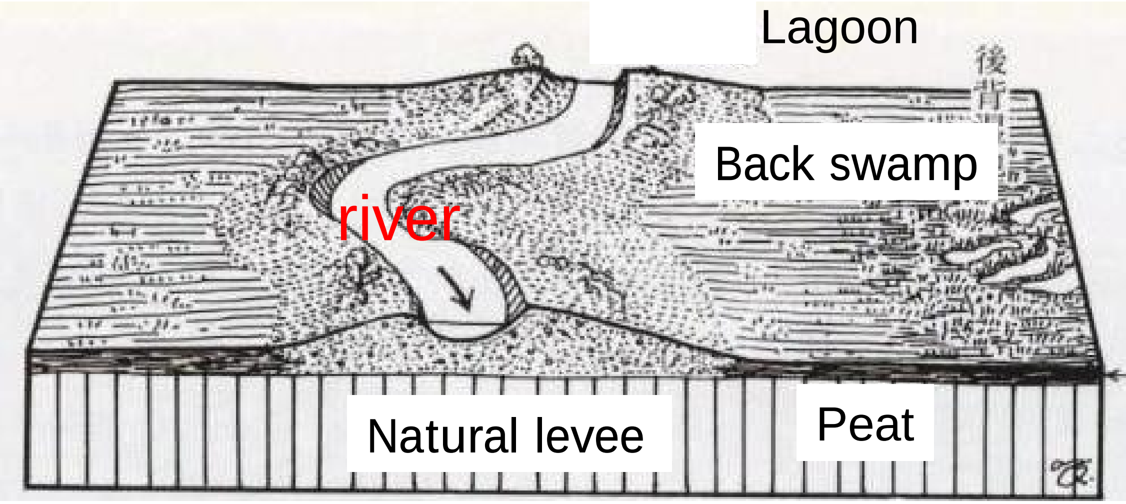
(Hori et.,al,2006)

Schematic concentration of Arsenic in organic remains



Natural levee (relatively high ridge) and back swamp (clayey materials deposited) , Peat (originated from reed etc.)

Kushiro wet land, Japan



Chemical behaviour of arsenic

- Natural source : arsenopyrite($FeAsS_2$),pyrrhotite($Fe_{1-x}S$), pyrite(FeS_2), realgar(AsS),geothermal activity($(AsS_2)^{3-}$)
- arsenic acid : + 5 : $H_3AsO_4^-$, $HAsO_4^{2-}$, AsO_4^{3-} chemically stable in oxidation environment, non-toxic
- arsenic trioxide : +3 : $H_3AsO_3^-$, $HAsO_3^{2-}$, AsO_3^{3-}, chemically stable in reduction environment, very toxic
- oxo-anion, easily combined with Fe,Mn,Al-cations, and flow then deposit
- Absorbed in fine particles such as clay minerals and organic materials
- Arsenic trioxide largely predominates in volume in fresh water, especially in Bangladesh
- Trigger, which dissolves arsenic in groundwater is listed up below,

  1)change of oxidation-reduction (ORP) environment, 2) change of Ph (alkalinize), 3) influence of phosphorus ion (H_3PO_3), 4) change of water level and speed of groundwater flow
- Reduction of $Fe(OH)_3$ $Fe(OH)_3 \rightarrow Fe^{2+}$

Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) inventory survey (excerpt)

As Criteria>0.05 mg/l (50 μg/l), WHO criteria>0.01 mg/l (10 μg/l)

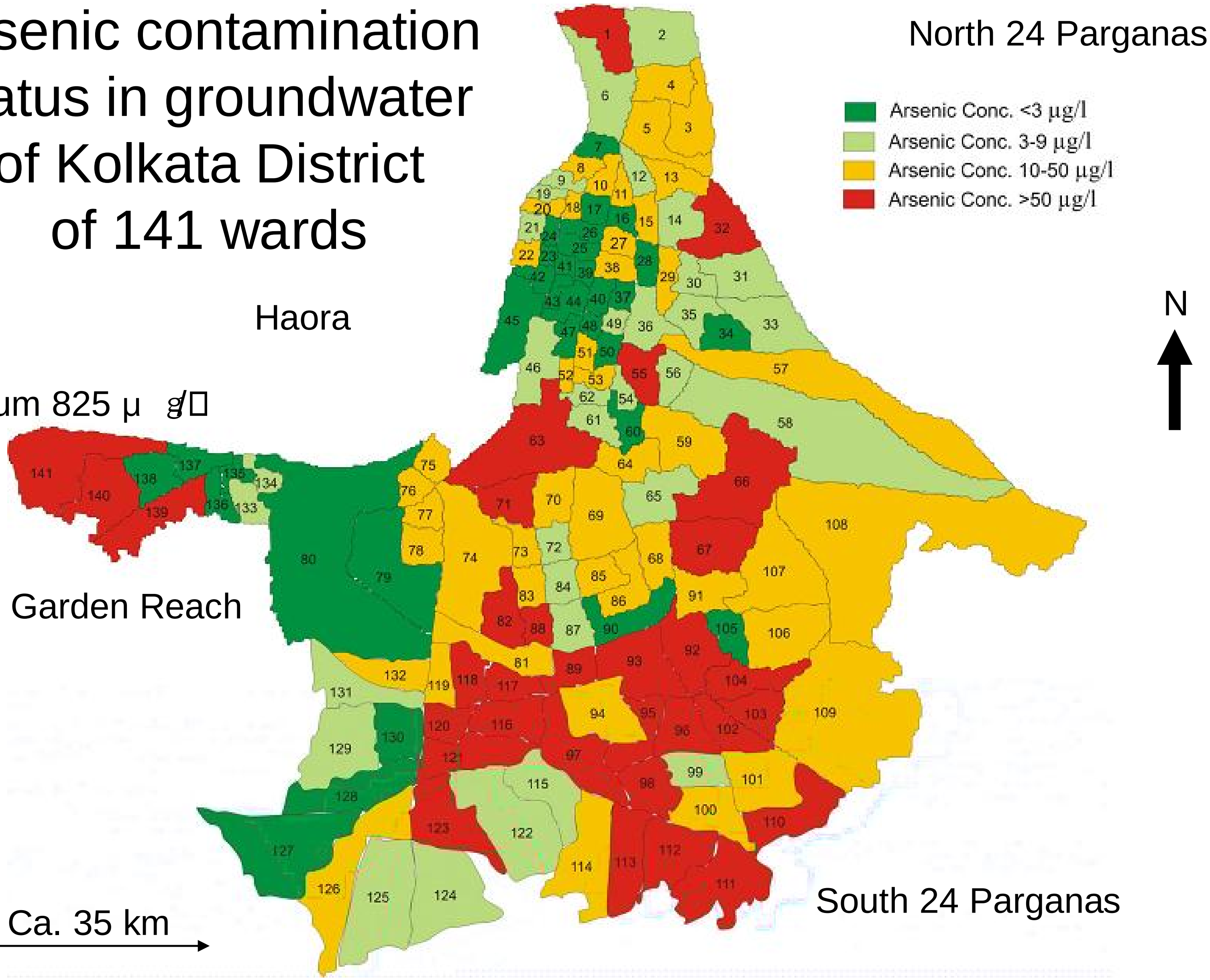
DIVISION	DISTRICT	UPAZILA	TWTESTED	TWOPERATIVE	AS_SAFE	AS_CONTA	PERC_CONTA
Chittagong	Lakshmipur	Lakshmipur Sadar	91	91	52	39	42.8
Chittagong	Lakshmipur	Lakshmipur Sadar	821	818	142	679	83.0
Chittagong	Lakshmipur	Lakshmipur Sadar	2	2	2	0	0
Chittagong	Lakshmipur	Lakshmipur Sadar	1	1	0	1	100
Chittagong	Lakshmipur	Lakshmipur Sadar	69	69	3	66	95.6
Chittagong	Lakshmipur	Lakshmipur Sadar	520	520	71	449	86.3
Chittagong	Lakshmipur	Lakshmipur Sadar	471	471	101	370	78.5
Chittagong	Lakshmipur	Lakshmipur Sadar	53	53	13	40	75.4
Chittagong	Lakshmipur	Lakshmipur Sadar	263	263	155	108	41.0

In 1998 ~ 2006, 270 upazilas (counties) were analysed on ca. 4.95 million wells

UNICEF 44 upazila、World Bank 197 upazila, AAN 1 upazila、Swiss（SDC）20 upazila、

Arsenic contamination status in groundwater of Kolkata District of 141 wards

Maximum 825 μg/l



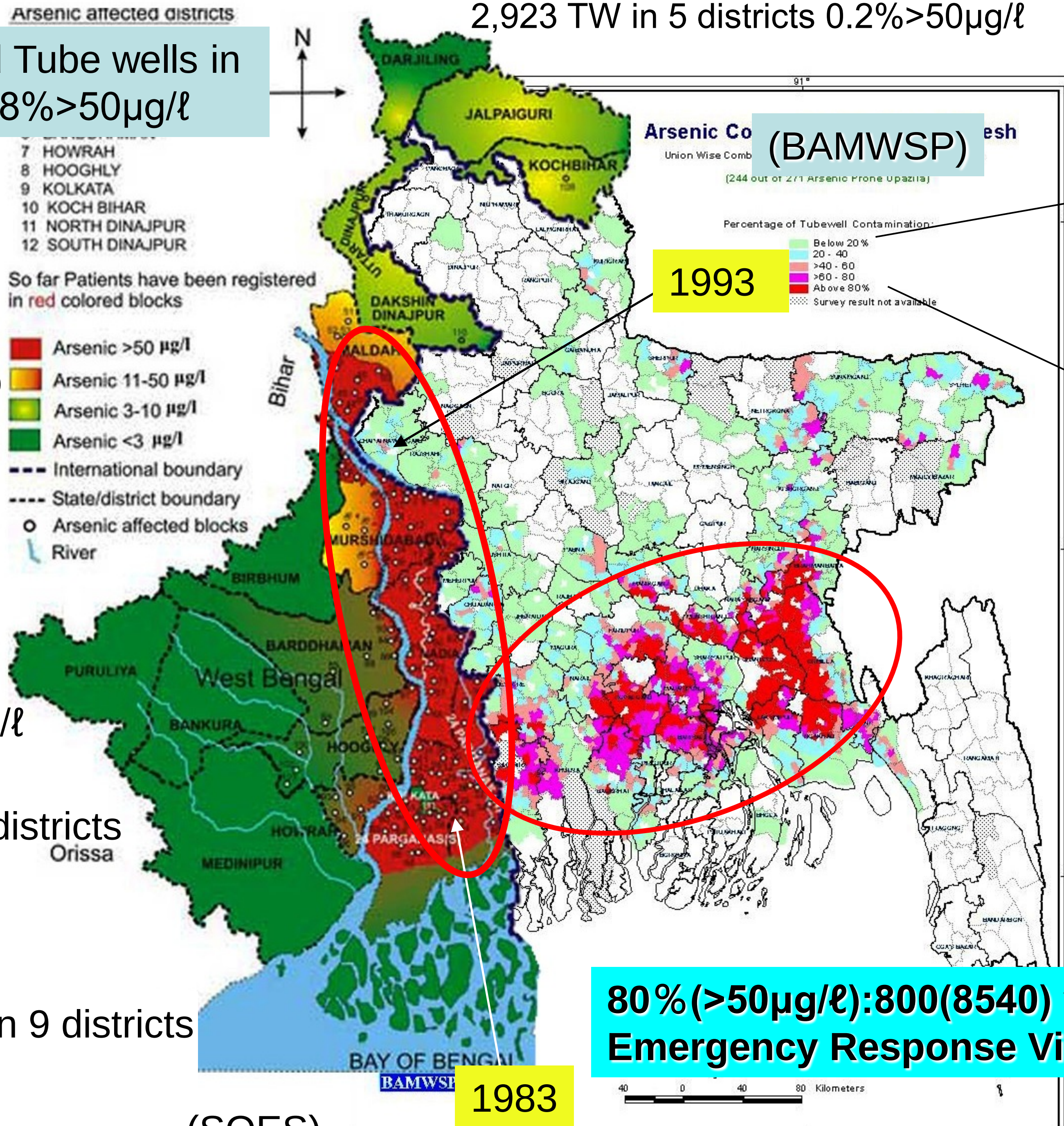
Ca. 35 km

140,150 hand Tube wells in 19 districts 23.8%>50μg/ℓ

2,923 TW in 5 districts 0.2%>50μg/ℓ

Percent of Arsenic Contami.

Arsenic content (μg/ℓ)



> 50
11 - 50
3 - 10
< 3

<20%
20-40%
40-60%
60-80%
>80%

4.95 million Tube wells

270 upazilas (0.3 mill.p.)

3.3%>300μg/ℓ Skin lesions
0.13%>1000μg/ℓ

29%> ca.24 mill. people

1,672 TW in 5 districts
100%<10 μg/ℓ

80%(>50μg/ℓ):800(8540) villages
Emergency Response Villages

135,555 TW in 9 districts
24.7% > 50μg/ℓ

(SOES)

BAMWSP

270 county
(upazila)

1998 ~ 2006
circa 4.95 million
wells inventoried

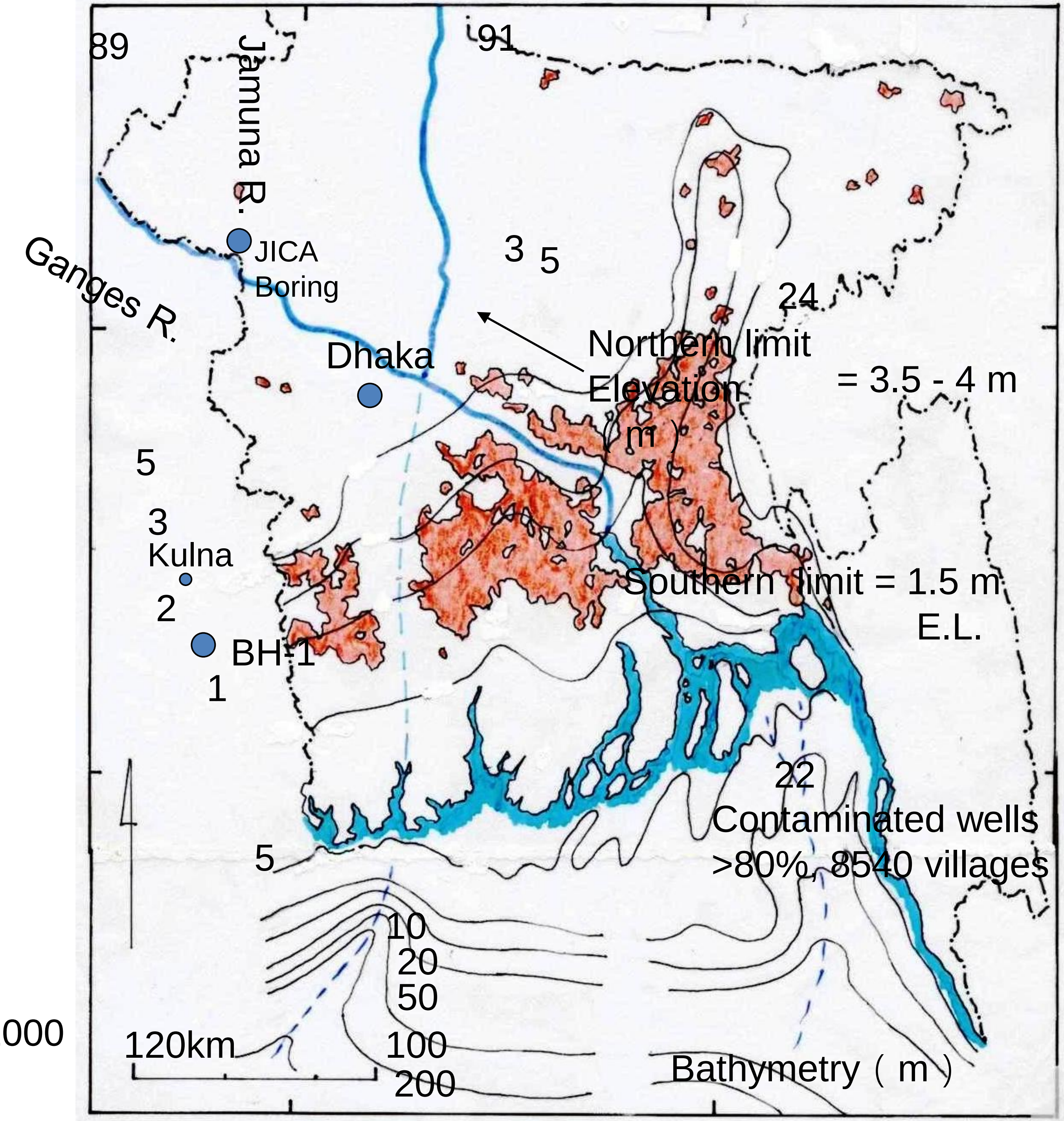
UNICEF 44 upazila、
World Bank 197 upazila
AAN 1 upazila、
Swiss (SDC) 19、DANIDA 8、
Total 269 upazila

29% wells >
50μg/ℓ

Distribution of Upazila, where 60% out of domestic wells exceed the Arsenic health ceiling (50μg/ℓ)

N

0 1000



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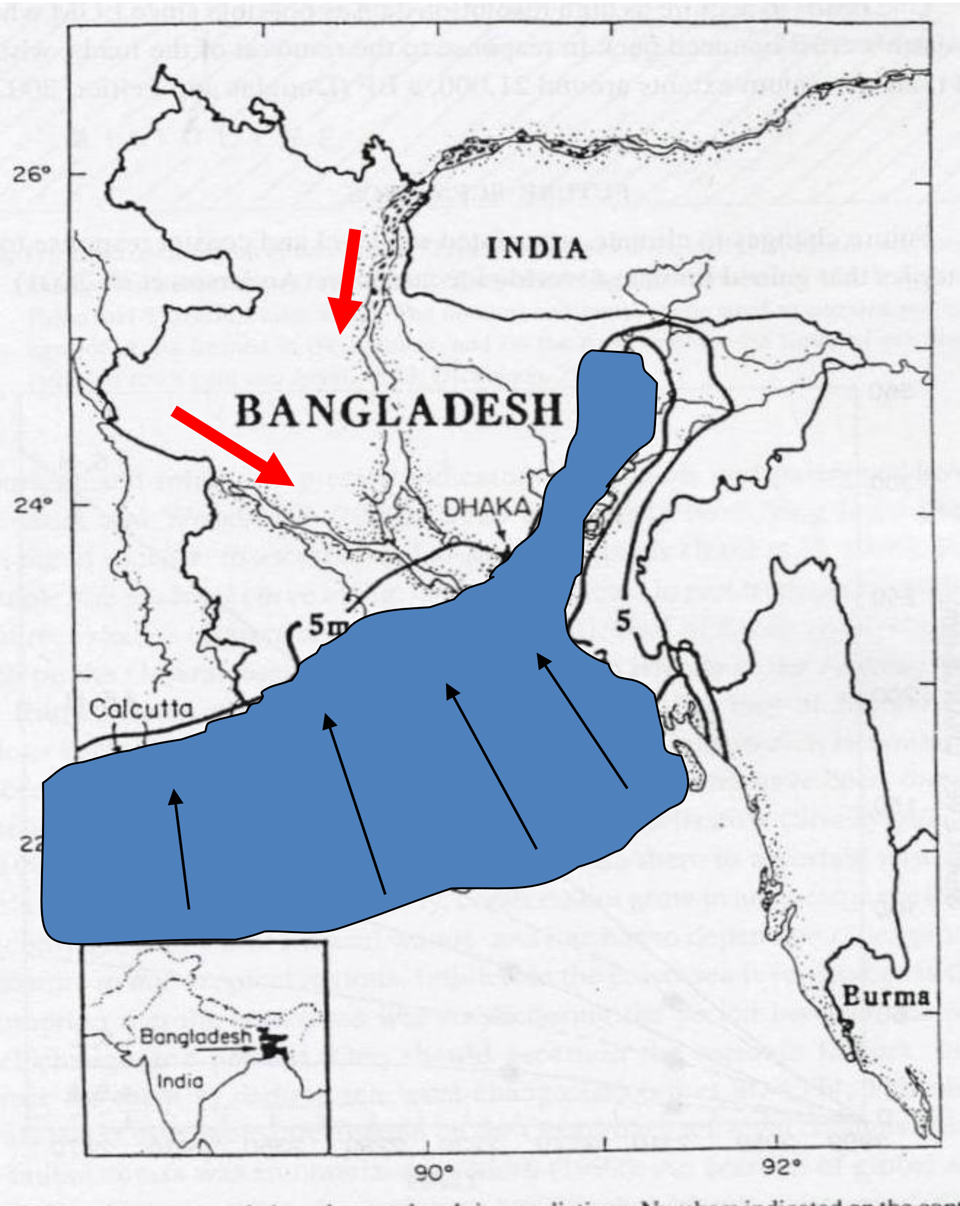

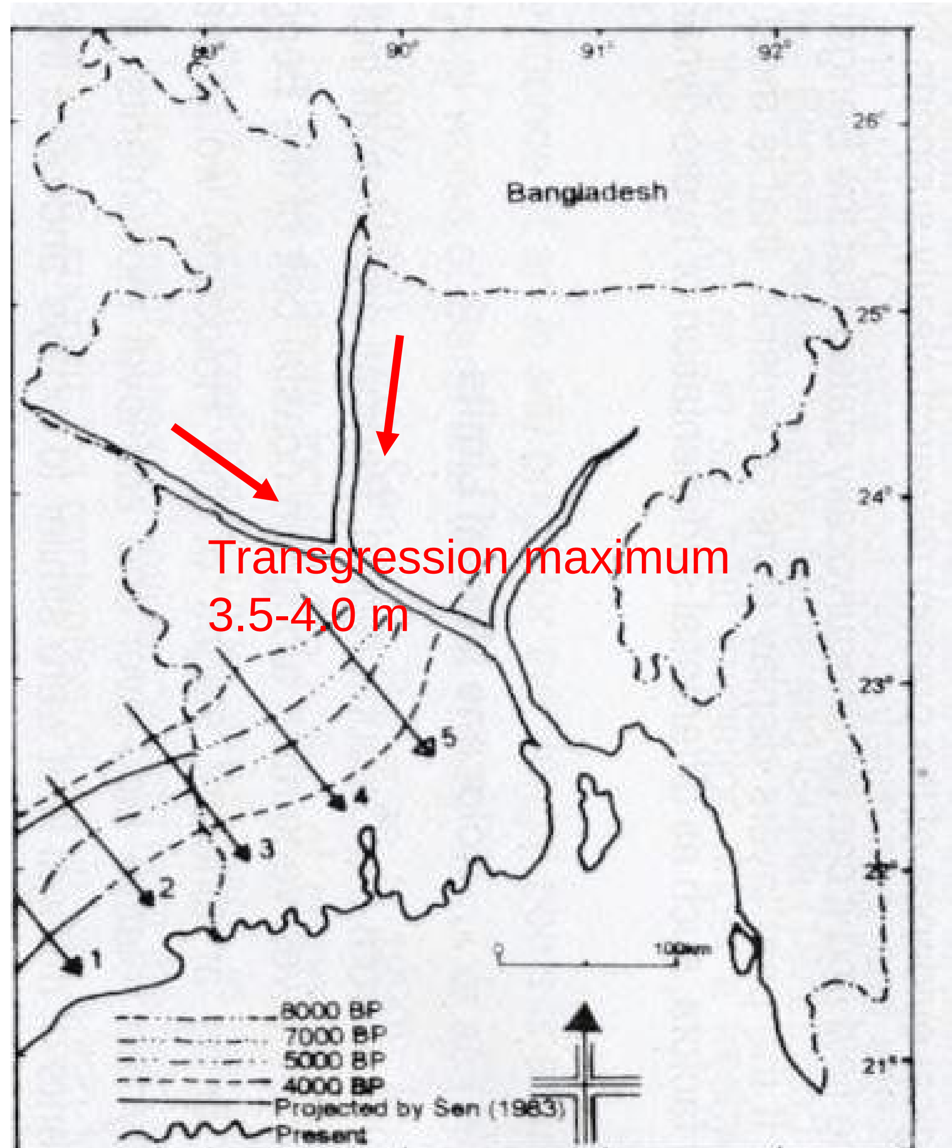

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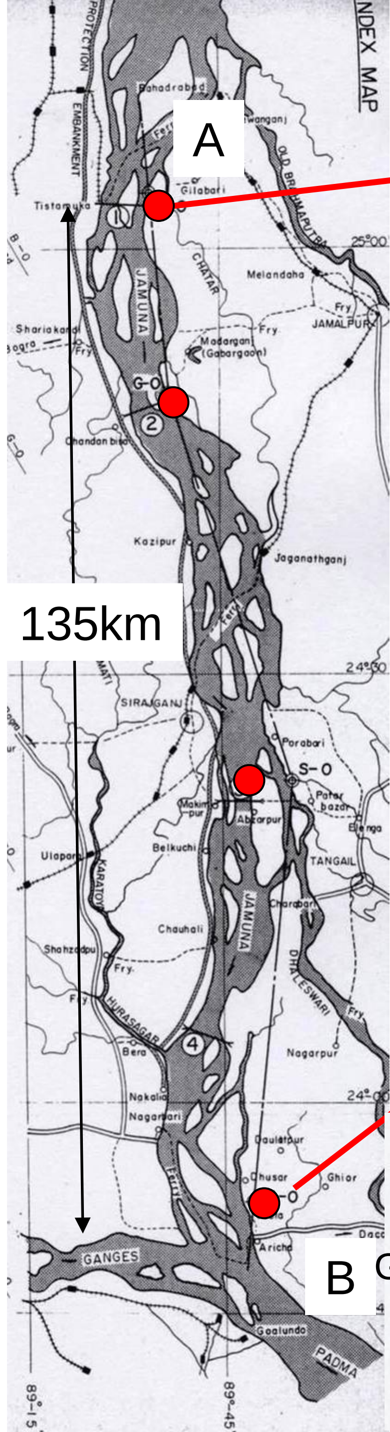

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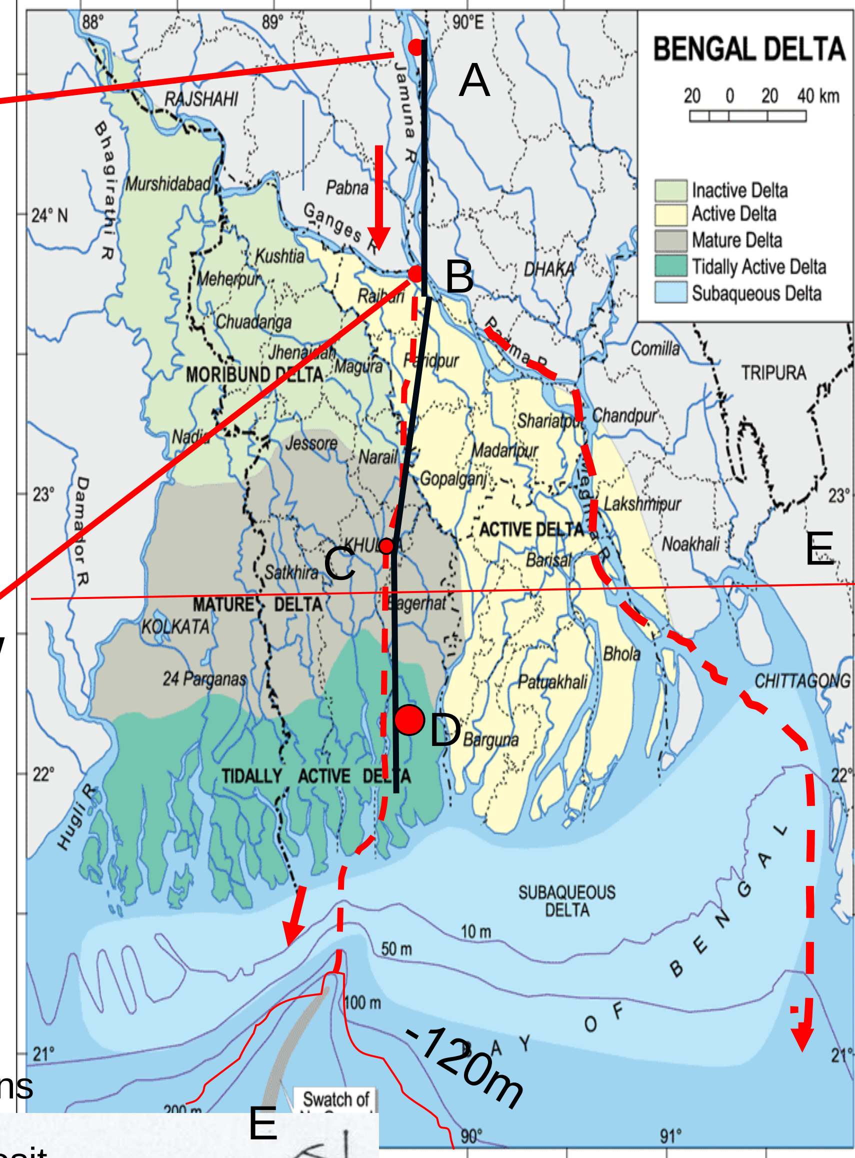
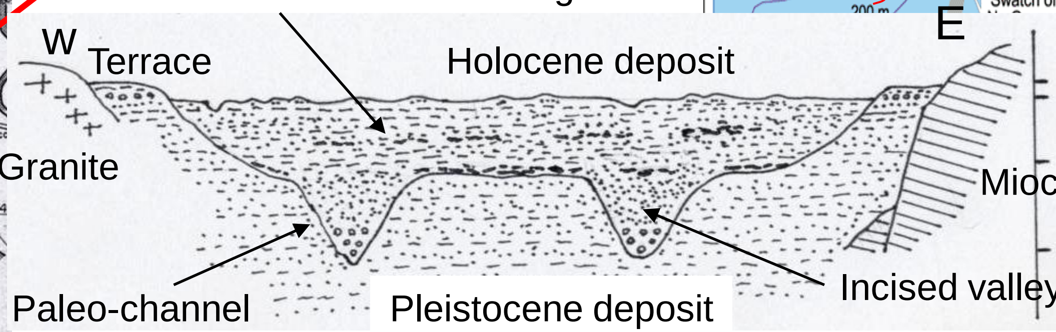
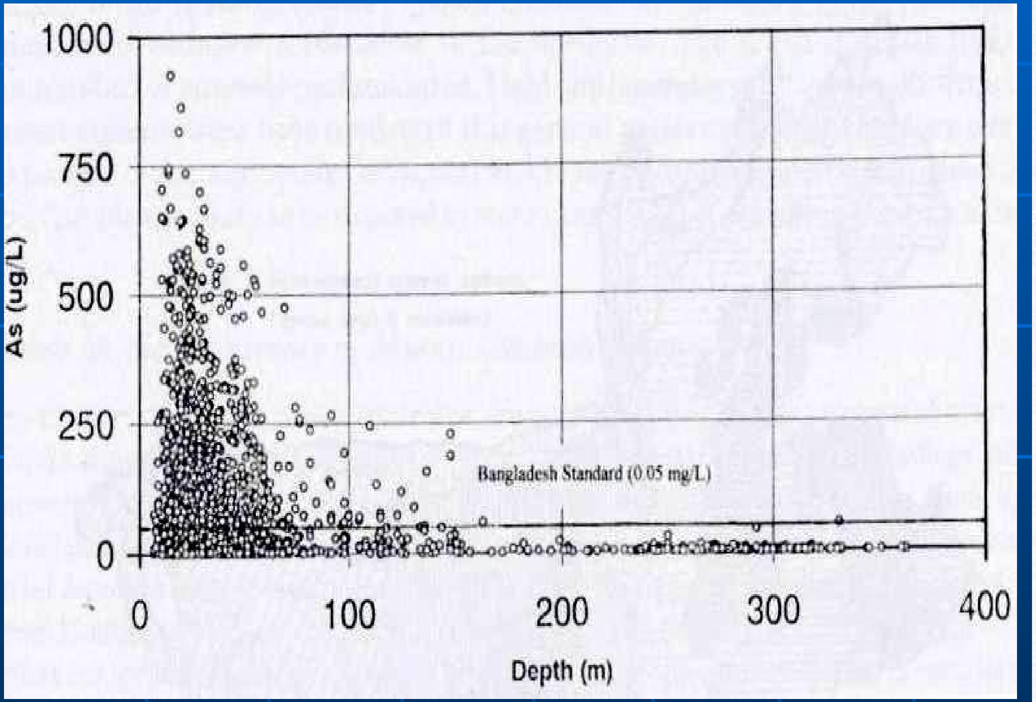
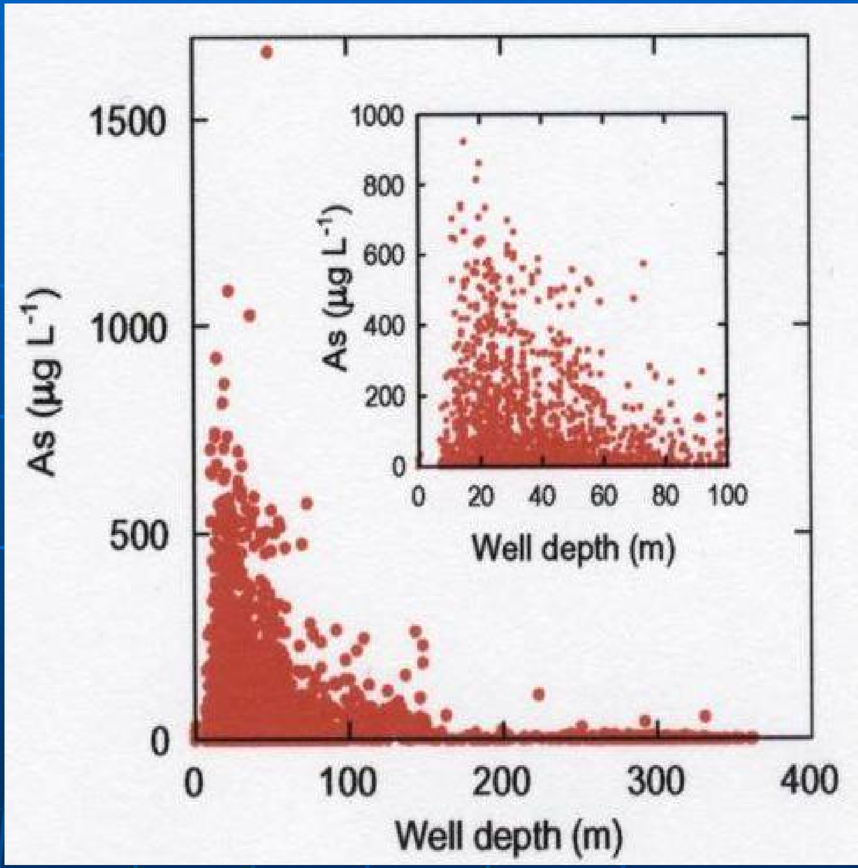




Arsenic Concentration of groundwater in wells from the DPHE/BGS National Survey plotted as a function of well depth



(DPHE)



(BGS)

Geohydrological Conclusion

- An extensive sedimentary basin was formed in the old estuary of the Ganges-Brahmaputra Rivers, where the basement rocks subsided deep, contrarily northern tract uplifted due to the Himalayan Mountains rise.
- The Ganges-Bramaputra delta initiated to develop from west to east by huge amount of debris sedimentation supplied by the Ganges-Bramaputra Rivers.
- The two old river channels were incised on the old plain composed of Pleistocene deposits at the time of latest regression, when sea level lowered 120m below the present sea level.
- Later the paleo- Jamuna (Bramaputra) River was buried at earlier stage of the Quaternary age.
- Northern limit of arsenic contamination area shows close relationship to transgression maximum seashore at the latest glacier age.
- This implies sedimentary environment where arsenic is accumulated, has close relation to estuarine to deltaic basin formed by stagnant and blackish river water during mainly latest transgression period of sea level.
- Presently they are composed of clay and peaty materials, which are predominant in shallow layers of less than 100m below ground level, from which arsenic contaminated groundwater is mostly abstracted.
- The two incised river channels were mainly infilled with fluvial dominated materials in turbulent flow, by which relatively permeable sand and gravel deposits predominant in the channnels.
- This may indicate why two less contaminated channels directed north to south in the zone.
- From the further south of the southern limit to seashore, there occurred no shallow wells due to sea water intrusion but deeper than 300m.

A process to be contemplated on Arsenic problems on groundwater is briefed up mainly from such geohydrological and institutional viewpoints as,

Natural, geo-chemical

- Origin & Transportation
- Absorb & Accumulation
- Sedimentation in estuary of deltaic basin
- Dissolution in groundwater exceeding health criteria, which is distributed in specific area

Socio-economic

- Pumping & leakage between aquifers
- Competitive use for drinking & irrigation
- Accumulation in human and cattle & Arsenic symptom

Policy, management

- Alternative water source
- Organization of a water union and maintenance

Conceptual profile of arsenic contamination caused by heavy pumping from an irrigation well

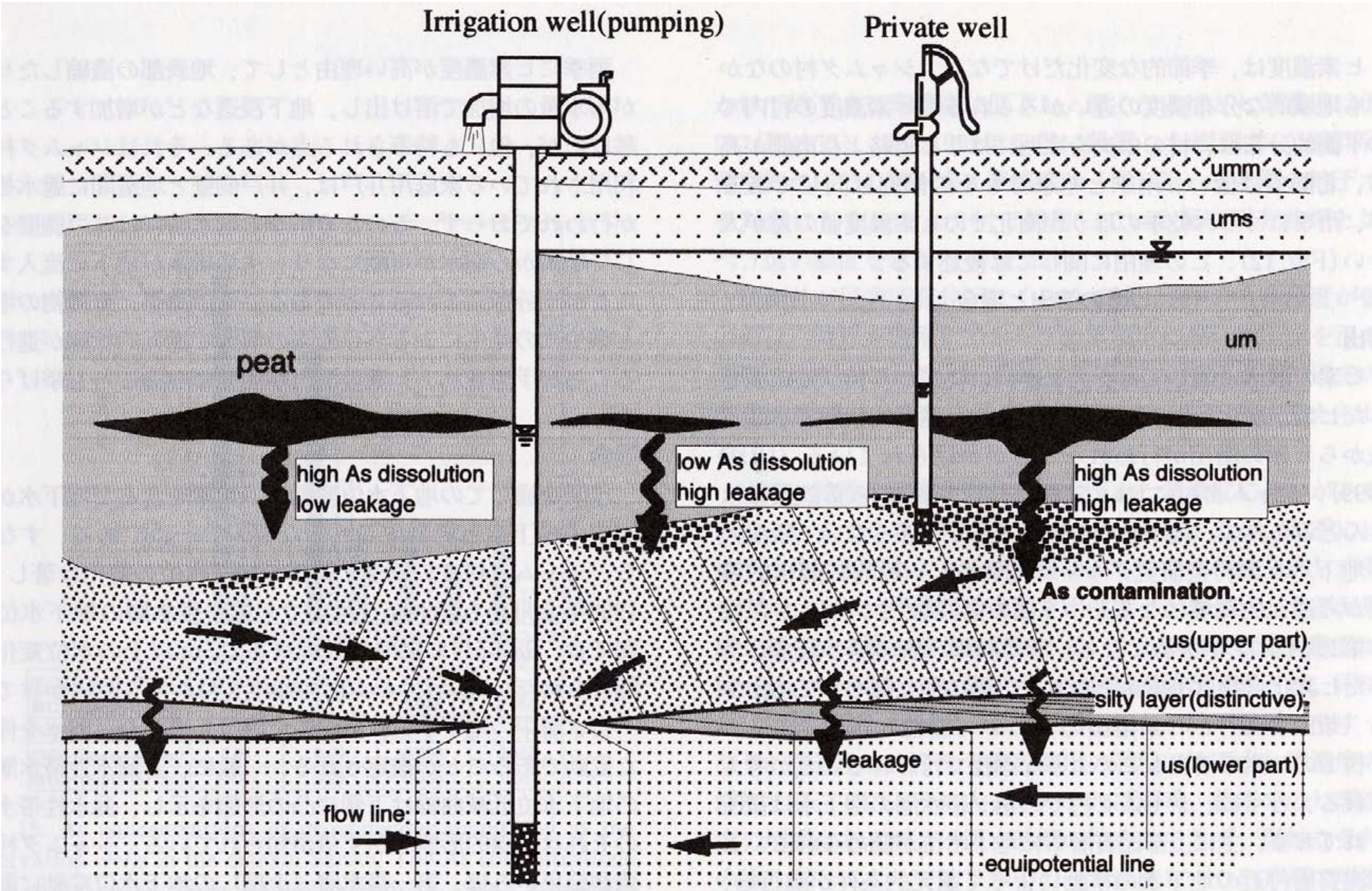


Fig. 17. Conc (Research Group for Applied Geology et al.,2000) the irrigation well.

Brief history of groundwater use in rural areas of Bangladesh and West Bengal

~1960s	Most people used water from dug wells and; ,surface water sources (rivers, pond, lakes etc). These water sources transmitted diseases such as diarrhoea, dysentery, typhoid, cholera and hepatitis.
1970s-1980s	UNICEF initiated a tube well campaign as the solution to diesease epidemics, providing materials for tube wells using UNICEF's own design and paying costs to install the wells (1 million or more wells were installed privately). At the peak of the program, 90%of the wells were installed within walking distance from a village. It was believed they supplied safe water.
1983	First patient was diagnosed with arsenic poisoning in West Bengal Province, India
late 1980s-early 1990s	Increasing numbers of people began to show signs of arsenic symptom illness.
1993	Bangladesh government firstly admitted arsenic poisoning patients near the western border.
1995	International conference on arsenic contamination in Kolkata. UN, the governments and NGOs joined the conference.
1998	BGS : geohydrological, geochemical and screening of wells contaminated by aresenic surveys (-2001), 1998 : SOES : Jadavpur University,Kolkata screening of wells contaminated by aresenic survey (-present)
1998-2006	Bangladesh Arsenic Mitigation and Water Supply Project (BAMWSP-2006) in nation-wide screening program of the drinking wells.
2004	National Water Management Plan (Approved by the Council, Ministry of Water Resources, Bangladesh) National Policy for Arsenic Mitigation 2004 &Implementation Plan for Arsenic Mitigation in Bangladesh (Local Government Division, the Ministry of Local Government, Rural Development &Co-operatives, Bangladesh)
2005	The West Bengal Ground Water Resources Act, West Bengal, India

Alternative supply for As mitigation water

Rural area

- Deep well(200m～300ｍ) ー＞Union water Pondー＞Ｐond Ｓand Filterー＞Union water
- Dug wellー＞Gravel Ｓand Filterー＞Union water
- One Facility for 100～300 people、＜500m

(Jessore district:332(22%)villages/1604>60% contam.,521350 households, Sharsha upazila:304,000 people)

Urban area in Dhaka & others

- Riverー＞Treatment plantー＞Tapped water
- Deep wellー＞Tapped water

Installation of alternative water resources and filter tank

Gravel Sand Filter

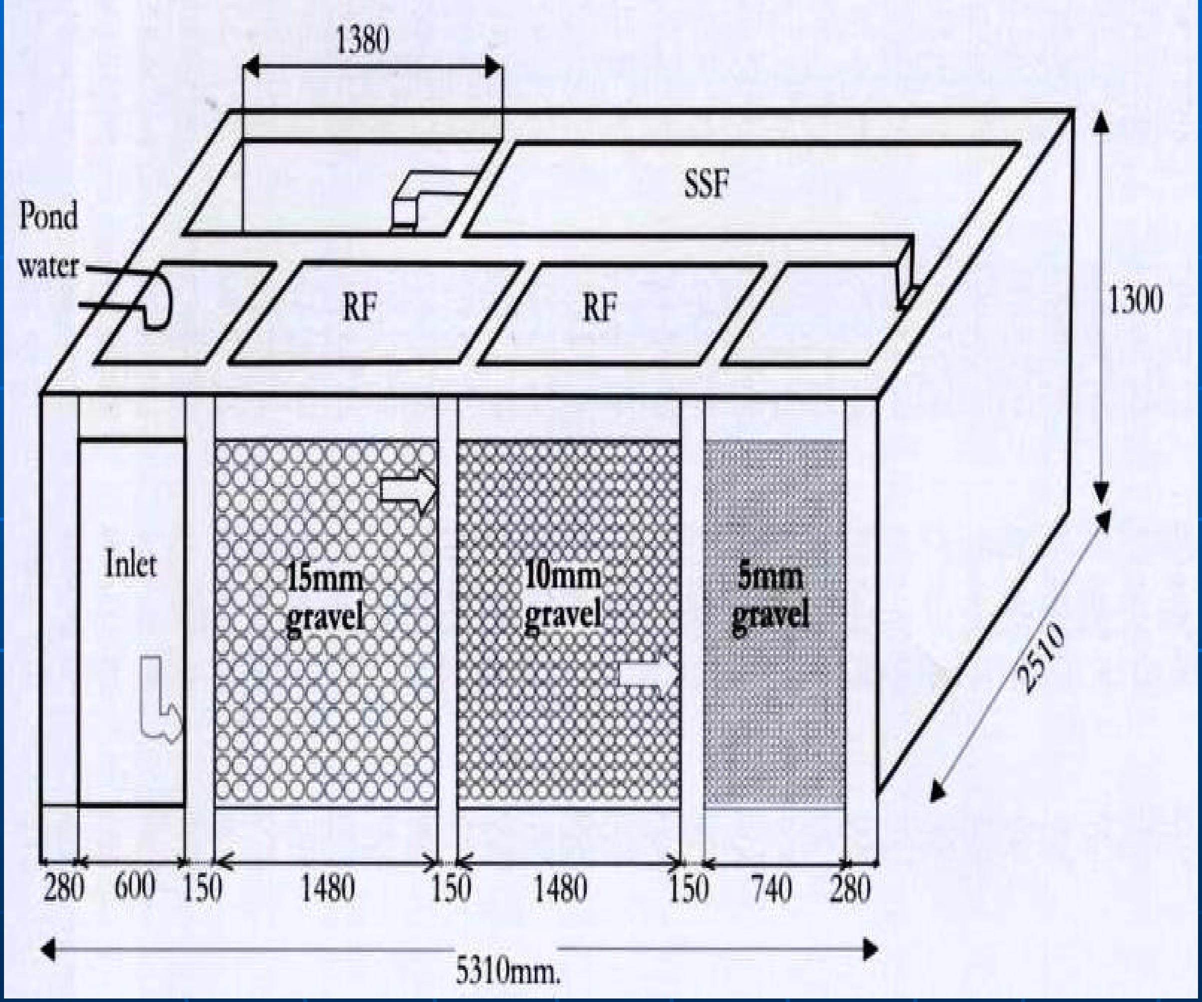
21,005　facilities installed 、 as of May,2005
21,005 * 500=10 million people

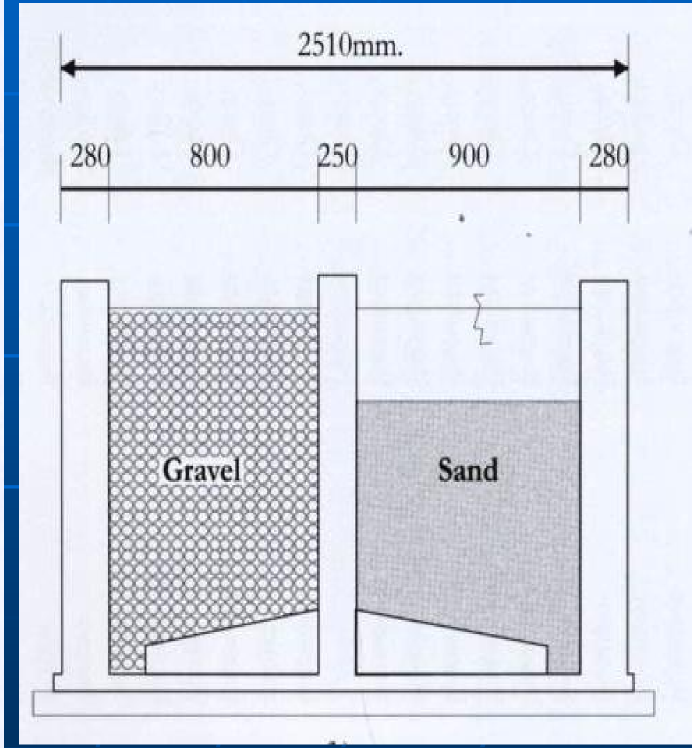
Donkey style drilling site
Max. 250 – 300 m deep


Inside of the sand and gravel filter
Aeration,settle

Dug well gravel sand filter

Brief design of Pond sand filter

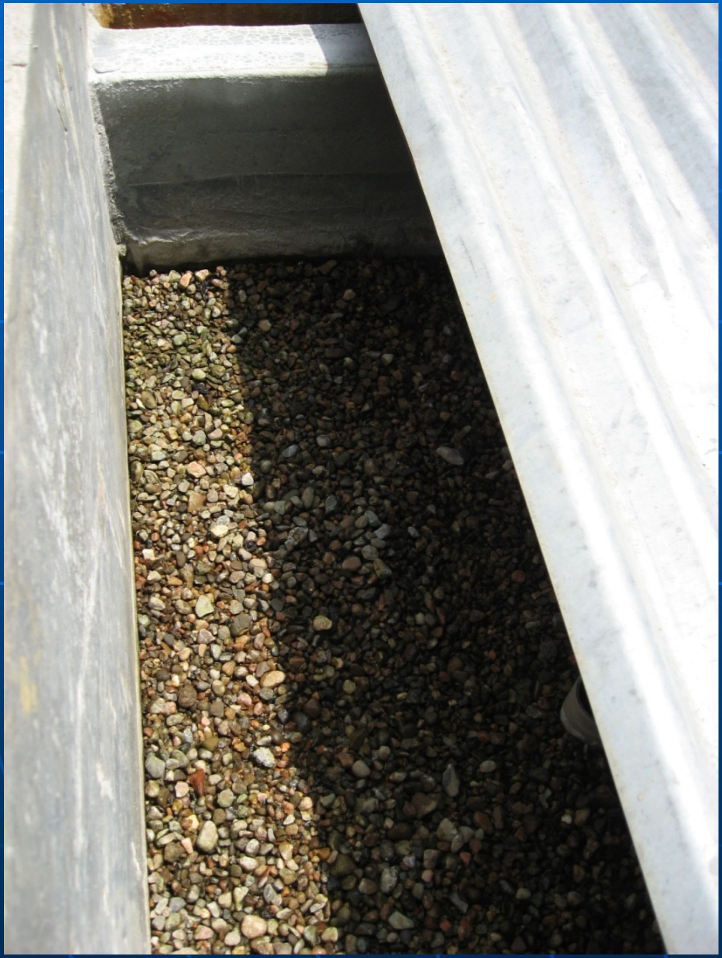




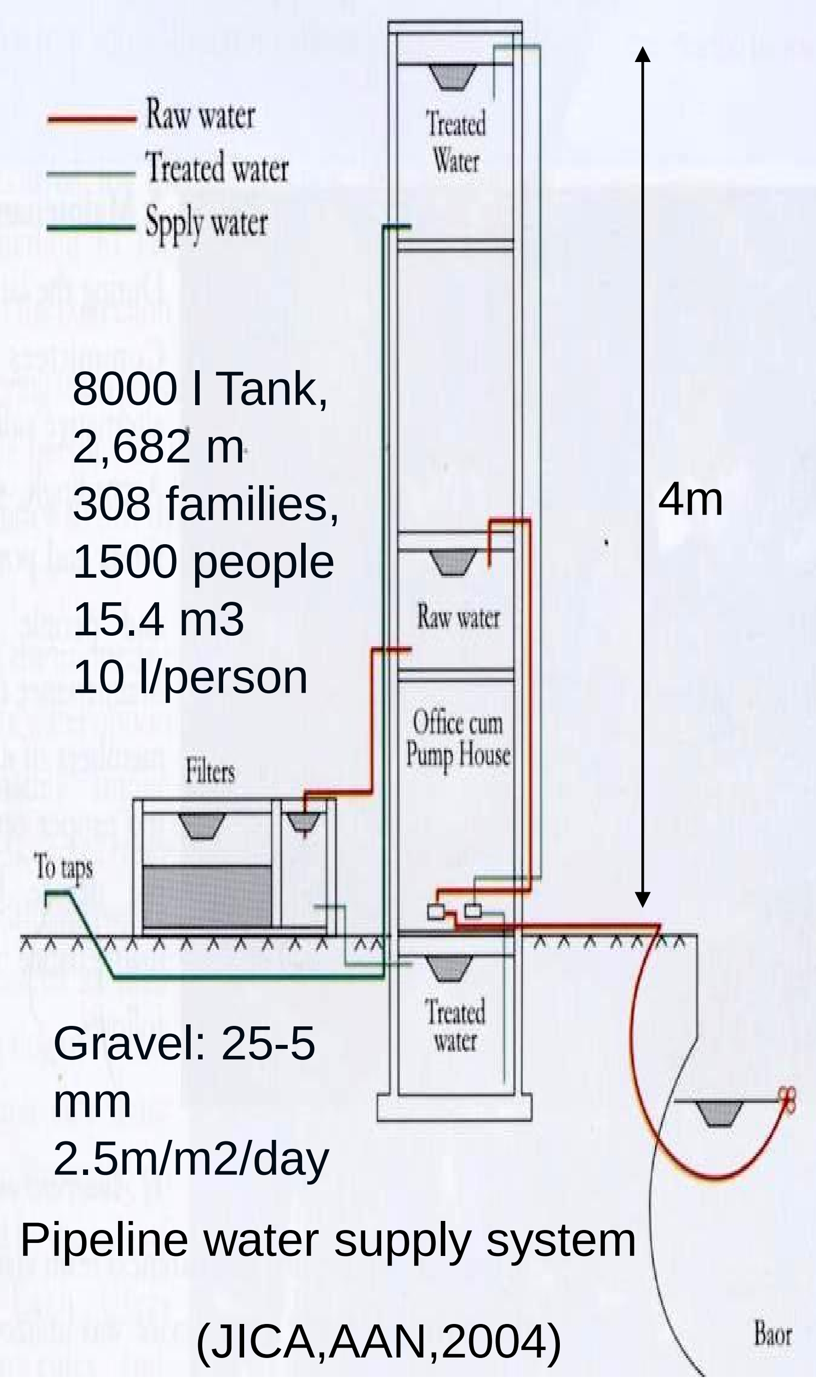
(JICA,AAN,2004)

(National Policy for Arsenic Mitigation ; LGD,MLGRDC,Bangladesh, 2004)

Gravel in the filter



Close up of gravel



8000 l Tank,
2,682 m
308 families,
1500 people
15.4 m3
10 l/person

Gravel: 25-5 mm
2.5m/m2/day

Pipeline water supply system

(JICA,AAN,2004)

Distribution pipeline water supply from crescent lake

Washing of gravel and sand in the filter

Water source of crescent lake


Deep well
(Newly developed, Arsenic free)
Shallow well
(Arsenic contaminated)

Pond sand filter →

Deep well

Chemical analysis of treated water (JICA,2004)

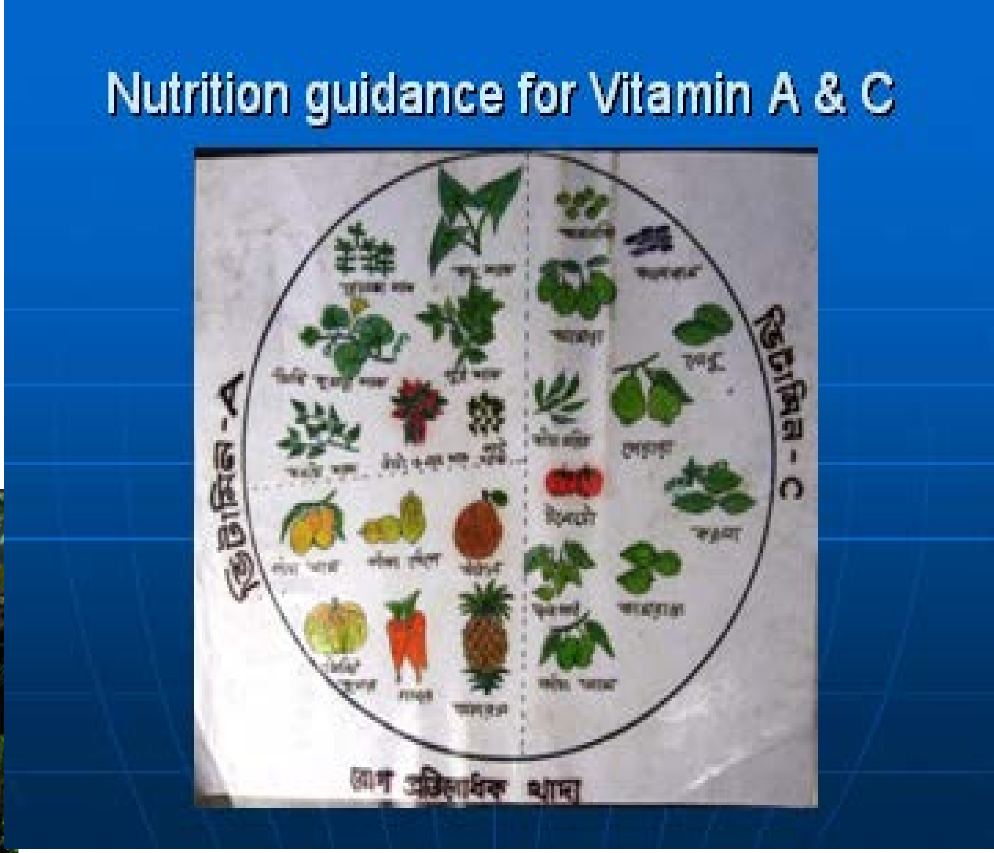
Physical and Chemical test (on 29 June 2004)

Parameters	Bangladesh Standard	Inlet Water (ox bow lake)	After URF	After SSF
pH	6.5~8.5	8.37	8.37	7.68
DO (mg/L)	6	7.2	4.8	4.7
Conductivity	-	1158	1185	1137
Turbidity (FAU)	10	46	0	0
As (mg/L)	0.05	0.014	0.006	0.003
Fe (mg/L)	0.3~1.0	0.660	0.00	0.00
Mn (mg/L)	0.1	0.079	0.00	0.00
NH_4^+-N (mg/L)	0.5	0.43	0.14	0.09
NO_3 (mg/L)	10	2.3	0.7	0.7
PO_4^{3-} (mg/L)	6.0	0.11	0.15	0.11

Bacteriological test (on 30 June 2004)

Parameters	Bangladesh Standard	Inlet Water	After URF	After SSF
Faecal Coliform cfu/100 ml	0	560	0	0

Nutrition guidance



Example of alternative water facilities constructed by several organizations (Tsushima.2004 etc)

Village	Alternative sources	Treated method	Family (house-hold)	People benefitted	Output	Cost J.￥*1,000 (US$)	Associates or NGOs	Yield (l /day)
Sonargaon	Deepwell, 244m	direct	110	667	10 taps	60 (5000)	NGO Forum Partner	
Daudkanji	Rain、Dug Well、8.5m	PSF	114	675	26 taps	82 (6833)	NGO Forum Partner	
Marwa	Dug Well, 9.1m	GSF	80		2 taps		AAN	1300～1500
Panjia	Deep Well, 220m	direct	45	220		9 (750)	Rotary Club	
Putkhali	Oxbow Lake (dead arm of river, Boar)	SSF	308 3 villages	1167	14 taps	US$ 23,500 Pipe line water supply system	JICA AAN 2004	8000 Tank

Safe water devices (SWD) in 179 villages in Jessore

SWD	constructed	operational	not in use	not in use ratio(%)
dug wells	108	71	37	34.3
pond sand filters	24	8	16	66.7
arsenic iron removal plants	22	18	4	18.2
deep tube wells	519	471	48	9.2
Total	673	568	105	15.6

Basic statistics in the upazilas of Chowgacha and Sharsha in Jessore District

Upazila	Number of villages	Total tube wells	Arsenic safe<50ppb	Arsenic cont.>50ppb	%of cont.	Number HH surveyed	Total population	Male patients	Female patients	Total patients
Chowgacha	159	24,204	18,984	5,256	21.72	52,207	253,457	156	119	275
Sharsha	172	32,441	24,879	7,562	23.2	75,830	303,876	184	128	312

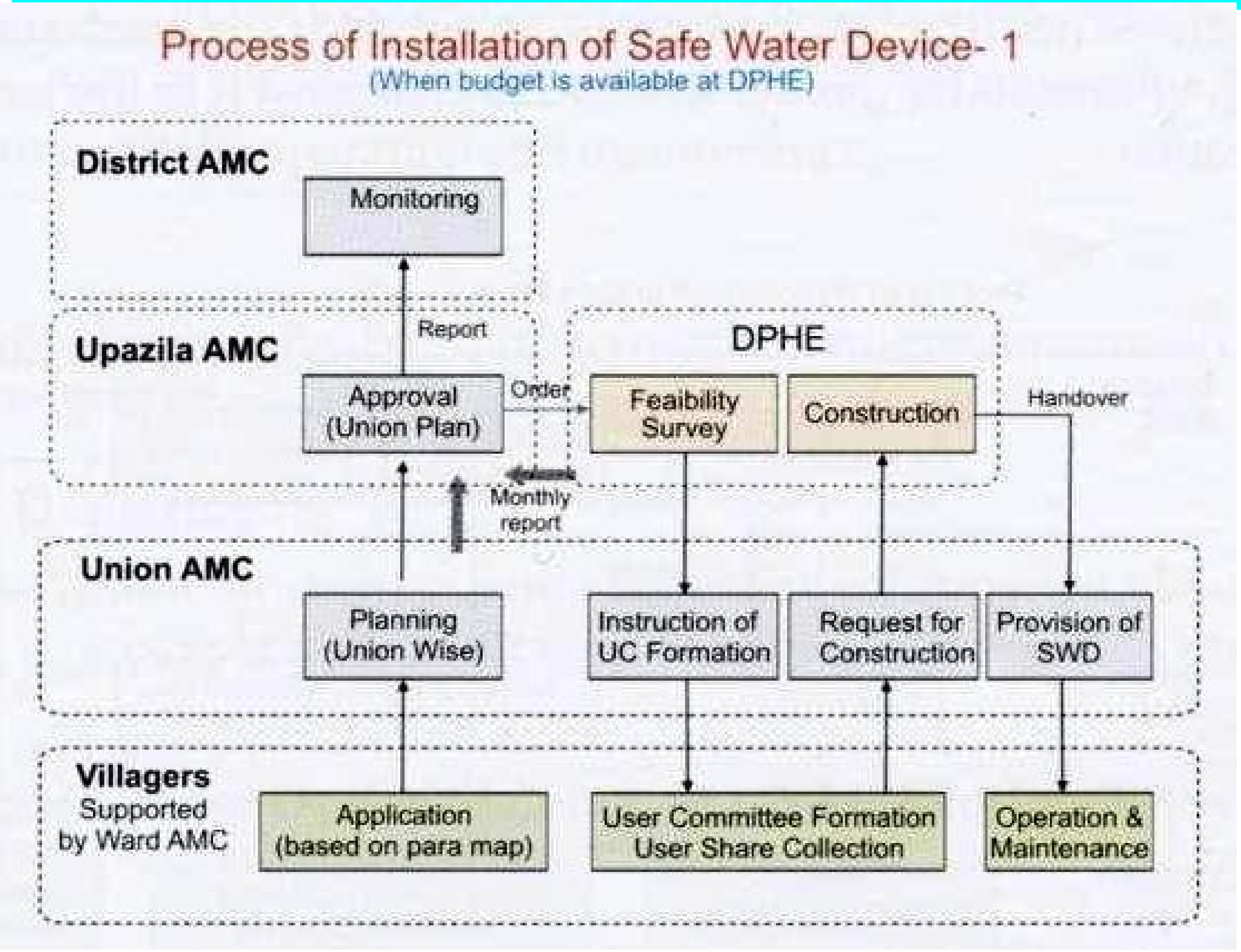
Sustainable Arsenic Mitigation under Integrated Local Government System

- Capacity building of villagers
- Coordination of arsenic mitigation committee
- Safe water supply
- Water quality monitoring
- Health management for arsenicosis patients
- Monitoring and evaluation

Let people convince a well poisoning and convert to safe water

- Release and Conception that a conventional well is contaminated by Arsenic
- How to organize a union supplied by a filter facility
- How to prepare a budget to make a filter facility
- How to maintain a filter facility
- How to gather money for maintenance cost of a facility
- How to check water quality afterwards
- How to organize and to train a local government (district level) staff to watch management of a village and/or a union

Schematic organization tree of AMC



Risk hiding in the Ganges TA contaminated by arsenic

- Risk that human health is exposed to toxic drinking water
- Risk that information concerning contamination mechanism, its distribution and symptom on groundwater is nether enough nor shared between Bangladesh and India.
- Risk that contamination may has impacts on soil, food chain and cattle.
- Anti-Risk that mitigation countermeasure and guideline, health care borne from human wisdom is urgently required at present.

Summary : Peculiar features of Ganges Delta Plain

- Rapidly increased population in rural area are totally dependent on groundwater since1960s for drinking water.
- After 20 years human security of a few tens millions people are still exposed to toxic groundwater contaminated by arsenic of natural origin.
- Hazard is greatly harmful for rural people with poor nutrition and lack of necessary information.
- Groundwater for irrigation in dry season is competitive with drinking water use.
- Change of World Bank Aid Policy ; Large scale irrigation => medium・self-help, small-scale, conjunctive use =>strengthening local governance
- Population is centered in urban area, and hence social infrastructure specially water supply is much behind minimum necessity of capacity.
- Extensive lowland suffers from very frequent flooding.
- River discharge is nor regulated in dry/wet season so that river water is not used for water resources.
- Transboundary rivers will occasionally cause a great deal of troubles in case of implementing a plan.

Policy and guideline relating to groundwater and water resources in Bangladesh

Year	Policy and Plan
1992	National Environmental Policy
1994	National Forestry Policy
1996	National Energy Policy
1998	National Fisheries Policy
1998	National Policy for Safe Water Supply & Sanitation
1999	National Agricultural Policy
1999	Industrial Policy
1999	National Water Policy
2004	National Policy for Arsenic Mitigation 2004 & Implementation Plan for Arsenic Mitigation in Bangladesh
2004	National Water Management Plan (Approved by the Council)
2005	Sector Development Programme, Water and Sanitation Sector in Bangladesh. Vol.1,Main Report
2005	Pro Poor Strategy for Water and Sanitation Sector in Bangladesh

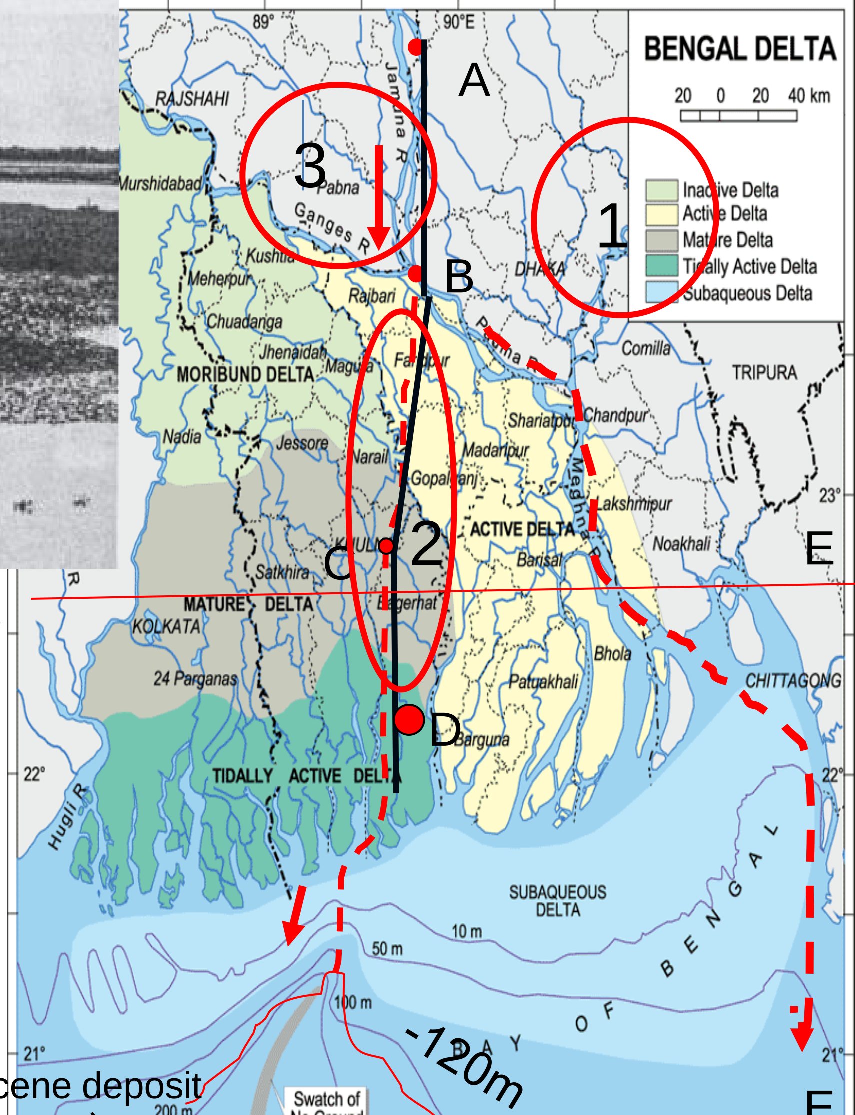
Three proposals from the geohydrological viewpoints

1 ）Surface water development of Haor and/or Beel lowland area in the Megna River basin

2 ）Less-toxic groundwater development along the buried old incised valleys

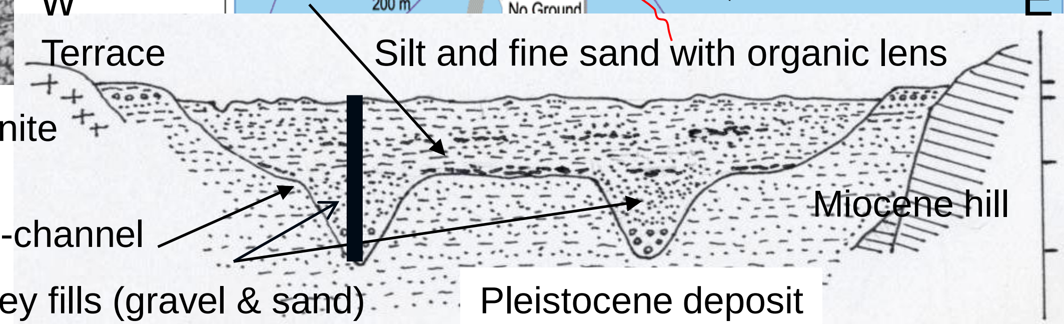
3 ）Artificial groundwater recharge making use of irrigation water on the terrace deposit in the northern hill

1) Haor in Sylhet of the Megna River basin



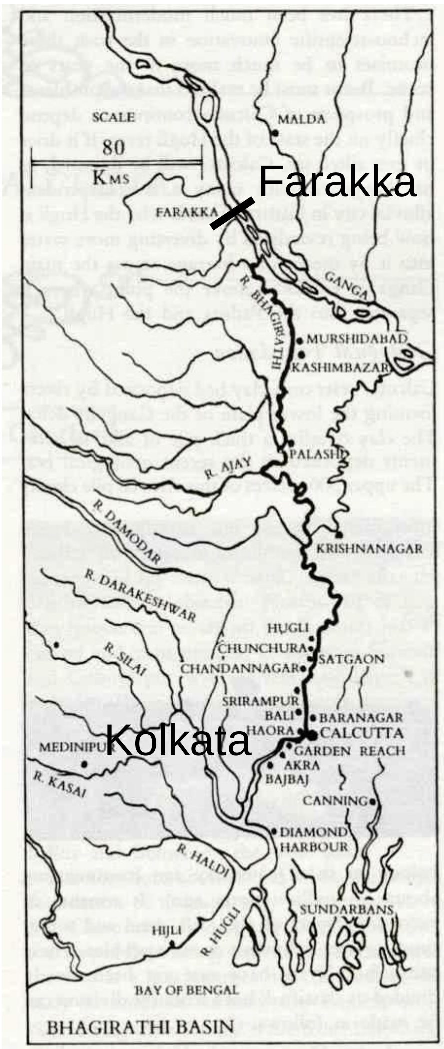
3) Terrace deposit in Barind tract

(Photo by Umitsu,1997)



Topographic features in Ganges Delta Plain

Hugli river



Part of Fig.2

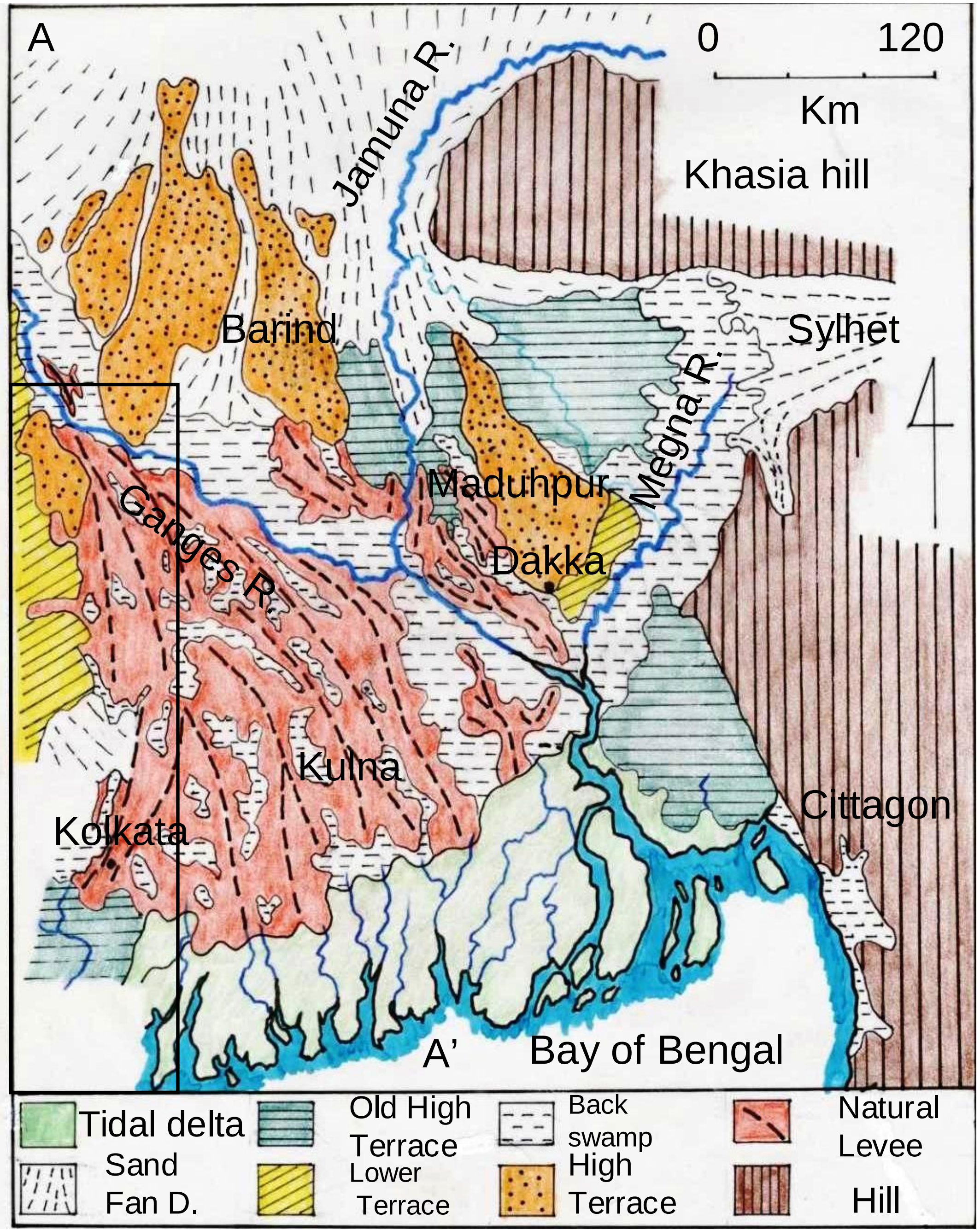
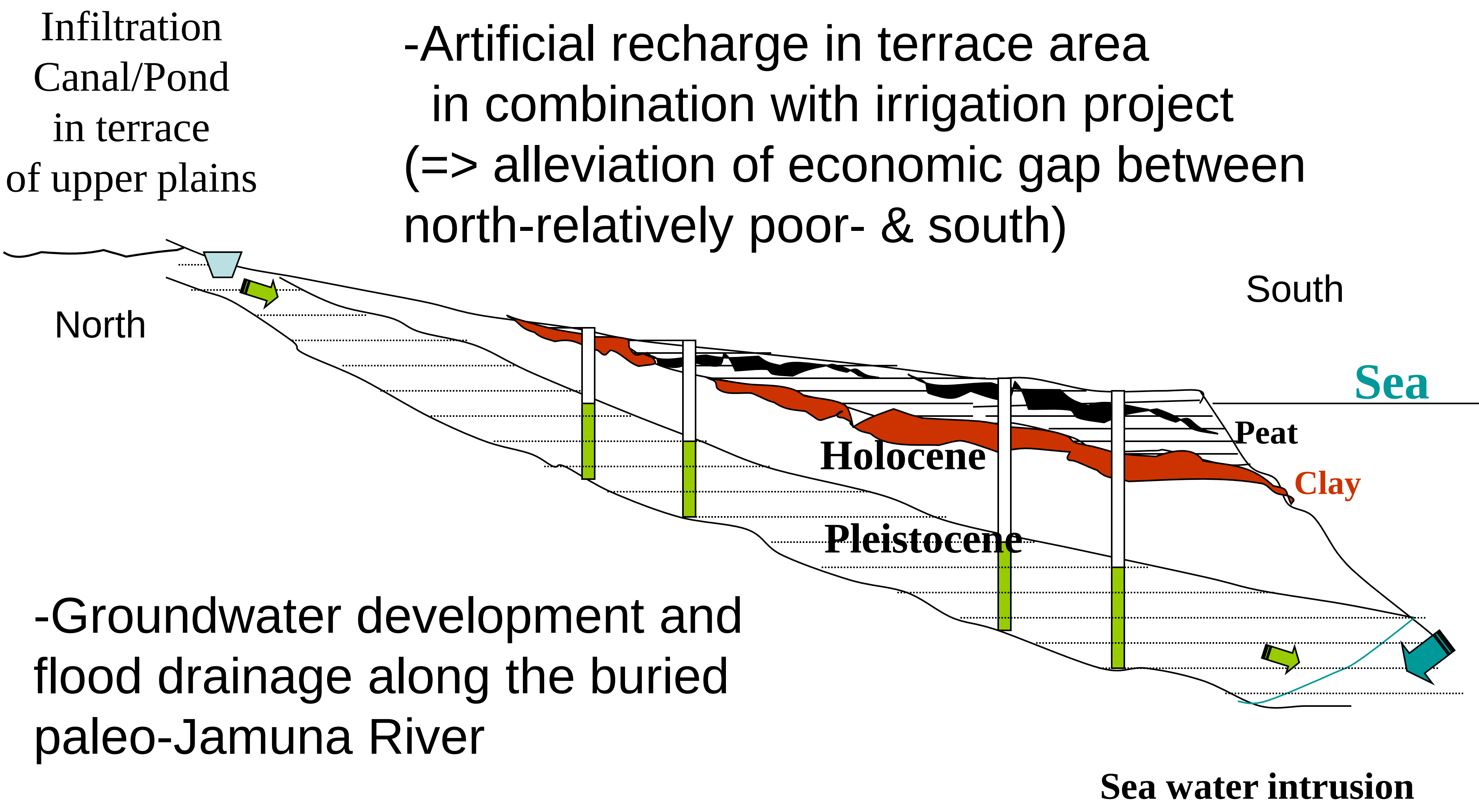


Photo by Kawahara,K.


Photo by Kawahara,K.

A tentative and practical proposal for preferable development of groundwater and recharge

-Artificial recharge in terrace area in combination with irrigation project (=> alleviation of economic gap between north-relatively poor- & south)



-Groundwater development and flood drainage along the buried paleo-Jamuna River


To all of You
Thank you for kind attention

GHS),workshop

UNITED NATIONS UNIVERSITY

UNU-EHS

Institute for Environment and Human Security

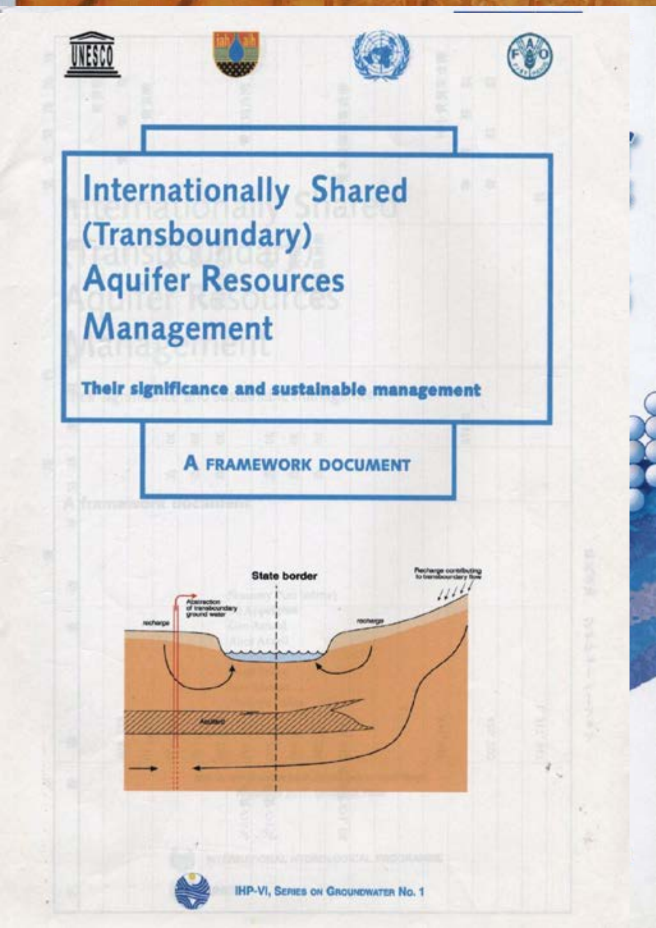
UNESCO / IHP

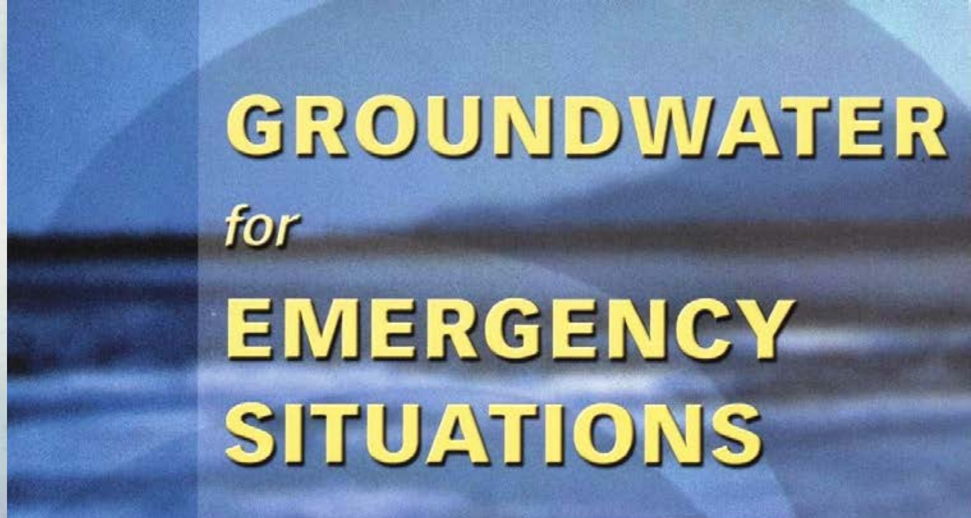
Division of Water Sciences

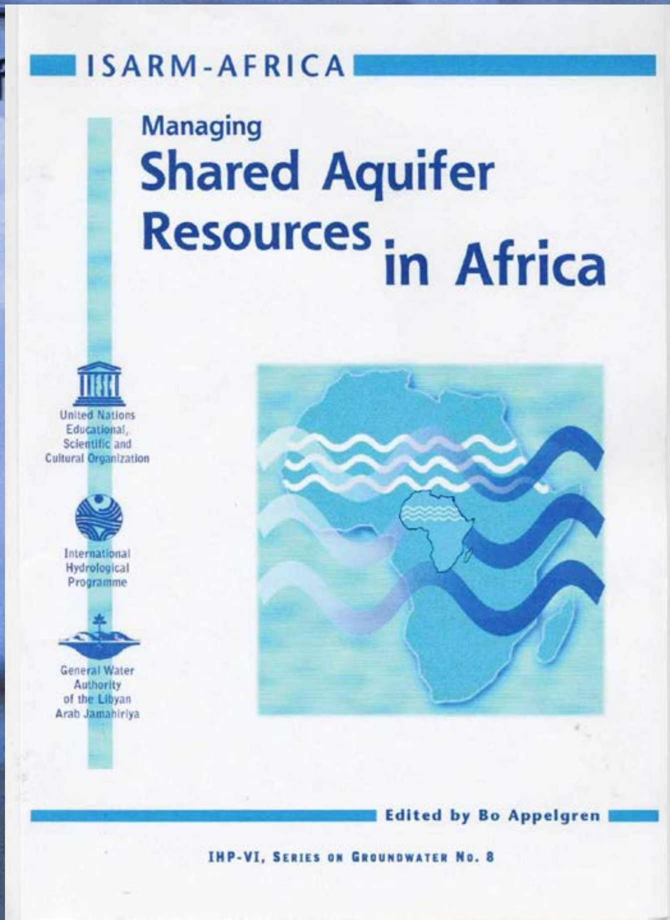
UNITED NATIONS UNIVERSITY

UNU-INWEH


Strategies
for Managed Aquifer
Recharge (MAR)
in semi-arid areas


UNESCO
Internationally Shared
(Transboundary)
Aquifer Resources
Management
Their significance and sustainable management
A FRAMEWORK DOCUMENT
State border
IHP-VI, Series on Groundwater No. 1


GROUNDWATER
for
EMERGENCY
SITUATIONS
UNESCO


ISARM-AFRICA
Managing
Shared Aquifer
Resources in Africa
United Nations
Educational,
Scientific and
Cultural Organization
International
Hydrological
Programme
General Water
Authority
of the Libyan
Arab Jamahiriya
Edited by Bo Appelgren
IHP-VI, Series on Groundwater No. 8

Groundwater and Human Security - Case studies

United Nations University, Jan.2008-Mar.2010

Institute for Environment and Human Security

- UN-Water Decade Programme on Capacity Development (UNW-DPC)
- United Nations Educational, Scientific and Cultural Organization (UNESCO) : International Hydrological Programme (IHP)-Ⅵ

- Groundwater and Human Security (UNU-GHS)

- Four case study areas in three countries, Egypt, Iran and Vietnam(2)

- 5th case study area : Bangladesh

Let's think about Groundwater and Human Security !

In line with the expanded definition of human security, the causes of insecurity are subsequently broadened to include threats to socio-economic and political conditions, food, health and environmental community and personal safety.
(UNDP,NHDR Paper 5)

United Nations Development Programme (UNDP, １９９４): Human Security

freedom from want ***freedom from fear***

- Threats to Economic security : lack of productive and remunerative employment etc.
- Threats to Food security : lack of food entitlement etc.
- Threats to Health security : infectious and parasitic diseases, lack of safe water etc.
- Threats to Environmental security : declining water availability ,water pollution etc.
- Threats to Personal security : violent crimes etc.
- Threats to Community security : ethnic discrimination and strife etc.
- Threats to Political security : systematic human right violation etc.

Awareness of importance of groundwater

- Groundwater resources occupy most of fresh water on the earth.
- People are mostly dependent on groundwater as domestic use for long, medium and even in the present.
- However, groundwater resources are exposed to a severe hazards(threat) caused by human activity.
- These hazards bring about a great damage on sustainability of resources and hence do harm human security.
- Accordingly, based on the recognition that groundwater deterioration in quantity and in quality has close relation to human security, UNESCO-IHP and UNU-EHS jointly established this GHS project.
- In order to tackle with such hard objectives it is necessary to work in cooperation with international network, taking not only development of investigation and management capability but also integrated conception of human security into consideration. Herewith we pick up notion of vulnerability, which retards security.
- What is the vulnerability, which human community are facing ?
- The answer for this difficult question is different area by area, because many factors drawing vulnerability show complicated aspects derived from varied viewpoints.

What does vulnerability mean?

- English Dictionary : *origin from Latin vulnerare "to wound"* exposed to the possibility of being attacked or harmed, either physically or emotionally

- Thesaurus : vulnerable ; in danger, in peril, at risk, unsafe, unprotected, easily hurt/wounded /damaged, powerless, resistless

- Primarily used : disaster prevention and/or reduction <= key factor to reduce disaster risk

Added to □International Strategy for Disaster Reduction□

Natural phenomina does'nt equal to disaster－Disasters are not "natural"

- Human cause：knowledge, evacuation, hazard map
- Socio-economic cause：centered population,poverty,urban plan systematic response capability
- Physical cause：land use, basic infrastructure
- Environmental cause：climatic change, environment deterioration, ecological degradation（seashore,riverbasin, swamp,marsh）

Natural hazard ✖ Vulnerability ＝ Disaster risk

＝＞G'water hazard

Vulnerability ＝ Disaster risk / Natural hazard

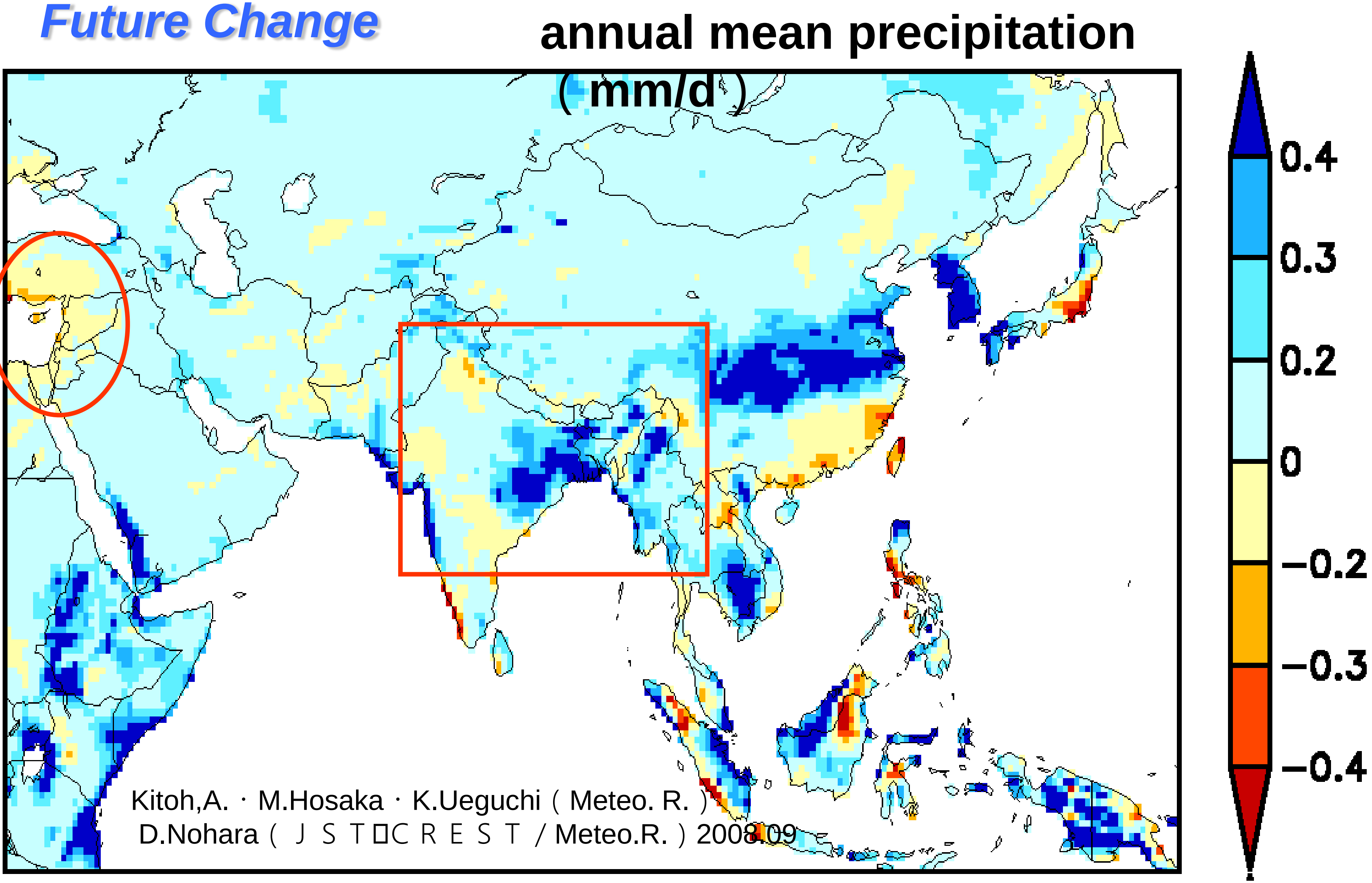
Out of natural disasters, a indicator, by which disaster risk increases or decreases on magnitude, depending on pre-awareness.

Environmental vulnerability in connection with groundwater problems

Basic data are originated from global warming of IPCC and climatic change, which were forecasted on the images of mid-21 century by the simulation model. The precise climatic change model covers from east, southeast to south Asia, which was resolved with 20km grid by the Meteorological Institute of Japan.

- Sea level rise will bring about sea water intrusion inland and groundwater below low flat land (southern half of the land elevates less than 5 m above mean sea level) will decay with salinity. Subsequently it will cause to damage cultivated land and residential area.
- Increase of flood river run-off will cause to decrease of base flow, which induces decrease of recharge to groundwater in shallow aquifer of less than 100m below ground surface.
- Longer span of dry season and more frequency of flood will cause stable river flow and finally decrease of base flow on river. Accordingly decrease of base flow of river induces decrement of recharge to shallow aquifer.
- In the longer dry season, deep wells(usually deeper than 100m) for irrigation will abstract more groundwater and hence extensive drawdown of piezometric head will occur.
- Drawdown of piezometric head of deep aquifer will induce downward leakage of groundwater from shallow aquifer to deep aquifer.
- It will bring about decline of ground table in shallow well and subsequent contamination of deep well by Arsenic.
- Groundwater of deep wells are used for irrigation of mainly rice and other crops.
- Therefore another problem will arise from the viewpoint of food chain.

Future Change

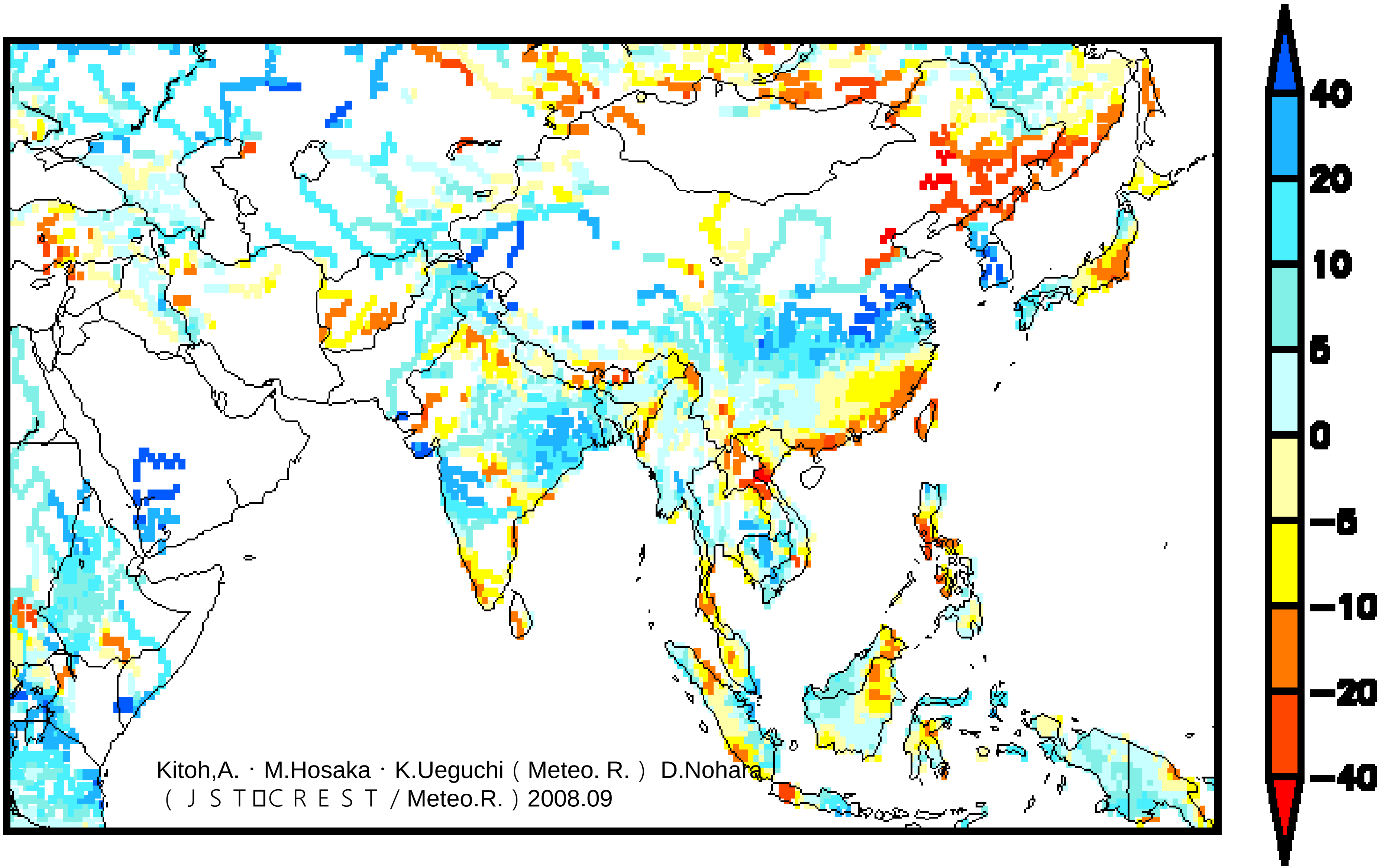


Middle East ~ Central Asia ⇒Decrease trend

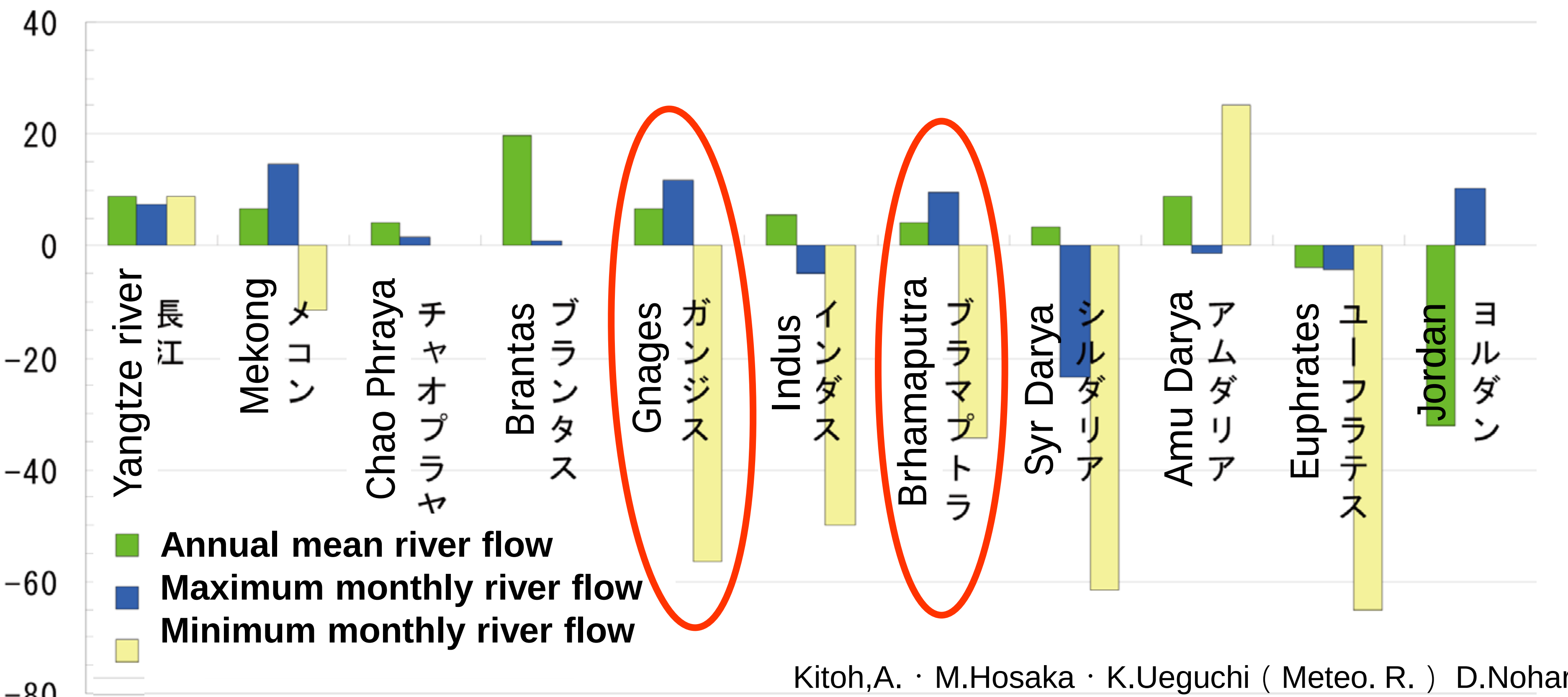
South Asia ~ Southeast Asia ~ East Asia ⇒Increase trend

Future Change

annual mean river flow（%）



Future Changes in Annual and Monthly river flow

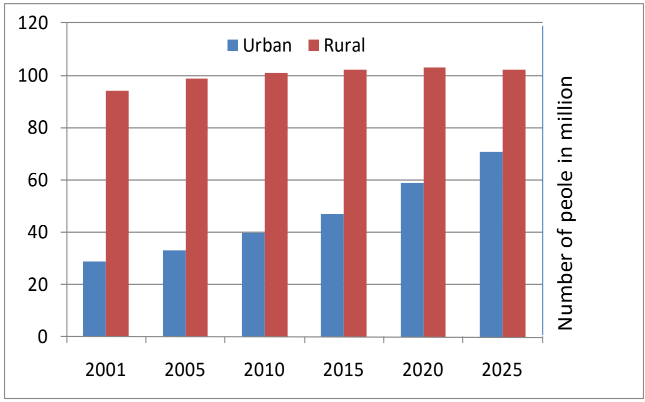


Kitoh,A.・M.Hosaka・K.Ueguchi（Meteo. R.） D.Nohar
（ＪＳＴ・ＣＲＥＳＴ／Meteo.R.）2008.09

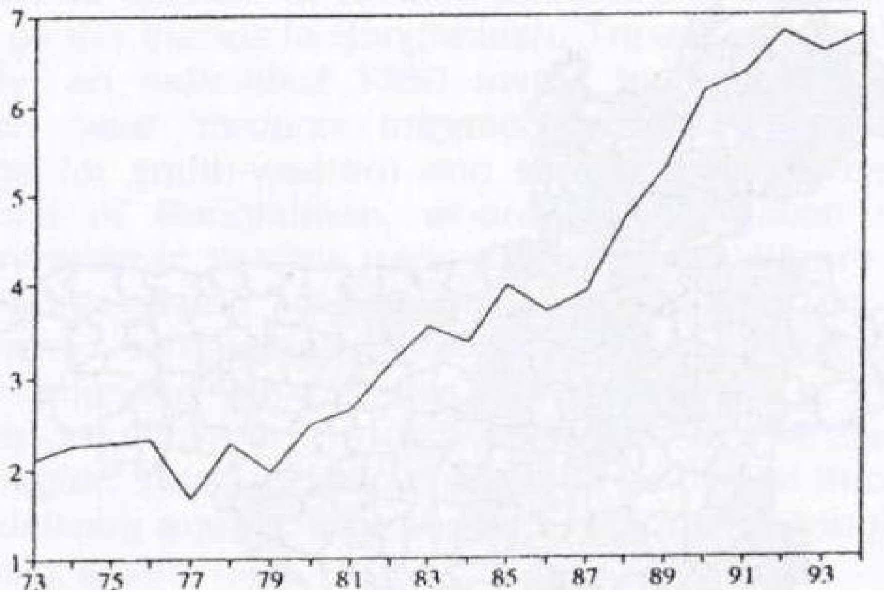
- **Too much water river**：
  - All rivers except Ganges increase in annual mean and maximum river flow.
  - Ganges, Indus and Brhamaputra which are insufficient of water in dry season decrease in minimum monthly river flow
- **Too short water river**：
  - Amu Darya decreases in annual mean and mimimum monthｌy river flow, Syr Darya and Euphrates decrease in annual mean river flow

Socio- economic vulnerability in connection with groundwater problems （1）

- Transboundary Aquifers（TA）：Toxic groundwater contaminated by arsenic was discovered in 1983 in southeast of Kolkata in West Bengal. It proved in 1993 in western border of Bangladesh. Ten years passed in vain between the two reports. It was supposed that some political confusions prevented free communication or others.
- Time gap and lack of information exchange between two countries caused to delay information release and to expose human life to risk of non-diagnose for ten years.
- Vulnerability related to upsurging increase of population and their concentration to urban area :
  People in Bangladesh depend on groundwater for domestic water by 97 % and hence purified surface water supplies only in major urban areas. Forecasted migration of millions of people will bring about over-capacity of purification plants and extreme deterioration of sanitary condition in urban areas, followed by shortage of safe water supply.



- Key industry of Bangladesh relies on rice. : Rice crop is irrigated by groundwater from deep aquifer in dry season. It is noted that specific chemical materials are accumulated in human body through food chain. The investigation to date revealed that arsenic concentration is found not only in soil on paddy field but also in rice.



Growth in dry season rice production
in Bangladesh (million tons)
(Chowdhury et al.,1997)

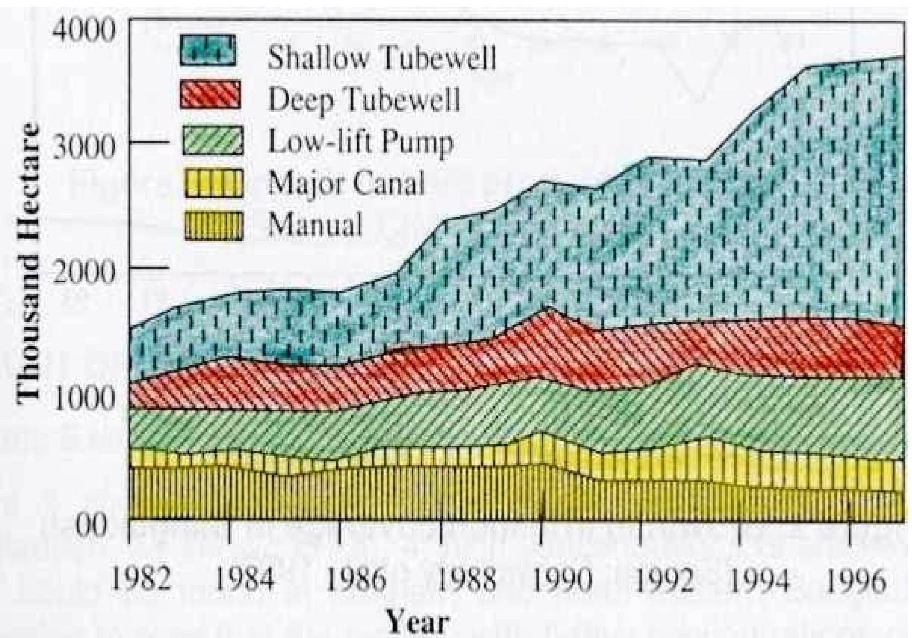


Figure 1: Increase in irrigated area in Bangladesh by different technology during 1982-1997 (WARPO, 1999)

Accumulation of arsenic in soil and rice

Table 1: Arsenic content of irrigation water, soil, different parts of rice plants and protein content of rice grain

As in Water (ppb)	As in Soil (mg/kg)	Rice Variety	As in Different Parts of Rice Plants (mg/kg)				Protein Content (%)	
			Rice Grain	Husk	Leaf	Stem	Measured	Stan-dard
156	7.52	BR-14	0.00	0.066	0.63	0.35	7.3	
364	2.07	BR-14	0.00	0.114	3.32	3.35	7.0	7.5
277	12.0	BR-14	0.00	0.052	0.29	15.8	6.8	
199	3.76	BR-28	0.00	0.150	2.45	3.10	6.2	
131	3.98	BR-28	0.032	0.060	0.19	1.25	7.0	8.6
188	3.30	BR-28	0.00	0.099	3.10	1.85	7.8	
255	2.42	BR-28	0.063	0.00	2.28	2.19	6.7	
62	2.01	BR-29	0.016	0.067	0.68	0.00	7.0	7.0
208	3.63	BR-29	0.00	0.015	0.62	1.40	6.6	
278	9.93	IR-50	0.00	0.00	0.52	0.85	7.0	-
105	3.37	Purbachi	0.022	0.035	0.53	2.65	8.9	
222	2.24	Purbachi	0.026	0.00	0.78	2.45	7.6	9.0
177	3.02	Purbachi	0.094	0.00	0.89	0.25	8.7	

(Md.Zahangir Alam &
Md.Mujibur Rahman,2003)

A lawsuit case claimed for health damage compensation （ A Bangradeshi appealed British ODA ）

HOUSE OF LORDS

SESSION 2005–06
[2006] UKHL 33

on appeal from[2004] EWCA Civ 175

OPINIONS

OF THE LORDS OF APPEAL

FOR JUDGMENT IN THE CAUSE

Sutradhar (FC) (Appellant)
v.
Natural Environment Research Council (Respondents)

Appellate Committee

Lord Nicholls of Birkenhead
Lord Hoffmann
Lord Walker of Gestingthorpe
Lord Brown of Eaton-under-Heywood
Lord Mance

Counsel

Appellants:	*Respondents*:
Lord Brennan QC	Michael Beloff QC
Andrew Spink QC	Charles Pugh
Richard Hermer	Ben Cooper
(Instructed by Leigh Day and Co)	(Instructed by Manches LLP)

Hearing dates:
22 and 23 May 2006

ON
WEDNESDAY 5 JULY 2006

HOUSE OF LORDS

OPINIONS OF THE LORDS OF APPEAL FOR JUDGMENT IN THE CAUSE

Sutradhar (FC) (Appellant) *v.* Natural Environment Research Council (Respondents)

[2006] UKHL 33

LORD NICHOLLS OF BIRKENHEAD

My Lords,

1. I have had the advantage of reading in draft the speeches of my noble and learned friends Lord Hoffmann and Lord Brown of Eaton-under-Heywood. For the reasons they give, with which I agree, I would dismiss this appeal.

LORD HOFFMANN

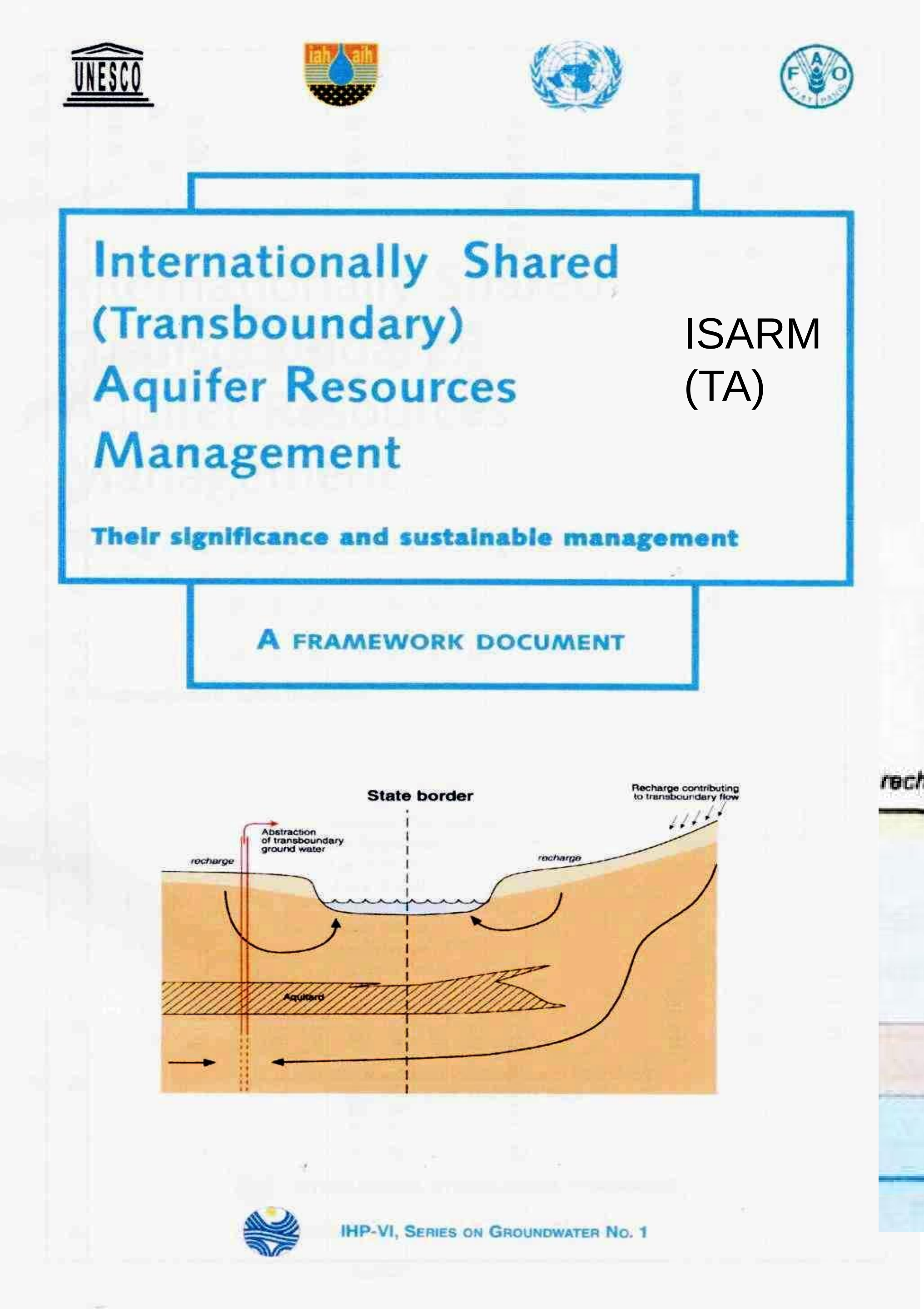
My Lords,

2. The question is whether the claimant, who lives in Bangladesh, has a reasonable prospect of success in an action against the Natural Environment Research Council ("NERC") for negligence in issuing a geological report which he says induced the health authorities in Bangladesh not to take steps which would have ensured that his drinking water was not contaminated by arsenic. In consequence he says that he has suffered injury from arsenical poisoning. The Court of Appeal, by a majority (Kennedy and Wall LJJ, Clarke LJ dissenting) and reversing the judge (Simon J) decided that the claimant had no reasonable prospect of satisfying a court that in all the circumstances the NERC owed him a duty of care. It struck out the claim. I agree. In my opinion the claim is hopeless.

Socio-economic vulnerability in connection with groundwater problems(2)

- Unexpectable issues arose from arsenic contaminated groundwater when groundwater is considered in view of the legal vulnerability.
- A Bangladeshii clamed Natural Environment Research Council(NERC,UK) for negligence in issuing a geological report in 2004. He says that it did not take steps to ensure his drinking water was not contaminated by arsenic. The well was drilled by UK ODA(1983-92) for irrigation purposes, which water was not analyzed on quality. He used the well water for drinking for 1983 to 1991, when he developed symptoms associated with arsenical poisoning.
- This appeal was dismissed in 2006 by House of Lords for the reason that NERC had no control over or responsibility for the provisions of safe water to the citizens of Bangladesh.
- With respect to groundwater contaminated by arsenic, it is unexpectable that any aspect of vulnerability is borne in terms not only of natural environment but also of socio-economics. Especially the latter bears something beyond expected.
- Taking the wide sides of groundwater into consideration from the viewpoints of vulnerability leads to establishing of policies, which prescribe use of safe water and sustainable water .
- Therefore ,release of necessary information is essential.

UNESCO IHP-6 (2001)



ISARM
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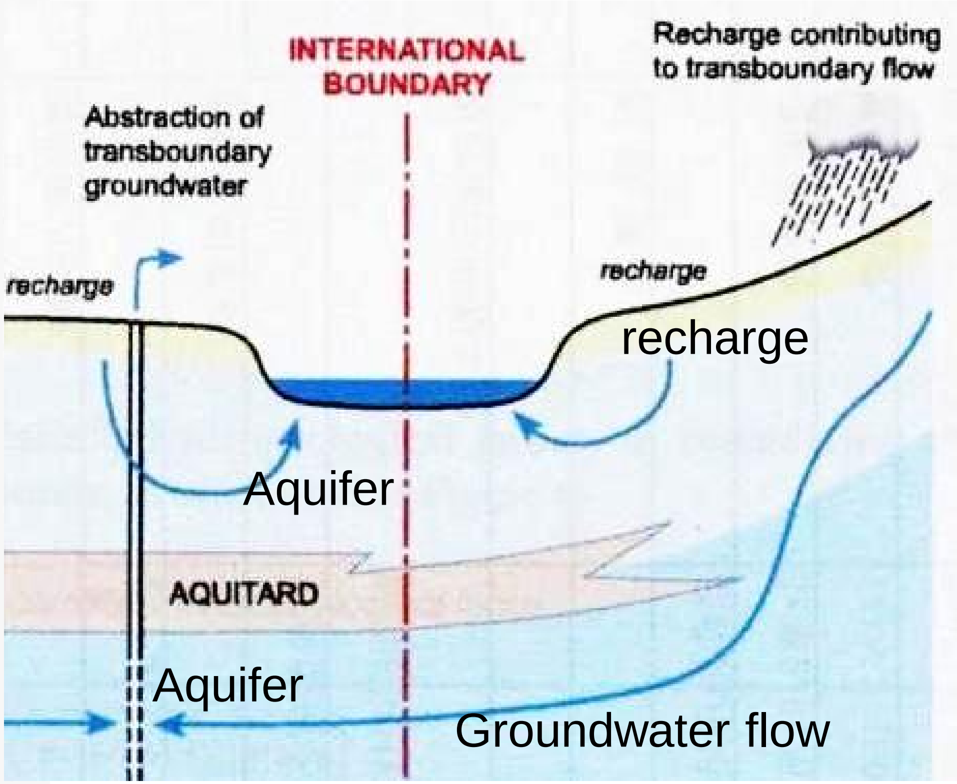

Fifth Report on shared natural resources : transboundary aquifers

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Fifth report on shared natural resources: transboundary aquifers

by Chusei Yamada, Special Rapporteur

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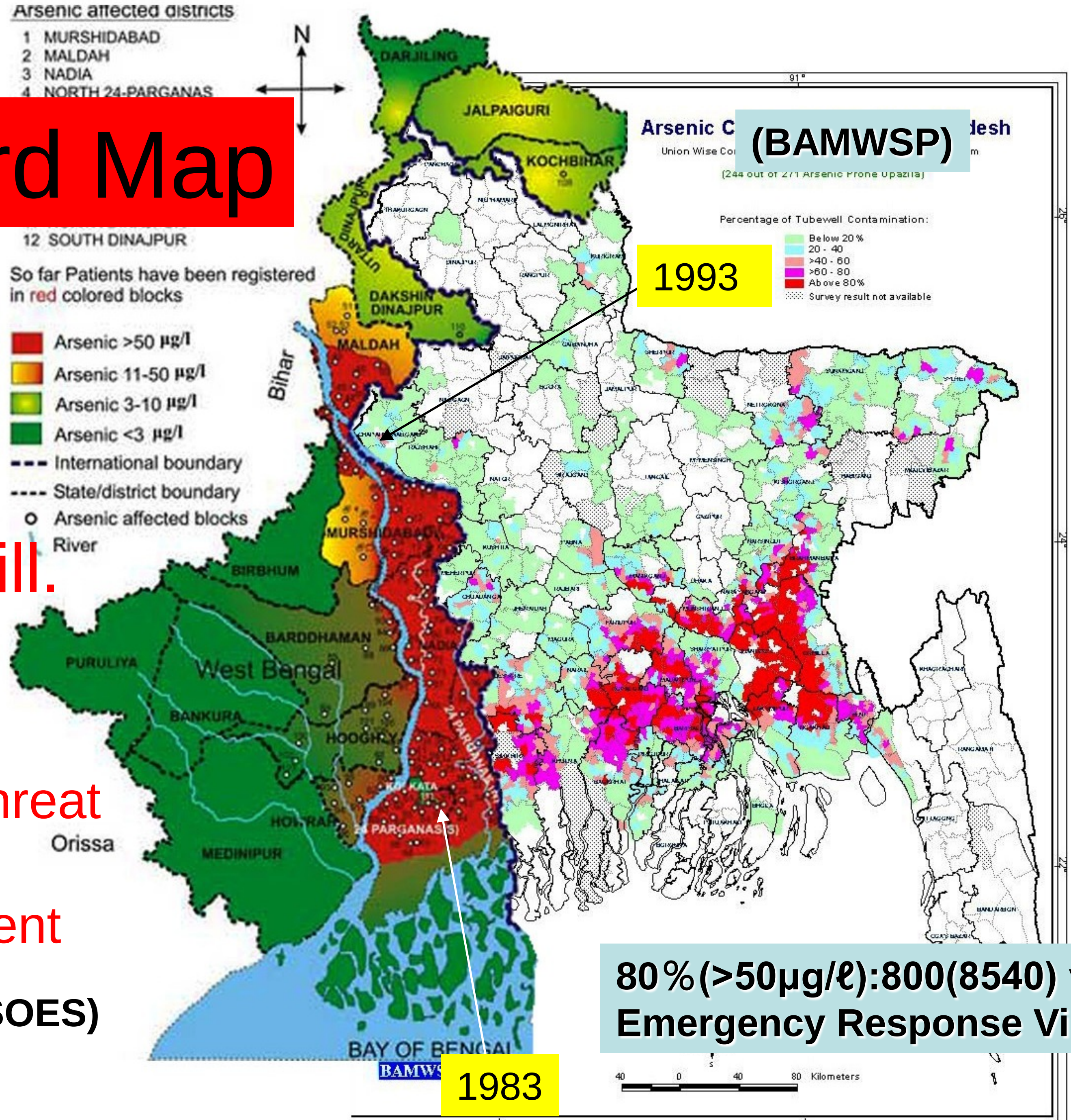
Summary : Risks which are derived from contaminated groundwater

- International exchange of information was not enough, so hazard to human security prevailed before countermeasures and diagnosis were systematically executed.
- In recent years arsenic contamination was detected not only in deep groundwater for irrigation purpose but also in soil.
- It indicates food chain of contamination may occur.
- Lawsuit was appealed in 2004 by a Bangladeshi to claim compensation for health disease borne from contaminated well water, which had been drilled by British foreign aid. However the appeal was dismissed in 2006 by the House of Lords.
- From 1990s to present, many policies and guidelines were established with regard to procedure of alternative water sources, management of local organization, maintenance of facility and diagnosis of symptom etc.
- Local Government, ODA, NPO and local union are not necessarily well cooperated and self-help effort on site is not enough.
- Groundwater law and a law related to water sources are not enacted.
- International Commission in UN prepared a draft law to control shared natural resources, including transboundary aquifers.
- It works as a solution basis against an international dispute and/or conflict.

Hazard Map

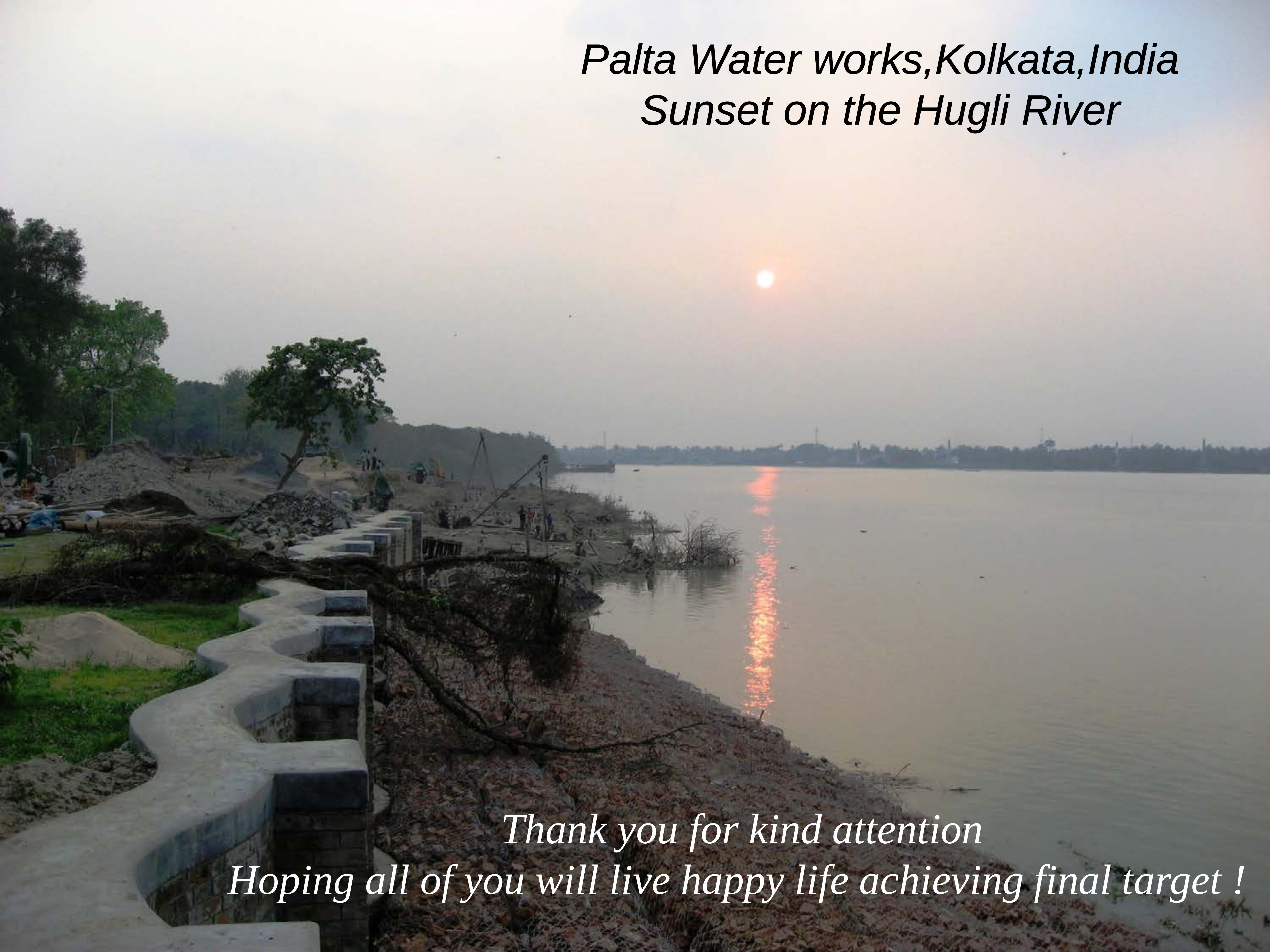
ca.12 mill.
people
+ ca.12 mill.
people
=ca.24 mill.



Creeping Threat
Silent killer
Every moment

(SOES)

80%(>50µg/ℓ):800(8540) villages
Emergency Response Villages


Palta Water works,Kolkata,India
Sunset on the Hugli River
Thank you for kind attention
Hoping all of you will live happy life achieving final target !