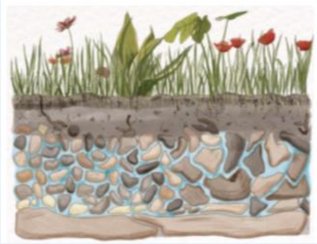
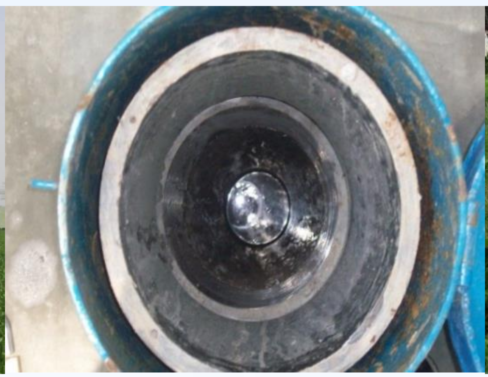


UN WATER 22 MARCH WORLD WATER DAY

Groundwater: Making the Invisible Visible

Good Groundwater Management: Justice in Achieving Sustainable Development Goal (SDG)

Anwar Zahid, *Ph.D.*

Director, Ground Water Hydrology, Bangladesh Water Development Board
Adjunct Faculty, Department of Disaster Science and Management and
Department of Soil, Water and Environment, University of Dhaka
E-mail: anwarzahidb@gmail.com

World Water Day 2022: Making the Invisible Visible

- World Water Day, on 22 March every year, is about focusing attention on the importance of water.
- This year's theme 'groundwater', draws attention to the hidden water resource that has always been critically important but not fully recognized in sustainable development policymaking.
- Under the title 'Groundwater – Making the invisible visible', this year's campaign will explain groundwater's vital role in water and sanitation systems, agriculture, industry, ecosystems and climate change adaptation.
- The overarching message of the campaign is that exploring, protecting and sustainably using groundwater will be central to surviving and adapting to climate change and meeting the needs of a growing population.

Life and Livelihood are dependent on the Withdrawal of Groundwater in Bangladesh, but Needs More Wise and Scientific Development and Management









Sustainable Development

Ensure access to water and sanitation for all

6 CLEAN WATER AND SANITATION

13 CLIMATE ACTION
11 SUSTAINABLE CITIES AND COMMUNITIES
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
8 DECENT WORK AND ECONOMIC GROWTH
3 GOOD HEALTH AND WELL-BEING
2 ZERO HUNGER
1 NO POVERTY

Serial No	Target Name
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving t he proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.4	By 2030, substantially increase water - use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary co operation as appropriate
6.6	By 2020, protect and restore water - related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
6.a	By 2030, expand international cooperation and capacity - building support to developing countries in water - and sanitation - related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies
6.b	Support and strengthen the participation of local communities in improving water and sanitation management

Importance of Groundwater Monitoring and Assessment for Good Groundwater Management as per Water Act 2013

পানি সম্পদের সুরক্ষা ও সংরক্ষণ

১৭। **পানি সংকটাপন্ন এলাকা ঘোষণা ও উহার ব্যবস্থাপনা।**—(১) সরকার নির্বাহী কমিটির সুপারিশের ভিত্তিতে জলাধার বা পানিধারক স্তরের সুরক্ষার জন্য, যথাযথ অনুসন্ধান, পরীক্ষা নিরীক্ষা বা জরিপের ফলাফলের ভিত্তিতে, সরকারি গেজেটে প্রজ্ঞাপন দ্বারা, যেকোন এলাকা বা উহার অংশবিশেষ বা পানি সম্পদ সংশ্লিষ্ট যেকোন ভূমিকে নির্দিষ্ট সময়ের জন্য পানি সংকটাপন্ন এলাকা হিসাবে ঘোষণা করিতে পারিবে।

১৯। **ভূগর্ভস্থ পানিধারক স্তরের সর্বনিম্ন সীমা নির্ধারণ ও ভূগর্ভস্থ পানি আহরণে বিধি-নিষেধ।**—(১) আপাততঃ বলবৎ অন্য কোন আইনে ভিন্নতর যাহা কিছুই থাকুক না কেন, নির্বাহী কমিটি, যথাযথ অনুসন্ধান, পরীক্ষা-নিরীক্ষা বা জরিপের ফলাফলের ভিত্তিতে, সরকারি গেজেটে প্রজ্ঞাপন দ্বারা, যেকোন এলাকার ভূগর্ভস্থ পানিধারক স্তরের সর্বনিম্ন নিরাপদ আহরণ সীমা (safe yield) নির্ধারণ করিতে পারিবে।

(২) ভূগর্ভস্থ পানিধারক স্তরের সর্বনিম্ন নিরাপদ আহরণ সীমা যে এলাকার জন্য প্রযোজ্য হইবে সেই এলাকার মৌজা ম্যাপ ও দাগ নম্বর উল্লেখ করিয়া উহার সীমানা উপ-ধারা (১) এর অধীন জারিকৃত প্রজ্ঞাপনে নির্দিষ্ট করিতে হইবে।

(৩) কোন ব্যক্তি বা উপযুক্ত কর্তৃপক্ষ, ভূগর্ভস্থ পানিধারক স্তরের সর্বনিম্ন নিরাপদ আহরণ সীমা ও বিদ্যমান অন্যান্য আইনের বিধানাবলি সাপেক্ষে, ভূগর্ভস্থ পানি আহরণের জন্য বিধি দ্বারা নির্ধারিত পদ্ধতিতে, গভীর বা অগভীর নলকূপ স্থাপন করিতে পারিবে।

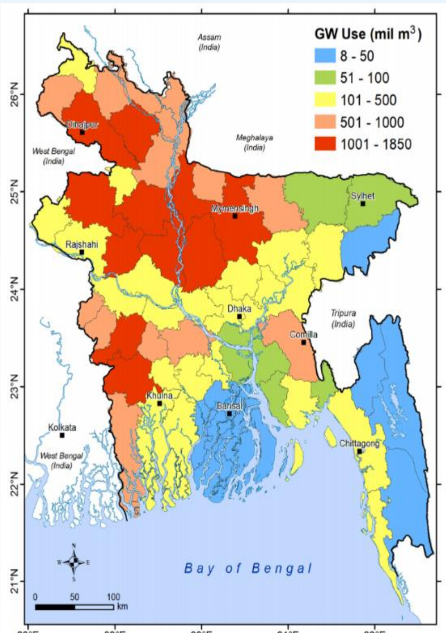
(৪) ভূগর্ভস্থ পানিধারক স্তর হইতে পানির নিরাপদ আহরণ নিশ্চিত করিবার লক্ষ্যে নির্বাহী কমিটি, এই আইনের বিধানাবলি সাপেক্ষে, সুরক্ষা আদেশ দ্বারা যেকোন বিধি-নিষেধ আরোপ করিতে পারিবে।

To achieve the target of water allocation for various uses considering environment and eco-system need, service providers, regulators, government, NGOs, the media, development partners, and residents can all help bring integrity towards sustainable development.

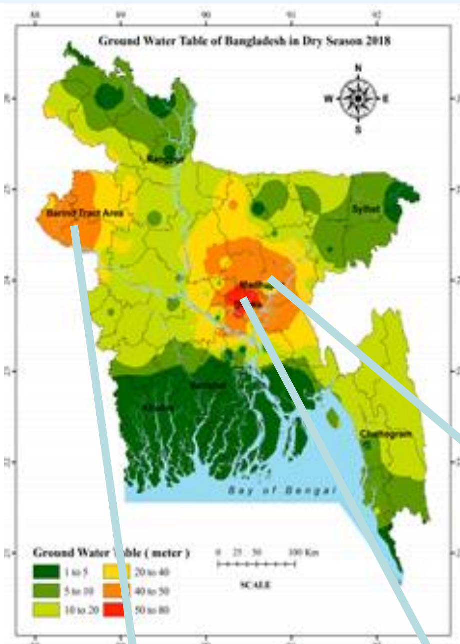
Challenges of Groundwater Use in Bangladesh

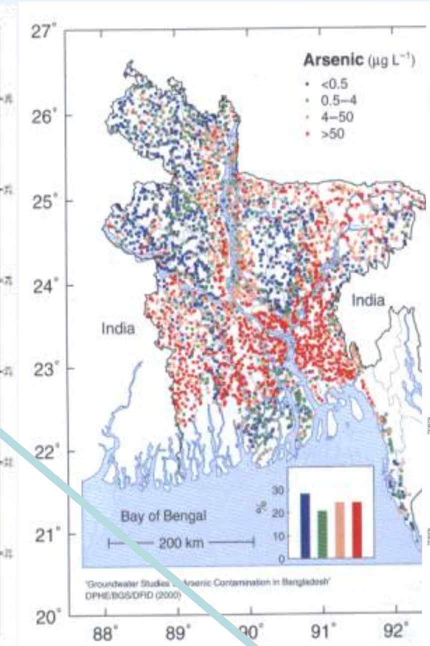
- The steady growth in agriculture has enabled Bangladesh to achieve nearly self-sufficiency in cereal production.
- On an annual basis, the total renewable water resources amount to about 1211 bcm. Of these, 21.1 bcm are groundwater resources (FAO 2013).
- An estimated 32 cubic km of groundwater is withdrawn annually in the country for irrigation (90%), domestic and industrial (10%) use (The World Bank 2019).
- The shallow irrigation wells have increased in numbers throughout the country from 1,33,800 in 1985 to 11,82,525 in 2006 and about 16,00,000 in 2019 (BADC, 2019).
- 24% land area is exposed to extremely high to high risks of elevated arsenic, salinity, and groundwater depletion hazards (The World Bank, 2019).
- Though Bangladesh is not an industrial country, however, the growth rate of industries in the country is significant. Availability of water, including rainwater, surface water, and groundwater calls for its sustainable development.

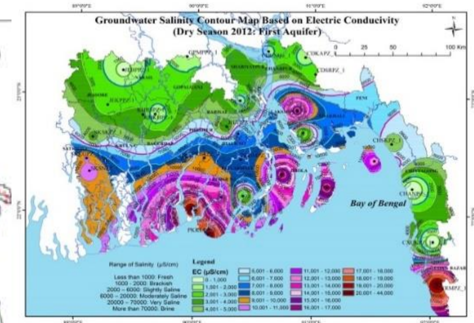
Major Challenges of Groundwater Development in Bangladesh

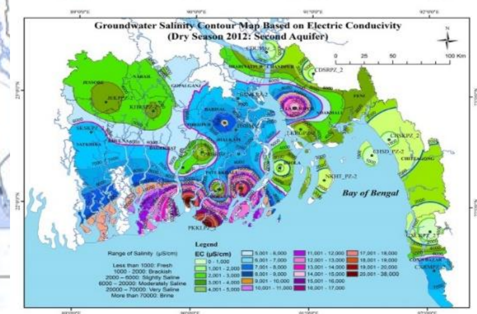


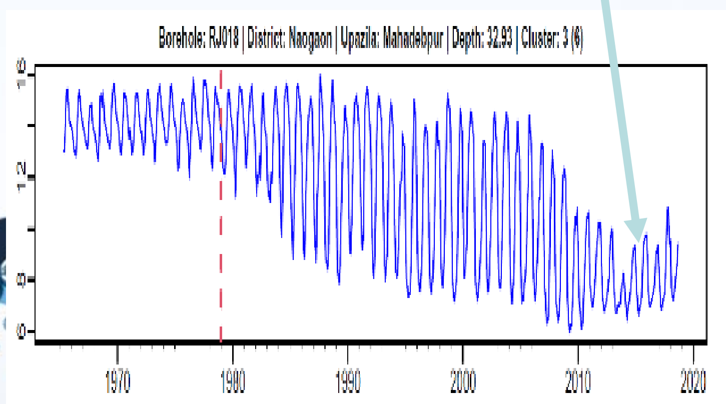
(Shamsudduha, …. Zahid et. al., 2019)

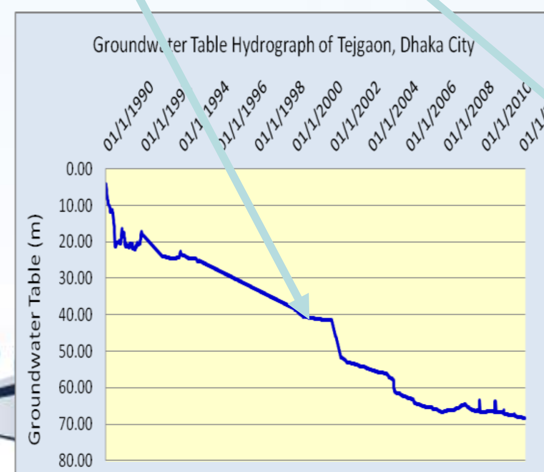


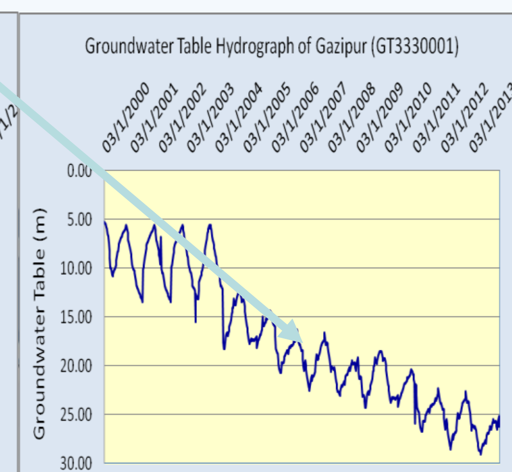






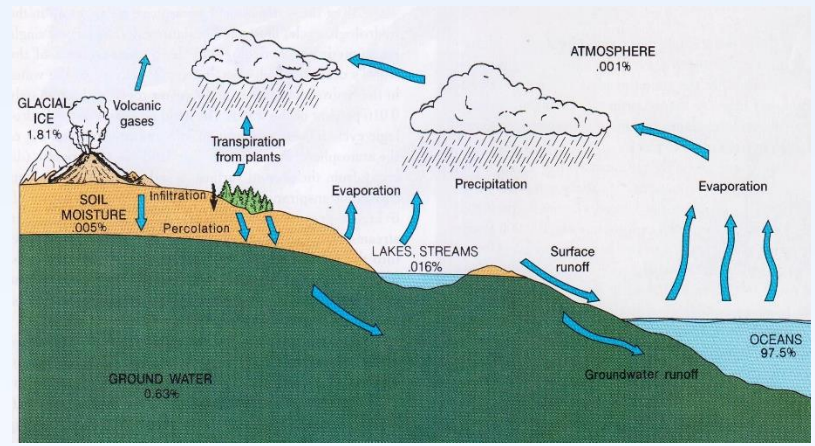






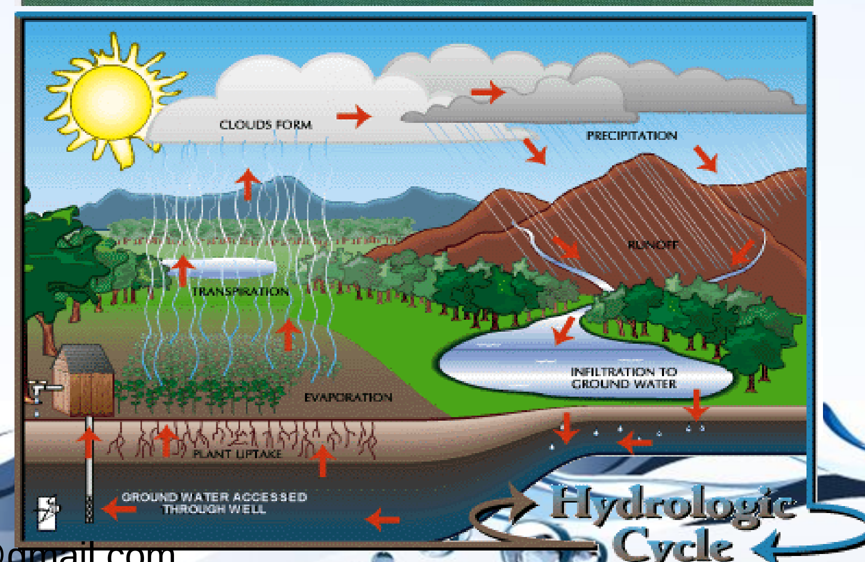
Distribution of Water in Water Cycle

- Hydrologic cycle – circulation of water in the environment



World Distribution of Water (%)

Source	%
Ocean (Saline)	97.2
Glaciers and Other Ice	2.15
Ground Water	0.61
Lakes (Fresh)	0.009
Lakes (Saline)	0.008
Soil Moisture	0.005
Atmosphere	0.001
Rivers	0.0001



JOB RESPONSIBILITIES OF BWDB
for Groundwater Monitoring and Management

- Conduct ground water survey and sub soil investigation of different projects of BWDB.
- Conduct qualitative study for the optimum utilization of ground water resources and collection of sediment samples for various studies.
- Maintain hydro-geological data (ground water table, aquifer test, ground water quality etc) collection network.
- Co-ordinate the activities of different agencies and organizations involved in ground water studies and render advise to ground water planners and end users.
- Maintain equipments such as drilling rigs, mud pumps, air compressor and other related equipments.
- Review comments on different paper clipping on drought conditions and technical reports on ground water resource utilization suggesting probable remedial measure, etc.

Exploratory Boring for Making Groundwater Aquifers Visible

Borehole Lithologic Logs

BANGLADESH WATER DEVELOPMENT BOARD

DIRECTORATE OF GROUND WATER HYDROLOGY

PROJECT ON ESTABLISHMENT OF MONITORING NETWORK AND MATHEMATICAL MODEL STUDY TO ASSESS SALINITY INTRUSION IN GROUNDWATER IN THE COASTAL AREA OF BANGLADESH DUE TO CLIMATE CHANGE

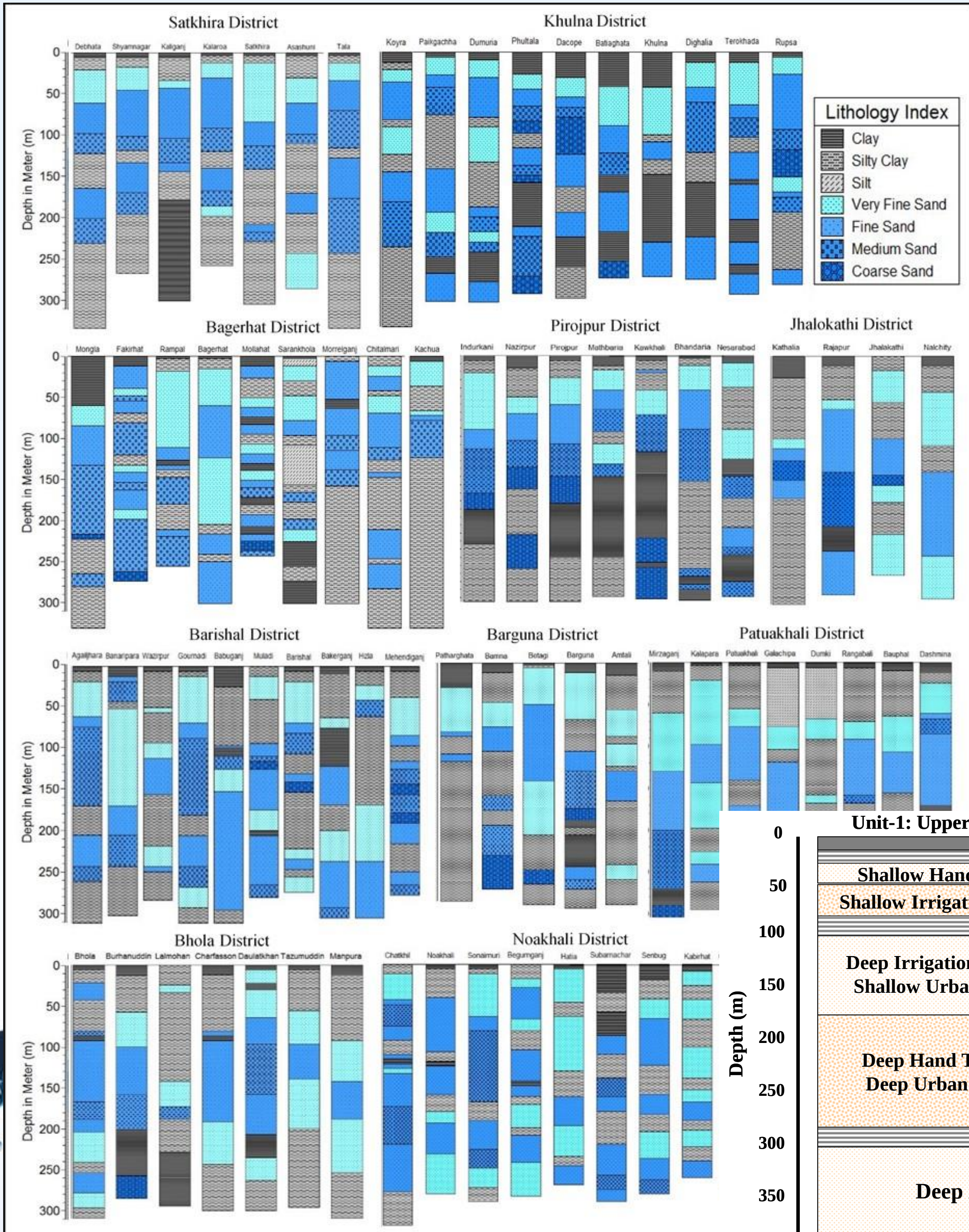
FIELD BORE HOLE LITHOLOGIC LOG

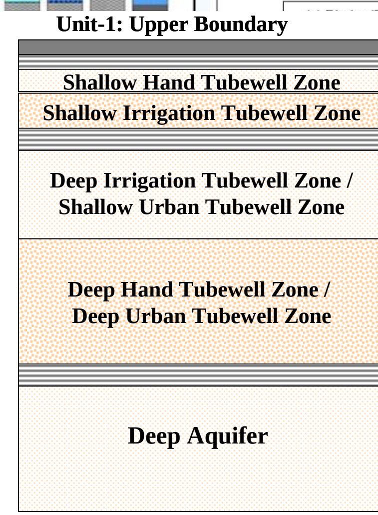
PROJECT: Climate Change Trust Fund		**CLIENT:** Ministry of Environment and Forest	
LOCATION: Jamiatus Sahabah Kaomi Madrasa, CNDB Bazar		**UPAZILA**: Bagerhat Sadar	**DISTRICT**: Bagerhat
HOLE ID: BABAPZ1	**GROUND LEVEL(RL-m):**	**LATTITUDE:** N 22.70538	**LONGITUDE:** E 89.6917
DATE STARTED: 12/12/12	**DATE COMPLETED**: 15/12/12	**TOTAL DRILLING DEPTH (m):** 210.37	
METHOD OF SAMPLING: Rotary Drilling Method (washed sample)		**GEOLOGIST**: Aminur Rahman, **CHECKED BY:** Dr. Anwar Zahid	

COMPLETE LOG

Sample No	Depth (ft)		Depth (m)		Thickness (m)	Color	Lithology
	From	To	From	To			
1	0	10	0.00	3.05	3.05	Gray	Very Fine Sand, Trace Silt, Trace LDM
2	10	20	3.05	6.10	12.20	Gray	Clay, Trace Silt
3	20	30	6.10	9.15		Gray	Clay, Trace Silt
4	30	40	9.15	12.20		Gray	Clay, Trace Silt
5	40	50	12.20	15.24		Gray	Clay, Trace Silt
6	50	60	15.24	18.29	15.24	Gray	Very Fine Sand, Some Fine Sand, Trace LDM
7	60	70	18.29	21.34		Gray	Very Fine Sand, Some Fine Sand, Trace LDM
8	70	80	21.34	24.39		Gray	Very Fine Sand, Some Fine Sand, Trace LDM
9	80	90	24.39	27.44		Gray	Very Fine Sand, Some Fine Sand, Trace LDM
10	90	100	27.44	30.49		Gray	Very Fine Sand, Some Fine Sand, Trace LDM

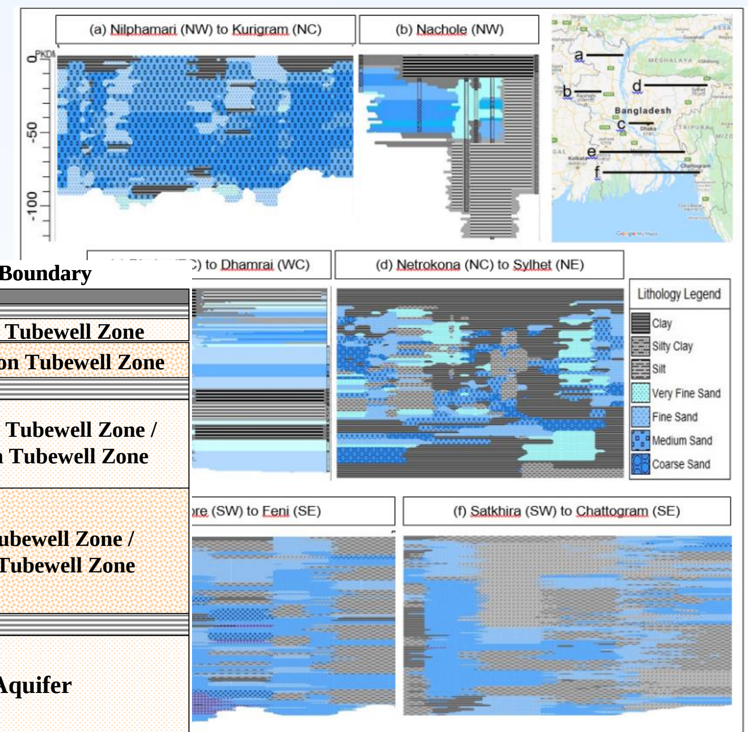
anwarzahidb@gmail.com





Multi-layered aquifer system in different areas of Bangladesh, based on borehole lithologic logs

(a) Tista Fan in the northwest;
(b) Pleistocene Barind Tract in the northwest;
(c) Dupi Tila aquifer around Dhaka;
(d) Sylhet Basin in the northeast;
(e) Deltaic Floodplain in the south-central;
(f) Tidal Delta in the southern coast.



Monitoring of Groundwater Level

- BWDB has 1272 groundwater observation wells throughout the country, maintained under 7 Ground Water Hydrology Sub-divisions and mostly installed with the UNDP assistance since more than five decades, mainly at shallow depths (25-50 m).

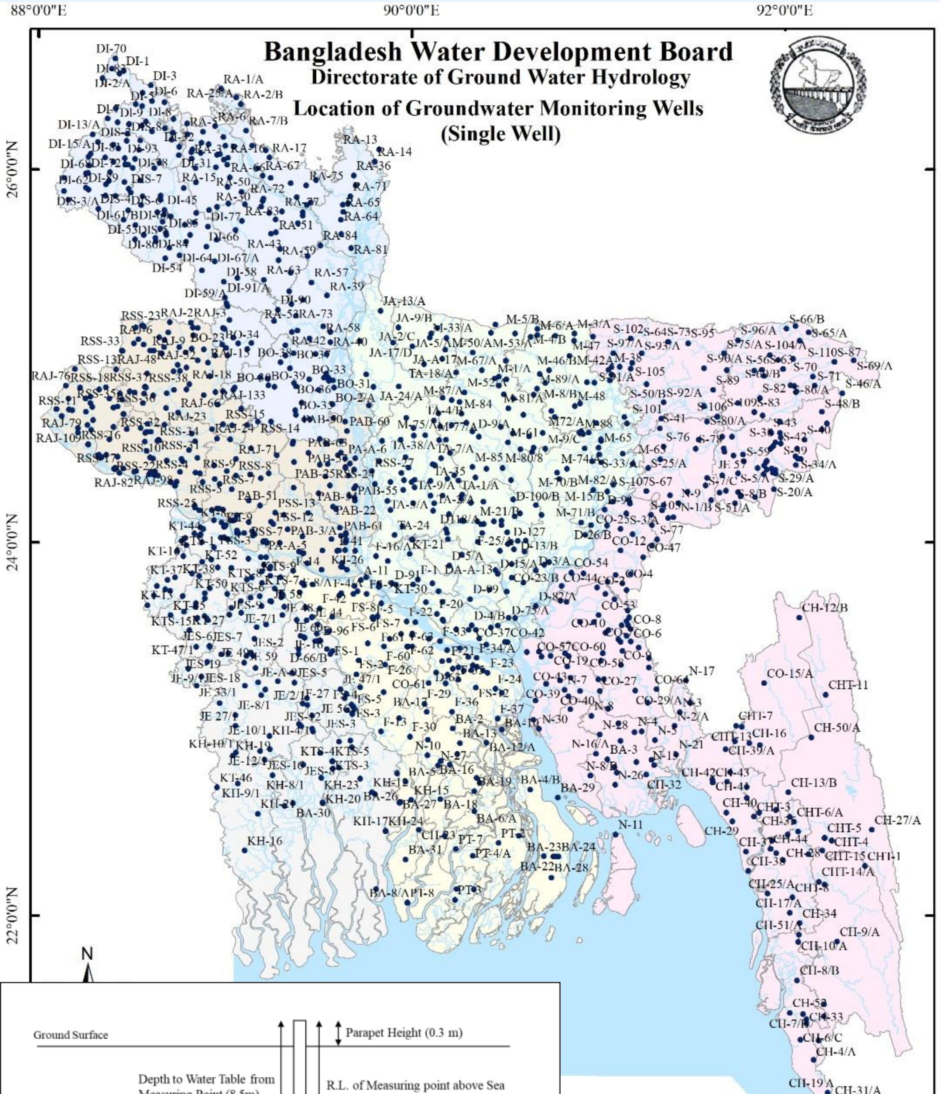
- Considering the quality problems in shallow and main aquifers and necessity to use deep groundwater BWDB has installed 42 clustered monitoring wells and 510 line wells in 2011-2012 upto the depth of 350 and 100 m respectively, in 19 coastal districts under the Bangladesh Climate Change Trust (BCCT) project.

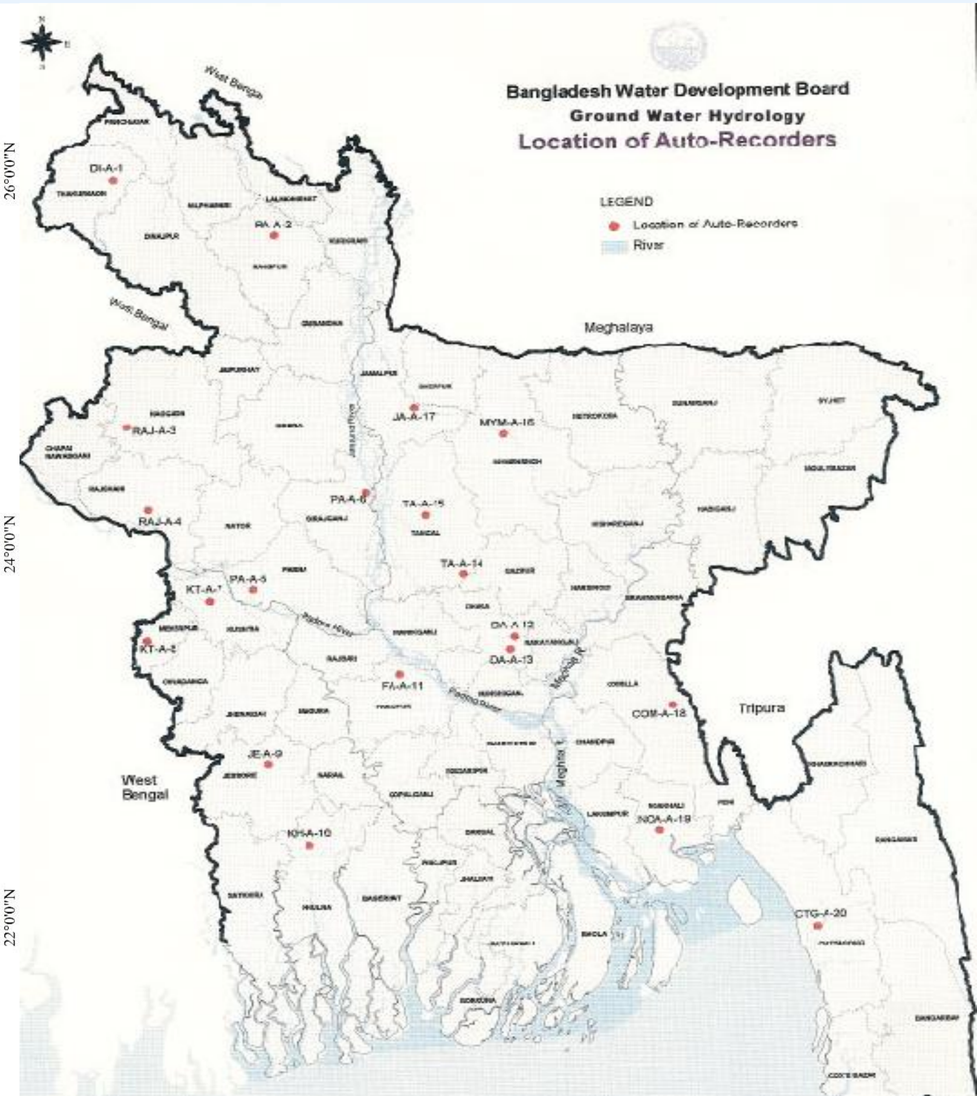
- Under the ongoing BWCSRP, Component B: Strengthening Hydrological Information Services and Early Warning Systems‘, funded by the IDA, the World Bank, 69 clustered monitoring wells have been installed in 2019-2020 covering entire country. Each unit consists of 4 wells having the maximum depth of 300 m.

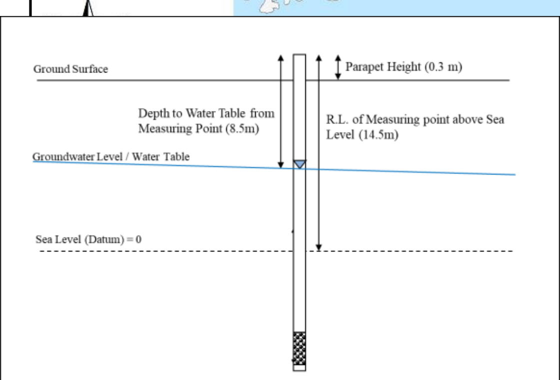
- Under the same project, 905 monitoring wells, including all clustered wells, are in process of automation with telemetry using data-logger for temperature, groundwater level and electric conductivity i.e. salinity. If these automated systems are maintained properly, the real-time data frequency and accuracy will be enhanced.

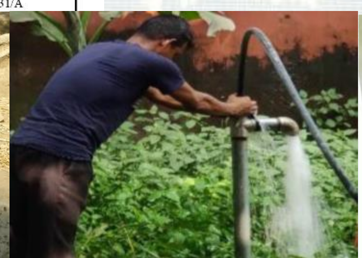
anwarzahidb@gmail.com

Location of BWDB Shallow Groundwater Table Monitoring Wells

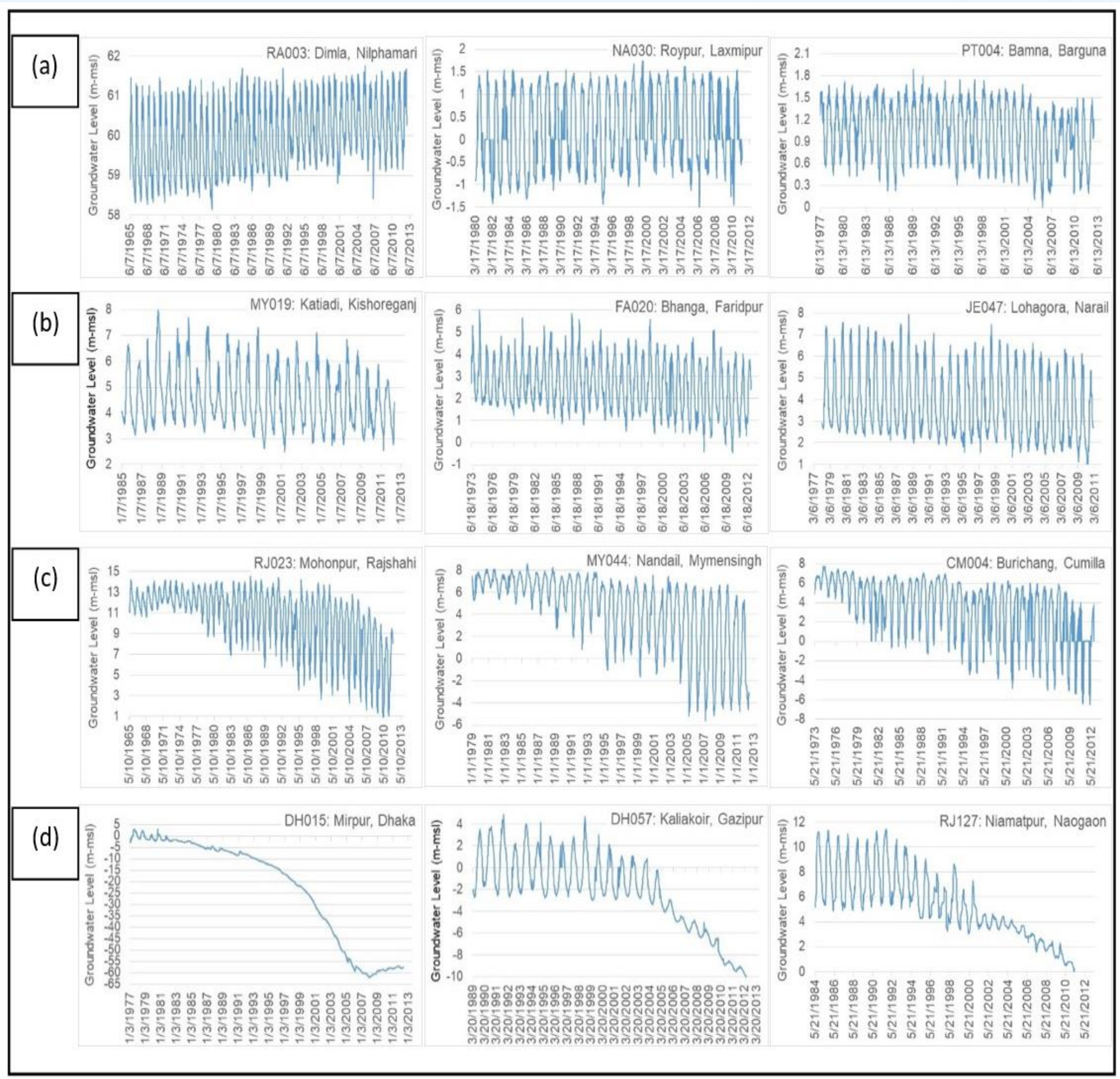








Groundwater Level Hydrographs of Upper Shallow Aquifers in Different Areas of Bangladesh



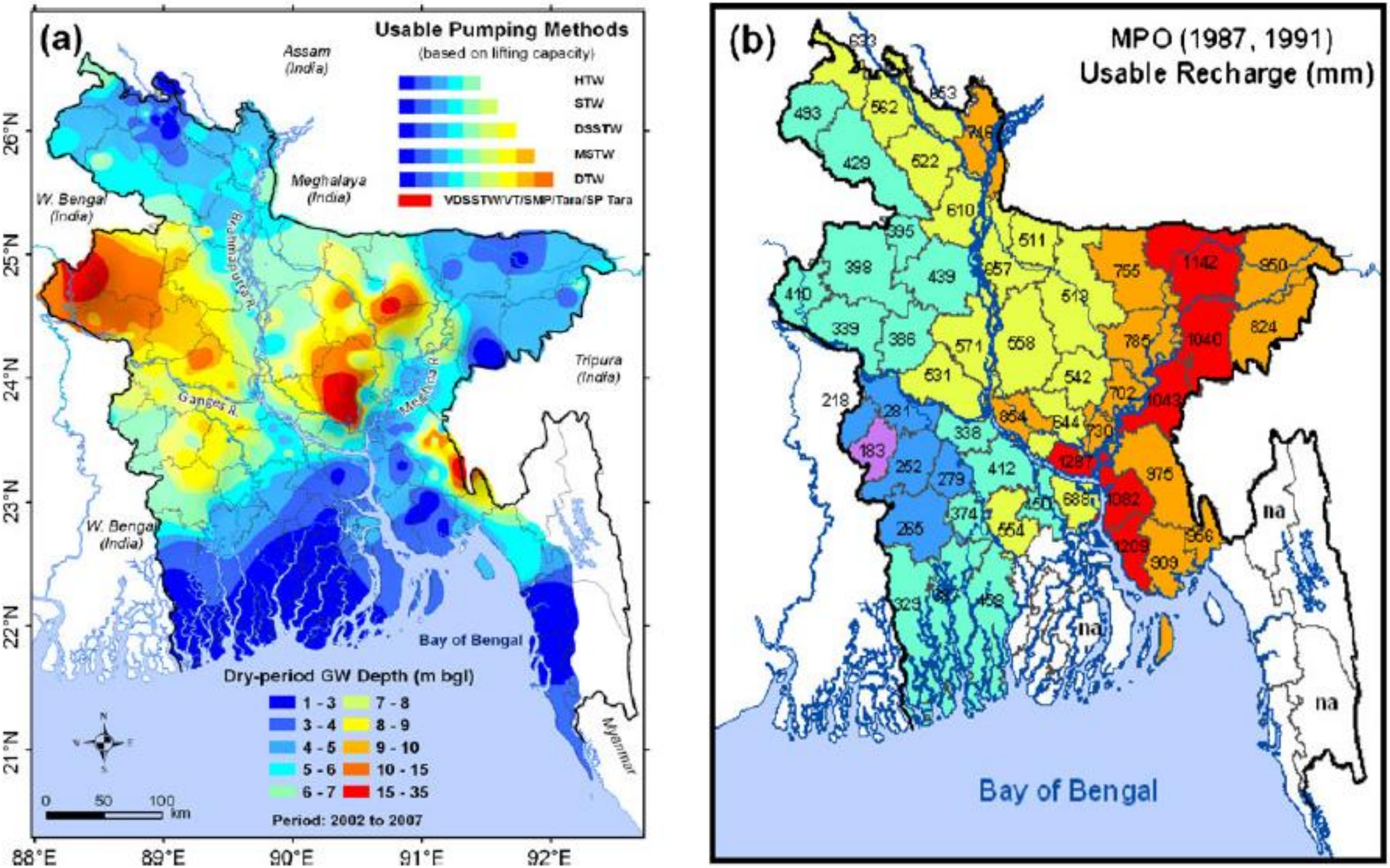
(a) the lowered water level during dry irrigation period regains it's static water level in monsoon as of the previous years;

(b) due to increased abstraction and where potential recharge is lower than actual recharge, the static or highest water level of the previous year declines during monsoon;

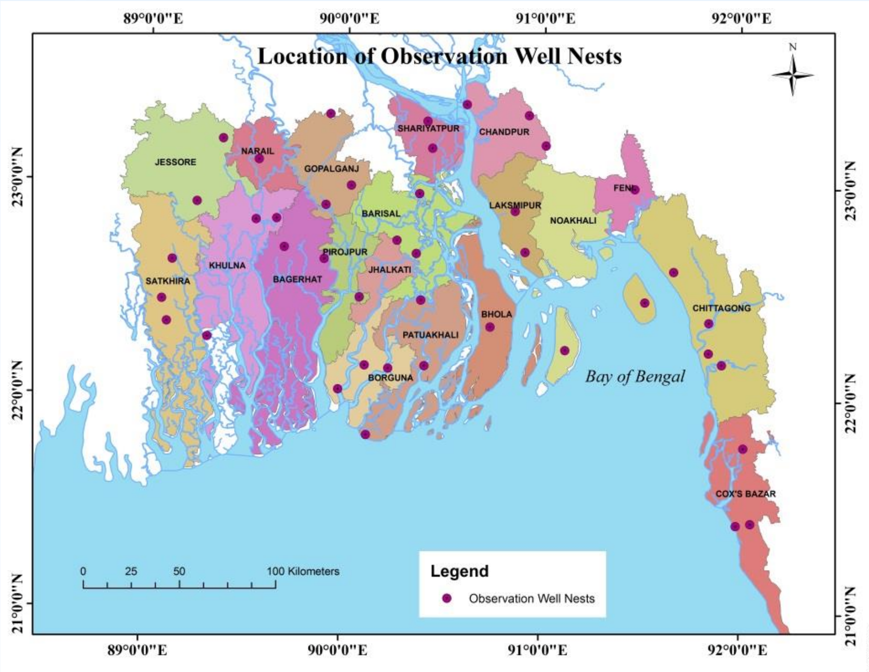
(c) with increased abstraction, fluctuation of groundwater level has been increased with time;

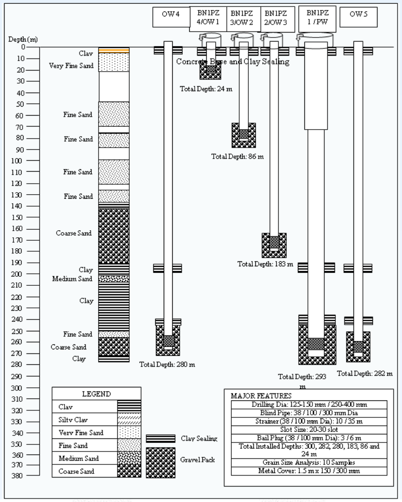
(d) permanent decline of water level is also observed as an alarming rate in urban areas and in the Barind tract.

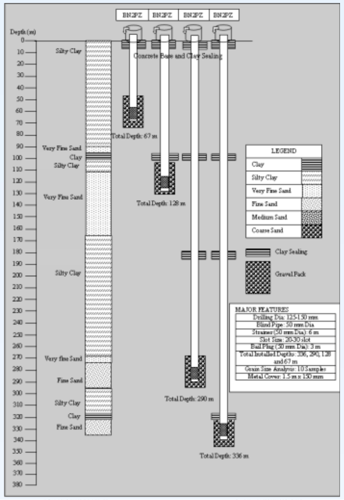
GROUNDWATER TABLE/LEVEL CONTOUR MAPS

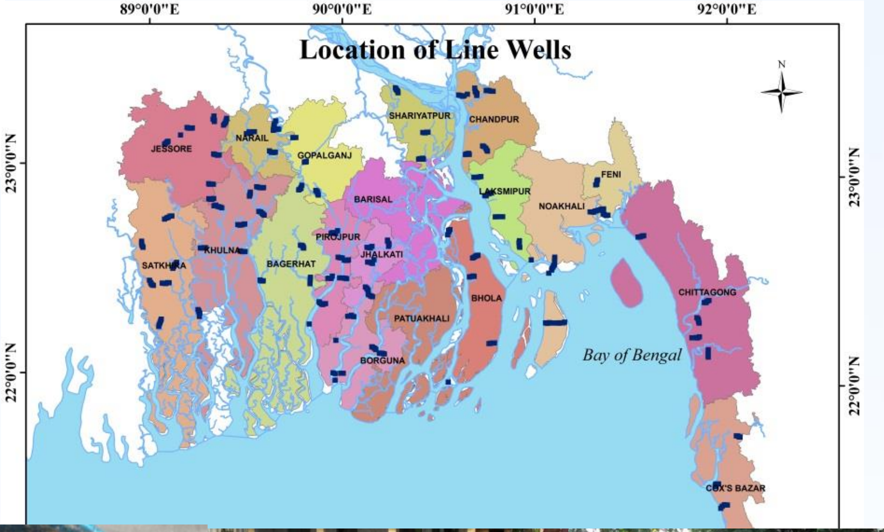


Location of Monitoring Well Nests and Line Wells in Coastal Districts









Groundwater Table/Level Monitoring Activities

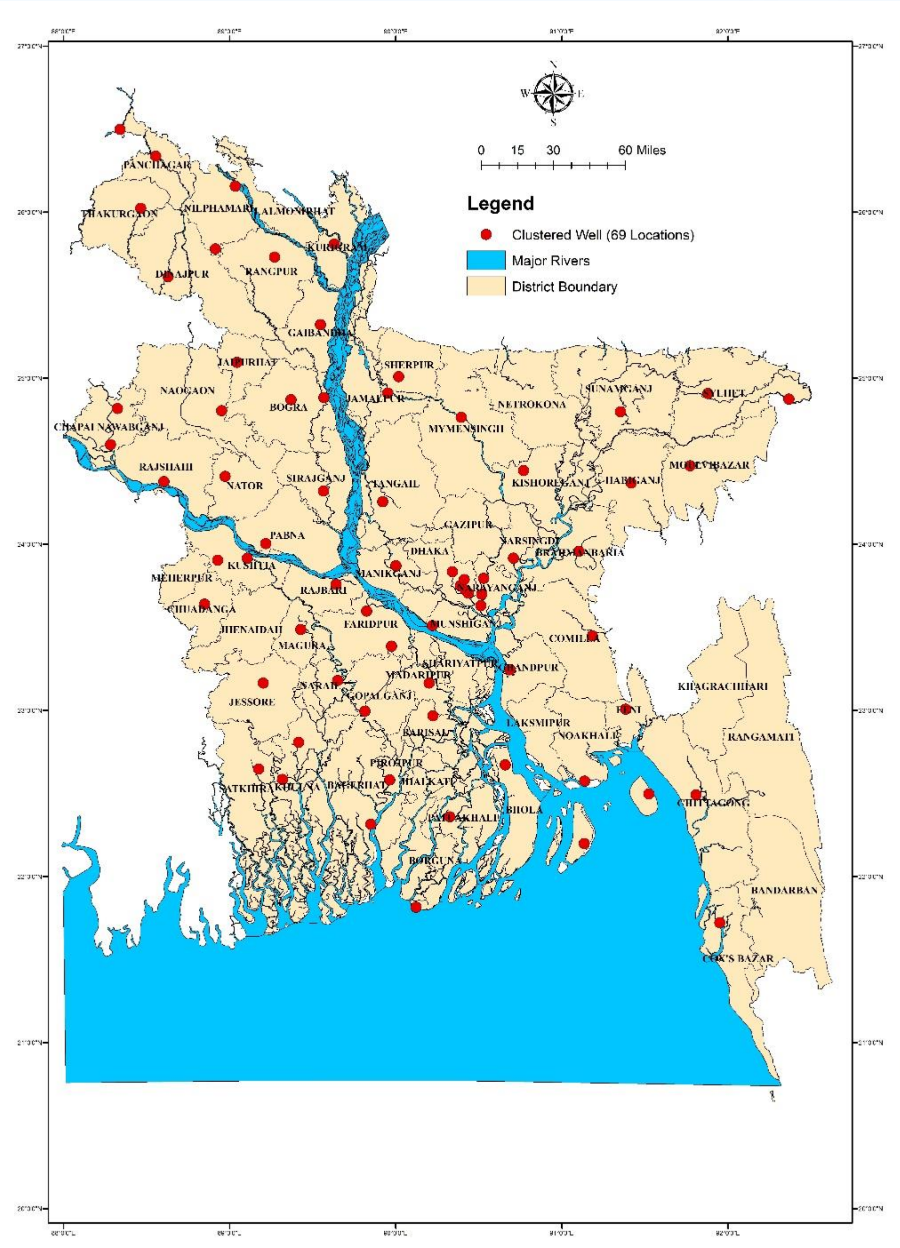


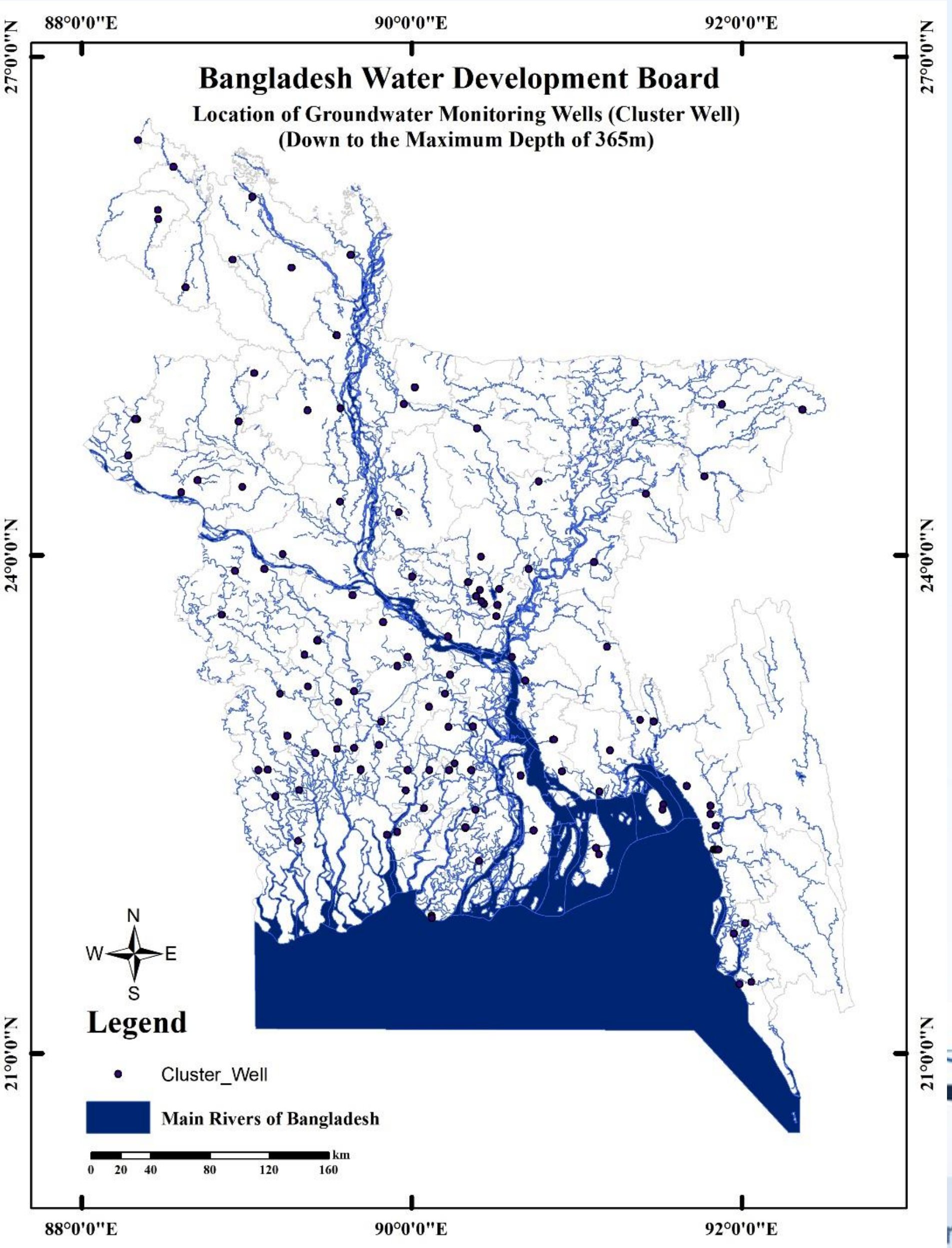




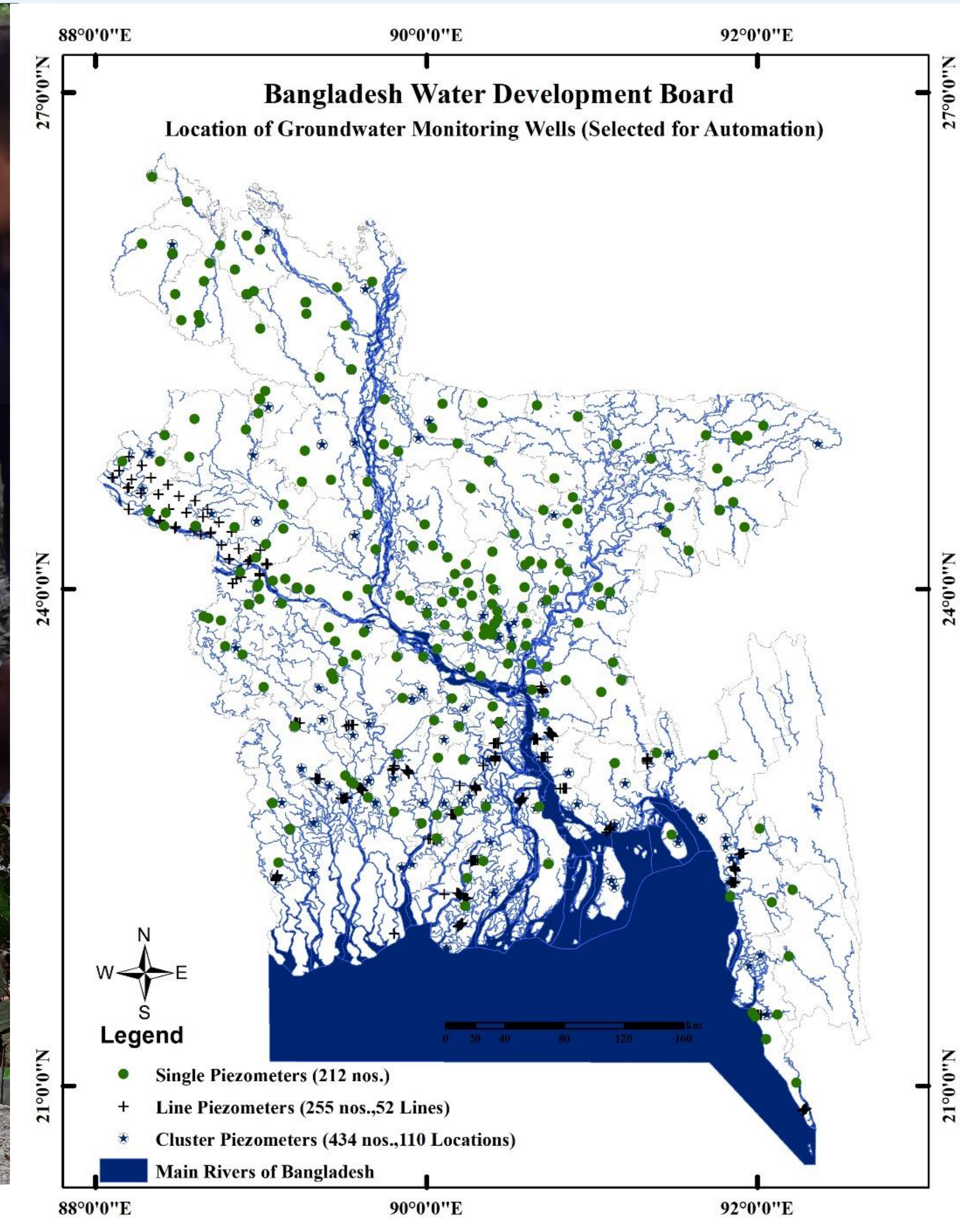


Clustered Wells (down to 330 m) Installed under Bangladesh Weather and Climate Services Regional Project (BWCSRP) and BCCT Project





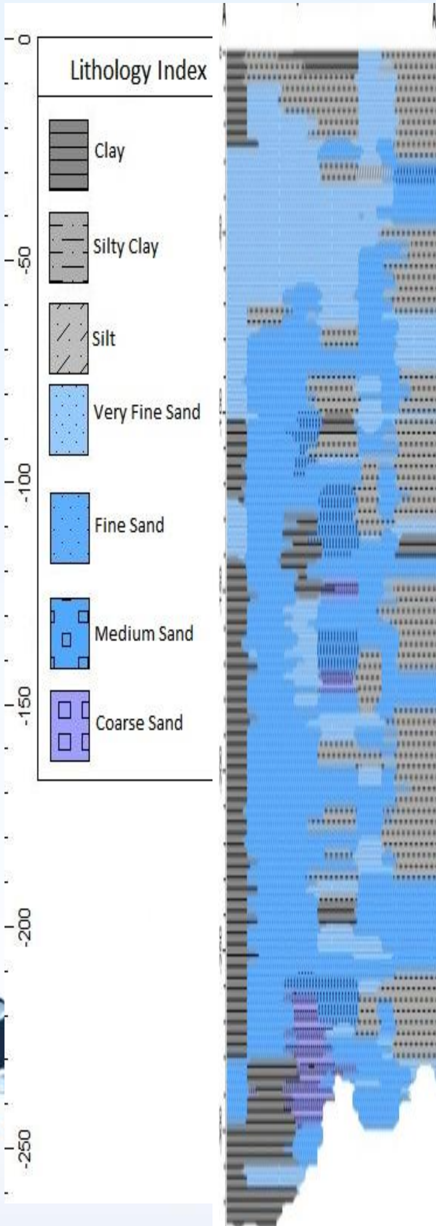
Automation of 905 BWDB Groundwater Observation Wells with Telemetry
(Installation Started on: November 30, 2020)

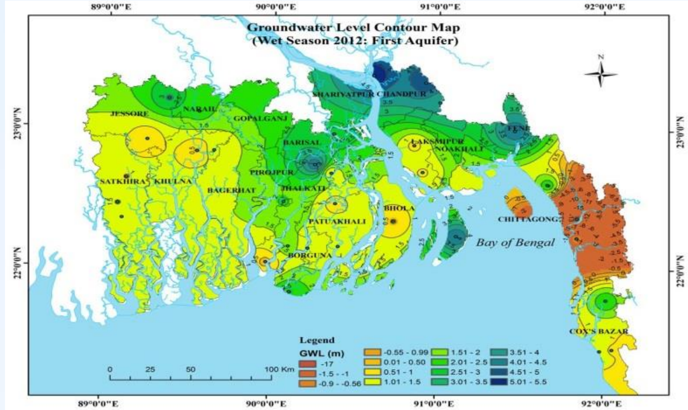


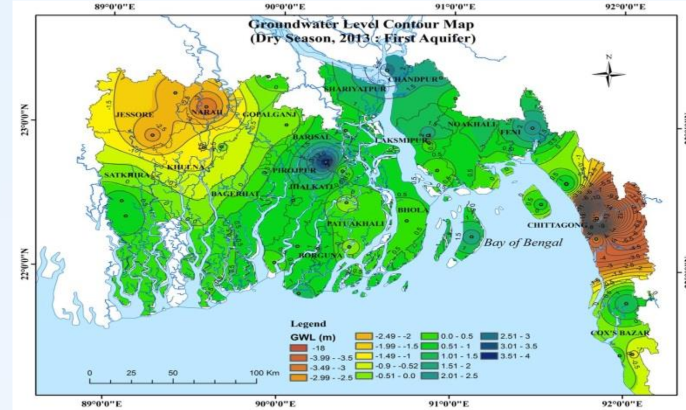
Depth-wise Groundwater Level Contour Maps

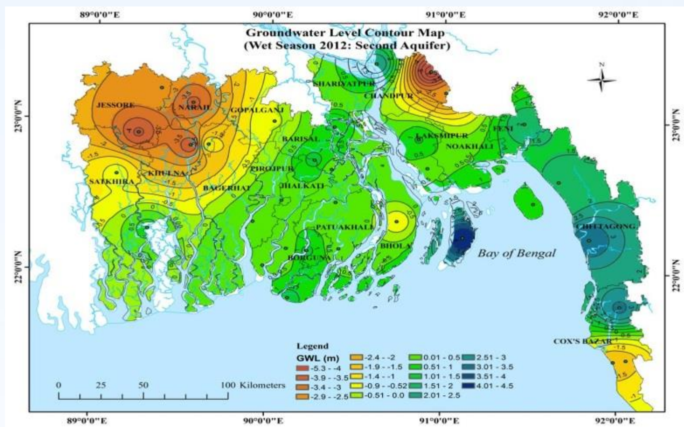
Monsoon/Wet Season

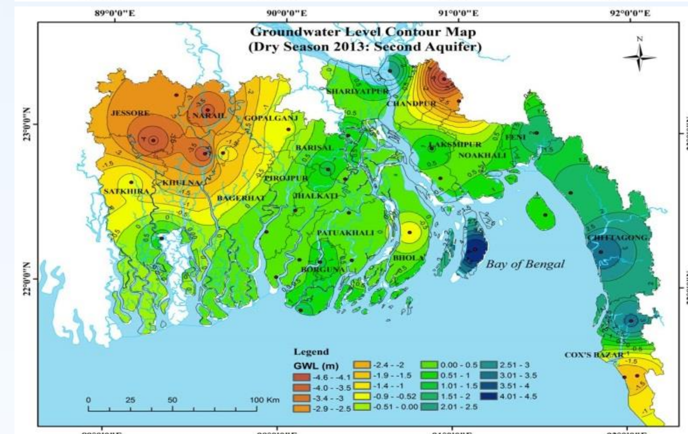
Pre-monsoon/Dry Season

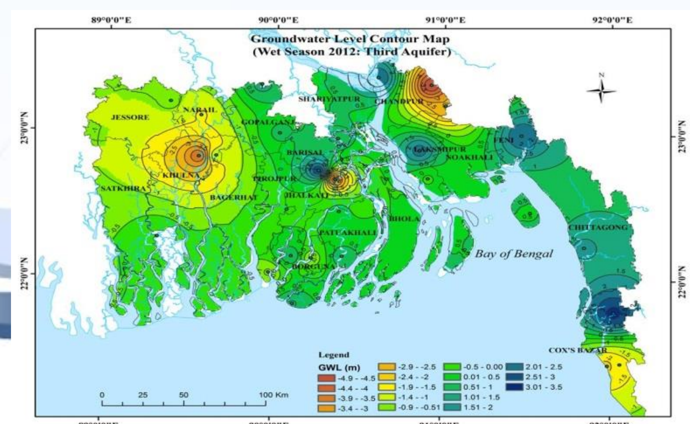


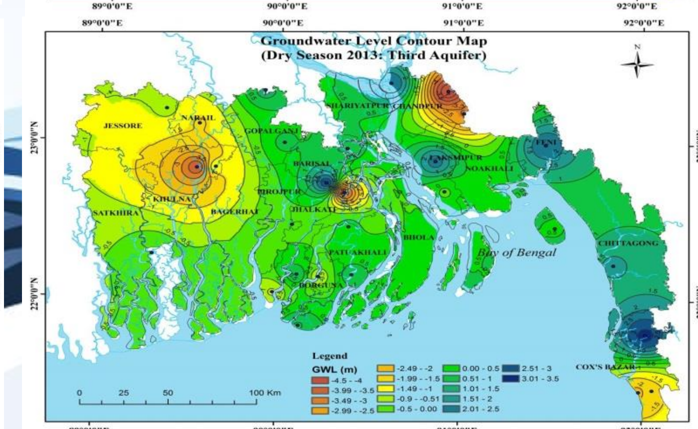












Monitoring of Groundwater Quality

Water-quality parameters that characterize water quality may be classified in several ways, including:

(a) Physical properties, for example, temperature, electrical conductivity, colour and turbidity;

(b) Elements of water composition, such as pH, alkalinity, hardness, Eh or the partial pressure of carbon dioxide;

(c) Inorganic chemical components, for example, dissolved oxygen, carbonate, bicarbonate, chloride, fluoride, sulfate, nitrate, ammonium,

calcium, magnesium, sodium potassium, phosphate and heavy metals;

(d) Organic chemicals, for example, phenols, chlorinated hydrocarbons, polycyclic aromatic hydrocarbons and pesticides;

(e) Biological components, both microbiological, such as faecal coliforms, and macrobiotic, such as worms, plankton and fish, or vegetation.

Analytical Methods

- Major cations and anions of groundwater sample are measured in the laboratory using Ion Chromatography (IC).
- Sb, Mo, Cd, Co etc. can be measured by ICP-MS (Inductively Coupled Plasma-Mass Spectrometry), while Al, Fe, Mn, P, Zn, Cr, Ni, Cu, Pb, Ba, B etc. can be analyzed by ICP-OES (Inductively Coupled Plasma-Optical Emission Spectrometry).
- HyAAS (Hydrous Generated Atomic Absorption Spectrometry) can be used to measure the As concentration.
- AAS can be used to measure some cations and trace metals.
- Gas Chromatography is used for organic substances.
- If advanced analytical facilities are not available, traditional methods can be used.

In-situ and Laboratory Analysis of Water Samples

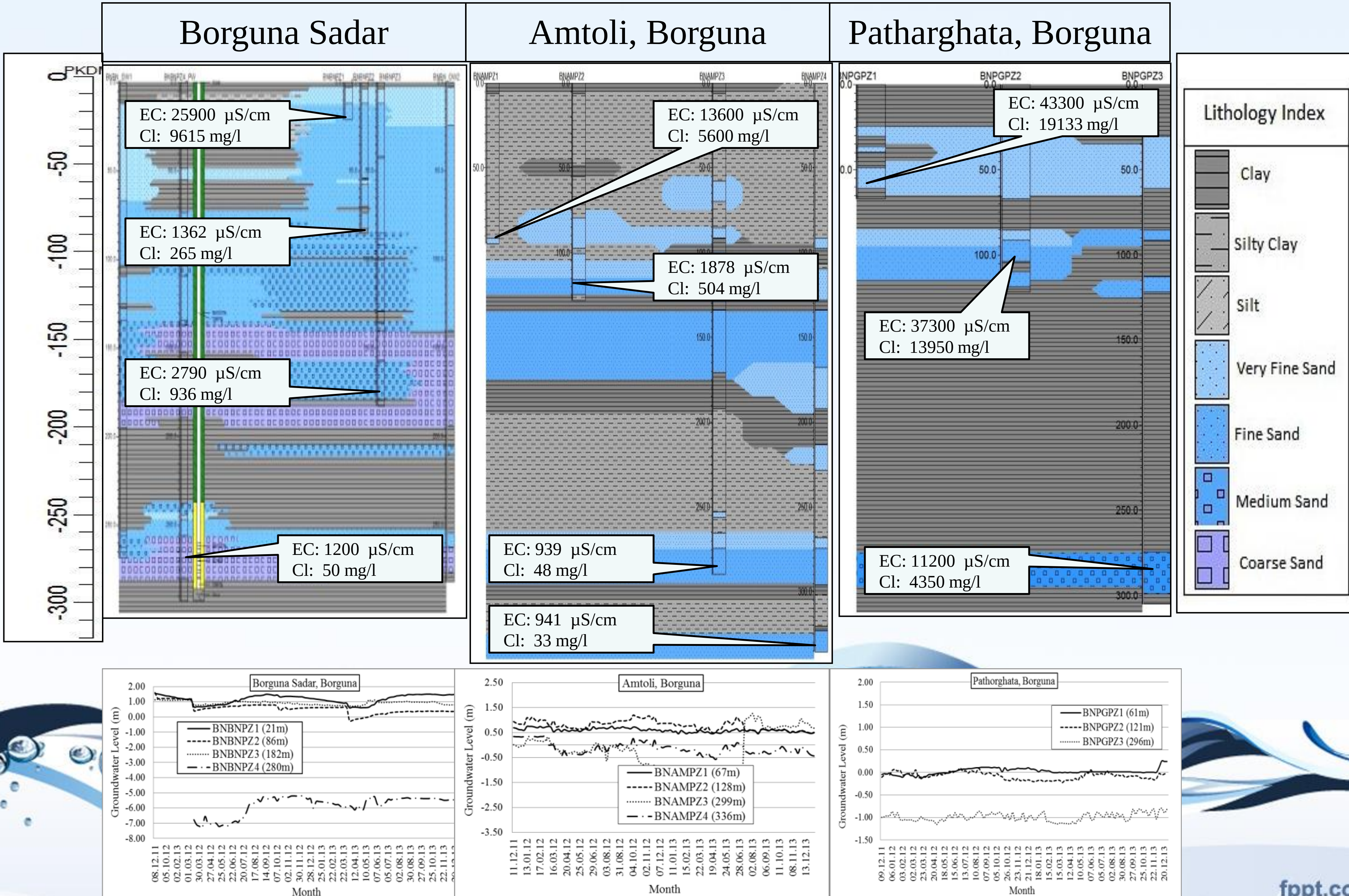




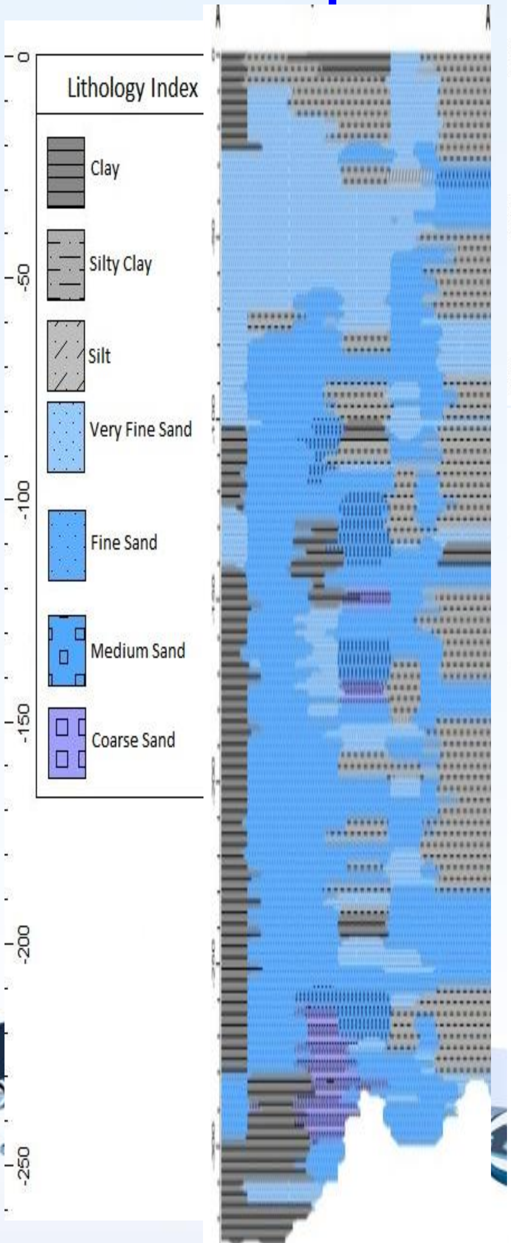




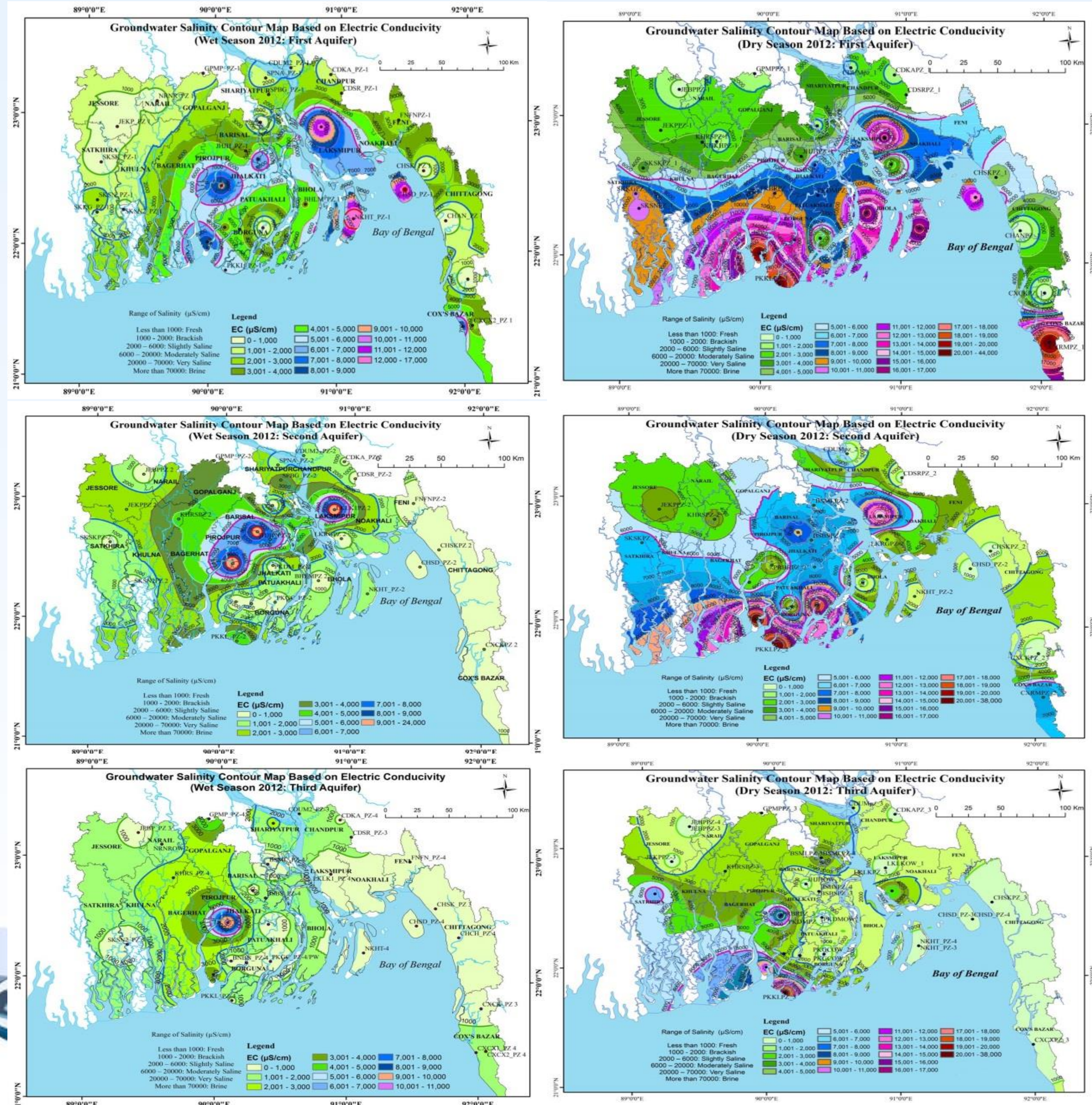
Groundwater Salinity in Tidal Delta



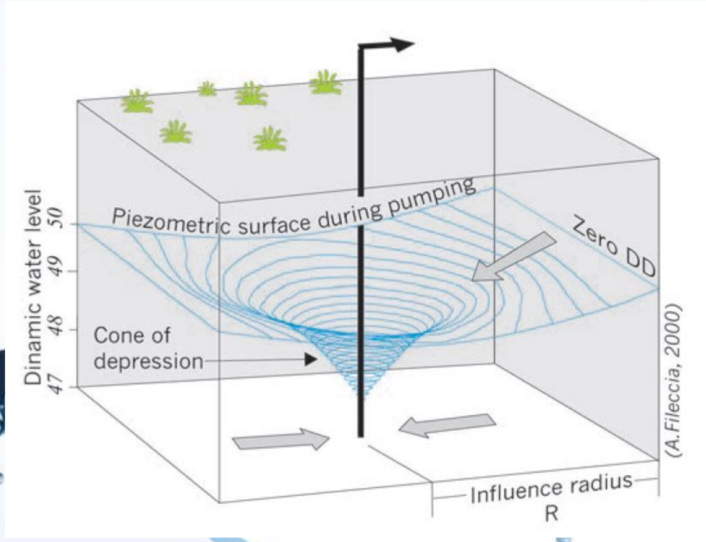
Groundwater Salinity in Coastal Aquifers

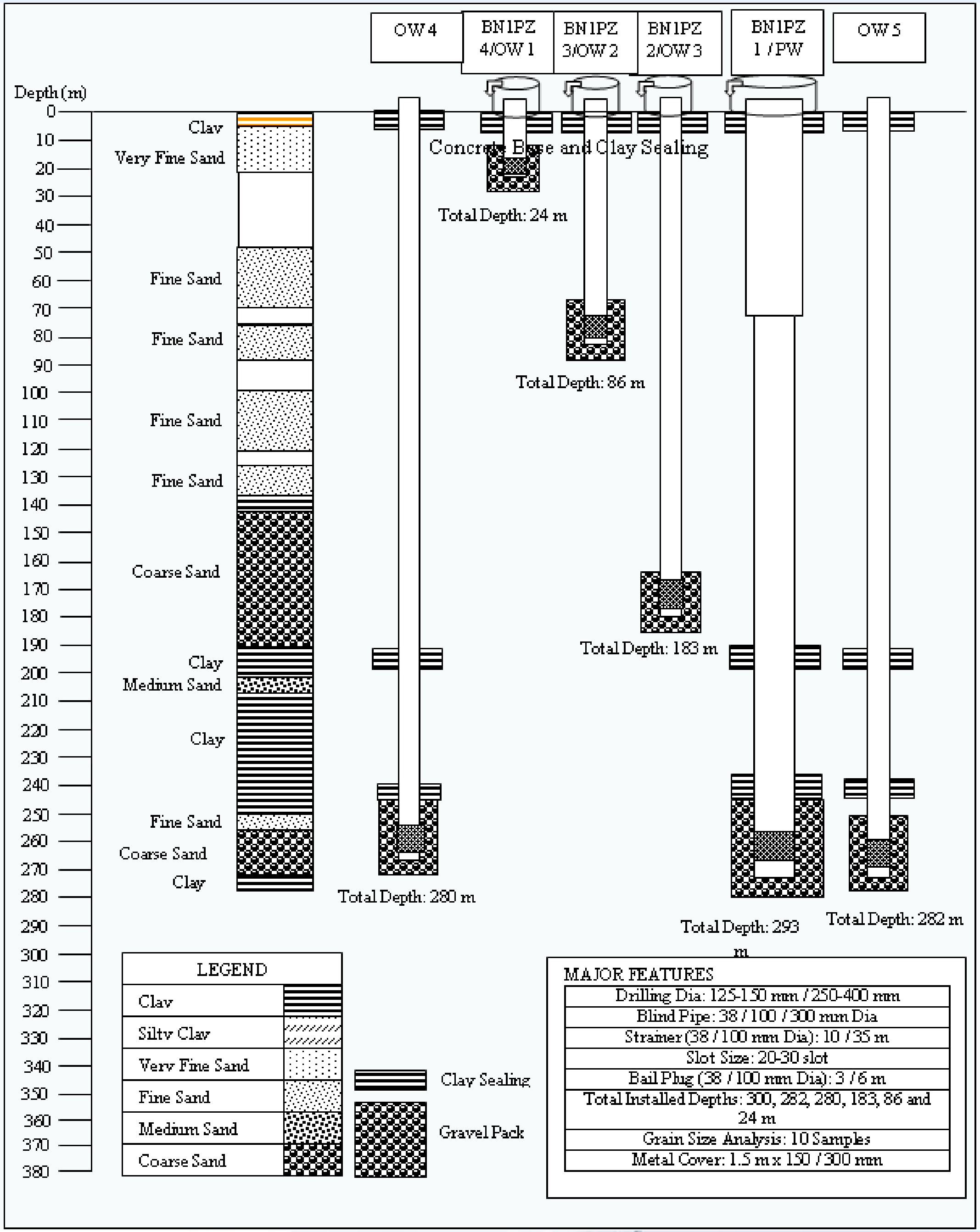


Monsoon/Wet Season | **Pre-monsoon/Dry Season**



Aquifer Pump Test to Determine Hydraulic Properties of Aquifer Sediments





Monitor Water Table (Drawdown) and Well Discharge

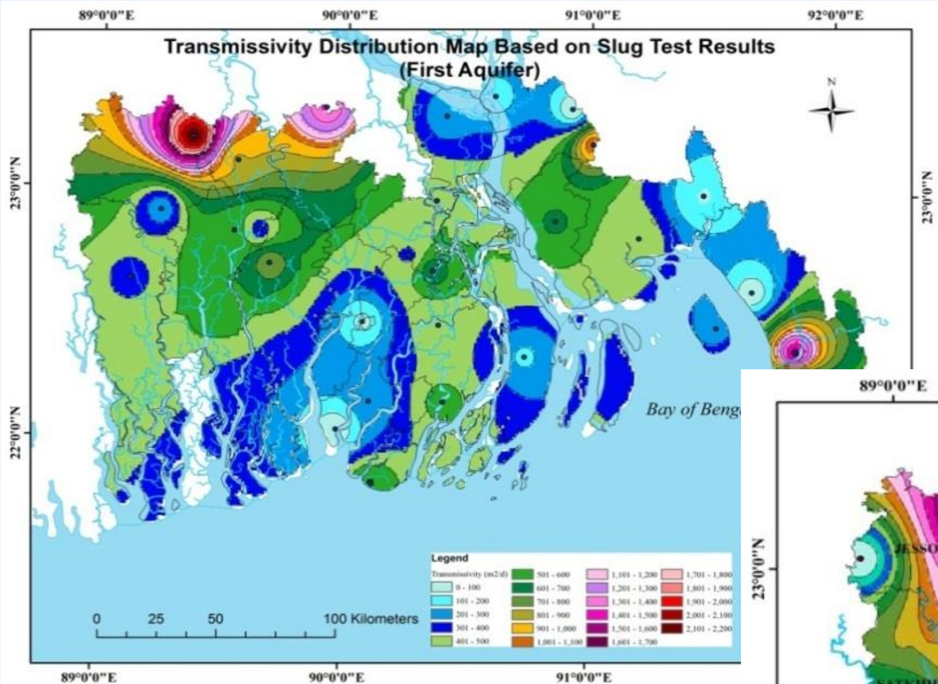


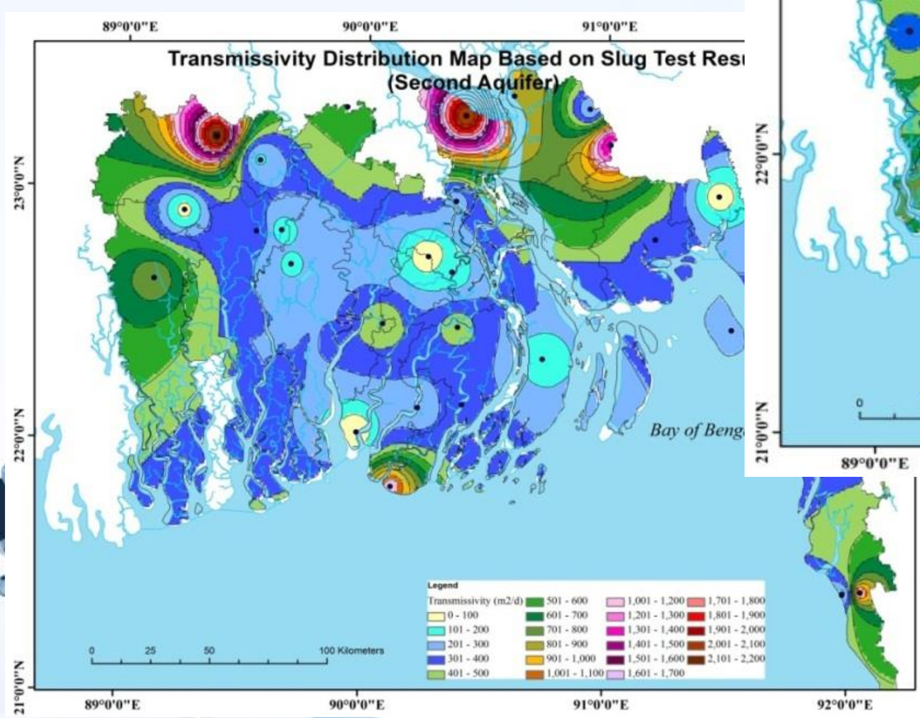


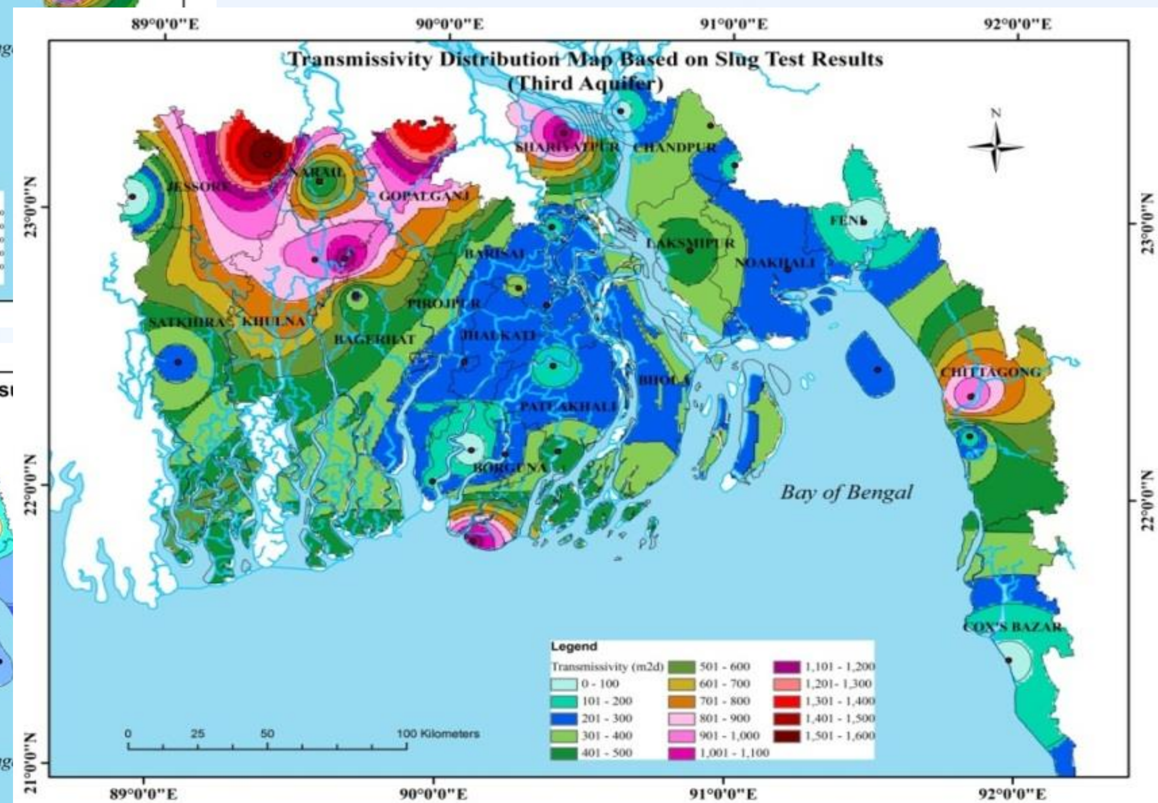




Depth-wise Transmissivity (T) of Coastal Aquifers



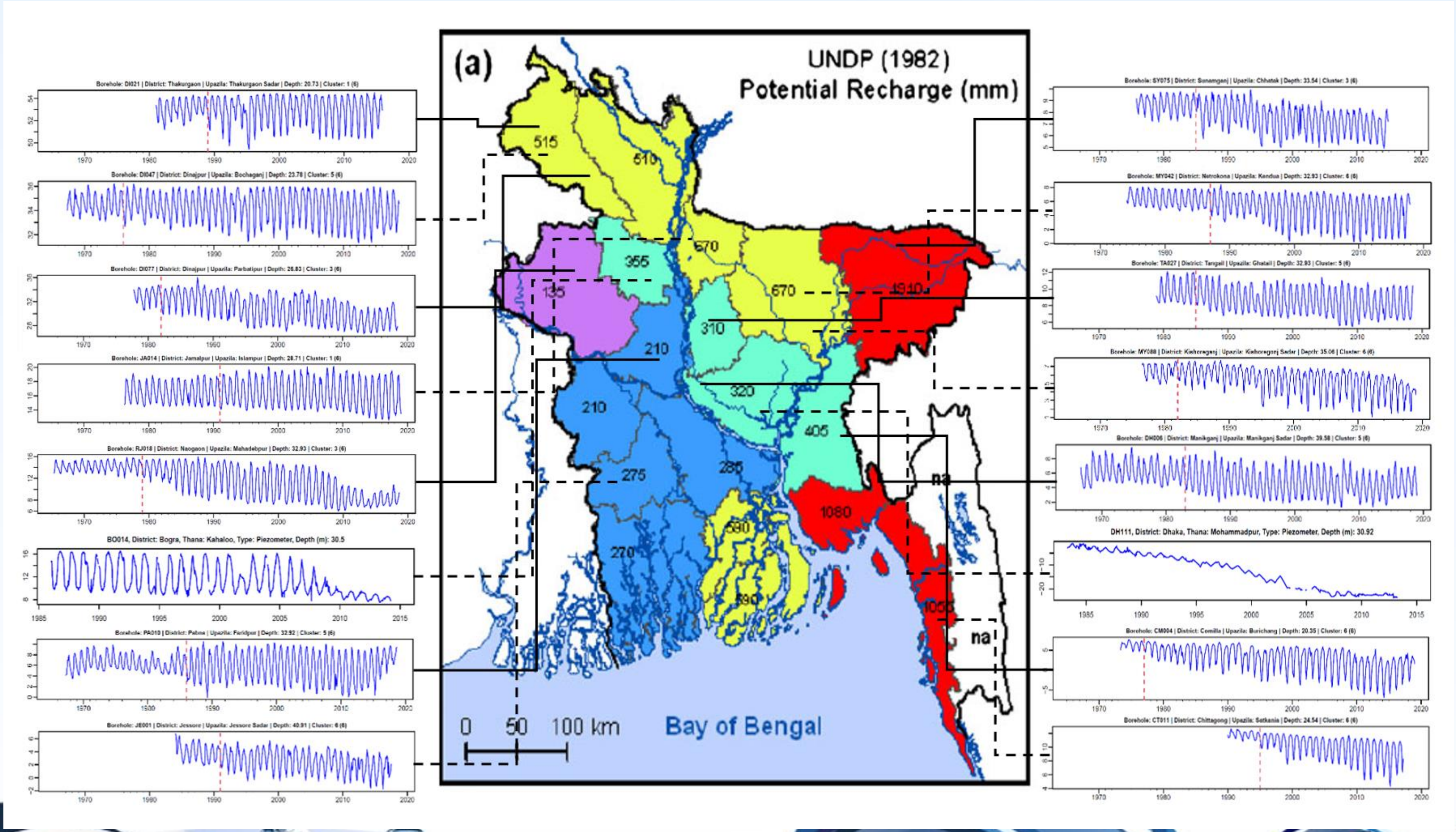




Challenges and Recommendations to Strengthening Groundwater Management Activities

anwarzahidb@gmail.com

Potential Recharge and Development Stresses



anwarzahidb@gmail.com

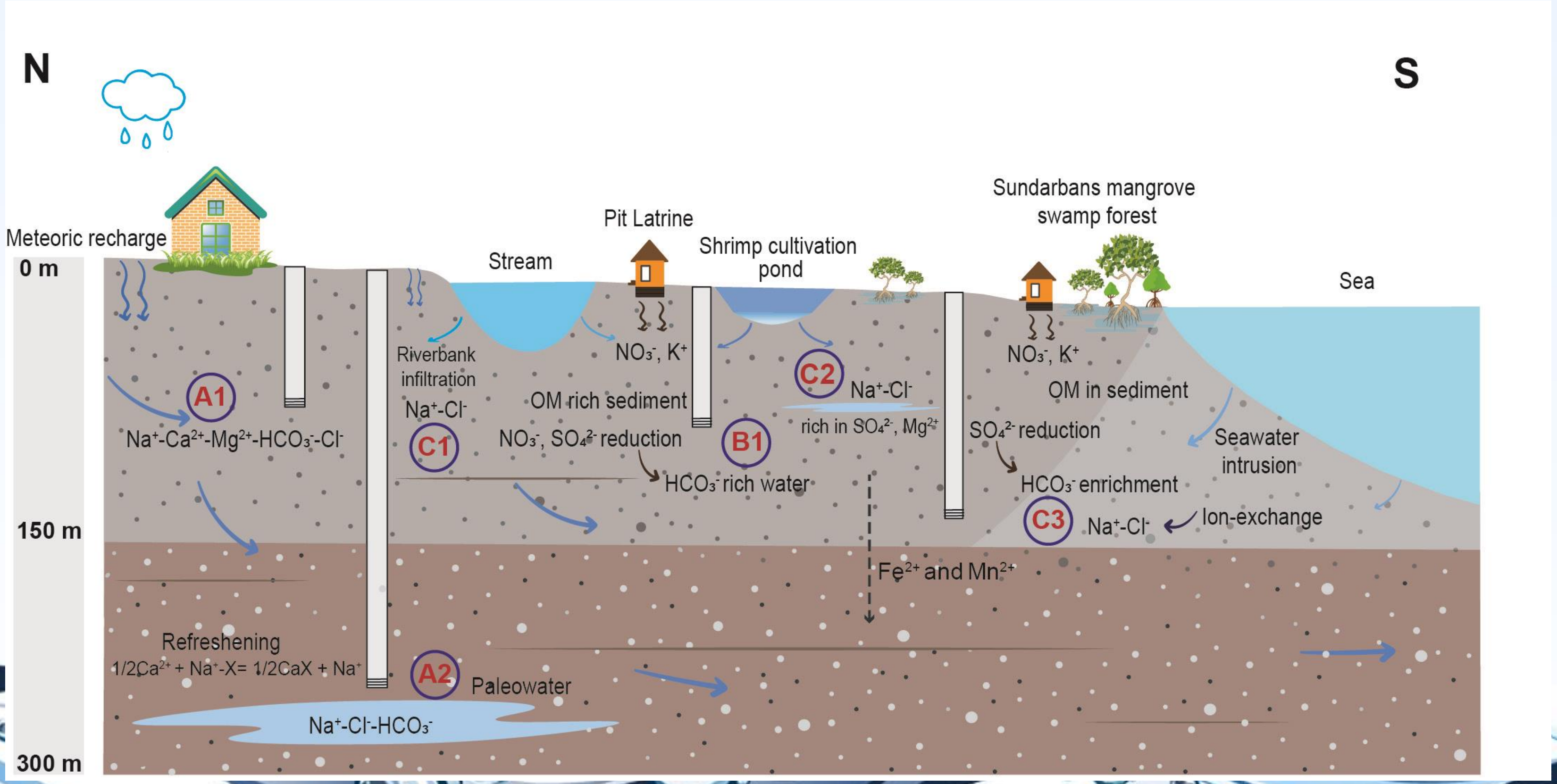
Groundwater Recharge Estimation Considering Aquifer Poroelastic Response

- Where hydro-mechanical coupling is significant, groundwater hydrographs are unreliable indicators of the status of groundwater storage.
- Assessments of recharge, judgement concerning sustainability, and comparisons with GRACE ΔGWS should acknowledge the coupled hydro-mechanical context, otherwise misleading conclusions will be drawn.
- The situation in the Bengal Basin may occur more widely in South and SE Asia, and in other deltaic regions and sedimentary basins worldwide.

(Zahid et al., 2019)

Conceptual Model on Hydro-geochemical Processes in the Coastal Aquifers

(Islam,…Zahid..et. al., 2019)



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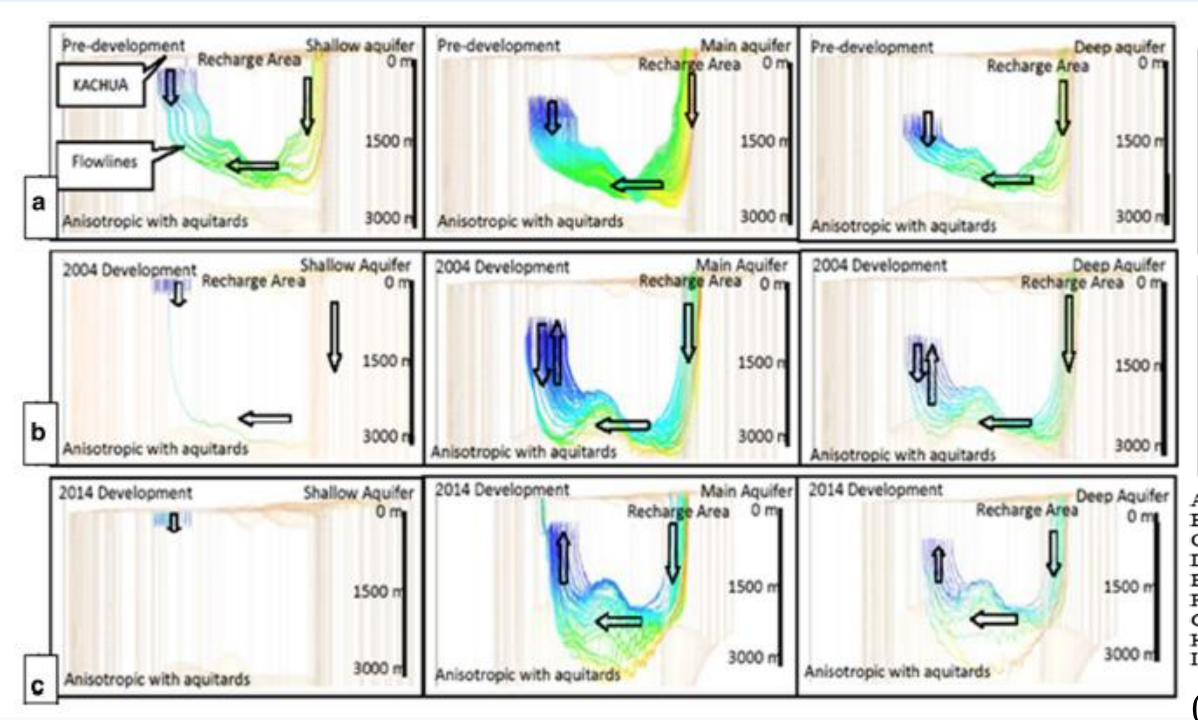
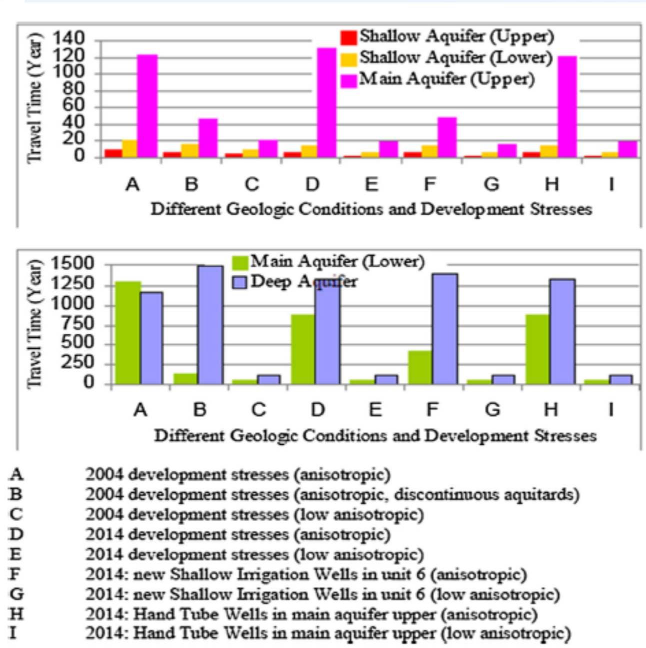
RESOURCE ASSESSMENT: MODEL TO DETERMINE FLOWPATHS AND TRAVEL TIME OF GROUNDWATER

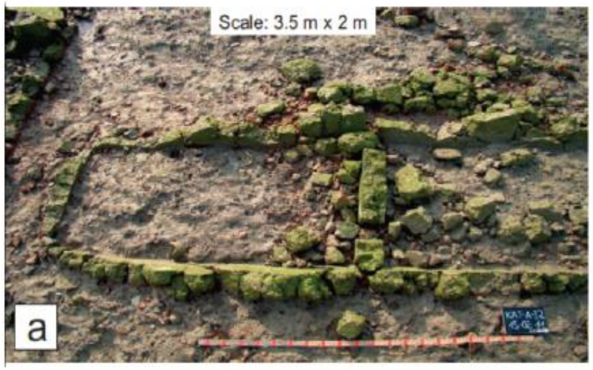


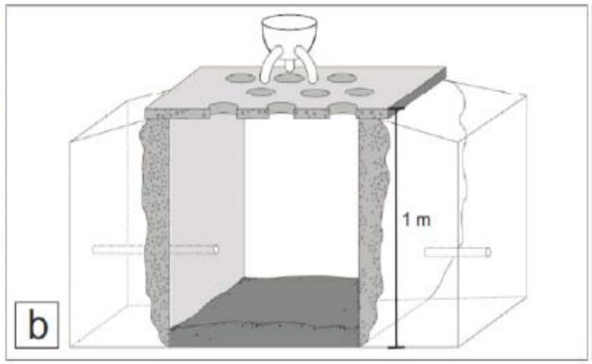


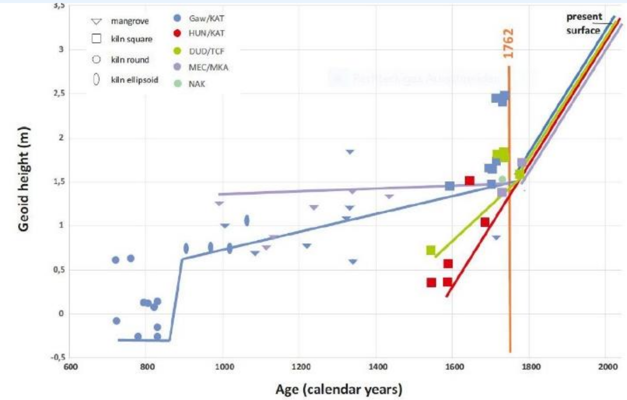
(Zahid et al., 2015)

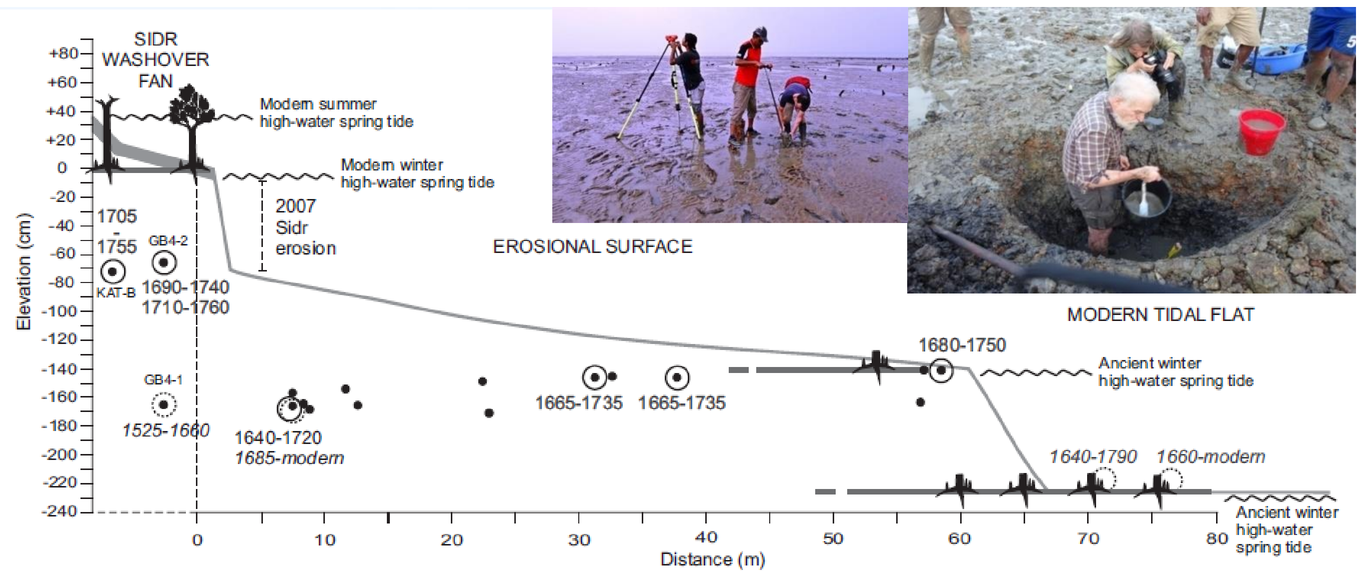
Flow paths and travel time of groundwater are primarily controlled by the hydrogeologic characteristics and the pattern of pumping. Aquifers are recharged by vertical percolation as well as long distance travel of water from highly elevated hilly areas, mainly to deeper aquifers. Under the current trend of groundwater development, the average travel time, i.e., age of water for the upper and the lower parts of the 1st and 2nd and the upper part of the 3rd aquifers at different geologic conditions is estimated between 37 and 234, 133 and 317,832 and 2,485, 1,009 and 3,027 and 1,065 and 3,543 years, respectively. Maintaining the current trend of irrigation abstraction, if only domestic wells are shifted to the 2nd aquifer from the 1st aquifer, would provide better results and the lower part of the 2nd aquifer and the 3rd aquifer will remain safe for a longer period of time. Where seawater encroachment is a problem in coastal basins, the possibility of sea-water intrusion may be increased with increased stress on groundwater.

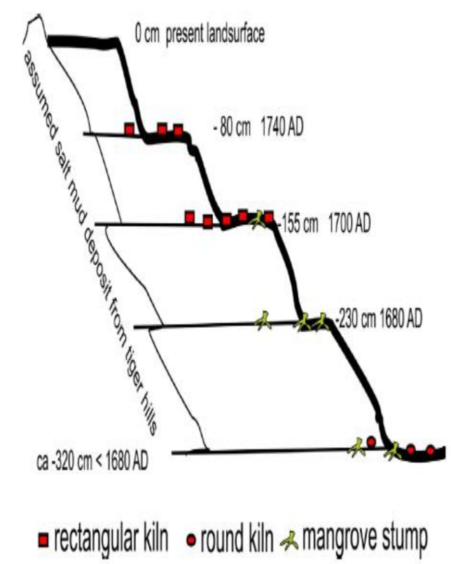
Impact of Climate Change: Estimation of Land Subsidence and Sea-level Rise in the Coastal Areas of Bangladesh (Hanebuth … Zahid et al. 2021)











Independent of the sinking scenario, new data allow for a precise subsidence calculation. The lower kiln base level subsided by 155 ± 20 cm in 305 ± 35 yr (A.D. 1705 ± 35) resulting in an *SLInd (sinking of paleo–sea-level indicator* level) rate of 5.2 ± 1.2 mm/yr. The lower mangrove root horizon subsided by 230 ± 10 cm in a maximum of 360 yr (A.D. 1650), resulting in a minimum subsidence rate of ~6.4 mm/yr. The long-term average subsidence rate over the past 1,300 years with respect to the elevation of the modern land surface was 2.7 ± 0.3 mm/yr. The subsidence rate has, however, considerably varied between the investigated coastal sections and over certain time intervals.

Example for Integrated Water Resource Management (IWRM)

Preparation of Water Budget (Yearly)
(and Water Allocation Plan)

Demand Calculation for Different Uses/Sectors

- Drinking and Potable
  (Data source: DPHE, population demand calculation, BBS etc.)
- Agriculture
  (Data source: BADC, DAE, BBS etc.)
- Others (if any)
  (e.g. industrial, ecosystem etc.)

Estimation of Available Fresh Water Resource

- Surface Water
  (Data source: BWDB, field survey, LGD etc.)
- Groundwater
  (Data source: BWDB, field survey etc.)
- Rainwater
  (based on reservoir capacity and shortage of SW and GW, if any)

Water Allocation (Priority: Water Act 2013)

- Drinking and potable
  (Source: groundwater, rain water and surface water)
- Agriculture
  (Source: surface water and rain water)
- Ecosystem
  (e.g. minimum stream flow, biodiversity etc.)
- Other Uses

Benefit: * Minimize unwise and misuse of inadequate fresh water resources in the coast.
* Mitigate social conflict by considering right and equality of water allocation.
* Preserve water for ecosystem and thus reduce water quality degradation.
* Lead to initiate the preparation of National Water Allocation Plan for entire country.

UN WATER
22 MARCH
WORLD WATER DAY 2015
WATER AND SUSTAINABLE DEVELOPMENT

Order of Water Use Priority based on Bangladesh Water Act 2013

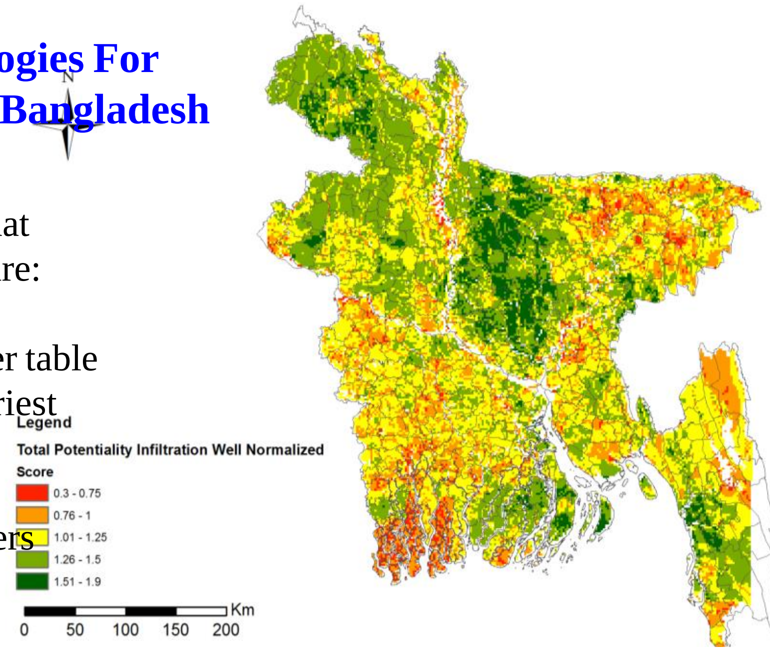
(a) Use of Water as Potable
(b) Use of Water in Household
(c) Use of Water in Agriculture
(d) Use of Water in Aquaculture
(e) Use of Water for Eco-system
(f) Use of Water for Wild Life
(g) Use of Water for Natural River Flow
(h) Use of Water in Industry
(i) Use of Water for Salinity Control
(j) Use of Water for Power Generation
(k) Use of Water for Amusement
(l) Use of Water for Other Purposes

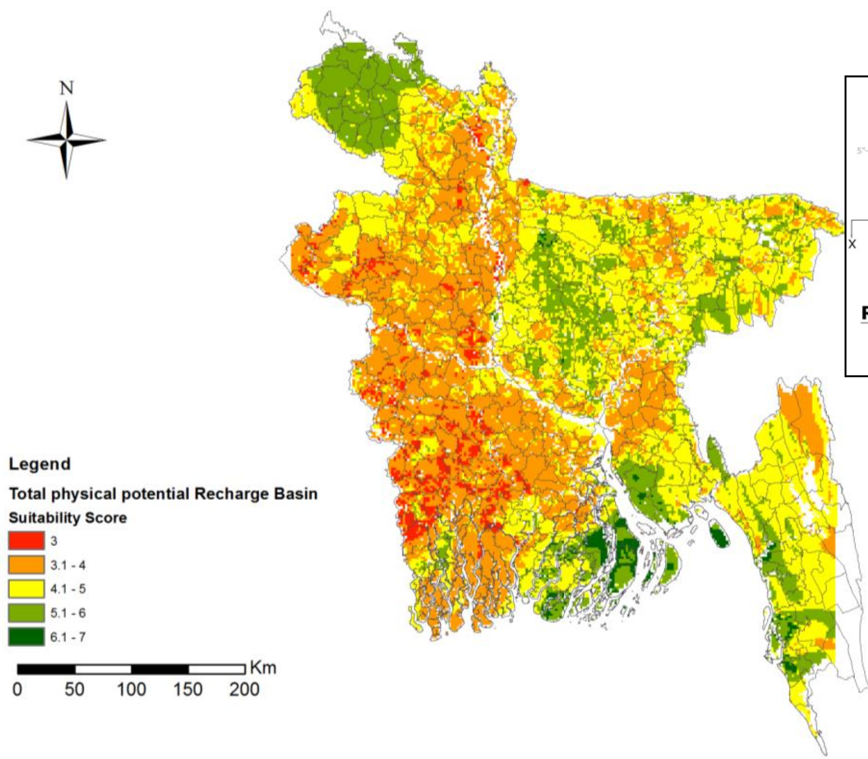
Mapping of Recharge Potential and Recharge Technologies For Enhancing Storage of Groundwater in Different Areas of Bangladesh

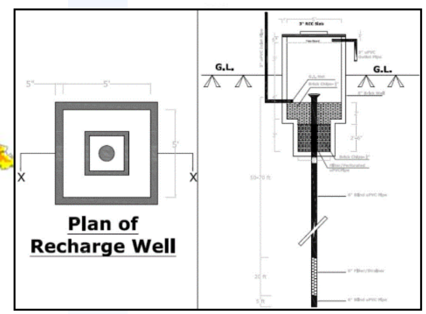
(Marta, Zahid et. al., 2019)

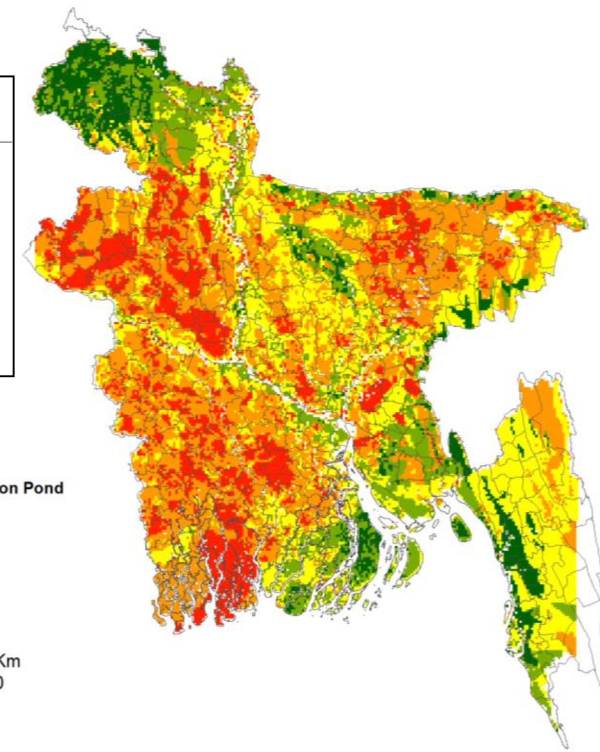
The identified variables that define the Physical Potential are:
- Precipitation intensity and duration
- Evaporation loss
- Surface geology
- Thickness of the aquitard
- Groundwater depth below the surfacein the middle of the Monsoon (June)
- Wells contaminated with Arsenic
- Inundation land type

The identified variables that define Demand Urgency are:
- Population density
- Depth of the groundwater table below the surface at the driest month (April)
- Poverty
- Absence of perennial rivers close by
- Irrigation demand









WAY FORWARD

- Sustainable use of available safe water including groundwater can be planned by analyzing data and information of the components of the hydrologic cycle.
- In Bangladesh where groundwater is the principal source of irrigation, industrial and potable water supply, regular assessment and monitoring of this resource is very important.
- Maintaining the water balance of withdrawals and recharge is vital for managing human impact on water and ecological resources. Groundwater resources that can safely be abstracted from both upper and deeper aquifers need to be assessed properly.
- Because of increasing demand of water and to reduce dependency on limited fresh groundwater resources, utilization of available surface water and conjunctive use should be emphasized as per National Water Policy 1999 and other guidelines of the Government.
- Regional modelling of the groundwater systems has to be developed for effective water resource management to plan agricultural, rural and urban water supplies and to forecast the groundwater situation in advance for dry seasons.

WAY FORWARD

- In present scenario, besides proper investigation of shallower aquifer formations, exploration on the deeper formation of aquifer systems (250-400 m deep), probable potential safe source of drinking water in many areas, is very important.
- Preparation of water budget and water allocation plans are important up to union level based on available data and information as well as conducting required survey and investigations. All of these tools can be implemented under the authority of the Water Act 2013 Water Rules 2018.
- Augmentation of both natural and artificial recharge of groundwater (MAR) can be done in groundwater depleted and water stressed areas by implementing appropriate programs and techniques.
- Extension and upgrading existing network of groundwater monitoring wells should be done spatially and vertically in different aquifers for estimating recharge, monitoring fluctuation of water table and movement of groundwater and water quality assessment.
- To facilitate the actions for sustainable development and management of groundwater resources of Bangladesh, strengthening and capacity building of appropriate organizations is required.

Integrity is Essential for Resource Management

TRANSPARENCY

Access for everyone to relevant information, including information about budgets, plans, and implementation progress, in an easily accessible and meaningful manner.

ACCOUNTABILITY

Responsive institutions and individuals who understand and fulfil their responsibility in ensuring access to decent water and sanitation services, and who can be sanctioned where this is not happening.

PARTICIPATION

Stakeholders, including marginalised and resource-poor groups, are meaningfully involved in deciding how water is used, protected, managed, and allocated, and how sanitation services are provided.

ANTI-CORRUPTION

Actions that reduce or minimise opportunities for corruption, and result in action taken where corruption is discovered.

THANKS

anwarzahidb@gmail.com