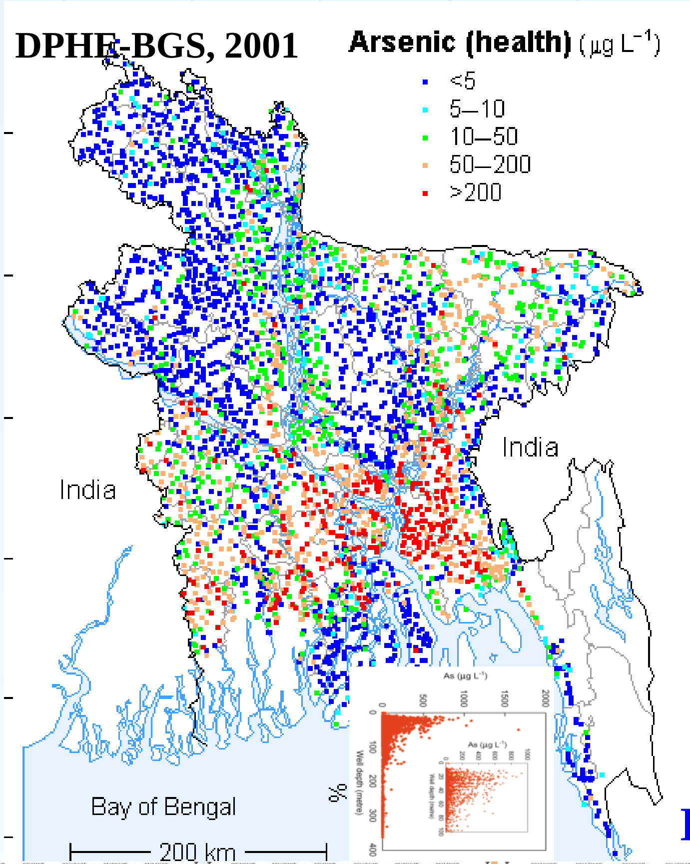
Arsenic Contamination of Groundwater in Bangladesh and Challenges to be Considered



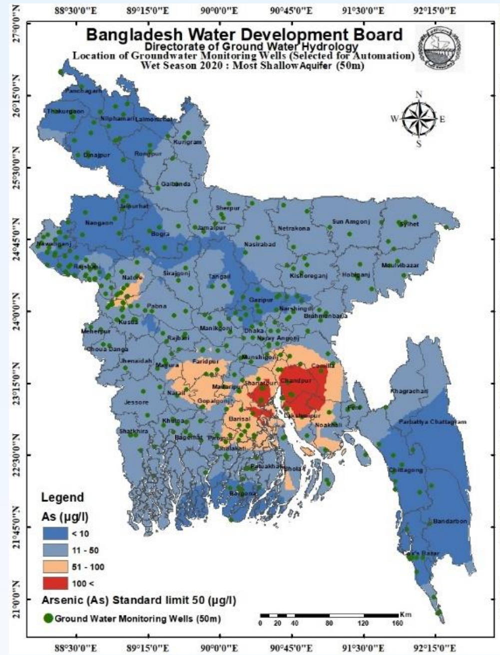

Anwar Zahid, *Ph.D.*

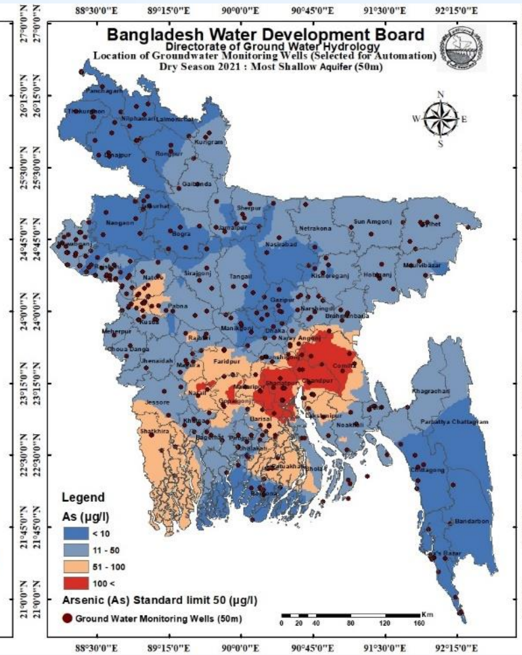
Director (Geology), Ground Water Hydrology, Bangladesh Water Development Board
Adjunct Faculty, Department of Disaster Science and Climate Resilience and
Department of Soil, Water and Environment, University of Dhaka
Adjunct Faculty (Ex.), Department of Geology, University of Dhaka
E-mail: anwarzahidb@gmail.com

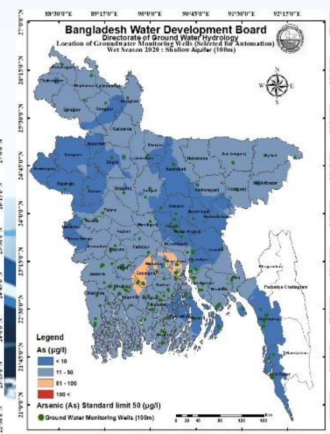
Update of the Arsenic Contamination in Bangladesh

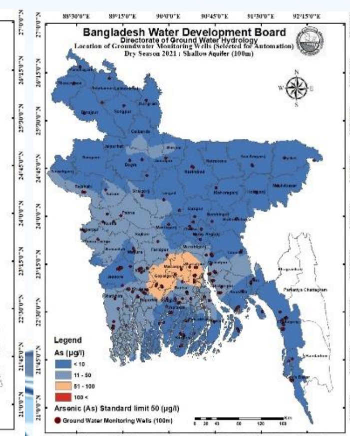


Shallow Groundwater

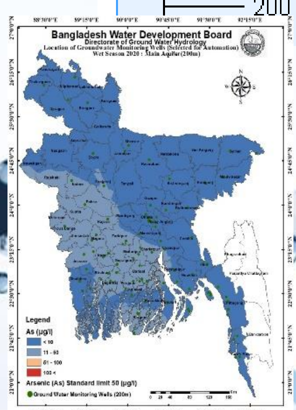


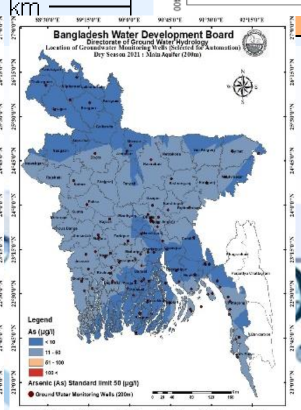


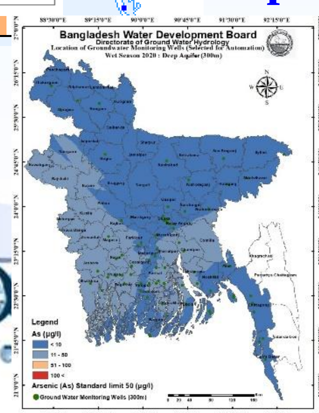


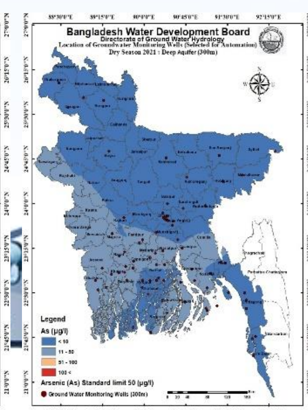


Deep Groundwater







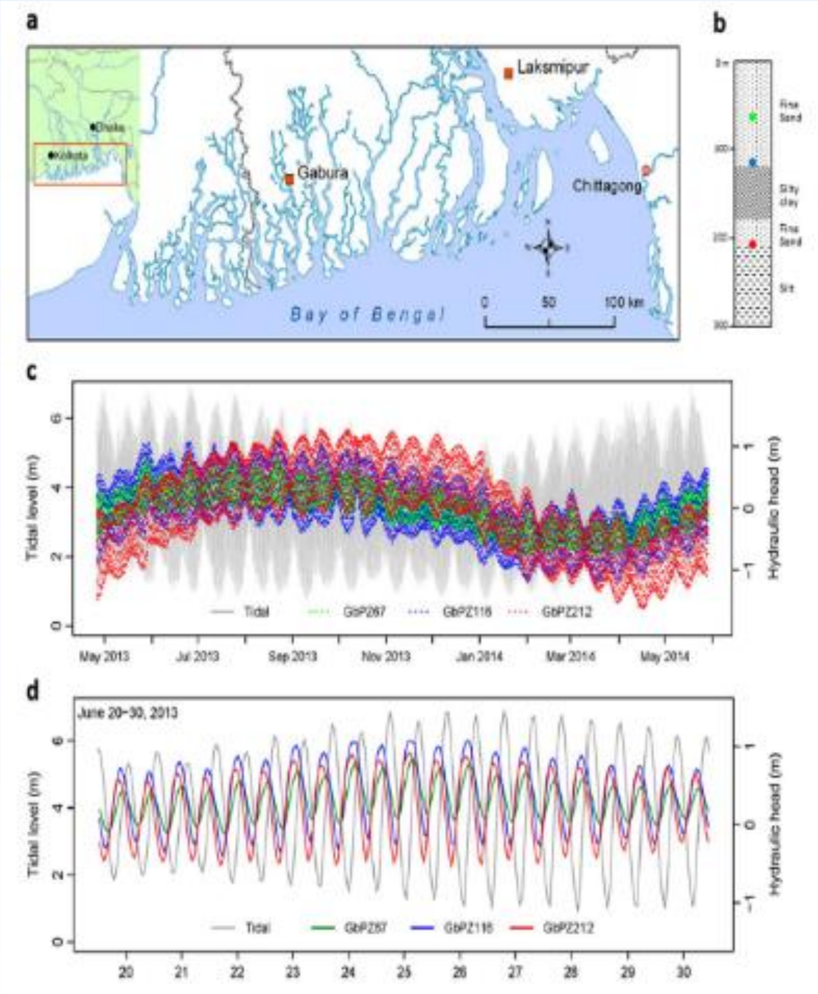


Environ Geochem Health
DOI 10.1007/s10653-008-9226-1

ORIGINAL ARTICLE

Accumulation of iron and arsenic in the Chandina alluvium of the lower delta plain, Southeastern Bangladesh

Anwar Zahid · M. Q. Hassan · G. N. Breit ·
K.-D. Balke · Matthias Flegr



Applied Geochemistry 27 (2012) 2324–2334

Contents lists available at SciVerse ScienceDirect

Applied Geochemistry

journal homepage: www.elsevier.com/locate/apgeochem

Organic carbon mobilization in a Bangladesh aquifer explained by seasonal monsoon-driven storativity changes

Britta Planer-Friedrich[a,*], Cornelia Härtig[a], Heidi Lissner[b], Jörg Steinborn[c], Elke Süß[a,d], M. Qumrul Hassan[e], Anwar Zahid[e,f], Mahmood Alam[e], Broder Merkel[d]

SCIENTIFIC REPORTS

OPEN

Terrestrial water load and groundwater fluctuation in the Bengal Basin

Received: 10 January 2017
Accepted: 17 May 2017
Published online: 20 June 2017

W. G. Burgess[1], M. Shamsudduha[2], R. G. Taylor[3], A. Zahid[4], K. M. Ahmed[5], A. Mukherjee[6], D. J. Lapworth[7] & V. F. Bense[8]

Hydrol. Earth Syst. Sci., 23, 2461–2479, 2019
https://doi.org/10.5194/hess-23-2461-2019

Hydrology and Earth System Sciences
Open Access
EGU

A partially coupled hydro-mechanical analysis of the Bengal Aquifer System under hydrological loading

Nicholas D. Woodman[1,a], William G. Burgess[1], Kazi Matin Ahmed[2], and Anwar Zahid[3]

@gma

(Zahid et al., 2019)

Groundwater Risks Mapping: Based on Storage and Quality including Arsenic Contamination

(Shamsudduha,…Zahid… et. al., 2019)

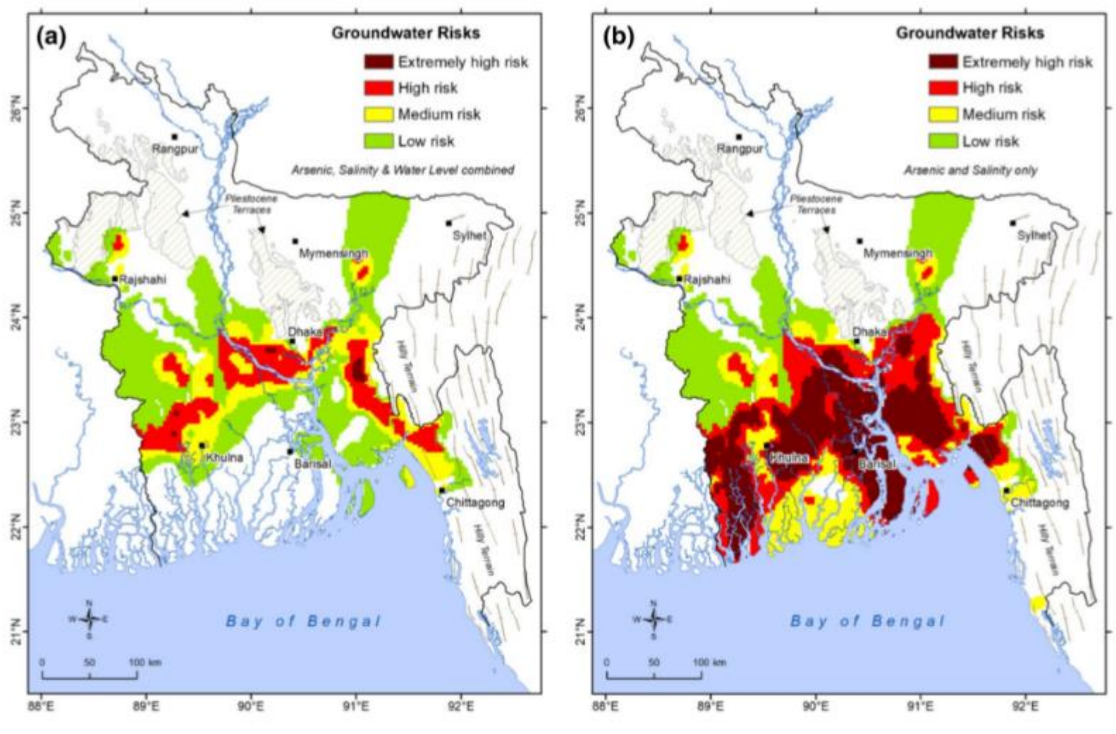


Fig. 4 Groundwater risk maps at the national scale in Bangladesh: **a** groundwater risk map based on model 1 (arsenic, salinity, and dry-season groundwater levels); **b** groundwater risk map based on model 2 (arsenic and salinity only). Both maps show four zones: extremely high, high, medium, and low risks to shallow groundwater based on a combination of two or three parameters above some threshold values described in the method. Maps of higher resolution are provided in the supplementary information

Fig. 3 A national-scale RGB (red–green–blue) color composite map of the three groundwater hazards: storage decline as indicated by the depth to dry-season groundwater levels (red), arsenic concentrations in shallow groundwaters (green), and groundwater salinity hazard as indicated by electrical conductivity (blue). The scale of each side of the triangle represents the range (minimum as 0 to maximum as 100%) of values for each hydrological parameter as shown in Fig. 2

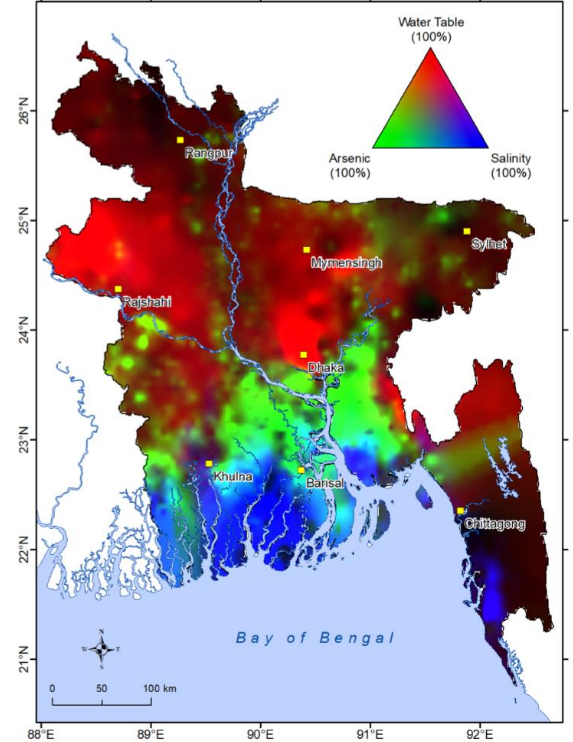
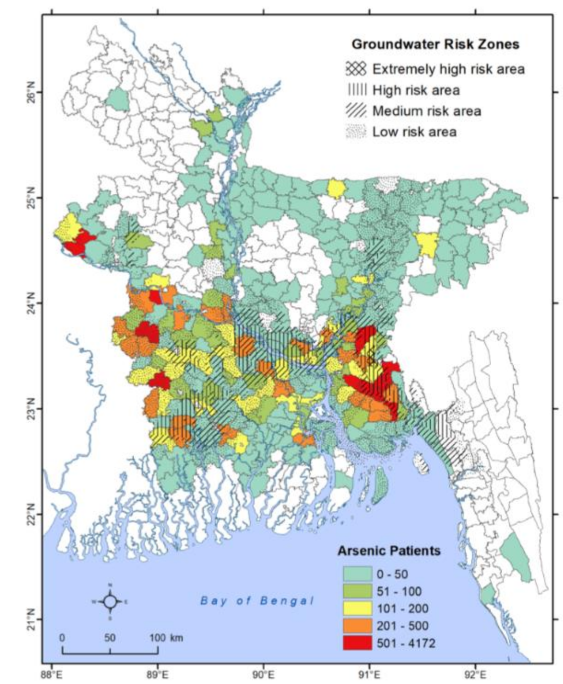
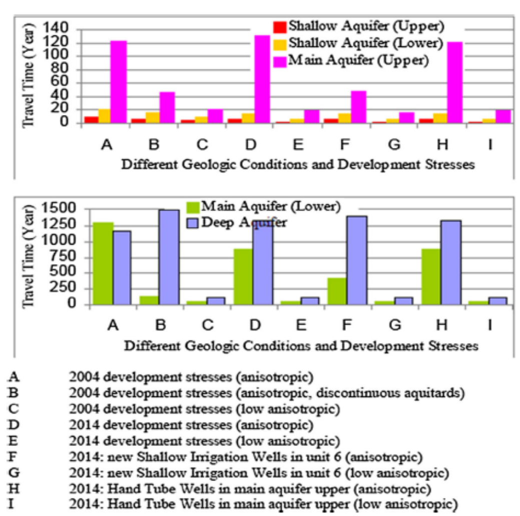


Fig. 5 Groundwater risk map and exposure of arsenic-affected population in Bangladesh. Upazila-wise number of arsenic-affected patients (i.e., cases of skin lesions) are mapped as solid colors and various groundwater risk zones (under model 1) are superimposed to show the spatial association between the two datasets. Upazilas without any reported arsenic-affected patients or data are left blanked (i.e., white)



MODEL TO DETERMINE FLOWPATHS AND TRAVEL TIME OF GROUNDWATER: Current Depth Zone for Irrigation Abstraction Seems Suitable to Mitigate Transport of Arsenic in Deep Groundwater



Environ Earth Sci (2015) 73:979–991
DOI 10.1007/s12665-014-3447-7

ORIGINAL ARTICLE

Simulation of flowpaths and travel time of groundwater through arsenic-contaminated zone in the multi-layered aquifer system of Bengal Basin

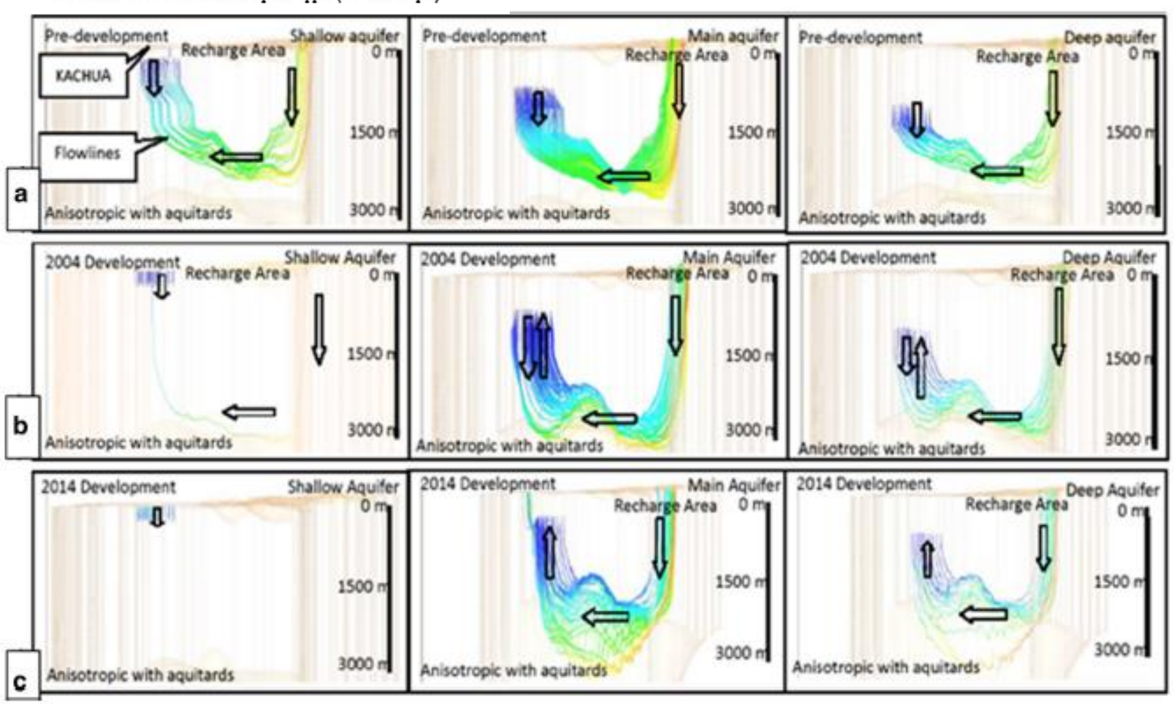
Anwar Zahid · M. Q. Hassan · K. M. U. Ahmed

Sustainable Water Resources Management
https://doi.org/10.1007/s40899-018-0275-z

ORIGINAL ARTICLE

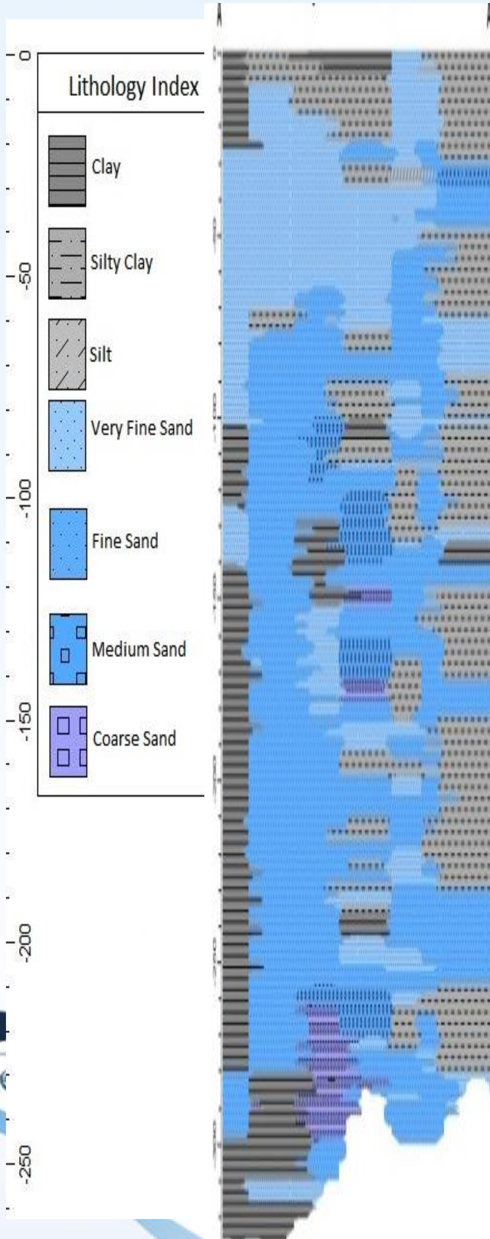
Security of deep groundwater against arsenic contamination in the Bengal Aquifer System: a numerical modeling study in southeast Bangladesh

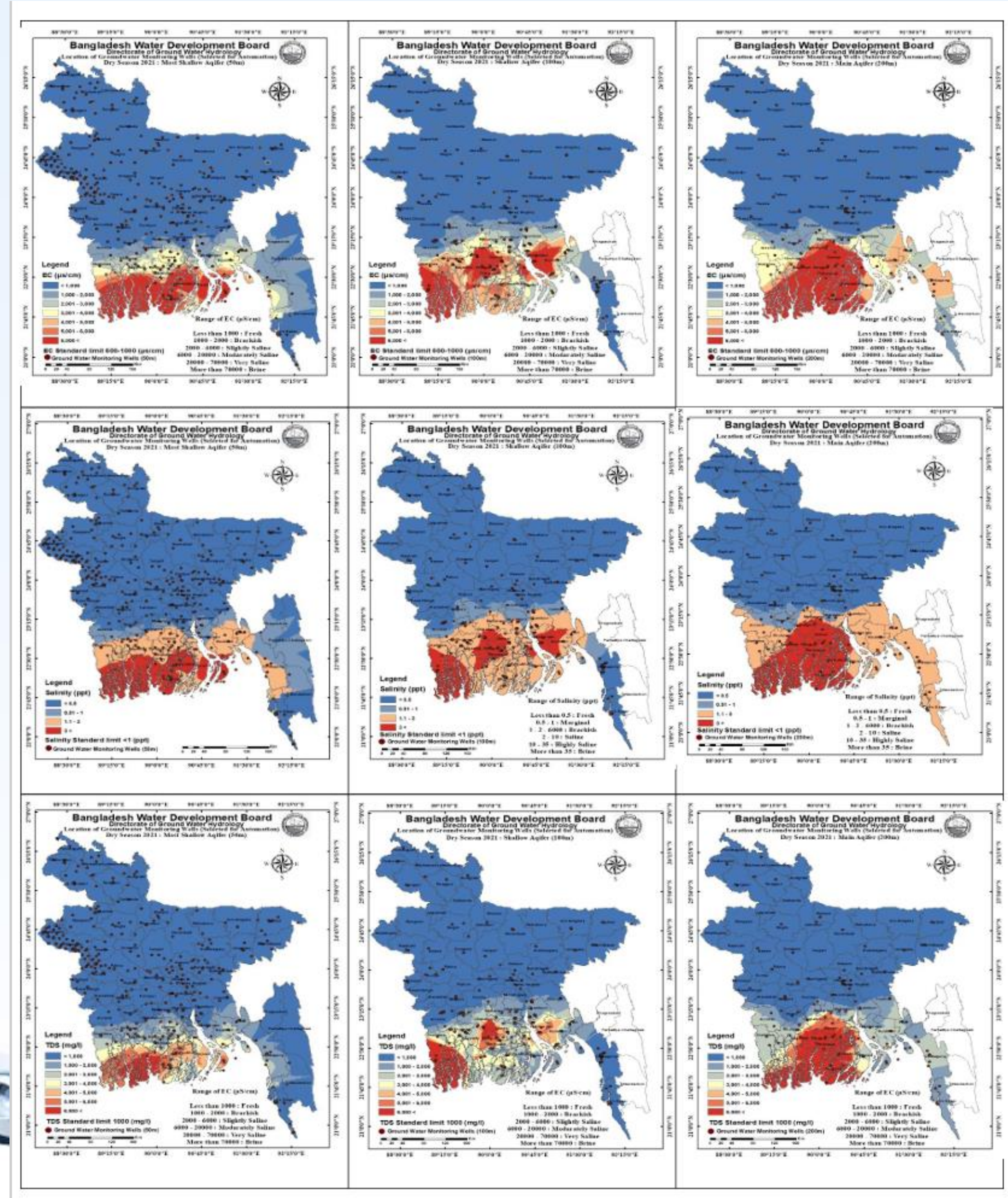
M. Shamsudduha[1] · A. Zahid[2] · W. G. Burgess[3]

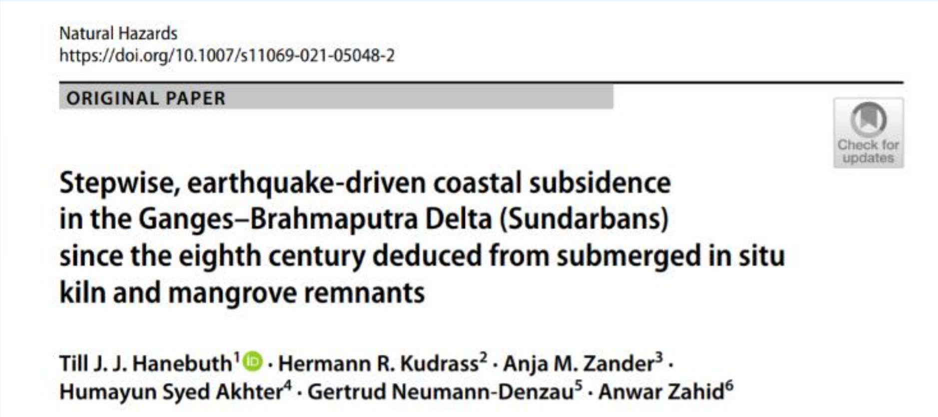


Flow paths and travel time of groundwater are primarily controlled by the hydrogeologic characteristics and the pattern of pumping. Aquifers are recharged by vertical percolation as well as long distance travel of water from highly elevated hilly areas, mainly to deeper aquifers. Under the current trend 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.

Groundwater EC, Salinity and TDS in the Multi-layered Aquifers





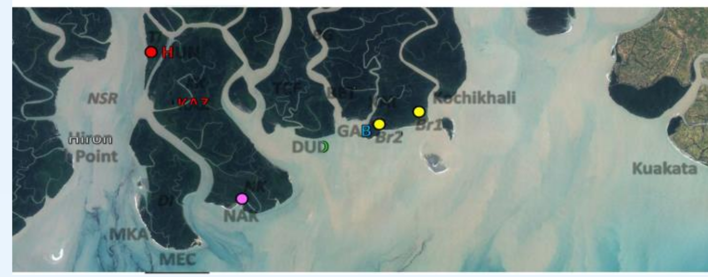

Natural Hazards
https://doi.org/10.1007/s11069-021-05048-2

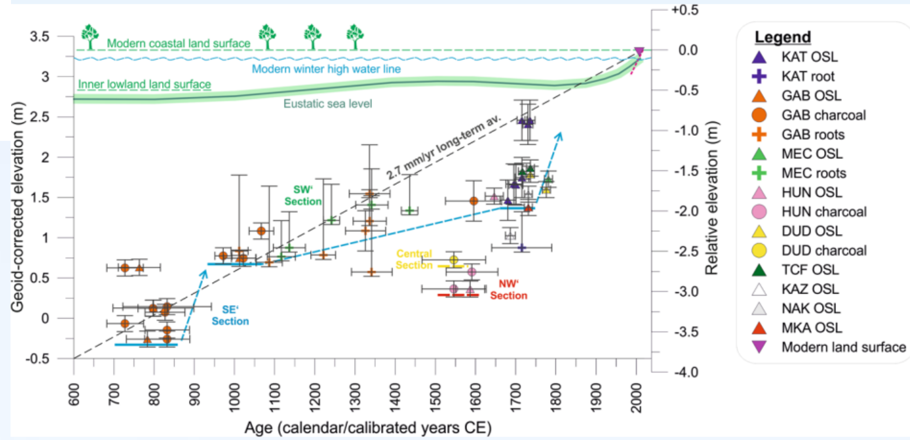
ORIGINAL PAPER

Check for updates

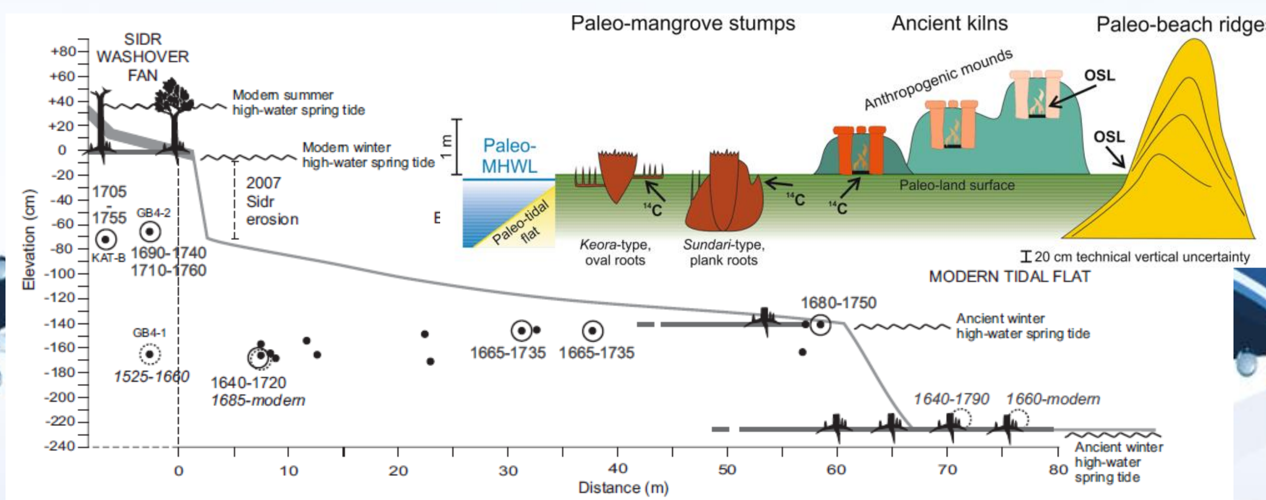
Stepwise, earthquake-driven coastal subsidence in the Ganges–Brahmaputra Delta (Sundarbans) since the eighth century deduced from submerged in situ kiln and mangrove remnants

Till J. J. Hanebuth[1] · Hermann R. Kudrass[2] · Anja M. Zander[3] · Humayun Syed Akhter[4] · Gertrud Neumann-Denzau[5] · Anwar Zahid[6]

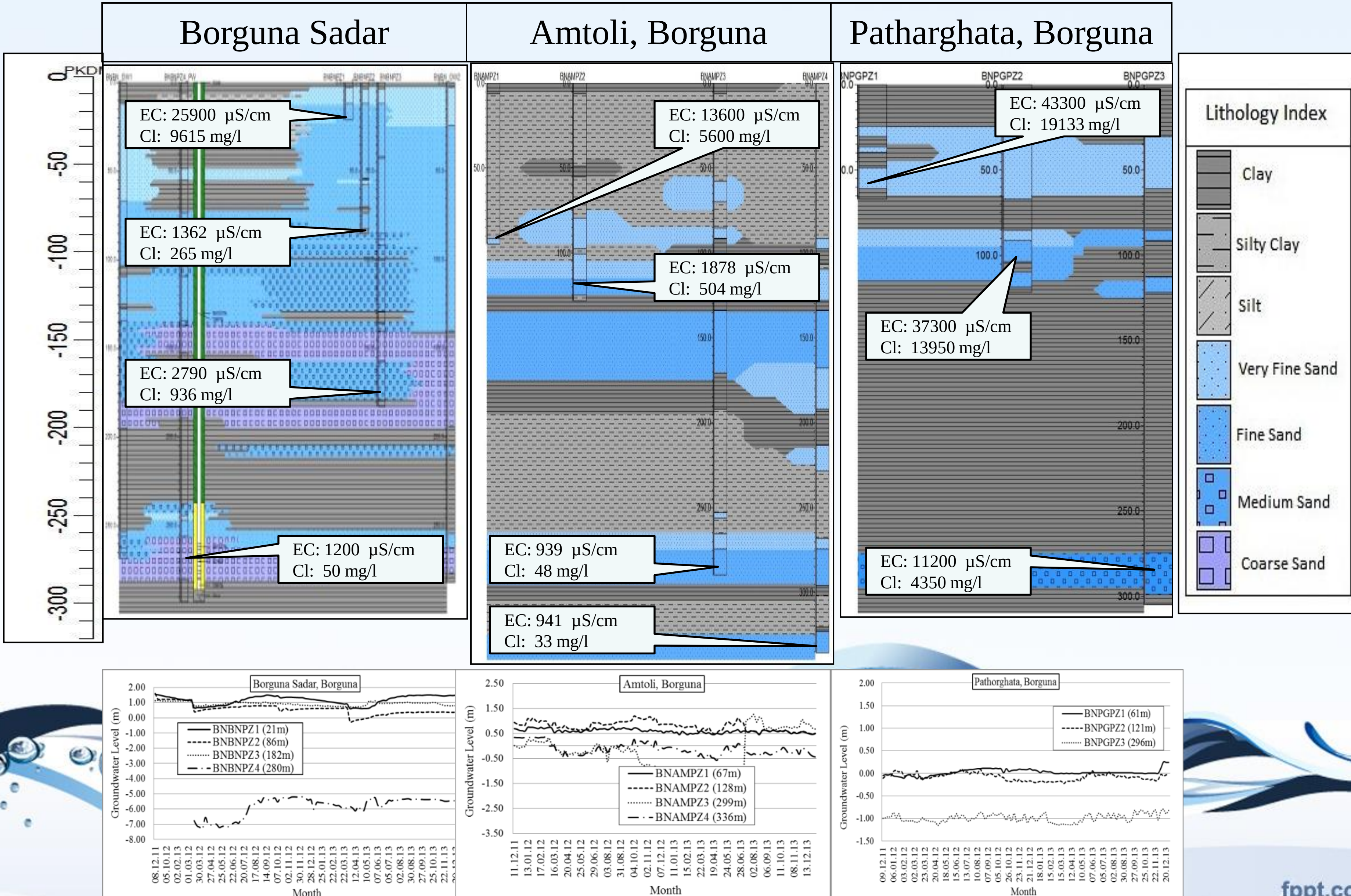


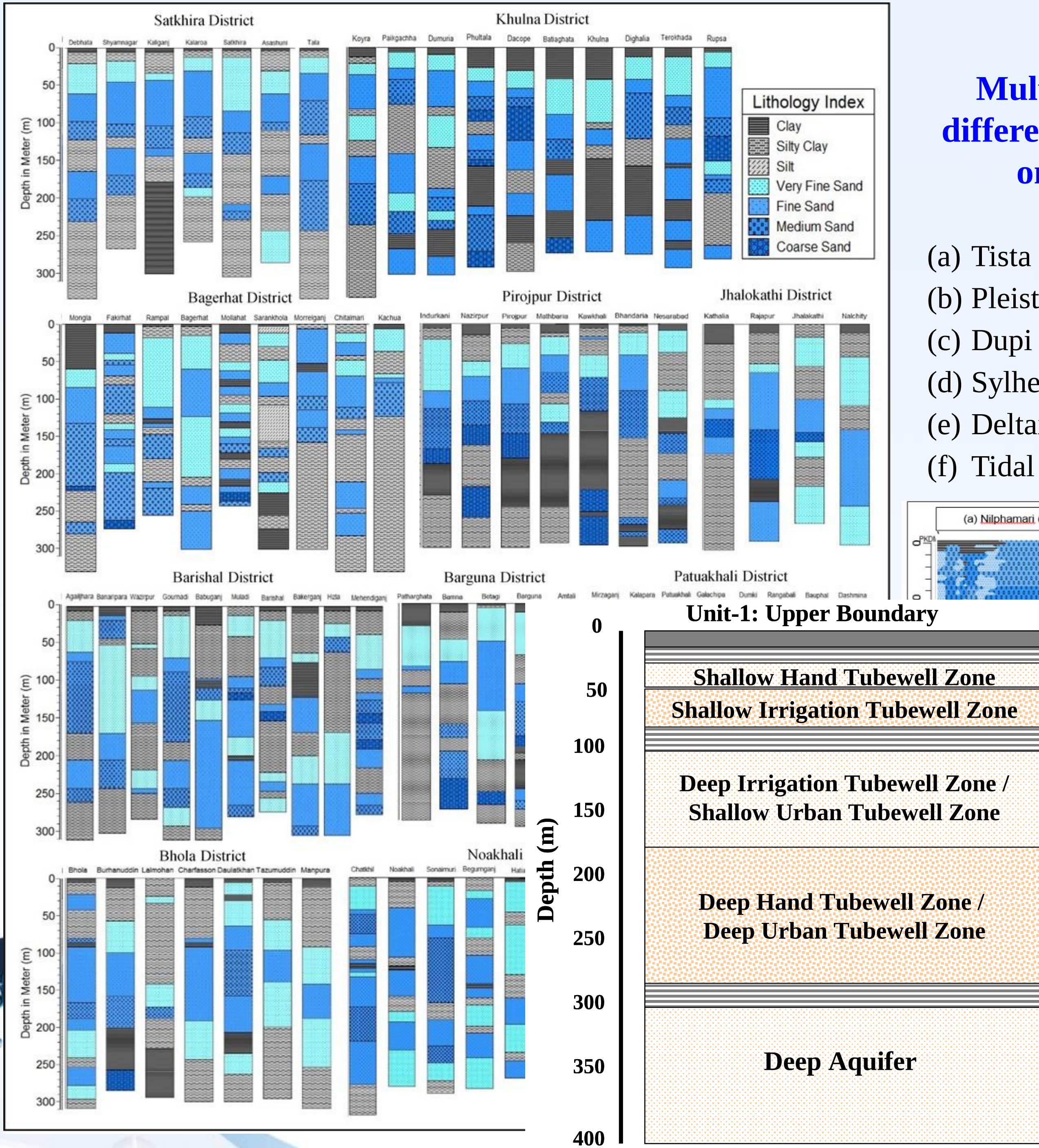


Study reconstructs the coastal subsidence over the past 1300 years in a mangrove region along the coast of the Ganges–Brahmaputra Delta, an area not affected by anthropogenic interference. The relative sea level (RSL) history is based on radiocarbon and luminescence ages measured on 108 submerged kilns and in situ mangrove stumps. While the regional, long-term average subsidence rate is calculated to be 2.7 ± 0.3 mm/yr, modern RSL (including eustacy, isostasy, ocean level, and subsidence) rises by 8.7 ± 0.4 mm/yr. This rate has been balanced by natural sediment accretion so far.



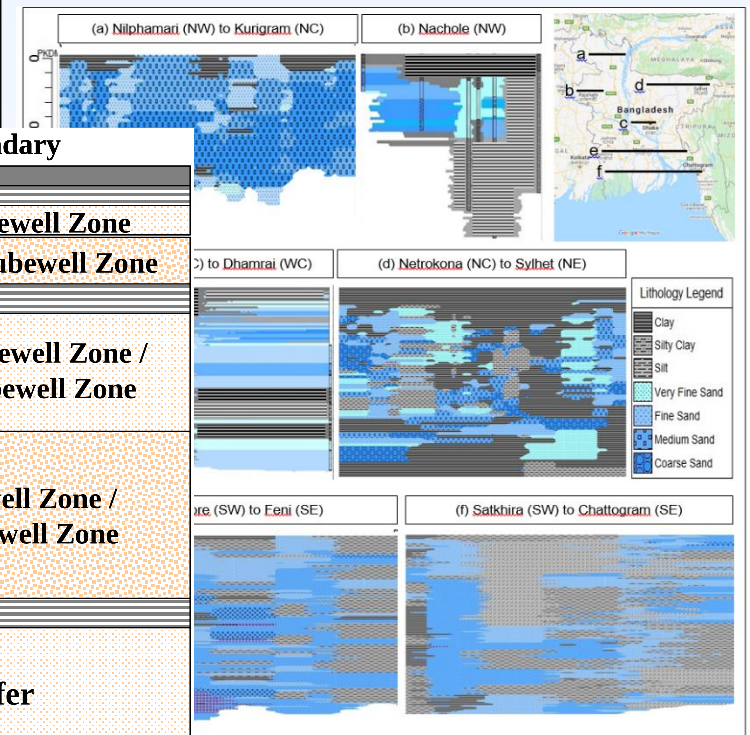
Uncertainty of the Occurrence of Groundwater Salinity in the Coastal Delta due to Complex Hydrogeological Characteristics





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.

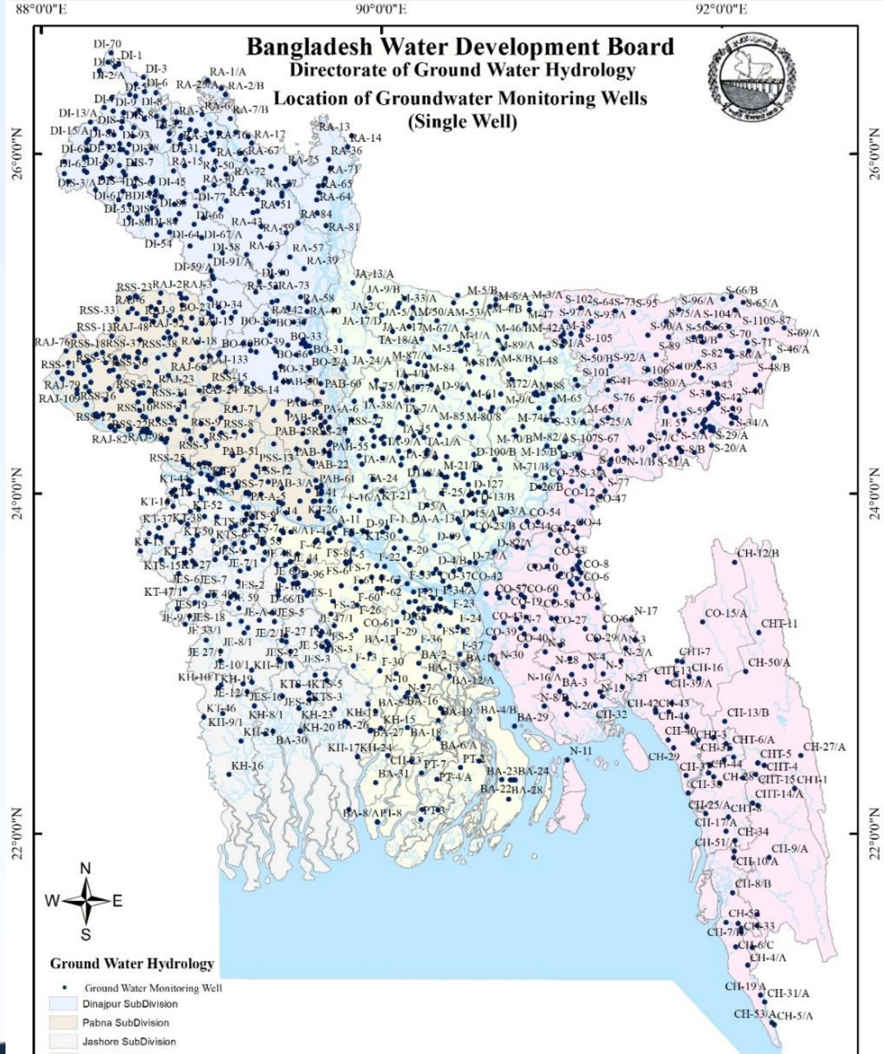


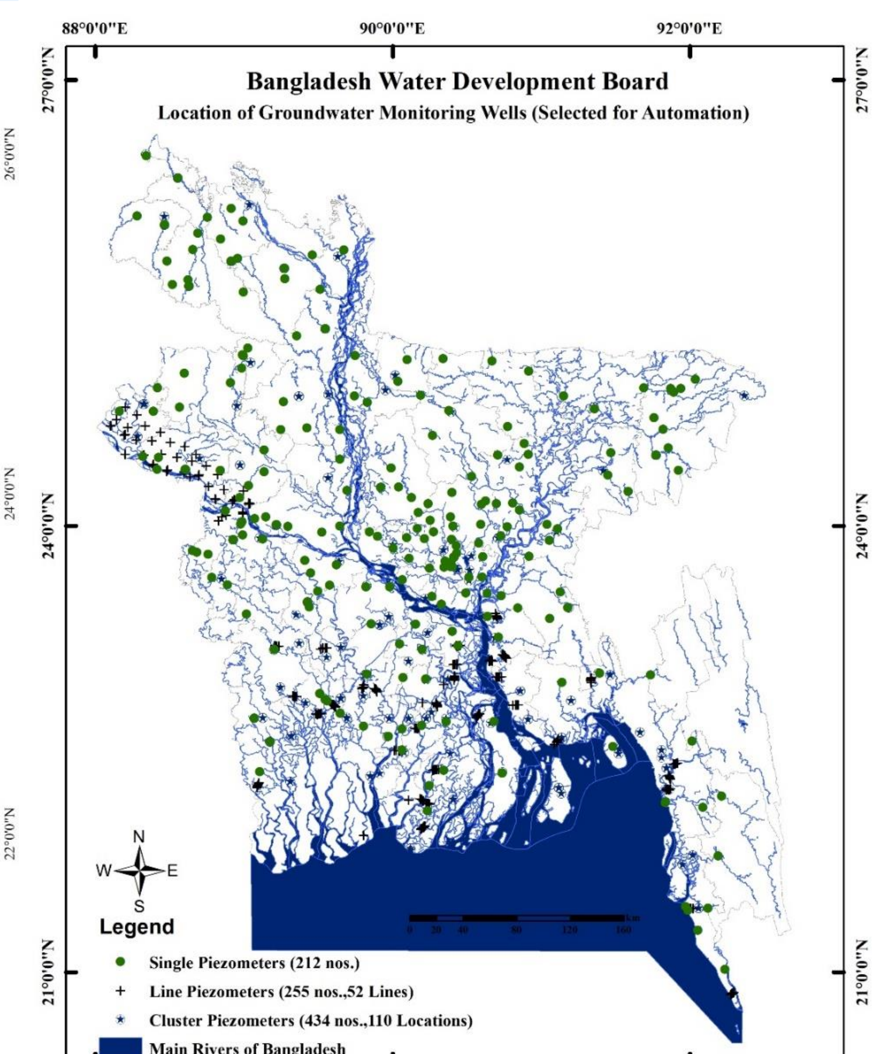
Monitoring of Groundwater Level

- 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

Groundwater Monitoring Wells of BWDB and Recent Automation



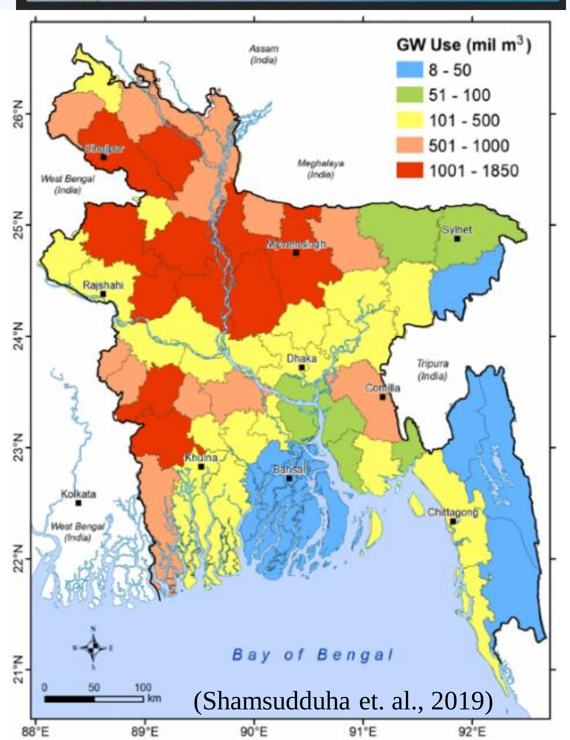


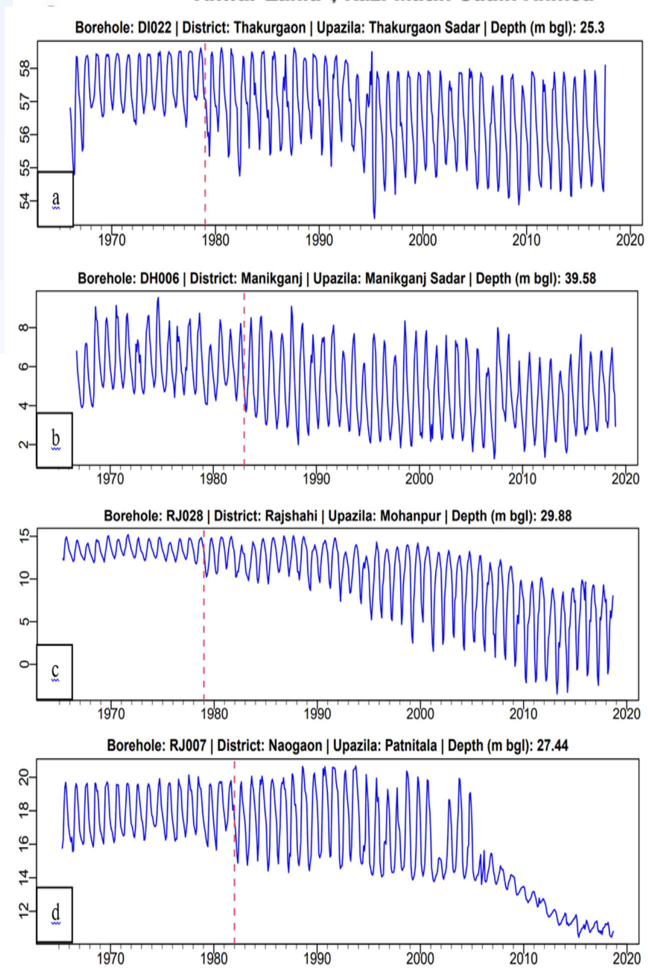
RESEARCH

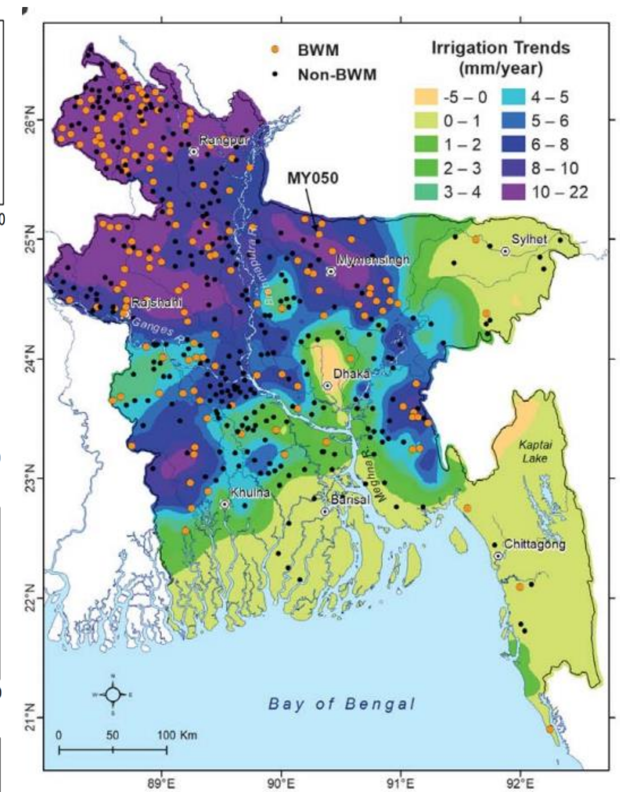
GROUNDWATER

The Bengal Water Machine: Quantified freshwater capture in Bangladesh

Mohammad Shamsudduha[1,2]*, Richard G. Taylor[3], Md Izazul Haq[3,4], Sara Nowreen[5], Anwar Zahid[6], Kazi Matin Uddin Ahmed[7]







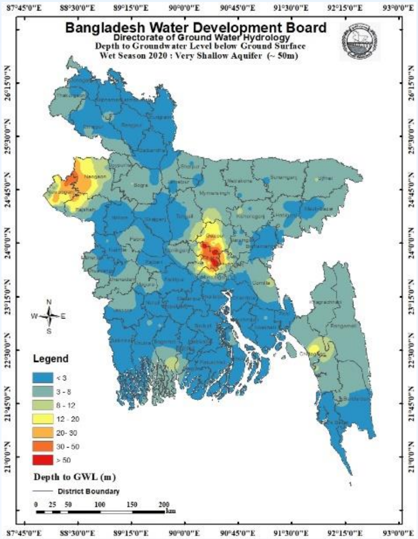
ation trends in Bangladesh. (**A**) High-resolution datasets, published by Copernicus Global Land the northwest of Bangladesh, where groundwater irrigation dominates. (**B**) Mapped trends (1985 to 2019) in groundwater-fed irrigation for dry-season crop cultivation in Bangladesh (supplementary text, section S1.2) and locations of 465 boreholes plotted in orange (BWM) and black (non-BWM) solid circles.

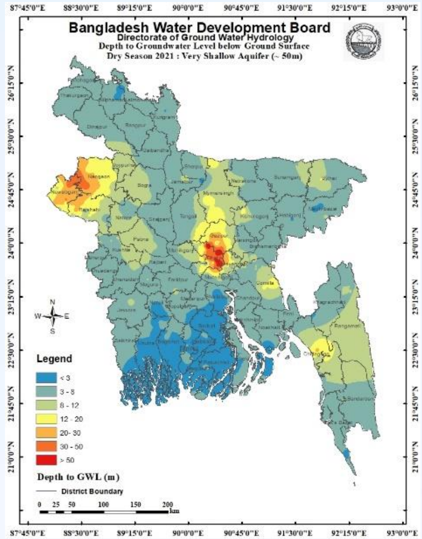
Salient Features of the Analysis

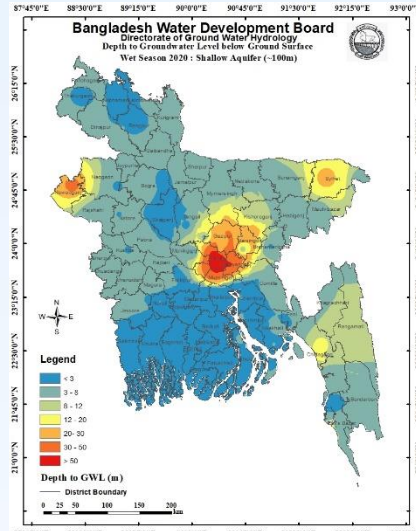
- Incremental increases in dry-season groundwater pumping for irrigation lower groundwater levels and enhance leakage under gravity of surface water from rivers, ponds and canals during the subsequent monsoon. This broad set of recharge pathways induced by dry-season groundwater pumping are described as ‘The Bengal Water Machine’ or BWM.
- This nature-based solution to seasonal freshwater storage capture, showing that the collective operation of ~16 million smallholder farmers in Bangladesh from 1988 to 2018 has induced cumulative freshwater capture of between 75 and 90 cubic kilometres.
- However, the research also highlights limitations to the operation of the BWM in areas where induced monsoonal recharge is insufficient to fully replenish groundwater abstracted during the dry season, depleting groundwater storage and rendering groundwater inaccessible to households reliant on shallow wells. Amongst 465 monitoring well locations, about two-third show non-functionality of the BWM.
- Therefore, it is vital to assess the suitability of locations for the operation of the BWM in order to maximise benefits to farmers and minimise the risks of groundwater depletion. The importance of long-term hydrological monitoring to assess the status and trends of country's groundwater resources are highlighted.

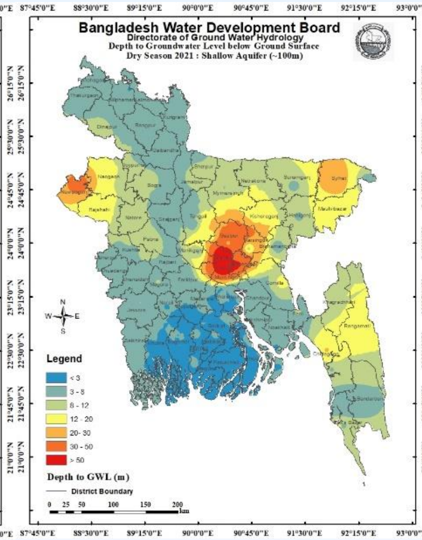
Depthwise Monitoring of Groundwater Levels in Multi-layered Aquifers

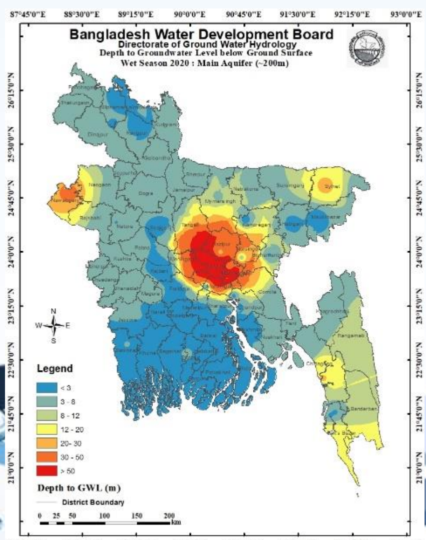
(about 50, 100, 200 and 325 m depths)

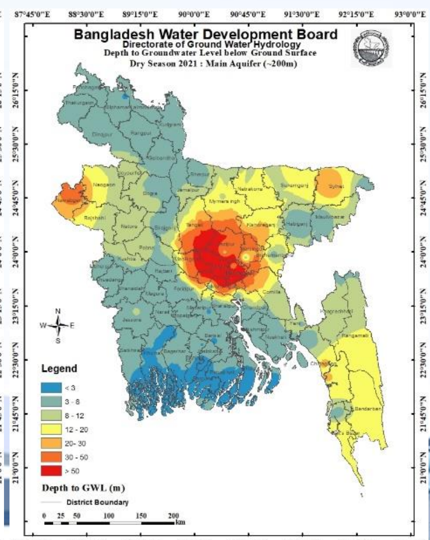


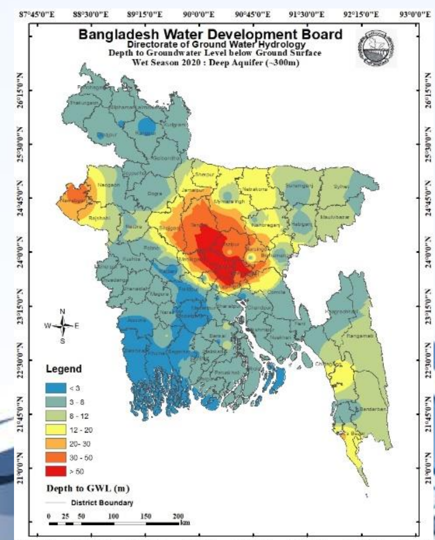


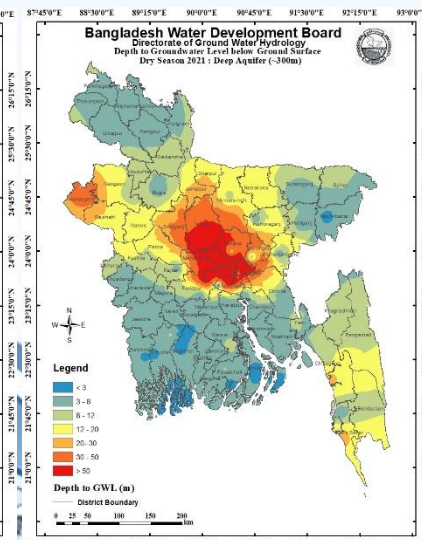












Need for Integrated Water Resource Management (IWRM)

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

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.

Mapping of Managed Aquifer Recharge Potential and Recharge Technologies For Enhancing Storage of Groundwater

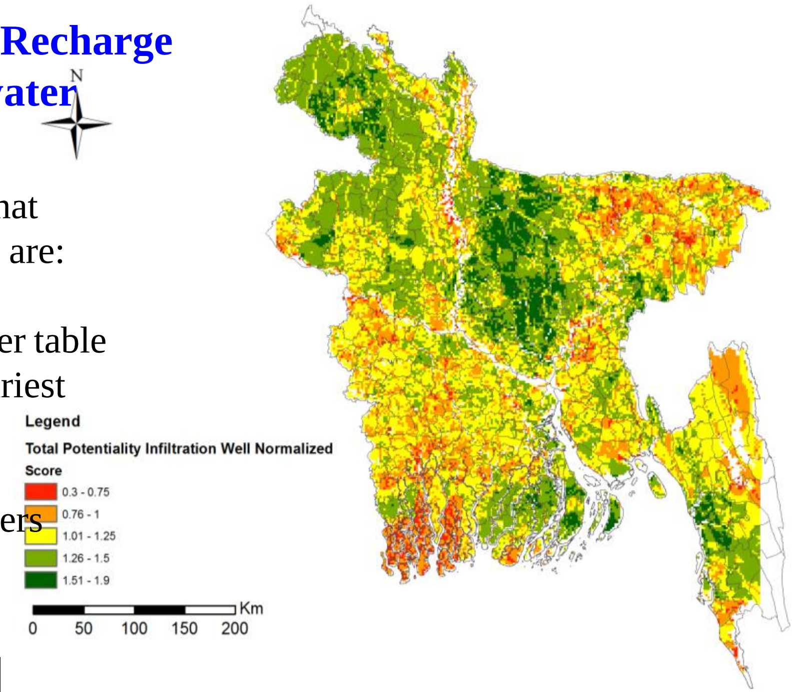
(Marta, Zahid et. al., 2019)

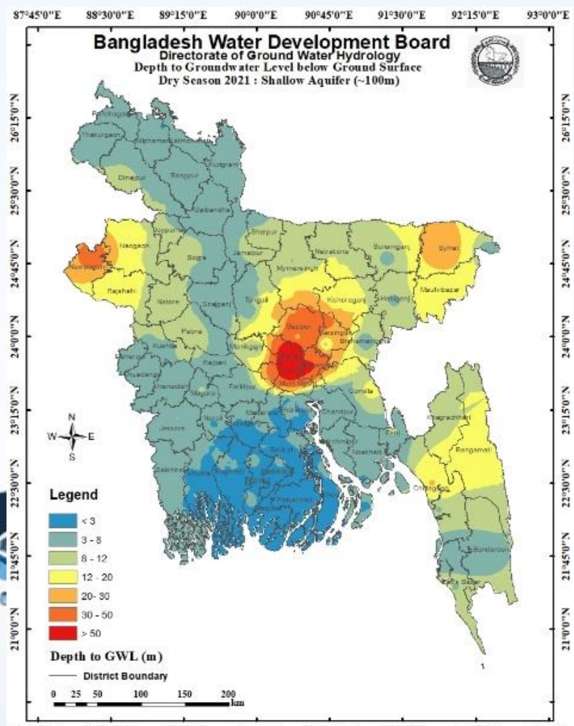
The identified variables that define the **Physical Potential** are:

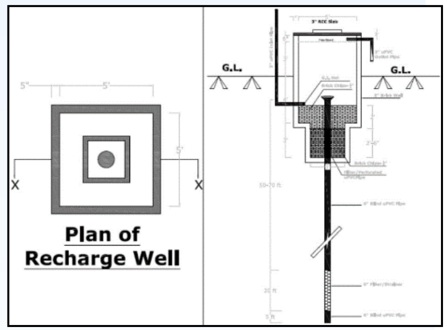
- Precipitation intensity and duration
- Evaporation loss
- Surface geology
- Thickness of the aquitard
- Groundwater depth below the surfacein the middle of the Monsoon (June)
- Wells contaminated with Arsenic
- Inundation land type

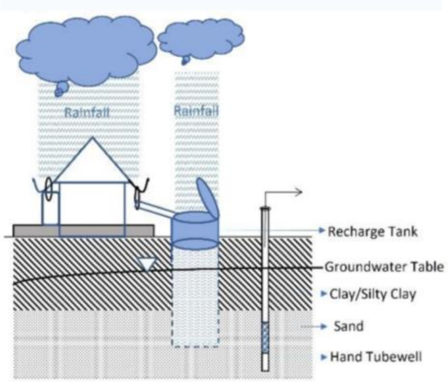
The identified variables that define **Demand Urgency** are:

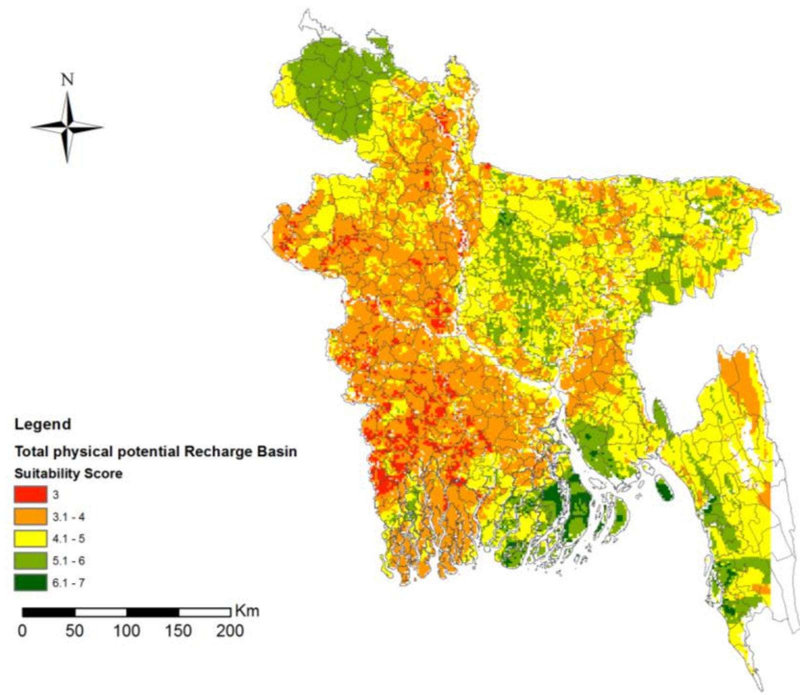
- Population density
- Depth of the groundwater table below the surface at the driest month (April)
- Poverty
- Absence of perennial rivers close by
- Irrigation demand



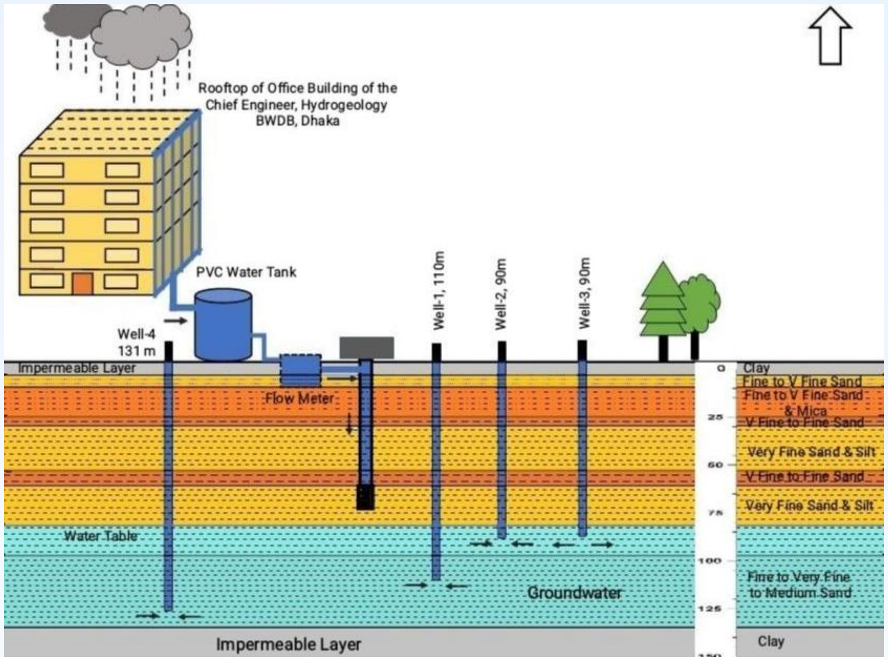








MAR (Infiltration/Recharge Well) Piloted by GWH, BWDB



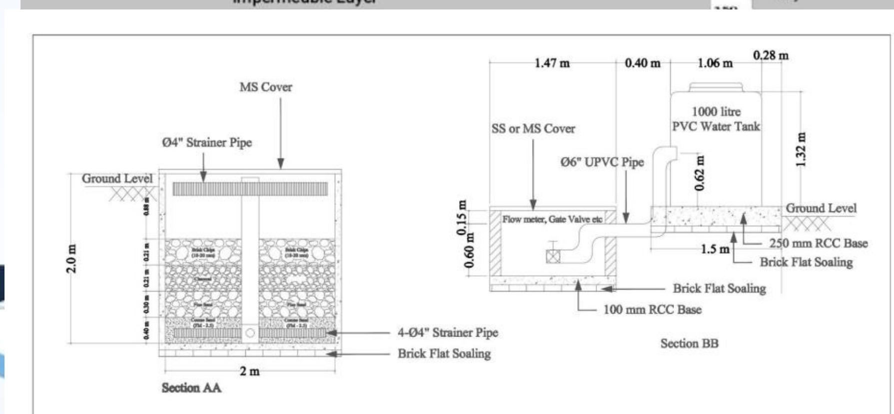


Figure: Managed Piloting Aquifer Recharge.

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

- 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.
- Isotope techniques can be used to investigate and assess groundwater resources potential towards sustainable development and management of water resources.

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




THANKS