Study on Abstraction-Induced Recharge as an Adaptation Response to Climate Variation for Shallow Aquifer in Bangladesh

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Abstract

The significance of groundwater is likely to grow in the coming years because of the need to mitigate the negative consequences of climate change. Adaptive capacity becomes important as more frequent and intense rainfall variability would quickly increase the possibility of large reduction in the amount of sustainable surface water supplies while aquifers will be affected considerably more slowly by anticipated climate change. On the other hand, the combined effects of population growth, irrigation demand, and climate change will continue to put pressure on the groundwater resource in the future. Against this backdrop, the abstraction-induced recharge (AI-R) concept should be regarded as a future adaptation option for some likely sites in Bangladesh to solve unmet water concerns. The inherent concept of the AI-R is that the sub-surface storage can rapidly be filled during the wet season and consume during the following dry season. Variable thickness in subsurface geology, aquifer system and inconsistent response to monsoon rainfall as well as flooding made Bangladesh incompatible for large basin wide AI-R concept. As a result, this research thoroughly observed the reaction to rainfall events, aquifer condition, historical water level and other factors in two case studies that have the potential to be used in AI-R operations. High-resolution (hourly) in-situ recordings of co-located groundwater level and rainfall data are compared to low-frequency (daily rainfall and weekly groundwater level) observations in this study. Historical groundwater conditions, as well as rapid groundwater response to both diffuse and concentrated recharge, were found to be favorable to AI-R at one place (Bhuapur, Ishwarganj). Nearby ponds which store huge monsoon water and have low aquitard thickness can play potential role in induced recharge in this place. On the other place (Bochaganj, Dinajpur), groundwater response to rainfall is complicated and groundwater level shows decreasing trend in recent years which can get worsen if AI-R concept is implemented here. So, this type of fine resolution field inquiry is at the very least need to be observed on possible AI-R piloting locations. Multi-isotope studies are also advised for assessing long-term effects.

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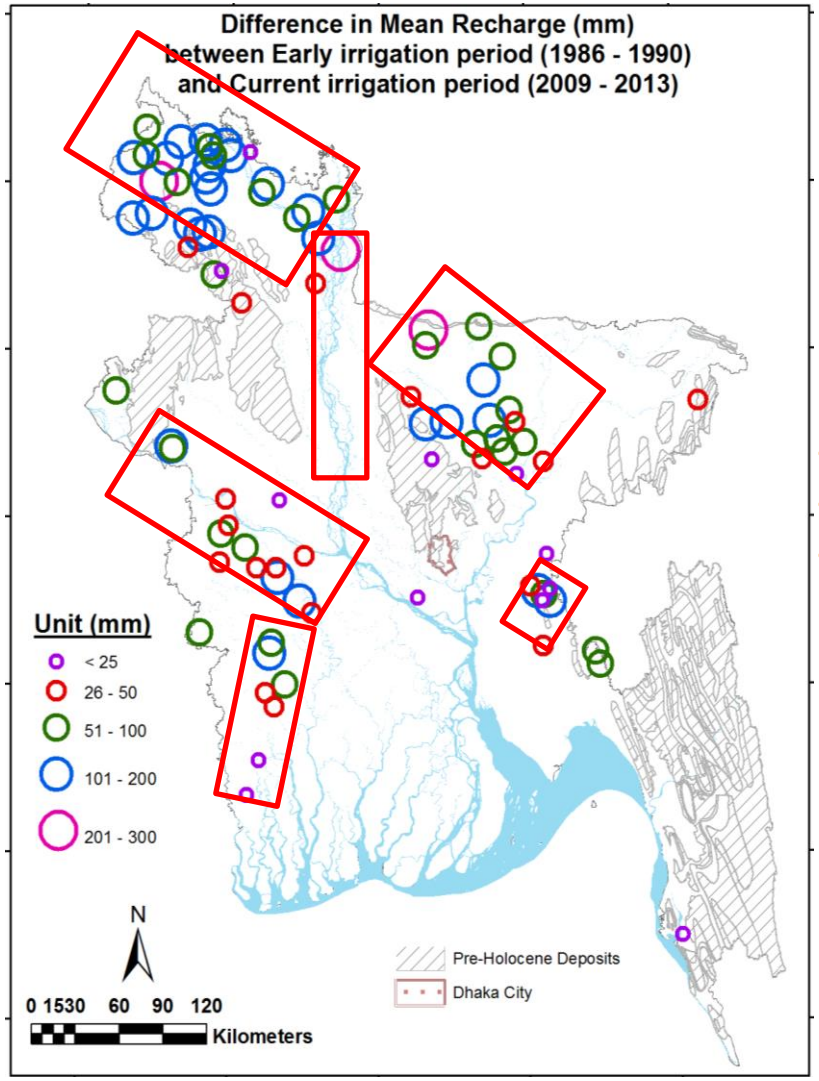
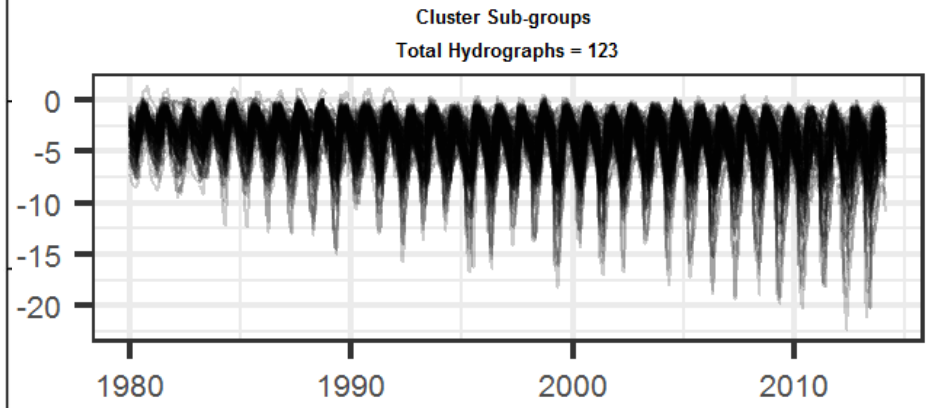
Presentation Outline

1. Abstraction Induced Recharge (AI-R)
2. Study Area
3. Methodology
4. Lithological Information
5. Climatic Observation
6. GWL Responses
7. Key Findings

Abstraction Induced Recharge



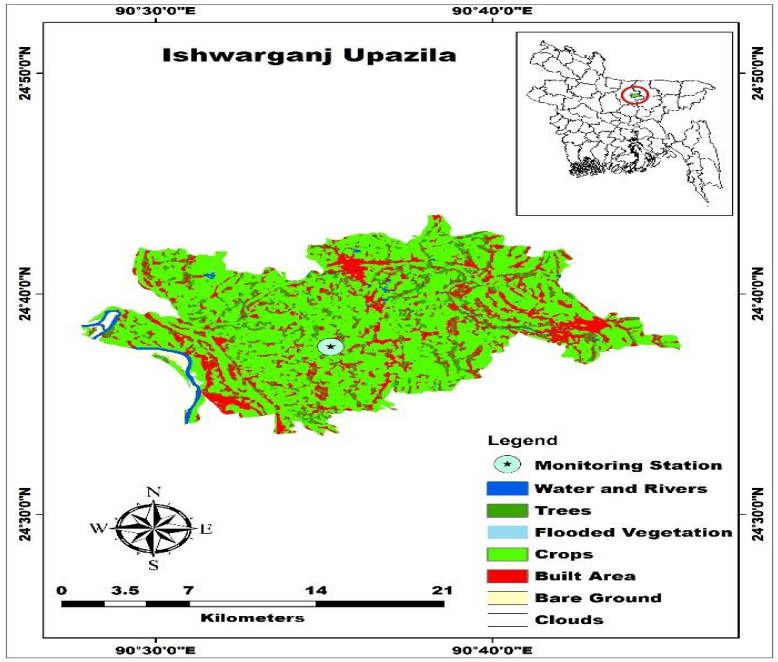


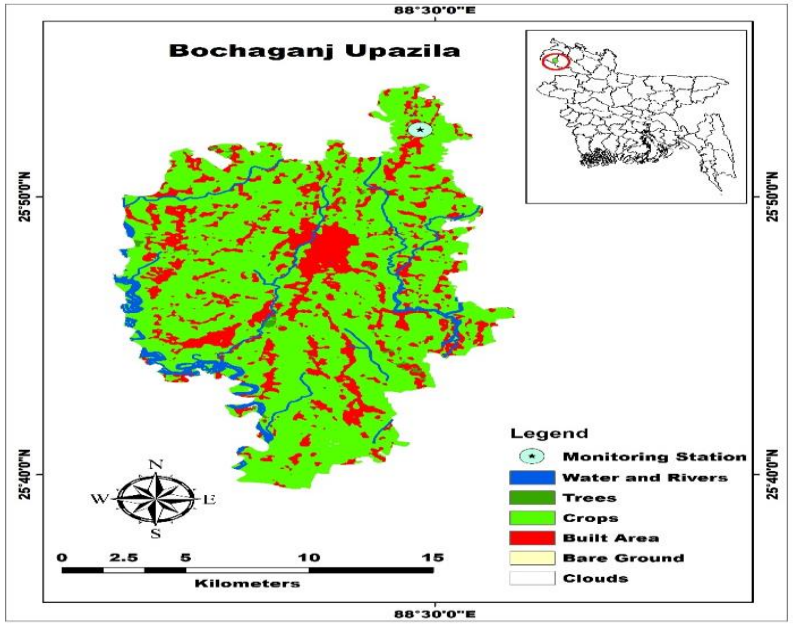
Bangladesh

Brief Description of Study Area

Types	Description	Types	Description
Study Area	Ishwarganj, Mymensingh	**Study Area**	Bochaganj, Dinajpur
Area	280.43 sq km	**Area**	224.81 sq km
Latitude and Longitude	Between 24°33′ and 24°34′ north latitudes and in between 90°28' and 90°46' east longitudes	**Latitude and Longitude**	Between 25°10' and 26°00' north latitudes and in between 88°30' and 99°10' east longitudes
Hydrological Region	North Central (NC)	**Hydrological Region**	North Western (NW)
Physiographic Zone	Old Brahmaputra Floodplain	**Physiographic Zone**	Part of Barind Tract and old Tista Floodplain
Nearest River	Old Brahmaputra	**Nearest River**	Tangon

Map of The Study Area





Methodology

- Selection of the study area

- In situ Observations (2019-2020)
  -In-situ high resolution measurements of GWLs and rainfall
  - a (pressure type) GWL logger and a tipping-bucket rain-gauge

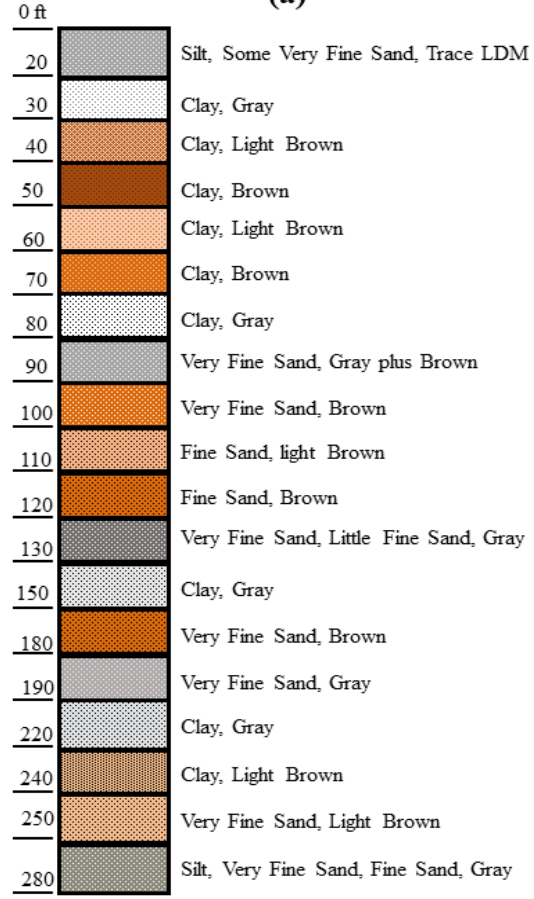
- Historical Data Analysis
  - Rainfall (1993-2020) from BMD
  - GWL (1980-2020) from BWDB
  - Spatial and Temporal variations of these data were examined by using 'R' Language

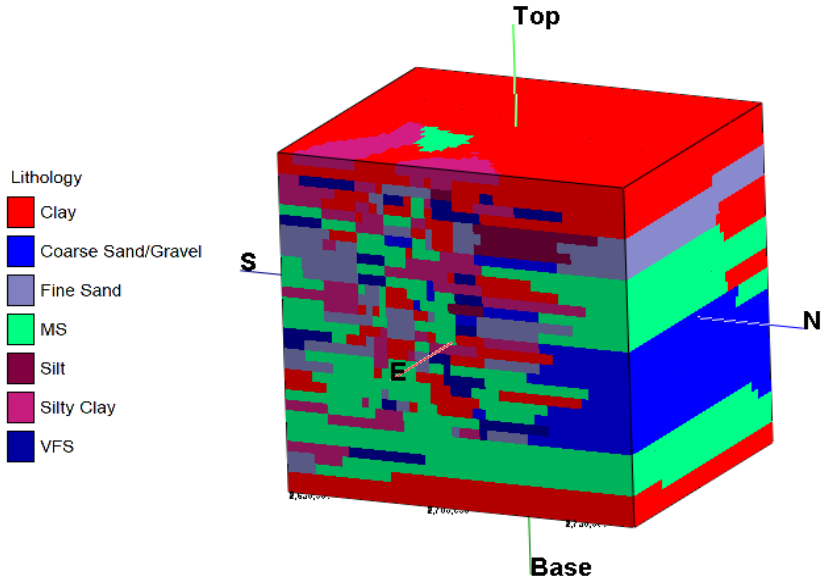
- Spatial Geophysical and Hydrological Investigations
  - The sub-surface geology was studied up to the depth of 100 m
  - Bore log information, pumping test data, soil texture data were analyzed using Rockworks

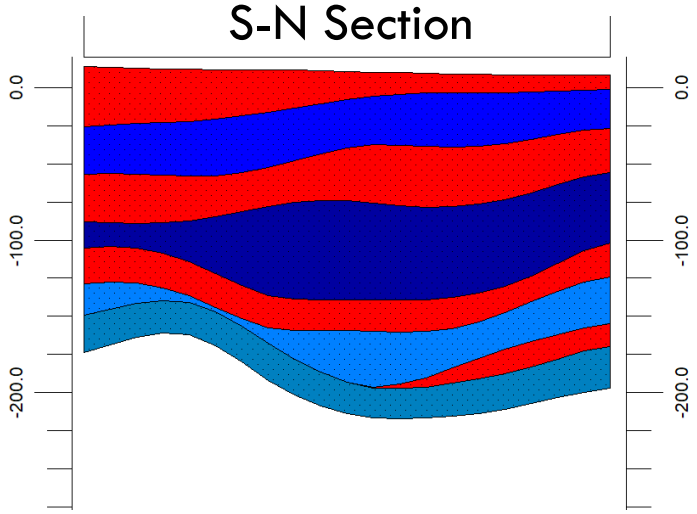
Data loggers that are set at piezometer and Rain Gauge

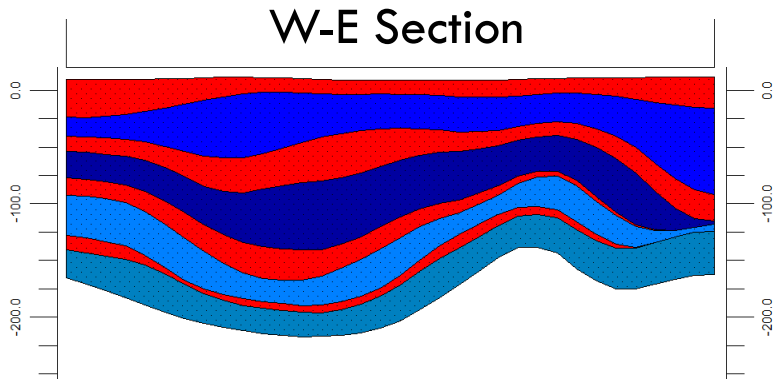
Lithological Information (Ishwarganj)

- The lithology is mostly quite heterogeneous with altering clay and sand
- 20 to 80ft of surface clays overlying uniform medium to coarse sands
- average depth range of aquifer is 40ft and ranges varies 90 to 130ft
- Absence or a thin top aquitard layer in some places at Ishwarganj indicates the presence of an aquifer very close to the ground.





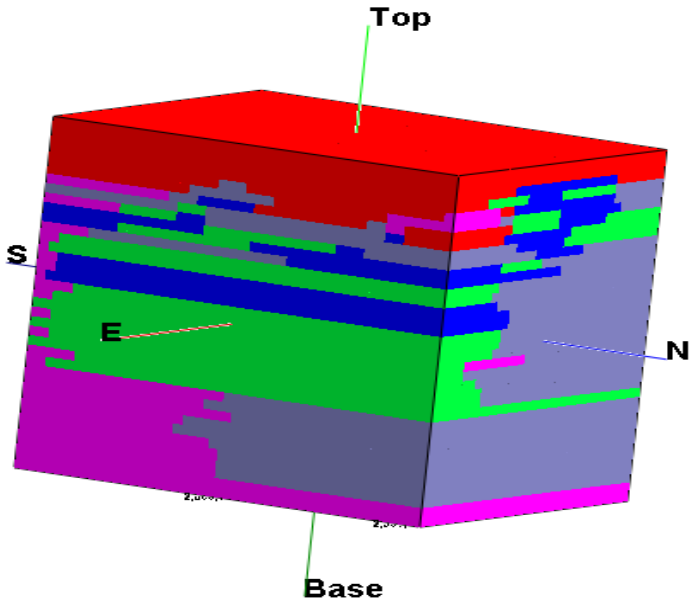


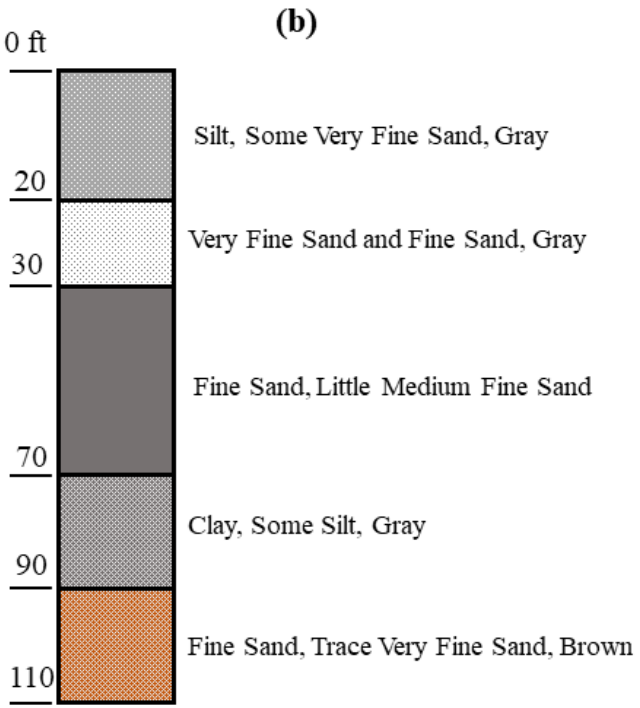


Red- aquitard layers, Blue- Aquifer layers

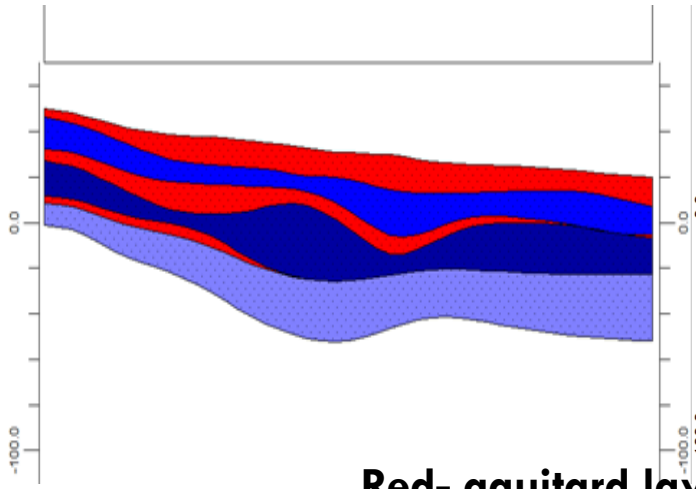
Lithological Information (Bochaganj)

- Depth range of aquifer is 50ft with ranges varying between 20 and 70ft
- Aquifer is mainly unconfined which locally varies and best characterized as regionally semiconfined.
- the main aquifer is underlain by few closely alternating aquifer and aquitard layers at lesser depths.

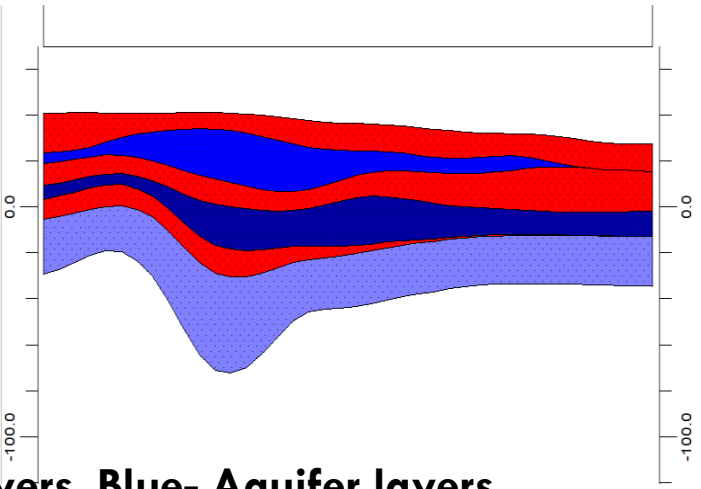




S-N Section



W-E Section



Red- aquitard layers, Blue- Aquifer layers

Climatic Observations(Ishwarganj)

BMD Station (1980-2020):

1-day maximum rainfall (RX1) - 508 mm

5-day maximum (RX5) rainfall- 640 mm

In-situ recorded data (2019-2020):

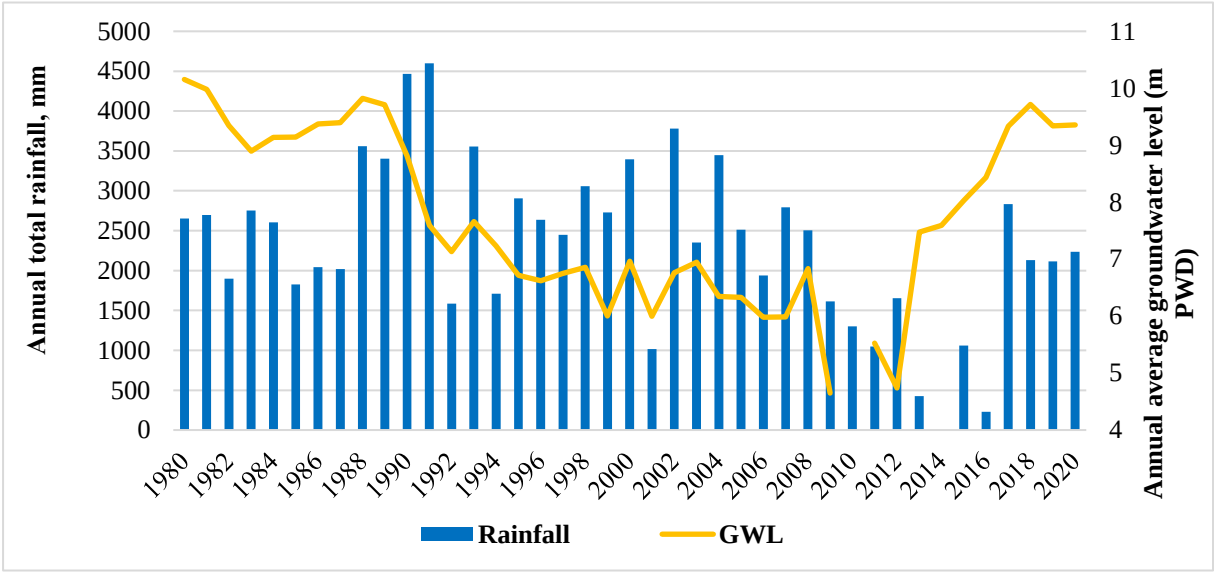
1-day maximum rainfall (RX1) -133.5 mm

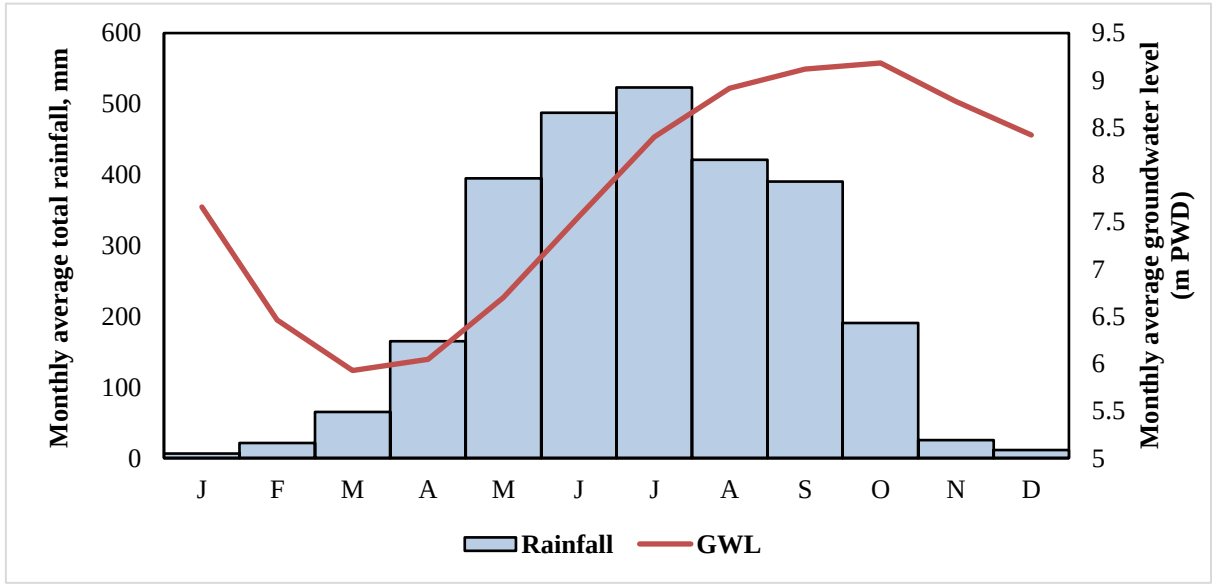
5-day maximum rainfall (RX5)- 262.5 mm.

Average annual fluctuation of GWL 4.16 m with a range varying from 1.15 to 7.28 m.

Average GWLs and annual total rainfall increases after 2012 till date

- Lowest GWL- March
- Highest GWL- October





Climatic Observations (Bochaganj)

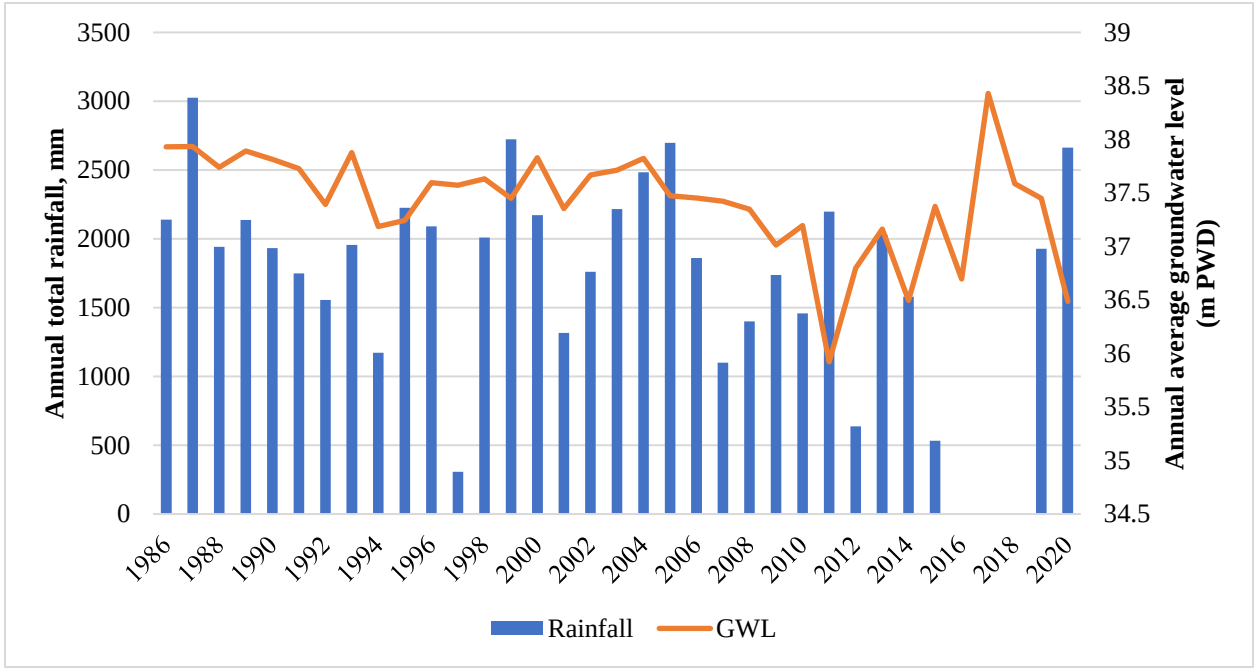
BMD Station (1986-2020):
1-day maximum rainfall (RX1) - 260 mm
5-day maximum (RX5) rainfall- 293 mm

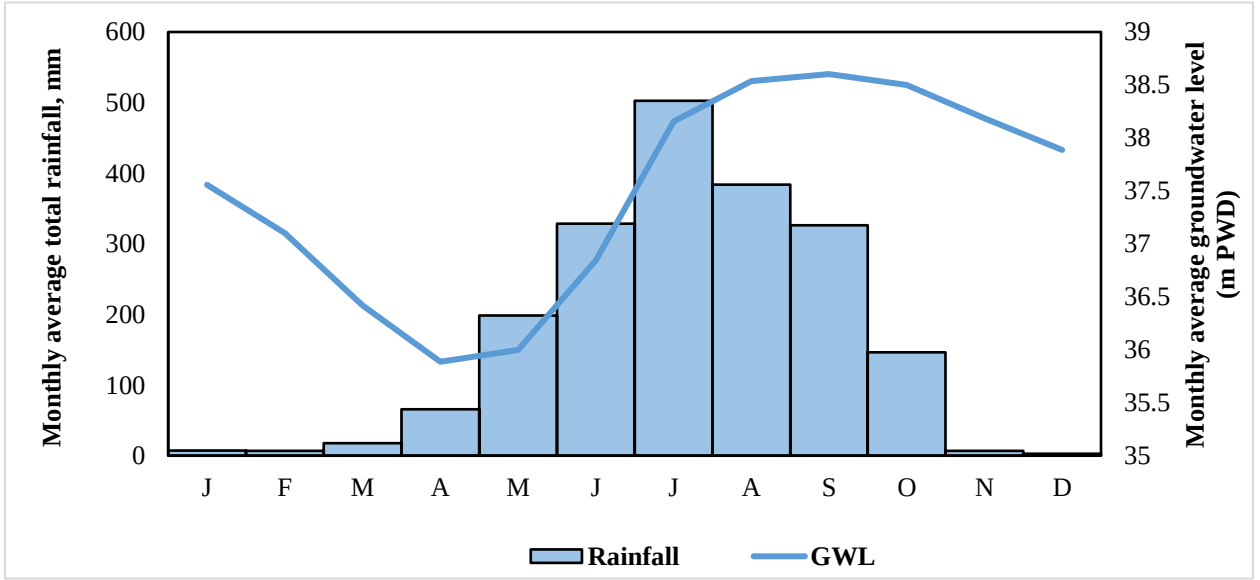
In-situ recorded data (2019-2020):
1-day maximum rainfall (RX1) -121.5 mm
5-day maximum rainfall (RX5)- 235.7 mm

500 mm is the highest monthly average rainfall

Average GWL decreases after 2018 though annual rainfall increases

- Lowest GWL- April
- Highest GWL- September





GWL Response (Ishwarganj)

Analysis of Water Level

Rainfall ~148 mm occurred on the 1st of July in 2019

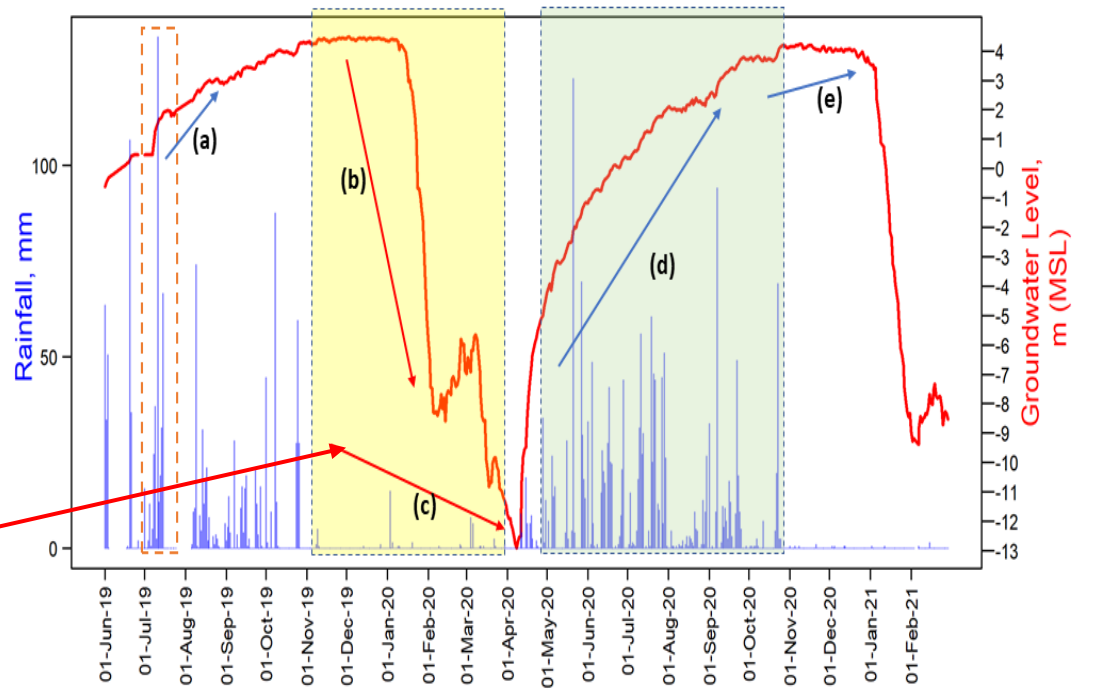
Declined furthest depth on 20th April 2020 up to 13m MSL

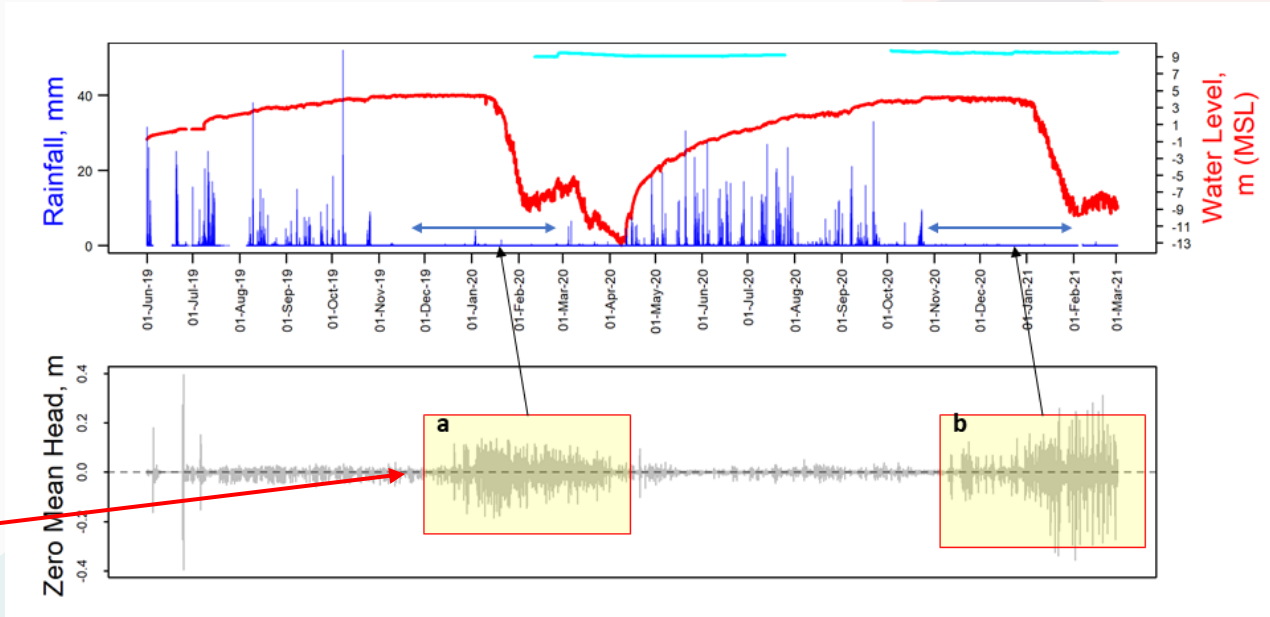
GWL has reached the top saturated condition till 1st January 2021

at the end of February 2020, there is a sharp rise in the GWL graph of approximately 4m.

simultaneous increase in the surface water level

High fluctuation of GWL in the dry season- Shaded a and b





GWL Response (Bochaganjganj)

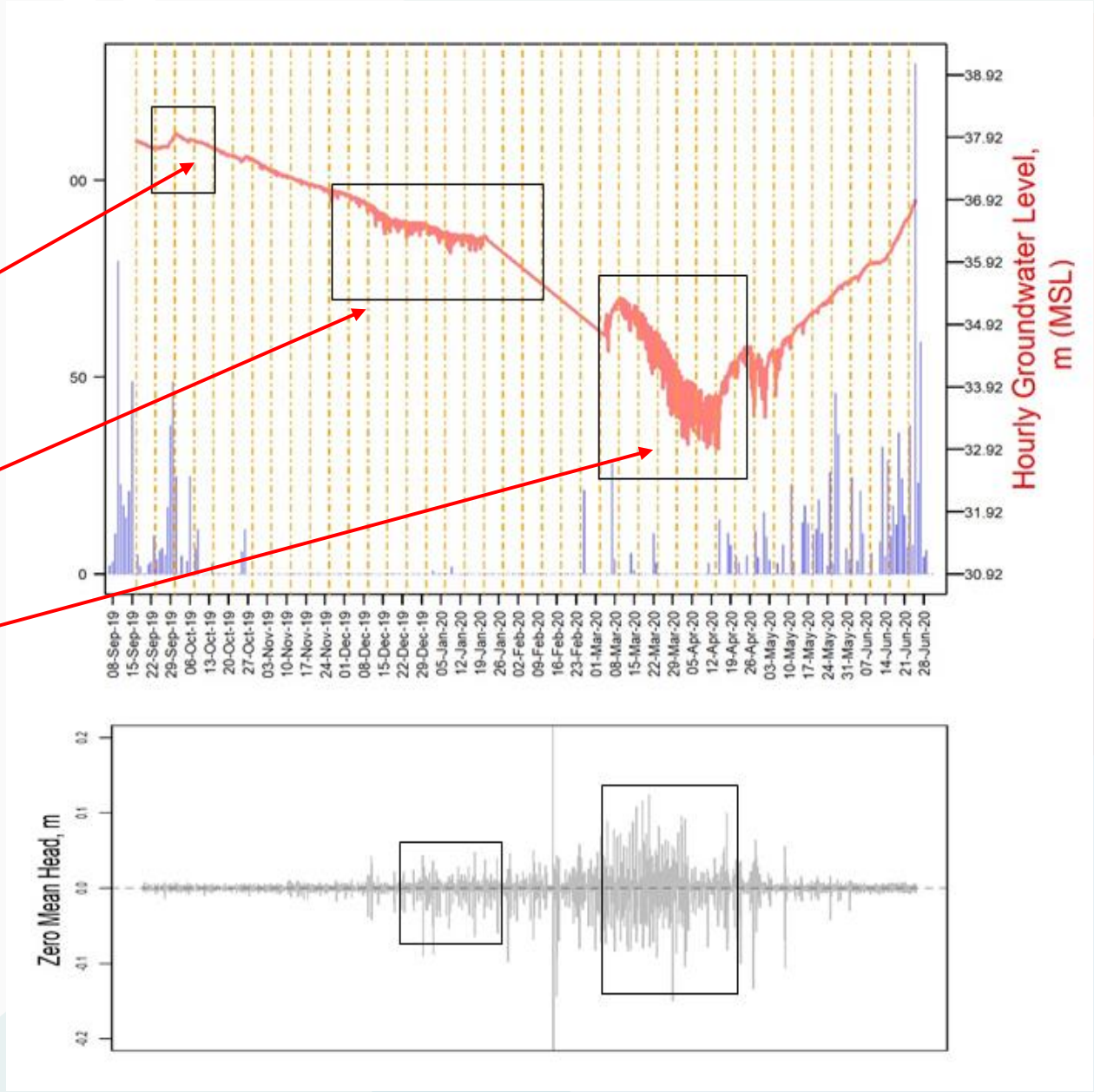
Analysis of Water Level

Good response to rainfall on 30 Sep 2019

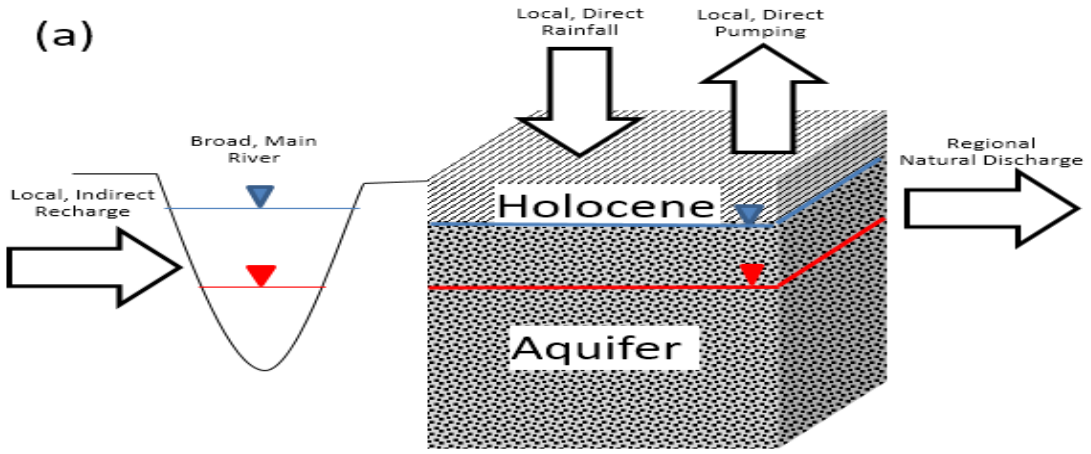
202 mm rise of GWL to cumulative rainfall (131 mm) of the past 3 days.

Perturbations in GWL in December and January

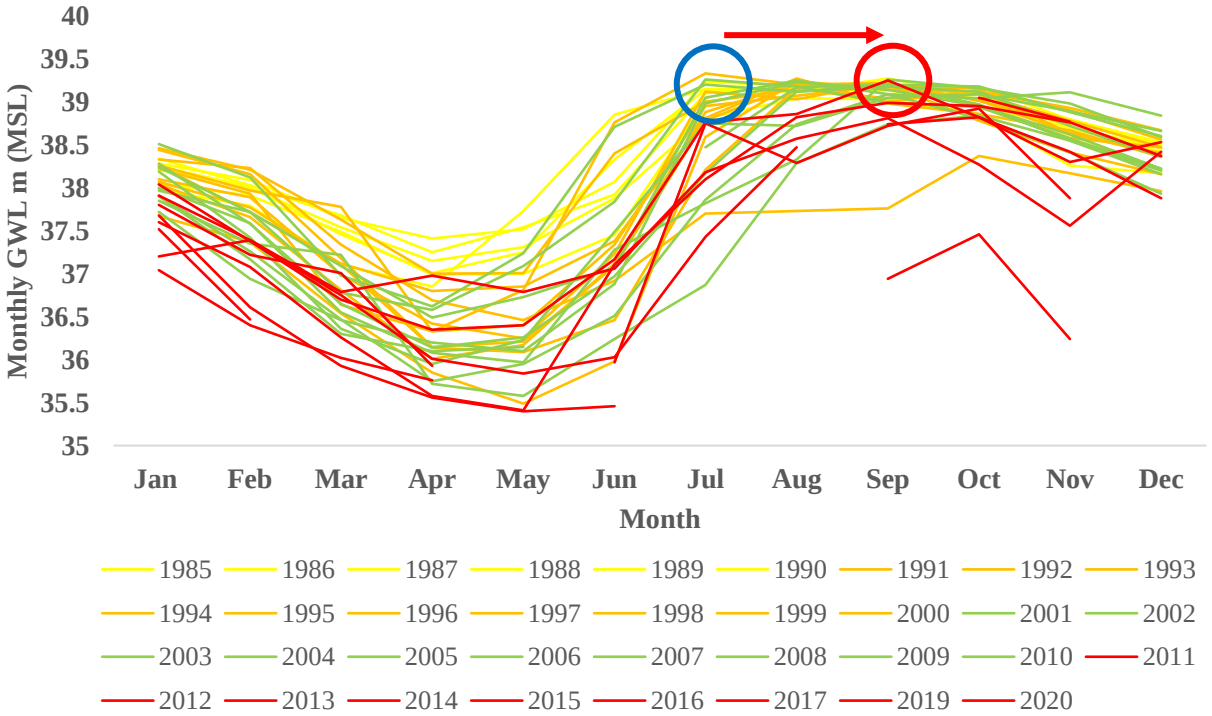
greater fluctuation in the GWL is seen in March and April



Key Findings



Temporal GWL change at Bochaganj



Upscaling AI-R not recommended without Piloting

Dinajpur not suitable for continuing

- Both diffuse and focused recharge in Ishwarganj but could not be confirmed for Dinajpur
- Continuous decrease in GWL
- Increase in Recovery lag time causes change in the aquifer characteristics as well as harvesting pattern.

References

- Nowreen, S., Taylor, R. G., Shamsudduha, M., Salehin, M., Zahid, A., & Ahmed, K. M. (2020). Groundwater recharge processes in an Asian mega-delta: hydrometric evidence from Bangladesh. *Hydrogeology Journal*, *28*(8), 2917–2932. https://doi.org/10.1007/s10040-020-02238-3
- R Core Team. (2020). R: A Language and Environment for Statistical Computing. In *R Foundation for Statistical Computing* (R-4.0.4).
- Rodell, Matthew, Velicogna, I., & Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature*, *460*(7258), 999–1002. https://doi.org/10.1038/nature08238
- Shah, T., Burke, J. J., Villholth, K. G., Angélica, M., Custodio, E., Daibes, F., Hoogesteger, J., Giordano, M., Girman, J., van der Gun, J., Kendy, E., Kijne, J. W., Llamas, R., Masiyandima, M., Margat, J., Marín, L. E., Peck, J. C., Rozelle, S., Sharma, B. R., … Wang, J. (2006). *Groundwater: a global assessment of scale and significance*.
- Shamsudduha, M, Chandler, R. E., Taylor, R. G., & Ahmed, K. M. (2009). Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta. *Hydrology and Earth System Sciences*, *13*(12), 2373–2385. https://doi.org/10.5194/hess-13-2373-2009
- Shamsudduha, Mohammad, Taylor, R. G., Ahmed, K. M., & Zahid, A. (2011). The impact of intensive groundwater abstraction on recharge to a shallow regional aquifer system: Evidence from Bangladesh. *Hydrogeology Journal*, *19*(4), 901–916. https://doi.org/10.1007/s10040-011-0723-4

Any Question?

Thank You