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**Open Access** **RESEARCH PAPER**

# Evaluation of Groundwater Potentiality and Exploitation in Barind Area, Rajshahi District, Bangladesh

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***Keywords:***

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**Abstract:**

Water, as a vital resource for human sustenance, is predominantly sourced from underground reservoirs, making groundwater a critical component of global water supply. The escalating demand for water necessitates the sustainable development and management of groundwater resources. This paper explores advancements in techniques for investigating the occurrence and movement of groundwater, the establishment of resource management concepts, and the research contributions enhancing our understanding of groundwater potential and exploitation.To assess groundwater storage and its efficient utilization in the Barind area, extensive data were collected from the Barind Multipurpose Development Authority. The specific yield of various upazillas was determined utilizing the Copper-Jacob method. Subsequently, the groundwater storage of the region was quantified based on this specific yield data. The annual volume of groundwater withdrawal was calculated by considering the number of deep tubewells, their capacity, and total running hours.

The study focused on the Barind area, encompassing Godagari, Paba, Mohonpur, and Tanore. The findings indicate that this region possesses a satisfactory volume of groundwater storage. Furthermore, the identified potential storage is deemed capable of meeting the gross water demand for the area. This research contributes valuable insights into the sustainable utilization of groundwater resources, offering a foundation for effective water resource management and future development planning in the Barind region. According to the study, there is a significant surplus of groundwater resources, which offers a chance to install more DTWs. But prudence is necessary, particularly in Godagari Upazila, where the supply of groundwater at the moment might not allow for unlimited extraction. To avoid overexploitation and unfavorable environmental effects, geologists and environmental engineers must closely supervise the construction and maintenance of DTWs in this region.

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## 1. Introduction

In the complex tapestry of global water resources, Bangladesh emerges as a critical player heavily reliant on groundwater to meet its multifaceted needs. Nestled in the expansive river delta, Bangladesh not only draws sustenance from its intricate network of waterways but also taps into the vast subterranean reservoirs that cradle approximately 30 percent of the world's fresh water. Groundwater, characterized by its pristine quality and cost-effective accessibility, holds unparalleled potential for addressing the diverse water requirements of both urban and rural populations, making it an invaluable resource for humanity.

The allure of groundwater extends beyond its ease of accessibility; it travels great distances through aquifers, offering a widespread and dependable source of clean water. The interest in harnessing this dynamic resource has captivated experts from various fields, including agricultural engineers, civil engineers, geologists, and geophysicists (Qureshi et al, 2015). Groundwater, a dynamic resource, experiences fluctuations influenced by the ebb and flow of monsoon rains, representing the difference between the optimum and minimum water table within aquifers.

In Bangladesh, often referred to as the "river delta" due to its intricate waterway network, groundwater plays a pivotal role in sustaining vital sectors of the economy, particularly agriculture. The eight-month dry season, from November to June, necessitates irrigation for agricultural activities, making groundwater indispensable for maintaining the country's food security. Groundwater, constituting a staggering 97% of the current drinking water supply, is primarily sourced from shallow depths through hand-operated tubewells (Zahid et al., 2021).

Since the 1970s, Bangladesh has strategically employed groundwater-fed irrigation to support dryseason rice cultivation (Boro), achieving a commendable level of food self-sufficiency. This success is underpinned by the National Water Policy, which emphasizes conjunctive usage of both surface and groundwater resources. The policy not only ensures water supply but also intertwines rural economic growth, poverty reduction, and overall economic development with the enhancement of the country's water infrastructure (Shamsudduhaet al, 2013). Groundwater irrigation, with its increased accessibility, has emerged as a catalyst for rising agricultural output, contributing significantly to the nation's economic prosperity. This paper delves into the intricate dynamics of groundwater utilization in Bangladesh, shedding light on its pivotal role in sustaining the nation's water-dependent sectors and fostering economic growth.

This comprehensive literature delves into a diverse array of studies, shedding light on the intricate dynamics and management strategies associated with groundwater resources, particularly within the distinctive socio-geographic context of Bangladesh. Groundwater stands as a linchpin in this region, constituting a staggering 97% of the overall water supply, meeting critical needs such as drinking water and serving as a lifeline for agricultural irrigation. A pivotal study by Aziz et al.,2015 conducted in the Barind Tract illuminates the formidable challenges arising from groundwater depletion, primarily attributed to the expansive growth of irrigation practices. The research underscores the paramount role of rainfall as the principal source of replenishing the aquifers in the region.

In parallel, studies conducted by Canagaratna accentuate the indispensable role of well-informed and adaptive water policies in effectively managing and preserving the intricate dynamics of groundwater resources. The nuanced insights gleaned from investigations in diverse regions, including Barind and Northern Ghana, contribute to a holistic understanding of the patterns of groundwater fluctuation and the complex dynamics of recharge processes. These studies, tailored to diverse environmental conditions, collectively enrich the broader narrative on groundwater management (Carrard et al, 2019).

The synthesis of these findings culminates in the recognition of an urgent need for targeted and comprehensive research initiatives, particularly within the Rajshahi district of Bangladesh. In this locale, the looming specter of groundwater depletion poses an imminent threat to water security, necessitating sustainable and context-specific management strategies. Beyond the immediate challenges, these strategies become pivotal for ensuring the long-term viability and resilience of groundwater resources in the face of evolving environmental and anthropogenic pressures (Aziz et al, 2015).

This synthesis serves as a clarion call to action, emphasizing the intricate interplay between research findings and the imperative for adaptive policies to safeguard and sustain groundwater resources. It acknowledges the indispensable role of groundwater in the socio-economic fabric of Bangladesh and underscores the necessity of proactive measures to address emerging challenges. By doing so, this comprehensive literature not only contributes valuable insights to the scientific community but also provides a foundation for informed decision-making in water resource management, critical for the well-being and agricultural prosperity of communities in Bangladesh. The synthesis advocates for a holistic approach that integrates scientific understanding, policy frameworks, and community engagement to ensure the resilience and sustainability of groundwater resources in the region (Moshfika et al., 2022).

## 1.1 Objectives of the study

The research focuses on evaluating groundwater potential and exploitation in the Barind area of Rajshahi, specifically in the Upazilas of Godagari, Mohonpur, Paba, and Tanore. It aims to assess groundwater potential comprehensively and analyze current exploitation practices about sustainable resource management. The study will utilize the Copper-Jacob method to determine specific yield, providing insights into groundwater storage capacity. Integration of data on deep tube wells, including their number, capacity, and total running hours, will enable the quantification of groundwater extraction volume per year.

The study will investigate the current hydrogeological conditions in the Barind area, considering aquifer characteristics, recharge patterns, and the impact of human activities on groundwater levels. Through hydrograph analysis and hydrological modeling, it aims to understand the complex dynamics of groundwater fluctuations in response to climate and human influences. Additionally, the research recognizes the socio-economic significance of groundwater in supporting agriculture and domestic water needs in the Barind Tract. The findings are anticipated to inform the development of effective water resource management strategies, emphasizing the need to balance groundwater exploitation with recharge mechanisms.

## 2. Study Area

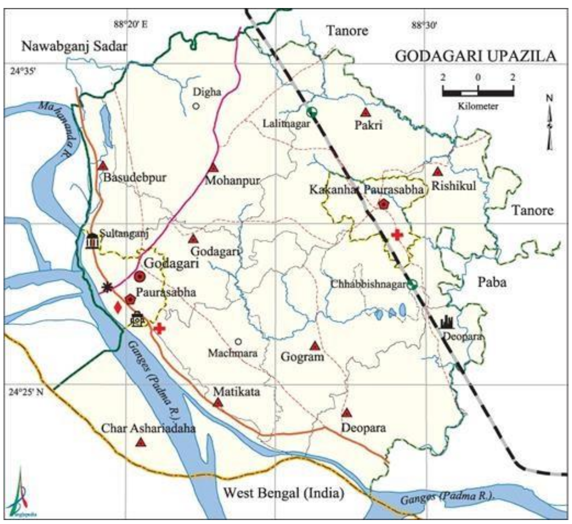
The research focuses on the evaluation of groundwater potentiality and exploitation in the Barind area of Rajshahi, specifically in the Upazilas of Godagari, Mohonpur, Paba, and Tanore. This region, known as the Barind Tract, faces critical challenges related to groundwater dynamics due to increased demand for water resources,

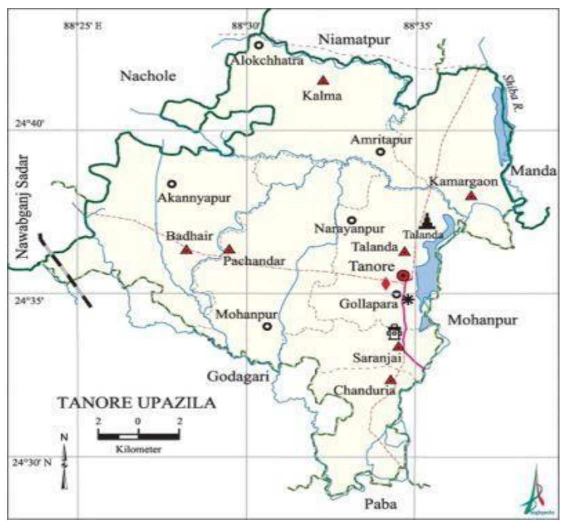
predominantly driven by agricultural
The Barind area, characterized by hard red soil, plays a pivotal role in supporting agricultural practices, particularly during the dry season. The dependence on groundwater for irrigation, facilitated through numerous deep tubewells, has intensified over the years.

In Godagari, Mohonpur, Paba, and Tanore, the assessment of groundwater potential becomes paramount for ensuring sustainable water management. The research on the

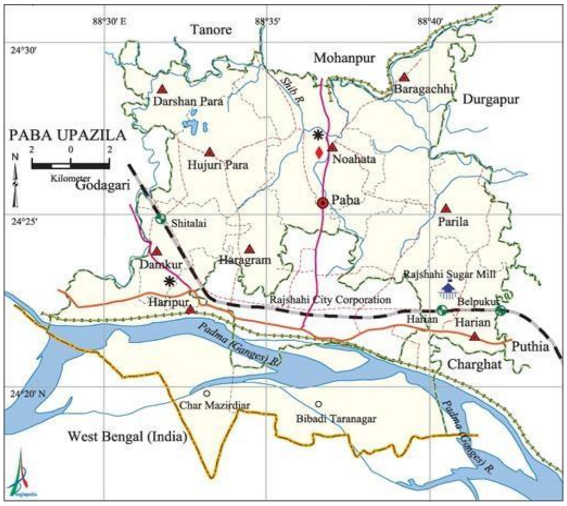
activities.

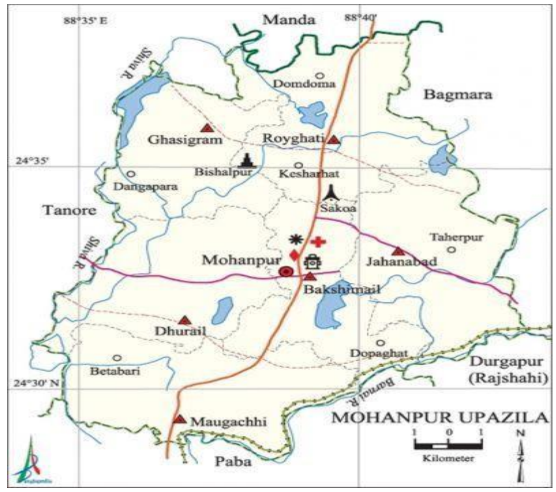
evaluation of groundwater potentiality and exploitation in Godagari, Mohonpur, Paba, and Tanore aligns with the broader objectives of sustainable development and environmental conservation. The outcomes of this study are anticipated to inform policy recommendations, technological interventions, and community-based initiatives aimed at ensuring the judicious use of groundwater resources in the Barind area of Rajshahi.




Godagari Upazila Tanore Upazila




Paba Upazila   Mohanpur Upazila

Figure 1: Location map Gadagari, Tanore, Paba, Mohanpur Upazila.

3. Methodology:

The specific yield of individual upazillas in the Rajshahi district was determined utilizing the Cooper-Jacob method. This method was chosen for its applicability, especially when dealing with small values of the radius of influence (r) and large values of time (t). Cooper and Jacob noted that under these conditions, the series terms in the equation become negligible after the first two terms, allowing for the drawdown to be expressed by an asymptote.

The Cooper-Jacob method of solution is represented by the following equations:

$$s = \frac{Q}{4\pi T}\log\left(-0.5772 - \ln\frac{r^2 s}{4Tt}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Rewriting and changing to decimal logarithms, this reduces to:

$$s = \frac{2.30Q}{4\pi T}\log\frac{2.25Tt}{r^2 s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

A plot of drawdown (s) versus the logarithm of time (t) forms a straight line. Projecting this line to , S = O where t = to , we get

$$O = \frac{2.30Q}{4\pi T}\log\frac{2.25Tt_o}{r^2 s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This leads to the relationship:

$$\frac{2.25Tt_o}{r^2 s} = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Resulting in the final expression for specific yield:

$s$ =2______.25$r$2$T$ to ………………………………(5)

The value for T can be obtained using Equation (3):

T= 2.30$Q$ …………………………………(6)

4$\pi\Delta s$

The straight-line approximation for this method is advised to be restricted to small values of u (u≤ 0.001) to minimize potential errors.

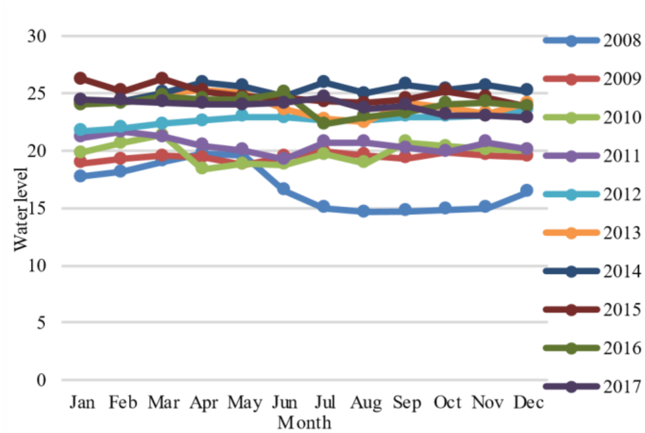
3.1 Procedure:

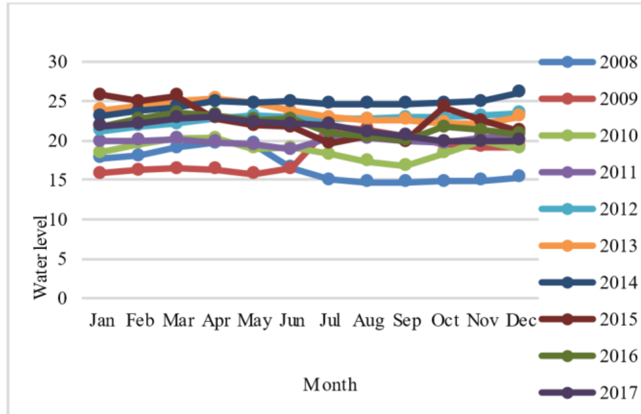
The study commenced with an extensive data collection phase, focusing on capturing the monthly variations in groundwater levels across diverse upazillas within the Rajshahi district. Subsequently, a meticulous analysis of the collected data was conducted, aiming to discern the monthly fluctuations in groundwater levels across the region's different upazillas. To gain insights into the long-term dynamics, a comprehensive ten-year static groundwater dataset was analyzed (Source: Secondary dataset collected from these zones), enabling the determination of the average fluctuation for each upazila. Employing the Cooper-Jacob method, the specific yield of groundwater for each upazila was then calculated, utilizing the established equations outlined in the methodology. The investigation proceeded to assess the overall groundwater storage capacity, achieved by multiplying the area, average fluctuation of groundwater, and specific yield for each upazila. Lastly, the withdrawal of groundwater was quantified by considering the number of Deep Tube Wells (DTWs), their respective capacities, and the hours of operation. This systematic procedure provides a robust framework for understanding the groundwater dynamics, specific yield, and storage capacity in the Rajshahi district, offering valuable insights for sustainable groundwater management.

By following these steps, a comprehensive understanding of the groundwater dynamics in the Rajshahi district was obtained, including specific yield values for individual upazillas, enabling informed decisions for sustainable groundwater management practices in the region.

4.Result and Discussion

4.1 Yearly Variation of Groundwater Level at Various Upazila of Rajshahi District



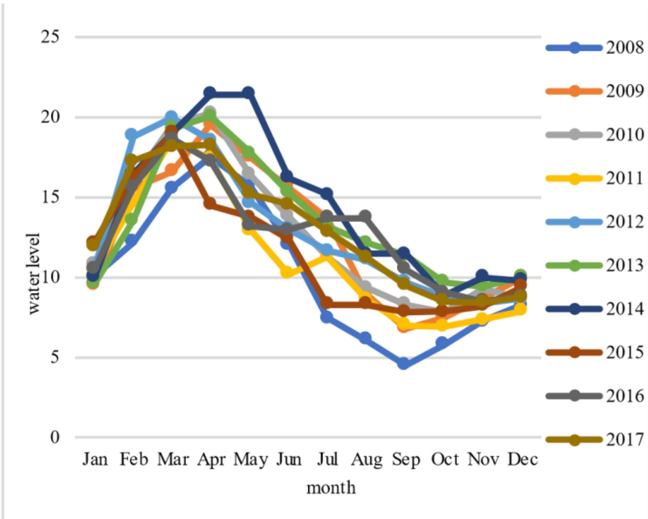



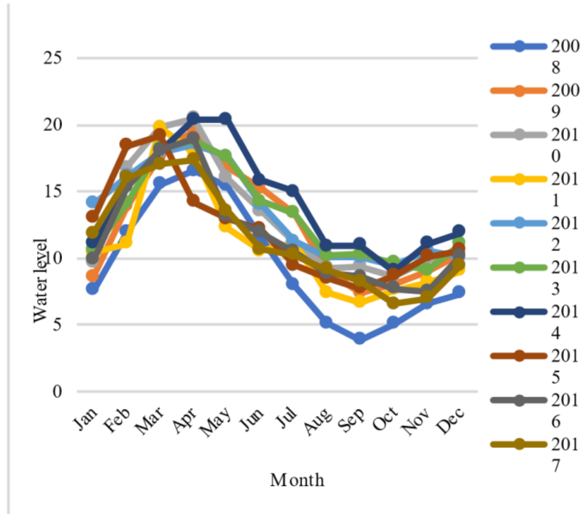

**(a)** **(b)**

Figure 4.1: Static Groundwater level of various years at (a) Amtoli Mouza and (b) Poromanondopur Mouza in

Godagari Union of Godagari Upazila

Figure 4.1 (a) shows the highest GWL fluctuates up to 25 m in July 2014 & March 2015 and the lowest GWL fluctuates likely 20 m in the month of July to November 2008. In 2009, 2010, and 2011, the GWL fluctuates likely 20 m. In 2012, 2013, and 2017 it fluctuates between 20 to 25 m. In 2014, 2015, and 2016, it fluctuates up to 25 m. Figure 4.1 (b) shows the highest GWL fluctuates up to 25 m in December 2014 & March 2015 and the lowest GWL fluctuates likely 15 m in the months of July to December 2008. In 2009 and 2010 the GWL fluctuates between 15 to 20 m. In 2011, the GWL fluctuated likely 20 m. In 2012, 2013, 2015, and 2016 it fluctuates between 20 to 25 m. In 2014 it fluctuates likely 25 m.

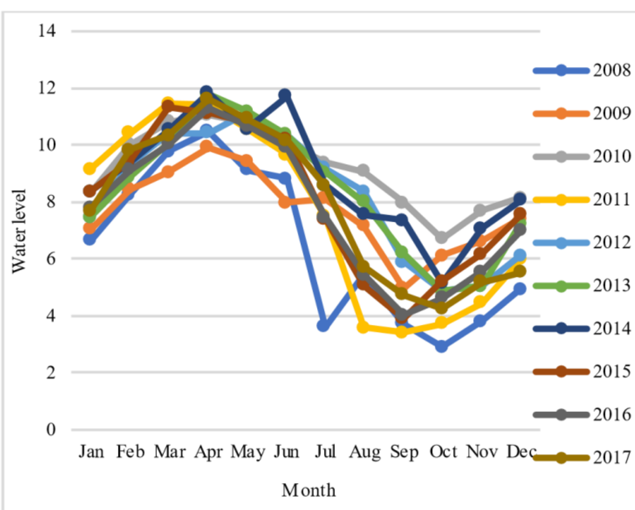


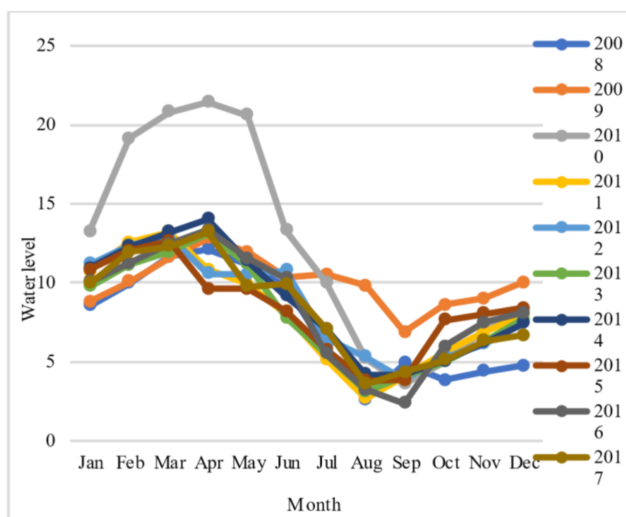




**(a)** **(b)**

Figure 4.2: Static Groundwater level of various years at (a)Boraeel Mouza and in Raighati Union and (b Matikata Mouza in Mougachi Union of Mohonpur Upazila.

Figure 4.2 (a) shows the highest GWL fluctuated up to 20 m in May 2014 and the lowest GWL fluctuates under 5 m in the month of September 2008. From 2008 to 2017 GWL fluctuation of all years was likely in between 5 m to 20 m. Figure 4.2 (b) shows the highest GWL fluctuates up to 20 m in May 2014 and the lowest GWL fluctuates under 5 m in the month of September 2008. From 2008 to 2017 GWL fluctuation of all years was likely in between 5 m to 20 m.

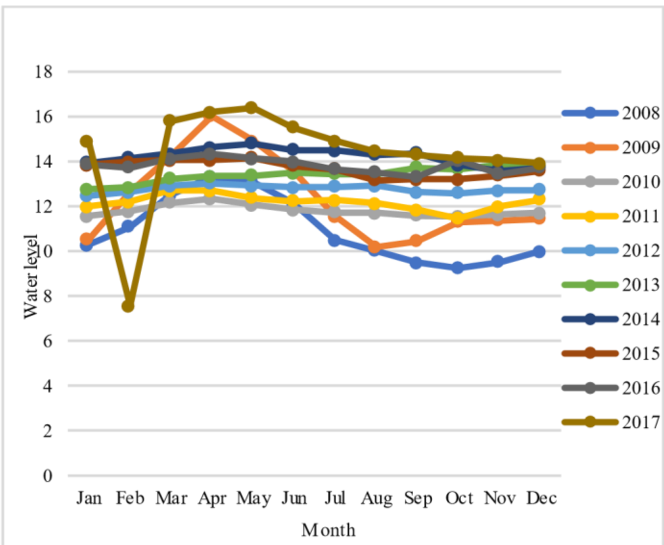


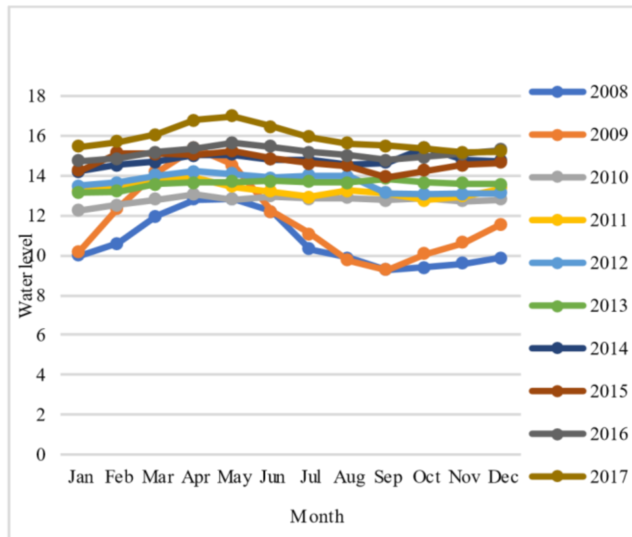

**(a)** **(b)**

Figure 4.3: Static Groundwater level of various years at (a) Baruipara/ Sontospur Mouza in Naohata Union and (b) Gopalpur Mouza in Haripur Union of Paba Upazila

Figure(a) shows the highest GWL fluctuates likely 12 m in June 2014 and the lowest GWL fluctuates under 4 m in the month of October 2008. From 2008 to 2017 GWL fluctuation of all years is likely in between 2 m to 12 m. Figure (b) shows the highest GWL fluctuated up to 20 m in April 2010 and the lowest GWL fluctuated under 5 m in the month of September 2016. In 2008, 2009, and from 2011 to 2017 GWL fluctuation of that years is likely in between 0 to 15 m.




**(a)**

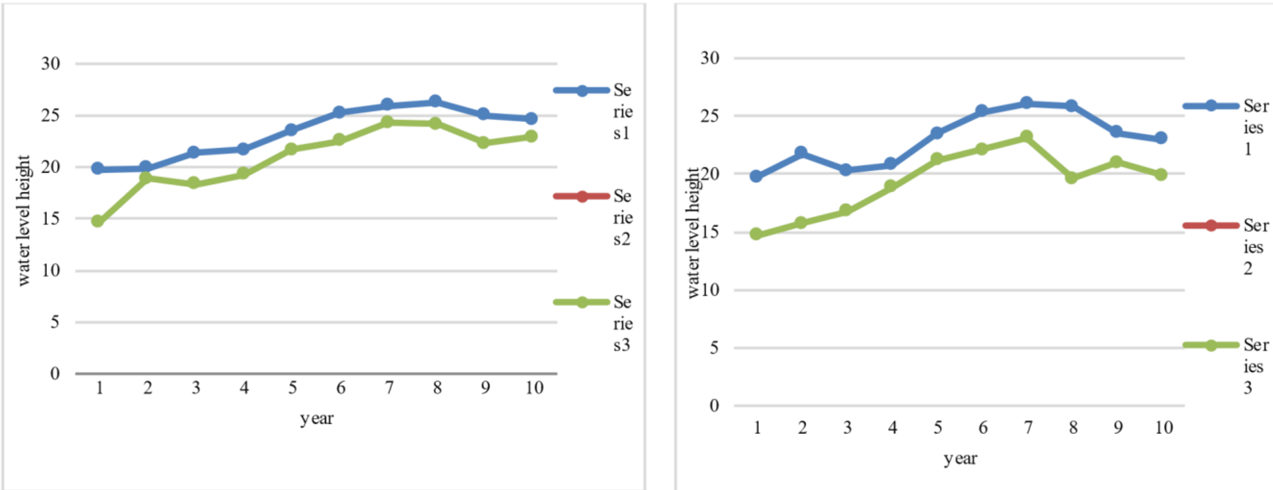



**(b)**

Figure 4.4: Static Groundwater level of various years at (a) Haripur Mouza in Kamarga Union and (b) Talondo Mouza in Talondo Union of Tanore Upazila

Figure (a) shows the highest GWL fluctuates likely 16 m in May 2017 and the lowest GWL fluctuates under 8 m in the month of February 2017. From 2008 to 2016 GWL fluctuation of all those years is likely in between 6 m to 16 m. Figure (b) shows the highest GWL fluctuates up to 16 m in May 2017 and the lowest GWL fluctuates under 10 m in the months of September 2009 and September 2012. From 2010 to 2016 GWL fluctuation of all those years is likely in between 8 m to 18 m.

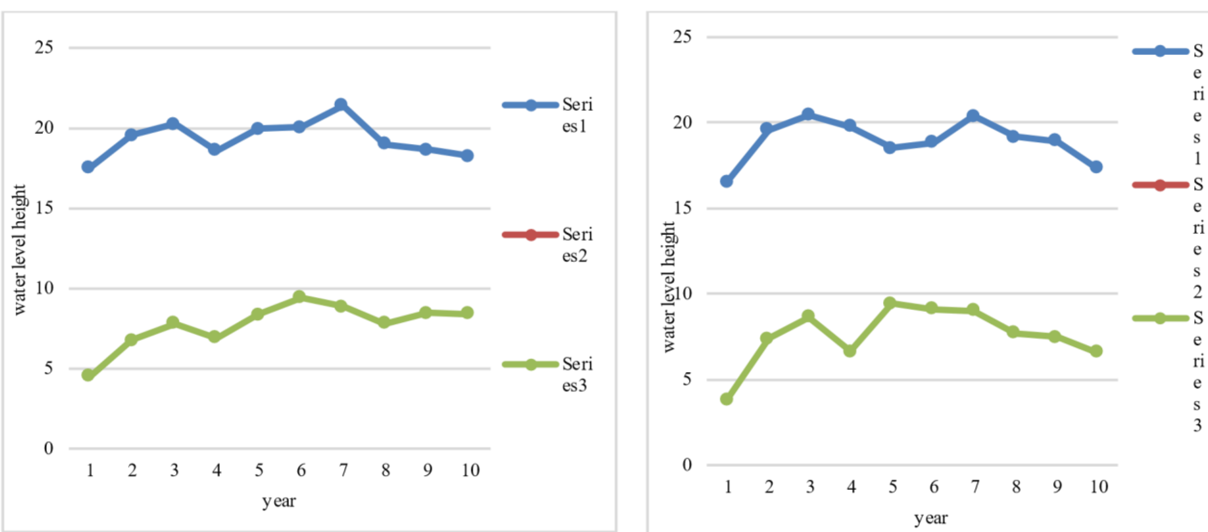
4.2Graphical Representation of Maximum and Minimum Variation of G.W. at Various Upazila of Rajshahi District




(a) (b)

Figure 4.5: Graph showing the peak and low value of each year (2008-2017) at (a) Amtoli Mouza in Godagari Union and (b at Poromanondopur Mouza in Godagari Union of Godagari Upazila

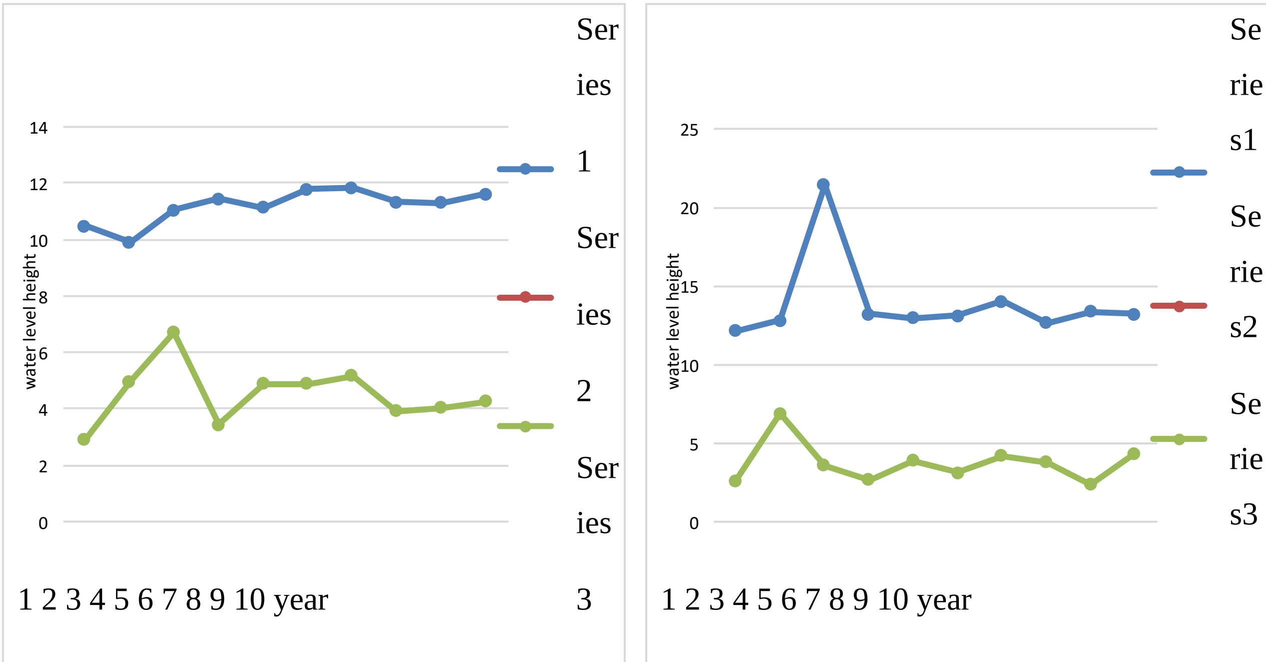
From Figure 4.5 (a) and (b) there is a significant variation as in (a) the maximum and minimum water level height is between 20 m to 30 m and 15 m to 25 m. In (b) the maximum and minimum water level height is between 20 m to 30 m and 15 m to 25 m.




(a) (b)

Figure 4.6: Graph showing the peak and low value of each year (2008-2017) at (a)Boraeel Mouza in Raighati Union and (b) at Matikata Mouza in Mougachi Union of Mohonpur Upazila

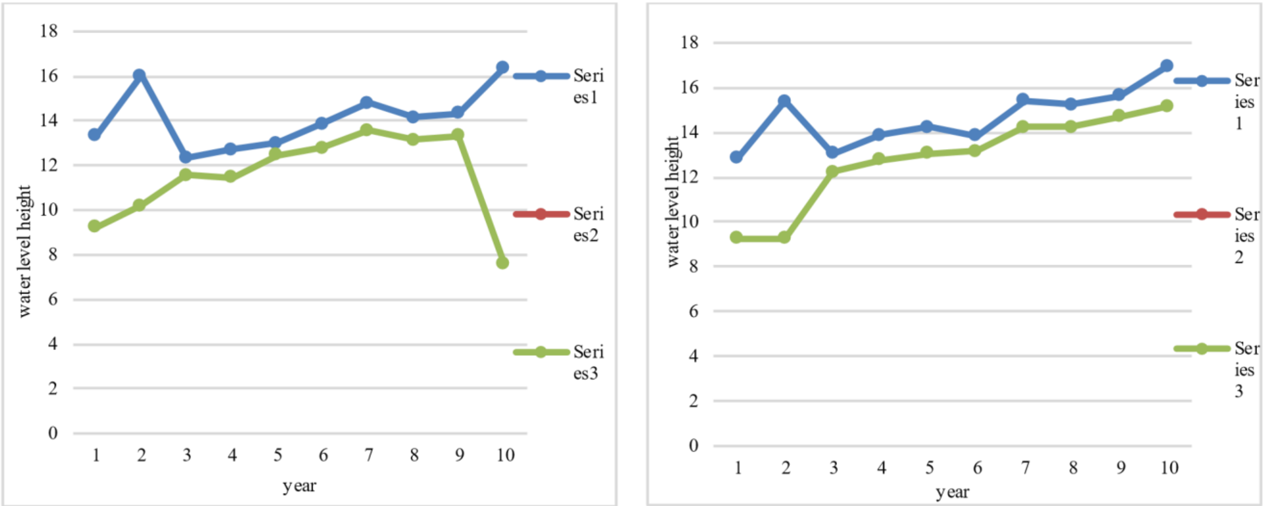
From Figure 4.6 (a) and (b) there is a significant variation as in (a) the maximum and minimum water level height is between 15 m to up to 20 m and 5 m to 10 m. In (b) the maximum and minimum water level height is between 15 m to 20 m and 5 m to 10 m.




(a) (b)

Figure 4.7: Graph showing the peak and low value of each year (2008-2017) at (a) Baruipara/Sontospur Mouza in Nouhata Union and (b) at Gopalpur Mouza in Haripur Union of Paba Upazila

From Figure 4.7 (a) and (b) there is a significant variation as in (a) the maximum and minimum water level height is between 10 m to 12 m and 2 m to 6 m. In (b) the maximum and minimum water level height is between 10 m to 20 m and 0 m to 5 m.

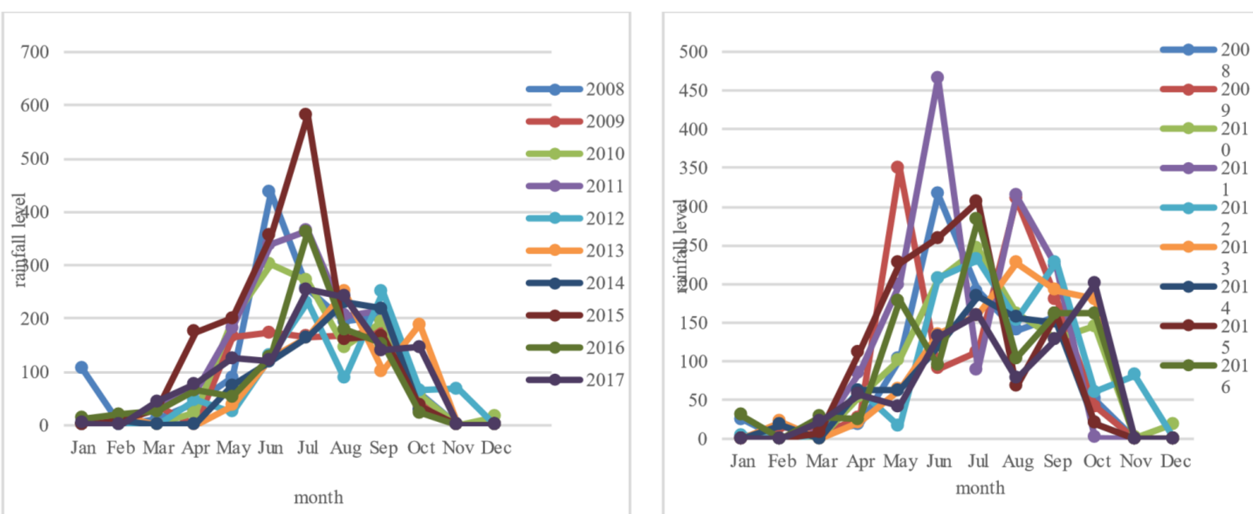



**(a)** **(b)**

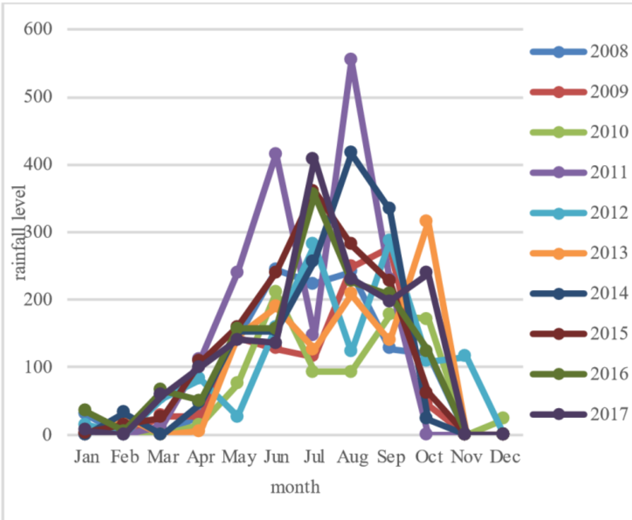
Figure 4.8: Graph showing the peak and low value of each year (2008-2017) at (a)Haripur Mouza in Kamarga Union and (b) Talondo Mouza in Talondo Union of Tanore Upazila

From Figure 4.8 (a) and (b) there is a significant variation as in (a) the maximum and minimum water level height is between 12 m to 16 m and 8 m to 14 m. In (b) the maximum and minimum water level height is between 12 m to 18 m and 8 m to 16 m

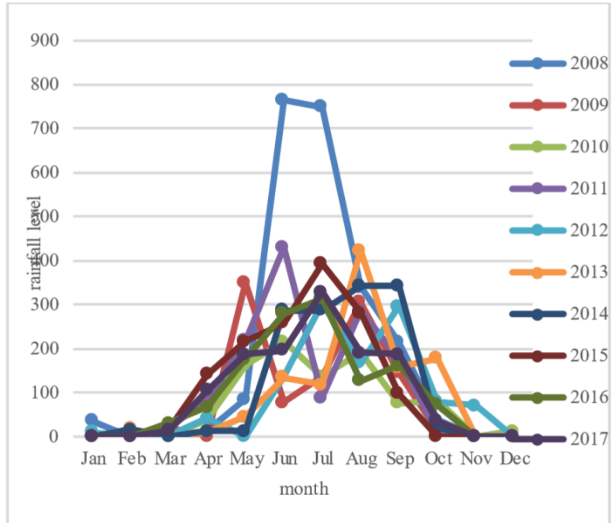
4.3Graphical Representation of Yearly Variation of Rainfall at Various Upazila of Rajshahi District




**(a)** **(b)**




**(c)**




**(d)**

Figure 4.9: Rainfall of various years at (a) Godagari Upazila, (b) Mohonpur Upazila, (c) Paba Upazila, and (d) Tanore Upazila

In Figure 4.9 (a), the rainfall is held during the month of April to October. In the year 2015 the month of July, the highest rainfall is held & the lowest rainfall is held in the year 2012 the month of May. This graph also shows that in the years 2008 to 2011, 2013, 2014, 2016, and 2017 all that the years the rainfall was almost the same. The rainfall level of this year is naturally 100 mm to 400 mm.In the figure (b), the rainfall is held during the month of May to October. The highest rainfall is held on June 2011 and the lowest rainfall is held on May 2012. This graph also shows that from the years 2008 to 2010 and 2013 to 2017 all that the years the rainfall was almost the same. The rainfall level of this year is naturally 50 mm to 350 mm.InFigure (c) the rainfall is held during the month of May to October. The highest rainfall was in August 2011 and the lowest rainfall was in May 2012. This graph also shows that from the years 2008 to 2010 and 2013 to 2017 all that the years the rainfall was almost the same. The rainfall level of this year is naturally 100 mm to 400 mm.In the figure (d), the rainfall is held during the month of May to October. The highest rainfall is held on June 2008 and the lowest rainfall is held on June 2009. This graph also shows that the year 2010 to 2017 all that the years the rainfall was almost the same. The rainfall level of this year is naturally 100 mm to 400 mm.

4.4Boring Log Data of Various Upazila in Rajshahi

Table 4.1: Boring log data of Godagari upazila

<table>
<tr><td colspan="2" rowspan="4">Project:<br><br>BARIND MULTIPURPOSE DEVELOPMENT AUTHORITY<br><br>RAJSHAHI</td><td>Well no:</td></tr>
<tr><td>District: Rajshahi</td></tr>
<tr><td>Upazila: Godagari-1</td></tr>
<tr><td>Mouza: Chalong</td></tr>
<tr><td rowspan="3">Engineer<br><br>Barind Multipurpose Development<br><br>Authority</td><td rowspan="3">Drilling Contractor<br><br>M/S Rokun Drillers</td><td>J.L.NO: 59</td></tr>
<tr><td>Plot NO: 330</td></tr>
<tr><td>TEST BORE LOG</td></tr>
<tr><td colspan="3">Date started. 10.01.17…..….7.00………..hrs; Date completed. 10.01.17……....17.30…...…hrs.<br><br>Logged by SAE: Rod length……………………….20 ft</td></tr>
</table>

| Drilling time log | | | Graphic log | Thickness (ft) | | Description of formation |
|---|---|---|---|---|---|---|
| rod | from | to | | from | to | |
| 1 | 7.00 | | | 0 | | |
| | | | | | | |
| | | | | | | |
| | | | | | | Hard clay |
| | | | | | | |
| | | 17.30 | | | 60 | |
| | | | | 60 | | Br. Vfs |
| | | | | | 80 | |
| | | | | 80 | | L.Br.Fs/Ms |
| | | | | | 100 | |
| | | | | 100 | 110 | L.Br.Ms |
| | | | | 110 | | L.Br.Ms/Cs |
| | | | | | 130 | |
| | | | | 130 | 140 | L.Br.Ms |
| | | | | 140 | 145 | P.Clay |

This indicates the typical data of the boring log of the mouza Chalong in the upazila of Godagari1. This project is under on Barind Multipurpose Development Authority, Rajshahi. Drilling Contactor as M/S Rokun Drillers examine boring log started at 7.00 hrs on 10 Jan 2017 and completed at 17.30 hrs on 10 Jan 2017. This boring log data determines the Hard clay on the length up to 60 ft. From 60 ft to 80 ft, the soil formation is Brown very fine sand. From 80 ft to 100 ft, the soil is formed as light brown fine sand or medium sand. From 100 ft to 110 ft, the soil is light Brown medium sand. The soil formed as light Brown medium sand or course sand in 110 ft to 130 ft. On 130 ft to 140 ft, the soil is light Brown medium sand. From 140 ft to 145 ft, the soil formed as P.clay.

Table 4.2: Boring log data of mohonpur upazila

<table>
<tr><td colspan="3" rowspan="5">Project:<br><br>BARIND MULTIPURPOSE DEVELOPMENT AUTHORITY<br><br>RAJSHAHI</td><td>Well no:</td></tr>
<tr><td>District: Rajshahi</td></tr>
<tr><td>Upazila: Mohonpur</td></tr>
<tr><td>Union: Bakaimill</td></tr>
<tr><td>Mouza: Parijonpara</td></tr>
<tr><td rowspan="3">Engineer<br><br>Barind Multipurpose<br><br>Development Authority</td><td colspan="2" rowspan="3">Drilling Contractor<br><br><br>M/S Piya Enterprise</td><td>J.L.NO: 169</td></tr>
<tr><td>Plot NO: 883</td></tr>
<tr><td>DRILLING LOG</td></tr>
<tr><td colspan="4">Date started. 1.04.16….….at: 09….hrs; Date completed. 1.04.16……..at 19…...hrs. Logged by: 99 AB. Rod length……………………….10 ft</td></tr>
<tr><td>Drilling time log</td><td>Graphic log</td><td>Thickness (ft)</td><td>Description of</td></tr>
</table>

| rod | from | to | | from | to | formation |
|---|---|---|---|---|---|---|
| 3 | 09 | | | 0.00 | | Sticky Clay |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | 19 | | | 40.00 | |
| | | | | 40.00 | | Fine Sand (Grey) |
| | | | | | 90.00 | |
| | | | | 90 | | Flexi Clay |
| | | | | | 110 | |
| | | | | 110 | | Medium Clay |
| | | | | | 165 | |
| | | | | 165 | | Fine Sand (Grey) |
| | | | | | 170 | |
| | | | | 170 | | Medium to Course Sand (Grey) |
| | | | | | 230 | |

This indicates the typical data of the boring log of the mouza Parijonpara at the union of Bakaimill the upazila of Mohonpur. This project is under on Barind Multipurpose Development Authority, Rajshahi. Drilling Contactor as M/S Piya Enterprise examine boring log started at 09.00 hrs on 1 Apr 2016 and completed at 19.00 hrs on 1 Apr 2016. This boring log data determines the Sticky Clay on the length up to 40 ft. From 40 ft to 90 ft, the soil formation is Fine Band(Grey). From 90 ft to 110 ft, the soil is Flexi Clay. The soil formed as Medium Clay from 110 ft to 165 ft. From 165 ft to 170 ft, the soil is Fine Sand (Grey). The Medium to Course Sand (Grey) is 170 ft to 230 ft.

Table 4.3: Boring log data of Paba upazila

| | |
|---|---|
| Project:<br><br>BARIND MULTIPURPOSE DEVELOPMENT AUTHORITY<br><br>RAJSHAHI | Well no: |
| | District: Rajshahi |
| | Upazila: Paba |
| | Union: Barogachi |

| | | Mouza: Datpur-2 |
|---|---|---|
| Engineer<br><br>Barinf Multipurpose<br><br>Development Authority | Drilling Contractor<br><br><br><br>M/S Water Well Drillers | J.L.NO: 97 |
| | | Plot NO: 1601 |
| | | DRILLING LOG |

Date started. 15.09.17…..….16.00….hrs; Date completed. 16.09.17……..10.00…...hrs.

Logged by SAE: Rod length………………………10 ft

| Drilling time log | | | Graphic log | Thickness (ft) | | Description of formation |
|---|---|---|---|---|---|---|
| rod | from | to | | from | to | |
| 1 | 16.00 | | | 0.00 | | Hard |
| | | | | | | |
| | | | | | 40.00 | |
| | | | | 40.00 | | Br. VFS |
| | | | | | 70.00 | |
| | | 10.00 | | 70 | | Br. Fs |
| 23 | | | | | 90 | |
| | | | | 90 | | Br. Fs/Ms |
| | | | | | 110 | |
| | | | | 110 | | Br. Ms/Fs |
| | | | | | 128 | |
| | | | | 128 | | Br. Fs |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 150 | |
| | | | | 150 | | Grey Ms |
| | | | | | 180 | |
| | | | | 180 | | Grey Cs/Ms |
| | | | | | 215 | |
| | | | | 215 | | Grey Fs |
| | | | | | 225 | |

This indicates the typical data of the boring log of the mouza Datpur 2 at the union of Baroigachi in the upazila of Paba. This project is under On Barind Multipurpose Development Authority, Rajshahi. Drilling Contactor as M/S Water Well Drillers examine boring log started as 16.00 hrs on 15 Sep 2017 and completed as 10.00 hrs on 16 Sep 2017. This boring log data determines the hard soil on a length of up to 40 ft. From 40 ft to 70 ft, the soil formation is Brown very fine sand. From 70 ft to 90 ft, the soil is formed as brown fine sand. From 90 ft to 110 ft, the soil is Brown fine sand or medium sand. The soil formed as Brown medium sand or fine sand in 110 ft to 128 ft. From 128 ft to 150 ft, the soil is Brown fine sand. The Gray medium sand is 150 ft to 180 ft. The Grey course sand or medium sand up to 180 ft to 215 ft soil. From 215 ft to 225 ft the soil formed as Grey fine sand.

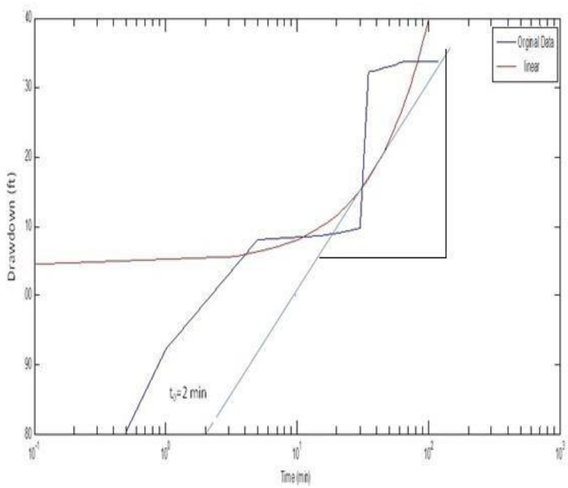
Table 4.4: Boring log data of Tanore upazila

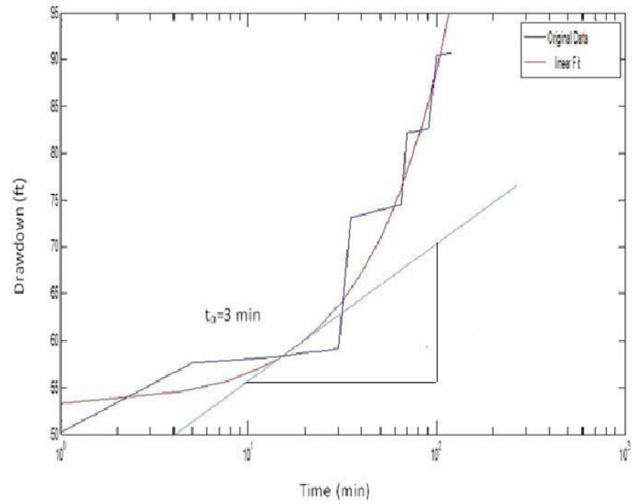
| | | |
|---|---|---|
| Project:<br><br>BARIND MULTIPURPOSE DEVELOPMENT AUTHORITY<br><br>RAJSHAHI | | Well no: |
| | | District: Rajshahi |
| | | Upazila: Tanore |
| | | Union: Tanore RE M/C |
| | | Mouza: Dhantori |
| Engineer<br><br>Barinf Multipurpose | Drilling Contractor | J.L.NO: 151 |
| | | Plot NO: 40 |

| Development Authority | | | MD KAMRUL ISLAM | | | DRILLING LOG |
|---|---|---|---|---|---|---|
| Date started. 11.03.15…..….at 03….hrs; Date completed. 11.03.15…….at 14…...hrs.<br>Logged by SSAE: Rod length………………………10 ft | | | | | | |
| Drilling time log | | | Graphic log | Thickness (ft) | | Description of formation |
| rod | from | to | | from | to | |
| 25 | 03 | 14 | | 0.00 | 40.00 | Alluvial loamy soil |
| | | | | 40.00 | 140.00 | Fine Sand (Grey) |
| | | | | 140.00 | 200 | Medium to Course Sand (Grey) |
| | | | | 200 | 250 | Course sand (Grey) with shingles |

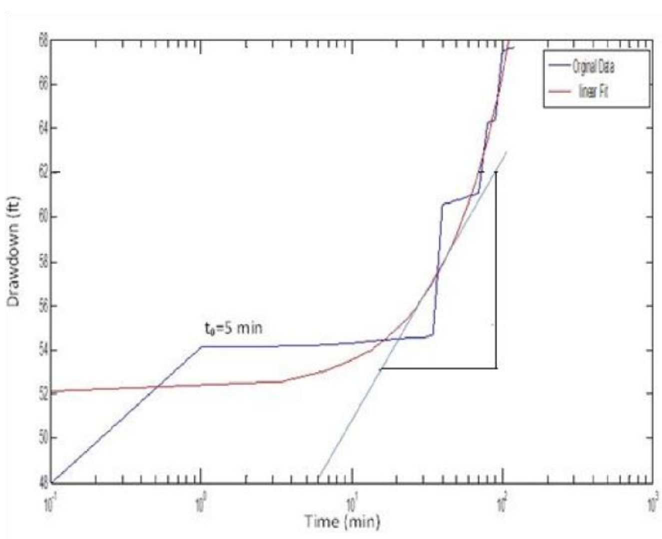
This indicates the typical data of the boring log of the mouza Dhantori at the union of Tanore RE M/C in the upazila of Tanore. This project is under on Barind Multipurpose Development Authority, Rajshahi. The drilling Contactor Md Kamrul Islam examined the boring log that started at 3.00 hours on 11 Mar 2015 and was completed at 14.00 hours on 11 Mar 2017. This boring log data determines the Alluvial loamy soil on a length of up to 40 ft. From 40 ft to 140 ft, the soil formation is Fine Sand (Grey). From 140 ft to 200 ft, the soil is formed as Medium to Course Sand (Grey). From 200 ft to 250 ft, the soil formed as Course sand (Grey) with shingles.

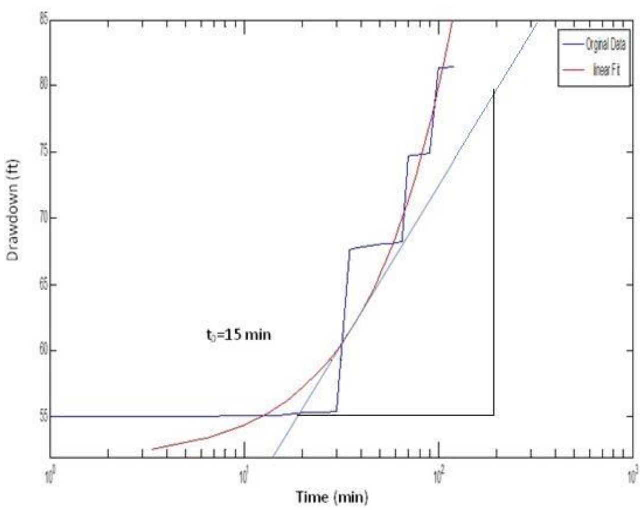
4.5Time Drawdown Curve to Calculate Specific Yield by Copper-Jacob Method




(a) (b)




(d) (c)

Figure 4.10: Time-drawdown curve for (a) Godagari Upazila, (b) Paba Upazila, (c) Mohonpur Upazila, and (d) Tanore Upazila.

Figure 4.10 represents the time drawdown curve for calculating the specific yield of Groundwater. Here using a logarithmic scale at the Horizontal axis and a normal scale at the vertical axis. Figure 4.10 (a) represents Godagari Upazila where the time is 2 minutes and the drawdown is 30 ft. Figure 4.10 (b) represents Paba Upazila where the time is 3 minutes and the drawdown is 15 ft. Figure 4.10 (c) represents for Mohonpur Upazila where the time is 5 minutes and the drawdown is 10 ft.

Figure 4.10 (d) represents Tanore Upazila where the time is 15 minutes and the drawdown is 23 ft.

Table 4.5: Determination of Specific Yield of various Upazila of Rajshahi

| Upazila | Discharge, Q Ft3/Min | ΔS Ft | Re Ft | To Min | Transmissivity, T= 2.3q/(4∏ ΔS) Ft2/Min | Specific Yield, Sp =2.25tto /Re2 (%) |
|---|---|---|---|---|---|---|
| Godagari | 60 | 30 | 14.8 | 2 | 881 | 18 |
| Mohonpur | 120 | 10 | 22.5 | 5 | 991 | 22 |
| Paba | 120 | 15 | 16.04 | 3 | 991 | 26 |
| Tanore | 120 | 23 | 62.36 | 15 | 991 | 8.6 |

4.6Groundwater Storage of Various Upazila of Rajshahi District

The storage of Groundwater at Various Upazila of Rajshahi District is as follows:

Groundwater storage of Godagari Upazila = (Specific Yield × Fluctuation of water table ×

Area of a Upazila)

Table 4.6: Storage of groundwater in various upazila of Rajshahi district

| SL. No. | Upazila | Specific Yield (%) | Area (Hec) | Fluctuation of G.W (ft) | Fluctuation of G. W. (m) | Storage of G.W. (Hec-m) |
|---|---|---|---|---|---|---|
| 1 | Godagari | 18 | 39500 | 12 | 3.658 | 26008 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | Paba | 26 | 28000 | 10 | 3.048 | 22189 |
| 3 | Mohonpur | 22 | 16200 | 15 | 4.572 | 16295 |
| 4 | Tanore | 8.6 | 2950 | 10 | 3.048 | 7733 |

Table 4.7: Volume of water extracted per year in various upazila of Rajshahi district

| Sl. No | Name of Upazila | Volume of water Extracted (Hecm) | Total volume Extracted (Hec-m) |
|---|---|---|---|
| 1 | Godagari | 5836.9 | 20938.8 |
| 2 | Paba | 4533.2 | |
| 3 | Mohonpur | 5270.2 | |
| 4 | Tanore | 5298.5 | |

Table 4.8: Groundwater Storage, at present extraction and additional safe extraction of various Upazila of Rajshahi

| SL No. | Upazila | Storage of G.W. (Hec-m) | Extracted G.W. (Hec-m) | Additional safe extraction (Hec-m) |
|---|---|---|---|---|
| 1 | Godagari | 5204 | 5837 | -633 |
| 2 | Paba | 7441 | 4533 | 2908 |
| 3 | Mohonpur | 8432 | 5270 | 3162 |
| 4 | Tanore | 4296 | 5299 | 1003 |

Number of Deep tube-wells that can be Installed to Withdraw Groundwater Safely

The volume of water withdrawing each DTW per year Capacity of each DTW* Running time per year

For Capacity of each DTW 2 cusec for Paba, Mohonpur and Tanore upazila and 1 cusec for Godagari upazila and Running time per year= 800 hr for all

Table 4.9: Possible number of new DTW installations at Upazila

| SL No | Upazila | The capacity of each DTW in (Hec-m) | Storage of G.W in (Hecm) | DTW that can be installed at present storage | DTW at present | New DTW can be installed |
|---|---|---|---|---|---|---|
| 1 | Godagari | 8.13 | 5207 | 641 | 714 | -73 |
| 2 | Paba | 16.32 | 7441 | 455 | 278 | 177 |
| 3 | Mohonpur | 16.32 | 8432 | 516 | 323 | 193 |
| 4 | Tanore | 16.32 | 4296 | 264 | 529 | 265 |

5. Conclusion:

The comprehensive assessment of groundwater resources in the Barind tract upazillas reveals a nuanced picture of distribution, capacity, and sustainability. With 714, 529, 278, and 323 Deep Tube Wells (DTWs) of varying capacities installed in Godagari, Tanore, Paba, and Mohonpur upazilas, respectively, it is evident that the extraction of groundwater is unable to meet the escalating demands of these regions. This shortfall underscores the pressing need for a judicious approach to groundwater management.

The specific yield analysis adds another layer of insight to the study, indicating a generally satisfactory state across the upazilas. However, the exception lies in Tanore upazila, where the specific yield falls below the critical threshold of 10%. This revelation raises concerns about the sustainability of groundwater extraction in Tanore, necessitating targeted interventions to ensure the long-term viability of this vital resource.

Despite these challenges, the study brings forth positive findings regarding the overall storage of groundwater in the Barind tract upazillas. The storage levels are deemed adequate concerning the present water usage patterns, reflecting a degree of resilience in the region's hydrogeological system. This positive aspect bodes well for the sustainable development of the upazillas, provided that the extraction practices align with the available groundwater storage.

Upon a broader evaluation of the Barind tract, the study indicates a substantial surplus of groundwater resources, presenting an opportunity for the installation of additional DTWs. However, caution is warranted, especially in Godagari upazila, where the current groundwater availability may not support unrestricted extraction. The installation and operation of DTWs in this area must be conducted under the careful supervision of geologists and environmental engineers to prevent overexploitation and adverse environmental consequences.

In conclusion, this research underscores the significance of a balanced and sustainable approach to groundwater management in the Barind tract upazillas. The identified challenges in specific yield and localized limitations emphasize the need for targeted interventions and collaborative efforts among stakeholders. As we navigate the complexities of groundwater utilization, a thoughtful and informed strategy, guided by the expertise of geologists and environmental engineers, is essential to ensure the resilience of this invaluable resource and the well-being of the communities dependent on it.

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