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Assessment of Groundwater Recharge and Discharge for Sustainable Development of Rangpur District in Bangladesh

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Abstract

Estimation of recharge to and discharge from the aquifer is a prime requisite for sustainable development and management of groundwater (GW) in any region. In this study, annual recharge and discharge of groundwater are assessed to evaluate the resource potentiality for groundwater development in Rangpur District. Analysis of bore logs and groundwater level (GWL) data reveal that a thick sandy aquifer with unconfined to semi-confined in nature is extended at shallow depth throughout the area. Groundwater recharge from rainfall is estimated using Water Level Fluctuation (WLF) and Rainfall Infiltration Factor (RIF) methods for both monsoon and non-monsoon seasons. The total estimated annual groundwater recharge is approximately 2409.4 Mm^3 and 51% of this total are recharged from annual rainfall, 48% from irrigation return flow and 1% from other sources. For monsoon season the main source of the recharged GW is rainfall but for non-monsoon it is irrigation return flow. The estimated annual abstraction of groundwater from the aquifer for irrigation, domestic and municipal purposes is 1527.55 Mm^3. Though the annual recharge to the aquifer is valued greater than the annual discharge of groundwater in the study area, due to rapid urbanization and increased abstraction of groundwater, a gradual depletion of maximum depth to GWL is observed in the central part of the Rangpur City Corporation area since 2017. The depletion rate is about 0.13 m/year. However, steady or increasing trend in elevation of the GWL is observed in the peripheral part of the study area. The availability of replenishable groundwater for further development is currently not a challenging issue but lack of proper management of this resource is a matter of concern and may cause of a threat to the aquifer environment for this area.

Keywords: Aquifer, groundwater, recharge, discharge, water resource management

Introduction

Groundwater is a crucial part of freshwater resources in the world. It serves as a vital source of drinking water, maintains ecosystems, and is required for agricultural, industrial and variety of economic activities. Rangpur district includes Rangpur City Corporation (RpCC), an important and comparatively new City Corporation in northwestern part of Bangladesh, and faces growing demands of freshwater for various purposes - domestic consumption, agricultural and industrial activities. Evaluation

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of the groundwater resource and development potentiality in this area is essential for sustainable urban planning and resource management. The study area (Fig. 1) is located in between 25°18′ to 25°57′ N latitudes and 88°56′ to 89°32′ E longitudes, covering a total area of 2400.56 sq. km. The area has a total population of about 3.17 million (BBS 2023) and approximately 796,556 people within the city corporation

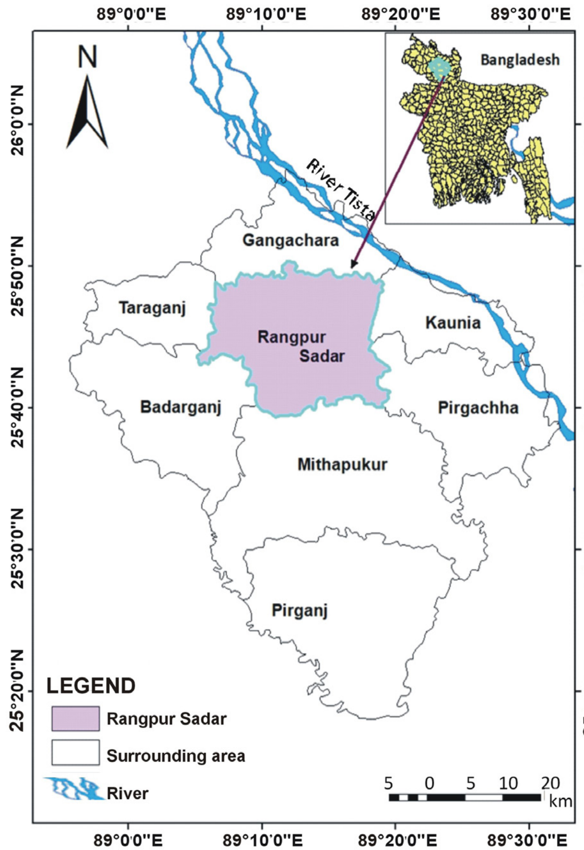

Fig. 1. Location map of the study area.

area (BBS 2024). Tectonically, the study area falls within the Rangpur Saddle, the Stable Shelf of Bangladesh (Alam 1972). Physiographically, the study area falls in the Tista Floodplain and the part of the Barind Tract (Rashid 1977). Surface geology of the area is composed of alluvial deposits containing gravel, sand, silt and clay of Recent age (UNDP 1982).

In 2016, a research work was conducted on groundwater vulnerability in the Rangpur area resulted from climate change using rainfall and temperature indicators. The results of this study showed that the groundwater is becoming more and more unstable due to the alarming rate of declination of groundwater level (HAQUE & TASNUVA 2016). The rapid decline of groundwater levels in the Rangpur district of northern Bangladesh is primarily due to excessive extraction of groundwater and land-based reservoir usage, reduced rainfall and climate degradation. Variations in rainfall and groundwater extraction are the most influential factors for the water resource management. A geochemical analysis indicates that most of the parameters of groundwater sample fall within the acceptable limits, some exceed the established permissible levels. The water quality may change due to contamination and seasonal variations, necessitating monitoring for temporal changes (RAFI *et al*. 2021). The water logging problem is also one of the major threats for the Rangpur City in recent future (SABNAM *et al*. 2021). The groundwater of Rangpur city area generally meets quality standards for drinking, domestic, and irrigation purposes, with sodium and bicarbonate as the dominant ions, though three samples exceed the potassium limit likely due to fertilizer use (SAHA *et al*. 2019).

In this study, the research mainly emphasize on assessment of groundwater recharge and discharge to evaluate the groundwater development potential of Rangpur District focusing on the City Corporation area. This research also focuses on sustainable management of groundwater resources in the study area.

Materials and Methodology

In this research, 36 exploratory bore log data were used to determine the depth, lateral extent, thickness, constituents of aquifers and aquitards, and the sequential position of subsurface layers of the rock formations. The bore log data were collected from Bangladesh Water Development Board (BWBD). In the data collection program, drilling holes were carried out by drilling rigs which collected split spoon and washed samples at selected intervals of depth and change in lithology. The lithological logs were prepared by the field geologists. Drilling depths of the wells for the bore log data were extend from 42.7 m to 85.4 m.

Groundwater level data from 10 piezometric wells for 35 years (1989 to 2023) were analyzed to observe the occurrence, movement and fluctuation of the hydraulic head of groundwater in and around the study area. Locations of the piezometers are shown in Figs. 3 and 4. The piezometric wells are installed at depths ranging from 20 to 30 meters. These data were collected from BWBD and the Department of Public Health Engineering (DPHE). Daily rainfall data for 28 years (1995 to 2023) collected from BWDB were also analyzed to observe the climatic conditions and their relation to the groundwater level in the study area.

Groundwater is a dynamic resource replenished annually or periodically through various sources, such as rainfall, irrigation return flow, dighis, ponds, and influent seepage. The estimation of groundwater recharge is a complex tusk due to various factors, including hydrogeological, hydrological, and climatological aspects controlling groundwater occurrence and movement. Moreover, the direct measurement of recharge and discharge are very difficult.

For the estimation of recharge and discharge, this research broadly follows the methodology suggested by Groundwater Resource Estimation Committee-1997 (CGWB-1997). Recent studies and reports, such as those by the Central Groundwater Board (CGWB-2014), validate the efficacy of Groundwater Resource Estimation Committee-1997. These assessments highlight the methodology and ability to provide reliable estimates amidst changing climatic conditions and land use patterns. They emphasize the methodology’s adaptability and robustness in addressing contemporary challenges in groundwater management and sustainability. Groundwater recharge in the study area has been estimated using various components such as recharge from rainfall, return-flow from irrigation, ponds, canal and other sources. For the estimation of recharge from rainfall, Water Level Fluctuation (WLF) method for monsoon and Rainfall Infiltration Factor (RIF) method for both monsoon and non-monsoon seasons are considered. Rainfall Infiltration Factor (RIF) method estimates groundwater recharge by analyzing how rainfall infiltrates the soil and contributes to aquifer replenishment. Effective rainfall is calculated by subtracting losses from runoff, evapotranspiration, and interception. On the other hand, rainfall recharge from Water Level Fluctuation (WLF) method is assessed from the values of storage change adding gross draft and subtracting recharge from other sources. Storage change in groundwater is evaluated by the product of annual fluctuation in groundwater levels, specific yield and recharge area. This technique requires continuous measurements of GWL with time from observation wells. For the comparison, percent difference (PD) between rainfall recharge from RIF and WLF is considered here. Data used in the recharge and discharge estimation methods are collected from BWDB, Bangladesh Meteorological Department (BMD), Bangladesh Agricultural Development Corporation (BADC), and Bangladesh Bureau of Statistics (BBS).

Results and Discussion

Aquifer System

The type and distribution of aquifers and aquitard within a geological system are determined by lithology, stratigraphy and sequential position of the layers. Fig. 2 shows bore log positions on the map (Fig. 2a) and the lithological cross sections (Fig. 2b & c) along the lines AA′ and BB′ from the specific bore logs. Analysis of the individual bore log and two cross-sections reveal that a thick sandy aquifer with occasional gravel existed at shallow depth throughout the study area. In some parts of the area, a very thin aquitard (clay and silt with very fine sand) are found at the top of the aquifer. Thickness of the aquitard varies approximately from 1 m to 12 m.

The sand aquifer with thickness ranging from approximately 60 m to > 80 m, is unconfined to semi-confined in nature. Available pumping test data from BWDB infers that the transmissivity and storativity values of the aquifer in the study area range from 300 m2/d to 2500 m2/d and 0.05 to 0.23, respectively, which indicates sufficient water transmitting capacity of the aquifer. The storativity values support that the aquifer is unconfined to semiconfined.

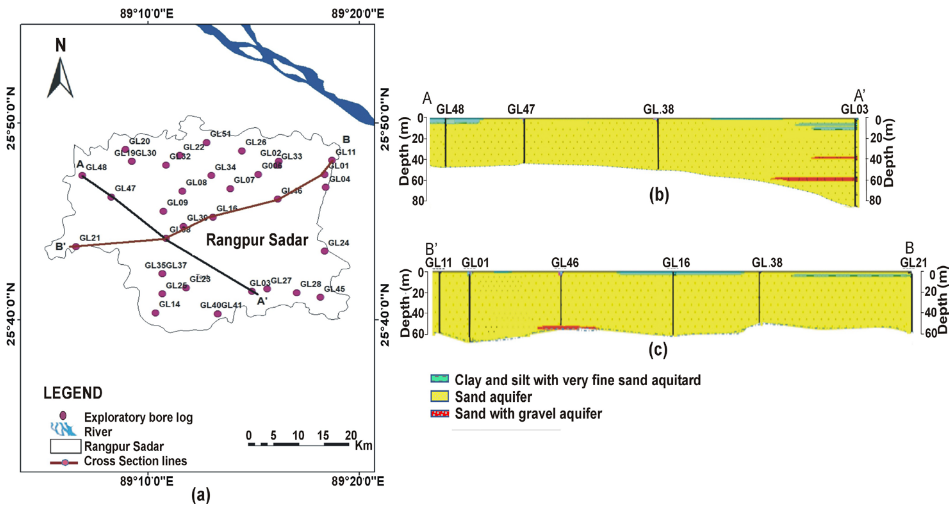

Fig. 2. (a) Location of exploratory bore logs in Rangpur Sadar area, and (b & c) subsurface hydro-stratigraphic cross-sections along lines AA′ and BB′.

Movement and Fluctuation of Groundwater

In this research, weekly groundwater level data for 35 years (1989 to 2023) are analyzed to observe the spatial movement of groundwater, seasonal and long term variation of GWL. The elevation contour maps (Fig. 3a & b) of GWL for 2021 show that the groundwater flows spatially from northwest to south-southeast direction for both wet and dry seasons.

To observe the fluctuations of GWL in different observation wells, a contour map (Fig. 4a) is prepared for the year 2021. The fluctuations of GWL in the study area range from maximum 4 m in Pirganj to minimum 1.5 m in Badarganj (Fig. 4a). Interaction between groundwater and rainfall are observed from the hydrographs (Fig. 4b). Seasonal fluctuation of the groundwater levels is highly associated with the variation of annual rainfall (Fig. 4b).

Fig. 5 demonstrate the long term variation in annual fluctuation and gradual declination trend in hydraulic heads of groundwater in 3 piezometric wells installed in the Rangpur Sadar area. Among these three, the piezometric well no. GT8549005

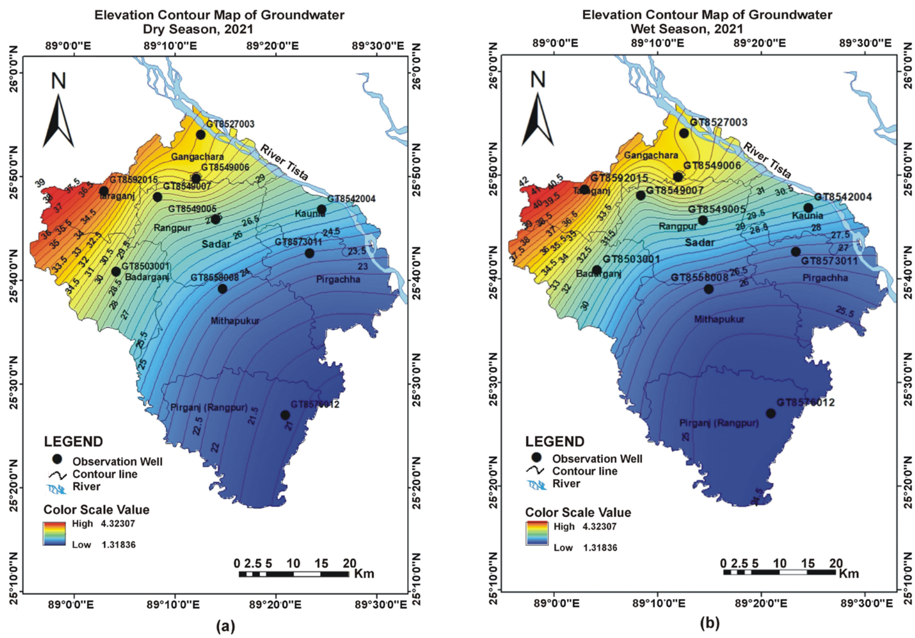

Fig. 3. Elevation contour maps of groundwater level (GWL) representing spatial movement of groundwater for dry (a) and wet (b) seasons of 2021.

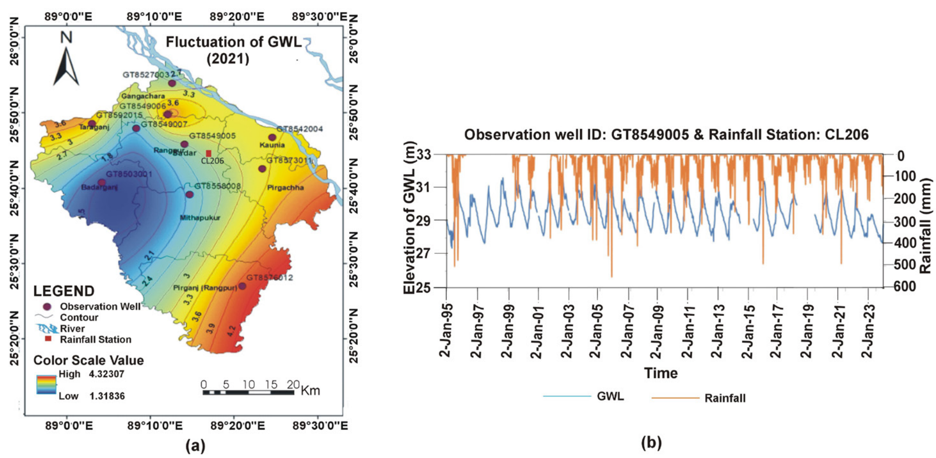

Fig. 4. (a) The contour map represents spatial variation of fluctuation of GWL for the year 2021. (b) Hydrographs of GWL and rainfall represent the fluctuation of GWL which is highly influenced by the seasonal variation of monsoonal rainfall.

(Fig. 5a) is situated in the city central area (Figs. 3 & 4) where the urbanization is growing very rapidly in the last few decades. From the recent research it is observed that the urban expansion trend in Rangpur City Corporation (RpCC) is 16 time greater from 2003 to 2023 (ADHIKARI *et al*. 2025). Rapid urbanization and significant changes in land use may impact on environmental sustainability and resource management in the RpCC area (RAHMAN *et al*. 2024).

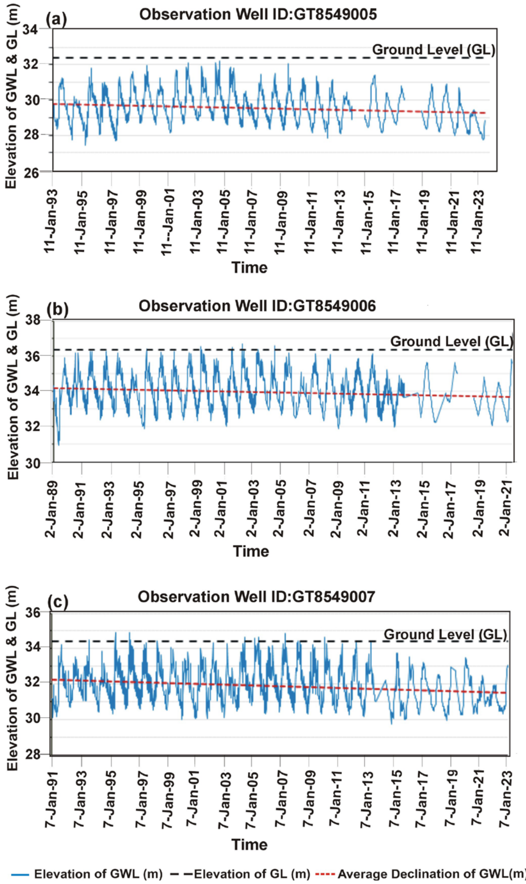

Fig. 5. Hydrographs represent the seasonal and long-term variation in hydraulic head of groundwater in Rangpur Sadar area.

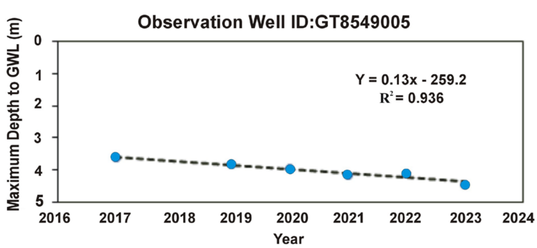

Fig. 6. Gradual declination of maximum depth to GWL in the city central part of Rangpur Sadar. The declination rate is about 0.13 m/yr since 2017.

Analysis of maximum depth to GWL (Fig. 6) clearly represents that the groundwater level (GWL) has been declining at an average rate of 0.13 m/yr from 2017 to 2023 in the city central part of the area. It indicates an alarming trend of declination in GWL which may impact on groundwater quality and other environmental degradation. Except Rangpur Sadar area, however, the elevation of GWL in other parts of Rangpur District is almost in steady condition or slightly increasing to some extent (Fig. 7).

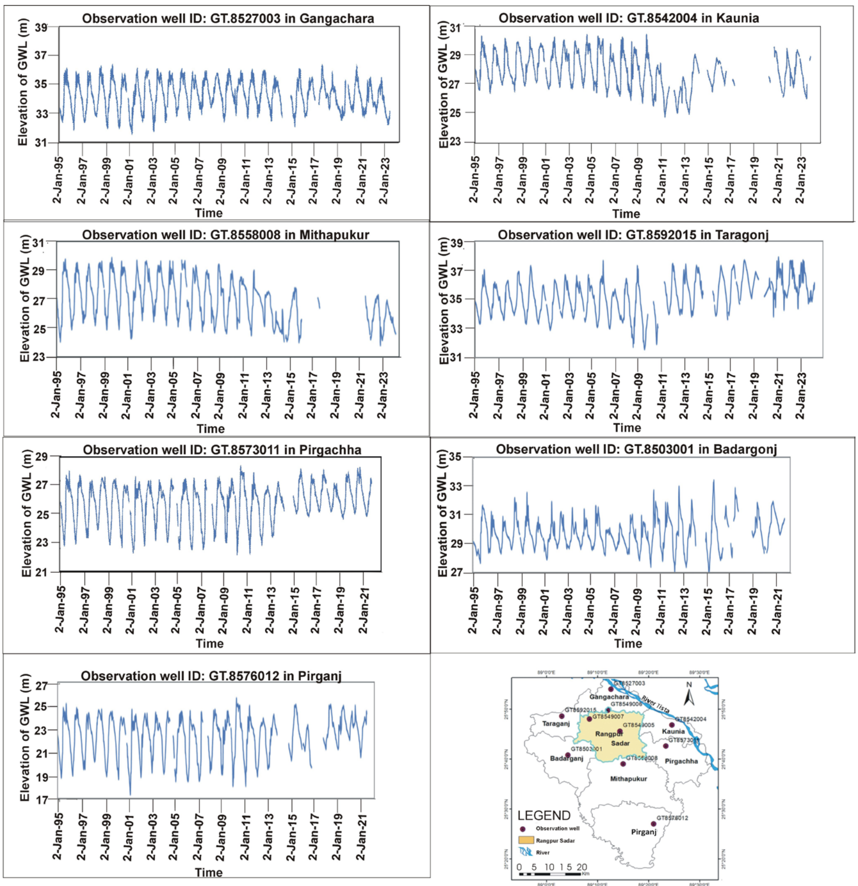

Fig. 7. Hydrographs represent the seasonal and long-term variation in hydraulic head of groundwater in peripheral parts of the Rangpur District except Rangpur Sadar area. The map represents locations of the observation wells.

Estimation of Groundwater Recharge and Discharge

Abstraction of groundwater for irrigation as well as domestic and industrial purposes and recharge of groundwater have been estimated to evaluate the future groundwater development potentiality in the study area. Rainfall and return flow from irrigated fields are the main components for groundwater recharge in this area.

The groundwater recharge from different sources are estimated for both monsoon and non-monsoon seasons. The assessment employs the WLF and RIF methods to analyze recharge components. These components include recharge from rainfall, canals, return flow from irrigation, and recharge from ponds, dighis and other sources.

Table1. Change in storage of groundwater for the Upazilas of Rangpur district.

District	Upazila	Area (km^2)	Specific yield (%)	Rise in water level due to monsoon (m)	Change in storage (Mm^3)
Rangpur	Badarganj	301.28	0.18	1.55	84.1
	Kaunia	147.64	0.18	3.27	86.9
	Mithapukur	515.63	0.18	2.19	203.3
	Rangpur Sadar	359.49	0.18	2.84	183.8
	Gangachara	269.67	0.18	2.75	133.5
	Pirganj	411.35	0.18	4	296.2
	Taraganj	128.65	0.18	3.14	72.7
	Pirgaccha	266.84	0.18	3.24	155.6
	Total	2400.55			1216.0

Table 2a. Rainfall recharge estimated using RIF method for monsoon and non-monsoon seasons.

District	Upazila	Area (km^2)	Rainfall (mm)		Recharge (Mm^3)	
			Monsoon	Non-monsoon	Monsoon	Non-monsoon
Rangpur	Badarganj	301.28	1188.2	616.9	89.5	46.5
	Kaunia	147.64	1188.2	616.9	43.9	22.8
	Mithapukur	515.63	1188.2	616.9	153.2	79.5
	Rangpur Sadar	359.49	1188.2	616.9	106.8	55.4
	Gangachara	269.67	1188.2	616.9	80.1	41.6
	Pirganj	411.35	1188.2	616.9	122.2	63.4
	Taraganj	128.65	1188.2	616.9	38.2	19.8
	Pirgaccha	266.84	1188.2	616.9	79.3	41.2
Total					713.1	370.3

Changes in groundwater storage are calculated as a product of total area, specific yield and fluctuations of GWL. Considering the properties of aquifer and upper aquitard of the study area, the specific yield value utilized in this method is 0.18% and the fluctuations of the groundwater level elevation are based on the collected GWL data for the period of 2021 to 2022. The results show that the total changes in groundwater storage is approximately 1216 Mm^3 (Table 1). Table 2a represents the rainfall recharge estimated by using Rainfall Infiltration Factor (RIF) method for monsoon (June to October) and non-monsoon (November to May) seasons for the same areas. The results from RIF method reveal that the estimated rainfall recharge for monsoon and non-monsoon are about 713.1 and 370.3 Mm^3, respectively. The rainfall recharge during monsoon season estimated using the WLF method are shown in Table 2b. Considering Percent Difference (PD) factor between values of rainfall recharges estimated by WLF & RIF methods, final rainfall recharge (855.72 Mm^3) are assessed for monsoon season (Table 2b). The availability of ground water recharge shows correspondence with amount of rainfall received because rainfall is one of the main component of groundwater recharge.

Table 2b. Rainfall recharge for monsoon season estimated using WLF method and considering factor of Percent Difference (PD) between WLF & RIF.

District	Change in Storage (Mm^3)	Total Groundwater Abstraction (Mm^3)		Total Recharge other than Rainfall (Mm^3)		Rainfall Recharge estimated from WLF method (Mm^3)	Considering PD between WLF & RIF, Rainfall Recharge in Monsoon season (Mm^3)
		Monsoon Season	Non-monsoon Season	Monsoon Season	Non-monsoon Season		
Rangpur	1216.0	292.99	1234.56	216.9	966.5	1560.1	855.72

Table 3. Recharge from canal seepage during monsoon and non-monsoon for the Upazilas of Rangpur district.

District	Upazila	Length (km)	Width (m)	Traversing area (m^2)	Seepage factor mm/day	Recharge during monsoon (Mm^3)	Recharge during non-monsoon (Mm^3)	Annual Recharge (Mm^3)
Rangpur	Badarganj	0	3.5	0	70	0.00	0.00	0.00
	Kaunia	0	3.5	0	70	0.00	0.00	0.00
	Mithapukur	10	3.5	35000	70	0.37	0.52	0.89
	Rangpur Sadar	0	3.5	0	70	0.00	0.00	0.00
	Gangachara	23	3.5	80500	70	0.86	1.19	2.06
	Pirganj	6	3.5	21000	70	0.22	0.31	0.54
	Taraganj	0	3.5	0	70	0.00	0.00	0.00
	Pirgaccha	5	3.5	17500	70	0.19	0.26	0.45
Total						1.65	2.29	3.93

Table 4. Irrigation return flow from groundwater (GW) and surface water (SW) during monsoon and non-monsoon seasons.

District	Total Area of SW Irrigation (ha)	Monsoon GW Irrigation Return Flow (Mm^3)	Non-monsoon GW Irrigation Return Flow (Mm^3)	Total GW Irrigation Return Flow (Mm^3)	Monsoon SW Irrigation Return Flow (Mm^3)	Non-monsoon SW Irrigation Return Flow (Mm^3)	Total SW Irrigation Return Flow (Mm^3)
Rangpur	163542	103.72	475.15	578.87	104.67	479.51	584.17

Table 5. Recharge from ponds and dighis during monsoon and non-monsoon seasons.

District	Upazila	Pond, Dhighee (acres)	Area of water spread (m^2)	Seepage factor mm/day	Annual Recharge (Mm^3)	Recharge during monsoon (Mm^3)	Recharge during Non-monsoon (Mm^3)
Rangpur	Badarganj	406	1643023.71	1.4	0.84	0.35	0.49
	Kaunia	432	1748241.97	1.4	0.89	0.37	0.52
	Mithapukur	59	238764.529	1.4	0.12	0.05	0.07
	Rangpur Sadar	3167	12816394.3	1.4	6.55	2.75	3.80
	Gangachara	1055	4269433.52	1.4	2.18	0.91	1.27
	Pirganj	1629	6592329.11	1.4	3.37	1.41	1.96
	Taraganj	564	2282427.02	1.4	1.17	0.49	0.68
	Pirgaccha	650	2630456.67	1.4	1.34	0.56	0.78
Total					16.46	6.90	9.56

Table 6. Estimated groundwater abstraction by DWTs and STWs for irrigation in monsoon and non-monsoon seasons.

District	DTWs (Nos.)	DTWs Irrigated Area (ha)	STWs (Nos.)	STWs Irrigated Area (ha)	Total Area of GW Irrigation (ha)	Monsoon GW Abstraction for Irrigation (Mm^3)	Non-Monsoon GW Abstraction for Irrigation (Mm^3)	Total GW Abstraction for Irrigation (Mm^3)
Rangpur	803	17872	78879	144184	162056	259.29	1187.87	1447.16

Table 7. Monsoon and non-monsoon abstraction of groundwater for domestic and municipal purposes.

District	Population in 2022 (K)			Water Demand in 2022 (Mm^3/yr)			Monsoon Water Demand in 2022 (Mm^3/yr)	Non-Monsoon Water Demand in 2022 (Mm^3/yr)
	Total	Urban	Rural	Urban	Rural	Total		
Rangpur	3169.61	2137.93	1031.68	59.31	21.09	80.39	33.70	46.69

Estimated values of recharge from other sources are disclosed in the Tables 3, 4 and 5. The total annual recharge from canal seepage is valued 3.93 Mm^3 during monsoon and non-monsoon seasons (Table 3). This estimation utilized a seepage factor of 70 mm/day. Table 4 shows that the irrigation return flow from groundwater and surface water are 578.87 Mm^3 and 584.17 Mm^3 respectively. Recharge from ponds and dighis exhibited in Table 5 reveals that the monsoonal recharge is 6.90 Mm^3 and non-monsoonal is 9.56 Mm^3.

Number of shallow tube wells (STWs) and deep tube wells (DTWs) installed in this area have been used to evaluate the discharge of groundwater during monsoon and non-monsoon periods. Groundwater withdrawn for domestic and municipal purposes has been estimated from the number of people living in the study area and the per capita water demand. The national growth rate of the population has been considered for calculating the annual increase in groundwater abstraction. Agriculture sector is the leading consumer of ground water in the study area. Results from data analysis presented in Table 6 which reveals that the annually total 1447.16 Mm^3 of groundwater is drafted for irrigation. The analysis further reveals that about 33.70 Mm^3/yr and 46.69 Mm^3/yr of groundwater are utilized for domestic and municipal purposes for monsoon and non-monsoon periods respectively (Table 7).

The total recharge to the aquifer and abstraction of groundwater during monsoon and non-monsoon periods of 2021 to 2022 are estimated and exhibited in Table 8. The results show that the total amount of annual recharge i.e., annual replenishable groundwater is about 2409.4 Mm^3. In the non-monsoon season, the recharge is approximately 1336.8 Mm^3, contributing 55.5% to the annual replenishable groundwater in the study area. During monsoon this amount is approximately 1072.7 Mm^3 contributing 44.5%. Return flow from water used for irrigation purpose in the non-monsoon season is the main source of recharge and contributing more recharge than that of the monsoon season. The results also reveal 51% of total GW recharge from annual rainfall, 48% from irrigation return flow and 1% from other sources.

Results from data analysis reveal that the total groundwater abstraction from the aquifer in this period for irrigation, domestic and municipal purpose is about 1527.6 Mm^3 (Table 8). Considering total annual groundwater recharge and discharge, the available groundwater resource for further development is estimated approximately 881.9 Mm^3 (Table 8). Annual recharge greater than annual discharge in the study area is reflected in Figure 7 which shows that the elevations of GWL are gradually increasing in Pirgachha, Badargonj, Taragonj and Pirganj, and it is almost constant in Gongachara, Kounia and Mithapukur. However, a noticeable declining trend in GWL elevation is observed in the observation wells installed in the city central part of Rangpur Sadar area (Fig. 5).

Table 8. Estimated groundwater recharge from various sources, annual replenishable groundwater and available resource for further development in Rangpur district area.

Season	Rainfall Recharge (Mm^3)	Irrigation Return flow from SW & GW (Mm^3)	Canal Seepage (Mm^3)	Recharge from other sources (Mm^3)	Total Recharge (Mm^3)	Groundwater Abstraction (Mm^3)	Available GW resource for further development (Mm^3)
Monsoon	855.7	208.39	1.65	6.90	1072.7	292.99	881.9
Non-monsoon	370.3	954.66	2.29	9.56	1336.8	1234.56	
Annual	1226.0	1163.0	3.9	16.5	2409.4	1527.6	

Declination rate in maximum depth to GWL in the city corporation area from 2017 is about 0.13 m/yr. (Fig. 6). Shrinkage of natural recharge area due to rapid urbanization and increased abstraction of groundwater could be the main causes of the declination of GWL in this area. A research study on monitoring the changing pattern of land use in the Rangpur City Corporation area found that in the urban area, wet lands are converted to settlement by earth filling. There was 21% low lying lands in 1989, it decreased to 15% in 2000 and 10% in 2014 (ISLAM & SARKER 2016).

Conclusions

The research work mainly focuses on the groundwater resource assessment and development potentiality in Rangpur City Corporation and its surrounding areas. A detail study involves the investigation on aquifer type and geometry, groundwater movement, estimation of seasonal and annual recharge and discharge, and assessment of replenishable groundwater resource for further development and sustainable management strategies in the research area.

A thick sandy aquifer with occasional gravel existed at shallow depth in this area is unconfined to semi-confined in nature. The groundwater in this area flows spatially from northwest to south-southeast direction throughout the year.

The total annual abstraction of groundwater for irrigation, domestic and municipal purposes in Rangpur district area is valued at about 1527.6 Mm^3. The total estimated annual replenishable groundwater is approximately 2409.4 Mm^3. For monsoon season, the main source of this recharge is rainfall but for non-monsoon, it is irrigation return flow. 51% of total replenishable groundwater is recharged from annual rainfall, 48% from irrigation return flow and 1% from other sources. 63.4% of total annual recharged water was abstracted for irrigation, domestic and municipal purposes. Rest of the storage, about 881.9 Mm^3, could be considered for further development in the peripheral part of Rangpur district area. Though the overall result shows that the annual recharge to the aquifer is valued greater than the annual discharge of groundwater, due to rapid urbanization and increased abstraction of groundwater, depth to the GWL in the city center part of Rangpur district area is declining from 2017 at a rate of 0.13 m/year. However, the elevation of GWL in other parts of the area are gradually increasing or in steady condition.

The results and findings of this research indicate that the availability of replenishable groundwater is not currently in a challenging position but proper management of this resource is a matter of concern as demand of groundwater has been increasing in this rapidly growing city corporation area. The estimation of groundwater recharge for dynamic part of the aquifer in Rangpur District provides valuable insights for sustainable management practices.

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টেকসই উন্নয়নের জন্য বাংলাদেশের রংপুর জেলার ভূগর্ভস্থ পানির পুনর্ভরণ এবং উত্তোলন মূল্যায়ন

মোছা: মরিয়ম আক্তার, সৈয়দা ফাহলিজা বেগম ও খায়রুল বাশার

সারসংক্ষেপ

এই গবেষণা প্রবন্ধে রংপুর সিটি কর্পোরেশন এবং এর পার্শ্ববর্তী এলাকার ভূগর্ভস্থ পানি সম্পদের মূল্যায়ন এবং উন্নয়ন সম্ভাবনার উপর আলোকপাত করা হয়েছে। বাংলাদেশের উত্তরাঞ্চলে রংপুর জেলায় অবস্থিত রংপুর সিটি কর্পোরেশন উক্ত অঞ্চলের প্রশাসনিক ও বাণিজ্যিক কেন্দ্র হিসেবে কাজ করে। এই অঞ্চলের মানুষের পানীয় জল, গৃহস্থালি, কৃষি এবং শিল্পের জন্য ব্যবহৃত প্রয়োজনীয় পানির চাহিদার একটি বড় অংশ ভূগর্ভস্থ জলাধার থেকে পূরণ করা হয়। সেইজন্য ভূগর্ভস্থ পানির টেকসই ব্যবস্থাপনা উক্ত অঞ্চলের অর্থনৈতিক উন্নয়ন এবং প্রকৃতির সুরক্ষার জন্য অপরিহার্য ।

এই গবেষণায় বোর লগ এবং ভূগর্ভস্থ পানিস্তরের উপাত্ত বিশ্লেষণ করে ৮৫ মিটার গভীরতার মধ্যে মাঝারি থেকে মোটা বালির একটি পানিবাহী শিলাস্তরের অবস্থান পরিলক্ষিত হয়, যা সমগ্র এলাকা জুড়ে বিস্তৃত। পানিবাহী শিলাস্তরটির পুরুত্ব ৩০ মিটার থেকে ৭০ মিটার। পানি উত্তোলনযোগ্য এই পানিবাহী শিলাস্তরটির জ্যামিতিক গঠন ও বৈশিষ্ট্য বিশ্লেষণে দেখা যায় যে, গবেষণা এলাকার অধিকাংশ অঞ্চলে এটি অনবদ্ধ থেকে আংশিক আবদ্ধ ভূগর্ভস্থ জলাধার বৈশিষ্ট্য সম্পন্ন । ভূগর্ভস্থ পানিস্তরের ৩৫ বছরের (১৯৮৯-২০২৩) উপাত্ত বিশ্লেষণে আরো পরিলক্ষিত হয় যে, এই অঞ্চলের ভূগর্ভস্থ পানি আদ্র ও শুষ্ক উভয় মৌসুমে উত্তর পশ্চিম থেকে দক্ষিণ-দক্ষিণ পূর্ব দিকে স্থানিকভাবে প্রবাহিত হয় এবং ভূগর্ভস্থ পানিস্তরের মৌসুমী হ্রাস-বৃদ্ধির উপর উক্ত অঞ্চলের বৃষ্টিপাতের প্রবল প্রভাব রয়েছে।

এখানে ভূগর্ভস্থ পানিস্তরের হ্রাস-বৃদ্ধি (Water Level Fluctuation) এবং বৃষ্টিপাত অনুপ্রবেশ ফ্যাক্টর (Rainfall Infiltration Factor) পদ্ধতি ব্যবহার করে বর্ষা এবং শুষ্ক উভয় মৌসুমের জন্য বৃষ্টিপাত থেকে ভূগর্ভস্থ পানির পুনর্ভরণ (Recharge) পরিমাপ করা হয় । গবেষণার ফলাফল বিশ্লেষণে দেখা যায় যে, মোট আনুমানিক বার্ষিক ভূগর্ভস্থ পানির পুনর্ভরণ (Recharge) প্রায় ২৪০৯.৪ মিলিয়ন ঘন মিটার এবং এই পুনর্ভরণের ৫১% বার্ষিক বৃষ্টিপাত, ৪৮% সেচ ফেরত প্রবাহ এবং ১% অন্যান্য উৎস থেকে হয়ে থাকে। বর্ষা মৌসুমে পুনর্ভরণকৃত ভূগর্ভস্থ পানির প্রধান উৎস বৃষ্টিপাত হলেও শুষ্ক মৌসুমে এটি সেচ ফেরত প্রবাহ। তথ্য উপাত্ত বিশ্লেষণ করে দেখা যায় যে, কৃষি, গৃহস্থালি এবং পৌর এলাকার অন্যান্য পানির চাহিদা পূরণের উদ্দেশ্যে ভূগর্ভস্থ জলাধার থেকে আনুমানিক বার্ষিক ১৫২৭.৫৫ মিলিয়ন ঘনমিটার পানি উত্তোলন (Discharge) করা হয় । যদিও সামগ্রিকভাবে গবেষণা এলাকায় ভূগর্ভস্থ পানির বার্ষিক উত্তোলনের তুলনায় ভূগর্ভস্থ জলাধারে বার্ষিক পুনর্ভরণের পরিমান বেশি, দ্রুত নগরায়ন এবং ভূগর্ভস্থ পানির ব্যবহার উল্লেখযোগ্য হারে বৃদ্ধি পাওয়ায় রংপুর সিটি কর্পোরেশন এলাকার কেন্দ্রীয় অংশে ২০১৭ সাল থেকে ভূগর্ভস্থ পানিস্তরে ক্রমবর্ধমান পতন পরিলক্ষিত হয় । এই পতনের হার বছরে প্রায় ০.১৩ মি.। তথাপি, রংপুর জেলার প্রান্তিক অংশে ভূগর্ভস্থ পানিস্তরের উচ্চতায় স্থির অথবা ক্রমবর্ধমান প্রবণতা পরিলক্ষিত হয় ।

পরিশেষে বলা যায় যে, রংপুর জেলার অধিকতর উন্নয়নের জন্য পুনর্ভরণযোগ্য ভূগর্ভস্থ পানির প্রাপ্যতা বর্তমানে বিপর্যয়কর পরিস্থিতিতে না থাকলেও এই পানিসম্পদের সঠিক ব্যবস্থাপনার অভাব উদ্বেগের বিষয়। রংপুর সিটি কর্পোরেশন এলাকায় ভূগর্ভস্থ পানির চাহিদা বৃদ্ধি এবং ভূগর্ভস্থ পানিস্তরের ক্রমবর্ধমান পতন ভবিষ্যতে এই অঞ্চলের ভূগর্ভস্থ জলাধারের পরিবেশের জন্য হুমকির কারণ হতে পারে। অতএব ভবিষ্যৎ প্রজন্মের জন্য ভূগর্ভস্থ পানির প্রাপ্যতা নিশ্চিত করার লক্ষ্যে আরো গবেষণা এবং ভূগভস্থ পানিসম্পদের টেকসই ব্যবস্থাপনায় কার্যকর পদক্ষেপ গ্রহণ করা প্রয়োজন।

Assessment of Groundwater Recharge and Discharge for Sustainable Development