Journal of Studies in Social Sciences and Humanities
http://www.jssshonline.com/
Volume 7, No. 4, 2021, 400-418
ISSN: 2413-9270

Assessment of potential groundwater zones based on AHP and Geospatial approach in Berhampore Block, Murshidabad District, West Bengal, India

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Abstract

Because of the scarcity or insufficiency of surface water, groundwater plays a crucial position in agriculture, residential, and industrial spheres for growth on a national to the local level. The research aimed to provide a thorough understanding of groundwater prospective zones based on twelve variables such as geomorphology, hydro-geology, lineament density, soil texture, drainage density, slope, rainfall, topographic wetness index, roughness, topographic position index, curvature, and land use and land cover by using a combination of the analytical hierarchy process (AHP) with GIS methodologies in Berhampore block, Murshidabad district. Then, the resulting output was cross-validated by employing bore well data from the Central Ground Water Board, West Bengal. GWPZ map was divided into five categories: very low, low, medium, high, and very high, with 2.74 percent, 38.55 percent, 48.50 percent, 9.92 percent, and 0.29 percent, respectively. It was discovered that the south and eastern parts were in the very high and high potential zone due to the poorest drainage density, the concentration of vegetation, agricultural land, and extremely low topographic position index. Therefore, it indicated that the analytical hierarchy process combined with geospatial technique is reliable and can verify GWPZs in any location or environment.

Key words: Groundwater potential zone, Analytical hierarchy process, Weighted overlay, Geospatial approach, Berhampore

Introduction

Groundwater is a dynamic and long-term natural asset that resides in subterranean porous spaces and defined channels, such as those seen in karst developments formed via its dissolution of soluble rocks, such as limestone. It contains almost 30 percent of the world's freshwater, whereas streams and lakes contain only 1.2 percent (Brands et al., 2016). In India, groundwater represents 62 percent of irrigation, 85 percent of arable water supplies, and 45 percent of urban water supply, respectively (Devanantham et al.,2020). Likewise, over 90 percent of the village people rely on groundwater for consumption and residential purposes (Reddy et al., 1996). As a result, several parts of the country's tropical and subtropical areas with high population and economic expansion have been experiencing severe groundwater problems on a daily basis. NITI Aayog, 2017-18 stated that almost 0.6 million people in India are facing severe to highly severe water stress due to inadequate access to groundwater. Gun, 2012 stated that the depleting ratio of underground water in India is believed to be 251 km3 per annum.

According to a World Bank assessment, "India will become a water-stress region by 2025 as well as a water-scarce zone by 2050" (Arulbalaji et al., 2019). On the contrary, in West Bengal, roughly 56 percent of the wells tested to keep a record of groundwater levels revealed a reduction in 2013 compared to 2003 to 2012 (Mukherjee, 2016). Hence, recognizing potential groundwater regions is crucial for optimizing the use and management of this valuable asset (Hutti and Nijagunappa, 2011). Since groundwater is impossible to detect clearly, monitoring, mapping, and modeling activities in an appropriate fashion are essential to understand its accumulation, diffusion, and trends of inflow (Brands et al., 2016). Test drilling and stratigraphic evaluations are the strongest reliable or conventional approaches for estimating positions, the thickness of springs, and other underlying details; in any case, such technologies are pricey, time-consuming, and require highly skilled personnel. Several approaches for defining prospective groundwater zones such as, "influence factor" (Selvam et al., 2015; Magesh et al., 2012; Nasir et al., 2018) "frequency ratio" (Guru et al., 2017; Al- Abadi et al., 2015), "logistic regression method"(Pourtaghi and Pourghasemi, 2014), "linear weighted combination method"(Abdalla et al., 2020), "electromagnetic survey" (Shaohong et al., 2010), "shannon entropy and random forest model" (Naghibi et al., 2016; Zabihi et al., 2015), "weights of evidence and evidential belief function model"(Tahmassebipoor et al., 2016), "certainty factor," "decision tree," "artificial neural network" have been used by different researchers. Nonetheless, among them, the analytical hierarchy process (AHP) with the mixture geospatial technique is thought to be a straightforward, dependable, and cost-efficient approach (Machiwal et al., 2011; Ishizaka and Labib, 2011; Maity and Mandal, 2017). In South Africa, Egypt, Burdur in Turkey, Ghana, Maknassy basin, Tunisia, Kurdistan region, and Iran, numerous proceedings have been done utilizing this combinational technique to evaluate groundwater assets (Roy et al., 2020). On the contrary, a similar investigation also has been conducted in India, particularly in South Western Ghats (Arulbalaji et al., 2019), Kancheepuram district, Tamilnadu (Saranya et al., 2020), Dumka district, Jharkhand (Murmu et al., 2019), semi-arid region of India (Machiwal et al., 2011), lower Rihand river basin (Verma et al., 2021), Gautam Buddh Nagar district, Uttar Pradesh (Banerjee et al., 2021). In the context of West Bengal, groundwater possibility zone studies using geospatial and AHP methods have been observed in Purulia district (Das et al., 2019), Gangajalghati block, Bankura district (Nag et al., 2014), red and lateritic zone (RLZ) of West Bengal (Roy et al., 2020), Purba Bardhaman district (Pal et al., 2020), Raniganj block, Paschim Bardhaman district, and Uttar Dinajpur district respectively (Biswas et al., 2020). Several professionals have recently discovered that combining AHP and geospatial strategy is a viable tool for water conservation since it provides structure, accountability, openness, and clarity to the decision-making process (Murmu et al., 2019). Against this backdrop, the fundamental purpose of this research is to use AHP in conjunction with geospatial techniques to identify potential groundwater regions in the Berhampore block of the Murshidabad district.

Study area

The investigated area (Fig. 1) is sited in the lengthy and slender Ganges-Bhagirathi drainage basin, in the latitudes of 24º 06'N and 88º 15'E, with a total landmass of 314.19 square kilometers. It is bounded to the north with Murshidabad Jiaganj C.D block, the east via Hariharpara C.D block, the south with Beldanga C.D block, and the west through Nabagram C.D block, with an overall altitude of 22 meters above mean sea level. The region has 1 panchayat samiti, 17-gram panchayats, 317 gram-sansads, 144 mouzas, and 124 populated villages (Wikipedia, 2021). The average annual temperature is around 27°C with 1600 mm of rainfall per annum and experiences tropical climate throughout the year. The 2011 census includes 446887 people, 228650 are males, and 218237 are females, with a population growth of 17.95 percent in the last ten years. The block has a total of 288,728 literates, with males accounting for 153,930 and females representing 134,798. The livelihood of the region depends upon farming. Around 40.56 percent (1581 hectares) and 59.44 percent (2317 hectares) area is irrigated by surface water and groundwater, respectively (District statistical handbook, 2018). As inhabitants rely on groundwater for residential, irrigation, and other activities, the groundwater level is progressively declining in most parts of the region, raising concern within surveillance authorities. As a result, adequate groundwater assessment, planning, and maintenance are crucial for the research area.

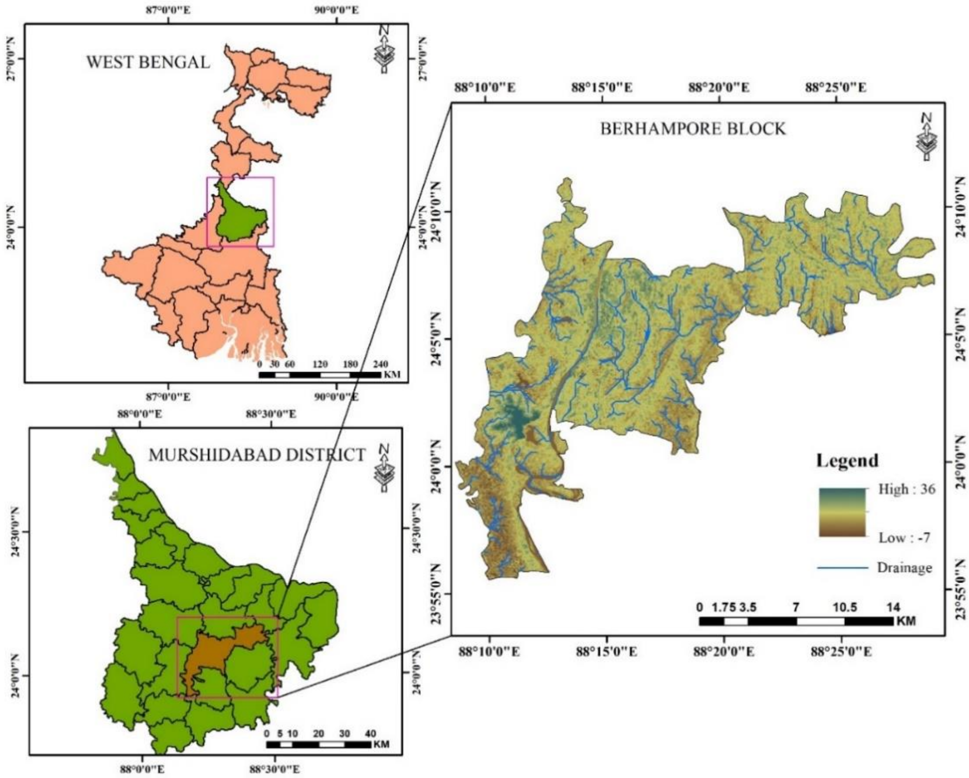

Fig. 1. *Locational diagram of the research area*

Source: Prepared by the author

Materials and method

Data employed during the study

The techniques to discover promising groundwater regions have been handled in this research, as shown in Fig. 2. The official maps of geomorphology, hydrogeology, and soil texture were collected from the Geological Survey of India, Central Ground Water Board, and the National Bureau of Soil Survey, digitized them by utilizing ArcGIS 10.8. The Landsat-8 OLI (30 m spatial resolution) satellite image from Earth Explorer-USGS was used to produce an LULC map by employing maximum likelihood classification technique via ERDAS Imagine (14) and ArcGIS 10.8 software. Rainfall map from the WorldClim data was created using the IDW or inverse weighted interpolation algorithm. Drainage density, slope, curvature, and roughness maps were constructed from 30 m SRTM DEM in ArcGIS 10.8. The surface toolbar had generated lineaments from SRTM DEM imagery by making four distinct hill shades of four various elevations, then had manually been digitized to obtain lineaments. Following that, the line density tool was used to create the lineament density map. The "TOPMODEL" index approach and Jennes's algorithm were used to calculate the topographic wetness and position index.

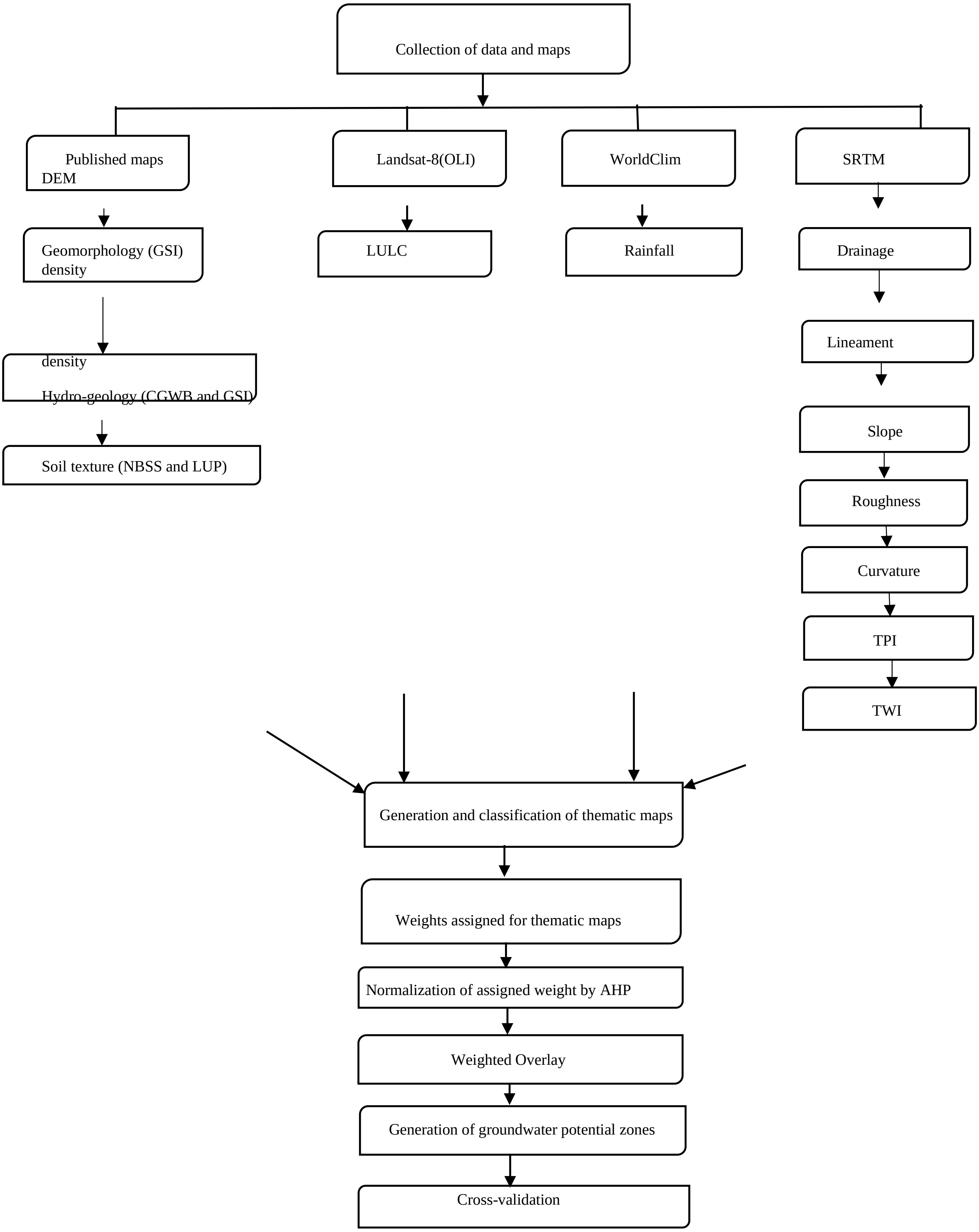

Fig. 2. *Flowchart of the methodology*

Source: Developed by the author

3.2. Assigning rank and weight using the AHP technique

The Analytical hierarchy process, designed by Saaty at the Wharton School of Business, is a progressively emerging and leading tool in subsurface expectation modeling, with quick, efficient, and cost-effective outcomes (Saaty, 1980). It is an excellent and flexible weighted scoring decision-making procedure that assists users in making judgments and selecting the best option (Velmurugan et al., 2011). For generating an eigenvalue pair-wise comparison matrix, field survey knowledge, stakeholder evaluation, existing literature discussions, and a specialist opinion poll were incorporated to decide each factor's weight, rating, and respective subclasses. As a fundamental scale of significance, Saaty designed a scale of 1–9 based on that; a matrix was done (Table 1). A layer with a strong influence is represented by a component with greater weight, whereas a more negligible impact on groundwater probability represents a layer with a lesser weight. The matrix was generated by contrasting each factor and assigning a rating based on their respective priority and water retaining capability, grouped in a row and column format (Table 4). The row was referred to as factor A, whereas the column was referred to as factor B. To see the given weights and ratings are flawed or not, the following equation was used to calculate the consistency index (CI) as deviance or degree of consistency:

$$\text{CI} = \frac{\lambda\, max - n}{n-1}$$

Where λmax is the highest eigenvalue in the pair-wise comparison matrix table and n is the number of factors. $\lambda\text{max} = \frac{144}{12} = 12$ and $\text{CI} = \frac{12-12}{12-1} = 0$

The underlying equation was used to determine the consistency ratio.

$\text{CR} = \frac{CI}{RI}$ Where CI= Consistency Index, RI= Random Index for different n values (Table 2).

$\text{CR} = \frac{0}{1.48} = 0$. When the consistency ratio value is lesser than or equivalent to 0.1, the consistency is accepted; otherwise, we must update our judgement (Saaty, 1990). If the consistency ratio's value is 0, it signifies that the pair-wise comparison has a flawless level of consistency, and the judgement matrix is quite consistent.

Table 1.

The 1-9 foundational scale of Saaty for the pair-wise comparison

Intensity of importance	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very to the extreme importance
9	Extreme importance

Source: Saaty, 1980

Table 2.

Random inconsistency index

n	1	2	3	4	5	6	7	8	9	10	11	12
R.I	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48

Source: Saaty, 1980

Table 3.

The weight assigned to various groundwater management variables in the case of this research

Factors	Normalized Weight	Influence (%)	Rate	Area(*in* km^2)
Geomorphology				
Major floodplain	0.121	12.12	7	116.04
Minor floodplain			7	76.97
Para deltaic fan surface			8	5.65
Upper mature deltaic plain			8	96.01
Upper mature deltaic plain clayey			8	39.58
Hydro-geology				
An alternating layer of sand, silt and, clay	0.106	10.61	8	291.34
Fine sand, silt and, clay			8	42.60
Rajmahal basalt impregnated with caliche nodules			7	334.21
River			9	12.70
Lineament density				
0 - 0.37	0.106	10.61	2	229.92
0.38 - 0.74			4	77.07
0.75 - 1.1			6	18.66
1.2 - 1.5			8	6.56
1.6 - 1.8			9	2.63
Soil texture				
Fine and coarse loamy	0.106	10.61	9	228.53
Fine and fine loamy			7	33.22
Fine loamy			8	30.93
Fine			6	57.59
Drainage density				
0 - 0.57	0.091	9.09	8	78.79
0.58 - 1.1			6	87.43
1.2 - 1.7			4	86.64
1.8 - 2.3			3	55.87
2.4 - 2.8			2	25.17
Slope				
0-1	0.091	9.09	8	102.64
1-2			6	143.17
2-3			4	54.97
3-5			3	24.26
>5			2	4.06
Rainfall				
154.608 – 157.2432	0.076	7.58	2	111.60
157.2433 – 159.8758			3	91.12
159.8759 – 162.5111			4	53.30
162.5112 – 165.1464			5	43.84
165.1465 – 167.7817			6	34.33
Topographic wetness index				

4.3 - 7.7	0.076	7.58	2	118.80
7.8 – 9.2			3	104.18
9.3 – 11			4	64.42
12 – 13			5	30.19
14 - 23			6	11.09
Roughness				
0.11 - 0.28	0.061	6.06	6	27.33
0.29 - 0.43			5	62.03
0.44 - 0.57			4	150.47
0.58 - 0.71			3	60.84
0.72 - 0.89			2	25.44
Topographic position index				
-24 - -3.1	0.061	6.06	6	25.69
-3 - -0.7			5	110.01
-0.69 - 1.4			4	119.76
1.5 – 4.4			3	66.64
4.5 - 17			2	11.63
Curvature				
-3.1- -0.35	0.061	6.06	2	12.06
-0.34 - -0.1			3	118.22
-0.09- 0.11			4	74.72
0.12- 0.33			5	97.58
0.34- 3.9			6	31.22
LULC				
Agriculture	0.045	4.55	5	181.58
Barren land			6	13.89
Vegetation			8	53.52
Settlement			2	62.34
Waterbody			9	22.77

Source: Calculated from Table 4

Table 4.

Pair-by-pair comparison matrix used in this investigation

Factors	Assigned weight	Geomorphology	Hydro-geology	Lineament density	Soil texture	Drainage density	Slope
Geomorphology	8	8/8	8/7	8/7	8/7	8/6	8/6
Hydro-geology	7	7/8	7/7	7/7	7/7	7/6	7/6
Lineament density	7	7/8	7/7	7/7	7/7	7/6	7/6
Soil texture	7	7/8	7/7	7/7	7/7	7/6	7/6
Drainage density	6	6/8	6/7	6/7	6/7	6/6	6/6
Slope	6	6/8	6/7	6/7	6/7	6/6	6/6
Rainfall	5	5/8	5/7	5/7	5/7	5/6	5/6
TWI	5	5/8	5/7	5/7	5/7	5/6	5/6
Roughness	4	4/8	4/7	4/7	4/7	4/6	4/6
TPI	4	4/8	4/7	4/7	4/7	4/6	4/6
Curvature	4	4/8	4/7	4/7	4/7	4/6	4/6
LULC	3	3/8	3/7	3/7	3/7	3/6	3/6

Table 4.

Continued…

Rainfall	TWI	Roughness	TPI	Curvature	LULC	Geometric mean	Normalized weight	Eigenvector (λ)
8/5	8/5	8/4	8/4	8/4	8/3	1.514	0.121	12
7/5	7/5	7/4	7/4	7/4	7/3	1.325	0.106	12
7/5	7/5	7/4	7/4	7/4	7/3	1.325	0.106	12
7/5	7/5	7/4	7/4	7/4	7/3	1.325	0.106	12
6/5	6/5	6/4	6/4	6/4	6/3	1.135	0.091	12
6/5	6/5	6/4	6/4	6/4	6/3	1.135	0.091	12
5/5	5/5	5/4	5/4	5/4	5/3	0.946	0.076	12
5/5	5/5	5/4	5/4	5/4	5/3	0.946	0.076	12
4/5	4/5	4/4	4/4	4/4	4/3	0.757	0.061	12
4/5	4/5	4/4	4/4	4/4	4/3	0.757	0.061	12
4/5	4/5	4/4	4/4	4/4	4/3	0.757	0.061	12
3/5	3/5	3/4	3/4	3/4	3/3	0.568	0.045	12

Weighted overlay approach to determine the prospective zone for groundwater

Groundwater potential zone was calculated by weighted overlay analysis by using the following formula

$$\text{GWPZ}= \sum_{i}^{n}(A_Y * B_Z)$$

GWPZ = groundwater prospective zone, A = weight of thematic layers, and B = rating of thematic layer's sub-class. Thematic maps were addressed by the Y term, while the Z term had represented the thematic map's sub-classes. Then region's subsurface potential zone map was generated and evaluated using groundwater wells data of the Central Ground Water Board, West Bengal. To examine the reliability of the present work, the well-discharging points were overlapped on the ultimately created output map, shown in Fig. 15.

Formulation and ratings of the various factor for potential groundwater zone

Geomorphology

Geomorphology encompasses the study of landforms, notably their nature, formation, evolutionary phases, and mineral constitution. The unusual activity of several topographical processes, such as thermal fluctuations, freezing, refreezing, molecular reactivity, seismic tremors, air, and water movement, create the geometrical features of various landscapes. As it affects groundwater's underlying growth, so performs a significant role in monitoring the underground water capacity and possibility. Major floodplain, minor floodplain, para deltaic fan surface, upper mature deltaic plain, and upper mature deltaic plain clayey are the five types of geomorphological units found in this area. Table 3 shows the desired rating for these units depending on the amount of water they can hold. The geomorphology of the examined area is depicted in Fig. 3.

Hydro-geology

Hydro-geology depicts fundamental topographical units, morphologies, and underneath geology to comprehensively understand dynamics, material/lithology, structures, and geological processes influencing groundwater occurrences and their consequences. The hydrogeological map depicts that potential groundwater regions are essential for planning and executing subsurface investigation. The land is divided into four hydrogeological classes, as demonstrated in Fig. 4 and Table 3.

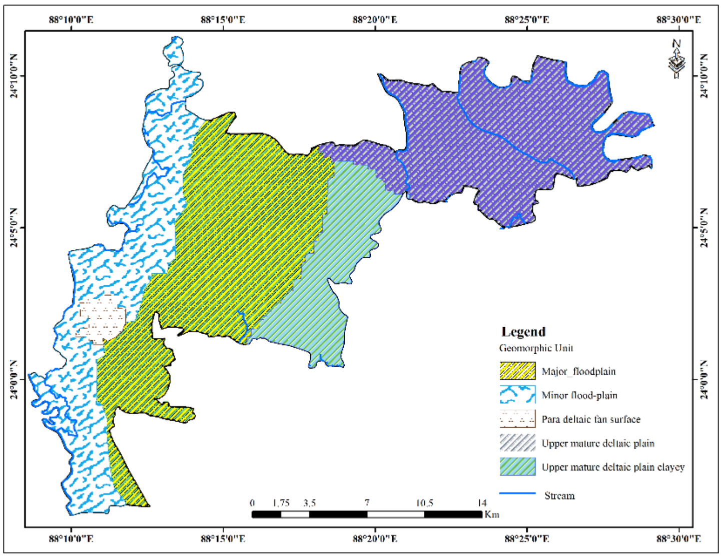

Fig. 3. *Geomorphology of the research area*

Source: Geological Survey of India

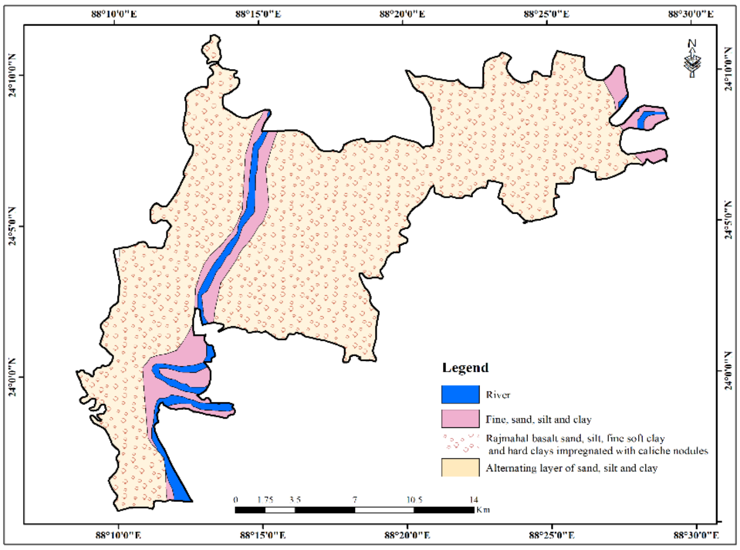

Fig. 4. *Hydro-geology of the research area*

Source: CGWB and Geological Survey of India

Lineament density

A lineament is a modifiable linear or curved pattern of a landscape, the pieces of which correspond in a straight or curving arrangement (Hung et al., 2005). Hydro-geologically significant joints, fractures, and faults act as a conductivity for subsurface flows, result in higher permeability, and thus function as a subterranean possibility zone. Owing to the considerable penetration rate, the terrain containing the lineament and its interconnecting site is thought to be a good location for groundwater holding. By applying the manual digitization procedures, the study area's lineaments have been derived, and then lineament density is created with the help of the line density module in the ArcGIS program, as displayed in Fig. 5. The area is divided into five sections, i.e., extremely low (0-0.37 km/ km^2), low (0.38-0.74 km/ km^2), moderate (0.75-1.1 km/ km^2), high (1.2-1.5 km/ km^2), and extremely high (1.6-1.8 km/ km^2). Based on the preceding explanation, we can accept that locations with a higher lineament concentration have a greater influence on the subsurface potential zone than areas with low lineament concentration.

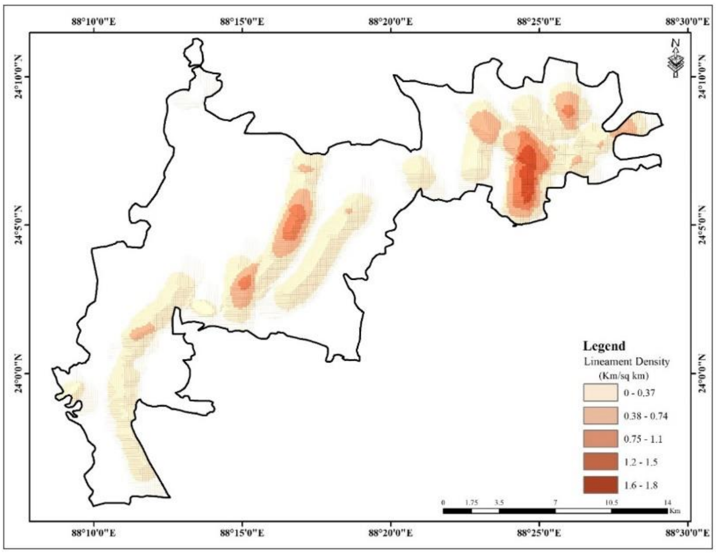

Fig. 5. *Lineament density of the research area*

Source: Prepared by the author

Soil texture

Run-off water and its replenishment are both affected by soil texture. The soil type, degree of absorption, permeation, and penetrability play a role in groundwater recharge (Jasrotia et al., 2016). Fine and coarse loamy, fine and fine loamy, fine loamy, and fine soil are the four varieties of soil found in the research area. Each soil unit has been assigned a rank based on the soil types and the degree of incursion (Murmu et al., 2019). Fine and coarse loamy soils have an excellent infiltration capacity; therefore, they have been allocated greater ranking, whereas fine soils have a poor infiltration rate, so they have been assigned lower value. The soil texture profile of the investigated area is depicted in Fig. 6.

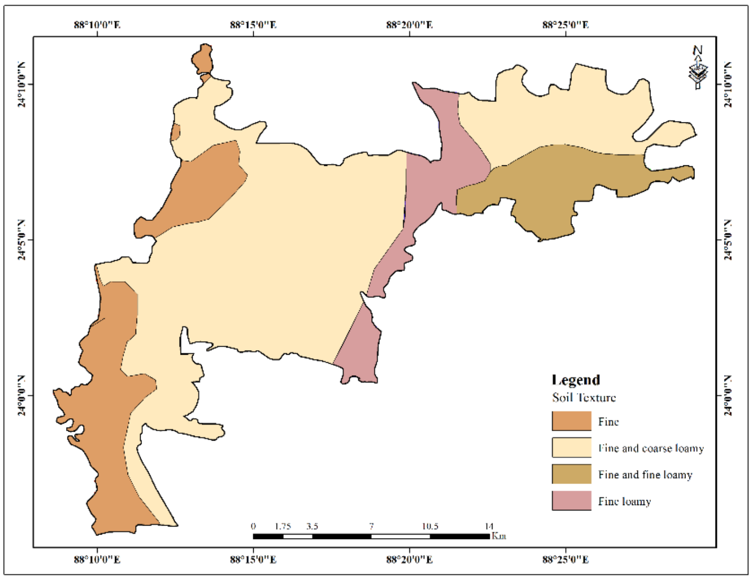

Fig. 6. *Soil texture of the research area*

Source: National Bureau of Soil Survey and Land Use Planning, Nagpur

Drainage density

Because of the entirely reliant on the landscape's fluidity, it is likely to be the essential aspect of topographic characteristics (Carlston, 1963). The greater the drainage density, the greater the run-off, and the lower the drainage density, the better the likelihood of recharging or subsurface zone possibility (Prasad et al., 2008). Drainage density of the research area is classified into four categories: very low (0.57 km/ km^2), low (0.58-1.1 km/ km^2), moderate (1.2-1.7 km/ km^2), high (1.8-2.3 km/ km^2), and very high (2.4-2.8 km/ km^2). For groundwater prospective zone's delineation, lower drainage density regions have been allotted high weight while higher regions have minimal weight (Fig. 7).

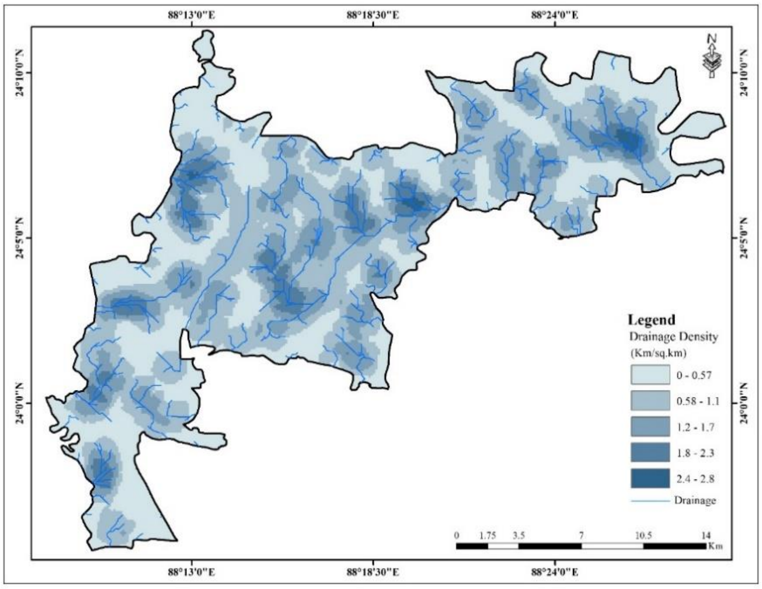

Fig. 7. *Drainage density of the research area*

Source: Prepared by the author

Slope

As it affects run-off velocity, run-off persistence, and penetration capability on the surface soil, that is why it is an essential factor in determining the groundwater replenishment zone in a place. Regions having cliffs have low groundwater levels since less time is given stream to infiltrate; thus, precipitation is easily adapted to run-off and rapidly flows down the slope; on the contrary, rainwater can permeate deeply into the subsurface in areas with low slopes. The slope has been characterized as extremely low (0-1), low (1-2), moderate (2-3), high (3-5), and extremely high (>5) shown in Fig. 8. Lesser slope categories have been allocated the greater rank because of smooth topography that allows for better groundwater preservation, whereas steepest slopes are the lowest due to higher run-off and lower penetration.

Rainfall

Rainfall is a significant supplier of water in the hydrological process and perhaps the most crucial contributing parameter in groundwater in any given area. The WorldClim data for August 2018 is employed to create a spatial rainfall dispersal map using the IDW interpolation technique (Fig. 9). The higher values have been assigned to places with significant precipitation, while the lower ones have been allotted to regions with very little rainfall.

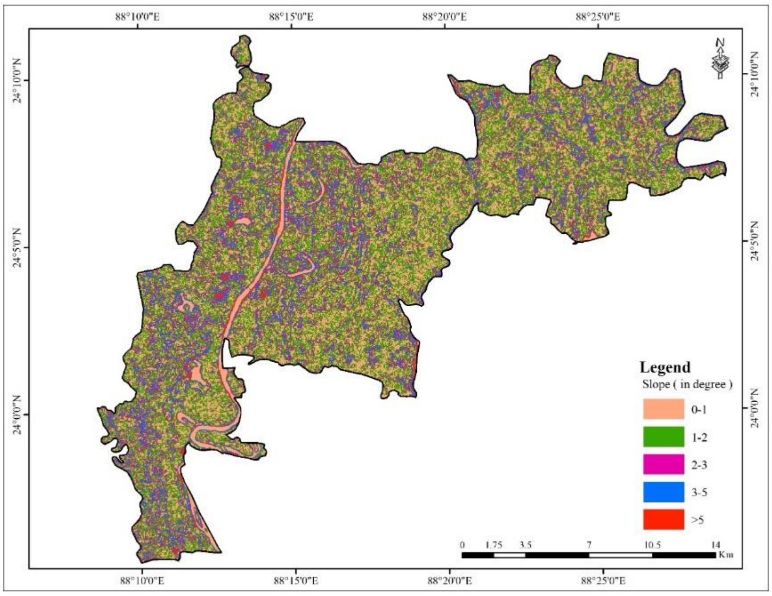

Fig. 8. *Slope of the research area*

Source: Prepared by the author

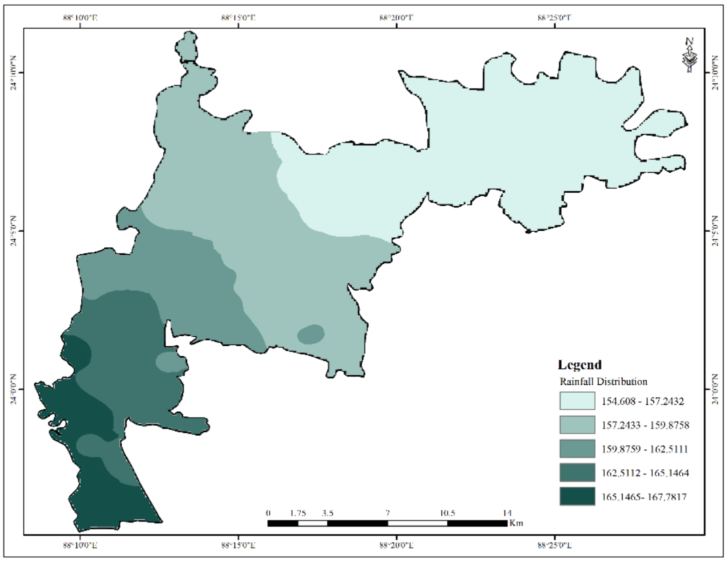

Fig. 9. *Rainfall of the research area*

Source: Prepared by the author

Topographic wetness index (TWI)

The compound topographic index (CTI) is a steady-state wetness indicator, commonly known as the TWI. It is utilized to figure out how topography affects hydrological systems and to show how landforms might influence groundwater infiltration (Arulbalaji et al., 2019). The TWI was prepared using TOPMODEL, which have the following equations TWI=In $\frac{\alpha}{\tan\beta}$

Where α=Upslope contributing area, β=Topographic gradient. Figure 10 demonstrates that the topographic wetness index of the area is categorized into five classes: relatively low (4.3-7.7), low (7.8-9.2), moderate (9.3-11), high (12-13), and incredibly high (14-23). For the high topographic wetness index, high ratings have been allotted, and vise - versa.

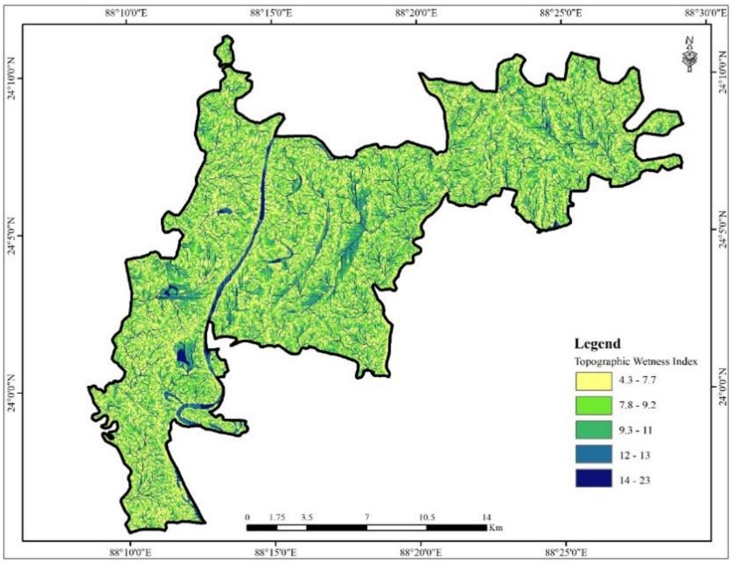

Fig. 10. *Topographic wetness index of the research area*

Source: Prepared by the author

Roughness index

The roughness index measures the undulation of landforms. There will be more undulation with more roughness and less undulation if there is less unevenness. The roughness value ranges from 0.11 to 0.89, and is grouped into five classes: 0.11-0.28, 0.29-0.43, 0.44-0.57, 0.58-0.71, and 0.72-0.89 found in Fig. 11. For lower surface roughness, large ratings have been allocated, and vice versa.

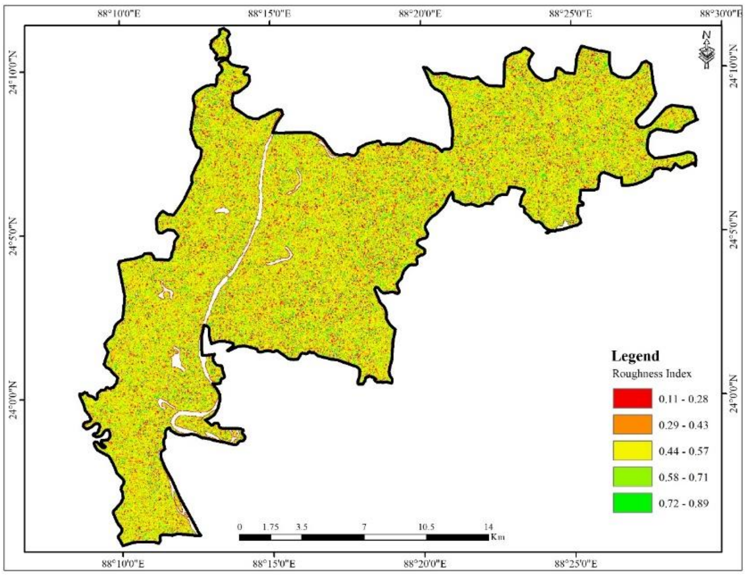

Fig. 11. *Roughness index of the research area*

Source: Prepared by the author

Topographic position index

The Topographic position index (TPI) is a method for classifying slope positions in the topography. Greater TPI rating is observed towards the peaks of hillsides, whereas lower TPI values are detected around the base of valleys. The TPI contrasts the rise of individual cells in a DEM to the average rise of the surrounding region. The rising value in the midpoint is subtracted from the average elevation (Vinod, 2017). The equation for calculating the Topographic position index is as follows $M_{0-\sum_{n-1} M_{n/n}}$ M_0= elevation of the model point under evaluation, M_n = elevation of the grid, n = the total number of surrounding points employed in the assessment. In Table 3, greater weight has been allotted to the lower TPI value, and a lesser weight has been applied to the high TPI values.

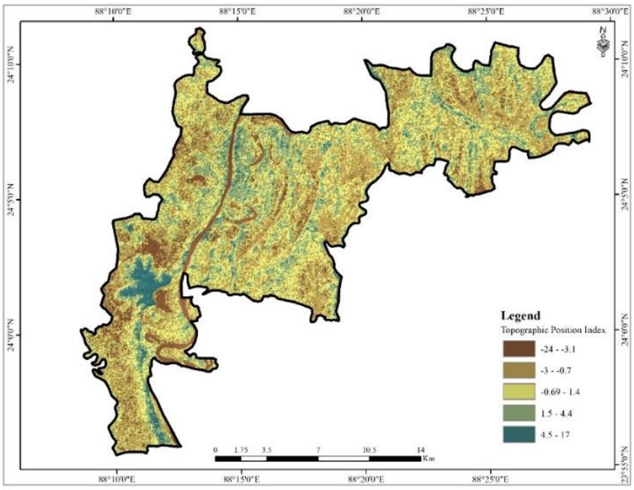

Fig. 12. *The topographic position index of the research area*

Source: Prepared by the author

Curvature

Curvature measurements reflect the geometry of the geographical terrain. A positive curvature implies a convex area, and a negative curvature represents a concave area. A flat area is represented by the value zero (Biswas, 2020). The curvature of the research area ranges from -3.1 to 3.9, as indicated in Table 3. The areas with higher curvature have been given more weight and vice versa. The curvature of the exploring area is depicted in Fig. 13.

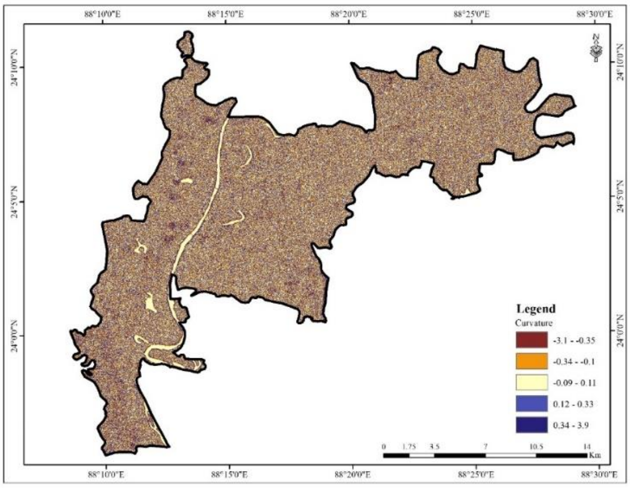

Fig. 13. *Curvature plot of the research area*

Source: Prepared by the author

Land-use and land-cover (LULC)

Land cover refers to the abiotic and biotic coverage above the ground's surface, such as water, plants, bare soil, and artificial structural features. On the contrary, land use is defined as the setting up of a plot of land for any function. LULC is a significant factor that determines subsurface recharge, prevalence, and availability. A supervised classification algorithm is employed to prepare and categorize the LULC utilizing a Landsat 8 (OLI) satellite imagery dated 2019 having a 30 m resolution. Agricultural land, barren landforms, vegetation, settlement, and water bodies are classified as part of the study area. Due to their continuous water replenishment to the subsurface (Srivastava and Bhattacharya, 2006), waterbodies have been assigned the highest weight among the LULC categories, accompanied by vegetation and barren land, which seems to be favorable for groundwater viability (Mallick et al., 2015). The lowest weight has been given to settlement. Fig. 14 depicts the distribution of LULC classes.

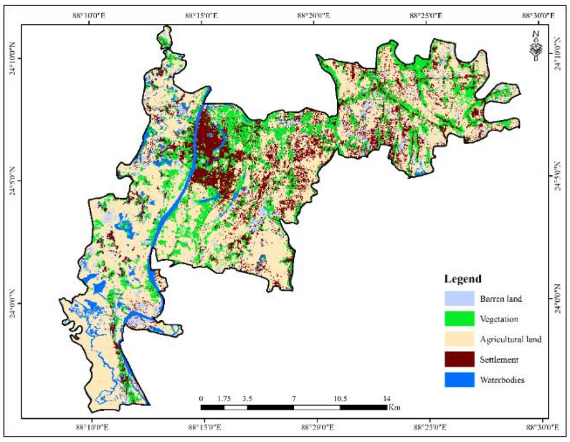

Fig 14. *Land use and land cover of the research area*

Source: Prepared by the author

Results and discussion

In this research, the GWPZs have been estimated using a combination of geospatial and AHP approaches that validates the equal importance of several thematic layers and their associated sub-classes impacting groundwater. Table 3 illustrates the weight and rating of each thematic layer and their corresponding subclasses using AHP. A solitary raster of the prospective groundwater zone is generated by combining all the raster layers utilizing the weighed overlay technique, as depicted in Fig. 15. Low to very low potential zones are primarily in the north, west, east, and some middle parts of the region, covered mainly by fine soil and built-up areas. The south and eastern parts of the region fall into the very high and high potential zones due to the poorest drainage density, the concentration of vegetation, agricultural land, and exceptionally low topographic position index. Because rain plays such a vital role, low rainfall has been detected in the middle region of the territory; as a result, most of the middle part of the area falls into the medium groundwater potential category. Only 0.29 percent of the area has the highest significant groundwater potential, according to the research. While 9.92 percent has high groundwater potential, 48.50 percent has medium groundwater potential, and 38.55 percent has low groundwater potential. As well as, 2.74 percent of the land has very low groundwater potential. The areas found from the GWPZ output map, i.e., the villages like the eastern part of Chumarigacha, Basabari, the northeastern part of Katalia, the western part of Charbhabanandapur, Jalalpurdiar, the northwestern part of Pakamati-Mahula, the southern part of Chardiar, the northwestern part of Sonadiar, the middle part of Bairagachi and Jadupur, some parts of Pratappur, Chandpara, the northern part of Nidhinagar sarsabad, the western part of Dadpur, the southern part of Sadipur, the northern part of Daulatabad and southern part of Goraipur are likely to be high groundwater potential zone.

On the contrary, the middle part of Majhira, Gopjan, and Berhampore city has very poor potentiality. To evaluate the potentiality of the groundwater, six observation bore wells and eight piezometers (Fig. 15) were used as approximations, collected from the Central Ground Water Board, West Bengal. It reveals that three wells are situated in excellent potential areas, and others fall under moderate areas.

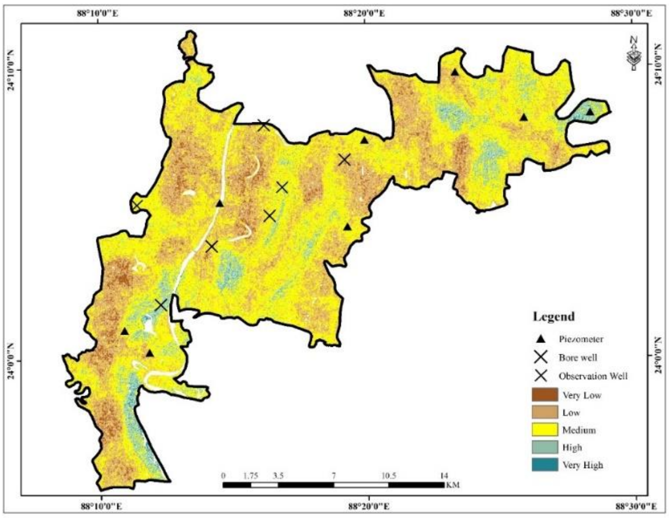

Fig. 15. *Depiction of groundwater potential zone of the research area*

Source: Prepared by the author

Table 5.

Groupings of groundwater potential zone

Sr. No.	GWPZ	Area (in km^2)	In percent
1	Very low	8.65	2.74
2	Low	121.85	38.55
3	Medium	153.33	48.50
4	High	31.37	9.92
5	Very high	0.92	0.29

Source: Computed by the author

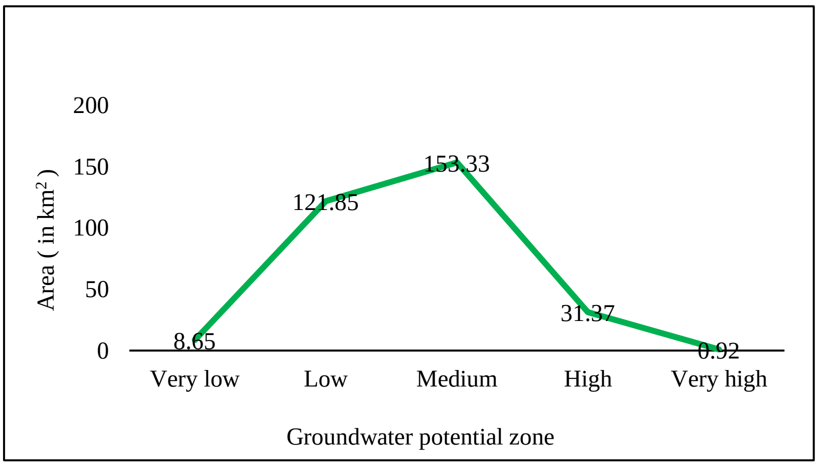

Fig. 16. *Distribution of potential groundwater zone of the research area*

Source: Prepared by the author

Conclusion

The sustainable use of groundwater is crucial in improving any region's deep-rooted agrarian viability and socio-economic stability. Agriculture is the primary profession in the Berhampore block, and it is reliant primarily on rainfall, rainwater harvesting via ponds and dug wells. Since monsoon rainfall is unpredictable and scanty nowadays, the demand for groundwater is rising to compensate for the water shortage during the post-monsoon and pre-monsoon seasons. The main objective of this research was to identify GWPZs using AHP and geospatial methodologies. Following that, a groundwater potential map was constructed and divided into five categories, i.e., very low, low, medium, high, and very high region with 2.74 percent (8.65 km^2), 38.55 percent (121.85 km^2), 48.50 percent (153.33 km^2), 9.92 percent (31.37 km^2), and 0.29 percent (0.92 km^2). It was observed that portions of Majhira, Gopjan, and Berhampore city had very low potentiality and should be targeted for groundwater maintenance and reconstruction through increased rainfall harvesting and water conservation measures.

Based on the above result, it will be reasonable to state that a potential groundwater zone map can be used for groundwater resource monitoring in an area like Berhampore block and can provide information to decision-makers in formulating an appropriate strategy for maintenance of groundwater for urbanization and agricultural uses, by choosing suitable exploration sites depending on requirements. However, there are certain limitations in this research, i.e., there is a lack of appropriate bore well data, which could have been used to check the more accuracy of the groundwater output map. Despite this, the research findings might have applied to local groundwater development and maintenance in the future.

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