Assessing groundwater status and human perception in drought-prone areas: a case of Bankura-I and Bankura-II blocks, West Bengal (India)

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Abstract

Ground water is a precious natural resource in every aspect of human life from natural to artificial environment. Ground water is an indicator of regional development by improving the economic domain through intensive agricultural practices, and aesthetic value through sufficient ground water supply as drinking water, fertile soil, and healthy vegetation. However, ground water availability and associated human perceptions were the main themes of the present study. In this study, both primary and secondary data were incorporated to understand the human adaptation behaviour in drought-prone areas of the fringe of Chhotanagpur plateau region (Bankura-I and II blocks) to ground water storage. GWPZ mapping is a very important exposure to knowing the ground reality. So, the MCDM-AHP method has been developed based on the eight dominant conditioning factors viz. geomorphology, lithology, lineament density, soil, drainage density, LULC, average slope, and slope aspect using GIS analytics with field expertise. The output result was validated with comparing 105 inventory stations where 0.850 AUC value was good for accepting the GWPZ model. As a result, a major portion of the study area is dominated by poor to moderate possibilities of ground water level (ground water level drops 1–2 m during the pre-monsoon) due to Proterozoic granite gneiss formation over the study area. With comparing demographic status, it was not favourable for a healthy lifestyle. Agriculture dominated rural environment of Bankura-I and II blocks is far away from the modern digital environment that is why ground water has played a very crucial role in the field of development. Moreover, to build up a good level of ground water recharge zone through rainfall harvesting, and sustainable land use planning will be the best management practices. So, availability of ground water should be a positive sign of development in the field of the economic sector and sustainable human society.

Keywords Groundwater resource (GWR) · Groundwater potentiality (GWP) · Drought · Human perception · Analytical hierarchy process (AHP)

Introduction

Groundwater is one of the world's most valuable natural resources, providing a crucial and dependable source of water in all the climate zones of the world. Groundwater is in high demand in locations where surface water supplies are limited or non-existent (Nag and Ghosh 2013). It is a reliable source of water for domestic, agricultural, and industrial applications (Nag and Das 2017). The rate of groundwater use is rapidly increasing throughout the world with population growth (Al Adaileh et al. 2019; Gogu and Dassargues 2000). As a result, the dependency on groundwater is fast increasing. These expanding needs frequently lead to over-exploitation, putting a significant strain on the limited supply of freshwater (Ahmed et al. 2021). Hence, groundwater

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depletion because of rising water demand for agricultural, household, and industrial purposes is a major concern all over the world (Gleeson et al. 2012; Scanlon et al. 2007). In many places of the world, including north Africa, the Middle East, south and central Asia, north China, North America, and Australia groundwater resources are being depleted (Konikow and Kendy 2005; Doll et al. 2014; Dalin et al. 2017; Ouyang et al. 2021). One-third of the world's population lives in places where there is a water shortage, with 1.1 billion people currently living without access to safe drinking water (Shaw and Thaitakoo 2010). Furthermore, due to unplanned irrigation patterns, high population density, and climatic change, groundwater problems have intensified, mostly in tropical and subtropical countries (Ahmed et al. 2021). Around 1.5 billion people rely on groundwater, while 2.53 billion people live in areas where water is scarce (Shen et al. 2015). In addition, the rate of water usage doubles every 20 years, approximately the doubling growth of population expansion in the world, and it is anticipated that by 2025 a minimum 3 billion people would be living in locations where it will be very difficult to solve the scarcity of basic water demands (Abedin et al. 2014). Groundwater (specifically from dug wells and tube wells) is the principal water supply for agriculture, industry, and home uses, etc., especially in dry zones where annual rainfall is low (Roy et al. 2020) whereas Taylor et al. (2013) have mentioned in their studies that about 42% of pumped groundwater is used for agriculture purpose. In general, the accessibility of groundwater and its quality are regulated by a range of factors, including geology, the intensity of chemical weathering of the prevailing lithology, the quantity of recharge water, pollution status and contributions from non-water-rock interaction sources (Hussein 2004).

Bankura is located within the red lateritic zone in West Bengal (Nag and Kundu 2016). The area is very susceptible to any change in rainfall due to the limited water holding capacity of soil, excessive drainage, surface runoff, and significant soil erosion (Milly 1994). This area also has a highly variable annual rainfall and is subject to recurrent droughts (Mukherjee and Patil 2013; Das et al. 2017; Roy et al. 2020). Moreover, water shortages have become a serious worry in India, particularly in the arid and semi-arid regions, due to the vagaries of the monsoon and a scarcity of surface water (Bhunia et al. 2018). Furthermore, in India, more than 90% of the rural population and roughly 30% of the urban population depend on groundwater for drinking and household requirements (Roy et al. 2020).

In recent years, groundwater resources in India and other countries have been depleting at an alarming rate, and they are not being recovered rapidly enough.

In dry, drought-prone areas of the world, groundwater is the only source of long-term water supply, and it is currently being progressively used for public drinking water and

agricultural reasons (Peters et al. 2005; Senapati and Das 2021). Bankura is in a semi-arid region which often experiences periods of below-average rainfall. Most of the surface water sources, such as ponds and streams, completely dry up during pre-monsoon and post-monsoon season due to the low rainfall and shortage of supply of water supplies during these times of the year (Nag 1998). As communities in Bankura have experienced severe water shortages over recent years, the population have had to change their water use practices due the changes in water availability. The perception of people in the region of groundwater accessibility depends on the nature of water availability, the extent of government interference and monsoonal activity (Hazra et al. 2017). Consequently, the people of this area have adapted to balance their livelihood with the availability of groundwater (Chatterjee 2018). Considering these factors, it is therefore important that the most suitable locations for obtaining groundwater in the region are identified in a manner that can be readily communicated to local communities.

Consequently, this study has been undertaken to determine the likely availability of groundwater in the area and to determine the community perception of groundwater availability. Information from this study could be used to improve planning and management measures in the region to improve the sustainability of groundwater use.

Brief description of the study area

Bankura is one of the important westernmost districts of West Bengal, and its location on the Tropic of Capricorn makes this district climatologically significant. It is indeed a semi-arid area but it is extremely vulnerable to drought. The study area is located on the groundwater management blocks which are the Bankura Block I and Block II which feature an undulating terrain and are underlain by Precambrian crystalline rocks (Fig. 1). The Bankura I and Bankura II in blocks are located between 23° 09' 24"–23° 22' 51" North latitude and 86° 53' 51"–87° 14' 19" East longitude. Geographically, the area of Bankura district comprising Bankura I and Bankura II forms the far eastern sight of the Ranchi Plateau, which associated with the depositional fluvial terraces of the Dwarakeswar–Gandheswari Rivers as it moves east (Nag and Das 2017). According to the Census (2011), the total population of Bankura District is 35, 96,674 in which Bankura I and Bankura II CD block had a total population of 107,685 and 140,864, respectively. The density of population in Bankura I is 574 per square kilometre and Bankura II is 640 per square kilometre. Based on the research facts, Dhalbanga is the most densely populated village in Bankura I CD block, followed by Andharthaul, Kalapathar, Kenjakura, Achuri, and Jagadalla (Fig. 2). The

Fig. 1 Location and geographical settings of the study area along with important drainage networks (a) the location of West Bengal state in India (b) the location of Bankura district in West Bengal (c)

the location of Bankura I and II blocks in Bankura district (d). Study area showing FCC format of Landsat 8 imagery along with surface elevation map

maximum household density in Bankura-I and II is 1416 per square kilometre, with a minimum density of 1 per square kilometre. Gauripur, Achuri, Papurdihi, Balardihi, and Sanaband are among the villages in Block Bankura-I that have a greater household density. Susunia, Helna, Nutangaon, Bhikurdihi, Baidhka, and Dakshin Bankati are among the villages in Block Bankura-II that have a greater household density (Fig. 3). The difference between the demand and supply of water is widening every day as the world's population increases. Both the physical and economic water shortages threaten to the people of this areas. The research region has been taken into consideration because of this and to better understand the current

situation, as well as the local people's ability to adjust to it and their opinion of the crisis (see Fig. 3).

Data and methodology

Data sources and preparation of the thematic layers for GWPM

To identify the groundwater potential zones (GWPZ) of the Bankura I and II blocks in the drought-prone region of West Bengal, eight thematic layers were selected viz. geomorphology, lineament density, lithology, average slope, slope

Fig. 2 Population density (person/km²) in Bankura I and Bankura II. Population data have been collected from district statistical handbook, Bankura district (2011)

Fig. 3 Household density (household/km²) in Bankura I and Bankura II. Data have been collected from district statistical handbook, Bankura district (2011)

aspect, soil type, LULC, and drainage density. All these layers have been processed and executed using the GIS analytics (ArcMap 10.5), based on both information from the literature, and field knowledge and investigations for assessing the final groundwater potential map (GWPM) output. All the selected thematic layers were transformed into a rasterized format, which was further projected into UTM Projection, WGS 84 Datum Zone 45, with a spatial resolution of 30 m.

SRTM-DEM with 30 m spatial resolution was obtained from USGS Earth Explorer application to prepare the average slope, slope aspect, and drainage network information for the study area, which was also taken as a base map to prepare the drainage density map. At first, the DEM was pre-processed in the GIS environment (ArcMap 10.5) using the sink-filling, flow accumulation, and flow direction technique, and then a stream order tool was used. Finally, a 1 km² grid

was developed to prepare the drainage density and lineament density maps. For the preparation of LULC, Landsat 8 OLI (30 m spatial resolution) images were collected from USGS Earth Explorer website. At first, Landsat image (Row 44 and Path 139) was mosaic, which was later pre-processed using atmospheric correction, DN's value of the individual band was converted to the ToA radiance by the spectral radiance scaling method and ultimately converted to the ToA reflectance, edge enhancement, and band composition techniques. Finally, supervised classification with a maximum likelihood algorithm was performed to generate the final LULC map with five classes (i.e., water body, barren land, vegetation cover, agricultural land, and settlements). For geomorphology, lithology, and lineaments, the data were collected from the Geological Survey of India (GSI) website. The layer is available in vector format, which was initially pre-processed in the GIS environment and then converted into a raster layer (with a 30 m spatial resolution). The study area's soil map was collected from the National Bureau of Soil Survey (NBSS) and Land Use Planning (LUP) and extracted using the GIS platform. According to several studies, the kriging interpolation technique seems to be more accurate and reliable for the delineation of drainage density and lineament density maps than any other technique (Kim et al. 2011; Ly et al., 2013). Further, all data sources and their details are summarized in Table 1.

After preparing all the selected thematic layers into a rasterized format with the same cell size (30 m), reclassification was done. Then, weights were assigned using the Saaty's scale in AHP-Excel by K. D. Geopel version 15.08.2018 and further weighted overlay analysis (WOA) was performed by integrating all the raster layers in the GIS environment using a weighted overlay tool to delineate the final GWPM

for Bankura-I and II blocks in the drought-prone Bankura district.

Use of the analytical hierarchy process (AHP) for developing the groundwater potential zoning map

AHP is a multi-criterion-based decision-making technique introduced by Saaty which is one of the most appropriate models for preparing the GWPZ map (Saaty 1980). The method was applied to a set of parameters to establish a hierarchical structure by giving weights to each criterion to reduce decision-making complexity (Kiker et al. 2005; Pramanik 2016). AHP is a systematic and powerful technique that integrates practical knowledge with subjective ideas to determine decision-making by assessing multiple variables based on expert views/experiences using the GIS platform (Sener et al. 2011; Hammami et al. 2019). To prepare accurate results, the assignment of weights to each parameter and their normalization is an utmost factor, as the outcome is exclusively conferred on the appropriate weight assignments (Muralitharan and Palanivel 2015). There are various weight estimation techniques, but AHP is one the most promising techniques in groundwater potential modelling that can produce the most reliable and cost-effective performance (Murmu et al. 2019).

The AHP model has been developed through four stages of functions. These steps are: the assignment of weights; development of a pairwise comparison matrix; carrying out a weight normalization; and undertaking a consistency ratio (CR) check (Hammami et al. 2019; Benjmel et al. 2020; Ghosh et al. 2021).

Table 1 Details of various data sets used for preparing the GWPM

Data type	Detail of data	Available format	Extracted layer	Generated layer	GIS data type
Satellite imagery ^a	Landsat 8 Path-139 Raw-044 Acquisition date—28.02.2021	Erdas imagine	LULC	LULC	Raster
Geomorpho-logy map ^b	Bhukosh-GSI	ESRI shapefile	Geomorpho-logy	Geomorpho-logy	Raster
Lithology map ^b	Bhukosh-GSI	ESRI shapefile	Lithology	Lithology	Raster
Lineament map ^b	Bhukosh-GSI	ESRI shapefile	Lineament	Lineament Density	Raster
Soil map ^c	NBSS and LUP WB Soil-Sheet 1 and 2 Scale: 1:500,000	JPG	Soil types	Soil types	Raster
SRTM-DEM ^a	Entity ID: SRTM1N23E087V3 Spatial resolution-30 m Publication Date: 2014-09-23	TIFF	Contour Elevation Drainage network	Average slope Aspect Drainage Density	Raster

Source: ^aUSGS earth explorer (<https://earthexplorer.usgs.gov/>)

^bBhukosh—geological survey of India (<https://bhukosh.gsi.gov.in/>)

^cNational Bureau of Soil Survey and Land Use Planning (<https://esdac.jrc.ec.europa.eu/>)

For the present study, a total of eight parameters were selected that are considered to regulate the occurrence of groundwater in the Bankura district. Here, expert opinions, field expertise, and multiple literature reviews were used to assign weights to each parameter (Magesh et al. 2012; Hammami et al. 2019). A high weight parameter resembles a high impact, and a low weight indicates a minor influence over the groundwater potential in the area.

At first, researchers selected factors that were considered to have a high importance in influencing groundwater occurrence, and described the criteria based on their significance, and influencing power towards groundwater potential (Tables 2 and 3). Then the assigned weights of each criterion were allotted based on Saaty's scale (ranges from 1 to 9) of relative importance to compare all parameters of the thematic layer in a matrix format with each other that is necessary in deriving the measurement. In Saaty's scale, 9

indicates extreme importance and 1 implies equal importance concerning the dominant factor (Table 4).

Table 5 shows the pairwise comparison matrix of groundwater formation factors, where parameters are arranged in a hierarchical order and assigned values according to their relative importance (Table 6). Scores of pairwise comparisons were normalized to prepare the standardized comparison matrix for flood susceptibility mapping. Consistency of the AHP method was then measured by the following equations (Das 2020):

$$CR = \frac{CI}{RI}, \quad (1)$$

where,

$$CI = \frac{\lambda_{\max} - n}{n - 1}, \quad (2)$$

Table 2 Assigned and normalized ranks of different features of eight conditioning factor for groundwater potential mapping

i	j	Criteria	More important?		Scale
		A	B	A or B	(1 - 9)
1	2	Geomorphology	Lineament Density	A	1
1	3		Lithology	A	2
1	4		Average Slope	A	7
1	5		Aspect	A	5
1	6		Soil	A	6
1	7		LULC	A	7
1	8		Drainage Density	A	8
2	3	Lineament Density	Lithology	A	1
2	4		Average Slope	A	5
2	5		Aspect	A	4
2	6		Soil	A	3
2	7		LULC	A	2
2	8		Drainage Density	A	6
3	4	Lithology	Average Slope	A	2
3	5		Aspect	A	6
3	6		Soil	A	4
3	7		LULC	A	5
3	8		Drainage Density	A	9
4	5	Average Slope	Aspect	A	2
4	6		Soil	A	3
4	7		LULC	A	2
4	8		Drainage Density	A	5
5	6	Aspect	Soil	A	2
5	7		LULC	A	2
5	8		Drainage Density	A	3
6	7	Soil	LULC	A	5
6	8		Drainage Density	A	4
7	8	LULC	Drainage Density	A	3

Source: weightage assigned by authors based on Saaty's scale (1980, 1994, and 1996)

*Using AHP by K. D. Geopel version 15.09.2018

Table 3 Assigned ranks of sub-classes of each conditioning factor

Sl. No	Causative factors	Sub-classes	Rank
1	Geomorphology	Older Alluvial Plain	4
		Older Flood Plain	3
		Lateral Bar	2
		Pediment	1
		Pediplain	1
		Plain (Lateritic)	3
		Point Bar	2
		Upland (Lateritic)	1
		Valley Fill	4
		Water body	5
		Less than 0.3	5
		0.3–0.6	4
		0.6–0.9	3
		0.9–1.2	2
		Greater than 1.2	1
		Biotite gneiss	1
		Ferruginous sandstone	3
		Gabbro	2
		Granite gneiss	1
2	Lineament density (km/km ²)	Hornblende gneiss	1
		Hornblende schist, amphibolite, meta ultrabasalt	2
		Laterite	5
		Lateritic soil	5
		Mica schist/schist	2
		Pegmatite	1
		Quartz tourmaline rock	2
		Quartzite, cherty, quartzite	3
		Sand, silt, clay, calcareous concentration	5
		Sand, silt, gravel (present day deposit)	4
		Yellowish brown fine sand, silt, clay	4
		Less than 0.5	5
		0.5–1.2	4
		1.2–1.9	3
		1.9–2.6	2
		Greater than 2.6	1
		Flat (– 1)	5
		North (0–22.5)	5
3	Lithology	Northeast (22.5–67.5)	4
		East (67.5–112.5)	4
		Southeast (112.5–157.5)	3
		South (157.5–202.5)	3
		Southwest (202.5–247.5)	2
		West (247.5–292.5)	2
		Northwest (292.5–337.5)	1
		North (337.5–360)	1
		W093	5
		W097	1
		W098	2
		W106	3
		W107	4
		Water body	5
		Water body	5
		Water body	5
		Water body	5
		Water body	5
4	Average slope in degree	Water body	5
		Water body	5
		Water body	5
		Water body	5
		Water body	5
		Water body	5
		Water body	5
		Water body	5
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5	Slope aspect	Water body	5
		Water body	5
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6	Soil types	Water body	5
		Water body	5
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7	LULC	Water body	5
		Water body	5
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		Water body	5

Table 3 (continued)

Sl. No	Causative factors	Sub-classes	Rank
8	Drainage density (km/km ²)	Vegetation cover	2
		Settlement	1
		Agricultural land	3
		Barren land	4
		Less than 0.2	5
		0.2–1.0	4
		1.0–1.8	3
		1.8–2.6	2
		Greater than 2.6	1

Source: prepared by authors

Table 4 Pair-wise comparison matrix for the AHP process

Matrix											normalized principal Eigenvector
	Geomorphology	Lineament Density	Lithology	Average Slope	Aspect	Soil	LULC	Drainage Density	0	0	
Geomorphology	1	1	2	3	4	5	6	7	-	-	28.64%
Lineament Density	1	1	1	2	3	3	4	5	-	-	20.68%
Lithology	1/2	1	1	1	2	3	4	5	-	-	16.43%
Average Slope	1/3	1/2	1	1	1	2	3	4	-	-	11.82%
Aspect	1/4	1/3	1/2	1	1	1	2	3	-	-	8.36%
Soil	1/5	1/3	1/3	1/2	1	1	1	2	-	-	6.14%
LULC	1/6	1/4	1/4	1/3	1/2	1	1	1	-	-	4.46%
Drainage Density	1/7	1/5	1/5	1/4	1/3	1/2	1	1	-	-	3.48%
0	-	-	-	-	-	-	-	-	1	-	0.00%
0	-	-	-	-	-	-	-	-	-	1	0.00%

*Consistency ratio = 1.30%, maximum acceptance level is 10% for more than 4 factors

*Using AHP by K. D. Geopel version 15.09.2018

Table 5 Details about the soil category with description

Sl. No	Soil category	Descriptions
1	W093	Shallow, somewhat excessively drained, gravelly loamy soils occurring on gently sloping subdued ridges with gravelly loamy surface and severe erosion
2	W097	Very deep, imperfectly drained, fine soils occurring on very gently sloping to undulating plain with loamy surface and moderate erosion
3	W098	Very deep, moderately well-drained, fine loamy soils occurring on very gentle sloping to undulating plain with loamy surface and moderate erosion
4	W106	Very deep, well-drained, fine loamy soils occurring on very gently sloping to undulating plateau with loamy surface and moderate erosion
5	W107	Very deep, well-drained coarse loamy soils occurring on very gently sloping valleys on undulating plateau with loamy surface and moderate erosion

Source: NBSS and LUP, India

Table 6 Calculated weightage of various controlling factors for creating the groundwater potential zones (GWPZ)

Table	Criterion	Comment	Weights	+/-
1	Geomorphology		28.6%	4.9%
2	Lineament Density		20.7%	4.3%
3	Lithology		16.4%	2.6%
4	Average Slope		11.8%	2.6%
5	Aspect		8.4%	1.9%
6	Soil		6.1%	1.1%
7	LULC		4.5%	0.8%
8	Drainage Density		3.5%	0.6%
9		for 9&10 unprotect the input sheets and expand the	0.0%	0.0%
10		question section ("+" in row 66)	0.0%	0.0%
Result				
Eigenvalue		Lambda: 8.129		MRE: 19.2%
Consistency Ratio		0.37	GCI: 0.05	Psi: 0.0%
			CR: 1.3%	

Source: calculated by authors

*Using AHP by K. D. Geopel version 15.09.2018

where CR denotes consistency ratio, CI indicates consistency index, RI is random index, $\lambda_{\max}$ is principal eigenvalue in the matrix and n is the number of parameters. In the present study, consistency ratio (CR) values are 1.30% means 0.013 which is lesser than the upper acceptance value (0.10 for more than 4 factors) stated by Saaty in 1980 (Tables 7 and 4).

Weighted overlay model (WOM)

The weighted overlay model is a simple, direct, and adequate methodology for evaluations of groundwater potential in a drought-prone area. In this study eight groundwater inducing factor maps were used for assessment of GWP mapping. To combine these in performing the analysis, each cell from each map layer had to be reclassified into a common preference scale (Saaty's scale). All thematic maps were integrated using WOM (Shit et al. 2016; Hammami et al. 2019; Das 2020).

$$S = \frac{\sum W_i S_{ij}}{\sum W_i}, \quad (3)$$

where W_i is the weight of the i^{th} factor map, S_{ij} is the i^{th} spatial class weight of the j^{th} factor map, S is the spatial unit value in the output map.

These weighted factor maps were integrated into the GIS environment using a weighted overlay analysis to prepare a GWPZ map (Fig. 4).

Modelling for determining the groundwater potential zones

The groundwater potential zones for the Bankura-I and II blocks were generated by overlapping multiple selected thematic layers that are likely to be contributing to groundwater occurrence based on GIS and the AHP technique (Table 6). The weighted integration technique was used to delineate the GWP areas based on Eq. 2 (Malczewski 1999; Muralitharan and Palanivel 2015; Bhattacharya et al. 2020; Das 2020).

$$GWPI = \sum_{w=1}^n \cdot \sum_{j=1}^n W_j \times X_i, \quad (4)$$

where W_j is considered as a normalized weight of the j^{th} thematic layer and X_i is the rank associated with classes of i^{th} thematic layer, m indicates the number of total thematic layers used and n denotes the total classes of thematic layers. Further, the modeling of GWPI was done based on the following Eq. 5, (Rao and Briz-Kishore 1991; Kumar et al. 2020; Berhanu and Hatiye 2020; Goitseman et al. 2020),

$$\begin{aligned} GWPI = & (GM_w \times GM_r) + (LD_w \times LD_r) \\ & + (LG_w \times LG_r) \\ & + (AS_w \times AS_r) + (SA_w \times SA_r) \\ & + (SL_w \times SL_r) + (LULC_w \times LULC_r) \\ & + (DD_w \times DD_r), \end{aligned} \quad (5)$$

where GM is geomorphology, LD is the lineament density, LG is the lithology, AS is the average slope, SA is the slope aspect, SL is soil type, LULC is the land use and land cover, and DD is the drainage density. Further, the subscripts 'w' and 'r' for each layer denote the AHP normalized weight and rank of each subclass.

Based on the above calculations, the entire study area was categorized into five zones of groundwater potential

Table 7 Saaty's significance scale for assigning weight of parameters

Intensity	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one element over another
5	Strong importance	Experience and judgement strongly favour one element over another
7	Very strong importance	One element is favoured very strongly over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation

2, 4, 6, 8 can be used to express intermediate value

viz.: “very poor”; “poor”; “moderate” “good”; and “very good” groundwater potential zones.

Geo-environmental factors affecting groundwater potential (WGP)

The extent to which groundwater will occur in any geologic and geomorphic setting will depend on both natural and anthropogenic factors. Based on the available literature, there are many conditioning factors that can influence groundwater availability. In the present study, eight parameters were considered to influence groundwater availability. These are: the lineament density; lithology; the average slope; the slope aspect; the soil type. Land use and land cover (LULC), and drainage density have been taken as conditioning factors to prepare groundwater potential map.

Geomorphology

Landscape features and surface structure are important for determining the groundwater potentiality (Ghosh et al.

2016; Murmu et al. 2019; Kumar and Krishna 2018). Both surface and sub-surface movement of water can be controlled by the topographic characteristics. Geomorphologically, the study area consists of: (1) older alluvial plain; (2) older flood plain; (3) lateral bar deposits; (4) pediment; (5) pediplain; (6) lateritic plain; (7) point bar deposits; (8) lateritic upland; (9) valley fill deposits; and (10) surface water bodies (Fig. 5a). The Damodar and Dwarkeswar rivers are the dominant waterways within the study area. Additionally, there are a few narrow channels and natural and anthropogenic water bodies in the study area (for example, the Saheb pukur pond, Lal bandh, the Kuch kuchia pond, Nutan pukur, Jamuna bandh and Gosai bandh). In total, an area of about 11.98 km² is covered by water bodies in the study area. Pediplain is the dominant geomorphological feature that exists throughout the study area (245.05 km², 58% spatial coverage). Valley-fill deposits are generally unconsolidated alluvial and colluvial materials consisting of sand, silt, gravels, pebbles, etc., deposited along the floor of a stream valley. This type of landform is mostly present along with the major river systems of the study area with a width of 1–2 km. A small portion of the blocks (Bankura-I

Fig. 4 Purpose of using groundwater to fulfil their basic need. Source: primary survey, 2021

Fig. 5 Controlling factors of the Groundwater Potential zones. (a) Geomorphology, (b) average slope, (c) lineament density, (d) land use and land cover (e), drainage density (f), soil (g), lithology, (h) aspect

and II) consists of deep or moderately buried pediments. These pediments are covered with thick weathered materials in the north and the south-western part of the study area as small patches (40.71 km²). Other important geomorphological features are plains (lateritic) and upland (lateritic) plains they comprise about 36.05 km² and 47.66 km² of the geographical area, respectively.

Lineament density

Lineaments are as the linear or curvilinear surface expression of structural features in underlying bedrock, including faults, cleavages, fractures, and other surfaces of discontinuity (O'Leary et al. 1976; Yeh et al. 2008), that can regulate groundwater accumulation (Roy et al. 2021). Because the existence of lineaments generally implies a permeable

Fig. 5 (continued)

zone, the density of lineaments in each region can immediately disclose the groundwater potential (Saranya and Saravanan 2020). Lattman and Parizek (1964) were the first to adopt a lineaments map to exploit groundwater. Following that, several researchers have used this method in difficult geological locations. High secondary porosity is inferred from a substantial lineament-length density, suggesting a zone with high groundwater potential (Yeh et al. 2008). In the present study area of the Bankura drought-prone region, the lineament density varies from 0 to 1.4 km/km² and can be divided into five classes viz. less than 0.3 km/km², 0.3–0.6 km/km², 0.6–0.9 km/km², 0.9–1.2 km/km², and greater than 1.2 km/km² (Fig. 5c). The central part of Bankura-I and the eastern and western part of Bankura-II block have the highest density of

lineament-lengths, which means that these areas are more likely to be prospective for groundwater than other parts of the study area. However, most of the study area has a negligible density of lineaments.

Lithology

Generally, the lithology of bedrock influences the porosity and permeability of materials in the overlying weathered profile that comprises regolith in many areas (Chowdhury et al. 2010) which, in turn, affects the specific storage of groundwater recharge. The lithology of bedrock also influences the extent to which water can be stored and will be transmitted in basement rock materials beneath the regolith (Singh et al. 2013; Abijith et al. 2020). In the study area,

Table 8 Details about the lithologic units with formation

Sl. no	Age	Group name	Formation	Lithologic
1	Pleistocene	Older alluvium	Lalgarh	Lateritic soil
2	Proterozoic	Chhotanagpur gneissic complex		Hornblende gneiss
3	Meghalayan	Newer alluvium	Hoogly	Sand, silt and gravel (present day deposit)
4	Archaean- palaeo-proterozoic	Unclassified metamorphics		Hornblende schist, amphibolite, meta ultrabasic
5	Proterozoic			Pegmatite
6	Pleistocene-holocene	Older alluvium	Sijua	Sand, silt, clay, calcareous concretions
7	Holocene	Newer alluvium	Panskura	Yellowish brown fine sand, silt, clay
8	Proterozoic	Chhotanagpur gneissic complex		Granite gneiss
9	Proterozoic	Chhotanagpur gneissic complex		Biotite gneiss
10	Proterozoic			Gabbro
11	Cenozoic			Laterite
12	Proterozoic			Quartz tourmaline rock
13	Archaean- palaeo-proterozoic	Unclassified metamorphics		Mica schist/schist
14	Cenozoic			Ferruginous sandstone
15	Palaeo-Proterozoic	Singhbhum		Quartzite, cherty quartzite

Source: geological survey of India (GSI)

fifteen lithologic units have been identified, with granite gneisses being the most important basement rocks (with an area of 355.58 km², or a spatial coverage of about 84% of the study area). Other geological materials that have been mapped in the study area are: (1) shallow regolith comprising sands, silts, clay sand calcareous concretions; (2) yellowish brown fine sands, silts, and clays; (3) lateritic soil; (4) biotite gneiss; and (5) recent alluvial sediments consisting of sands, silts and gravels). They comprise about 34.04 km², 13.33 km², 7.84 km², 5.81 km², and 3.12 km², respectively. Out of the total geographical area and can influence groundwater availability. Further details about the different lithologic units are presented in Table 8.

Average slope

The steepness of the land slope can directly control the rate that in incident rainfall can infiltrate through the soil profile and recharge groundwater. A steeper slope results in more surface runoff and lower groundwater recharge due to insufficient time to percolate into the soil profile, and so there is always an inverse connection between surface water infiltration and slope (Ghosh et al. 2020; Rajasekhar et al. 2019; Murmu et al. 2019; Roy et al. 2021). On the other hand, almost flat and gentle slope gradients have a good prospect for groundwater recharge as there is sufficient time to allow surface water to infiltrate into a soil profile and reach the water table.

The study area has been categorized into five distinct slope zones viz.: < 0.5 degrees (covering an area of 62.85 km²); 0.5–1.2° (covering an area of 230.51 km²), 1.2–1.9° (covering an area of 101.56 km²); 1.9–2.6° (covering an area of 7.53 km²); and > 2.6° (covering an area of 0.06 km²). Based on the spatial coverage, 72.34% (the “very low” to “low” slope gradient zones) of the total geographical area is suitable for significant groundwater recharge (Fig. 5b).

Slope aspect

The slope aspect influences the amount of water that is available for infiltration due to impacts on local soil water balances (Ercanoglu and Gokceoglu 2002). In this study, the slope aspect layer was extracted from GSI shapefile layers and divided into ten classes, including nine directions and one flat class (Fig. 5h). It is noteworthy that around 14.95 km² area was classified as having a flat slope aspect, which has a positive influence on groundwater recharge.

Soil type

Soil data is routinely and widely used in groundwater recharge and vulnerability studies (Vias et al. 2005;

Samadder et al. 2011; Mokadem et al. 2018). This is because soil permeability is proportional to effective porosity, grain shape and size, and void ratio, implying that soil type has a significant impact on infiltration. Simply stated that sandy- and gravelly textured soils have a higher infiltration potential, whereas clayey- and silty-textured soils have a lower infiltration capacity (Das and Paul 2015; Brady 1984). Permeability is likely to be modest in fine sands and loamy soils. In the present study area, there have been identified five types of soil viz. W093, W097, W098, W106, and W107. For details about the soil types, see the National Bureau of Soil Survey and Land Use Planning (NBSS and LUP) map sheets of West Bengal (Sheet 1–4). About 261.50 km² (61.93%) and 123.07 km² (29.15%) of the study area was classified as having W098 and W097 soil types, respectively, which cover a larger portion of the study area. Additionally, areas of 4.86 km², 15.59 km², and 17.21 km² are covered by the W093, W106, and W107 soil categories respectively in the study area (Fig. 5f). For details about the characteristics of different soil categories are represented in Table 5.

LULC

Groundwater is primarily connected with the landscape and land use. LULC alteration can directly influence the groundwater recharge. The natural landscape is ideal for balance but artificial settings (e.g., by landscape modification in built-up areas, paved surfaces, deforestation, excessive use of groundwater, etc.), can cause declines in groundwater levels (Lerner and Harris 2009; Mishra et al. 2015). LULC was included in this study as an important factor affecting the groundwater.

It is noteworthy that groundwater recharge rates are lower in places with deep-rooted vegetation, such as trees also known as forest cover, than in areas with shallow-rooted vegetation, such as annual crops (Gee et al. 1992; Keese et al. 2005). The conversion from natural vegetation to controlled land use types frequently results in a one or two order of magnitude rise in recharge rates (Scanlon et al. 2006). Several factors influence the response of water resources to LULC change, including the original vegetation to be replaced, the vegetation that is replacing it, whether the change is permanent or temporary, and whether the changes are linked to land management practises involving drainage network changes (Scanlon et al. 2007). That's why LULC was included in this study as an important factor affecting the groundwater. In this study, LULC has been categorized into five LULC classes viz. water bodies, vegetation cover, settlements, agricultural land, and barren land. About 40.51% of the total area is under vegetation cover, 9.21% under agricultural land, 29.95% under barren land, 9.52% under settlements, and the remaining 17.84% constitutes

water bodies (Fig. 5d). In some of cases, agricultural land and water bodies receive a high ranking due to their ongoing recharge capacity, whereas settlement areas receive a poor ranking due to their worsening influence on groundwater capacity (Ghosh et al. 2016; Roy et al. 2021).

Drainage density

The form and structure of the bedrock, the kind of vegetation, the rainfall absorption capacity of soils, infiltration, and slope gradient all influence the drainage system of a given location (Rahmati et al. 2015). Generally, more infiltration and less surface runoff takes place in low-drainage-density areas. It indicates that low-drainage-density locations can be conducive to groundwater development. Based on the surface drainage density, the study area can be grouped into five classes: < 0.2 ("very low"), $0.2\text{--}1.0$ ("low"), $1.0\text{--}1.8$ ("moderate"), $1.8\text{--}2.6$ ("high"), and > 2.6 ("very high") km/km^2 , as shown in Fig. 5e. The very high drainage density (2.81 km^2) is scattered over the study area. The low and moderate drainage densities cover most of the study area (195.01 km^2 and 132.01 km^2).

Ground truth validation of the GWPZ map

Whenever possible, the output from a groundwater potential mapping exercise should be validated with information obtained from the mapped area. One of the most significant components of any multi-criteria decision making (MCDM) methodology is assessing the precision of the output models.

Fig. 6 ROC curve and AUC value analysis for validating the groundwater potential zones map. With the help of 105 groundwater sample stations (i.e., wells and tube wells), the results demonstrate a very good degree of satisfaction ($\text{AUC} = 0.850$, 85.00%)

Because of its simple nature, comprehensiveness, and reasonable agreement with the forecast, the area under the curve (AUC) based on inventory data (groundwater level data at various sample stations) is a well-established measure for validating such MCDM models (Pourghasemi et al. 2012; Tehrany et al. 2013; Das 2020). A value of 1 under the area indicates the highest level of accuracy without any bias. AUC values greater than 0.7 are generally regarded as acceptable discrimination and, as a result, acceptable models.

In this research work, the AHP-based GWPZ map was divided into five classes. A total of 105 groundwater monitoring sites (wells) were selected as sample points to validate the GWPZ map. The number of possible groundwater points for each class was determined by comparing the flood inventory points to the output groundwater potential zone map. Here, all the processes have been executed in the GIS environment using the ArcSDM tool. For calculating the ROC curve and AUC value, a GWPZ map in raster format was initially used as a classification model with inventory points in a GIS environment. This allowed a ROC curve and an AUC value to be produced in a PNG format (Fig. 6).

The high AUC value (0.850) indicates that groundwater potentiality mapping in the drought-prone Bankura-I and II blocks is quite precise (Das 2020), which could be useful for managing, controlling, planning, and reducing future vulnerability with high confidence.

Primary data collection process to understand how groundwater is utilised by communities in the study area

Field studies are an important part of research because they help to make the connection between the theoretical knowledge with actual behaviours of water use in the crisis and allowing researchers to better comprehend the real-world circumstances (Kandamby 2018; Kundu 2019). Due to the current COVID-19 epidemic and lockdown, a predesigned and organised questionnaire was implemented through an internet platform to acquire the information regarding the availability, facilities, and condition of groundwater in the Bankura I and Bankura II blocks. The descriptive survey was conducted among 112 respondents from the different functional groups of Bankura I and Bankura II. The study is based on both qualitative and quantitative data. The surveyed data were tabulated in various tables and visually presented using several cartographic techniques including bar diagrams, pie graphs, and figures. Specific statistical and quantitative techniques including factor analysis (FA) with the Likert scale test have been used to find out the importance of the parameters.

Table 9 Details about the primary data collection process

Sample blocks	Total no. of Village	Sample household	Purpose of Data collection	Methods of data collection	Target group
Bankura I, Bankura II	352	112	To know the situation of water status and safe drinking water scarcity and examines communities' perception of the local people.	Google form survey (Questionnaire)	Villagers
				Phone call survey	
				Observation	Administrative Household

Source: Prepared by authors

Factor analysis using the Likert scale

Likert (1932) initially proposed the Likert scale which is used to measuring attitudes or opinions based on an odd-numbered response set with possibilities or perceptions such as “strongly approve,” “somewhat approve,” “no idea,” “somewhat disagree,” and “strongly dislike.” Using Principal Component Analysis (PCA) in popular social one of the most common approaches to perform factor analysis is to use science software such as SPSS (FA). In this study, factor analysis (FA) was used to assess the responses of different information which were collected through the questionnaire based on the Likert scale. Attribute variables with the response on a 1–5 scale (e.g., better condition, good, moderate, low, poor condition, etc.) (Yong and Pearce 2013) were assessed (see Table 9).

Results and discussion

Groundwater potential (GWP) status in Bankura I and Bankura II blocks

The preparation of a groundwater potential map is one of the most important measures that can be undertaken in a groundwater assessment in a region. The groundwater potential zone (GWPZ) map of the Bankura-I and Bankura-II blocks that was produced in this study is shown in Fig. 7. In this map, the total geographical area of the district has been categorized into five distinct groundwater potential zones. These are: “very poor”, “poor”, “moderate”, “good”,

and “very good” groundwater potential zones which were derived through the MSDM-AHP semi-controlled GIS application. Details of these groundwater potential zones are summarized in Table 10. The output map indicates that much of the Bankura-I and Bankura-II blocks has only a poor to moderate groundwater potential. Considering the total spatial coverage of the study area, about 0.68 km² (0.17%) has a very poor groundwater potential, while an area of about 0.27 km² (0.07%) is mapped as having a very good potential for groundwater occurrence. Similarly, 250.57 km² (62.26%), 130.74 km² (32.48%) and 20.20 km² (5.02%) of the study area is mapped as having a poor, moderate, and good potential for groundwater potential, respectively.

The area mapped as having a “good” potential for significant groundwater occurrence is distributed in the eastern part of the Bankura-II block and near to the active river course as well as near water bodies. These areas are situated where there are lateritic plains, old alluvial deposits, areas gentle slopes, areas with agricultural activity, areas with barren land, and moderately well-drained soils which are conducive factors for increasing water infiltration. The moderate groundwater potential zones, on the other hand, are found in areas where soils have a much lower infiltration capacity.

Much of the study area is underlain by granitic basement rocks overlain by a clayey weathered profile which is mapped as having a low to moderate groundwater potential. Consequently, there are several villages (i.e., 9, 29, 46, and 47 in Bankura-II; and 895, 899, 900, 901, 902, 903, and 930 in Bankura-I) in the study area that are likely to have limited prospects for obtaining additional groundwater.

Fig. 7 Present scenario of the groundwater potential zones at Bankura-I and Bankura-II blocks based on AHP model. Most of the spatial extension is covered with poor condition of groundwater potential

Table 10 Spatial coverage and village distribution under five groundwater potential zones

Sl. No.	GWPZ*	Area (km ²)	Remarks
1	Very poor	0.68	• Very poor GWP villages – 9, 29, 46 & 47
2	Poor	250.57	(Bankura-II); 895, 899, 900, 901, 902, 903 &
3	Moderate	130.74	930 (Bankura-I)
4	Good	20.20	• Very good GWP villages – 1 & 2 (Bankura-I);
5	Very Good	0.27	64, 149, 157, 159 & 160 (Bankura-II)

Source: calculated by authors

*GWPZ – Groundwater Potential Zone

Status of groundwater use in the study area

The water level of the Bankura-I and Bankura-II blocks drop by about 1–2 m during the pre-monsoon season but in some sites may not show significant changes in the monsoon season despite heavy rainfall. Groundwater of the study area is mostly used for agriculture and domestic purposes (Fig. 4). The respondent's choice of groundwater use is based on their basic need, and it depends on the use of water for a particular purpose. The results of the questionnaire indicated that 82.14% of respondent utilized groundwater for household purposes only. As the Bankura district is a drought-prone area, agriculture highly dependent on groundwater. Consequently, nearly 82.14% of the respondents supported that groundwater was mainly used for agriculture, cleaning, and other purposes. According to the questionnaire, nearly 82.85% of respondents observed the level of groundwater is declining and 7.15% noticed the change in water quality appearances (Table 11).

Table 11 Respondent views groundwater level and average depth from 2006 to 2016

Perception of groundwater level and average depth from 2006 to 2016			
Types	Hard rock area	Respondent observation (%)	
Block covered	Bankura-I, Bankura-II	Water level fallen	Non-changeable
Area in km ²	391.9	92.85	7.15
Average depth to water level	7–8 m	–	–

Source: Surface Water Investigation Department (SWID), West Bengal and primary survey, 2021

Availability of water and drinking water status

West Bengal's water demand is constantly rising because of increased population and higher per-capita needs brought on

Fig. 8 Water collecting from the different source by the respondent Source: primary survey, 2021

by economic progress. According to the National Water Policy of 2002, which states that sufficient safe drinking water must be supplied to the whole population, both in urban and rural regions, where there is no other safe source of drinking water. This means that irrigation and multipurpose projects should always include a component to meet the drinking water demand, although this may also be met from other sources (Wang et al. 2012). This explains that, on average, households who pick surface water for their utilization, mostly collect them from the primary water sources. Apart from drinking and cooking, utility of water is necessary for all domestic uses (Prouty 2013). According to the UN, one-third of the world's population lives in water-scarce areas, with 1.1 billion people lacking access to safe drinking water (Shaw and Thaitakoo 2010).

Different types of sources of water availability in the study area have been shown in the Fig. 8. The results of the study indicated that respondents rely on hand pumps and bore wells 86.61 and 88.39%, respectively. About 33.04% respondents received a piped water supply and 58.93% people are used public taps. The availability of surface water resources in the region appears to be declining due to siltation and large rainfall fluctuations. The respondents who drank tap water they said it was their primary source and it was the only safe option to them (Grothmann and Patt 2005). Rainwater, surface water, and borehole water were identified by many respondents as sources of drinking water. As the whole Bankura district lies under a drought-prone area so water scarcity is always high. Surface water supplied depend on the arrival of monsoonal rainfall. However, when the monsoon does arrive, the water from surface water sources is muddy and unsuitable to drink. When the wells and the river run drying the summer, life becomes difficult, and it is difficult to use water from other sources (see Fig. 8).

Ground scenario of water use practices

Multiple factors, including those related to climate change, threaten rural livelihoods in many parts of the world. People in rural areas adopt different traditional and modern methods to solve water scarcity, helps to increase water availability and help to fulfil their basic needs. It includes modifying food storage practices, modifying farming techniques, diversifying livelihoods, leveraging social networks, and adapting water management practices, etc (Yohannes et al. 2017).

Due to the detected groundwater depletion in the area, some of these alternatives must be proposed in the Bankura district (Chatterjee 2018). The District Development and Water Management Department of Bankura is trying to cope up the problems by arranging different programs such as the Backward Region Grant Fund, but these have yet to show clear results (BRGF 2013). Additionally, three significant surface water-based supply initiatives are underway: the Barjora-Bankura I and Bankura II water supply schemes, the Hirabadh-Khatra and Ranibundh water supply system, and the Saltora-Chhatna water supply plan which may help to increase water availability.

The people of this village who are collecting water from the different sources they are using the boiling method to purify the water (Fig. 9). The quality of drinking water is one of the important indicators of living healthy. In case of the tap water nearly 43.21% of respondents are using boiling method to purify the water and a small percentage of a using boiling method as purifying methods resting that part most of the people are not using any methods as they directly using water for drinking. Nearly 0.98% of respondents are using aqua guards for purifying. On the other hand, as the people are facing scarcity of water, they are using several harvesting methods to store water (Lichtenthäler and Turton

Fig. 9 Adaptation behaviour of respondent according to their needs and treatment process of the water before utilization

1999). Rooftop rainwater harvesting and surface runoff harvesting were employed by around 7.1% and 2.3% of respondents, respectively, to store the water (Fig. 9). Residents in the study areas are likely to use a variety of methods to obtain drinking water due to the general fluctuating pattern of water availability.

Perception of respondents on water quality and availability

People respond to threats they perceive, which is why risk perception is so important in risk management and behavioural change (Gbetibouo 2009; Maddison 2007). Risk perceptions have been found as a key factor in human behaviour (Fishbein

and Ajzen 2011; Gbetibouo 2009; Grothmann and Patt 2005). Several approaches have been developed to understand risk perception and its impact on behaviour (Grothmann and Patt 2005).

In the Bankura district especially in Bankura I and Bankura II, groundwater levels fluctuate dramatically during the pre-monsoon and post-monsoon seasons, with water table fluctuations as high as 8.36 m being recorded in the area (Nag and Ghosh 2013). In general, the ground water quality in the area is suitable for potable use (Attari 2014) but is highly differ across the area.

The output is the table of commonalities which shows how much of the variance (i.e., the value of communality that must be more than 0.5) to be considered for further analysis. Otherwise, many variables would have to be removed from the factor

Table 12 Factor analysis based on Likert scale regarding respondent's perception on groundwater condition and vulnerability

Total variance explained						
Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.23	44.589	44.589	2.23	44.589	44.589
2	1.82	36.296	80.885	1.82	36.296	80.885
3	0.85	16.972	97.857	—	—	—
4	0.06	1.131	98.988	—	—	—
5	0.05	1.012	100	—	—	—
Communalities						Initial Extraction
Drinking water services						1 0.954
Water service for agriculture						1 0.247
Groundwater quality						1 0.954
Drinking water quality						1 0.954
Water management						1 0.935

Extraction method: principal component analysis (PCA)

analysis, the variables have been accounted for by the extracted factors. For instance, over 90% of the variance in “Groundwater quality, drinking water quality and water Management” is accounted for, while 24.7% of the variance in “Water service for agriculture” is accounted for. The table of Eigenvalue has been separated into three sub-sections, i.e., Initial Eigenvalues, Extracted Sums of Squared Loadings, and Rotation of Sums of Squared Loadings. Based on the table, the first factor accounts for 44.589% of the variance, the second 36.27%, all the remaining factors are not significant (Table 12). Based on the above analysis the five key factors using the Likert scale such as drinking water services, water service for agriculture, groundwater quality, drinking water quality, indicate that the current water management system of Bankura district is not satisfactory to the people. According to the responders, the area is suffering several crises, including environmental issues, climate change, and water fragility, among others. The perception of the people on the above aspect is not satisfactory, it also supports that the people of Bankura are facing several problems with arranging or using the water from different sources.

Conclusion

The study area lies in Bankura district, a part of Bankura-Bishnupur rarih plains, under the state of West Bengal. The population in the study area is concentrated around the central part, mostly at and around the Bankura sadar. Agriculture dominated rural economy (besides pottery industry) is the backbone in the study area. Bankura Region is one of the most drought-prone areas in West Bengal. The area characterised by arid climate with annual average rainfall around 115 mm and which suffers from water stress and periodic uncertainty of supply.

The main geological units in the examined area are: Chhotanagpur gneissic complex, older alluvium, younger alluvium, and unclassified metamorphics. Proterozoic granite gneiss vastly covered the substrate of the study area. Therefore, red laterite surface soil is one of the triggering factors for cultivation. Geomorphologically, versatile landscapes in the study area cannot accentuate agricultural production. Damodar and Dwarkeswar Rivers are the dominant river within the study area and act as important groundwater recharge units. Nowadays, a total geographical area of the selected blocks (Bankura I and II) is experiencing different status of groundwater potential vis. very poor, poor, moderate, good, and very good groundwater potential based on MCDM-AHP model which is developed in a reliable GIS environment. But poor (250.57 km² area) to moderate (130.74 km²) groundwater potential is dominating because of paucity of rainfall, dry climatic condition, unfavorable substrate characteristics and so on. However, groundwater table being a perfectly distinguishable seasonal undulating in nature which directly affects the residents as well as the natural environment. Furthermore, the ground water potential status of the Bankura-I and Bankura-II blocks is unsustainable, putting local inhabitants' everyday lives in jeopardy during the summer months. Low ground water tables impede not just the provision of drinking water, but also every element of human life, from economic to cultural aspects. In the study area, local groundwater is being used as a major source of water supply in the form of hand pump and bore wells. The usage of groundwater is linked to a variety of activities, including drinking, cleaning, cultivating, pottery industry, and other applications that means it has immense value. So, sustainable management of groundwater is not only important for present society, but also for future generations also. Water being an inseparable part of human life, the need for

water in mother earth is rapidly increasing, owing to both rising population and higher per-capita needs brought on by economic expansion, to preserve natural resources (i.e., groundwater) is not our gaining knowledge rather primary duty.

People in rural regions employ several strategies to prepare for and adapt to water scarcity, including food storage, changing agricultural practices, diversifying livelihoods, leveraging social networks, and water management, among others. Several programs implemented in the area in the previous 5 years, particularly under the Backward Region Grant Fund (BRGF), have yet to bear fruit, even though the Bankura District Development and Water Management Department is attempting to deal with the situation by arranging various measures. Here, one surface water-based supply initiative is currently underway: the Barjora-Bankura I and Bankura II water supply schemes, which may help the entire blocks to provide sufficient water, despite the fact that the problem has worsened due to changes in climatic conditions and environment. Although groundwater shortage is the burning issue that is why sustainable management practices, e.g., rainwater harvesting, wastewater management, dry agricultural practices, formation of water reuse connectivity, etc., will be the best way to catch up energy to sustain. Finally, considering the foregoing facts about the importance of water, the effects of water scarcity, and sustainable water use, it is critical that people from all sections of the study area, as well as governmental and non-governmental organizations, collaborate in a holistic manner to secure water for future generations and protect the world's natural ecosystem. Also, this research might help policymakers and environmentalists develop an effective plan for sustainable groundwater exploitation and watershed protection, as well as provide recommendations to government authorities.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper and no other third-party interferences so far, their knowledge and belief.

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