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Application of Geoinformatics with Frequency Ratio (FR) Model to Delineate Different Groundwater Potential Zones in Ken Basin, India

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Abstract: The goal of present study was to make groundwater potential zones map using the frequency ratio (FR) model (i.e., probabilistic based bivariate statistical approach) and Geoinformatics technique in Ken Basin, India. Very few studies have been done yet to demarcate the groundwater potential zones using FR model in India. This research contains the analysis of spatial relationships between groundwater and its contributing factors viz., geology, geomorphology, lineament density, land use/ land cover, soil texture, rainfall, slope, drainage density, depth to water level – pre monsoon and depth to water level – post monsoon. The ten groundwater contributing factors were collected from different resources and prepared in 10 m spatial resolution in ArcGIS 10.8.There are 425 observation wells located in the study area, out of these, 296 (70%) observation wells were randomly selected as training datasets for the model and the remaining 129 (30%) were used as a training dataset for the validation purpose. The final output of groundwater potential zones map was classified into five different zones as very high, high, moderate, low, and very low. A more significant portion of the Ken Basin, nearly 30.66%, falls within the moderate groundwater potential zone followed by poor and good potential zones. For quantitative validation, ROC curve analysis was executed through the IBM SPSS software by comparing existing groundwater well locations in the validation datasets (well yield data) with the groundwater potential map obtained by the FR model. The validation results illustrated that the area under the curve (AUC) for the frequency ratio model is 78.1% which achieved fair satisfactory prediction accuracy. The outcome of this study is highly reliable which can serve as a guideline for the planning of exploration, exploitation, and sustainable management of groundwater resources in the study area.

Keywords: Groundwater potential zones, Frequency ratio, Geoinformatics, Ken Basin

Water is the essential resource of all living things and it ought to be accessible adequately for all the required demands like domiciliary, agriculture, manufacturing & engineering, recreational and environmental needs. Groundwater is one of the most valuable natural resources which support human health and economic development. As a result of its constant accessibility and excellent natural quality, groundwater turns into a significant source of water supply in several rural and urban areas of the world (Todd and Mays 2005). Groundwater is a hidden natural resource that cannot be directly distinguished, consequently, mapping of this asset could be a challenging task. Illustration of groundwater potential zones (GPZs) is essential for the optimum utilization of accessible water resources to address the needs of the communities (Etikala et al 2019).

The unsustainable management of groundwater resources is transforming into an evident problem for many developing countries (Hussein et al 2017). The unavailability of updated spatial information on the volume and movement of groundwater isa huge problem in the sustainable management of groundwater. Presently days, there is a solid need to utilize groundwater for the socio-economic advancement in the country, especially for rustic regions. As well as practical knowledge of groundwater potential assessment should be required before exploitation and managing it. Presently, the Geoinformatics technique (an RS & GIS integrated approach) is becoming a powerful tool for the assessment of earth's natural resources. The assessment of groundwater potential zones mapping is less time taking and very cost-effective using these techniques. These geoinformatics approaches make the analysis easier as compared to conventional methods like ground drilling, geophysical assessment of lineament features, and field observations. In earlier years, various types of studies have been accomplished through the implementation of different multi-criteria decision making approaches. Most of the researchers have endeavoured to demarcate the groundwater potential zoning maps viamulti influencing factors and the AHP method around the world. FR model has been widely used for the assessment of landslide susceptibility mapping. A very few works are found to demarcate the groundwater potential zones using the frequency ratio model (Das and Pardeshi 2018, Prasad et al 2020, Arjun KC et al 2021). All these approaches are taken by various researchers for groundwater investigation, which are simpler, cost, and time saving.

Due to the highly variable geological conditions in the Ken Basin, groundwater potential mapping is more complex and challenging. However, the demarcation of the groundwater potential areas in the Ken Basin is still not studied well. Hence, an attempt has been made in this study to demarcate different groundwater potential areas in Ken Basin by using the Frequency Ratio model with the help of geoinformatics techniques.

MATERIAL AND METHODS

Study area: The Ken River Basin is an interstate river between Madhya Pradesh and Uttar Pradesh. The total length of the river from its origin place to confluence point with the river Yamuna is 427 km, out of which 292 km lies in Madhya Pradesh, 84 km in Uttar Pradesh and 51 km forms the common boundary between Madhya Pradesh and Uttar Pradesh. The study area extends over approximately of 28,671 km^2, and lies between 23°07' – 25°51' N latitudes and 78°30'-80°38' E longitudes. The Ken River originates near the Ahirgawan village on the north-west slopes of Barner Range in Katni district and confluence in Yamuna River at Chilla village, Banda district in Uttar Pradesh. About 86.73% area of this basin lies in Madhya Pradesh and the remaining 13.27% of the area lies in Uttar Pradesh. The basin covers eight districts (i.e., Katni, Sagar, Damoh, Chhatarpur, Panna, Satna, Narsinghpur, & Raisen) of Madhya Pradesh and three districts (i.e., Hamirpur, Mahoba, and Banda) of Uttar Pradesh. It is bounded by Vindhyan range in the south, Betwa basin on west, a free catchment of Yamuna below Ken on east, and the river Yamuna on north. The important tributaries of Ken Basin are Alona, Bearma, Sonar, Mirhasan, Shyamari, Banne, Kutni, Urmil, Kail, and Chandrawal. Ken Basin consists of central high lands of Vindhyan and Bundelkhand region. The Vindhyans have sedimentary rocks, granites, and alluvium whereas Bundelkhand have granite gneisses. The 10 years (2011-2020) average annual rainfall in the basin is 1050 mm. The average maximum and minimum temperatures are 44.2°C and 6.7°C respectively.

Data collected: Satellite imageries of SENTINEL-2B, (10 m spatial resolution) were downloaded from Earth Explorer portal of USGS having data acquisition of February 2021. Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM) (30 m spatial resolution) was also acquired from USGS Earth Explorer. SRTM DEM data were used to prepare basin map of Ken River through ArcSWAT tool in ArcGIS 10.8 software as well as drainage density and slope map. The vector data on geomorphology and lineament at 1:250,000 scale and geology at 1:50,000 scale was derived from Bhukosh portal of the Geological Surveyof India. Average monsoon rainfall data (0.25 x 0.25 degree gridded data) for the year 2020 were collected from India Meteorological Department (IMD) website. The data on soil parameters at 1:500,000 scale was acquired from the National Bureau of Soil Survey and Land Use planning (NBSS&LUP), Nagpur to prepare a soil texture map. Observation Wells (POWs) data of Ken Basin was obtained from State Ground Water Data Center, Bhopal and Ground Water Department, Lucknow.

Primarily, ArcSWAT model was employed to delineate the Ken Basin map using SRTM DEM (30 m spatial resolution) in ArcGIS 10.8 environment. Also, the Drainage map, Drainage Density map, and Slope map were organized by analysing the SRTM DEM data. After acquisition of geology, geomorphology, and lineament data from Bhukosh portal of GSI, these data were rectified and then employed in ArcGIS 10.8. After the construction of lineament map, line density tool was employed to prepare lineament density map. Soil texture map was prepared using the digitization technique in GIS environment with the help of soil texture data map sheets acquired from NBSSLUP. The rainfall gridded data of the year 2020 was obtained from IMD, Pune, and prepared monsoon rainfall map of Ken Basin. Also, the Observation Wells (OWs) data of Ken Basin were acquired from both the GW centers and prepared pre and post depth to water level maps using IDW tool in ArcGIS environment. Sentinel-2B imagery of 10 m spatial resolution was considered in this study for the making of a land use/ land cover (LULC) map of Ken Basin using ERDAS IMAGINE 2020 software. As well as, the accuracy assessment was employed for land use/ land cover and calculated kappa coefficient using ArcGIS 10.8.

The collected thematic data which was primarily not in projected system was projected in WGS_1984_UTM_ Zone_44N projected coordinate system (PCS) using ArcGIS 10.8 software. Vector data of the different theme were converted to raster form using spatial analyst tool in GIS environment. Line density conversion tool was considered to converting polyline to raster data format. As ever, all the raster dataset of different groundwater contributing themes were prepared, these data were reclassified based on the utility and then exported into 10 m x 10 m cell size raster data for further integration analysis for Groundwater Potential Zoning using Frequency Ratio model. After the making of Groundwater Potential Zones map, the Receiver Operating Characteristics (ROC) method was employed for the validation purpose to estimate area under curve (AUC) considering observation wells (training data set) and groundwater potentiality zones. The overall methodology adopted in the current study are shown in Figure. 2.

Frequency ratio model: Frequency ratio model can be characterized as the possibility of event of a specific factor (Bonham-carter, 1994).The value of frequency ratio of a certain factor can be simply determined using the following equation:

$$FR = \frac{\left(\frac{W_x}{W_y}\right)}{\left(\frac{A_x}{A_y}\right)} = \frac{W}{A} \qquad (1)$$

Where,

Wx = number of observation wells exists in each class of certain factor

Wy = total number of observation wells exists in the study area

Ax = area covered by each class of certain factor (sq km)

Ay = total area of the study area (sq km)

W = percentage of observation wells

A = percentage of area

FR = value of frequency ratio of a class for the certain factor

If the FR value is lesser than 1 that shows to lower importance of the groundwater potentiality and a value greater than 1 depicts more importance of the groundwater potentiality.

To prepare the groundwater potential zones map, all the groundwater governing factors with their frequency ratio values were integrated in ArcGIS 10.8 and summed using the below given expression:

$$GPZ = \sum_{i=1}^{n} FR$$
$$= GL_{FR} + GM_{FR} + LD_{FR} + LULC_{FR} + ST_{FR} + RF_{FR} + SL_{FR} + DD_{FR} + DTWL\_Pre_{FR} + DTWL\_Post_{FR} \qquad (2)$$

Where,

GPZ = groundwater potential zones

GL_{FR} = reclassified layer of geology using FR values

GM_{FR} = reclassified layer of geomorphology using FR values

LD_{FR} = reclassified layer of lineament density using FR values

$LULC_{FR}$ = reclassified layer of land use/ land cover using FR values

ST_{FR} = reclassified layer of soil texture using FR values

RF_{FR} = reclassified layer of rainfall using FR values

SL_{FR} = reclassified layer of slope using FR values

DD_{FR} = reclassified layer of drainage density using FR values

$DTWL\_Pre_{FR}$ = reclassified layer of depth to water level-pre monsoon using FR values

$DTWL\_Post_{FR}$ = reclassified layer of depth to water level-post monsoon using FR values

To perform FR model, a total number of 296 observation wells were randomly selected as training datasets for the model and the remaining 129 observation wells were used as a training dataset for the validation purpose.

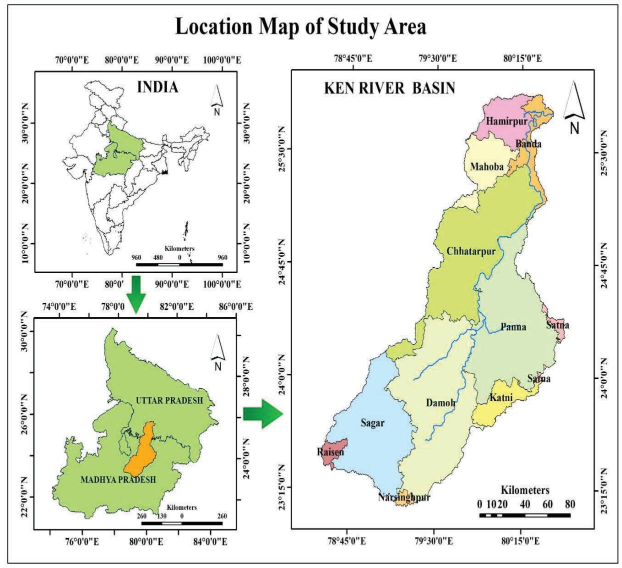

Fig. 1. Location map of Ken Basin

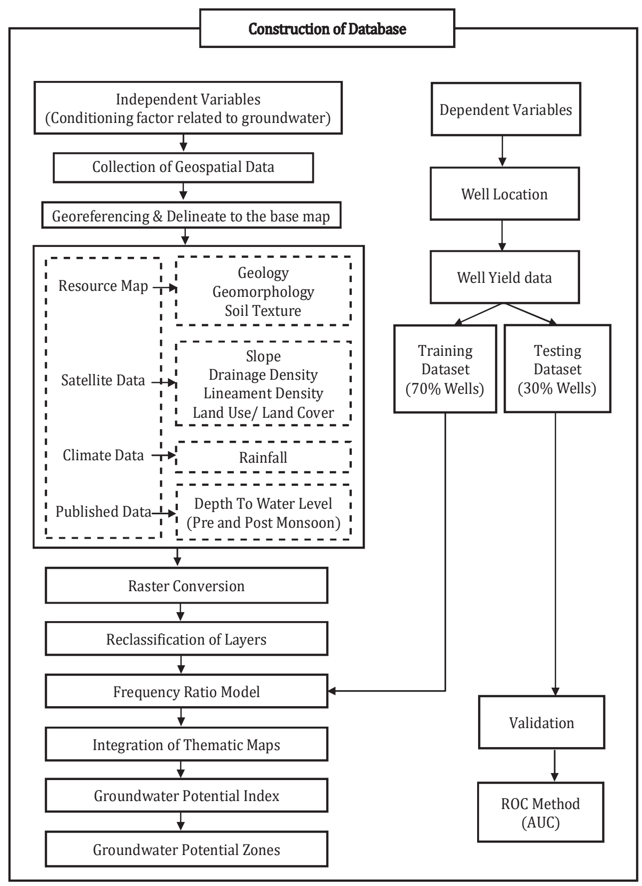

Fig. 2. The overall methodology adopted in the current study

RESULTS AND DISCUSSION

Assessment of Factors Contributing to Groundwater Potential

Geology: Geology Map of the Ken Basin was prepared using the raw gridded vector data of Geology (scale of 1:50,000) downloaded from Bhukosh portal of Geological Survey of India. The geology of the study area has been comprised mainly of ten major groups which are given as below: Alluvium, Bhander, Bijawar, Bundelkhand Granite Complex, Kaimur, Lameta, Laterite, Malwa, Rewa, and Semri group.Bhander group covered most of the area of Ken Basin.

Geomorphology: The raw vector data of Geomorphology (scale of 1:250,000) was downloaded from the Bhukosh portal of GSI. Ken Basin is covered by various types of geomorphological features such as alluvial plain, flood plain, dissected hills and valleys, pediment pediplain complex, piedmont undulating upland, etc. Ken basin is mostly covered by pediment pediplain complex.

Lineament density: Lineaments play a vital role in the recharge process of groundwater in hard rock territories. Vector data of Lineaments (scale of 1:250,000) was downloaded from Bhukosh portal of Geological Survey of India. This data has been clipped by the Shape file of Ken River Basin. Used the clipped lineament file and applied the line density tool in ArcGIS 10.8 software. Then, the Lineament Density map has been finalized. Lineaments on a surface level have been perceived early as conduits for groundwater flow in fractured aquifers and henceforth it will be helpful to focus on the area of creation wells. The lineament density is high in the southern and central parts of the Ken Basin.

Land use/ land cover: LU/LC influences evapotranspiration volume, duration, and recharge of the groundwater system. The false color composite (FCC) image was prepared using Sentinel-2B imagery with a band combination of 2,3,4 and 8. Then the satellite image was classified by the onscreen visual interpretation technique, based on the available auxiliary data, previous knowledge, and appropriate ground truth points using ERDAS IMAGINE®2020 software. After the visual interpretation, six major classes were identified, viz. water bodies, agricultural land, forest, grasslands, wasteland, and built-up. Then, the area of interests (AOI) of all classes was prepared and further recoded on the unsupervised classified image. Finally, classified raster output was used as LULC map. Accuracy assessment of land use/ land cover was accomplished and overall accuracy was calculated as 92.0%.

Soil texture: Different soil map sheets with scale of 1:5,00,000 of Ken River Basin has been geo referenced in ERDAS IMAGINE 2020 and then digitization was done in ArcGIS 10.8 software. Soil texture map has been finalized. Most of the area of Ken River Basin is covered by the loamy soil and very least area comes under the silty soils.

Rainfall: The rainfall factor plays a key role in the groundwater recharge system which surface water infiltrates into subsurface media by fractures and soils. About 90% of the rainfall occurs from June to September. The Ken basin is fed by south-west monsoon which starts from mid of June and lasts till the end of September. The spatial map of monsoon rainfall has been prepared using ArcGIS 10.8 software. The monsoon rainfall found ranges between 572.72 to 1225.53 mm in the year 2020 over the study area. The decreasing trend of rainfall pattern demonstrates from south to north within the basin.

Slope: The slope is also an important factor in groundwater prospect mapping which influences the runoff because of its direct proportionality. Groundwater recharge will be less in steep slope due to increasing of runoff and decreasing percolation & infiltration. Commonly, in gentle slopes, groundwater recharge will be more because of greater infiltration and percolation. A slope map of Ken Basin was prepared using the SRTM DEM data by slope tool under spatial analysis tool in ArcGIS 10.8 software. Most parts of the study area have slopes within the range of 103 percentage.

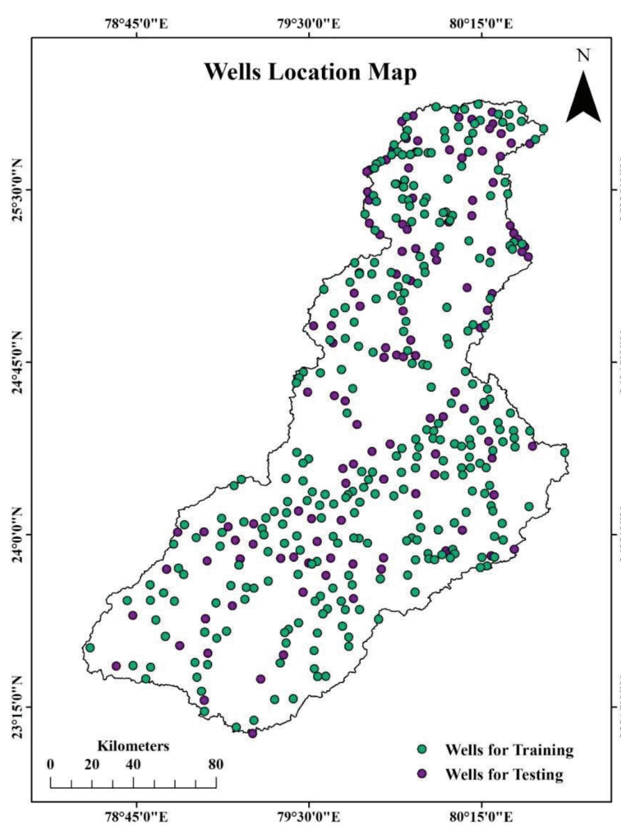

Fig. 3. Well location map of Ken Basin, India

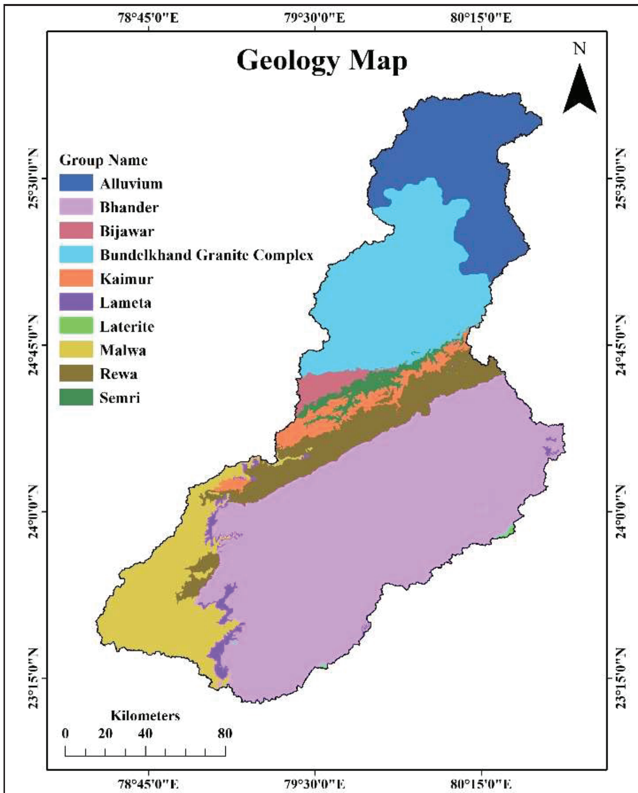

Fig. 4. Geology map of the Ken Basin

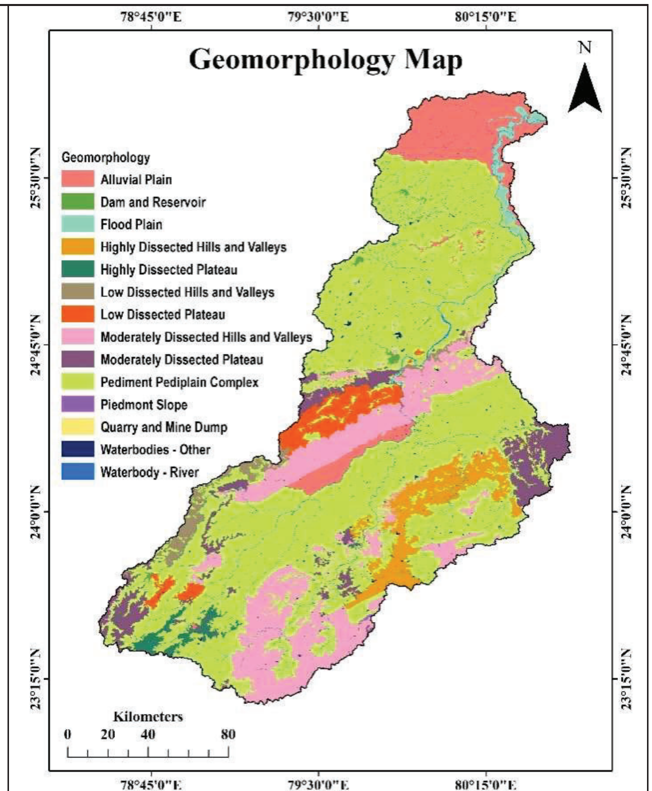

Fig. 5. Geomorphology map of the Ken Basin

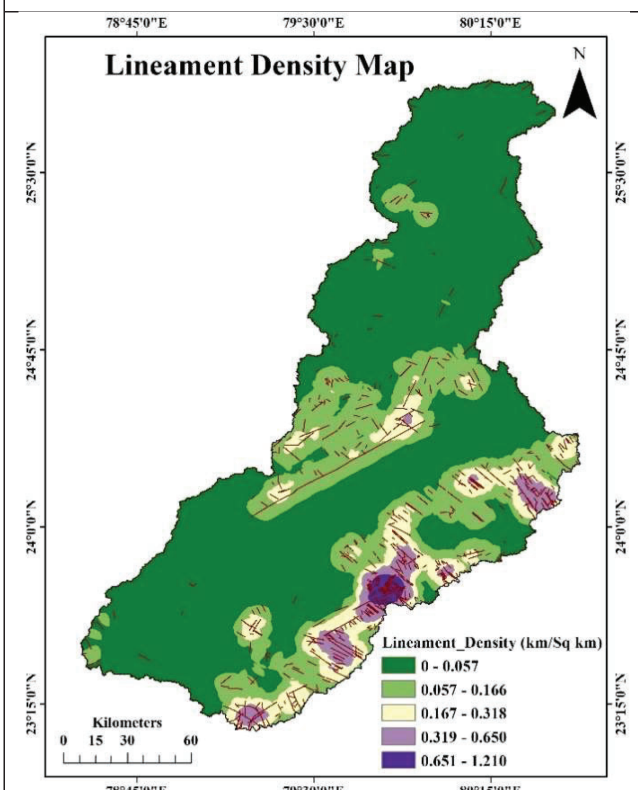

Fig. 6. Lineament density map of the Ken Basin

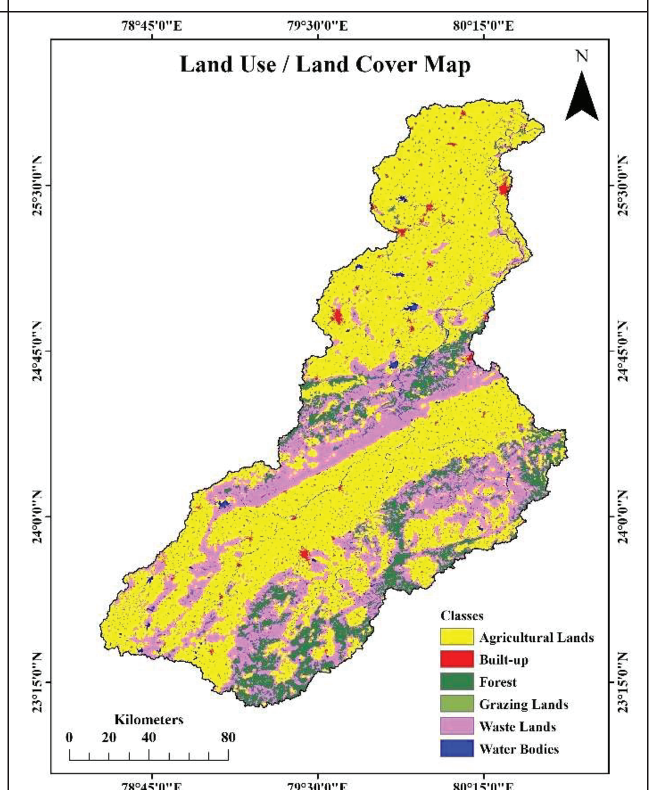

Fig. 7. Land use/ land cover map of the Ken Basin

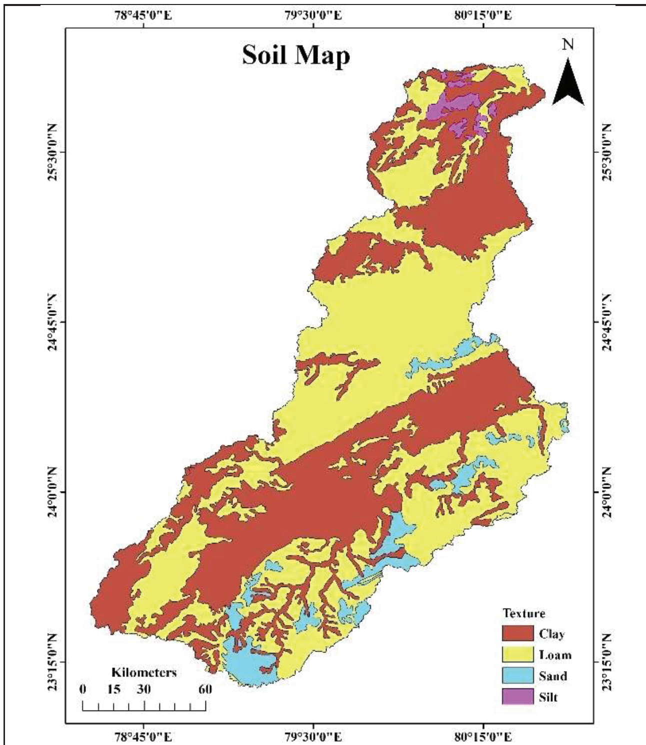

Fig. 8. Soil texture map of the Ken Basin

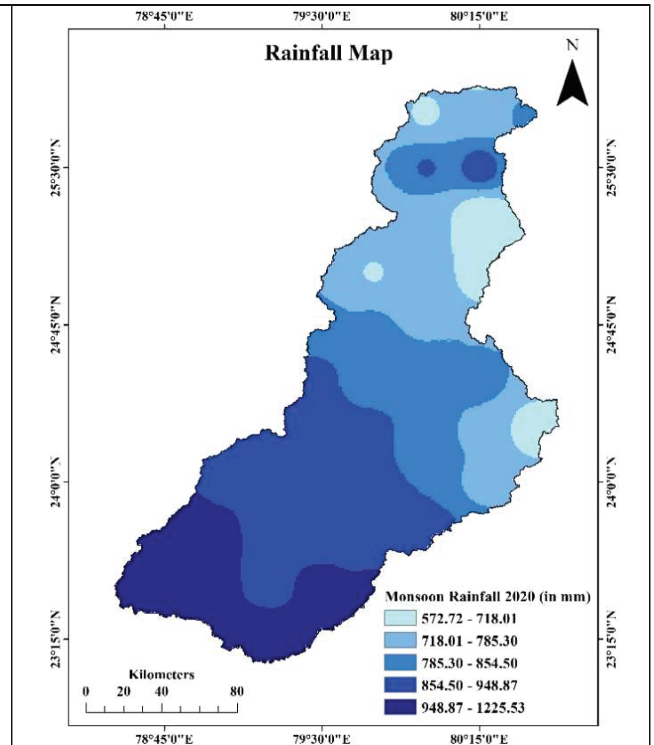

Fig. 9. Rainfall map of the Ken Basin

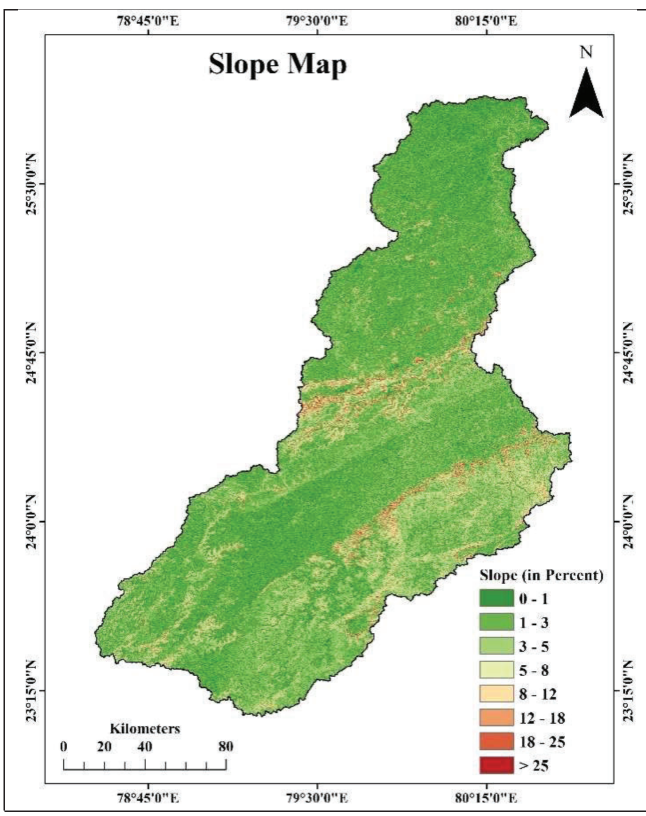

Fig. 10. Slope map of the Ken Basin

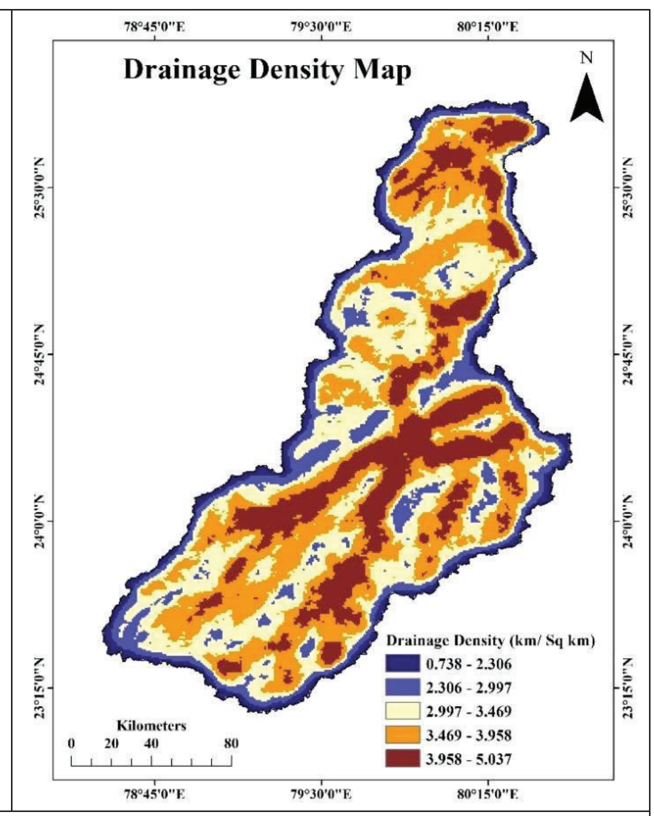

Fig. 11. Drainage Density map of the Ken Basin

Southern part of the Ken Basin displays a steeper slope, whereas the northern parts are associated with lower slopes.

Drainage density: Drainage of Ken Basin was produced from SRTM DEM data and verified with the Survey of India toposheets (scale of 1:50,000). Drainage density of the study area in km/km^2 was calculated by line density tool under spatial analyst tool in ArcGIS 10.8 software. The drainage pattern in the area was dendritic & pinnate type and the southern portion of the Ken Basin is associated with very high drainage density. About 40% of the area upstream of the medium drainage density. The higher the drainage density, the lower is the infiltration and the faster is the movement of the surface flow. The drainage density in the study area was found to range from 0.738 to 5.037 km/km^2.

Depth to water level – pre monsoon: The depth to water level map for pre-monsoon was produced by the inverse distance weighting (IDW) interpolation technique using ArcGIS 10.8. In Pre-monsoon season, depth to water level within the study area ranges between 1.11 to 27.59 m bgl. Broadly, Shallow groundwater levels indicate high groundwater potentiality whereas the deeper groundwater level shows fewer groundwater potential zones. This parameter is important for the groundwater potential zone.

Depth of water level – post monsoon: The depth to water level map of post-monsoon was also generated by the inverse distance weighting (IDW) interpolation method using ArcGIS 10.8 software. During the post-monsoon season, depth to water level within the study area varies 1.0 to 26 m bgl. In the post monsoon season, water level depth in the wells nearby the lineaments rises considerably. The depth to water level map of post-monsoon is more reliable factor to understanding the groundwater recharge in any area. After the preparation of thematic maps, training data (296 observation wells) was overlaid on each theme and the percentage of wells in every class (or category) of each factor was estimated. The area and the percentage of area for each class of each factor were calculated. Then FR value was calculated for every class of each theme by the ratio of the percentage of observation wells to the percentage of area in the basin. Frequency Ratio values of different thematic layers and their attributes were illustrated in given Table 1.

Development of groundwater potential zones: Once the FR values were obtained, all the thematic layers with their attributes were reclassified by FR values through ArcGIS 10.8 software. All the reclassified raster themes were integrated using the raster calculator tool in ArcGIS 10.8 ® environment and summed using equation 2. Resulted Groundwater Potential Index (GPI) was found ranging from 1.39 to 4.37.High GPI denotes high groundwater potentiality whereas low GPI depicts low groundwater potentiality. The GPI was classified into five different groundwater potential zones using Natural Jenks Classification method. The study

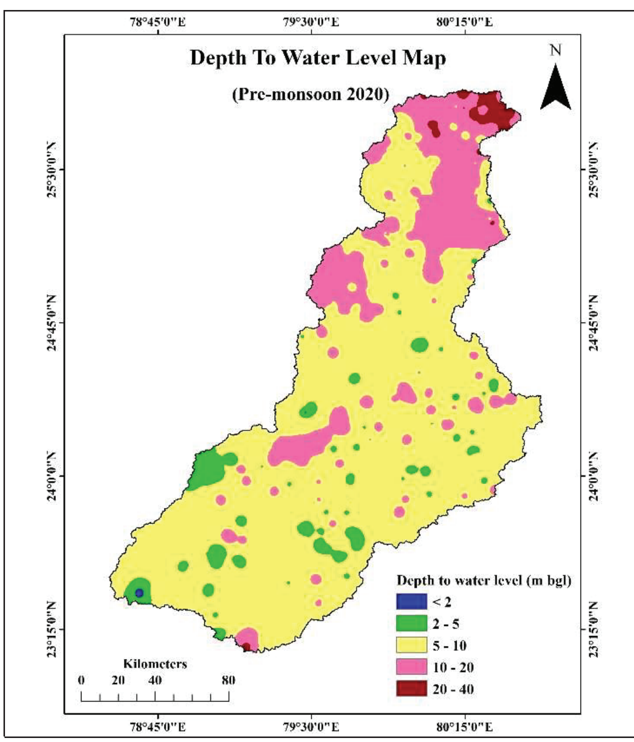

Fig. 12. Depth to water level – pre monsoon map of the Ken Basin

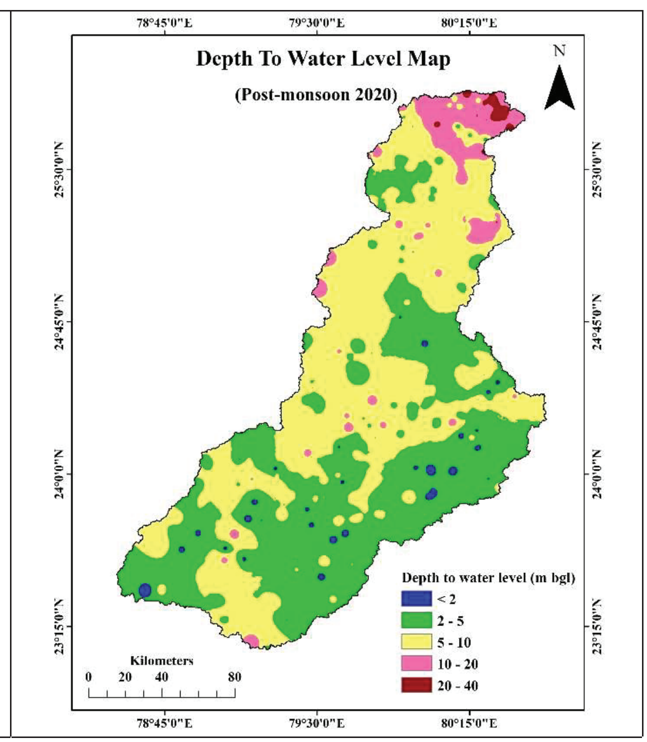

Fig. 13. Depth to water level – post monsoon map of the Ken Basin

Table 1. Frequency ratio values of different thematic layers and their attributes

Factors / Themes	Classes / Ranges	No. of wells	Total no of wells	% of wells	Area (km^2)	Total area (km^2)	% of area	FR value
Geology	Alluvium	56	296	18.919	3730.023	28671	13.010	1.454
	Bundelkhand Granitoid Complex	56	296	18.919	4999.094	28671	17.436	1.085
	Bijawar	1	296	0.338	352.646	28671	1.230	0.275
	Semri	1	296	0.338	462.374	28671	1.613	0.209
	Kaimur	2	296	0.676	766.588	28671	2.674	0.253
	Rewa	13	296	4.392	2186.252	28671	7.625	0.576
	Malwa	24	296	8.108	2950.570	28671	10.291	0.788
	Bhander	142	296	47.973	12849.619	28671	44.817	1.070
	Lameta	1	296	0.338	340.538	28671	1.188	0.284
	Laterite	0	296	0.000	33.297	28671	0.116	0.000
Geomorphology	Alluvial plain	40	296	13.514	2189.002	28671	7.635	1.770
	Dam and reservoir	1	296	0.338	70.842	28671	0.247	1.367
	Flood plain	4	296	1.351	277.497	28671	0.968	1.396
	Highly dissected hills and valleys	5	296	1.689	1316.055	28671	4.590	0.368
	Highly dissected plateau	2	296	0.676	312.419	28671	1.090	0.620
	Low dissected hills and valleys	5	296	1.689	530.451	28671	1.850	0.913
	Low dissected plateau	2	296	0.676	846.640	28671	2.953	0.229
	Moderately dissected hills and valleys	16	296	5.405	4519.933	28671	15.765	0.343
	Moderately dissected plateau	2	296	0.676	1657.014	28671	5.779	0.117
	Pediment pediplain complex	215	296	72.635	16528.139	28671	57.648	1.260
	Piedmont slope	0	296	0.000	5.595	28671	0.020	0.000
	Quarry and mine dump	0	296	0.000	1.468	28671	0.005	0.000
	Waterbodies-Other	2	296	0.676	129.264	28671	0.451	1.499
	Waterbody - River	2	296	0.676	286.681	28671	1.000	0.676
Lineament Density (km/ km^2)	0.000 - 0.056	222	296	75.000	18968.603	28671	66.160	1.134
	0.056 - 0.166	54	296	18.243	6172.920	28671	21.530	0.847
	0.166 - 0.317	15	296	5.068	2418.630	28671	8.436	0.601
	0.317 - 0.650	5	296	1.689	933.886	28671	3.257	0.519
	0.650 - 1.210	0	296	0.000	176.961	28671	0.617	0.000
Land use / land cover	Water bodies	2	296	0.676	351.189	28671	1.225	0.552
	Forest	6	296	2.027	3191.585	28671	11.132	0.182
	Grazing lands	0	296	0.000	1.035	28671	0.004	0.000
	Agricultural lands	219	296	73.986	17363.506	28671	60.561	1.222
	Waste lands	23	296	7.770	6862.150	28671	23.934	0.325
	Built-up	46	296	15.541	901.504	28671	3.144	4.942
Soil texture	Clayey soil	167	296	56.419	13446.139	28671	46.898	1.203
	Loamy soil	121	296	40.878	13807.438	28671	48.158	0.849
	Sandy soil	8	296	2.703	1387.604	28671	4.840	0.558
	Silty soil	0	296	0.000	29.819	28671	0.104	0.000
Monsoon rainfall (mm)	572.72 - 718.01	14	296	4.730	1919.886	28671	6.696	0.706
	718.01 - 785.30	99	296	33.446	6837.454	28671	23.848	1.402
	785.30 - 854.50	68	296	22.973	6262.335	28671	21.842	1.052
	854.50 - 948.87	79	296	26.689	8528.477	28671	29.746	0.897
	948.87 - 1225.53	36	296	12.162	5122.847	28671	17.868	0.681

Cont...

Table 1. Frequency ratio values of different thematic layers and their attributes

Factors / Themes	Classes / Ranges	No. of wells	Total no of wells	% of wells	Area (km^2)	Total area (km^2)	% of area	FR value
Slope (%)	0 - 1	60	296	20.270	4163.355	28671	14.521	1.396
	1 - 3	103	296	34.797	9016.265	28671	31.447	1.107
	3 - 5	73	296	24.662	6681.979	28671	23.306	1.058
	5 - 8	39	296	13.176	4661.162	28671	16.257	0.810
	8 - 12	14	296	4.730	2027.528	28671	7.072	0.669
	12 - 18	4	296	1.351	1056.904	28671	3.686	0.367
	18 - 25	2	296	0.676	488.829	28671	1.705	0.396
	> 25	1	296	0.338	574.979	28671	2.005	0.168
Drainage density (km/ km^2)	0.738 - 2.306	37	296	12.500	2174.224	28671	7.583	1.648
	2.306 - 2.997	32	296	10.811	4366.489	28671	15.230	0.710
	2.997 - 3.469	64	296	21.622	8588.034	28671	29.954	0.722
	3.470 - 3.958	102	296	34.459	8699.349	28671	30.342	1.136
	3.958 - 5.037	61	296	20.608	4842.904	28671	16.891	1.220
Depth to water level – pre monsoon (m bgl)	< 2	5	296	1.689	23.638	28671	0.082	20.489
	2 - 5	39	296	13.176	1348.632	28671	4.704	2.801
	5 - 10	162	296	54.730	21487.381	28671	74.945	0.730
	10 - 20	78	296	26.351	5455.830	28671	19.029	1.385
	20 - 40	12	296	4.054	355.519	28671	1.240	3.269
Depth to water level – post monsoon (m bgl)	< 2	29	296	9.797	264.721	28671	0.923	10.611
	2 - 5	117	296	39.527	12798.282	28671	44.638	0.885
	5 - 10	115	296	38.851	13804.663	28671	48.149	0.807
	10 - 20	26	296	8.784	1657.123	28671	5.780	1.520
	20 - 40	9	296	3.041	146.211	28671	0.510	5.962

area under the very poor, poor, moderate, good and very good zones contributing to 3157.82 km^2, 7497.75 km^2, 8789.82 km^2, 2032.30 km^2, and 7193.31 km^2. The Groundwater Potential Zones map of Ken Basin is shown in Figure 14.

Validation of groundwater potential zones: The area under curve (AUC) of ROC shows the accuracy of a prediction system by representing the model's capability to correctly or incorrectly identify the successful event. In ROC method, the AUC ranges from 0.5 to 1 which can be classified into the following categories: 0.5–0.6 (poor) 0.6–0.7 (average); 0.7–0.8 (good); 0.8–0.9 (very good); and 0.9–1 (excellent) (Yesilnacar 2005). Well Yield data of the Testing dataset (30% Wells) has been superimposed on the GPZ raster data in the ArcGIS Platform for validation purposes. Groundwater Potential Zones has been verified with well yield data and a prepared table that includes true data and false data for each well. Sensitivity has been calculated using POWs Groundwater Yield data with their classes. After that, 1-Specificity has been calculated using the Groundwater Potential Zones data with their classes. IBM SPSS software was used to calculate the area under curve.

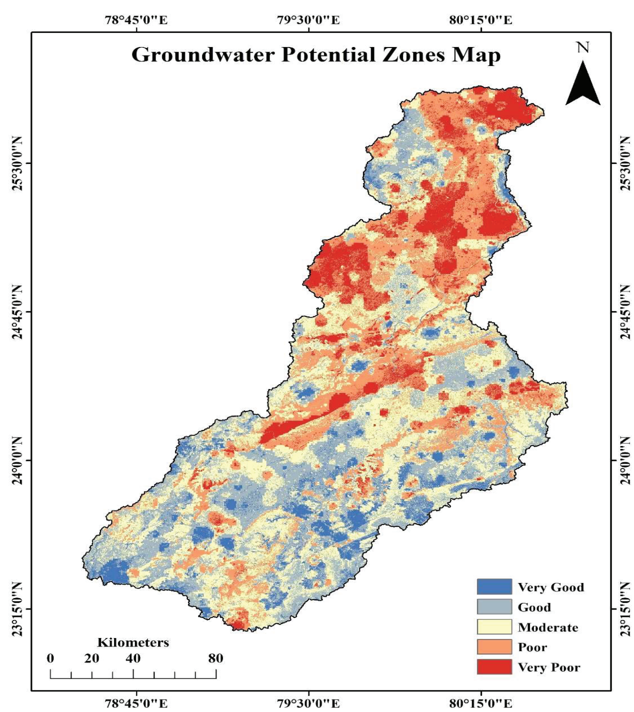

Fig. 14. Groundwater potential zone map of the Ken Basin

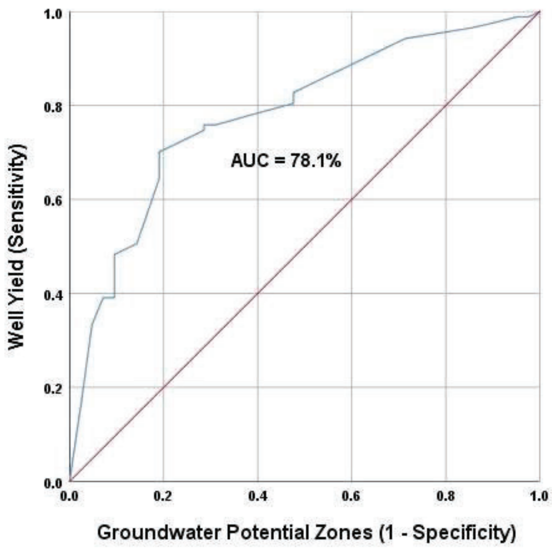

Fig. 15. Validation of groundwater potential map of Ken Basin through ROC curve method

The AUC has been obtained 78.1%, which was in the fairly accepted condition.

The Geoinformatics approach is a prevailing tool for assessing groundwater potential zones as well as identifying suitable and unsuitable locations for groundwater extractions (Awasthi and Patle 2019, Patle and Awasthi 2019, Awasthi and Patle 2020).The Frequency Ratio model is more efficient for geospatial assessment of groundwater potential zones based on relationships between dependent variable viz. groundwater well data and independent variables like groundwater contributing factors (Trabelsi et al 2019, Rajasekhar et al 2021). Such types of studies will help in the identification of prospective areas for reducing targets to detailed hydrogeological and geophysical surveys at suitable places for drilling.

CONCLUSIONS

Geoinformatics techniques are more powerful tools to delineate groundwater potential zones, which helps to save money, reduce time and provide relatively an accurate outcome. In the current study, a frequency ratio (FR) model was employed for groundwater potential zoning in Ken Basin using geoinformatics techniques. Geology, geomorphology, lineament density, land use/ land cover, soil texture, rainfall, slope, drainage density, depth to water level – pre monsoon and depth to water level – post monsoon were used as vital contribution factors for the FR model. All the factors were reclassified with obtained FR values and integrated into the GIS environment and resulted Groundwater Potential Index found. GPI was classified in different groundwater potential zones whereas the study area falls mostly covered in moderate groundwater potential zones followed by poor and good potential zones. Validation of the result shows that the output of groundwater potential zones through FR model was found fairly satisfactory. This study will be beneficial for the planning of drought mitigation strategies and the identification of critical sites for groundwater recharge plans. The generated groundwater potential map can help policymakers and engineers to the enhancement of groundwater resources in hard regions also.

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