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ORIGINAL ARTICLE

Spatial mapping of groundwater potential in Ponnaiyar River basin using probabilistic-based frequency ratio model

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Abstract Water is a precious natural resource without it life is not possible. The demand for water has rapidly increased over the last few years and this has resulted in water scarcity in many parts of the world. The main aim of this study is to examine the application of the probabilistic-based frequency ratio (FR) model in groundwater potential mapping at Ponnaiyar River basin in Tamil Nadu, India. In the present study includes the analysis of the spatial relationships between groundwater yield and various hydrological conditioning factors such as altitude, slope angle, curvature, drainage, lineament, lithology, soil depth, and land use/land cover for this region. The eight groundwater conditioning factors were collected and extracted from topographic data, geological data, satellite imagery, and published maps. Then, the 74 groundwater data with high potential yield values of ≥40 m^3/h were collected and mapped in GIS. Out these, 44 (60%) cases were randomly selected for models training, and the remaining 31 (40%) cases were used for the validation purposes. Finally, the frequency ratio coefficients of the hydrological factors were used to generate the groundwater potential map. The receiver operating characteristic (ROC) curve was drawn for groundwater potential map, and the area under curve (AUC) was computed. Results indicated that the rainfall and slope percent factors have taken the highest and lowest weights, respectively. Validation of results showed that the FR method (AUC = 78.90%) performed fairly good prediction accuracy. Results of this study could be helpful for better management of groundwater resources in the study area and give planners and decision makers an opportunity to prepare appropriate groundwater investment plans for sustainable environment.

Keywords Geographic information system · Frequency ratio · Groundwater potential · Ponnaiyar River · India

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Introduction

The quality of groundwater over surface water is that it is less affected by catastrophic events, and it can be tapped when required, exploitation of groundwater as alternative to inadequacy of surface water is ever increasing (Manap et al. 2013). Hence, it is necessary to recognize the methods to approach towards groundwater management and to predict the groundwater potential at the national, regional, and local scales (Vaux 2011; Page et al. 2012). Therefore, groundwater potential mapping (GPM) is essential, and it can be one of the preliminary steps toward managing the groundwater resources (Todd and Mays 1980). As a result, researchers have demonstrated that constructing a GPM constitutes an effective way to explore these invaluable natural resources (Anbazhagan et al. 2001; Madan et al. 2010; Oh et al. 2011; Adiat et al. 2012; Manap et al. 2013; Machiwal et al. 2011; Madrucci et al. 2008; Malczewski 1999; Moore et al. 1991; Mukherjee et al. 2012; Musaka et al. 2000). There are several methods for assessing the groundwater status (Anbazhagan 2004; Pradhan 2009; Nampak et al. 2014; Nazari et al. 2012; Neshat et al. 2013; Nosrati and Eeckhaut 2012; Ozdemir 2011b). Recently, GIS has also provided another cost and time effective approaches of spatial prediction of groundwater productivity (Jha Arkoprovo et al. 2012; Manap et al. 2014; Anbazhagan and Jothibasu 2015). GIS technique is a popular tool to handle huge amount of spatial data and can be utilized in several fields in environmental and water resources management (Anbazhagan and Ramasamy 1997; Chowdhury et al. 2009; Dar et al. 2010; Gaur et al. 2011; Magesh et al. 2012; Rahmati et al. 2014b). Several studies have been applied using index based models for producing the GPM (Solomon and Quiel 2006; Prasad et al. 2008; Elewa and Qaddah 2011; Manap et al. 2014). In some studies, frequency ratio, have been used for groundwater potential mapping (Oh et al. 2011; Davoodi Moghaddam et al. 2013).

Recently, Manap et al. (2014) applied FR model to map the groundwater potentiality in Kuala Langat, Malaysia. In the FR model, the study considered the relationship between groundwater occurrence and each conditioning factor separately, while not considering the relationships among all the conditioning factors themselves. The application of this method for demarcating groundwater potential zones is still limited. The studies by Naghibi et al. (2014) and Al-Abadi (2015) successfully applied this technique for demarcating groundwater qanat potential and groundwater potential yield, respectively. Remote sensing and geographic information system (GIS) technologies have great potential for use in groundwater hydrology. GIS is a powerful tool for handling spatial data and decision making in several areas, including geological and environmental fields (Stafford 1991; Goodchild 1993). Remote sensing is one of the main sources of information about surface features related to groundwater such as lineament, land use, and landforms. Such information can be easily input to a GIS environment for integration with other types of data, followed by analysis (Faust et al. 1991; Hinton 1996; Jha et al. 2007; Pradhan and Lee 2010; Rahmati et al. 2014a; Rao and Briz-Kishore 1991; Saaty 1980; Shahid et al. 2002; Shekhar and Pandey 2014; Singh and Prakash 2003).

The main objective of this study is to assess the competence of the FR model for groundwater probability index (GWPI) at Ponnaiyar River basin, Tamil Nadu, India. The GWPI will be helpful to the decision makers in groundwater resource management and identifying prone areas for future plans. Also, this research is essential for rapid identifying of groundwater resource potential in the study area. Population growth and inadequate public water supply have led to increased demand for groundwater in Tamil Nadu during the past decade. Meanwhile, these models are almost new in groundwater probability mapping, and the efficiency and capability of them can be examined. Therefore, to assess the groundwater probability, an effective and low expense approach is needed for preventing the undesirable effects of future plans.

Study area

Ponnaiyar River basin an interstate river is one of the largest rivers of the state of Tamil Nadu, often reverently called 'Little Ganga of the South'. The river has supported may a civilizations of peninsular India across the history and continues to play a vital role in supplying precious water for drinking, irrigation and industry to the people of the states of Karnataka, Tamil Nadu and Pondicherry. The study area extends over approximately of 11,595 sq. km, and lies between 11°35′ and 12°35′ N latitudes and 77°45′ and 79°55′E longitudes (Fig. 1). Ponnaiyar River originates on the south eastern slopes of Chennakesava Hills, northwest of Nandidurg of Kolar district in Karnataka State at an altitude of 1000 m above mean sea level (amsl). The total length of Ponnaiyar River is 432 km of which 85 km lies in Karnataka state, 187 km in Dharmapuri, Krishnagiri and Salem districts, 54 km in Thiruvannamalai and Vellore districts and 106 km in Cuddalore and Villupuram districts of Tamil Nadu. The Ponnaiyar basin is predominantly built up with granite and gneisses rocks of archean period. The granite is of very good quality and extensive outcrops and masses of it are commonly found. The chief components of rocks are hornblende and feldspar. Foliation is seldom seen. In the plains of reserve forest, quartz is found commonly. The diamond granite is also found in scattered pockets in the area of Chitteri hills in Dharmapuri and Krishnagiri sub-divisions. Charnockite rocks of archean period are also seen in some areas. Alluvium and sand-dunes of quaternary period are also seen at a few places. The 15 years (2000–2014) average annual rainfall in the basin is 969 mm. The catchment falls under the tropical belt. The climate in general is hot; April and May being the hottest months of the year when the temperature rises to 34 °C (Fig. 2).

Methodology

The brief methodology of the present study is to assess the groundwater potential using probabilistic-based frequency ratio model in Ponnaiyar River basin, South India. Survey of India topographic maps, geology map published by GSI (1998), satellite data and other existing data were utilized in the present study. The ArcGIS 9.3 software is utilized for data generation and spatial integration. The topographic maps were utilized for extraction of basin information such as roads and drainages. IRS P6 LISS III satellite data is procured from National Remote sensing Council (NRSC) and utilized for interpretation of land use and lineaments. The pre-processed geometrically rectified satellite data received in BIL format. The LISS III satellite data have 4 bands with 23.5 m spatial resolution. The satellite data is digitally

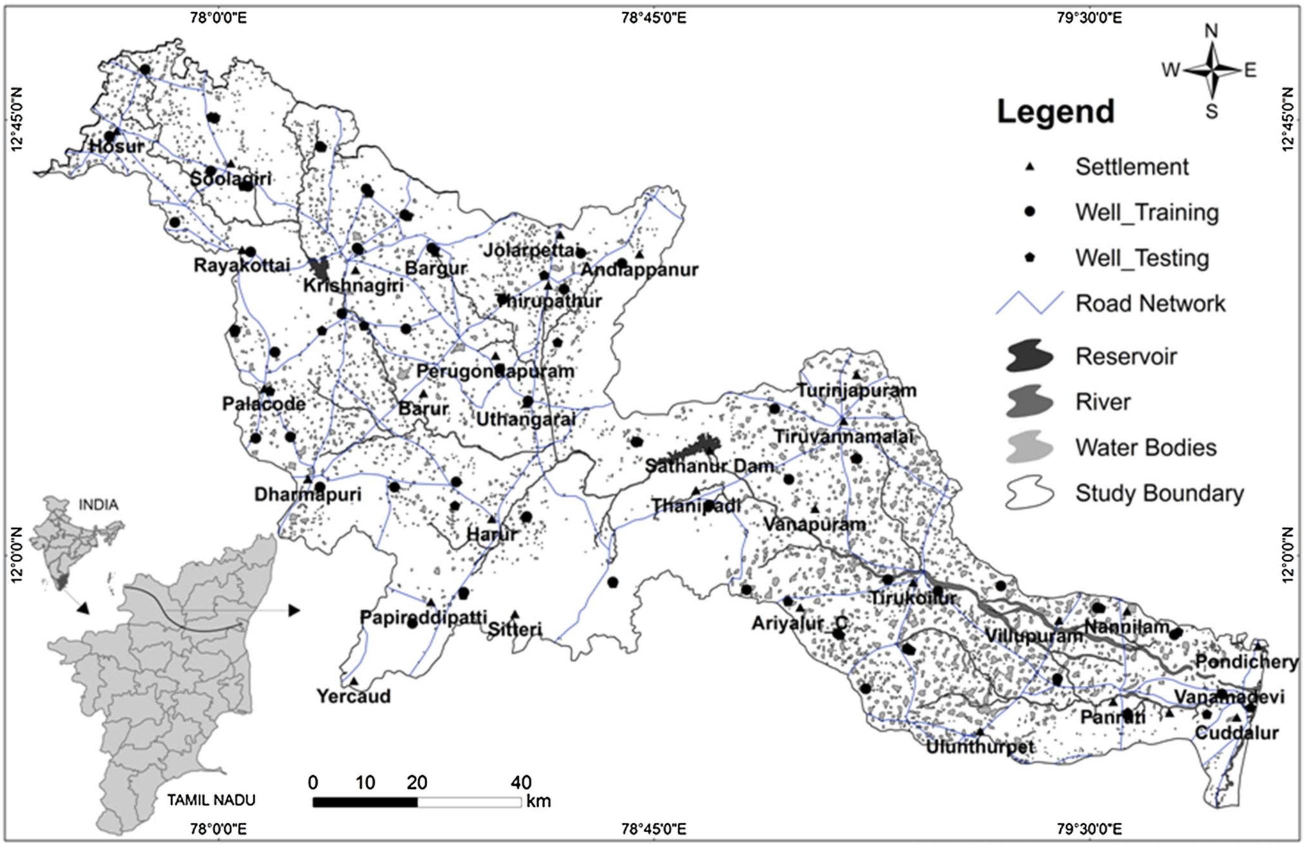

Fig. 1 Study area and groundwater well locations of Ponnaiyar river basin

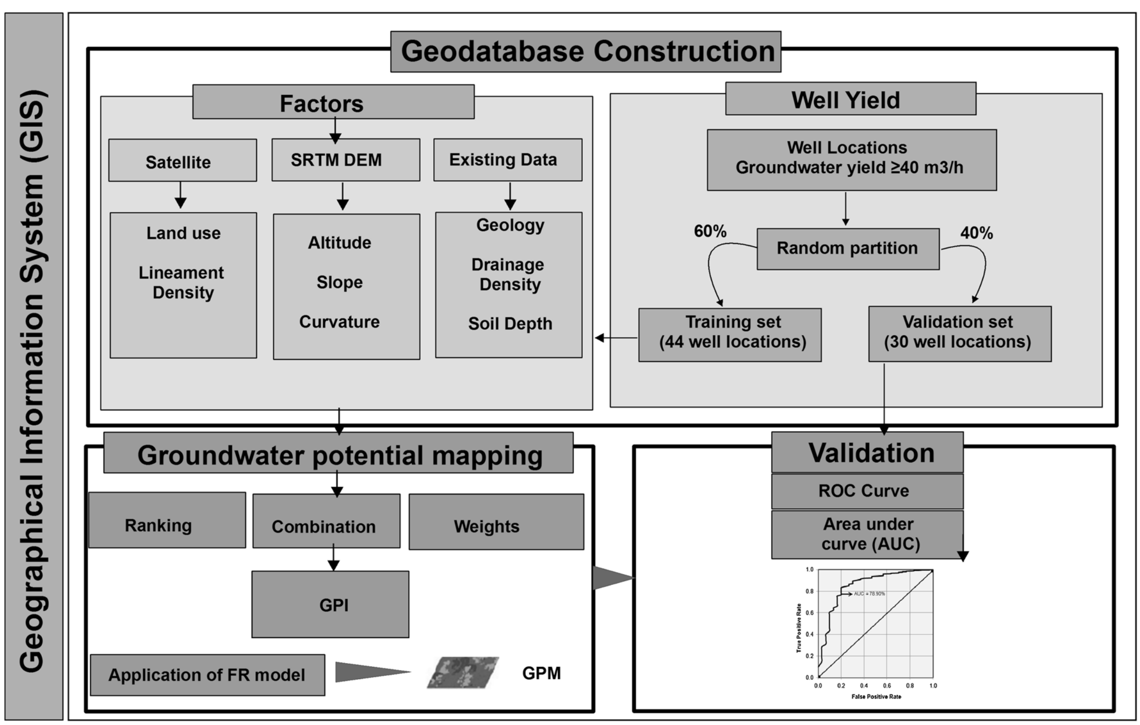

Fig. 2 Flowchart showing the methodology adopted in this study

processed with the help of ENVI 4.3 image processing software. The false colour composite (FCC), histogram equalization and pseudo colour composite (PCC) images were generated for interpretation. The processed satellite outputs in raster format were imported to GIS using ‘add data module’. All thematic maps were commonly projected to ‘geographic coordinate system’ with WGS 1984 datum.

Surface indicators and other factors select

There are eight groundwater-related factors such as altitude, slope angle (degree), curvature, drainage density, lineament density, lithology, soil depth and land use / land cover were considered in calculating the probability. The altitude, slope angle (degree) and curvature can be considered as surface indicators for assessing the groundwater potential (Ettazarini 2007; Al Saud 2010). SRTM satellite data were applied to create a digital elevation model (DEM) of the study area with spatial resolution of 90 m. Different altitudes have altered climate conditions, and this caused differences in soil condition and vegetation type (Aniya 1985). Altitude map of the study area was created from the DEM. The altitude map was grouped into six classes: −4 to 205 m, 205–386 m, 386–556 m, 556–750 m, 750–1009 m, and 1009–1635 m based on the quantile classification method (Fig. 3a) (Tehrany et al. 2013). Slope angle (degree) largely controls the groundwater recharge processes, infiltration and runoff (Sarkar et al. 2001; Ettazarizini and El Mahmouhi 2004; Prasad et al. 2008), therefore, it is an effective factor for the spatial prediction of groundwater potential. The slope map of the study area was generated based on DEM using the Spatial Analysis tools in ArcGIS 9.3. Based on the quantile classification scheme (Tehrany et al. 2014), the slope angle map was grouped into six classes such as <7°, 7°–15°, 15°–20°, 20°–25°, 25°–30° and >30° (Fig. 3b). Curvature, (Tc) was calculated from the DEM (Fig. 3c). The map comprises five classes ranging from very high class to very low class. Negative values for curvature (<−2) correspond concave and accumulation zones, zero values for curvature represent the flat and transitional zones and the positive values for curvature represent the convex and dissipation zones (Florinsky 2000). The very high classes are reflecting high value (4.97) for the frequency ratio, suggesting high infiltration and for potential groundwater.

Drainage density is considered as the closeness of spacing of stream channels (Magesh et al. 2012) and a high drainage density causes lower infiltration and increased surface runoff. It means that drainage density is an inverse function of permeability hence; areas having high drainage density are not suitable for groundwater development (Dinesh Kumar et al. 2007). In order to determine drainage density of study area, Line Density tool in ArcGIS 9.3 was used. The drainage density quantity of study area was computed through sum of lengths of streams in the mesh (km), and area of the grid (km^2). The drainage density map of the study area was divided to five classes such as very low (<0.72 km/km^2), low (0.72–1.45), moderate (1.45–2.17), high (2.17–2.90) and very high (>2.90) (Fig. 3d), and it reveals that high drainage density is observed in the center of the study area. Lineaments are defined as significant line of landscape which reveals the hidden architecture of rock basement (Hobbs 1904). Anbazhagan et al. (2001) interpreted lineaments from remotely sensed data and compared with aquifer parameters. Lineaments in the basin are of great importance in the present studies as they are considered as zones of good infiltration. Lineaments and lineament intersection zones in the basin enriched with vegetation cover were interpreted with the help of red tonal contrast in FCC and histogram equalized outputs. The linear drainages with moisture content manifested as dark tonal contrast in the satellite data. The lengths of the lineaments were measured in the calculation of the lineament density using ‘density module’ in ArcGIS 9.3. The output image has shown the lineament density at 1 km2 interval area. The lineament density is classified into (0-0.10 km/sq.km), (0.10–0.28 km/sq.km), (0.28–0.44 km/sq.km), (0.44–0.61 km/sq.km), (0.61–1.08 km/sq.km), density zone in the basin (Fig. 3e). The higher the lineament density is directly related to favorable condition of groundwater potential.

The lithology is considered as one of the most important indicators of hydro-geological features which play a fundamental role in both the porosity and permeability of aquifer materials (Ayazi et al. 2010; Charon 1974). The analog lithology map (1:100,000) was obtained from the Geological Survey of India (GSI 1998) and the digital lithology map was generated using ArcGIS 9.3 (Fig. 3f). According to Geological Survey of India the lithology of the study area is varied and covered by twenty-two rock types.

Land use and soil is important ecological factors for life. Land use types play a significant role, which directly or indirectly influence on some of hydrological processes components such as infiltration, evapotranspiration and run-off generation. Land use types within the study area are agriculture land, built-up land, forest cover, river, water body, barren land, and grass land (Fig. 3g). Built-up areas, which are mostly made by impervious surfaces, increase the storm run-off and inundation (Shafapour Tehrany et al. 2013). On the other hand, agricultural areas are less prone to flooding due to the positive relationship between infiltration capability and vegetation density. The land use/ land cover map was prepared from IRS P6 LISS III image through supervised classification using maximum likelihood algorithm, and false color composite (FCC) techniques in ENVI 4.3 software. Soil is defined in different

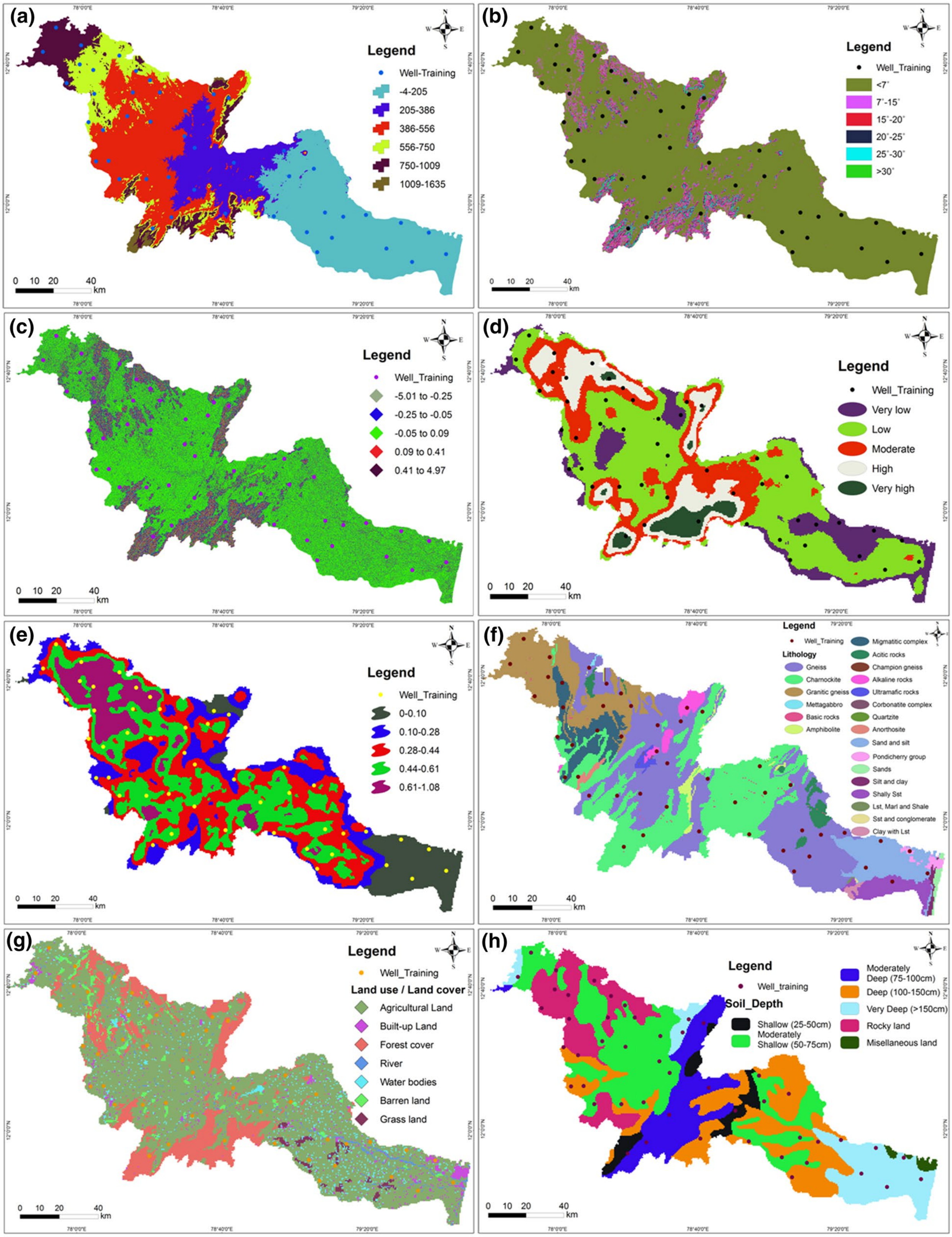

Fig. 3 Groundwater conditioning factors of Ponnaiyar river basin; **a** altitude **b** slope angle (°), **c** curvature, **d** drainage density **e** lineament density **f** lithology **g** land use/land cover and **h** soil depth

ways for different processes. Generally, it is a complex bio-geochemical material on which plants may grow. Information on the type of soil is often needed as a basic input in hydrologic evaluation. Mapping soil usually involves delineating soil types that have identifiable characteristics. The delineation is based on many factors garment to soil science such as geomorphologic origin and conditions under which the soil formed (Vieux 2004). Soil depth is one of the most important factors in the surface and subsurface runoff generation and infiltration process (Mogaji et al. 2014). The soil depth map was obtained from the Central Groundwater Board (CGWB 2012). There are four classes of soil depth in the study area (Fig. 3h).

Frequency ratio (FR) model

Frequency ratio (FR) model is a bivariate statistical approach which can be used as a useful geospatial assessment tool to determine the probabilistic relationship between dependent and independent variables, including multi-classified maps (Oh et al. 2011). Recently, FR model has been successfully used for groundwater potential mapping by Ozdemir (2011a), Manap et al. (2014), Davoodi Moghaddam et al. (2013), and Pourtaghi and Pourghasemi (2014). In fact, the FR is defined as the ratio of the area where groundwater wells (high groundwater productivity) occurred in the total study area. FR model structure is based on the correlation and observed relationships between each groundwater conditioning factor and distribution of groundwater well locations. Figure 4 presents the steps for calculating the frequency ratio, namely: (a) finding well locations, (b) representing cells of class 1 for factor A, and (c) describing the area of spatial overlap for well areas and areas of class 1 for factor A. In the present example, in which the study area comprises 44 cells, 5 well cells and 4519 cells are of class 1 for factor A. Three well cells are also cells of class 1 for factor A. The percentages for cell areas with respect to class 1 for factor A and the entire domain are 20.45 and 13.20%, respectively. Therefore, the frequency ratio of class 1 for factor A is 1.55. FR value in each class of the groundwater-related factor can be expressed based on Eq. 1:

$$FR = \left(\frac{A/B}{C/D} \right) \tag{1}$$

where, A is the number of groundwater well training set for each factor; B is the number of total groundwater well training set in study area; C is the number of pixels in the class area of the factor; D is the number of total pixels in the study area.

The complete calculation of weight determination for individual parameters is presented in Table 1. In a given pixel, groundwater probability can be determined by summation of pixel values according to Eq. (2):

$$\begin{aligned} GWPI = & Rf_{FR} + At_{FR} + Sad_{FR} + Sa_{FR} + Tc_{FR} \\ & + TWI_{FR} + SPI_{FR} + Dd_{FR} + Dmr_{FR} \\ & + Dwl_{FR} + Li_{FR} + Fd_{FR} + LULC_{FR} + Sd_{FR} \end{aligned} \tag{2}$$

Well yield data set

In order to prepare groundwater database, well yield data of study area were collected from the State Surface and Groundwater Division, and extensive field surveys. Due to

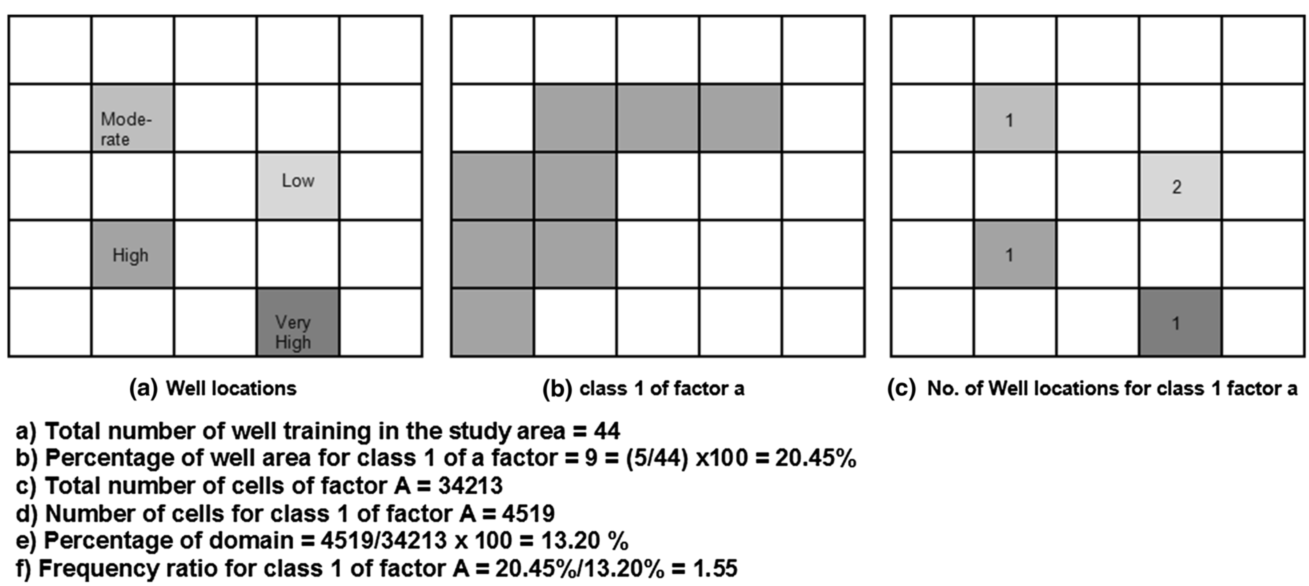

Fig. 4 Diagram showing the processes for calculation of frequency ratio values

Table 1 Spatial relationship between each effective factor and well locations using frequency ratio model

Factors	No. of pixel in domain	% of domain	No. of well	% of well	FR
Lithology					
Gneiss	11,933	34.879	16	36.364	1.04
Charnockite	10,057	29.395	13	29.545	1.01
Granitic gneiss	4519	13.208	9	20.455	1.55
Mettagabbro	25	0.073	0	0.000	0.00
Basic rocks	66	0.193	0	0.000	0.00
Amphibolite	377	1.102	0	0.000	0.00
Migmatitic	1777	5.194	6	13.636	2.63
Granitic	663	1.938	0	0.000	0.00
Champion gneiss	12	0.035	0	0.000	0.00
Alkaline rocks	567	1.657	0	0.000	0.00
Ultramafic rocks	165	0.482	0	0.000	0.00
Ultrabasic	10	0.029	0	0.000	0.00
Quartzite	5	0.015	0	0.000	0.00
Anorthosite	153	0.447	0	0.000	0.00
Sand and silt	2278	6.658	0	0.000	0.00
Pondicherry	202	0.590	0	0.000	0.00
Sands	150	0.438	0	0.000	0.00
Alter sand	128	0.374	0	0.000	0.00
Shaly sand stone	1001	2.926	0	0.000	0.00
Lime stone, marl	14	0.041	0	0.000	0.00
Conglomerate	7	0.020	0	0.000	0.00
Lay with lst	104	0.304	0	0.000	0.00
Lineament density					
0-0.10 km/km2	4241	12.396	6	13.636	1.10
0.10–0.28	5770	16.865	4	9.091	0.54
0.28–0.44	10,473	30.611	14	31.818	1.04
0.44–0.61	9758	28.521	16	36.364	1.27
0.61–1.08	3971	11.607	4	9.091	0.78
Land use land cover					
Agricultural land	24,296	71.014	40	90.909	1.28
Built-up land	1153	3.370	4	9.091	2.70
Forest cover	5859	17.125	0	0.000	0.00
River	437	1.277	0	0.000	0.00
Water bodies	1260	3.683	0	0.000	0.00
Barren land	814	2.379	0	0.000	0.00
Grass land	394	1.152	0	0.000	0.00
Soil depth					
Shallow	1457	4.259	2	4.545	1.07
Mod, shallow	10,091	29.495	9	20.455	0.69
Mod, deep	4831	14.120	5	11.364	0.80
Deep	7802	22.804	6	13.636	0.60
Very deep	4932	14.416	10	22.727	1.58
Rocky land	4821	14.091	12	27.273	1.94
Miscellaneous	279	0.815	0	0.000	0.00
Drainage density					
Very low	5391	15.757	8	18.182	1.15
Low	15,308	44.743	16	36.364	0.81
Moderate	7151	20.901	11	25.000	1.20
High	4850	14.176	5	11.364	0.80

Table 1 (continued)

Factors	No. of pixel in domain	% of domain	No. of well	% of well	FR
Very high	1513	4.422	4	9.091	2.06
Altitute					
(−4-205)	463,487	33.577	14	31.818	0.95
205–386	208,941	15.136	7	15.909	1.05
386–556	399,278	28.925	12	27.273	0.94
556–750	160,107	11.599	6	13.636	1.18
750–1009	133,540	9.674	5	11.364	1.17
1009–1635	15,038	1.089	0	0.000	0.00
Curvature					
(−5.01–0.25)	34,153	2.474	1	2.273	0.92
(−0.25–0.05)	275,679	19.971	25	56.818	2.85
(−0.05-0.09)	947,734	68.657	12	27.273	0.40
0.09–0.41	102,835	7.450	5	11.364	1.53
0.41–4.97	19,990	1.448	1	2.273	1.57
Slope angle (°)					
<7°	1,206,725	87.419	40	90.909	1.04
7°–15°	84,829	6.145	4	9.091	1.48
15°–20°	35,695	2.586	0	0.000	0.00
20°–25°	27,425	1.987	0	0.000	0.00
25°–30°	18,224	1.320	0	0.000	0.00
>30°	7493	0.543	0	0.000	0.00

limited availability of the groundwater data, indirect indicator of yield measurement was applied in these models instead of hydraulic constants of specific capacity as considered by Oh et al. (2011). Groundwater yield is determined based on actual pumping test analysis of groundwater well e.g., m^3/h. About 74 groundwater productivity data with high potential yield values of ≥ 40 m^3/h were collected from well locations. Out these, 44 (60%) groundwater data were randomly selected for training of the models and the remaining 30 (40%) were used for the validation purposes. Figure 1 shows the groundwater well locations (training and validation data set) in the study area.

Validation of the groundwater probability index

From scientific significance viewpoint, validation is considered to be the most important process of modeling (Chung and Fabbri 2003). Therefore, it is very important to evaluate the resultant GWPI. The receiver operating characteristics (ROC) curve was applied to determine the accuracy of the GWPI (Davoodi Moghaddam et al. 2013; Pradhan 2013; Pourtaghi and Pourghasemi 2014). The GWPI delineated in the current study was verified using the groundwater well locations in the validation datasets. Based on the groundwater yield data (with high potential yield values of ≥40 m^3/h) acquired from the State Surface and Groundwater Division, the accuracy assessment of the GPMs was made. The ROC curves were then obtained by considering cumulative percentage of probability index maps (on the x axis) and the cumulative percentage of groundwater occurrence (on the y axis) (Negnevitsky 2002; Pourghasemi et al. 2012a, b). The area under the curve (AUC) was calculated based on ROC curve analysis and it demonstrates the accuracy of a prediction system by describing the system's ability to expect the correct occurrence or non-occurrence of pre-defined "events" (Bui et al. 2012; Jaafari et al. 2014). According to Yesilnacar (2005) the quantitative–qualitative relationship between the AUC value and prediction accuracy can be grouped as follows: poor (0.5–0.6); average (0.6–0.7); good (0.7–0.8); very good (0.8–0.9); and excellent (0.9–1). Finally, all three classified models are verified through frequency percentage.

Results and discussion

According to observed relationships between groundwater well locations (with yield value ≥40 m^3/h) and each conditioning factor, the FR model was applied in GIS for groundwater probability index mapping in the study area. The results of spatial relationship between groundwater well locations and conditioning factors using FR model is shown in Table 1. The ratio of the area where groundwater yield value of ≥40 m^3/h observed to the whole area is the relation analysis; so, the value of 1 indicates an average spatial correlation between groundwater well locations and conditioning factors. If the value would be lower than 1, there is a low correlation, and a higher correlation equals to the value larger than 1 (Lee and Pradhan 2006). The analysis of FR for the relationship between groundwater well locations and lithology indicate that micmatitic rocks has the highest value of FR (2.63) followed by granitic gneisses class (1.55); charnockite (1.01) and gneissic rock (1.04); thus, the above-mentioned lithological groups have the most probability for groundwater.

Based on the mentioned results, lithology directly and/or indirectly influences the porosity and permeability of the terrain. The fault density classes of very low, moderate and high is higher correlation with groundwater probability. The built-up (2.70) and agricultural (1.28) land use / land cover classes also indicated that the highest FR values. Shallow (1.07), very deep (1.58) and rocky land (1.94) of soil depth characteristics having a highest FR values. Assessment of slope angle indicated that slope angle class <7°–15° has the highest value of FR. The drainage density very low, moderate and very high have the largest frequency ratio values (FR = 1.15, 1.20, 2.06), which means that the attributes of these classes have the strongest relationship with groundwater probability. In Table 1, for the altitudes of 556–750 and 750–1009 m, the FR was 1.18 and 1.17, respectively; it indicates a high probability of groundwater occurrence. The final groundwater probability index map obtained by FR model is shown in Fig. 5. It is seen that, high groundwater probability are located at the central and northern side of the study area.

For quantitative validation, used of ROC curve analysis by comparing the existing groundwater well locations in the validation datasets with the groundwater probability map obtained by FR model (Pradhan 2009, 2013; Mohammady et al. 2012; Davoodi Moghaddam et al. 2013; Regmi et al. 2013; Pourtaghi and Pourghasemi 2014). Figure 6 shows the ROC curve of the GPMs obtained using FR model. These curves indicate that the FR model (AUC = 78.90%) performs. Therefore, it can be seen that the FR model applied in this study showed reasonably good accuracy in spatial predicting of groundwater probability. According to previous studies, FR model are effective and reliable approach for groundwater probability mapping (Oh et al. 2011; Davoodi Moghaddam et al. 2013; Manap et al. 2014). In the models frequency ration of well dataset indicates that the most of the wells fall under the moderate to low groundwater probability. It means that the well water

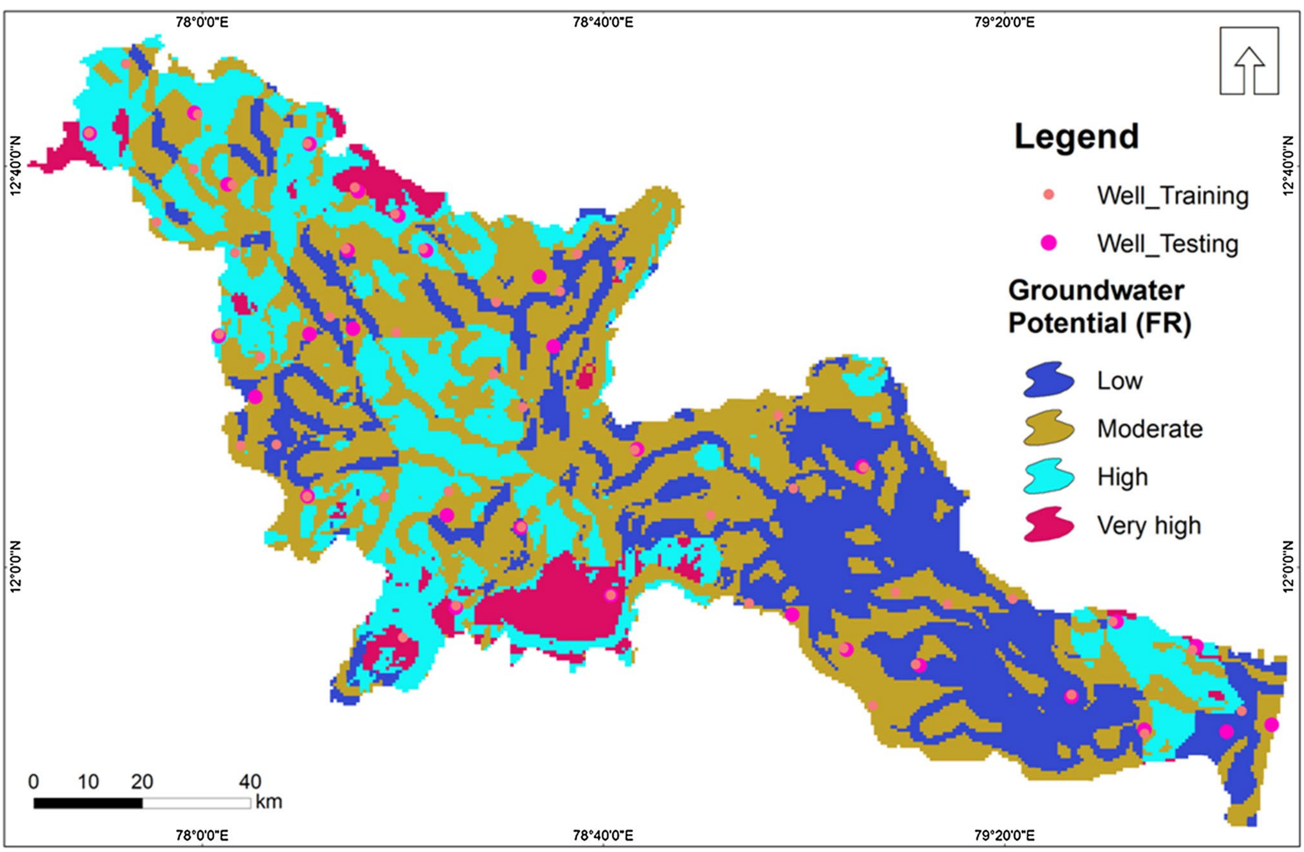

Fig. 5 Groundwater potential map of FR model in Ponnaiyar River basin

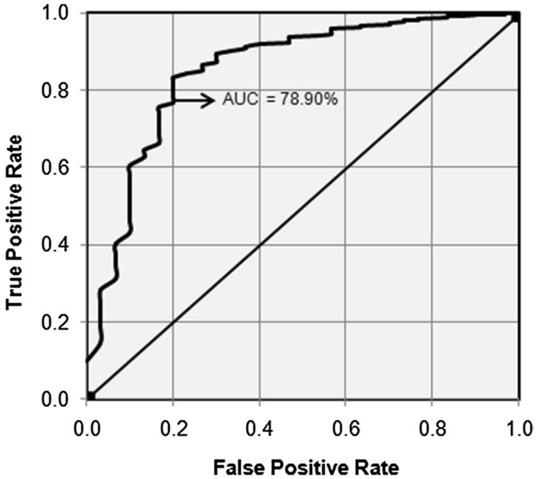

Fig. 6 ROC curve for the groundwater potential maps produced by FR model of Ponnaiyar river basin

level undergoes falling down in future. The effective watershed management will enhance the sustainable water environment which will be useful for the further planning and development of the area.

Conclusion

Groundwater probability analysis is one of the most popular areas of research, especially in arid and semi-arid regions. Various methods have been applied for regional groundwater potential assessment globally. Government and research institutions worldwide have tried for years to assess groundwater potential and predict its spatial distribution. In the present study, groundwater probability index maps have been prepared using FR method with the integration of remote sensing and GIS. In general, all used factors have relatively higher values of variation index implying the importance of all factors for accurate demarcation of groundwater probability. FR model is effective and reliable approach for groundwater probability index mapping in the present study. From the analysis, it is seen that the FR model (AUC = 78.90%) performs better model for delineate groundwater potential zones. As a final conclusion, the results of the present study proved that FR model can be successfully used in groundwater probability index. So, the result of GWPI indicated that the Ponnaiyar river basin has undergone a significant amount of the groundwater abstraction has already reached more than exploitable groundwater resources which requires immediate attention on groundwater management. The produced groundwater potential maps can assist planners and engineers in groundwater development plans and land use planning in the study area.

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