Multi-influence factor method to determine groundwater potential zone using GIS and RS (Remote sensing) techniques in parts of Rajasthan, India.

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Abstract

The enormous groundwater demand globally have possessed a threat to groundwater security. Rajasthan being one of the water deficit states of India is pivotal to determine its groundwater potential zone for sustainability. Diverse thematic layers such as drainage density, landuse, rainfall, geology, geomorphology was prepared. The geomorphology, landuse, drainage and soil map was prepared using IRS-1D LISSIII satellite image. Through, appointing the relative weightage to the thematic maps the final groundwater potential map was prepared. A comparative analysis for the groundwater potential map and the groundwater level data was done for confirmation. The groundwater potential zone can be classified as high, medium or low. The positions of various existing wells along with the contour map of groundwater table can be draped with groundwater potential map. The groundwater table usually found flat over the regions of higher groundwater potential zones. Thus, with the increasing demography along with rising demand the wells should be laid over the area with higher potential. The remote sensing and GIS can be efficiently and smoothly used to determine the groundwater potential zones with suitable sites for well construction.

Keywords: Groundwater sustainability, Remote Sensing, Geographic Information System, Thematic layers, Groundwater potential map.

Objective:

1. To develop the various thematic maps of the study area such as Geomorphology, Lithology, Drainage density, Lineament density, slope, Rainfall, and Land use land cover using remotely sensed data from the data collected from different agencies.

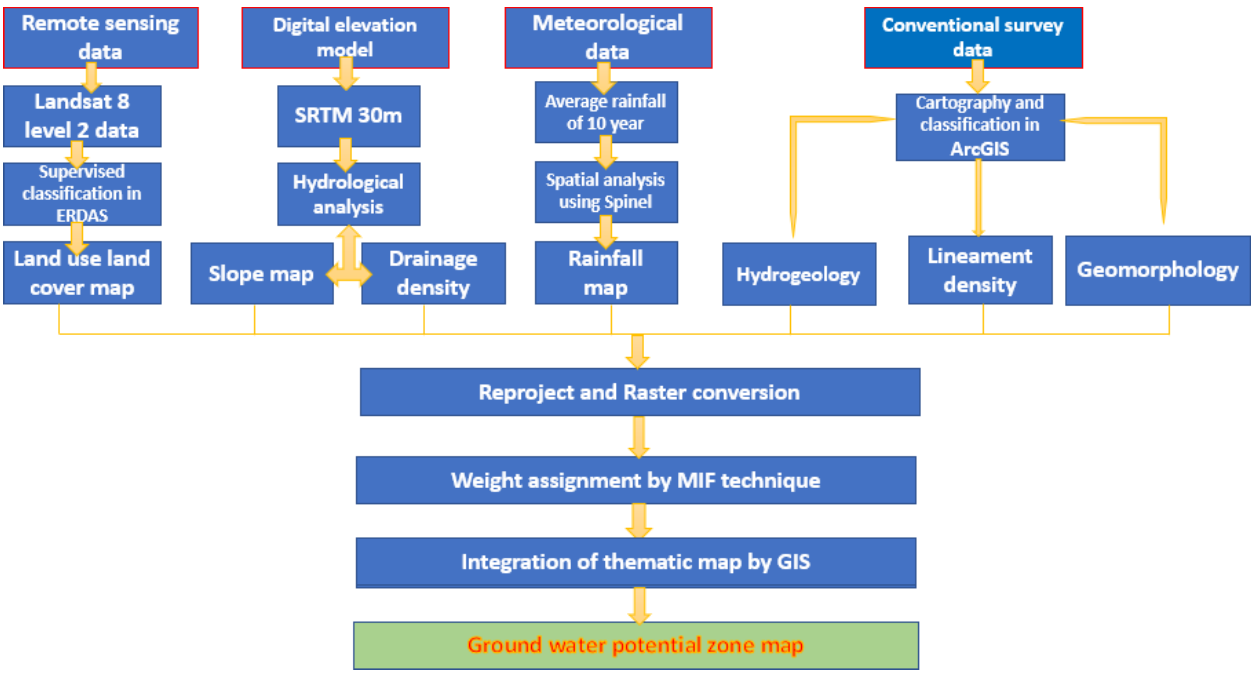
2. To delineate the potential groundwater recharge zones in the area by integrating the thematic maps and GIS.

3. To identify the degree of the role of groundwater potential controlling and determining parameters and their interrelationship with each other.

4. To develop a GIS model for Groundwater potential zone mapping.

5. To access the ability of currently used Remote sensing and GIS model in identifying Groundwater potential zones.

METHODOLOGY



The first step is to identify Groundwater controlling parameters (Al-Ruzouq, R., Shanableh, 2019) and reviewed papers with the most common parameters used in various similar studies. In this study, we selected the 7 Most influencing and available datasets for our area: Geomorphology, hydrogeology, Land use land cover, Lineament density, slope, Rainfall, and drainage density.

Dataset preparation

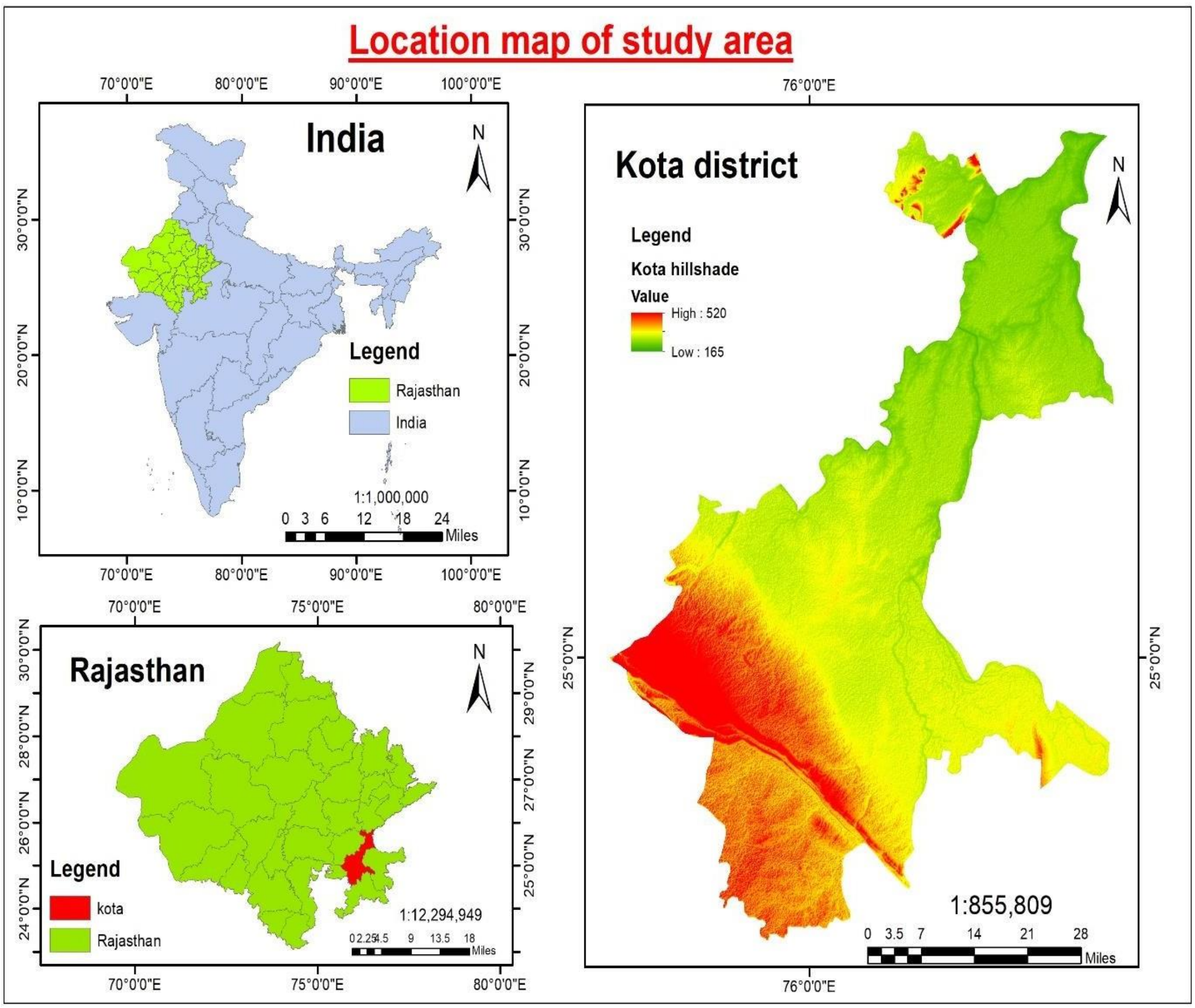
The generated data is then digitalized and organized into groups of logical entities concerning various parameters. Then individual entities are converted into a spatial characteristic format to make them appropriate for analysis. After making a judgment over the research geodatabase, the Data Sets are prepared, so it helps to develop the following maps in the target area.

Slope and drainage density are prepared using the ArcGIS Hydrology toolbox on DEM data. The hydrogeology map is prepared using cartography tools in ArcGIS.

Data analysis MCDA

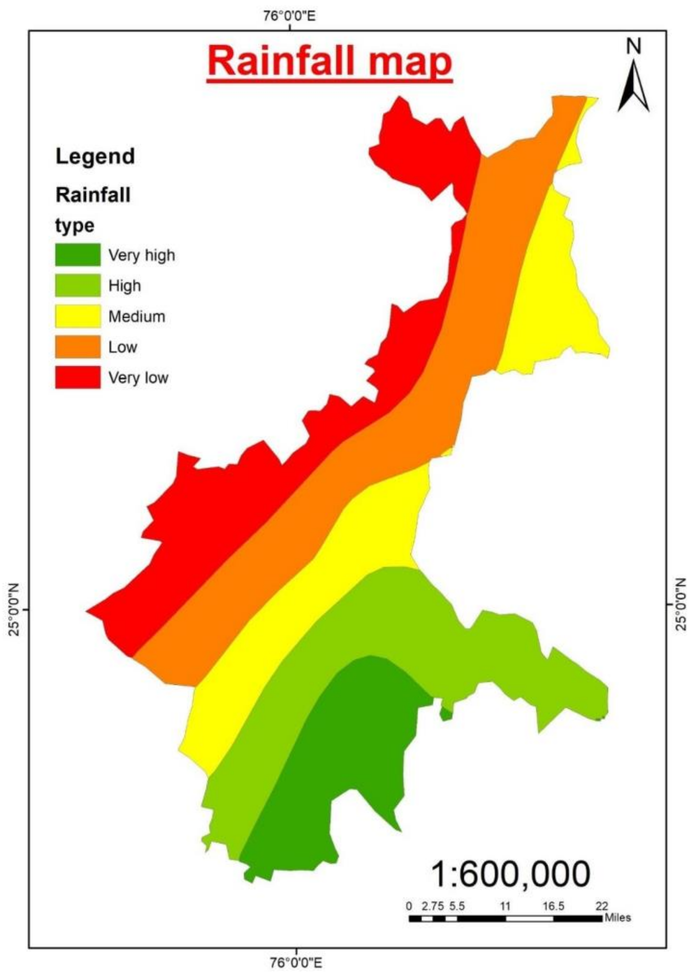
Multiple-criteria decision analysis (MCDA) is a part of operational research that evaluates multiple conflicting parameters in decision making (both in daily life and in complex research problems). Suppose if you have to buy a car you will consider certain points in mind, those may be either cost, comfort, speed, looks, etc. The selection and importance of parameters are up to the intuitions of the individual but when stakes are high it is important to structure the problem and precisely evaluate the multiple criteria. A similar approach has been used in the field of scientific research when more the one influencing criteria. Huge studies have been done using the MCDA methodology in groundwater potential mapping (Adiat, 2012); (Singh, 2018) which established the efficiency of this method in groundwater potential analysis. One of the very primitive studies of groundwater potential zone mapping using RS, GIS, and MCDA is done by (Krishnamurthy, 1996).

STUDY AREA



Kota region is situated between 24°32' and 25°50 N Latitude and 75°37' and 76°34' E Longitude in the southeast of the territory of Rajasthan with a region of 5203.94 sq. It is limited on the north by Bundi and Sawai-Madhopur regions, on the east by Baran area, south by Jhalawar region, and on the west by Chittorgarh locale. In the upper east, the region is limited by Madhya Pradesh. The area is named after Kota town and is essential for Kota Division. Authoritatively, the locale is isolated into five improvement squares and five tehsils. The absolute quantities of towns in the region are 805, and it has five metropolitan towns, including one city organization. The number of inhabitants in the locale according to 2011 enumeration is 1951014 people, including rural and urban populace of 774410 and 1176604 individually. The whole district lies in the Chambal river basin. The five major blocks of Kota are Itawa, khairabad, Ladpur, Sangod, and Sultanpur. Kota has 903 villages, including block headquarters.

Climate and rainfall



Kota locale has a semi-parched environment. Summers are long, warm, and dry, beginning in late Walk and enduring until June's finish. The rainstorm season follows summer with relatively lower temperatures yet higher dampness and continuous, heavy storms. The rainstorm dies down in October, and temperatures rise again tolerably. The brief, however charming winter begins in late November and goes on until the most recent seven-day stretch of February. Temperatures drift between 26.7°C (max) to 12°C (min). The average yearly Precipitation in the Kota area is 707.7 mm. A large portion of the Precipitation can be ascribed toward the southwest rainstorm, starting around the most recent seven-day stretch of June and may last work mid-September. Pre-rainstorm showers start towards the center of June, with post-storm downpours sporadically happening in October. The colder time of year is to a great extent dry, albeit some precipitation occurs because of the Western Aggravation ignoring the area.Average Precipitation occurs in the area with overall conveyance of Precipitation across can be envisioned from isohyets where the more significant part of the region got Precipitation in the scope of 600-700 mm in the year 2010. The complete yearly average Precipitation is 663.4 mm, dependent on the information of accessible blocks. Itawa block got the most elevated Precipitation (917.6 mm), though the least was in the Sangod block (418.4 mm).

Topography

A significant piece of the locale goes under plain territory; however, slopes mostly occupy the southern part, is moving from west to east. Kota is an essential part Chambal waterway bowl. Chambal is the significant stream in the locale, which generally grew excellent seepage framework alongside feeders like Sukhal, Andheri, Alina, Ujar, Parwan, and A major. The general geographical height of Kota is between 250 m to 300 m above mean ocean level. Rise goes from at least 175.9 m above indicate ocean level in Itawa block in the northern part of the area to a limit of 517.5 m above the main sea level in Ladpura in the southwestern region (Gautam, 2018).

Agriculture and Irrigation practices

The chief methods for the water system in the area are waterways and wells/ tube wells. Groundwater is connected through tube wells, burrowed wells, and burrowed cum bore wells. Net watered territory in the region is 226019 ha which is about 93% of the gross watered area (243313 ha). Agriculture action is spread over both Kharif and Rabi development. Kharif development is downpour taken care of, and Rabi development is, for the most part, dependent on Groundwater. During the Kharif development, just 10.10 sq. km territory is an underwater system, while during Rabi development, 1012.41 sq. km regions are under development (counting region under twofold yields). The primary Kharif crops filled in the territory are rice (13974 ha), oilseeds (224274ha), Jowar (6721ha), while the head Rabi crop is wheat (115280ha). The complete trimmed zone in the area is 458857ha.

RESULTS AND DISCUSSION

Hydrogeology

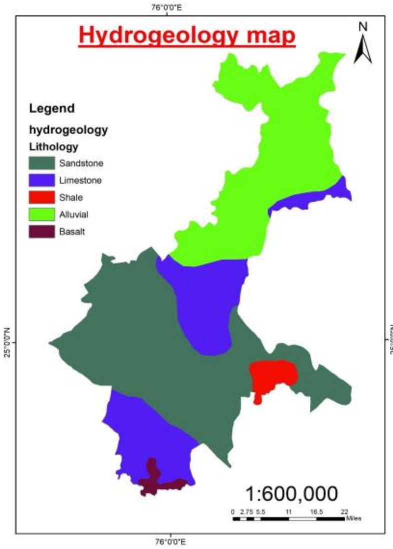
A significant part of the Kota district is covered byVindhyan, which is a part of the Great-Vindhyan basin, extends from Rohtas in Bihar to Chittorgarh of Rajasthan. The site has been divided into four major groups: Semi, Kaimur, Rewa, and Bhander, separated from Kaimur by a conglomerate horizon, which also marks break in sedimentation.

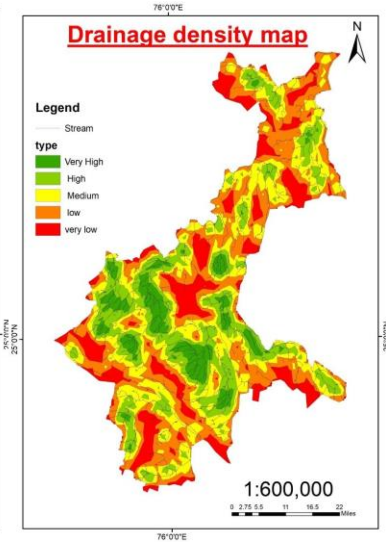
The limestone of the Sirbu shale horizon contains evidence of stromatolites. Sandstone occurred at different horizons, which reflect the fluctuation in sea level as repeated transgression and regression. The succession is Vindhyan above which quaternary alluvials.

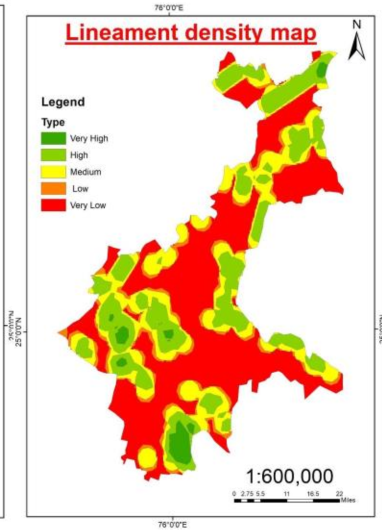
Hydrogeology data is collected from the SGWB website; using the ArcGIS cartography tool; the GIS map is extracted out. It is majorly classified into five hydrogeological units: sandstone, shale, limestone, alluvial, and basalt. Sandstone mainly occurs in Eastern, southwestern, and central parts of the district; it is rigid, compact, and quarzitic, with Groundwater, mostly occurring in weathered residual and joints, fractures, bedding planes, and other planes of structural weakness. The groundwater potential in Sandstone is very high.Basalt mainly occurs in the southern part of the district, which contains Groundwater mostly in secondary porosity as fractures and lineaments. But compared to other hydrological units, it has poor groundwater prospectus.

Limestone is a part of the Vindhyan supergroup; it is fine to medium-grained, yellowish buff, brown, grey, and red- coloured. Grey and yellowish limestone are silicious in nature and are hard and less susceptible to weathering. It is often interbedded with shale, but we considered the dominating litho units only for the sake of classification.

Shale is part of the Rewa group of Vindhyan and often interbedded with Sandstone and limestone. Shale is occurred as a big patch in between the Sandstone.







	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	Band 1 - Coastal aerosol	0.43 - 0.45	30
	Band 2 - Blue	0.45 - 0.51	30
	Band 3 - Green	0.53 - 0.59	30
	Band 4 - Red	0.64 - 0.67	30
	Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
	Band 6 - SWIR 1	1.57 - 1.65	30
	Band 7 - SWIR 2	2.11 - 2.29	30
	Band 8 - Panchromatic	0.50 - 0.68	15
	Band 9 - Cirrus	1.36 - 1.38	30
	Band 10 - Thermal Infrared (TIRS) 1	10.60 - 11.19	100
	Band 11 - Thermal Infrared (TIRS) 2	11.50 - 12.51	100

CONCLUSION.

Groundwater is vital in the sustainable growth of an economy; it is a hidden treasure for any nation's development. Proper investigation and management of Groundwater are necessary for the sustainable use of Groundwater. To provide first-hand information regarding suitable sites of groundwater recharge to policymakers and local authorities for effective groundwater management and exploration, an integrated approach of remote sensing, GIS, and MIF technique is proposed for the Kota district in Rajasthan, India. The integrated approach of Remote sensing and GIS is very useful, efficient, time-saving, and cost-effective for groundwater analysis. This study integrates seven different thematic maps, namely Hydrogeology, Geomorphology, Lineament Density, Drainage density, Slope and Land use, and land cover map. Proper weights are assigned through the MIF technique and integrated in the ArcGIS 10.3 environment. According to the resultant groundwater potential map, the Kota district (figure 14) is divided into five zones based on their groundwater potential. Very good prospects zones are located in sandstone facies, low drainage density, low slope, high lineament density, high rainfall, below vegetation, and floodplain area. Conversely, very poor potential zones are located in desiccated structural hills, high drainage density, low lineament density, high slope, low rainfall, and built-up areas. Most of the area lies in a moderate to high Groundwater potential zone.

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