International Journal on Emerging Technologies **11**(2): 1047-1053(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Ground Water Prospect Zone Mapping in the Barkheda Nathu Basin of Kolans River using Remote Sensing and Geographical Information System

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(Received 09 December 2019, Revised 01 January 2019, Accepted 02 January 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: This study is conducted to determine Ground Water Potential Zones in Kolans River Watershed and to suggest the Recharge Structures for augmenting the Ground Water Level. Artificial groundwater recharge is a method to increase the groundwater level as a replacement of Groundwater used for a different purpose. Remote Sensing and GIS techniques are used in this study to prepare different thematic layers, and ArcGIS is used to prepare the Ground Water Prospect map of Watershed. In this study, it is proven that Remote Sensing and GIS are the best techniques for data preparation and different Weightage Overlay Analysis for Ground Water Prospect Map Generation.

Keywords: Remote Sensing, GIS, Ground Water, Weightage Overlay Analysis.

Abbreviations: GHGs, greenhouse gases; PCM, phase changing material; SC, solar chimney; GCHE, ground coupled heat exchanger; EAHE, earth air heat exchanger; GSHP, ground source heat pump; PV, photo voltaic; HVAC, heating ventilation and air conditioning; AC, air conditioner; PBP, payback period.

I. INTRODUCTION

Leonardo da Vinci termed Ground Water as a Lifeline of Nature. It is a genuinely unique blessing from nature to humanity. There is no life without water, and the amount of freshwater available on earth is contained primarily in the form of groundwater. It is, therefore, important to use and increase groundwater sustainably for the survival of our future generations. Artificial recharge is the intentional human activity of increasing the amount of groundwater by systems designed to increase the normal recharge or percolation of surface water in groundwater layers, resulting in an increase in the amount of groundwater for extraction. Artificial recharge is a way to increase the hydrological cycle and thus provide groundwater that is accessible through natural processes. Satellite Remote Sensing (RS) and Geographic Information System (GIS) have opened panoramic new groundwater research. This is because the space observation equipment on the spacecraft provides up-to-date, accurate, unbiased, and detailed spectral, space, and time information about the state of natural resources [31].

Remote Sensing (RS) is the science, art and technology of obtaining information (spectral, spatial and temporary) about material objects, areas or phenomena without physical contact with the object, area or phenomenon being investigated [36-40].

GIS and remote sensing tools are often used to control various natural resources. Geographic Information System (GIS) is a computer system for collecting, processing, evaluating, managing and displaying all forms of geographical data. This offers special functions for data entry, collection, management, visualization and visualization [33-35].

Main objectives of this study are given below:

– Groundwater resource utilization and evaluation.

– Formulation of a remote sensing and GIS-based methodology for identifying suitable groundwater recharge areas.

Study Area: Barkheda Nathu (Kolans River) watershed study area (Fig. 1) is part of the district of Bhopal and Sehore, Madhya Pradesh.

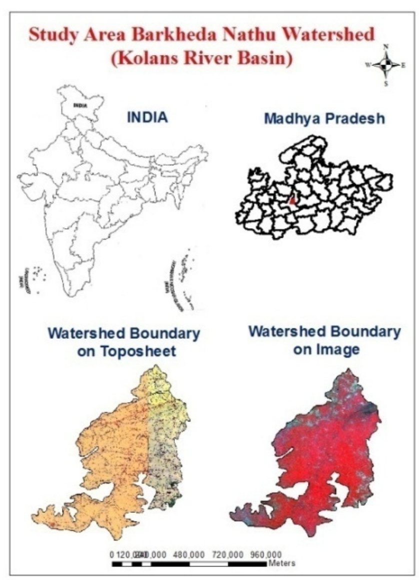

Fig. 1. Study Area.

The study area is situated geographically between the 23°04'49.09"N and 77°06'18.13"E and 23°17'57.56"N and 77°18'9.22"E falling in Survey of India Toposheet No. 55E/3, 55E/4, 55E/7 and 55E/8 with a total geographical area of 381.916 Sq. Km.
The study area belongs to the catchment of Kolans river having up to 5th order drainage, which is starting at near Bamulia Village of tehsil Sehore of Sehore District, and its pore point is at the Western end part of the upper lake near Kalukhedi Village tehsil huzur of Bhopal District. Up to half catchment of the river, it is flowing as 4th order drainage, near village Intkhedi chap two 4th order drains meet, and it becomes fifth-order drainage, which is the highest order drain of this basin [12].

II. MATERIALS AND METHODS

The following data sets and software have been used for the analysis and results.
- Survey of India topographical maps nos.: 55E/3, 55E/4, 55E/7and 55E/8.
- IRS-P6 (Indian Remote-Sensing Satellite-P6) LISS-III Data downloaded from Bhuvan, Indian Geo-Platform of ISRO.
- SRTM (Shuttle Radar Topography Mission) (Digital Elevation Model (DEM) of 30 m (USGS/NASA ASTER DEM data), available from http://www.gdem.aster.ersdac.or.jp
- ArcGIS Version 10.

III. METHODOLOGY

This method involves preparing various thematic maps (resource maps) using data from remote sensing and / or conventional sources. Key analysis of thematic maps derived from satellite data interpretation and other incidental data helps identify issues and capabilities for each thematic information in terms of resource availability, quality, severity and criticality. An integrated map for the development of water resources for this river basin was generated by combining these thematic layers under the GIS environment using a set of logical conditions; Identification of suitable groundwater development areas and location of loading locations depending on the location [1-6].

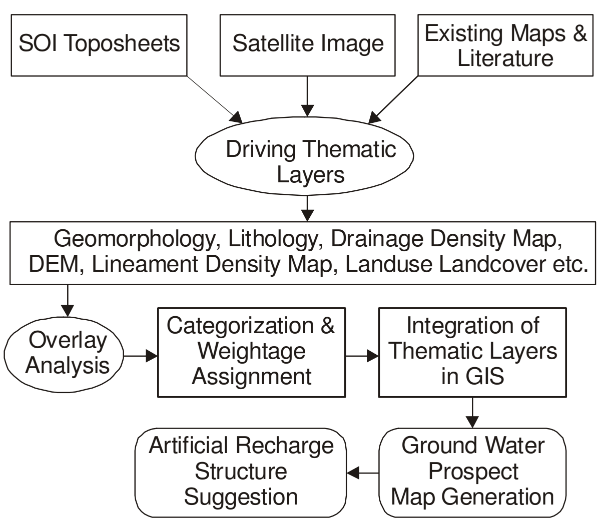

Fig. 2. Flowchart of Methodology.

The research would be carried out in 3 steps, whereby image interpretation, spatial database creation, groundwork of the thematic maps and fieldwork would be carried out in the first 2 steps, starting from front field to fieldwork. The integration and analysis will be carried out in the third step (Fig. 2)

Maps Preparation using different Data:

(a) *Watershed Boundary Map*: First of all, the watershed boundary is delineated by drawing a line on topographical maps across the contours joining the highest elevations around the basin [9, 10]. For this study, Kolans river catchment has been taken and named it as Barkheda Nathu Watershed. Watershed Boundary is displayed on both topographical maps as well as Image (Fig. 3).

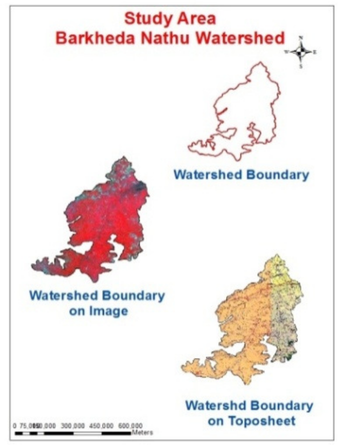

Fig. 3. Study Area Boundary, On Image, On Toposheet.

(b) *Drainage Map:* A drainage basin or watershed is the region in which surface water flows into a specific body of surface water. The drainage map is designed by digitizing the topographical map. Further, these drainages have been divided into different orders according to drainage orders. First-order to fifth-order drainages are present in this watershed [11]. Koans River is the main drain found in the watershed. Finally, it is submerging in the upper lake of Bhopal (Fig. 4).

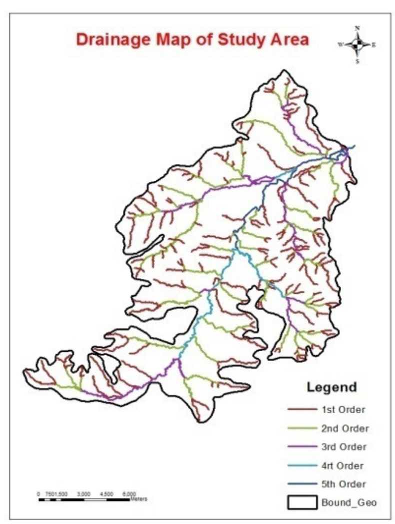

Fig. 4. Drainage Map.

(c) *Drainage Density Map:* Drainage density is the cumulative length of all the rivers and streams in a drainage basin divided by the overall drainage basin area [13]. This is a measure of how well or how poorly stream channels drain a watershed. High drainage densities also mean a high bifurcation ratio and a low bifurcation ratio (Fig. 5).

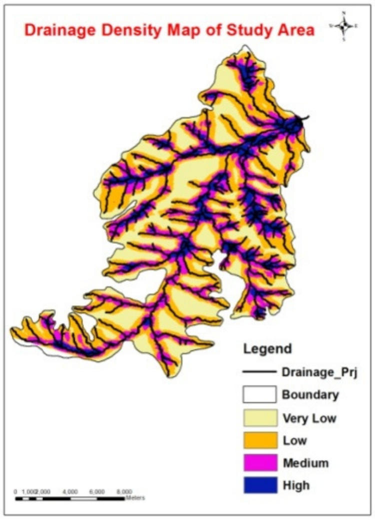

Fig. 5. Drainage Density Map.

(d) *Geomorphological Map:* Zone geomorphology map is prepared using data from IRS-P6 LISS III. Geomorphologically, as shown in Fig. 6, the study area consists of Buried Pediplain, Pediment, Denudational Hills, Structural Hills, and Valley Fill. Around 90% area comes under buried peneplain category. It is a plain covered with thick soil cover. Some part of the study area is coming under Pediment, it is a very gently sloping inclined bedrock surface having some boulders and thin soil cover. Very few percents is containing three units denudational hill, structural hill and valley fills. Valley fill is found near river and drains. A very small patch is of the structural hill is present at the eastern corner of a watershed [14-18].

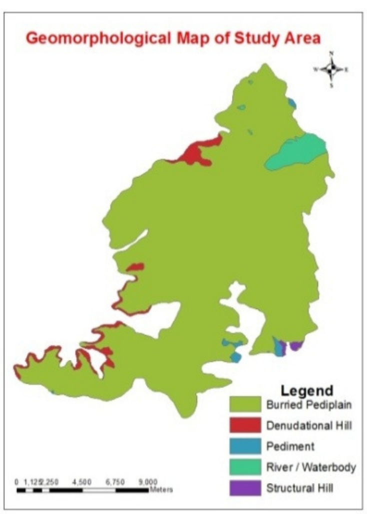

Fig. 6. Geomorphology Map.

(e) *Geological Map:* Geology map of the region is prepared using data from IRS-P6 LISS III. After field verification it is found that some area is coming under Vindhyan Sand Stone Along structural hills. Then Deccan trap Basalt is present on denudational hills and pediment, which belongs to upper cretaceous to lower Eocene age and rest of the area which comes under buried pediplain is fully covered by Black Cotton Soil forms by the weathering of basaltic rocks (Fig. 7) [7, 8].

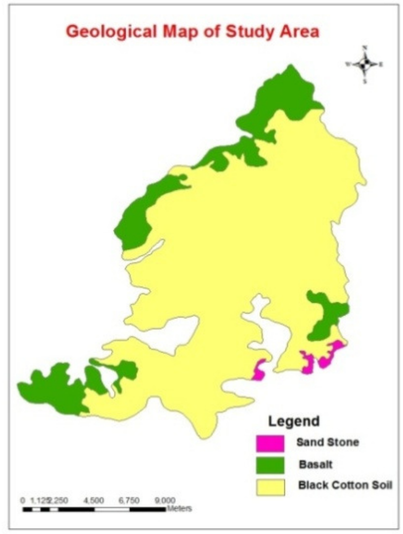

Fig. 7. Geological Map.

(f) *Land Use/Land Cover Map:* LULC map was compiled using data from IRS-P6 LISS III. It is divided into four main categories: Agricultural land, built-up land, Forest land, Wasteland, and water bodies. Approximately 50-60 percent of the area is occupied by farmland due to the dense soil cover present in the area. Next there is waste land and then forest in the area, the remaining part of the study area is covered by water bodies (Fig. 8).

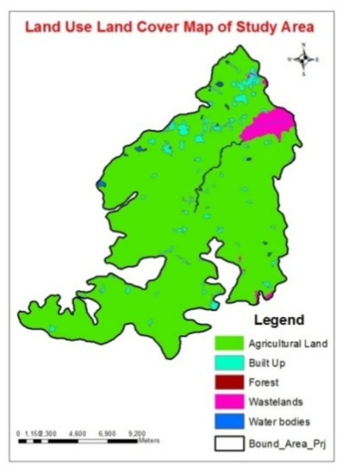

Fig. 8. LU/LC Map.

(g) *Lineament Map:* Lineaments are linear or curvilinear structures on the surface of the earth; they depict the weaker zone of bedrocks and are regarded as secondary aquifers in hard rock regions.

These lineaments are mapped using satellite data and correlated with defects, fractures, joints, bedding planes, discrepancies and lithological contacts [14]. There are a variety of lineaments in the study area. (Fig. 9). Additional lineament density map was created using the ArcGIS toolbox Spatial Analyst Tool (Fig. 10).

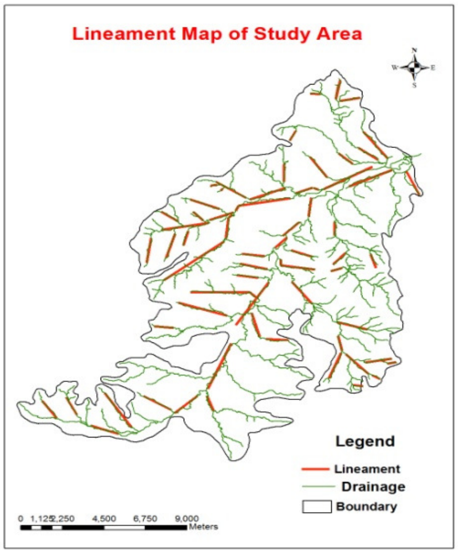

Fig. 9. Lineament Map.

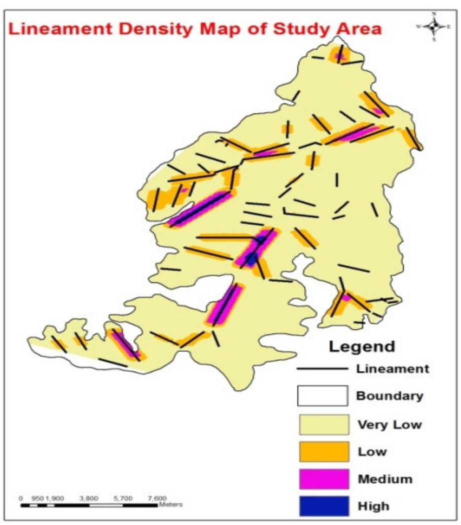

Fig. 10. Lineament Density Map.

(h) *Soil Map:* This map has been taken from District Resource Maps available on internet. It is scanned and digitized using Arc GIS software. It shows that almost ninety percent area of the watershed is covered with Vertisol forms by the weathering of basaltic rocks. The rest part of the watershed is covered with Inceptisols and Entiols (Fig. 11).

(i) *Slope Map:* The Slope map is developed from Arc Map software 10.00 using SRTM data and spatial analyst tool. The Madhya Pradesh grid is downloaded to prepare the slope map from SRTM (Shuttle Radar Topography Mission) data. Then DEM of study area has been clipped using mask command in Arc GIS. After that slope map is generated by Slope command present in Arc GIS Spatial Analyst tools (Fig. 12 and 13).

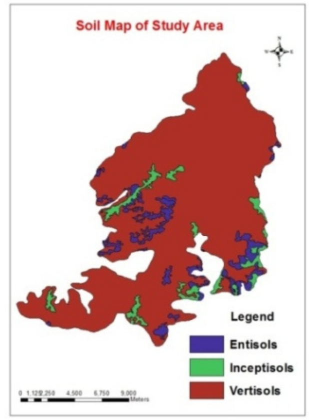

Fig. 11. Soil Map.

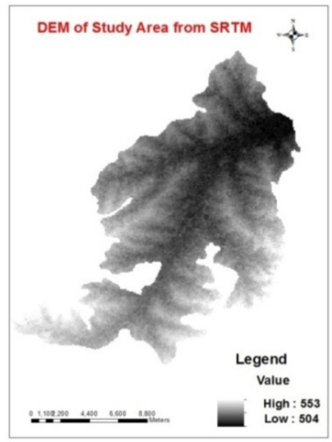

Fig. 12. DEM of Study Area.

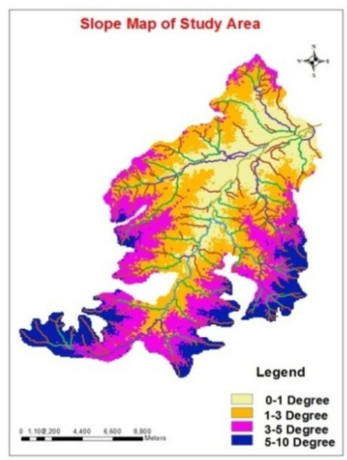

Fig. 13. Slope Map of Study Area.

(j) *Weightage Analysis:* Weighted overlay analysis is a method for modeling an application of suitability. In the Weightage Overlay Method weights were assigned to different classes of different thematic layers, such as geology, geomorphology, lineament, soil, slope, drainage, depending on the importance of these classes to support groundwater zone assessment [19, 20]. For this Study Same weight is given to geomorphology, lithology, land use landcover, slope, drainage density and lineament density map. Each themed class or unit was also classified according to their impact on the mapping of the groundwater prospect zone (Table 1).

Table 1.

Ranks and weightage of parameters of Groundwater recharge potential zone:			
Layers	Theme Weightage	Doman of effects	Layer Weightage
Geomorphology	15	Pediment	5
		Burried Pediplain	8
		Structure Hill	4
		Denudational Hill	5
		Water body	9
Land Use and Land Cover	15	Agriculture	8
		Built-up	2
		Forest	6
		Wasteland	3
		Water body	9
Soil	10	Entisols	3
		Inceptisols	5
		Vertisols (Fine Clay)	8
Lithology	15	Sand Stone	4
		Basalt	5
		Black Cotton Soil	8
Slope	15	0-1 Degree	8
		1-3 Degree	8
		3-5 Degree	5
		5-10 Degree	2
Drainage Density	15	Very low	8
		Low	8
		Moderate	5
		High	2
Lineament Density	15	Very low	1
		Low	4
		Moderate	6
		High	8

(k) *Ground Water Prospect Map:* Different thematic maps such as geology maps, geomorphology maps, slope maps, soil maps, drainage maps and lineament maps are reclassified into ArcGIS and then incorporated using overlay analysis and allocated with different weightings and ratings (Table 1) for all to prepare Ground Water Prospect Map. The zoning chart for the groundwater was divided into four groups i.e. (i) Good (ii) Moderate to Good (iii) Moderate (iv) Poor (Fig. 14) [25, 26].

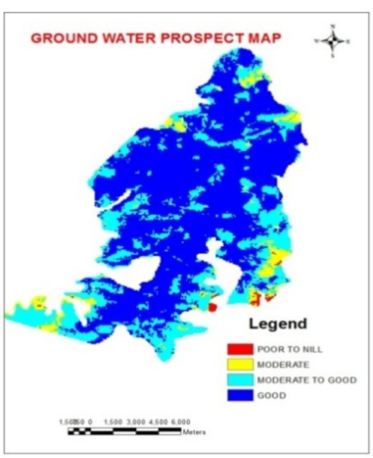

Fig. 14. Ground Water Prospect Map of Study Area.

IV. CONCLUSION

Increasing demand for freshwater is developing the need of Groundwater Prospect Zone mapping. The data which is most commonly used for groundwater zonation mapping are geomorphology, lithology, land use the land cover map, soil, slope, lineament map, drainage map etc. Integration of all these thematic layers was done in the ArcGIS environment and the groundwater prospect zones were delineated using the application of a weighted index overlay method. In this study, it is proven that Remote Sensing and Geographic Information System techniques are the best suitable tools for locating groundwater potential zone maps [20-24].

The groundwater prospects are categorized in four classes good, moderate to good, moderate and Poor to Nil. Good groundwater prospects zones mainly fall in the Buried peneplain consisting of Black Cotton Soil, moderate to good prospect is mainly occurring in pediment zone, moderate prospects zones mainly fall in the denudational hills consisting lineaments [27-29]. The structural hills and the residual hills fall mainly in categories poor to nil [30-32]. But the prospect of groundwater availability in hilly terrain lies more along structurally weak planes like lineaments, faults, fractures, joints and narrow valleys etc. [41-44].

ACKNOWLEDGEMENTS

All acknowledgments (if any) should be included at the very end of the paper before the references and may include supporting grants, presentations, and so forth.

Conflict of Interest. Compulsory.

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How to cite this article: Varma, Hridayesh, Sarup, Jyoti and Mittal, S.K. (2020). Ground Water Prospect Zone Mapping in the Barkheda Nathu Basin of Kolans River using Remote Sensing and Geographical Information System. *International Journal on Emerging Technologies*, *11*(2): 1047–1053.