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Application of Remote Sensing and GIS in Preparing Groundwater Prospect Map of Ujjain District, Madhya Pradesh

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Abstract—*Remote sensing and Geographic information system (GIS) as a unit provide useful tools for the exploration, management, and conservation of natural resources. Groundwater being the most important limited resource available should be optimally utilized. Relevant exploration is needed in conserving its quantity and quality. In the present study an investigation is carried out to identify the ground water potential zones in Ujjain district, Madhya Pradesh, using weighted overlay analysis. Factors that influence the occurrence of ground water include rainfall, soil, land-use, slope, lithology, geomorphology, stream density and lineament, which have been prepared in the form of thematic layers, obtained from the district resource map and ASTER GDEM data. The output map obtained from the study is categorized according to the groundwater potential. This study shows that GIS and remote sensing provides an efficient tool for better planning and management of ground water resource.*

Keywords: *GIS, Remote sensing, Web mapping services*

1. INTRODUCTION

Groundwater constitutes 30. 1% of fresh water resources (USGS). It is needed not only for drinking and agricultural purposes but also for industrialization. In recent years there has been immense extraction of groundwater resulting in fall in groundwater levels and deterioration of water quality so there is a need of exploration and preservation of groundwater. In India central ground water board (CGWB) prepares ground water maps based on borehole data. Conventional method of preparing groundwater map is tedious and very expensive.

Remote sensing techniques play an important role in terrain evaluation surveys for natural/physical resources inventorying and mapping as remotely sensed data providessynoptic view, multispectral and unbiased informationrepetitively for change detection studies (B. S. Chaudhary, Manoj Kumar, A. K. Roy and D. S . Ruhal). Many factors affect the occurrence and movement of groundwater in a region including topography, lithology, geological structures, depth of weathering, extent of fractures, primary porosity, secondary porosity, slope, drainage patterns, landform, land use / land cover, and climate (Mukherjee 1996; Jaiswal et al. 2003). Geospatial technology is a rapid and cost-effective tool in producing valuable data on geology, geomorphology, lineaments slope, etc. that helps in deciphering groundwater potential zone (M. Kavitha Mayilvaganan, P. Mohana and K. B. Naidu). Many researchers have used integrated remote sensing and GIS approach to delineate groundwater potential zones in different parts of world. Integrated remote sensing and GIS techniques were used for groundwater exploration and identification of artificialrecharge sites (A. K. Saraf& P. R. Choudhury 1998). Delineation of groundwater potential zones in Theni district, Tamil Nadu was done using remote sensing, GIS and MIF (N. S. Magesh, N. Chandrasekhar)

In the present study thematic layers were prepared using remotely sensed data. Groundwater prospect map was then prepared by performing weighted overlay analysis on these layers.

2. STUDY AREA

Historical city of Ujjain is located in central India in the Madhya Pradesh. The district has an area of 6,091 km^2. The district is bounded by the districts of Agar Malwa on the northeast, Shajapur on east, Dewas to the southeast, Indore to the south, Dhar to the southwest and Ratlam to the west and northwest. Geographically it is bounded by (longitudes 22º 43” N to 23º36” N and latitudes 75º00”E to 76º30” E). Ujjain city is situated on the right bank of ShipraRiver. It is a part of Malwa plateau. The soil is black and stony. The vegetation is typical of arid regions. The total geographical area of the district is 609100 hectares wherein only 3200 hectare is the forest area. Boreholes constitute as a source of irrigation for 65. 70% of total irrigated area.

3. DATA

District planning map from Survey of India (SOI), Bhuvan (ISRO) thematic maps and ASTER GDEM data have been utilized to prepare thematic layers.

4. METHODOLOGY

4. 1 Preparing thematic layers

4. 1. 1 District Resource Map

District resource map was georeferenced and digitized in ArcGIS 10. 1 to obtain boundary, lithology, soil, stream network and rainfall map of Ujjain district.

4. 1. 2Bhuvan (ISRO)

Bhuvan's web mapping service (WMS) has been used to prepare land use, lineament and geomorphology map.

4. 1. 3 ASTER GDEM

Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (DGEM) data was obtained from Earth Explorer (USGS). This was than projected in UTM projection and used to prepare slope map.

4. 2 Operations on thematic maps

Land use, lithology, lineament, soil, rainfall and geomorphology map were first digitized as feature class and then converted from feature to raster at 30m resolution. Digitized stream network and lineament map was analyzed to create drainage density and lineament density map using line density tool in spatial analyst tool. Slope map was prepared using surface tool in spatial analyst.

4. 3 Weighted Overlay Analysis

Weighted overlay analysis is used for solving multi-criteria problems such as site suitability analysis. It is a technique for applying a common scale of values to diverse and dissimilar inputs to create an integrated analysis.

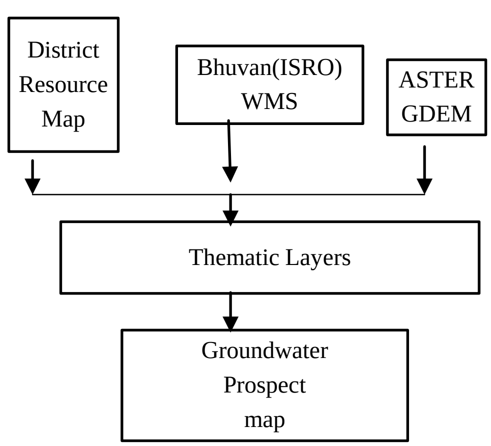

Fig. 1: Flow chart for preparing groundwater Prospect map

Inter-relationship between influencing factors was used to calculate percentage influence of thematic layers on the output. Scale values were decided depending upon the relative influence of different category of inputs in thematic layers on the groundwater potential.

4. 3. 1 Calculation of value of percentage influence for each thematic layer

Percentage influence of each layer on ground water prospect map has to be given as an input in weighted overlay analysis. Sum of percentage influence of all layers should equal 100. This was calculated on the basis of interrelationship between different thematic layers. Interrelationship between thematic layers was categorized as major and minor and value of 1 and 0. 5 was assigned to them. Following formulae was used

Percentage influence = $[(A+B) \div \sum(A+B)] \times 100$

In the following Fig. interrelationship between different layers has been shown. Major effect is shown using solid line and minor effect is shown using dotted line.

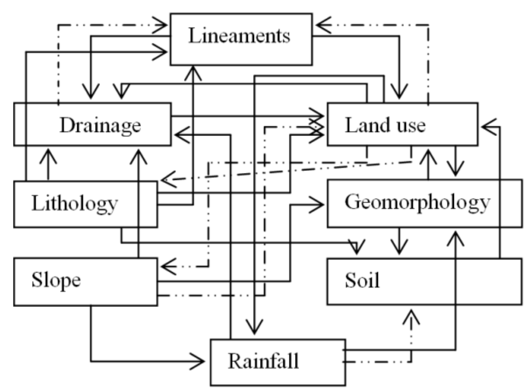

Fig. 2: Interrelationship between influencing factors

Table 1: Percent influence value for different influencing factors

Factor	Major effect A	Minor Effect B	A+B	%
Lineament	1+1	0	2	10
Geomorphology	1+1	0	2	10
Lithology	1+1+1+1	0	4	19
Drainage	1	. 5	1. 5	7
Slope	1+1+1	. 5	3. 5	17
Rainfall	1+1	. 5	2. 5	12
Soil	1	0	1	5
Land use	1+1+1	. 5+. 5+. 5	4. 5	20

5. RESULT AND DISCUSSION

5. 1 Land use

The major portion of land is used for agriculture. Forest constitutes only 0. 53% of the area of the district. No large water bodiesare within the area. Other land use types are barren land and built up area. Land use map was prepared using Bhuvan's(ISRO) web mapping service. Land use/land cover (LULC) was added as a layer using add GIS server in add data in arc map. The map was than digitized to obtain land use map.

5. 2 Geomorphology

Geomorphology is defined as scientific study of landforms. The identification of geomorphologic features is very important for demarcating groundwater potential. Denudationorigin pediment pediplaincomplex coverslarge area of the district. In the north eastern part of the district structural origin-moderately dissected lower plateaumakes the larger portion. Other geomorphological features in the area are anthropogenic origin-anthropogenic terrain,structural origin-low dissected lower plateauand fluvial origin-active flood plain. Geomorphology map was also prepared using web mapping service.

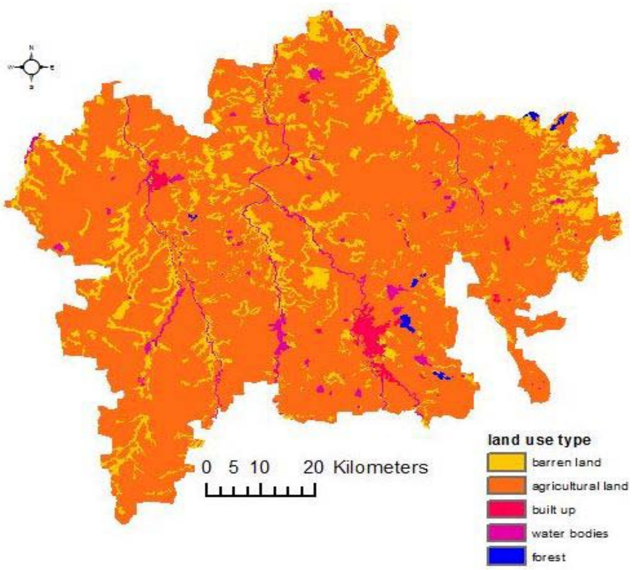

Fig. 3: Land use map of Ujjain District

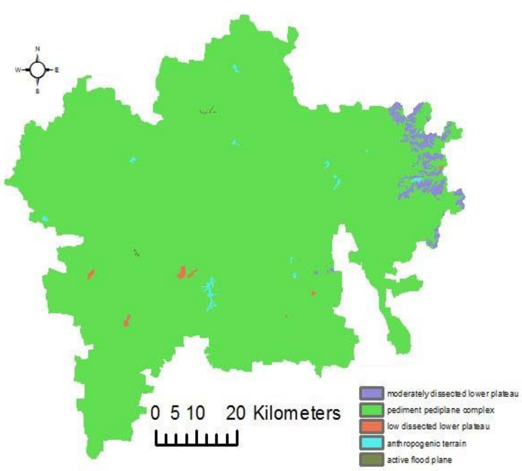

Fig. 4: Geomorphology map of Ujjain District

5. 3 Lithology

Lithology is the description of rock composition and texture. . The area is mainly covered by Deccan Trap basaltic flow consisting weathered, vasicular, hard massive fractured basalts. Alluvium is other lithological formation in the area. Lithology map was prepared using district planning map of Ujjain district.

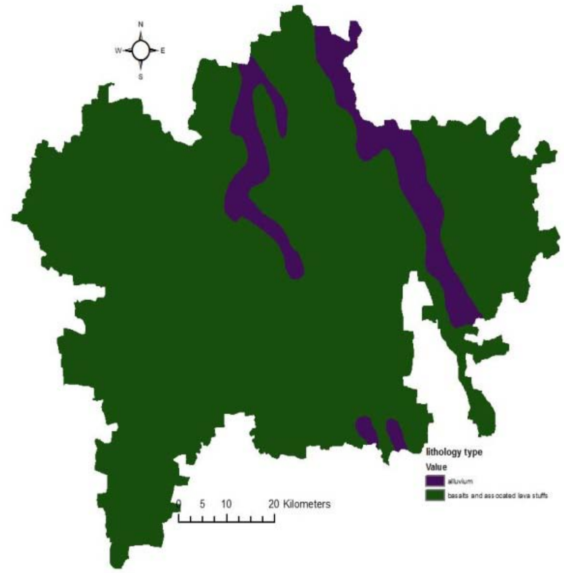

Fig. 5: Lithology map of the area

5.4 Rainfall

Rainfall in the region is due to south-west monsoon in the months of June to September. Average annual rainfall from 2009-13 was 976. 18 mm. Rainfall decreases as we move from South-East to North-West.

5.5 Soil

Soils in Ujjain arevertisols medium and deep black. This type of soil contains mineral montmorillonite which expands when soil becomes saturated. In saturated conditions this kind of soil becomes impermeable so less weighted has been given to this.

5.6 Lineament

Lineaments are linear features on the earth surface which indicate the presence of underlying geological structure such as fault, fractures etc. Lineament was digitized using WMS. Density analysis was then performed using line density tool in spatial analyst.

Table 2: Value assigned to different features within thematic layer

Thematic Layer	Subclass	Value
Lithology	Alluvium Basalts and associated Lava stuffs	25 9

Land use	Barren land	10
	Agricultural land	22
	Built up	5
	Water bodies	26
	Forest	16
Soil	Vertisolsmedium black	3
Geomorphology	ModeratelyDissected Lower plateau	8
	Pediment-PediPlain Complex	10
	Low Dissected Lower Plateau	12
	Anthropogenic Terrain	4
	Active flood plain	16
Rainfall	Above 1050	9
	950-1050	7
	Below 950	5
Stream density (m/km2)	0-1289	2
	1289-2812	4
	2812-4452	6
	4453-9963	8
	9960-29882	10
Lineament density(m/km2)	0	1
	0-261	2
	261-708	6
	708-3939	10
Slope(in degree)	0-13	12
	13-20	9
	20-39	6
	39-52	3

5.8 Stream density

Kshipra river is the main river in Ujjain which flows north across Malwa plateau and joins Chambal river. Khan and Gambhir are main tributaries. Stream networkwas digitized from district resource map and analyzed to prepare stream density map.

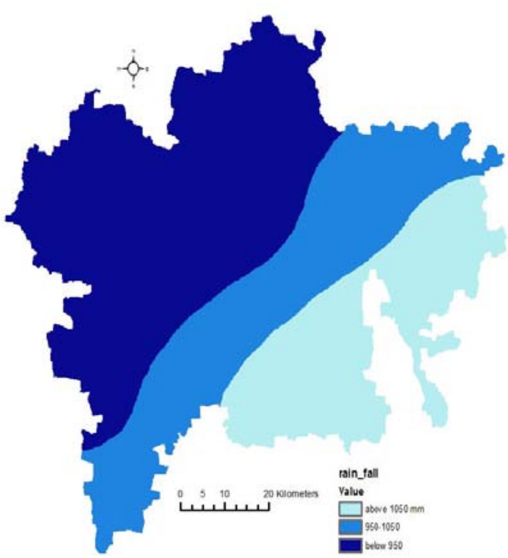

Fig. 6: Rainfall amp of Ujjain district

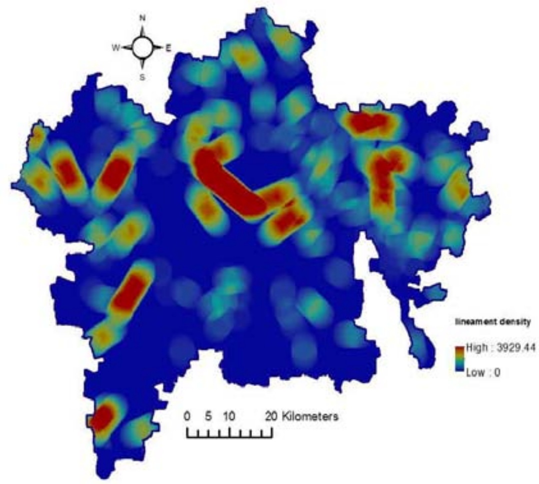

Fig. 7: Lineament density map

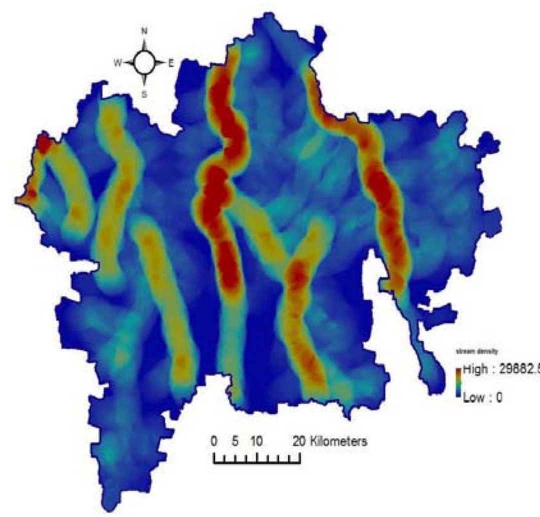

Fig. 8: Stream density map

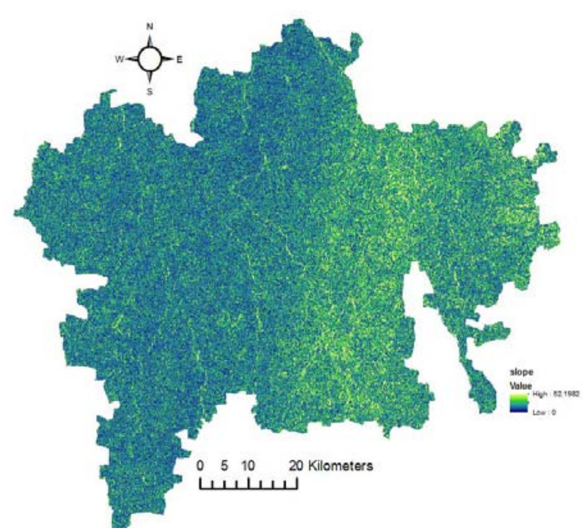

Fig. 9: Slope map of the area

5.9 Slope map

Slope map was prepared using ASTER GDEM data using surface tool in spatial analyst. Ujjain district is flat in topography.

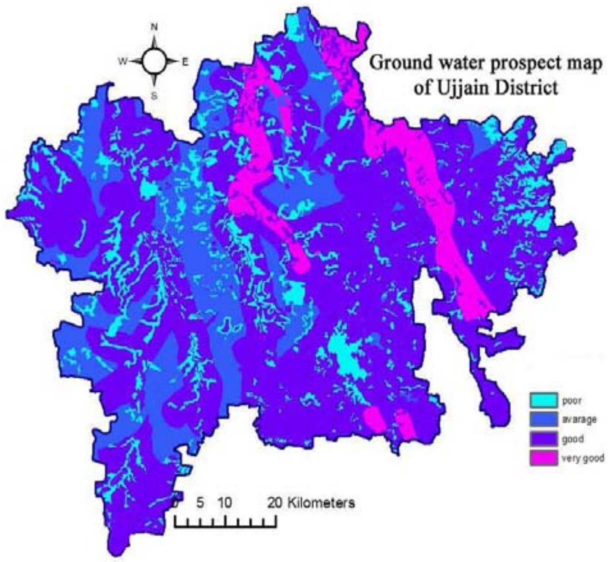

Fig. 10: Groundwater prospect map of Ujjain district

5.10 Ground water prospect map

Groundwater prospect map obtained after performing weight overlay analysis on thematic layers was reclassified in three categories namely good, average and poor groundwater potential zones. Areas having high lineament and stream density and alluvium lithology show good ground water potential. Areas having higher slopes, low rainfall, and low stream density show poor ground water potential. The map was than validated with ground water depth data and was found resembling the data.

6. CONCLUSION

Present study shows usefulness of remote sensing and GIS in the estimation of groundwater potential. This can primarily be employed for economical and rapid estimation and management of groundwater resources. Further standardization of estimation process and use of detailed data can be helpful in obtaining more accurate results.

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