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Identification of groundwater potential zones using Geoinformatics in upper Bhima basin, Pune, Maharashtra, India.

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Abstract— Groundwater is one of the most precious natural resources on the earth due to which all human activities sustains. All the social and economic progress of any region depends, not merely but mostly, on availability of water. The scarcity of water affects the environmental and developmental activities of a region. Continuous failure of monsoon, increasing water demand and over expoiltation of water leads to depletion of groundwater level. This problem could be sorted out, to certain exent, by identifying groundwater potential zones so as to distribute the water demand load evenly for maximum proper utilization of available water resource in that region.Present study is toposheets, satellite imagery and other collateral data are used for knowledge based ranking from1 to 3 depending on their suitability to hold groundwater and their weightages are calculated. Using overly analysis tool in ArcGIS software, all thematic maps are integrated to produce a composite groundwater potential zones map for the study area. This map was further classified into three categories which represents poor to good groundwater potential zones. The study reveals that valley is the geomorphology feature with good potential for groundwater occurrence alongwith burried Pediplain, followed by Pediplain for moderate potential zone. The structural hills and butte due to high slope and absence of primary porosity lies in the poor potential zones.

Index Terms — Groundwater, Potential zones, Remote Sensing, GIS, Overlay analysis, Geomorphology, Geoinformatics, Pune.

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1 Introduction

The geoinformatics technique is mainly applied through interpretation of satellite data alongwith use of collateral data. Geoinformatics is a tool which can be used for rapid and cost-effective assesement, planning, monitoring and management of precious natural resources like groundwater. Integration of multi-temporal and multi-sensor data covering large and inaccessible area within short span of time has been imerged as a essential tool for collection, storing, transformation, retrival, display and analysis of spatial data with particular reference of real world, such as place, use, purpose, etc. Nowadays GIS is being used extensively for variety of purposes such as evaluation of ground and surface water resources, feasibility of groundwater recharge sites, indentification of contaminated sites, land use- land cover pattern, hill top-hill slope analysis, etc. In recent years several researchers such as Rajat C. Mishra et al. 2010, Basavaraj Hutti and Nijagunappa R. 2011, Binay Kumar and Uday Kumar 2011, M.P. Sharma, Anukaran Kujur and Udayan Sharma, 2012 have successfully applied remote sensing and GIS technique(i.e. Geoinformatics) for groundwater prospect mapping. Sitender and Rajeshwari 2011, Nag S. K. and Anindita Lahiri, 2011, M. Kavitha Mayilvagana et al., 2011 have used GIS to delineate groundwater potential zones. SS. Asadi et al, 2012 have used remote sensing and GIS technique for estimation of groundwater potential zones. In present study, the remote sensing data of LISS III , geo coded at the scale of 1:50000 and Survey of India toposheets No. 47 F/14, 47 F/15, 47 J/ 2 and 47 J/3 have been used for the preparation of various thematic maps such as geomorphology, geology, lineament, slope and drainage density. The Geoinformatics technique has been applied to delineate groundwater potential zones in the area constituting pre and post monsoon fluctuation in groundwater table.

Study area – The study area lies in SOI toposheets No. 47 F/14, 47 F/15, 47 J/ 2 and 47 J/3 falling between latitude 18°15′0″ - 18° 45′0″ N and longitude 73°31′0″- 73°40′0″ E. in Haveli taluka, Pune district of Maharashtra state and situated near Pune city, admeasuring about 220 Sq. Km.

Location map of the study area is exhibited in fig.1 and fig. 2 as below:

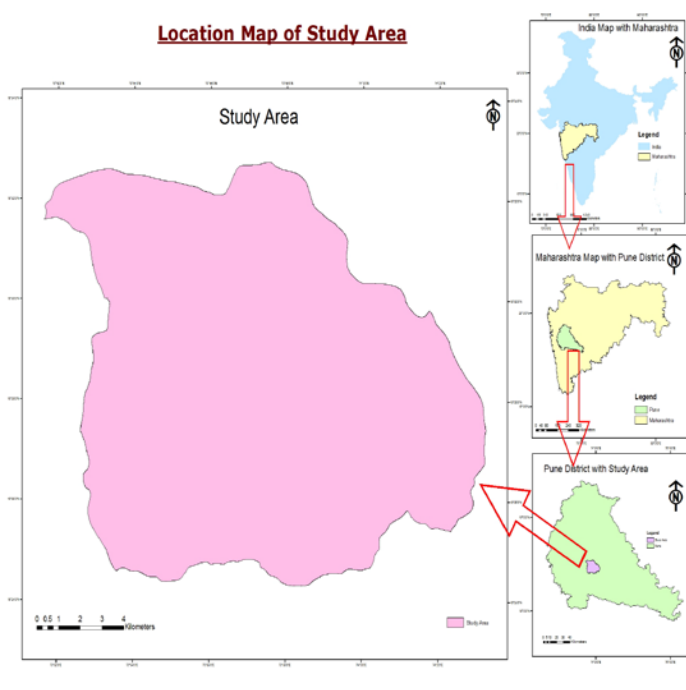

Fig. 1: Location map of the study area

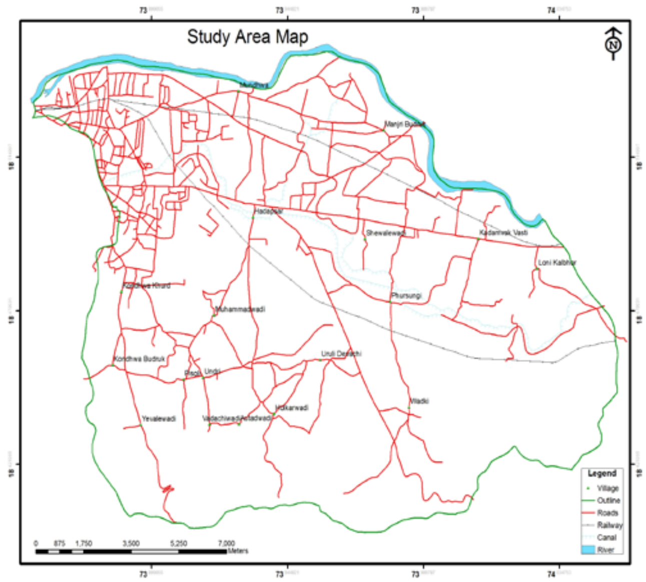

Fig. 2: Map of the study area

2 DATA USED

a. IRS- P6, LISS-III data (path-row 96-58), 27 March 2007, geocoded at the scale 1:50000
b. Survey of India toposheets No. 47 F/14, 47 F/15, 47 J/ 2 and 47 J/3 on scale 1:50000
c. ASTER GDEM 30m (USGS/NASA ASTER DEM data, available from http://www.gdem.aster.ersdac.or.jp

3 METHODOLOGY

Methodology adopted in the study area is as follow:
The IRS P6 LISS-III is rectified geometrically and registered with SOI toposheets on 1:50000 scale using Geomatica image processing software through map to image registration technique. The FCC generated from red, green and blue spectral bands (1, 2 and 3). Linear, equalization and root enhancement techniqoues have been followed in enhancing the satellite imagery for better interpretation of the geomorphological, soil and structural information. ArcGIS software has been used for digitization, editing, and topology creation. Assignment of weightages of different themes and classes, integration of multi-thematic information and delineation of groundwater prospect map generated through GIS processing. The groundwater prospect map, thus generated through this technique has been verified with field data to ascertain the validity of the model developed.

3.1 Spatial database building

ArcGIS software provides various tools to generate datasets of features, attribute tables, topology / geometric network and other data items in database. Thematic maps are created using following procedure:

I. Digitization of scanned toposheets / maps
II. Editing for elimination of errors
III. Building network / topology
IV. Assignment of attributes for each layer
V. Providing projection

3.2 Spatial database analysis

Spatial analysis is a significant process using study of locations of geographic phenomena together with their dimensions and attributes, table analysis, classification, polygon classification and weightage assignment and classification. All thematic maps, such as geomorphology, soil, slope and land use land cover map, have been prepared and duly assigned weightages depending upon its influence on groundwater occurrence and movement. For example geomorphology plays prominent role in identification of groundwater potential zones than slope hence higher weightage is given to geomorphology.

3.3 Data integration through GIS

Various favourable groundwater thematic maps have been integrated into a single groundwater preospect zone with the application of GIS techniques. This required three steps, which are as follow:

- Sspatial database building
- Satial database analysis
- Data integration through GIS
- Generation of groundwater potential zones map

It is evident that each thematic map such as geomorphology, soil, land use-land cover and slope map provides certain clue regarding groundwater occurrence in study area. All these thematic layers are overlaid on each other to generate intersecting polygons, in a paired combination. Using this overlay analysis a new composite map is generated which is integration of various features from these thematic maps and this is the final composite map for groundwater potential zones.
In assigning final weightages to the polygons in the final integrated layer overlay analysis has been adopted to integrate various thematic maps. Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis. The final groundwater potential zones map (fig. 9) has been categorized into three zones viz. poor, moderate and good, from groundwater prospect point of view.

I. The thematic maps of (i) Geomorphology, (ii) Soil, (iii) Land Use and Land Cover and (iv) Slope, alongwith well locations spread over the study area, have been prepared on the scale 1:50000 using remote sensing data, and field data, well location data obtained through GPS receiver, on Arc GIS software.
II. Slope map has been generated from Aster DEM 30m.
III. For generation of these thematic maps IRS P6 data LISS

standard FCC of March 2007, in the scale of 1:50000 has been used and Survey of India toposheets number 47 F/14, 47 F/15, 47 J/ 2 and 47 J/3 on scale 1:50000 were used as a base information.

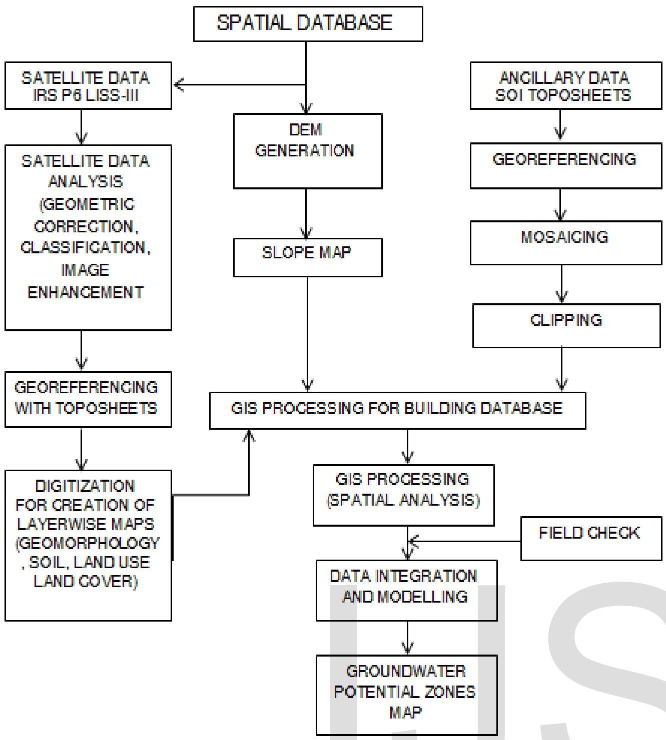

Fig. 3: Methodology Flowchart

4 Analysis and Discussion

4.1 Geomorphology

Geomorphology reflects various landforms and structural features. These units are deciphered from the remote sensing data and are shown in Figure 4. The major geomorphological units found in the study area are structural hills, butte, pediplain, burried Pediplain and valley.
Geomorphological features combined with soil and slope control the occurrence, movement and quality of the groundwater. An integrated study of the soil and the evolution of landforms is useful to understand the occurrence of porous and permeable zones. The study area has complex geomorphical features, which are described as follow:

a. Valley - This landform, which is a local depression formed logitudnaly along the streams, shows good groundwater potential.
b. Burried pediplain – This landform also indicates good groundwater potential.
c. Pediplain – This landform indicates moderate groundwater potential.
d. Butte – This landform isa small portion of land which has moderate high elevation compared to local surrounding land and has poor groundwater potential.
e. Structural Hill – This is part of land which has high or very high elevation compared to surrounding land in that region and contains very low or poor groundwater potential.

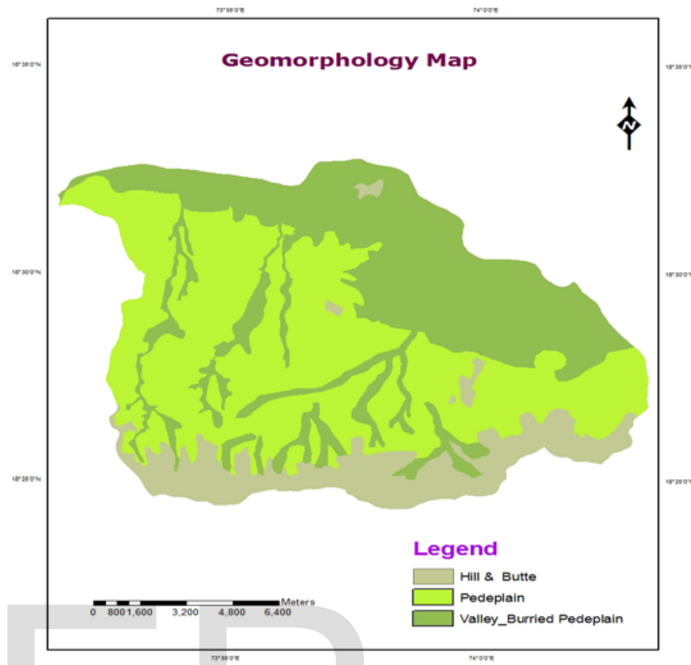

Fig. 4: Geomorphology Map of study area

Generalized geomorphological nature of the study area is indicated in the table below

Table 1

Sr. No.	Geomorphic Unit	Alpha Code	Ranking (In word)	Weightage (In number)
1	Valley	V	Good	3
2	Burried Pediplain	BP	Good	3
3	Pediplain	P	Moderate	2
4	Butte	B	Poor	1
5	Structural Hill	SH	Poor	1

4.2 Soil

The study area falls partly under the structural hills and partly under regur soil plaeuto. The study area is prominently consisting in the basaltic region of Maharashtra. The study area is broadly in the elevation of the region ranges between 550-1005 m AMSL. The study area lies over the combination basaltic plaeuto and regur soil. On the southward part, where structural hills exist, the area is exposed to rocks and on the northern part periphery where Mula-Mutha river exists regur to alluvium soil occurred.

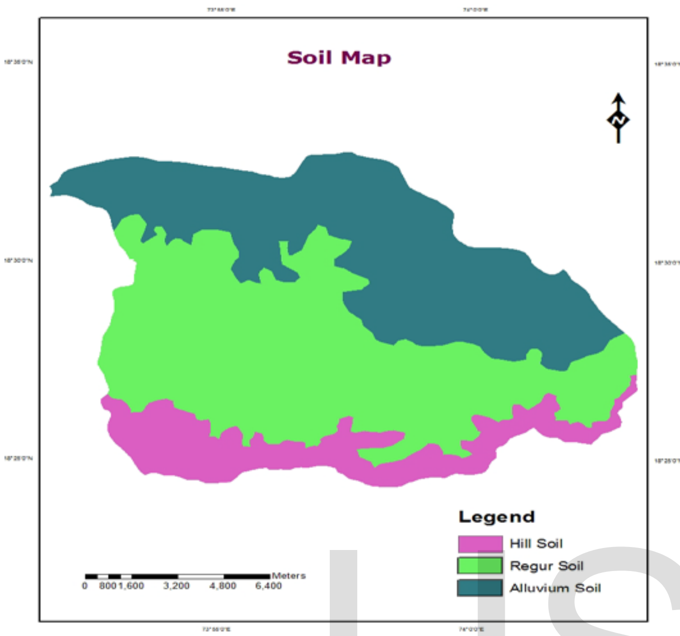

Fig. 5: Soil Map of study area

4.3 **Slope**

Slope of an area is one of the controlling factors of groundwater occurrence and recharge. It influences surface and subsurface flow of rainwater and its recharge to the groundwater reservoir. Gentle slope of an area provides more time to infiltrate the rainwater to aquifer zone, whereas high slope allows lesser time resulting low infiltration to underlying groundwater reservoirs. The slope map of the study area has been prepared from ASTER DEM 30 m. The slope of the study area has been classified into three classes. The area constitutes 0 to 2 %, 2 to 5 % and more than 5% slope. Most of the area falls between the areas with slope from 0 to 5 % i.e. nearly 50 % of total area. High slope is observed in the southern part and southeast part of the study area, which is nearly 50 % of total area. Slope map of the area is as shown in Fig. 6.

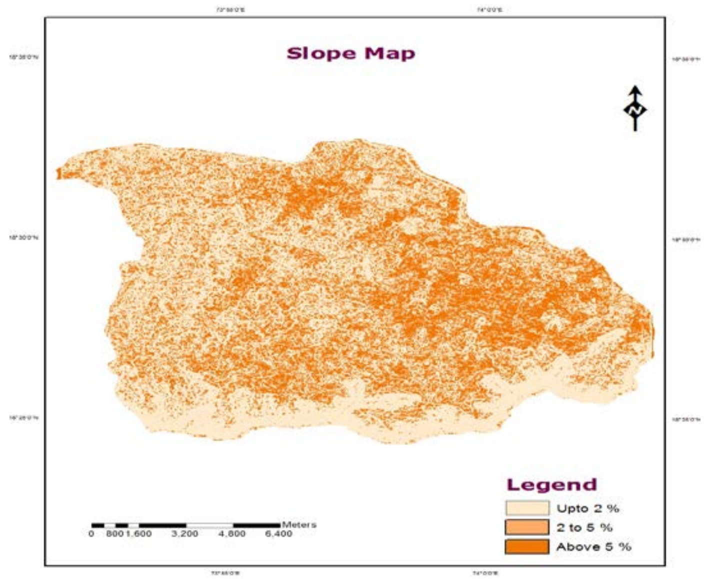

Fig. 6: Slope Map of study area

4.4 **Land Use / Land Cover**

Land is one of the important natural resources and is a precious asset. The actions related to land and water management influences the vegetation and land use-land cover. Information on existing land use-land cover and pattern of their spatial distribution forms the basis for any developmental planning. Current land use-land cover has to be assessed for its suitability for groundwater prospects. Land use-land cover map is as shown as Figure 7.

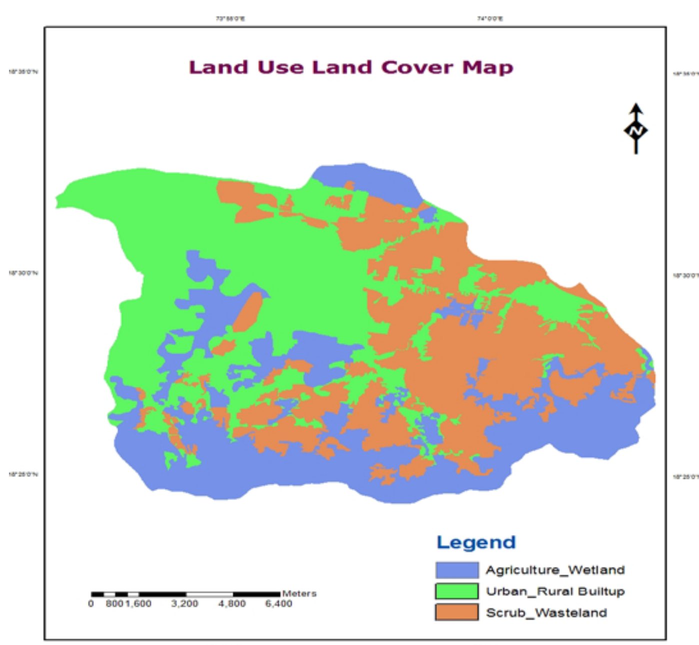

Fig. 7: Land Use Land Cover Map of study area

5 RESULTS

Remote sensing and GIS have been used to generate and integrate various thematic maps viz. geomorphology map (fig. 4), soil map (fig. 5), slope map (fig. 6) and land use land cover map (fig. 7), which being very informative and plays important role in the study of occurrence and movement of groundwater for identification of groundwater potential zones in the study area. The various thematic maps were assigned with different weightages of numerical value to derive groundwater potential zones. On the basis of weightage assigned to these maps and bringing them into the function of spatial analyst for integration of these thematic maps, a map indicating groundwater potential zone is obtained.

GROUNDWATER PROSPECTS MAP

According to the flow chart prepared in fig. 3, the final map i.e. the composite map, by integrating four thematic maps, has been prepared, which has been named as groundwater prospect map (fig. 8). The groundwater prospect map has been categorized into three zones viz. poor to good groundwater potential zones. Field checks has been made through the water level data of dug wells, which satisfy the above analysis.

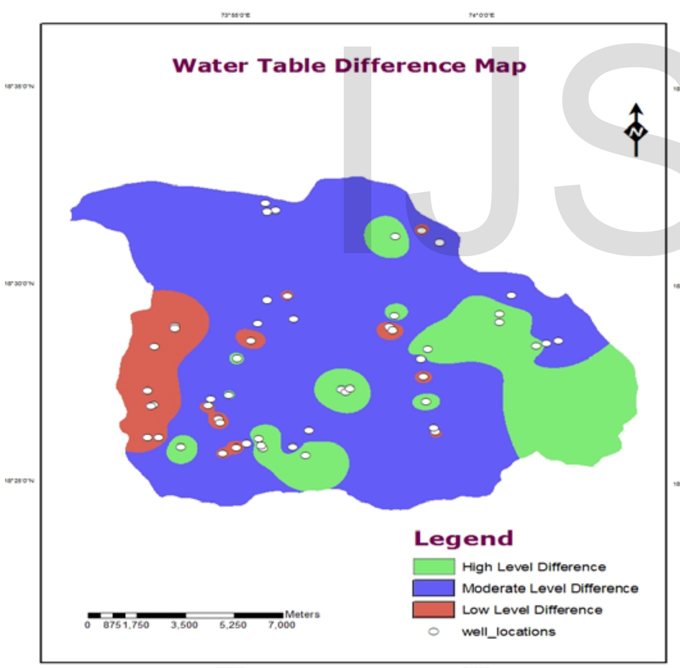

Fig. 8: Slope Map of study area

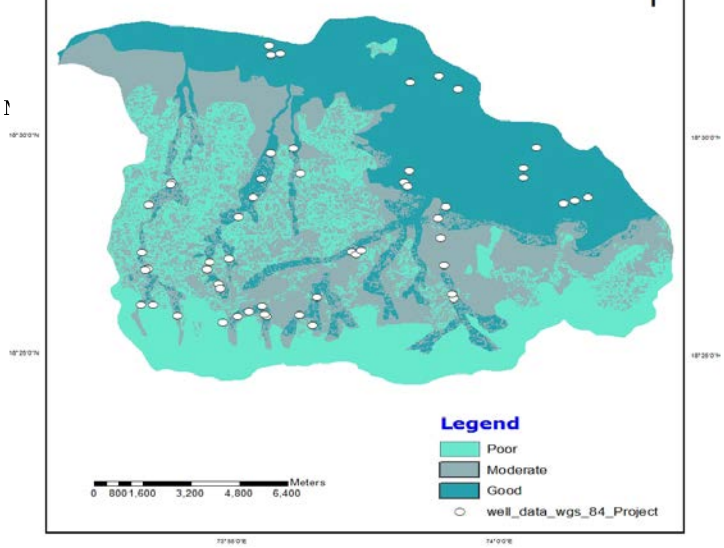

Fig. 9: Groundwater Prospects Map of study area

6 CONCLUSION

GIS approach has been used to integrate various thematic maps which are very important to identify the groundwater occurrence and movements. The integrated groundwater prospect map has been categorized into three classes on the basis of the cumulative weightages assigned to different features of the thematic maps. For more realistic evaluation through field checks were made with water level data of dug wells. The deciphered map could be used for various purposes like identification of location of drinking water wells, irrigation tubewells and management of groundwater, etc.

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REFERENCES

[1] Rajat C. Mishra, Biju Chandrasekhar, Ranjitsingh D. Naik, 2010, “Remote sensing and GIS for groundwater mapping and identification of artificial recharge sites”, GeoShanghai International Conference / Geoenvironmental Engineering and Geotechnics; ASCE/216-221.

[2] Basavaraj Hutti, Nijagunappa R., 2011, “Identification of groundwater potential zone using Geoinformatics in Ghataprabha sub-basin, North Karnataka, India”, International Journal of Geomatics and Geosciences; Volume 2 Issue 1, 91-109; ISSN 0976 – 4380.

[3] Binay Kumar, Uday Kumar, 2011, “Groundwater recharge zonation mapping and modelling using Geomatics techniques”, International Journal of Environmental Sciences Volume 1 No.7, 1670-1681; ISSN 0976 – 4402.

[4] M.P. Sharma, Anukaran Kujur, Udayan Sharma, 2012,“Identification of groundwater prospecting zones using remote sensing and GIS techniques in and around Gola block, Ramgargh district, Jharkhand, India, International Journal of Scientific & Engineering Research Volume 3, Issue 3,1-6; ISSN 2229-5518.

[5] Sitender, Rajeshwari, 2011, “Delineation of groundwater potential zones in Mewat district, Haryana, India”, International Journal of Geomatics and Geosciences, Volume 2 Issue 1, 270-281; ISSN 0976 – 4380.

[6] Nag S.K., Anindita Lahiri, 2011,” Integrated approach using remote

sensing and GIS techniques for delineating groundwater potential zones in Dwarakeswar watershed, Bankura district, West Bengal", International Journal of Geomatics and Geosciences; Volume 2 No.2, 430-442; ISSN 0976 – 4380.

[7] M. Kavitha Mayilvaganan, P. Mohana and K. B. Naidu, 2011, "Delineating groundwater potential zones in the Thurinjapuram watershed using geospatial techniques", Indian Journal of Science and Technology; Vol. 4, No. 11 (Nov 2011) 1470-1476; ISSN:0974-6846

[8] S.S. Asadi, P. Neela Rani, 2012, "B.V.T .Vasantha Rao and M. V. Raju, Estimation of ground water potential zones using remote sensing and GIS: a model study", International Journal of Advanced Scientific Research & Technology; Issue 2, Vol. 2, 265-276; ISSN 2249 – 9954.

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