

Utility of Geoinformatics in Watershed Management and Water Quality Analysis for North-East Region of Pune District

1. Anil F. Dhobale, 2. Dr. N. S. Jain, 3. Shivaji Govind Patil

Abstract — Systematic planning and management of groundwater exploitation using modern techniques is essential for proper utilization and management of this precious but shrinking natural resource. With the advent of powerful and high-speed personal computers, efficient techniques for water management have evolved, of which Geoinformatics technology includes RS (Remote Sensing), GIS (Geographic Information System) and GPS (Global Positioning System) are of great significance. Elaborate study has been carried out in BM-18 watershed in North-East region of Pune District. In this study, an attempt has been made to highlight possible avenues to find groundwater using Geoinformatics as a tool. Groundwater studies have become crucial not only for targeting its potential zones, but also for monitoring and conserving this vital resource. The thematic layers which will be considered in this study are geomorphology, soil, slope and land use land cover, which were prepared using the geospatial data and conventional primary and secondary data. Geoinformatics has proved as an efficient tool in integrating primary and secondary data for ground water quantity and quality studies. Attempt has been made with the help of Arc GIS software to generate potential zones map for watershed management and water quality of the study area.

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

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 assesment, 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, retrieval, 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/13, 47 J/ 1 and 47 J/2 have been used for the preparation of various thematic maps such as geomorphology, soil, slope, land use land cover, water table difference. The Geoinformatics technique has been applied to delineate groundwater potential zones in the area constituting pre and post monsoon fluctuation in groundwater table alongwith water quality.

00'0" N and longitude 73°49'0" - 74°12'0" E. in Haveli taluka, Pune district of Maharashtra state and situated near Pune city, admeasuring about 218 Sq. Km.

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

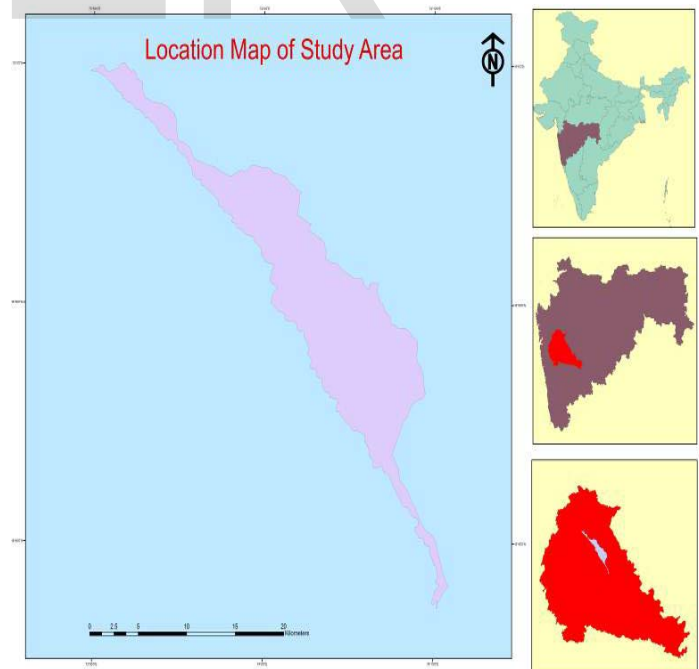


Fig. 1: Location map of the study area

Study area - The The study area lies in SOI toposheets No. 47 F/13, 47 J/ 1 and 47 J/2 falling between latitude 18°36'0" - 19°

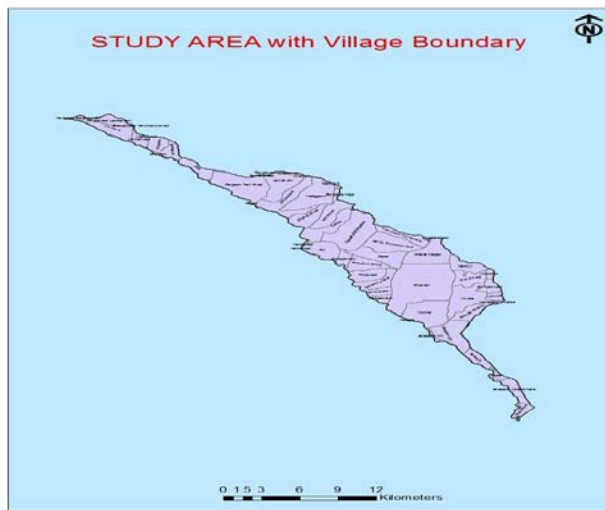


Fig. 2: Map of the study area

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/13, 47 J/ 1 and 47 J/2 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 ArcGIS 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 techniques 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. Methodology flow chart is given below, as per fig. 3.

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 map projections

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 potential zones map alongwith groundwater quality, using Geoinformatics technique. The five steps of data integration are as follow:

- Spatial database building
- Spatial database analysis
- Data integration through GIS
- Generation of groundwater potential zones map
- Generation of groundwater quality 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 and groundwater quality map.

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 and water quality map (fig.10) has been categorized into two zones viz. suitable and unsuitable from water quality 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/13, 47, 47 J/ 1 and 47 J/2 on scale 1:50000 were used as base information.

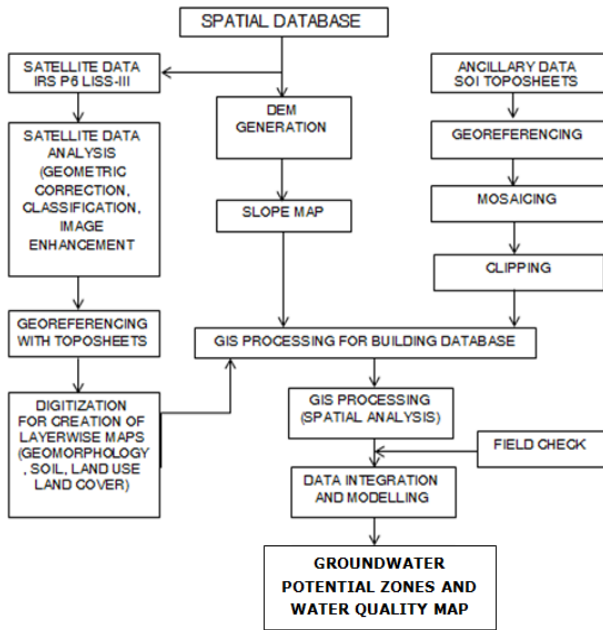


Fig. 3: Methodology Flowchart

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 highly, moderately, slightly, weathered dissected, etc.

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 are useful to understand the occurrence of porous and permeable zones. The study area has complex geomorphical features.

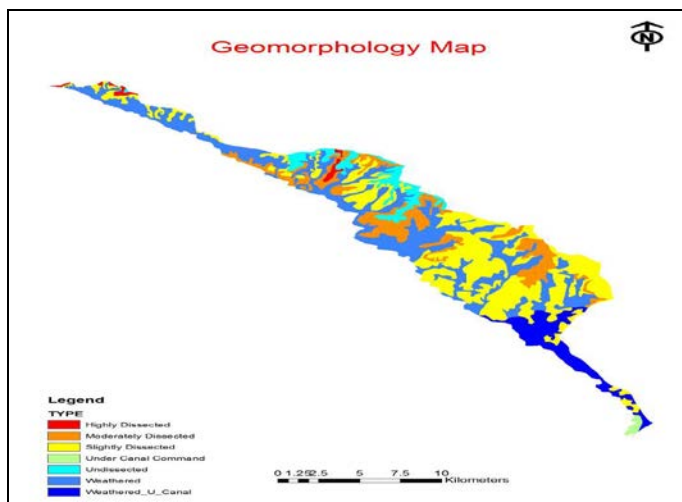


Fig. 4: Geomorphology Map of study area

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	Highly Dissected	HD	Moderate	2
2	Moderately Dissected	MD	Poor	3
3	Slightly Dissected	SD	Poor	3
4	Under Canal command	UC	Good	1
5	Un-dissected	UD	Poor	3
6	Weathered	WT	Moderate	2
7	Weathered under Canal command	WUC	Good	1

4.2 Soil

The study area falls partly under the structural hills and partly under regur soil plateau. 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 plateau and regur soil. On the some part, structural hills exist, the area is exposed to rocks and on the some part on periphery of study area, regur to alluvium soil occurred.

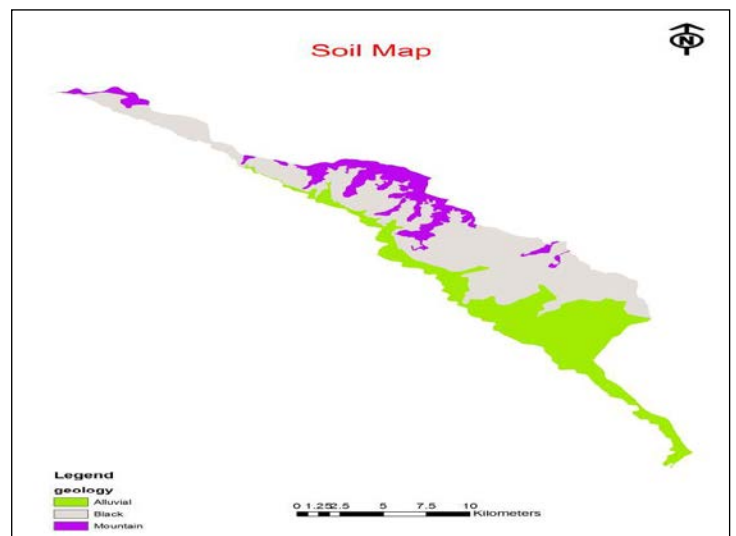


Fig. 5: Soil Map of study area

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 five classes. The area constitutes 0 to 1 %, >1 to <3 %, >3 to <5 %, >5 to <25 % and more than 25% slope. Slope map of the area is as shown in Fig. 6.

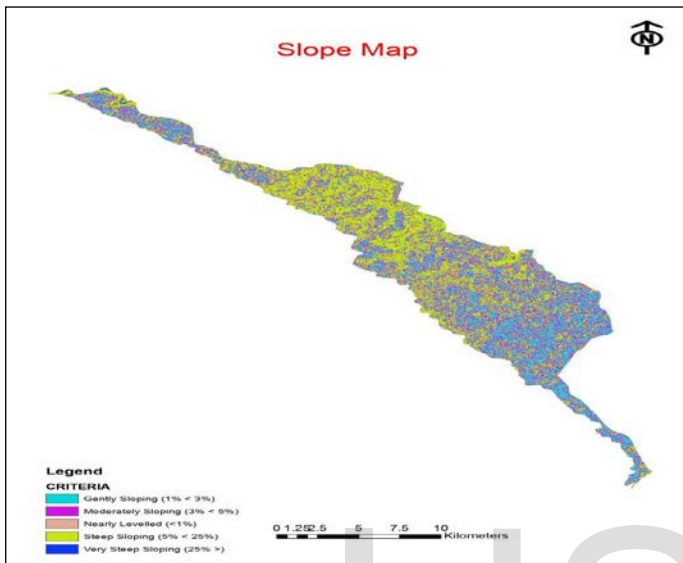


Fig. 6: Slope Map of study area

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.

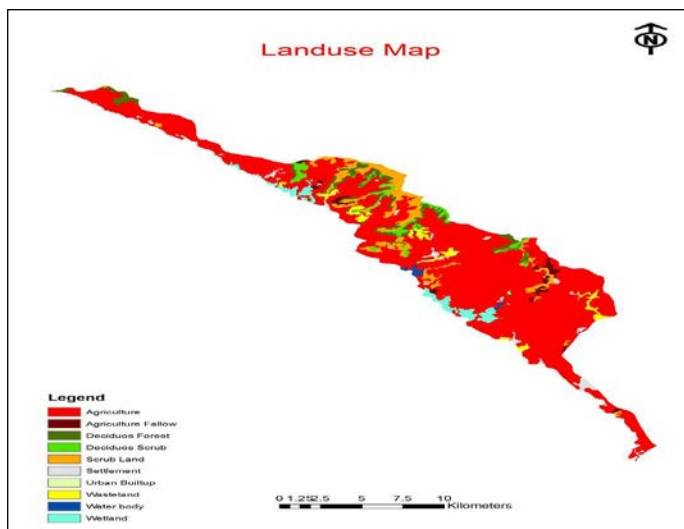


Fig. 7: Land Use Land Cover Map of study area

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 zones is obtained. For groundwater quality, water samples from 59 dug wells has been tested in the laboratory for the various parameters to check the suitability of the ground water in the study area for human use, a map indicating the water quality is also obtained.

GROUNDWATER POTENTIAL AND WATER QUALITY MAPS

According to the flow chart prepared in fig. 3, the final map i.e. the composite map, by integrating various thematic maps, has been prepared, which has been named as groundwater potential 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. The water quality map has been categorized viz. suitable and unsuitable for the use of humans as shown in fig. 10.

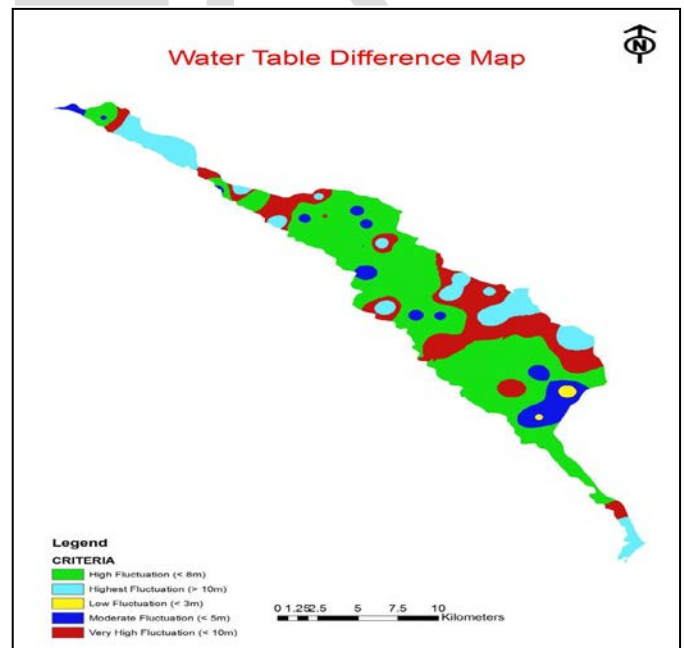


Fig. 8: Water Table Difference Map of study area

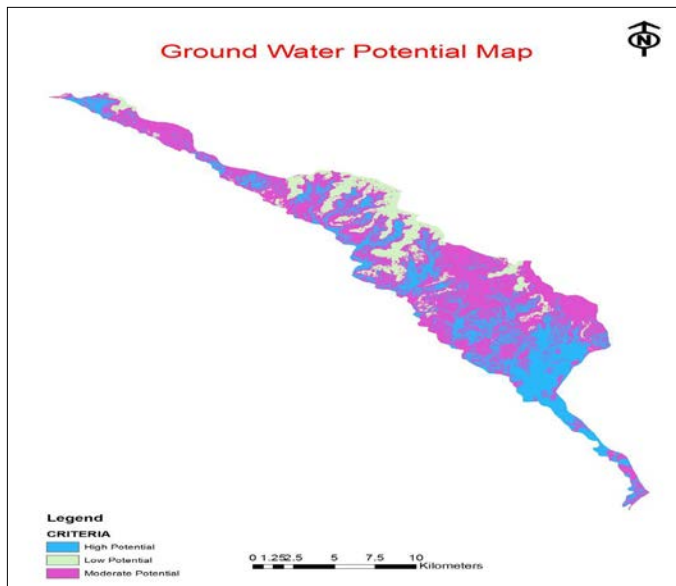


Fig. 9: Groundwater potential zones map of study area

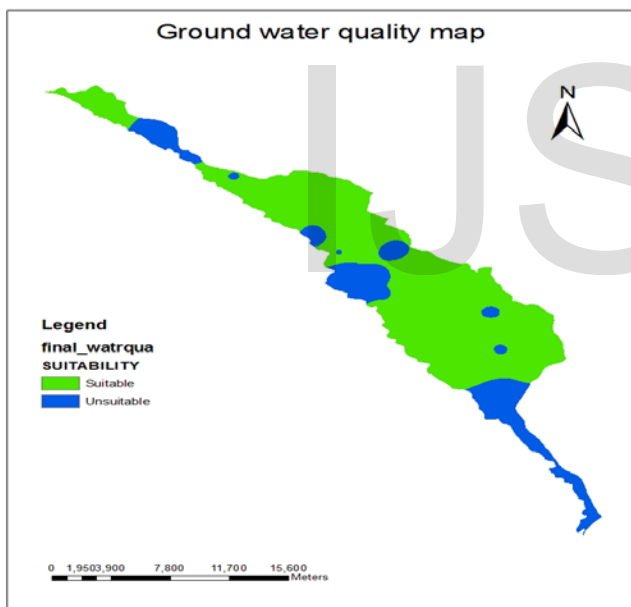


Figure 10: Groundwater water quality map of study area

6 CONCLUSION

Geoinformatics approach has been used to integrate various thematic maps which are very important to identify the groundwater occurrence and movements. The integrated groundwater potential zones 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 and also to identify the quality of the groundwater, field investigations were carried out with water level data of dug wells in the study area. 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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AUTHORS

1. Anil F. Dhobale, Post Graduate Student, D.Y. Patil College of Engineering, Department of Civil Engineering, Akurdi, Pune - 411044.
2. Dr. N. S. Jain, Associate Professor, D.Y. Patil College of Engineering, Department of Civil Engineering, Akurdi, Pune - 411044.
3. Shivaji Govind Patil, Assistant Engineer, Maharashtra Industrial Development Corporation, Wakdevwadi, Pune - 411003

Corresponding Authors' e-mail ID

1. anil.dhobale@yahoo.co.in
2. nsjain63@gmail.com
3. shivajipatil@midcindia.org