Delineation of Ground Water Potential Zones in Nilagiri Block of Baleswar District, Odisha: A Remote sensing and GIS Approach

[1]Joydeep Paikray, [2]Pramod Chandra Sahu
[1]Research scholar: North Orissa University, Takatpur, Baripada, Odisha
[2]P.G Department of Geology: MPC Autonomous College, Baripada, Odisha

Abstract:

In the present research, several groundwater potential zones for the calculation of groundwater accessibility in the Nilagiri block have been explained using Remote Sensing and GIS advanced techniques. Survey of India toposheets with the scale of 1:50,000 and LISS-III satellite imageries with the resolution of 30 meters are used to prepare several thematic layers viz. lithological map, slope map in degree, land-use land cover map, lineament map, lineament density map, drainage map, soil map, and geomorphological map. These maps were transformed into a raster format. The raster maps of these factors are allocated a fixed score and weight computed from multi influencing factor (MIF) technique. Moreover, each weighted thematic layer is statistically computed to get the groundwater potential zones. Thus, four different groundwater potential zones were identified, namely 'Very Good' 'Good', 'Moderate', and 'Poor'.

Keywords: Groundwater Potential, Remote Sensing &GIS, Weight Overlay Analysis.

I.INTRODUCTION

Groundwater is the most vital natural resource in the world, especially in India. In most part of the India agricultural activities depend upon the monsoon. The water from the monsoonal rain is very much uncertain for cultivation. To have sustained agriculture activities and to meet other necessities of life it is essential to understand the hydrogeological setup of an area so that groundwater condition could be understood in a better way. Knowledge of geological setting and terrain condition are required for sustainable water allocation and to guide water management policies. The role of terrain condition such as geology, geomorphology, soil and hydraulic gradient has a definite influence on the groundwater condition of an area. It also controls the groundwater flow, which could be inferred by the groundwater level fluctuations observed through surface indications. Previously, study of groundwater condition was a difficult task since it was involved tedious ground based investigation. But, with the advent of satellite remote sensing, it has become relatively easier to understand the regional setting of a terrain. Earlier and at present numerous articles have been published on the study of ground water development using the RS and GIS techniques. The authors cite the articles such, (Sahu 2017; Acharya et al., 2017; Nandi, et al. 2014, 2015: Saraf and Choudhury 1998; et al., 2003; Nandi, et al. 2017). Regional inferences of the terrain can be drawn through interpretation of satellite data. The regional pattern and trend of many of the geological and structural information may be obtained from study satellite data. Integration of such level of information could be easily carried out in GIS platform. In the present study, such a methodology is adopted to understand the regional geological setting of Nilagiri block of Baleswar district which influences the spatial variations in groundwater level fluctuations. For such an approach, image analysis of the study area was carried out, to understand the trend of hidden features, so that the knowledge that was gained could be used while carrying out spatial analysis to locate probable zones of groundwater in the study area. Geographic Information System (GIS) is well suited to the integrated systems approach required in the analysis of groundwater condition (Sander et al., 1996; Chowdhury et al., 2009; Jha et al., 2010). This study incorporates the benefits from the spatial data management capabilities and spatial operations ranging from Boolean weight overlay to analysis (Burrough, 1986).

II.STUDY AREA

The proposed study was conducted in the Nilagiri block of Baleswar district, Odisha, India. It is located between 21°36′ 29″ to 21° 23′ 36″ N latitude and 86°33′ 04″ to 86° 49′ 39″ E longitude. It falls in the Survey of India toposheet numbers 73K/10, 73K/11, 73K/14 and 73K/15. The study area encompasses 408.76 sq. km. The average elevation of the study area is 23 meters. Physiographically the study area comes under Chhotanagpur plateau. The three distinct seasons characterize the study area are summer, monsoon, and winter, with mean temperatures ranging from 10°C in winter to 43°C in summer . As per census 2011, the population of the Nilagiri block is 129360.

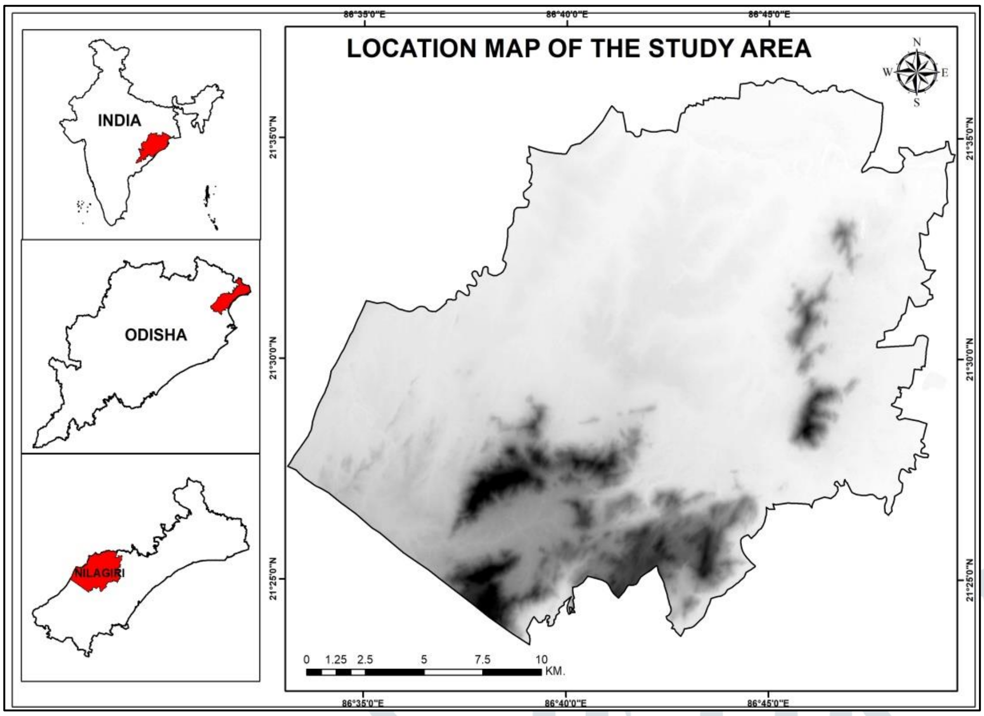

Fig.1 Location map of the study area

III.METHODOLOGY

The Base map for the study area was prepared using the Survey of India toposheets in 1:50,000 scale. For demarcating the groundwater potential zones, the thematic maps related to slope, drainage density, geology, geomorphology, lineament density, soil and land use / land cover of the study area were considered. Maps relating to slope and drainage density were generated using Survey of India toposheets of 1:50,000 scale. The other thematic maps, which include geology, geomorphology, soil, land use/land cover and lineaments, were interpreted from IRS ID - LISS III geocoded data of 1: 50,000 scale. From the lineament map, the lineament density map was generated. Based on the groundwater potential, suitable weightage values were assigned. By integrating these maps using GIS software, groundwater potential zones of the study area were demarcated. The methodology chart is shown in Fig.2.

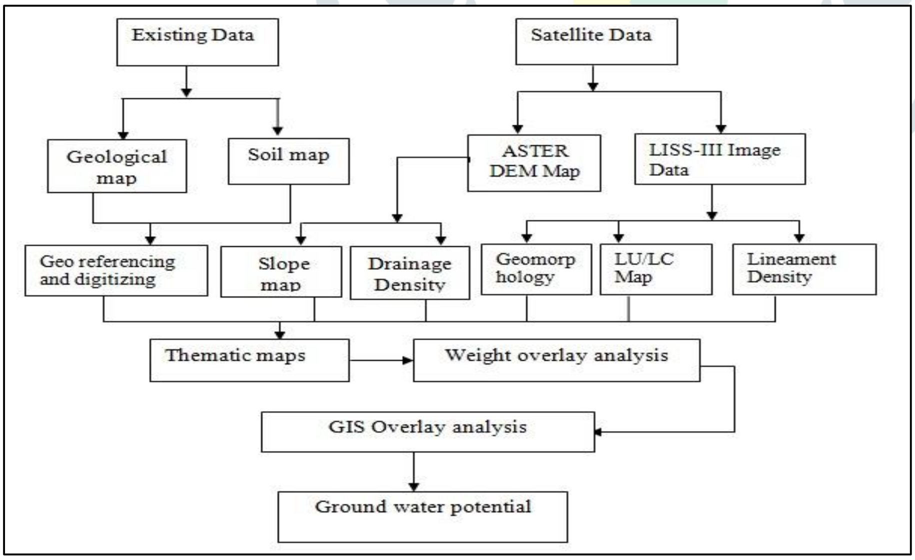

Fig.2 Flowchart for delineation of groundwater potential zone using geospatial techniques

IV.RESULT AND DISCUSSION

Geology

Most of the part of the Nilgiri Block is covered by greyish greenish clay. Apart from this, older alluvium of Pleistocene-Holocene age covers a larger area of the block. This older alluvium contains oxidised sand, silt and clay. Granite/Gneiss of Singhbhum Granite Complex of Archean age is exposed within the study area. Most of the part of the study area is under consolidated zone. Due to wide variation in hydrogeological set up within the block, the occurrence and distribution and yielding properties of aquifers is not uniform. The Geological map of the study area is shown in Fig.3.

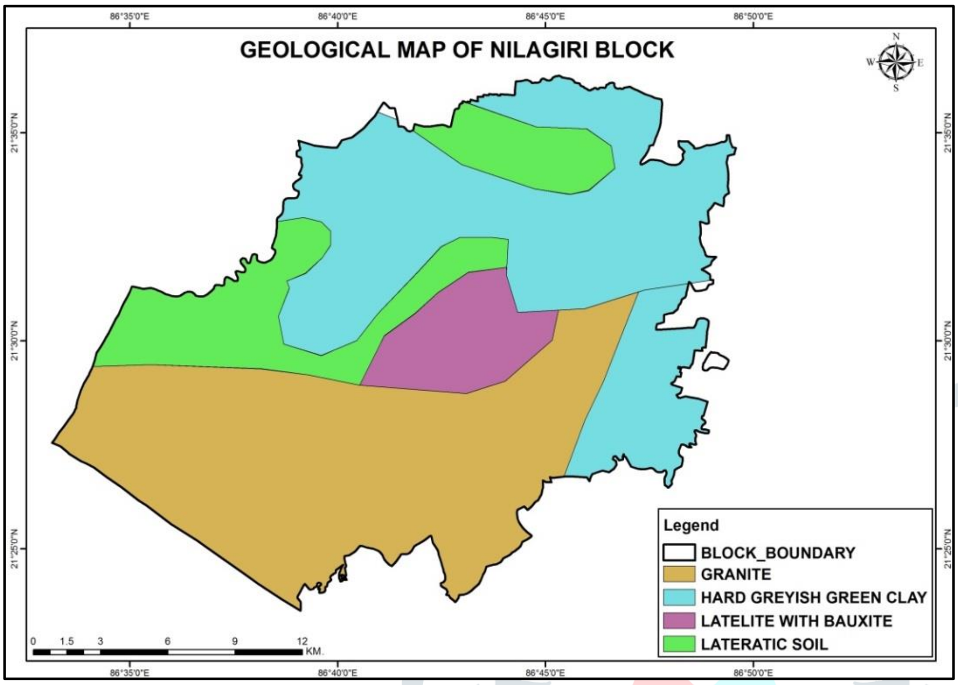

Fig.3. Geological map of the study area

Hydro Geomorphology

The study of hydrogeomorphological shows that there is a close relationship between the hydrogeomorphic units and groundwater resources (Subba Rao and John Devada 2003). Hydrogeomorphological units are very helpful for delineating groundwater potential zones (Elango et al. 2003). By the help of seven image interpretation keys such as tone, texture, shape, colour and association over the rectified false colour Composition (FCC) image, the geomorphologic units and landforms are interpreted. The geomorphological feature of the Nilagiri block are Pediplains 33.92%, Structural Hill 19.39%, pediments 14.31%, Platue 10.83%, Aluvial plain 12.29%, Denudation hills 4.19%, Flood plain 2.78%, Water body 1.22%, Residual hills 0.13%, Habitation 0.29%, . The Geomorphological map of the study area is shown in Fig. 4 and the geomorphological units in percentage are shown in Fig 4.1.

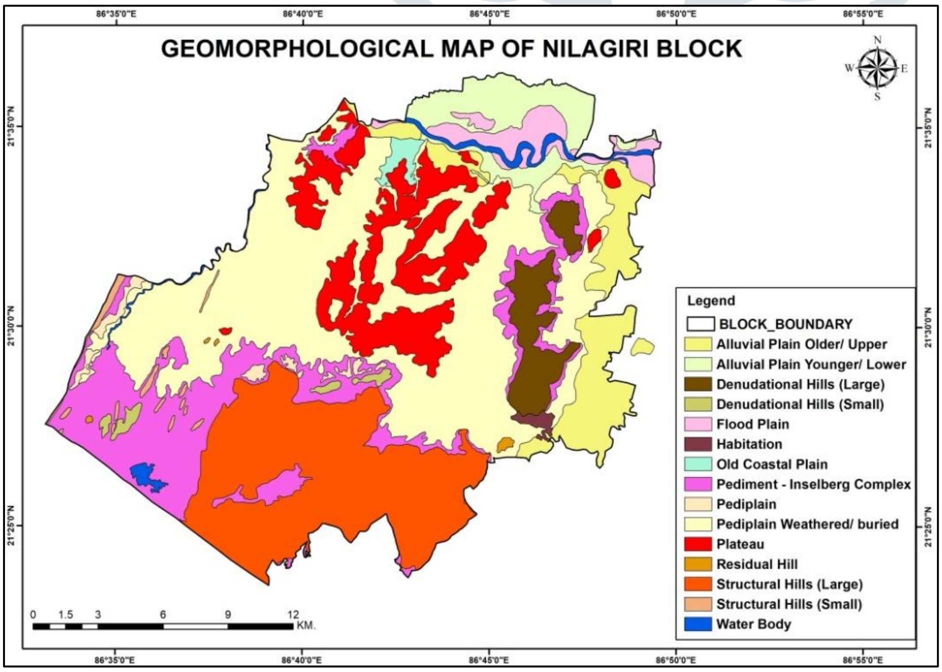

Fig.4 Geomorphological map of the study area

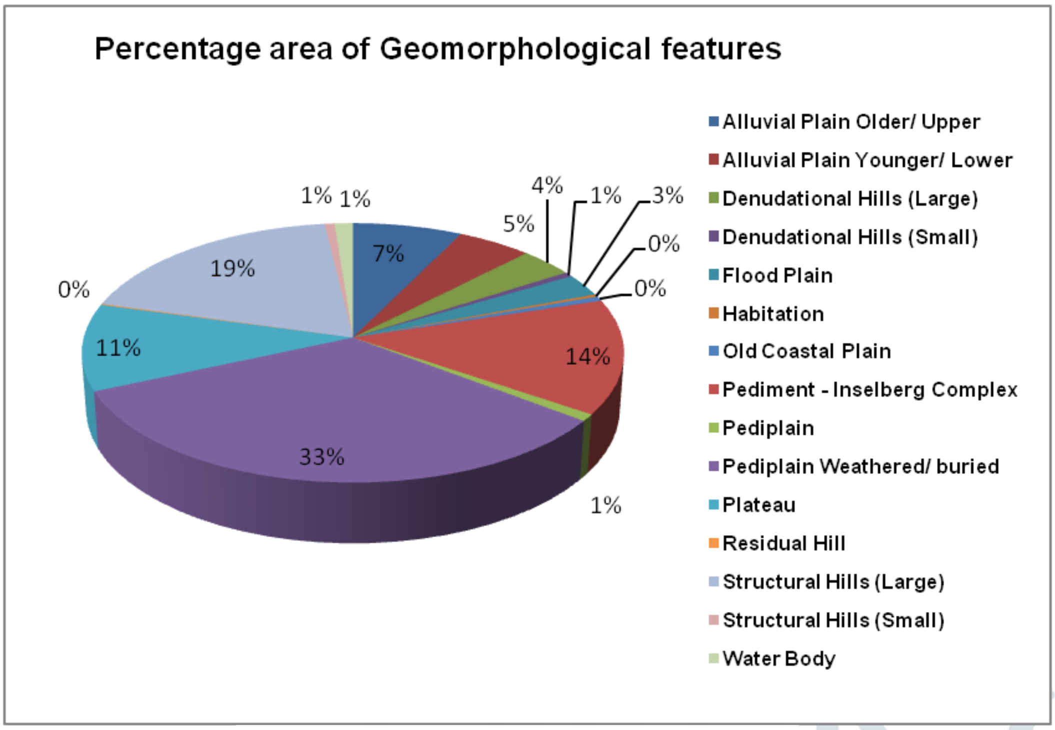

Fig.4 .1 Geomorphological units in percentge

Lineament density

Lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault, ridge, dyke, etc. which is identified from the satellite imagery by their relatively linear alignments. Lineament density of an area has a major role for the groundwater potential. Higher lineament density is good for groundwater potential zones (Haridas et al., 1998). In hard rock terrain lineaments and fractures act as principal conduits in movement and storage of groundwater. Most of the lineaments are aligned in North East to South West direction. The lineament density is shown in Fig.5.

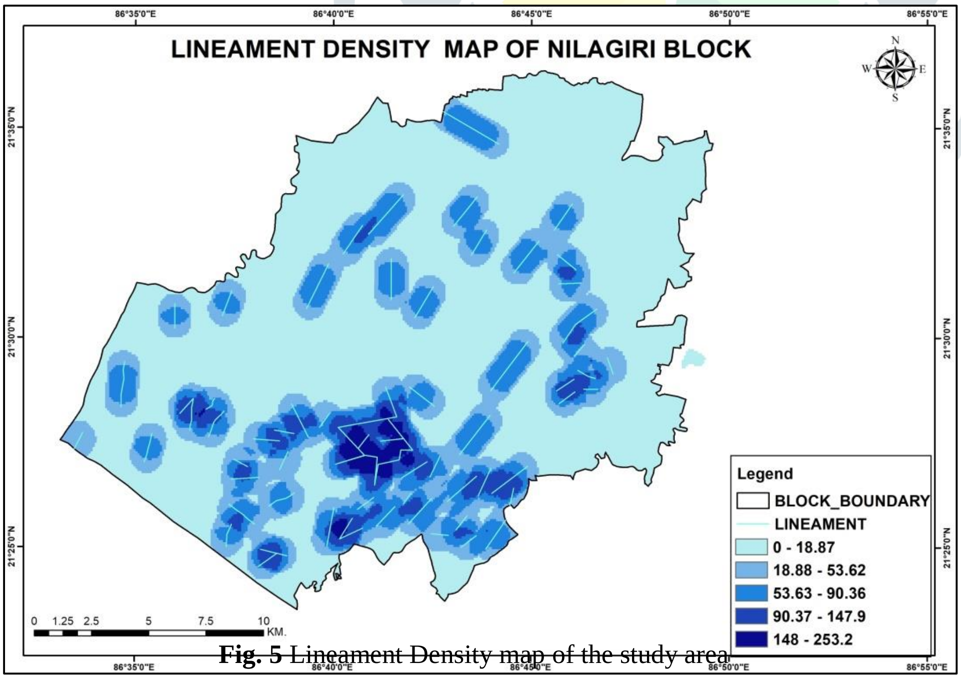

Fig. 5 Lineament Density map of the study area

Drainage Density

Usually drainage density is the quantity of the total length of streams of all the orders per unit area. The drainage density is inversely proportional to the permeability. The non-permeable rock conversely tends to be concentrated in surface runoff. Drainage density of the study area is calculated using GIS tools. The drainage pattern in the study area is mostly dendritic type. Most of the dendritic drainage patterns are found in South-east portion of the study area as streams are flowing over hard rock like granites. The drainage pattern map is shown in Fig.6

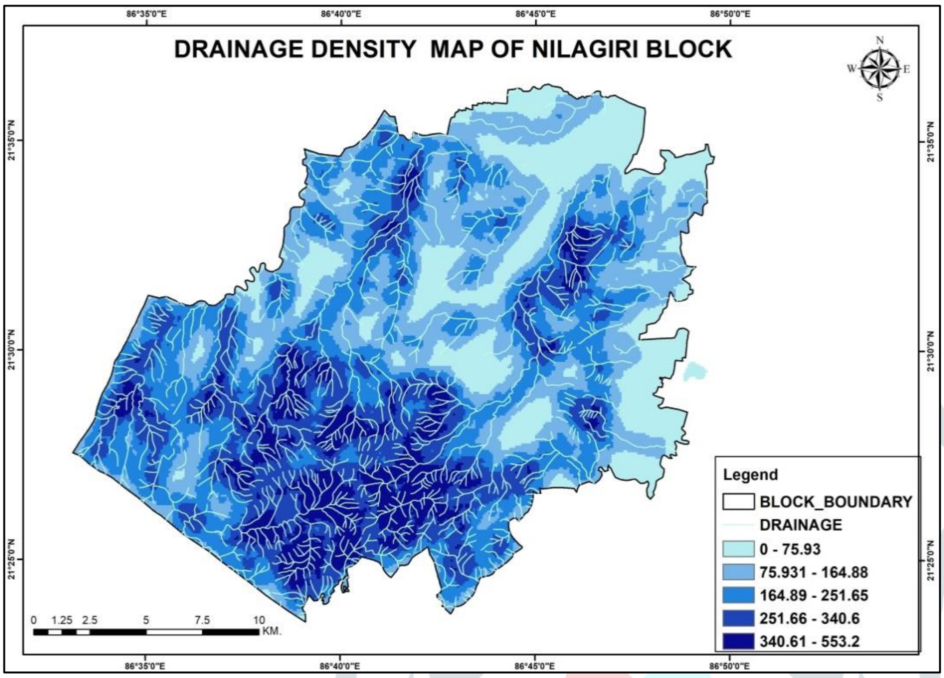

Fig. 6 Drainage and Drainage Density map of the study area

Slope

The term slope is a common geomorphic expression referring to some area of the land surface which is inclined from the horizontal. Thus, the slope may be designated as mountain slope, hill slope, and valley side slope. The slope is one of the major factors which influences on groundwater potential. From the slope of the study area, we found that the most of the steep slope is in the southeast part of the Nilagiri block. The study area is divided into four classes on the basis of slope. The areas which come under 0 degree to 3 degree is designated as very low, similarly 3 degree to 9 degree is low, 9 degree to 17 degree highly moderate, > 52 degree is very high .So the ground water potential will be more in the areas of low slope to very low slope where as the ground water potential will be comparatively less in the areas of higher slope. The slope map is shown in Fig.7

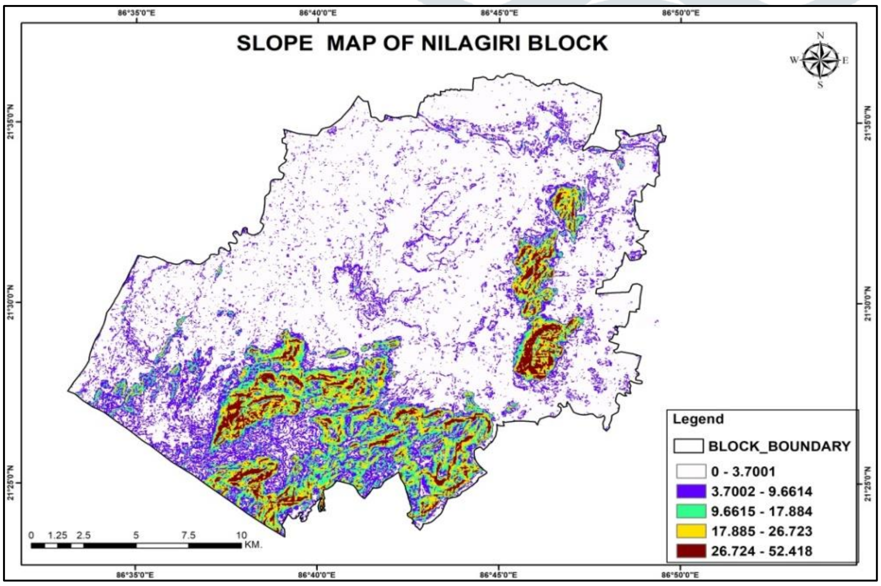

Fig. 7 Slope map of the study area

Soil

Soil is a one of the important factor for the delineating ground water potential zone. The soil acts as a natural surface of filter and penetration for water into an aquifer system and directly related to rates of penetration, percolation and permeability .The movement and penetration of surface water into ground is based on the porosity and permeability of soil. The result of soil classification found that, the study area has six types of soils such as, clay, clay loam, sandy clay, sandy loam, sand, lateritic soil. The soil map of the study area is shown in Fig. 8.

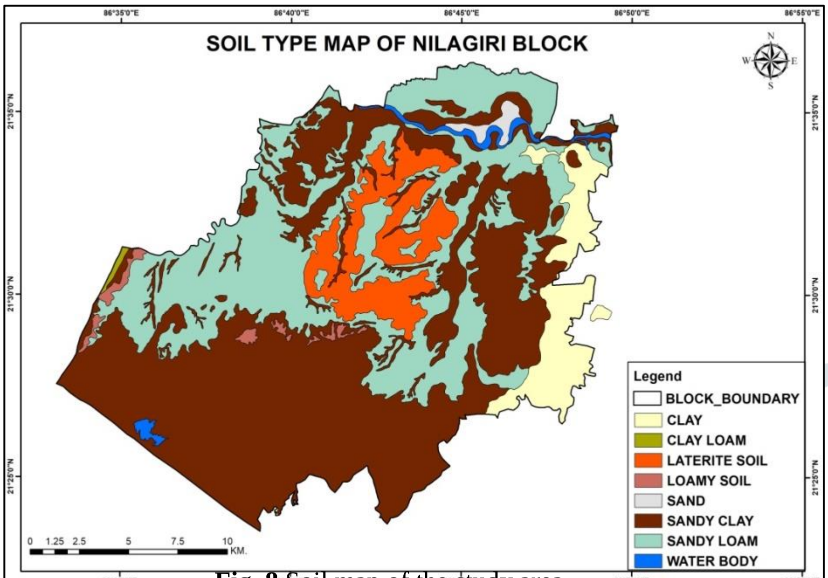

Fig. 8 Soil map of the study area

Land Use land Cover

Land use/land cover map was prepared using Liss-III image Carto Sat remote sensing data. The data was digitally classified in GIS using supervised classification technique. The parallelepiped supervised classification technique was applied to extract different types of thematic layers. The study area has five major land use classes i.e forest, agriculture land, waste land, settlement and water bodies .The agricultural land covers the highest percentage of area 43.39%,and water bodies covers 2%,where as forest covers 32% of area. The weights were assigned according to influence on groundwater occurrence. Water bodies comes under good categories and lands which are not useful in terms of ground water occurrence classified as wasteland and built up land is categorized as poor for groundwater prospects, agricultural land is categorized as moderate for groundwater occurrence, holding and recharge. The land use Land Cover map is shown in Fig.9.

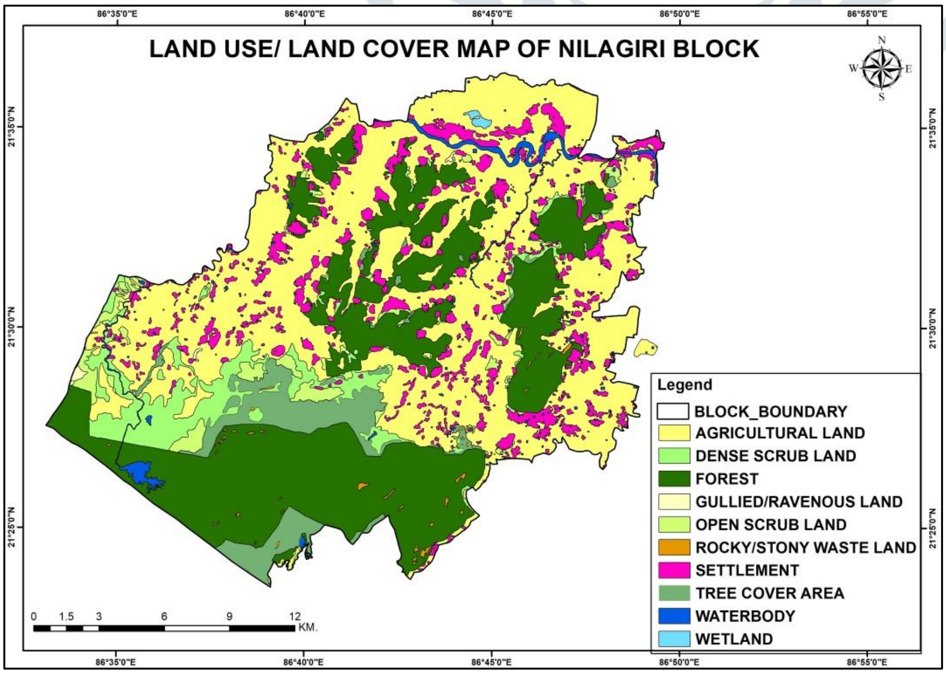

Fig. 9 Land use / Land cover map of the study area

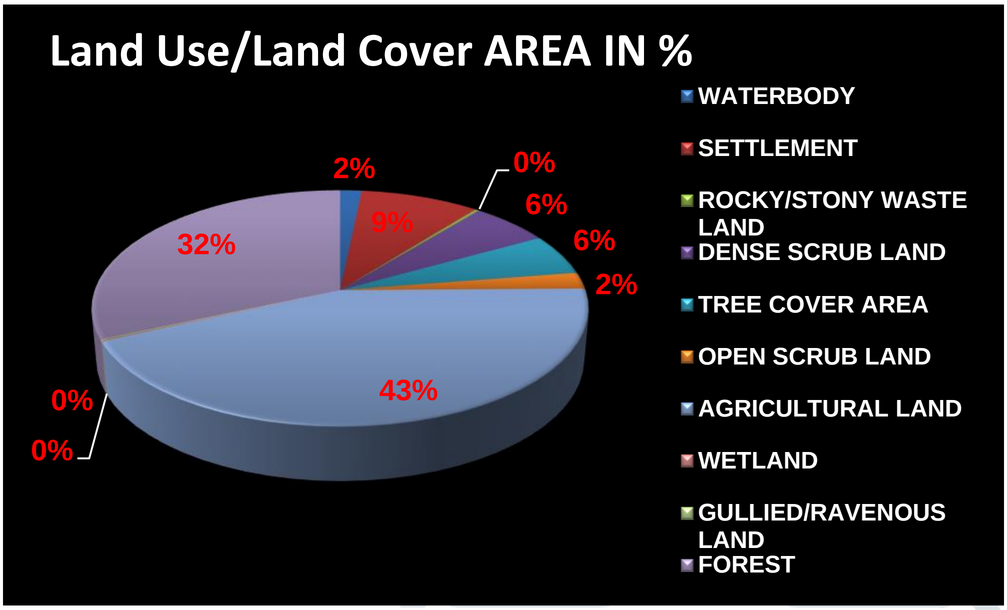

Fig. 9.1 Different units of Land use / Land cover in areal percentage

Weight assignment and Geospatial modeling

Depending on the groundwater potentiality suitable weights were assigned to the seven themes according to their hydrogeological importance in groundwater occurrence in the study area. The normalized weights of the individual themes and their different features were obtained through the Saaty's analytical hierarchy process (AHP). The weights assigned to different themes are presented in Table 1. After deriving the normal weights of all the thematic maps are converted into raster format and superimposed by weighted overlay method and all the thematic layers were integrated with one another using spatial analysis of GIS software to delineate groundwater potential zones in the study area. The final integrated layer was divided into four equal classes, i.e. 'Very Good', 'Good' 'Moderate', and ' Poor' in order to delineate groundwater potential zones. The groundwater potential map is shown in Fig. 10.

Table 1: Ranks assigned to different parameters used for overlay

Sl No	Parameters	Classes	Feature score	Map Weight
1	Geomorphology	Denudational Hills (Large) Denudational Hills (Small) Habitation Intermontane valley/ Structural Valley (Small) Pediment/ Valley Floor Pediplain Plateau Shallow weathered/ shallow buried Pediplain Structural Hills (Large) Valley Fill/ filled-in valley Water Body	1 1 1 8 8 2 7 2 6 6 2 8 10	25
2	Slope classes	0 to 4 4 to 11 18to 21 >21	8 6 3 1	15

3	Drainage density (Km/Km^2)	0-93 93-186 186-280 280-373 373-467	9 7 6 4 3	10
4	Lineament density (Km/Km^2)	0 - 0.9 0.9 - 1.9 1.9-2.9 2.9-3.9	9 8 6 3	10
5	Land use /land cover	Agriculture Land Built up land Forest land Water body Waste land	8 2 6 9 3	15
6	Geology	Granite Granite Gness Migmatite Augen Gness	1 1 2 1	10
7	Soil	Clay Clay loam Sand Sandy clay Sandy loam	1 2 8 3 2	15

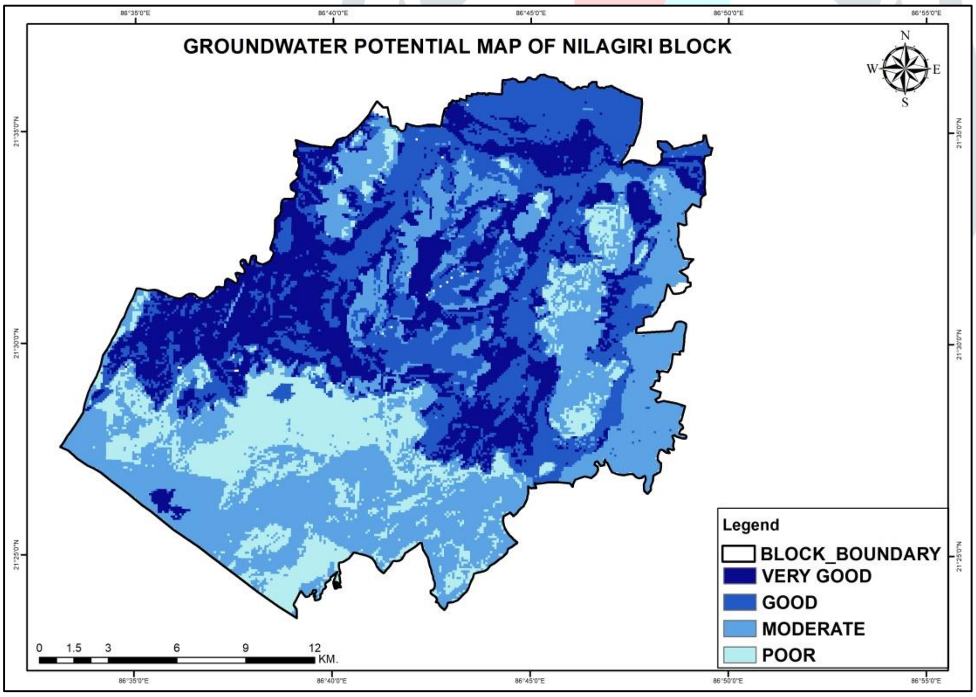

Fig. 10 Ground water prospect zone map of Nilagiri block

IV.CONCLUSIONS

Delineation of the groundwater potential zones in Nilagiri block of Balasore district using Remote sensing and GIS techniques is found efficient to minimize the time, it enables quick decision-making for sustainable water resource management. Satellite imageries, topographic maps and conventional data were used to prepare the thematic layers of lithology map, lineament density map, drainage density map, slope map, soil map, land-use land cover map. The various thematic layers are assigned proper weightage and then integrated in the GIS tools to prepare the groundwater potential zone map of the study area. According to the groundwater potential zone map, the block is categorized into four different zones, which are ‘Very Good’, ‘Good’, ‘Moderate’, and ‘Poor ’. This study indicates that mostly the western portion of the Nilagiri block is characterized by ‘Very Good’ groundwater potential zone where as the central and northern portion are characterized by ‘Good’ and southern portion comes under ‘Moderate’ to ‘Poor’ category for ground water potential. Thus, the study has clearly indicated that the Remote Sensing and GIS can be used in the demarcation of the different ground water potential zones in a non uniform terrain condition.

ACKNOWLEDGEMENT

The Authors are grateful to do this research work to North Orissa University and Head of the Department of Geology of M.P.C Autonomous college.The authors are also very much thankful to Mr. Debabrta Nandi, Asst.Prof. Department of Remonte Sensing and GIS, North Orissa University, Baripada for providing all types support to do this research work.

Reference

1. Acharya T · Kumbhakar S · Prasad R· Mondal S and Biswas.A (2017) Delineation of potential groundwater recharge zones in the coastal area of north-eastern India.

2. Burrough PA 1986. Principles of Geographical Information Systems for land resources assessment. Clarendon Press, Oxford.

3. Chowdhury A, Jha MK, Chowdary VM, Mal BC (2009), Integrated remote sensing and GIS-based approach for assessing groundwater potential in West Medinipur district,West Bengal, India. IntJ Remote Sens 30(1),pp.231–250

4. Elango, L., Suresh Kumar, S., & Rajmohan, N. (2003). Hydrochemical studies of groundwater in Chengalpet region, South India. Indian Journal of Environmental Protection, 23(6), 624–632.

5. Haridas, V.R., Aravindan, S., Girish, G., 1998. Remote sensingand its applications for groundwater favourable areaidentification. Quarterly Journal of GARC 6, 18-22

6. Jaiswal RK, Mukherjee S, Krishnamurthy J, Saxena R (2003), Role of remote sensing and GIS techniques for generation of groundwater prospect zones towards rural development – an approach. Int J Remote Sens 24(5),pp.993–1008.

7. Jha MK, Chowdary VM, Chowdhury A (2010) Groundwater assessment in Salboni Block, West Bengal (India) using remote sensing, geographical information system and multi-criteria decision analysis techniques. Hydrogeol J 18(7):1713–1728

8. Nandi, D., Sahu, P.C. and Goswami, S. (2017)Hydrogeomorphological Study in Bamanghaty Subdivision of Mayurbhanj District, Odisha an Integrated Remote Sensing and GIS Approach. International Journal of Geosciences , 8, 1361-1373.https://doi.org/10.4236/ijg.2017.811079

9. Nandi.D, Kant J., Sahu C.K.(2015), Integrated approach using Remote Sensing and GIS for hydrogeology of Moroda Block in Mayurbhanj District, Odisha, India, International Journal of Conservation Science, 6 (3), pp. 383-390

10. Nandi.D, Mishra .S.R.,(2014), Groundwater quality mapping by using geographic information system (GIS): A case study of Baripada city, Odisha, India, International Journal of Conservation Science, 5 (1), pp. 79-84

11. Sahu.P.C. (2017), groundwater resource conservation and Augmentation in hard rock terrain: an integrated Geological and geo-spatial approach international journal Of conservation science Volume 8, Issue 1, 145-156

12. Sander P, Chesley MM, Minor TB (1996) Groundwater assessment using remote sensing and GIS in a rural groundwater project in Ghana: lessons learned. Hydrogeol J 4(3),pp.40–49.

13. Saraf AK, Choudhury PR (1998) Integrated remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. Int J Remote Sens 19(10):1825–1841.

14. Subba Rao, N., & John Devada, D. (2003). Flouride incidence in ground water in an area of peninsular India. Environmental Geology, 45, 243–251.