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ASSESSMENT AND MANAGEMENT OF GROUNDWATER RESOURCES FOR SUSTAINABLE DEVELOPMENT OF PART OF BAGHAIN WATERSHED AREA USING GEO-INFORMATICS

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ABSTRACT

Geo-informatics is a potential tools for facilitating the generation and use of thematic information has been applied to assessment and management of groundwater resources of part of Baghain watershed of Majhagawan block, Satna District Madhya Pradesh India. The sources of groundwater is limited and use of groundwater increasing day to day to meet the needs of the domestic, agricultural and other uses. The role of various parameters namely drainage, lineament, lithology, geomorphology, soil, LULC have been emphasized for delineation of groundwater resources. WV02 imagery and part of 63C/12 and 63C/16 topographic map along with field survey have been used as the data source. Every citizen has full right to use water but there is no right to own water. Still don't know why people use it arbitrarily as owner. Appropriate management plans are very essential to control the water crisis. Preference should be given to wells dug in some areas. Study area is categorized into five different zones, namely covered very good area 27.98 Ha, good 5.80 Ha, Moderate 2.94 Ha, poor 12.87 Ha, and very poor 5.77 Ha.

KEYWORDS: Drainage, Lineament, Lithology, LULC, Groundwater, R S & GIS.

1. INTRODUCTION

India is a country of diversity with tropical climate. Where in the last few decades, there has been an unprecedented change in the climate, for which we ourselves are responsible. Knowing that the sources of water are fixed, yet we are not managing it properly. If this situation continues continuously, then the day is not far when our earth, where two-third of the water is there, will be completely waterless. Groundwater resources are an important natural resource for its use in domestic, agriculture, and industries purposes. There has been a tremendous increase in the demand for groundwater due to increase in population, advanced irrigation practices and industrial usages. Groundwater is an significant natural resource in present day, but of limited use due to frequent failures in monsoon, undependable surface water, and rapid urbanization and industrialization have created a major risk to this valuable resource (Vasu *et al*., 2017).

At present, due to the rapid growth of industrialization and the population, there is an increasing demand for fresh water, which directly affects groundwater availability. (Ahmadi et al., 2021) Water is a very priority thing for all living beings. Life is not possible without water. At this time, if there is any need of the biggest thing in the world, then it is the availability of pure drinking water. Water crisis is a big problem in the recent era, due to which water management and evaluation study is necessary. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century (Duncan, MacDougall; Digby, 2003).

Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Leblanc *et al*., 2003). In addition it is widely used to characterize the earth surface (such as lineaments, drainage patterns and lithology) as well as to examine the groundwater recharge zones (Sener et al., 2005). To understand groundwater prospects of an area, integration of different thematic layers is required. In the hard rock terrain, availability of groundwater is limited and its occurrence is essentially confined to fractures and/or weathered horizons (Krishnamurthy *et al*., 2000; Reddy & Nandini, 2011). Groundwater has become a major source of supply to the village population. So that reason assessment and management of groundwater studies are very necessary to this area. The objective of the present study is an attempt has been discuss for assessment and management of groundwater resources of part of Baghain watershed of Majhagawan block, Satna District Madhya Pradesh, Central India (Fig.1).

Several techniques have been adopted by various researchers that do not require fieldwork, e.g., the decision-tree model (Lee & Lee, 2015) principal component analysis (PCA) (Helena et al., 2000) and the logistic-regression model. Most of these methods are based on multivariate statistical techniques (Thapa *et al*., 2017) In contrast, the analytical hierarchy process (AHP) is considered to be a simple, effective, transparent, and reliable technique (Machiwal *et al*., 2011).

Study Area

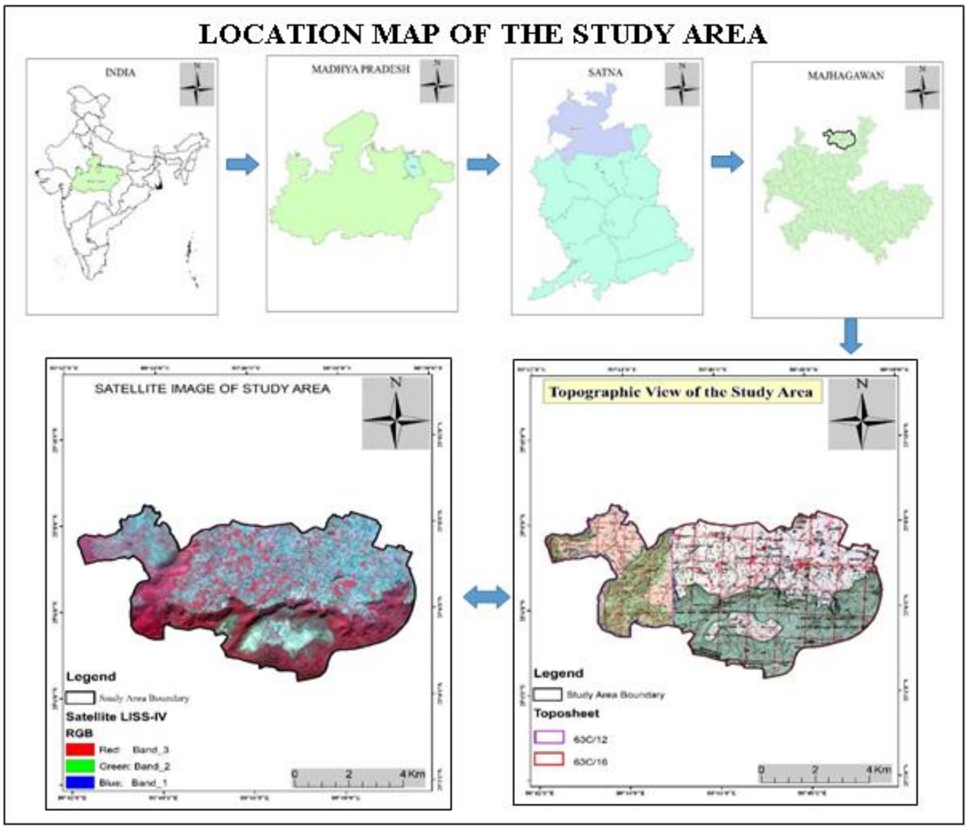

Figure 1: Location Map of the Study Area.

The study area located between 25°01'30"N 25°12'00"Nlatitude and 80°42'00"E 25°7'15.642"N 80°50'00"E longitude (approx.). Satna, also known as the 'Land of Red Soil', is well known for its culture values. The base of this triangle is marked by river Ajoy separating the boundary of Satna with Satna district. On the East and north, Satna district as per agro-climatic classification with the majority of soil being Kaimur Sandstone and Rewa sandstone content.

2. MATERIALS AND METHODS

Indian Remote Sensing satellite (IRS) P-6 LISS-4 MX data with spatial resolution of 5.8 meter is used to period of November 2017. Resourcersat-2, LISS-4 MX data of November

2017 period, in FCC form, that is, standard combination of wavelength bands 2 (0.52–0.59 µm), 3(0.62–0.68µm) and 4 (0.77–0.86 µm) and also the shortwave infrared (SWIR) have been used for mapping and preparation of maps and inventory data sheets. Elevation information is obtained from Shuttle Radar Terrain Mapping Mission (SRTM) DEM. The methodology adopted for the present study is shown in (Fig 2). The base map of Satna district was prepared based on Survey of India topographic maps (63-C/12, 63-C/16) shown in (Fig 1) on a 1:50,000 scale. Various thematic maps (Drainage, Lineament, Slope, Soil, Geology, Land use Land cover, Geomorphology) were prepared and integrated all in Arc GIS. By assigning weightage to each theme a final map was prepared having different categories such as (i) Very Good (ii) Good (iii) Moderate (iv) Poor and (v) Very Poor. The drainage network for the study area was scanned from Survey of India (SOI) toposheets and digitized in ArcGIS 10.4 platform. The slope map was prepared from SRTM DEM data in ArcGIS 10.4 Spatial Analyst module.

Satellite images from IRS-P6, LISS-IV sensor, on a scale of 1:50,000 (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 44 North) have been used for delineation of thematic layers such as land-use, lithology, lineament, and soil types. These thematic layers were converted into a raster format (5.8m resolution) before they were brought into GIS environment. The groundwater potential zones were obtained by overlaying all the thematic maps in terms of weighted overlay methods using the spatial analysis tool in Arc GIS 10.4. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned according to the multi influencing factor (MIF) of that particular feature on the hydro-geological environment of the study area (Shaban *et al*., 2006).

Flowchart for groundwater potential using RS, GIS

The methodology proposed in this study to identify and delineate groundwater potential zones using RS and GIS techniques is illustrated in Fig.2. The selected six thematic maps were integrated in the GIS environment to generate.

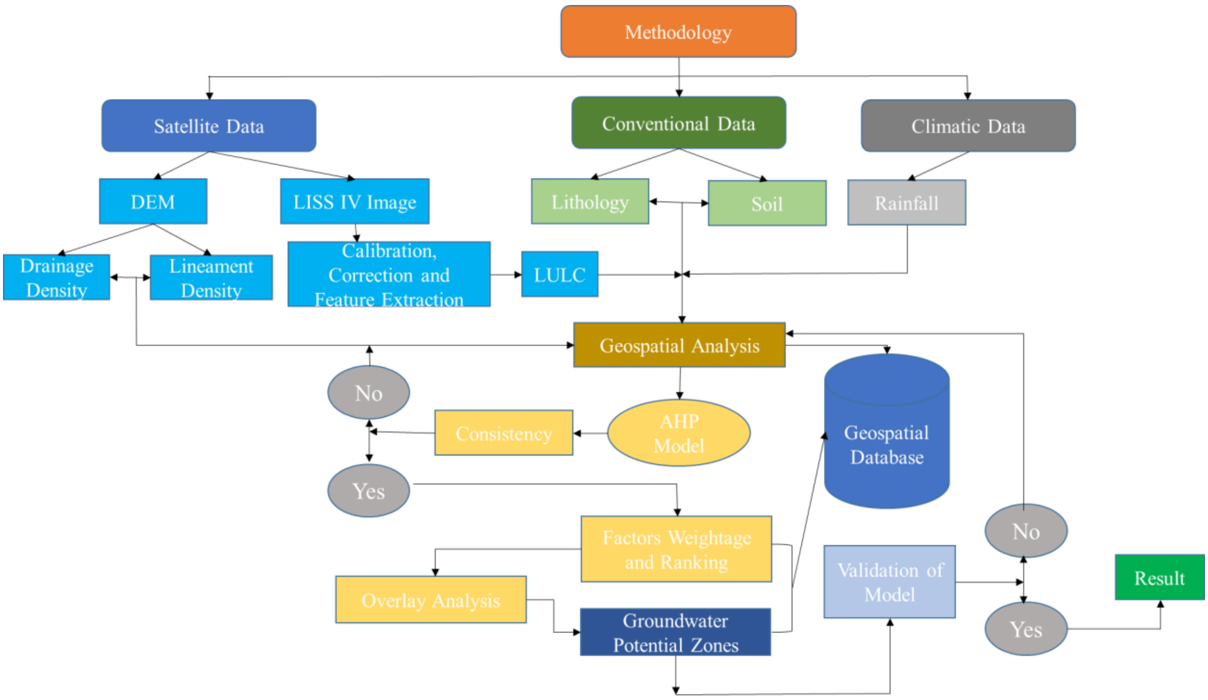

Figure 2: Flowchart of Groundwater Potential Zone Mapping.

3. Analysis

There are mainly seven factors we analysed in this study which are below

1. Drainage Density
2. Lineament Density
3. Slope
4. Soil
5. Lithology
6. Land Use Land Cover
7. Geomorphology

3.1 Drainage Density

Drainage density Drainage density is one of the important parameter in the determination of ground water recharge potential. High drainage density in an area reflects high runoff and low infiltration whereas low drainage density may result in less runoff and high infiltration (Maniar *et al*., 2019). Drainage density map of the area was prepared using DEM and classified into five classes very low, low, medium, high and very high. The drainage density was calculated using following formula:

Drainage Density = $(\Sigma Li) / A$; in (km/ km^2)

Where, Li is the total length of drainage of all stream order in km and A is area of the study area in km^2.

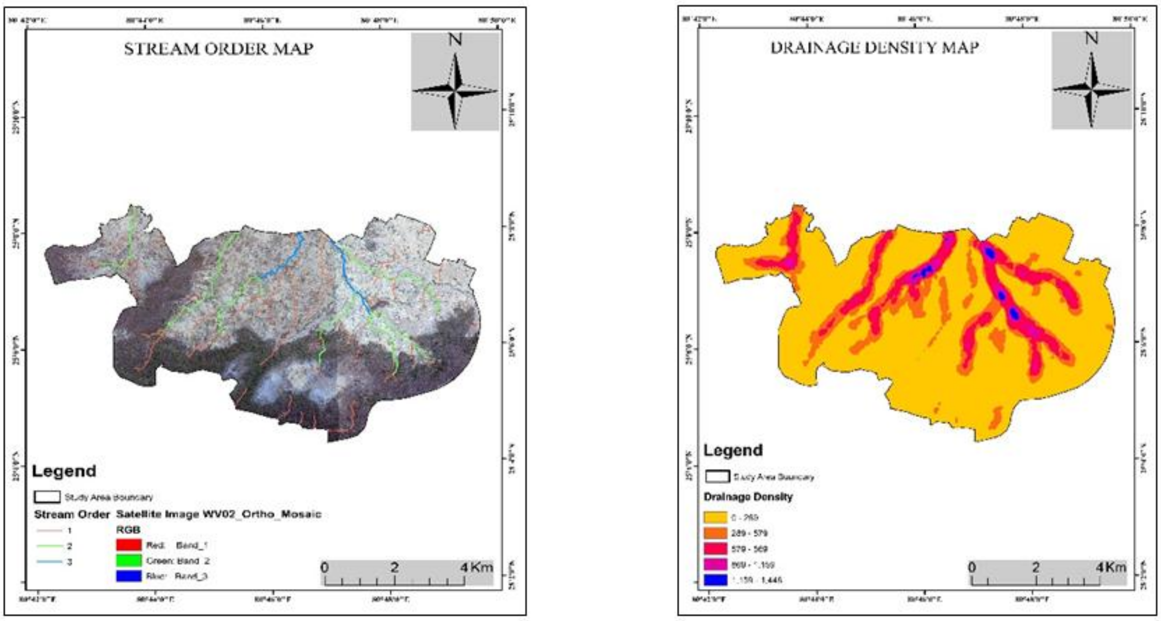

Figure 3: Stream order and Drainage Density (per km) of study area.

3.2 Lineament Density

Lineament Density Lineament map was prepared from the Landsat image in conjunction with the published geological map of the area. Lineaments include major joints, shears, faults and dykes traversing the area. (Maniar *et al*., 2019). These features act as secondary permeability zones in otherwise less impermeable basalt. However, dykes may also act ground water barrier in some cases. Lineament density was calculated using following formula:

Lineament Density = $(\Sigma L) / A$; in (km/km^2)

Where, L is the total length of the lineaments in km and A is area of the study area in km^2.

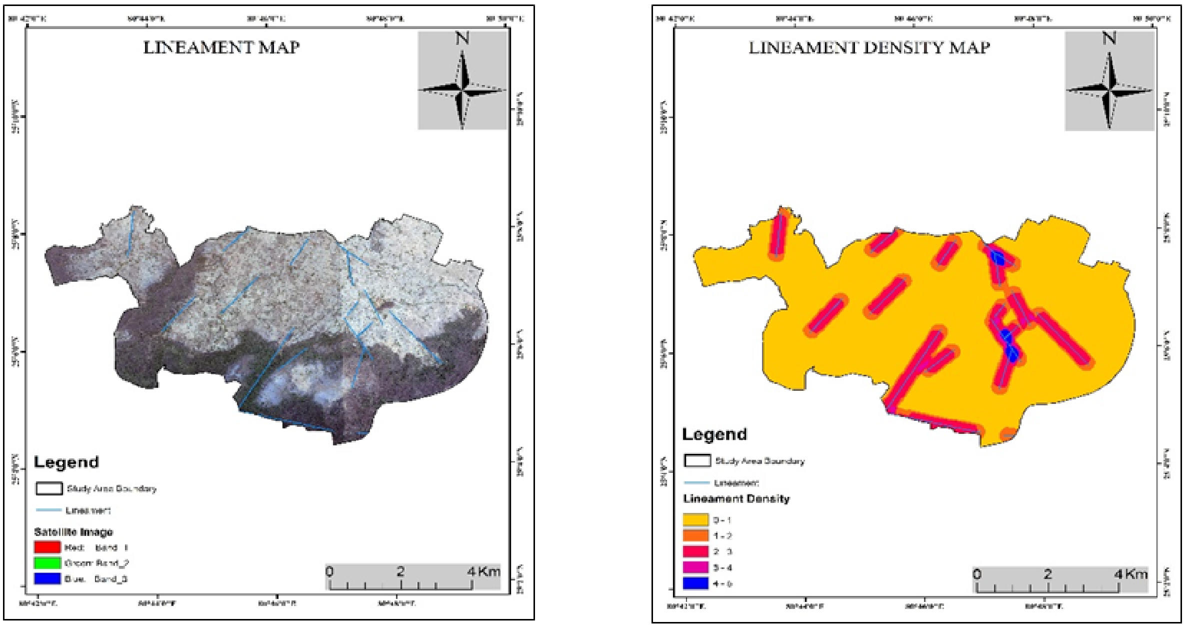

Figure 4: Lineament and Lineament Density (per km) of study area.

3.3 Slope

Slope The slope of ground surface mainly determines the runoff and infiltration in the area. Gentle sloping surface will have greater potentiality of infiltration and less runoff. Higher value of ground slope represents steeper terrain, whereas lower slope values indicate flatter terrain (Pankaj Kumar *et al*. 2016). In the present study percentage slope map was prepared from ASTER DEM. The percentage slope map was classified into seven classes (Fig.5).

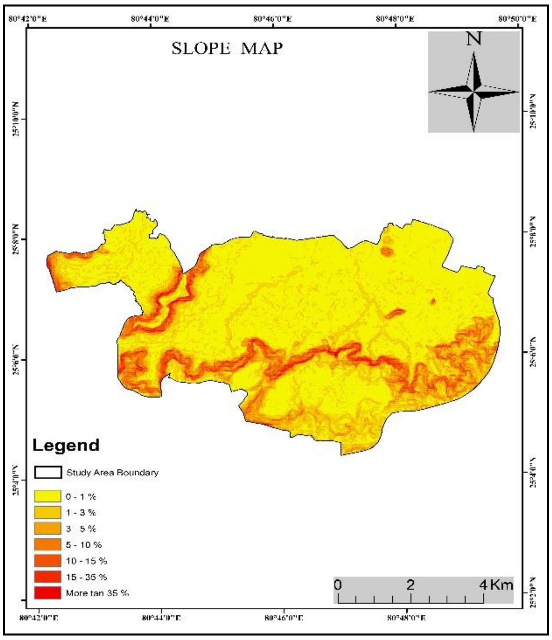

Figure 5: Slop of study area.

3.4 Soil

Soil is an important factor for delineating the groundwater potential zones. The analysis of the soil type reveals that the study area is predominantly covered by red gravelly soil (in deeply buried pediments and moderately buried pediments) with Sandy Clay Loam soil and Sandy Loam soil (in the flood plains) at some places as shown in Surface layer is dark brown fine sandy loam. Subsurface layer is pale brown fine sandy loam. Subsoil is red clay loam and sandy clay loam (Maniar *et al*., 2019).

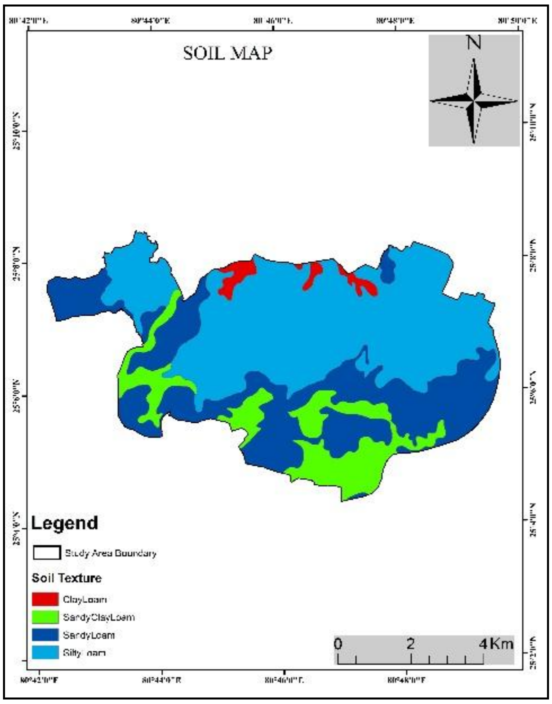

Figure 6: Soil of study area.

Soil play important role in the infiltration of surface water to recharge the ground water in the study area. Impervious clayey soil results in more runoff, respective to others on the contrary sandy and gravelly soil results in more infiltration. Map was classified in four classes Clay loam, Sandy clay loam, Sandy loan and Silty loam.

3.5 Geology

The Vindhyan Super group has been lithostatigraphically subdivided into four groups, in stratigraphic order these are: the Semri Group, the Kaimur Group, the Rewa Group and the Bhander Group. The Vindhyan sediments show much facies variation and both horizontal and vertical gradation in lithology. Thus, areas show different lithostratigraphic succession. This aspect is well demonstrated when a comparision of lithostratigraphic (Kumar *et al*., 2018).

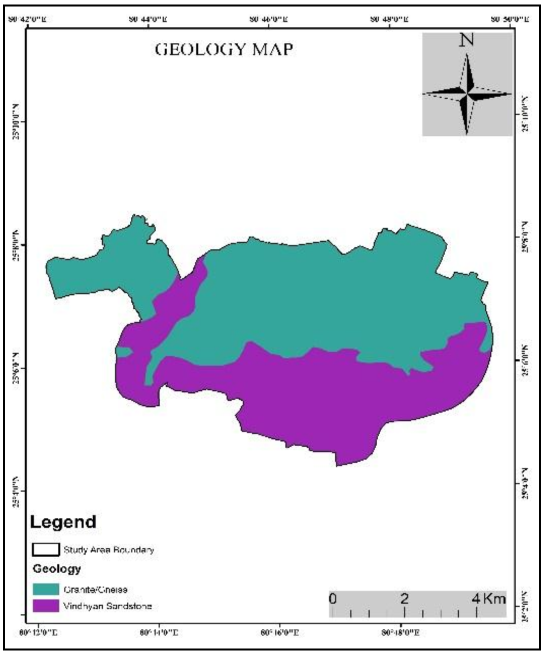

Figure 7: Geology of study area.

A few minor lineaments are also oriented in NE-SW and NW-SE directions. Primary porosity of basalt is almost negligible. Shears, joints and lineaments form secondary porosity in the rock mass helping infiltration of surface water and movement of ground water. (Maniar *et al*., 2019). The entire area is occupied by rocks of Vindhyan Supergroup. It comprises of sediments of Argillaceous and Arenaceous facies represented by Sand stone and Shale. Alluvium of recent to subrecent period is met within the area. The main lithounits which are: Rewa Sand stone of Rewa group and Ganurgarh Shale of Bhander group. Geology of the area is dominated by sandstone and shale formations of Bhander Group and Rewa group of Upper Vindhyan Supergroup.

3.6 Land Use Land Cover

Infiltration of rain fall depends on the land use pattern of the study area. Land use map was prepared with the help of Google Earth, LISS IV and WV 02 images. It is very well known that area covered by vegetation increases infiltration, whereas roads and concrete pavement and buildings reduces infiltration. In the study area LU/LC map was prepared and classified into five classes namely Agriculture, Built up, Forest, Wastelands and water bodies (Fig.8). Land use Land cover mapping is one of the important applications of remote sensing. Land use plays a significant role in the development of groundwater resources. Remote sensing provides excellent information with regard to spatial distribution of vegetation type and land use in less time and low cost in comparison to conventional data (Waikar & Nilawar, 2014).

The study area shows that major portion in land use is covered by Agriculture land 28.75 KM^2, Built up 1.65 KM^2, forest land 21.33 KM^2, wasteland 4.42 KM^2, water bodies 1.18 KM^2.

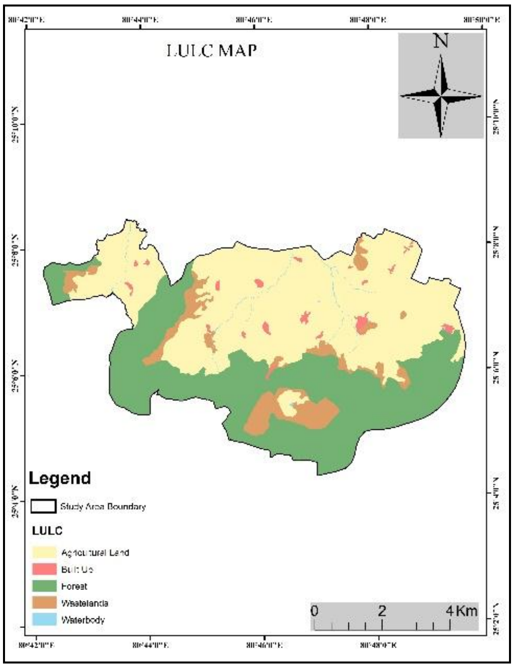

Figure 8: Land Use Land Cover of study area

3.7 Geomorphology

Geomorphology Map Geomorphologic map depicts important geomorphic units, landforms and underlying geology so as to provide an understanding of the processes, materials/lithology, structures, and geologic controls relating to groundwater occurrence as well as to groundwater prospects. Geomorphologically, the study area consists of inselberg 0.27 KM^2, Mesa 2.67 KM^2, pediment 5.77 KM^2, Scarp 5.80 KM^2 Low Dissected Lower Plateau 12.87 KM^2, Pediplain 27.98 KM^2, as shown in Fig. 5. The study area has buried pediment mainly in east and southeast portions encompassing an area. It is moderate to good for groundwater occurrence.

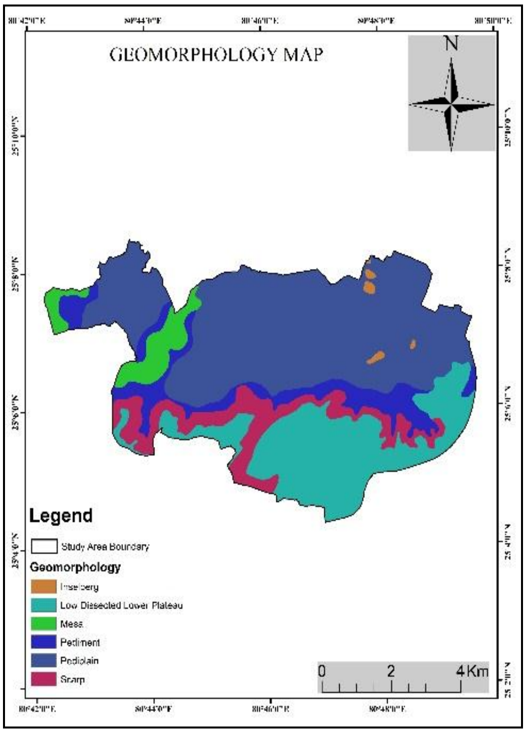

Figure 9: Geomorphology of study area.

4. RESULT AND DISCUSSION

The assessment and management studies of groundwater, the geological and hydrogeological factors are of great importance. The assessment is primary demand of this era of water conservation point of view. (Singhal & Gupta, 1999). The groundwater management implies the extraction of maximum quality of water with a minimum cost. For the measurement of a groundwater balance study, following data are required in the particular areas:

i. Infiltration patterns	ii. Land use patterns	iii. River data
iv. Pond data, Canal data	v. Water table data	vi. Groundwater draft

4.1 Groundwater Recharge

The total draft from all sources as well as total recharges from various sources are computed for correct appraisal of groundwater resources of an area. The important sources of recharging the groundwater as suggested by CGWB are as follows:

i. Rainfall recharge	ii. Irrigation water applied by surface water irrigation
iii. Seepage from canals	iv. Irrigation water applied by groundwater sources
v. Tanks and ponds	vi. Water conservation structures.

Every year approximately 25% to 30% rains falling on the surface, goes underground to recharge the dynamic shallower part of groundwater (Singhal & Gupta, 1999).

4.1.1 Groundwater Balanced Method

During the last two decades, exploitation of groundwater resources has considerably increased. Major part of this precious resource is being taken by the agriculture sector. In almost each form a deep bored wells has been dug, because of these bore wells a large quantity of groundwater is being extracted. This is leading to an imbalance between the recharge and discharge condition. Therefore, estimation of the discharge and recharge are the two main components in a groundwater balance study of a basin. More than 50% of irrigation water in agriculture comes from ground water sources. This indicates the importance of the role of groundwater in the nation's economy and food production. The wide spread and uncontrolled extraction of groundwater has resulted in the formation of several over-exploited zones, where the level of groundwater utilization exceeds 90% (Singhal & Gupta, 1999).

4.1.2 The Soil-Water Method

This method was suggested by Thornthwaite and Mathew (1955). It is suitable for area where rainfall infiltration through the soil uniform cover. For correct estimation of rainfall recharge, database on land cover, soil type, crops, climate etc. should be available. In the area of study, the above data were not readily available also the infiltration is not uniform. Hence, it is not preferred (Sharma & Hughes, 1985) suggested that 50% of the recharge is through preferred pathways bypassing the soil profile.

4.1.3 The Rainfall Infiltration Method

It is well known that when rain water falls on the surface of soils or rocks, a part of it seeps into the soils or rocks through pores of different types. The movement of water through the soil surface is known as infiltration. The infiltration process is affected by number of factors such as texture, structure, permeability, drainage etc. Infiltration of rainwater takes place in almost all types of terrains; therefore, rainfall infiltration method is widely used for estimating rainfall recharge. However, this method gives satisfactory results only when a suitable infiltration factor is determined (GWREC 1997) proposed a range of infiltration factor for different types of terrains.

4.2 Verifying Groundwater Potential Zone Map

The groundwater potential zones for the study area were generated through the integration of various thematic maps viz., drainage, lineament, slope, lithology, soil, land-use land cover and geomorphology using remote sensing and GIS techniques. The demarcation of groundwater potential zones for the study area was made by grouping of the interpreted layers through weighted multi influencing factor and finally assigned different potential zones. The groundwater potential zone of this study area can be divided into four grades, namely very good, good, Moderate, poor, and very poor. The groundwater potential map demonstrates that the excellent groundwater potential zone is concentrated in the north-eastern region of the study area.

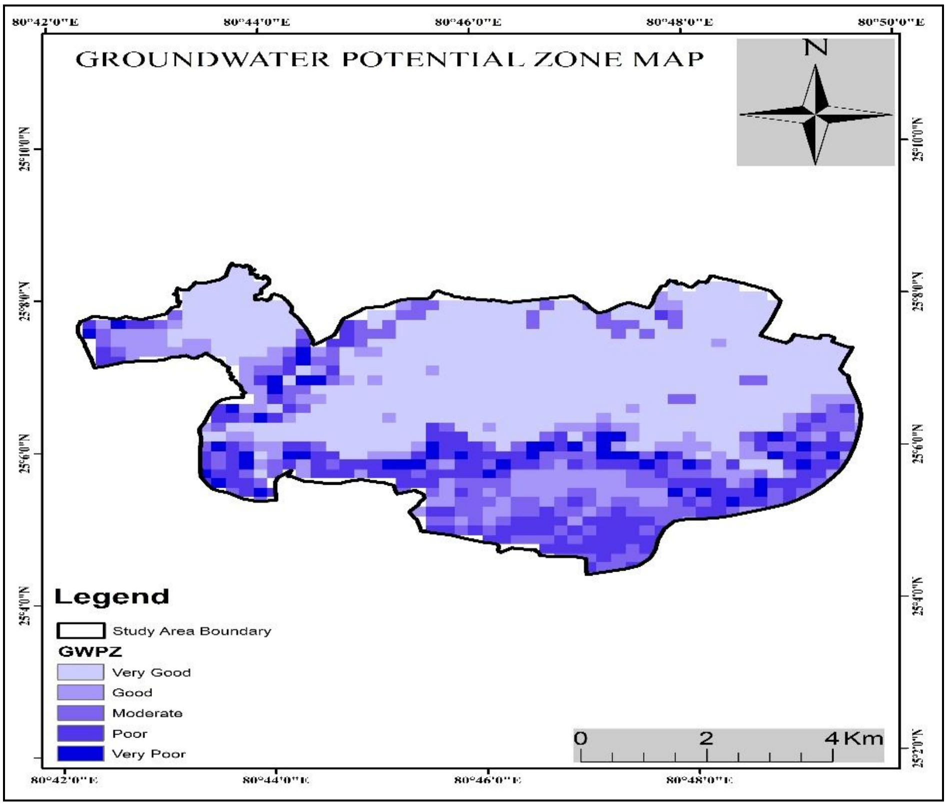

Figure 10: Groundwater Potential Zone of study area.

5. CONCLUSIONS

Satellite imageries, topographic maps and conventional data were used to prepare the various thematic layers are integrated in the GIS environment to prepare the groundwater potential zone map of the study area. According to the groundwater potential zone map, study area is categorized into five different zones, namely covered very good area 27.98 Ha, good 5.80 Ha, Moderate 2.94 Ha, poor 12.87 Ha, and very poor 5.77 Ha. The results of the present study can serve as guidelines for planning future artificial recharge projects in the study area in order to ensure sustainable groundwater utilization.

The groundwater potential map demonstrates that the excellent groundwater potential zone is concentrated in the north and north-eastern region of the study area. This indicates that, soil type and slope plays a vital role in groundwater augmentation. There are not enough wells, particularly to the southeast of the site, to properly assess the extent and movement of contaminants.

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7. REFERENCES

1. Ahmadi, H., Kaya, O. A., Babadagi, E., Savas, T., & Pekkan, E. *GIS-Based Groundwater Potentiality Mapping Using AHP and FR Models in Central Antalya, Turkey*, 2021; 1–15.
2. Duncan, MacDougall; Digby, S. *The Challenge of Slums: Global Report on Human Settlements, 2003*; *28*: 1.
3. GWREC (n.d.). *Water Resources*, 1997; 113.
4. Helena, B., Pardo, R., Vega, M., Barrado, E., Fernandez, J. M., & Fernandez, L. Temporal evolution of groundwater composition in an alluvial aquifer (Pisuerga River, Spain) by principal component analysis. *Water Research*, 2000; *34*(3): 807–816. https://doi.org/10.1016/S0043-1354(99)00225-0.
5. Krishnamurthy, J., Mani, A., Jayaraman, V., & Manivel, M. Groundwater resources development in hard rock terrain - An approach using remote sensing and GIS techniques. *ITC Journal*, 2000; *2*(3–4): 204–215. https://doi.org/10.1016/S0303-2434(00)85015-1.
6. Kumar, S., Chaurey, R., Singh, R. M., Dubey, R., & Patel, A. K. *Identification of Groundwater Potential Zone using Geoinformatics in part of Mandakini River Basin*, 2018; *3*: 33–39.
7. Leblanc, M., Leduc, C., Razack, M., Lemoalle, J., Dagorne, D., & Mofor, L. Applications of remote sensing and GIS for groundwater modelling of large semiarid areas: Example

of the Lake Chad Basin, Africa. *IAHS-AISH Publication*, 2003; *278*: 186–194.

8. Lee, S., & Lee, C. W. Application of decision-tree model to groundwater productivity-potential mapping. *Sustainability (Switzerland)*, 2015; *7*(10): 13416–13432. https://doi.org/10.3390/su71013416.
9. Machiwal, D., Jha, M. K., & Mal, B. C. Assessment of Groundwater Potential in a Semi-Arid Region of India Using Remote Sensing, GIS and MCDM Techniques. *Water Resources Management*, 2011; *25*(5): 1359–1386. https://doi.org/10.1007/s11269-010-9749-y.
10. Maniar, H. H., Bhatt, N. J., Prakash, I., & Mahmood, K. Application of Analytical Hierarchy Process (AHP) and GIS in the Evaluation of Groundwater Recharge Potential of Rajkot District, Gujarat, India. *International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)*, 2019; *5*(04): 1–11.
11. Reddy, P. S., & Nandini, N. Leachate characterization and assessment of groundwater pollution near municipal solid waste landfill site. *Nature Environment and Pollution Technology*, 2011; *10*(3): 415–418.
12. Sener, E., Davraz, A., & Ozcelik, M. An integration of GIS and remote sensing in groundwater investigations: A case study in Burdur, Turkey. *Hydrogeology Journal*, 2005; *13*(5–6): 826–834. https://doi.org/10.1007/s10040-004-0378-5.
13. Shaban, A., Khawlie, M., & Abdallah, C. Use of remote sensing and GIS to determine recharge potential zones: The case of Occidental Lebanon. *Hydrogeology Journal*, 2006; *14*(4): 433–443. https://doi.org/10.1007/s10040-005-0437-6.
14. Sharma, M. L., & Hughes, M. W. Groundwater recharge estimation using chloride, deuterium and oxygen-18 profiles in the deep coastal sands of Western Australia. *Journal of Hydrology*, 1985; *81*(1–2): 93–109. https://doi.org/10.1016/0022-1694(85)90169-6.
15. Singhal, B. B. S., & Gupta, R. P. Assessment and management of groundwater resources. *Applied Hydrogeology of Fractured Rocks*, 1999; *5*(1): 329–367. https://doi.org/10.1007/978-94-015-9208-6_17.
16. Thapa, R., Gupta, S., Guin, S., & Kaur, H. Assessment of groundwater potential zones using multi-influencing factor (MIF) and GIS: a case study from Birbhum district, West Bengal. *Applied Water Science*, 2017; *7*(7): 4117–4131. https://doi.org/10.1007/s13201-017-0571-z.
17. Vasu, D., Singh, S. K., Sahu, N., Tiwary, P., Chandran, P., Duraisami, P., Ramamurthy, V., Lalitha, M., Kalaiselvi, B., Bureau, N., Survey, S., Planning, U., & Management, N. R. Assessment of spatial variability of soil properties using geospatial techniques for farm

level nutrient management. *Published by Elsevier*. https://www.sciencedirect.com/science/article/pii/S0167198717300065, 2017.

18. Waikar, M. L., & Nilawar, A. P. *Identification of Groundwater Potential Zone using Remote Sensing and GIS Technique*, 2014; *3*(5): 12163–12174.