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Application of Remote Sensing and GIS in Ground Water Potential Zone Mapping

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ABSTRACT

The development of groundwater requires the collection of a substantial quantity of data from a range of different sources. As a consequence of this, the process of constructing a groundwater potential model for a study region involves stages that are necessary processes such as the identification and measurement of certain characteristics. As a consequence of the drought crisis, The topic of groundwater is currently receiving an increasing amount of attention as a result of the The investigation of groundwater has remained riskier despite the substantial amount of research that has been carried out and the technological advancements that have been made. This is due to the fact that there is no direct method that can assist in the observation of water that is located below the surface. The only method to determine whether or not it is present through direct or indirect evidence is to investigate the geological and surface variables. ArcGIS 10.8 was used to create all of the relevant thematic maps for this inquiry. These maps, which were produced from the datasets that were obtained, were necessary for the investigation. At the very end, each of the aforementioned subjects is subjected to additional processing and analysis in overlay, and then rankings are provided to evaluate suitable groundwater potential zones. In order to combine each of the thematic layers, the integration strategy known as weighted overlay analysis was selected as the strategy of choice. Taking this strategy requires assigning a rank and a weight to each of the many thematic levels.

Keywords: *Ground Water, Mapping, Gis And Zone*

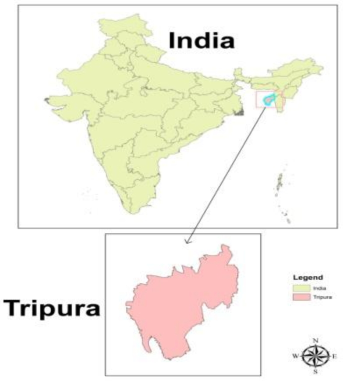
1. INTRODUCTION

Because it is necessary for the upkeep of human health, the growth of the economy, and the safeguarding of the biological diversity that already exists on the earth, groundwater is one of the natural resources that is considered to be among the most significant and significant. As a consequence of the many different inherent features that it contains, it has evolved into an extremely These regions include both urban and rural areas of nations that have already developed and those that are still in the process of developing. This is as a result of the fact that it is able to function well in a wide variety of various environments. Specifically, this is because of its adaptability. The type of water that can be found filling all of the holes that are present inside of a geological strata is the type of water that is referred to as groundwater. Not only do the water-bearing formations of the earth's crust act as conduits for the transmission of water, but they also serve as reservoirs for the storage of water in both temporary and permanent forms. These functions are provided by the water-bearing formations. Porosity is the key factor that defines whether or not a geological formation contains groundwater and the extent to which that groundwater may be utilised. Porosity is also a factor that influences how much groundwater may be used. When there is a high relief and steep slopes, runoff is enhanced, but when there are topographical depressions, infiltration is increased. Runoff is the opposite of infiltration. When contrasted with a location that has a low drainage density, a region that has a high drainage density will also have higher surface runoff. This is because of the increased number of drainage outlets. Surface water features such as rivers, ponds, and other bodies of water with comparable characteristics can sometimes have recharge zones. The rising significance of groundwater as a direct result of an expanding demand has, throughout the years, directly resulted in the development of a condition referred to as water stress. This stress is caused by a lack of available water resources. The ever-increasing need is the driving force behind its expanding significance. In light of these worrying trends, it is vital to establish a strategy that is both inexpensive and efficient with regard to the evaluation of groundwater resources and the formulation of management plans. This is necessary in order to meet the demands of the situation. The development of groundwater requires the collection of a substantial quantity of data from a range of different sources. As a direct result of this, the steps that are included in the process of developing a groundwater potential model for a study region contain operations that are required to complete, such as the identification and measurement of certain qualities.

STUDY AREA

In Tripura, the districts of West Tripura, Khowai, and Dhalai are included in the watershed that is being studied, which encompasses the entirety of the state. The watershed covers a landmass that is 1292 square kilometres in size and features surface elevations that range from 18.55 to 453 metres. The vast bulk of the available water originates from the ground, and it is extracted from the ground for use in farming and drinking by means of wells and boreholes that have been dug across the land. This region has a tropical climate that is characterised by high temperatures and high levels of humidity, with an annual average rainfall of 2063 millimetres. During the summer, temperatures average 34.2 degrees Celsius, while during the winter, the temperature drops to 22.3 degrees Celsius on average.

Figure i. Location of Tripura



2. REVIEW OF LITERATURE

Murugesan Bagyaraj and colleagues (2012) Researched groundwater at Dindigul, Kodaikanal Hill, in Tamilnadu's Western Ghats. Published in Groundwater. Using remote sensing and GIS, potentially viable groundwater extraction zones have been defined (GIS). When determining the appropriate weight factors for the various geomorphic units, one of the aspects that was taken into consideration was how well those units were able to store groundwater. Within an arid region of the Kachchh district in the state of Gujarat in India, an attempt was made by Prabir Mukherjee and his colleagues (2012) The development of thematic layers was accomplished through the use of extra data in conjunction with digital satellite images. The weighted overlay analysis that was done allowed for the creation of the possible zones. Each individual component of each thematic map has been ranked, and weights have been assigned according to the influence that each parameter has. You may see the ranks and weightings for yourself down below. A standard method for locating groundwater potential zones was developed by Deepesh Machiwal and colleagues (2010). Integrated remote sensing, geographic information systems, and multi-criteria decision making (also known as MCDM) approaches were utilised in the process of formulating the methodology. We shall examine a case study that was conducted in the Udaipur region of

Rajasthan, which is found in western India, as an illustration of the procedure. Rajasthan is located in the northwestern part of India. When we originally began coming up with ideas, one of the first things that came to mind was to employ 10 separate theme layers. After that, the AHP (analytic hierarchy process), the MCDM approach, and the eigenvector method were utilised in order to normalise the weights of the thematic layers as well as the characteristics of those layers. This was done in order to ensure that the results were accurate. In the end, a groundwater potential map was produced by combining the relevant thematic maps inside a GIS environment using a weighted linear combination approach. This was done in order to get the desired result. In order to create the map, this step needed to be taken. It was recommended by Cheng-Haw Lee and colleagues (2008) that understanding the potential zone of groundwater recharge is highly significant for the management of groundwater systems in addition to the preservation of water quality. This was said in the context of ensuring that water is of high quality. The findings of their investigation were recently presented in a paper that was published in the journal Environmental Research Letters Utilizing aerial images, geology maps, a land use database, and field verification are some of the ways in which one may evaluate the relative significance of the many elements that play a role in groundwater recharge. All of this information may be located on the internet. Through the utilisation of GIS and other remote sensing techniques, Jobin Thomas and his colleagues (2011) were able to identify the groundwater potential zone in a tropical river basin in Kerala, India. This was accomplished in 2011. Landsat ETM+ data and toposheets with a scale of 1:50,000 that were created by the Survey of India were used in order to gather data on geology, geomorphology, lineaments, slope, and land use/land cover. These types of data were collected by the Survey of India (SOI). In addition to that, a GIS platform was used in order to merge the many themes that were collected in order to provide a more comprehensive picture. Following the creation of the composite map, it was then further subdivided in accordance with the geographical variance of the groundwater potential. Because of the geographical diversity of the potential, one may reach the conclusion that geology, structures, slope, and landforms all have a role in determining where groundwater emerges. This is because of the fact that groundwater can only appear in certain places. In the Indian state of Andhra Pradesh, researchers Kamaraju et al. investigated the groundwater potential of the West Godavari region (1995). Arc Info GIS was used to conduct an analysis on the data acquired from the study region in order to establish the factors that govern the level of groundwater. This was done in order to determine the elements that regulate the level of groundwater. These aspects include the lithology, geomorphology, structural make-up, and the state of the recharge. In addition to giving an analysis of the groundwater potential, we also drew up a map that depicted three essential hydro geological conditions along with a number of other groundwater options. Utilizing this map as an important tool will be of tremendous assistance in the process of getting groundwater resources from the municipality. The benefits of this will be significant.

RESEARCH METHODOLOGY

The methodology of the study that was proposed included a number of different activities, such as the preparation of DEM maps and LULC maps, the utilisation of the ArcGIS 10.8 software, and the interpretation of the results. Using GIS and remote sensing, groundwater themed maps are created. Drainage density, contour, and stream length are shown. The digital elevation model served as the basis for the creation of slope, drainage, and elevation maps. Downloading the CRU monthly climate dataset allowed for the creation of the rainfall map, which was followed by the "netcdf" file being converted to a format that could be used. In addition, the bands were differentiated by only using bands from 2019 when creating an annual average rainfall map for the year 2019. First, a soil map was generated through the utilisation of FAO data. Next, a soil map of the study area was obtained through the utilisation of the shapefile of the study area. The following are some of the goals of the study:

1. To conduct a comprehensive review of the prior literature in order to obtain some useful information on the project.
2. To generate a soil map of the research region using the data that was acquired from the FAO website (Food and Agriculture Organization of the United Nations).
3. Using the weighted overlay function in the ArcMap GIS programme, the map of groundwater potential zones is to be created.

4. DATA ANALYSIS AND INTERPRETATION

Soil Map

The soil is one of a number of elements that have a substantial influence on the amount of precipitation that is absorbed by the ground after it has fallen. The grain structure can influence not only the rate but also the amount of water that is able to penetrate the soil. A higher quantity of groundwater is able to permeate coarse-grained porous structures than other types of porous structures. Clay and other fine-grained soils have an infiltration rate that is both slower and lower than coarser-grained soils. When it comes to the movement of groundwater and the subsequent recovery of that water, permeability and porosity are two important aspects to consider. The capacity of the region to store water is mostly determined by the different kinds of soil that are found there and the permeability of those soils. Other elements that play a role in this determination include the climate of the area. The soil data for the research region was obtained from the website www.indiaremotesensing.com using the SWAT (Soil and Water Assessment Tool) tool. This data was then utilised to produce a soil map of the region. Data obtained from the Food and Agriculture Organization of the United Nations were utilised in the creation of the map (FAO). In addition to that, the data obtained from the FAO was utilised in the process of making the map. After that, the map of the delimited research region was superimposed on the projected soil map, and in the end, the soil map that corresponded to the study area was obtained with the use of a GIS environment. It was established that the soil in the area under examination was a loam soil after the findings of the SWAT soil analysis were analysed. The relative amounts of clay, silt, and sand in the soil were determined to be 22%, 34%, and 44% respectively. According to the soil map of the study location, which can be seen in Figure xi, the whole ground beneath our feet is composed of loam. This information is readily apparent.

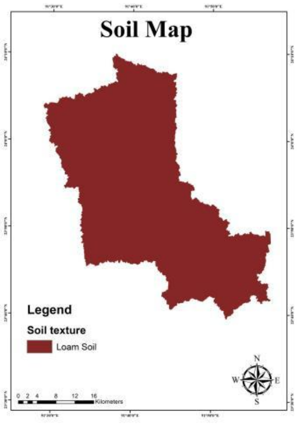


Figure ii. Soil map

4.2 Data Reclassification

- In order to do an overlay analysis, you are required to reclassify the data.
- After reclassification, the same value will be assigned to the range of pixel values, i.e.
- As example

1 - 50 (actual value of range) = 1 (New single value for range)

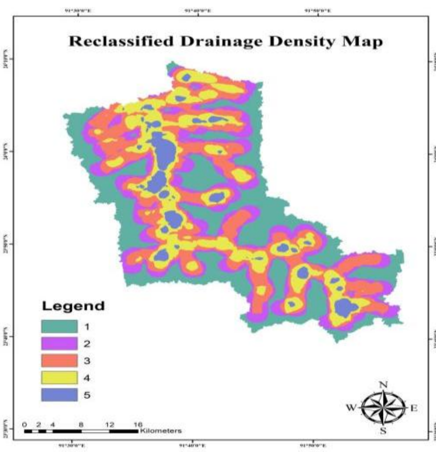
51 – 100 = 2

101 – 200 = 3

201 – 300 = 4

301 – 450 = 5 and so on

Without having access to this information, we are unable to carry out an overlay analysis for the aim of determining ground water potential zones. In order to classify the thematic maps, the Natural Breaks (Jenks) technique of classification was used in an ArcGIS 10.8 setting. This was done so that the maps could be organised into categories. The factors of drainage density, slope, DEM, and rainfall were dissected into a total of five unique categories each. The land use map, land cover map, and soil map do not need any further categorization because they are already categorised throughout the process of preparing their respective maps. Both the land use and the land cover of the area under study were classified according to one of these four distinct groups. On the other hand, the soil in the area can only be classified as belonging to a single group. The classification was completed with the assistance of the reclassify tool, which is located in the reclass area of the special analyst tools. This helped ensure that the classification was accurate. The reclassified maps of drainage density, slope, and DEM are displayed in the figures xii, xiii, xiv, and xv, respectively. The reclassified maps of rainfall are displayed in figure xv. The tables numbered 1, 2, 3, 4, and 5 include a breakdown, in percentage terms, of the total land areas that are represented by the various types of thematic maps. The areas are displayed as the number of square kilometres.



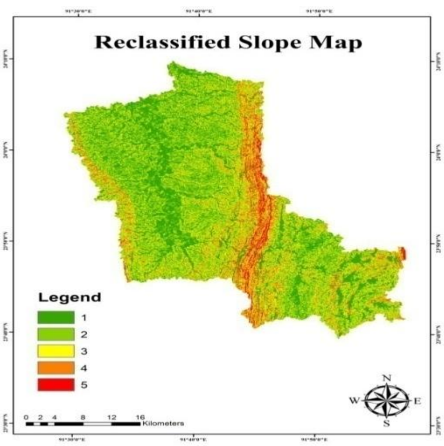
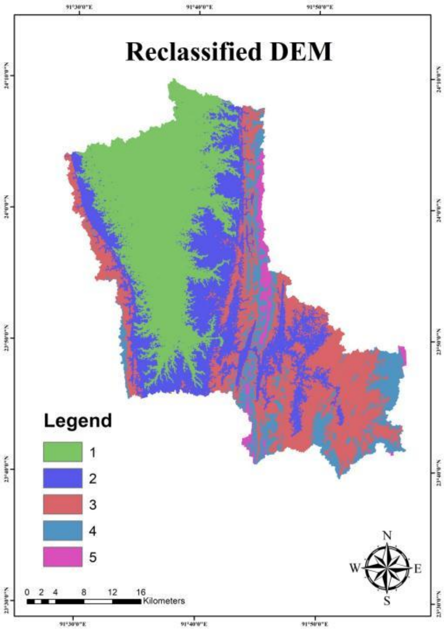


Figure iii. Reclassified drainage density mapFigure iv. Reclassified slope map



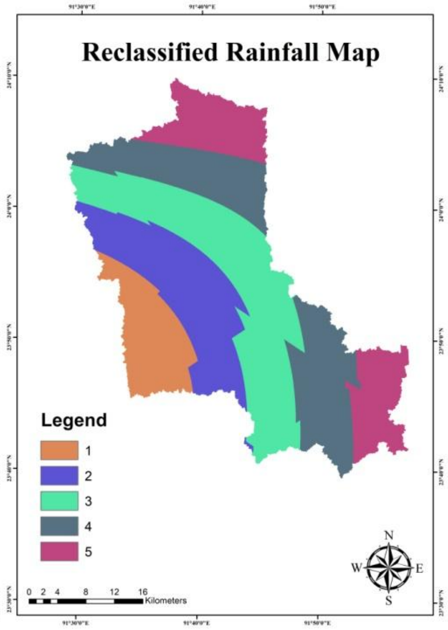


Figure v. Reclassified DEM map **Figure vi. Reclassified rainfall map**

4.3 Groundwater Potential Zones Analysis

Using the spatial analysis tool in ArcGIS 10.8 to overlay all thematic maps with weighted overlay is one way to create groundwater potential zones. Using this technology, groundwater potential zones may be created. All the maps may then be combined into one. The weights and the rank were both established by taking into account the work that was completed by a large number of other researchers. After being converted to raster format in ArcGIS 10.8, each of the thematic maps may then be placed on top of one another in a weighted overlay fashion. When it came time to distribute the weight, drainage density and DEM were given a greater weight, while slope and soil were given a lesser weight to account for in the overall calculation. The procedure of assigning weights to the different parameters is followed by the process of assigning individual rankings to the subvariable. During this stage of the process, the GIS layer including information on drainage density, rainfall, slope, DEM, soil, and land use land cover was examined in great detail, and ranks were assigned to each subvariable in accordance with their results. The attribute that possesses the greatest potential for groundwater is given the highest value, while the attribute that possesses the least potential is given the absolute minimum value that may be assigned. When it comes to the slope, a moderate slope is given a higher rank value, while a steeper slope is given a lower rank value. This is because a milder slope is easier to navigate. When there is a high drainage density, a higher rank value is allocated, and when there is a low drainage density, a lower rank value is assigned. When there is no drainage density, the rank value remains the same. In terms of rainfall, a high rank is provided for an annual average rainfall total that is higher, whilst a low rank is given for an annual average rainfall total that is lower. This is because larger yearly average rainfall totals are more desirable. This is because locations with lower elevations have better conditions overall. Due to the fact that the area under study has only a single variety of soil, we were only able to assign it one ranking out of a possible five. Within the framework of LULC, bodies of water are accorded a high rank, whereas barren ground is accorded a low grade. Table No.1 contains the tabular presentation of the full analysis that was carried out (APPENDIX) We were able to assess whether areas had a high, medium, or low potential for groundwater charging zones by making use of the model that we employed for this inquiry. The accuracy of the information that is being double checked out in the field is required in order for the thematic data that were created using this approach to even be possible. Even if this method is not always inexpensive or speedy, it is possible to compare the water budgets of the basins with the field test by using this strategy. This is despite the fact that it is viable to do so. Nevertheless, the results that were obtained using this technique play an important part in the type of study that is now being undertaken on the management of groundwater.

5.CONCLUSION

Groundwater is essential for the sustainable management of a country's water supplies and its growth. Remote sensing, GIS, Thematic maps were utilised to analyse groundwater potential zones in the research region. Weighted thematic layers were layered and blended to produce groundwater potential zones. This work is crucial for sustainable use of groundwater resources for development and for improving groundwater recharge via management. The research shows that the examined region may be divided into four groundwater potential zones. Very good (23.43%), good (47.73%), awful (28.68%), and extremely poor (0.14%) describe these zones. Rainfall supplies most of the area's replenished groundwater. The study found this. This research can be used to provide guidelines for future artificial recharge initiatives in the investigated region to guarantee sustainable groundwater use. This study can be used to generate guidelines. This study's results help policymakers make quick decisions on sustainable water management. This helps developing nations like India, which have limited infrastructure and a lack of data. This is effective in India.

5.2 Scope for Future Work

Using the same thematic maps, one may produce a Flood Risk Zone and a Drought Zone, as well as compute groundwater fluctuation for the study region using the same set of maps. To make thematic maps, you don't need to limit yourself to just these six traits; there are a great deal more you may draw on. In order to improve the precision of groundwater potential zones, it is possible to make use of a wide variety of additional types of thematic maps, such as geomorphology, lineament density, and topographic wetness index maps, as well as a wide variety of geological and hydrological factors that have an impact on groundwater. The gaining of this knowledge about the potential of the groundwater will be beneficial in efficiently selecting locations that are suitable for the extraction of water. In addition, the methodology used in this study project is seen to have the potential to act as a template for further studies that will be conducted in the years to come.

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Parameter	Classes	Groundwater prospect	Weight (%)	Rank
Drainage Density (Km/Km^2)	0 - 0.32 0.32 - 0.65 0.65 - 0.97 0.97 - 1.30 1.30 - 1.63	Very poor Poor Moderate Good Very good	30	1 2 3 4 5
Average Annual Rainfall (mm/year)	1857 - 1911 1911 - 1946 1946 - 1976 1976 - 2006 2006 - 2063	Very poor Poor Moderate Good Very good	15	1 2 3 4 5
Slope (degrees)	0 - 2.68 2.68 - 6.70 6.70 - 11.49 11.49 - 18.20 18.20 - 48.85	Very poor Poor Moderate Good Very good	5	5 4 3 2 1
DEM (m)	18.55 - 67.96 67.96 - 108.85 108.85 - 151.44 151.44 - 226.44 226.409 - 453	Very poor Poor Moderate Good Very good	30	5 4 3 2 1
Soil	3665	Moderate	10	1
Land Use Land Cover	Water Bodies Forest Bare Land Agriculture	Very good Moderate Poor Good	10	4 2 1 3

APPENDIX

Table No.: 1*, Weights for groundwater potential zone parameters