Delineation of ground water potential zones in Dhanbad district, Jharkhand, using Remote Sensing and GIS Techniques

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Abstract- *Ground water is one of the vital natural resource available on the earth. Due to rapid growth of population, urbanization and industrialization the available water resource are unable to meet the agriculture, industrial and domestic needs. The application of remote sensing and GIS rapid effective technique for ground water potential zone mapping has become a breakthrough in the field of ground water research. The present study has been undertaken to demarcate the ground water recharge potential zone using GIS approach. In this present study indicate various ground water potential zone for the assessment of ground water availability in Dhanbad district. The study has been delineated using remote sensing and GIS technique. Thematic map such as Geology, hydro geomorphology, Land Use / Land Cover, Drainage density, Slope and Water table maps are prepared in Arc GIS 10.1 based on weighted overlay analysis. Moreover each weighted thematic layer is statistically computed to get the ground water potential zone. The ground water potential zone were divide into four categorize very low, low, moderate & high. The result depicts the ground water potential zone helpful for better planning and management of ground water resource.*

Keywords: *Groundwater potential, Arc GIS 10.1, Remote Sensing & GIS, weighted overlay analysis, water table map, thematic maps, Ground water prospect.*

1. Introduction:

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 has created a major risk to this valuable resource (Ramamoorthy. P.et al, 2014). Delineating the potential groundwater zones using remote sensing and GIS is an effective tool. In recent years, extensive use of satellite data along with conventional maps and rectified ground truth data has made it easier to establish the base line information for groundwater potential zones (Tiwari and Rai, 1996; Das et

al., 1997; Thomas et al., 1999; Harinarayana et al., 2000; Muralidhar et al., 2000; Chowdhury et al., 2010;). Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Murthy, 2000; Leblanc et al., 2003; Tweed et al., 2007; Magesh et al., 2012). Remote sensing and GIS technique is an excellent tool for understanding the problem of ground water exploration. Satellite remote sensing data is not only cost effective, reliable and timely but also meets the essential requirements of data in the geographical Information System (GIS) domain, which are "current, sufficiently accurate, comprehensive and available to a uniform standard".

2. Study Area:

Dhanbad district lies in the mid eastern part of Jharkhand state. Giridih bound it in the north, Bokaro in the west, Purulia district in the south and Jamtara district in the east. It is connected through NH-2 and NH-32 from state capital and different district headquarters of the state. The district has total area of 2089 sq. km and is located between 23^0 26' - 24^0 01' North latitude to 86^0 10' - 86^0 48' East longitude (Fig: 1). The Dhanbad district consist of 8 blocks of Dhanbad district namely Baghmara, Baliapur, Dhanbad, Govindpur, Jharia, Nirsa, Topchanchi & Tundi. The district comprises of 157 numbers of panchayats and 1052 no. of villages. The total population of the Dhanbad district as per the 2001 census is 23, 97,102.Rural population is 11, 41,744 and Urban population is 12, 55,358. The density of population is 1167 person per sq. Km.

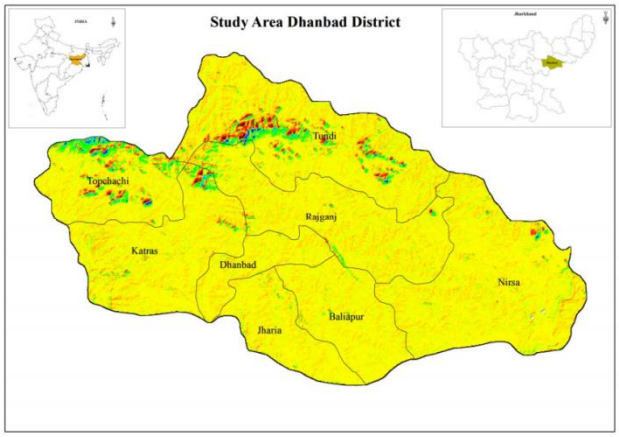

Fig- 1: Location Map of the Study Area

3. Data & Software Used:

3.1 Data Used:

a. Landsat TM-5 image of May 2012
b. Survey of India Toposheet
c. Hydro geomorphology Map.
d. Water table map.

d. Geological Map

f. SRTM DEM.

3.2 Software Used:

a. Arc GIS (10.1).
b. ERDAS (10.0).
c. Microsoft Office (2007).

4. Methodology:

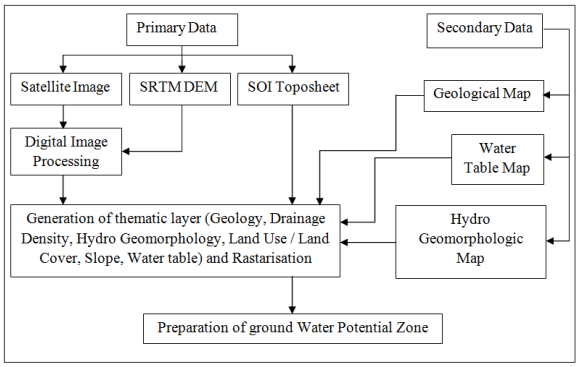

Fig- 2: Methodological Flow Chat

In this present study primary and secondary data ware used to thematic map preparation. The base map of the study area was prepared based on Survey of India toposheets. The Landsat TM-5 & SRTM DEM satellite image data ware used to prepared Land Use / Land Cover, Slope & Drainage density map. The methodology (Fig: 2) includes generation of others thematic layers on Geology, Hydro geomorphology, & water table map based on their characteristics. Remote Sensing & Geographic information system (Arc GIS 10.1 and ERDAS 10.0 software) was used for the mapping of individual layers and final integration of map. Based on the character, the features in different thematic layers were assigned with different weighted values according to the potential for groundwater. After the layers were integrated using GIS and then the area can be classified as high, moderate, low and very low groundwater potential zones.

5. Result & Discussion:

5.1 Drainage Density:

Drainage density is defined as the closeness of spacing of stream channels. It is a measure of the total length of the stream segment of all orders per unit area. The drainage density is an inverse function of permeability. The less permeable a rock is, the less the infiltration of rainfall, which conversely tends to be concentrated in surface runoff (Magesh et al., 2012). Using line density analysis tool in Arc GIS 10.1 software prepared drainage density map. The five class have been assigned very low, low, moderate, high & very high (Fig: 3). Very high drainage density is recorded in the north-western part of the study area. The sustainability of ground water potential zone is indirectly related to drainage density because of its relation surface runoff and permeability. Very low drainage density is recorded southern and eastern part of the study area. Very low drainage density indicates more suitable for ground water prospects because available surface water and high ground water recharge rate.

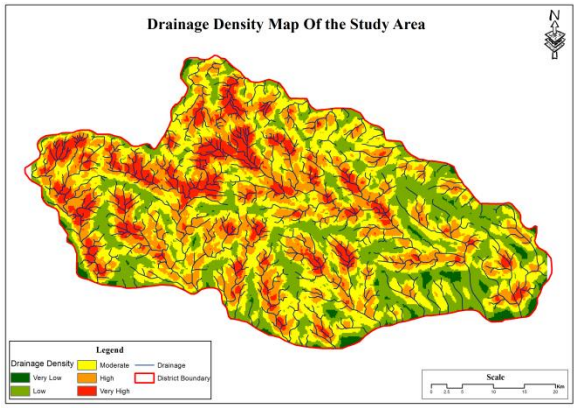

Fig -3: Drainage Density Map

5.2 Slope:

Slope is an important factor for the identification of groundwater potential zones. Slope grid is identified as "the maximum rate of change in value from each cell to its neighbors" (Burrough, 1986). The slope map ware prepared using spatial analysis tool in Arc GIS 10.1 software (Fig: 4). Slope is important factor for ground water potential zone mapping. Based on slope map high degree of slope (33-89.50) north-western part of the study area indicates rapid runoff and high erosion consider as a "very poor" ground water potential zone. The areas having (0-2.81 degree) slope fall into the 'very good' category because of the nearly flat terrain and relatively high infiltration rate. The areas having a slope of (13.67-33 degree) cause relatively high runoff and low infiltration, and hence are categorized as 'poor' and the areas having a slope (2.81-13.67 degree) are considered as 'good' due to low slope and runoff.

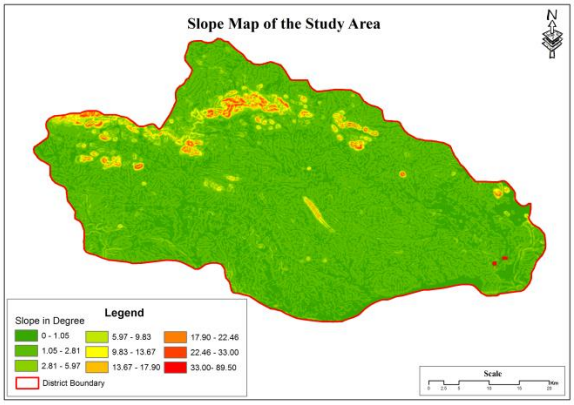

Fig- 4: Slope Map of the Study Area

5.3 Land Use / Land Cover:

The major land use type in the study area is vegetation, settlement, agriculture land and fallow land. Other minor land use type is mining, highland, river, water body and river sand. These land cover class are delineated from Landsat TM-5 satellite data and intense field verification (Fig: 5). Around 32.39 % area of the total area is under vegetation, 23.21 % area under agriculture land, 19.97 % area under settlement, 9.47 % area under fallow land, 5.18 % area under mining activities, 5.31 % area under highland, remaining water body, river and river sand are 2.29 %, 1.17 % and 1.01 % respectively.

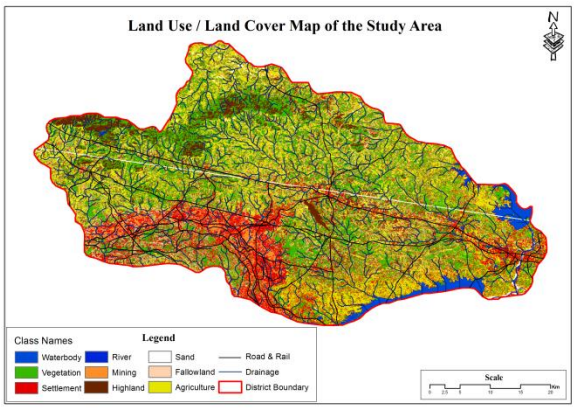

Fig -5: Land Use / Land Cover Map

5.4 Geology:

The storage capacity of the rock formations depends on the porosity of the rock. In the rock formation the water moves from areas of recharge to areas of discharge under the influence of hydraulic gradients depending on the hydraulic conductivity or permeability (Manikandan.J et al, 2014).

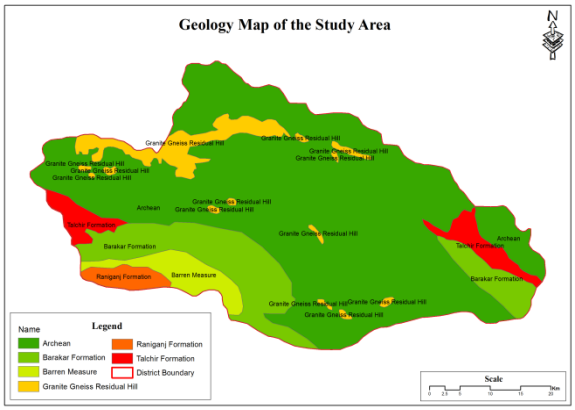

Fig -6: Geology Map of the Study Area

The major part of the Dhanbad district underlain by Archean age. Barakar formation present in the Southern and Eastern part of the study area (Fig: 6). In the Eastern region river site present Barren measure formation and Raniganj formation. The North-Western part and minor part of the area presents of Granite Gneiss Residual hill.

5.5 Hydro Geomorphology:

The map showing five distrinct Hydro geomorphological features in the study area (Fig: 7). The Denudational Hills covered with mixed forest and has moderate to low slope resulting in moderate run off. It is shallow and well drained. It is gravelly loamy soil and non-sticking. It is friable when moist. The region is covered with few lineaments/fractures with sub radial drainage pattern and hence the groundwater prospect is moderate. The Pediment area is covered with bushes with cultivated land in low valley and has moderate to steep slopes. The region has dense lineaments. Drainage pattern is dendritic to sub parallel with linear parallel radial drainage pattern. The groundwater prospect is good. The Undulating Upland represents the buried pediments with intermountain valley. These areas are characterized by moderate to high steep slope resulting in very high run off. Groundwater prospect is poor. The Pedeplain / Peneplain are relatively flat rock surfaces formed by the joining of several pediments and Peneplain. They are gently undulating, almost featureless and plain. The region is covered with moderate number of lineaments with sub parallel to sub dendritic drainage

pattern. Groundwater prospect is low to moderate.

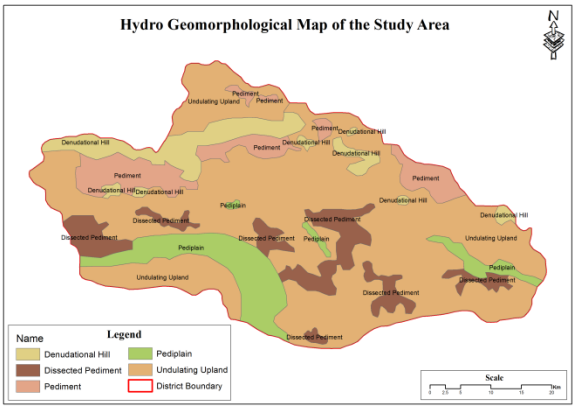

Fig- 7: Hydro Geomorphology Map

5.6 Water Table depth:

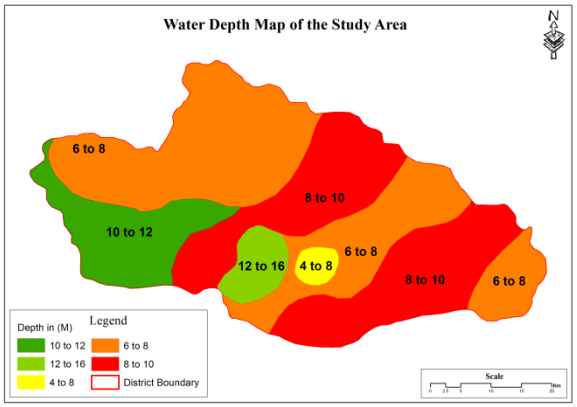

Fig- 8: Water Table Depth Map

ground water depth is one of the important criteria for ground water potential zone delineation (Fig: 8). High level of ground water depth is more accessible for ground water extrusion and low ground water depth is less accessible for ground water extrusion.

5.7 Ground Water Prospect:

The ground water potential zone in the district of Dhanbad was generated through integration of various thematic maps via. Land use / land cover, drainage density, geology, slope, hydro geomorphology and water table depth using remote sensing and GIS technique. The ground water recharge potential model has been developed based on weighted overlay analysis method. In the weighted overlay analysis method were assigned to each theme according to their importance (Table: 1). The recharge potential zone were delineated as very low, low, moderate and high depending on the final weighted were assigned in Arc GIS software. The ground water recharge potential map show in (fig-9) the map provides broad idea about the favorable ground water recharge area. In this result it is shows that southern and eastern part of the study area is highly suitable for ground water recharge and middle part is low suitable. Some part of the northern, southern and eastern site is moderate suitable, part of the north-western site in hilly region is very low suitable for ground water recharge.

Features	Class Name	Class Weight	Theme Weight
Land Use / Land Cover	Vegetation	4	20
	Agriculture Land	4	
	Settlement	1	
	Water body	2	
	River	3	
	Mining	2	
	Fallow Land	1	
	Highland	0	
	Sand	3	
Geology	Archean	3	15
	Barakar Formation	2	
	Barren Measure	4	
	Granite Gneiss Residual hill	1	
	Raniganj Formation	3	
	Talchir Formation	2	
Drainage Density	Very Low	6	15
	Low	4	
	Moderate	3	
	High	1	
	Very High	1	
Slope	0-1.05	6	25
	1.05-2.81	5	
	2.81-5.97	4	
	5.97-9.83	3	
	9.83-13.67	2	
	13.67-17.90	2	
	17.90-22.46	1	
	22.46-33.00	1	
	33.00-89.50	1	
Hydro geomorphology	Denudational hill	5	15
	Dissected Pediment	2	
	Pediment	3	
	Pedeplain	4	
	Undulating Upland	1	
Water Depth	4 – 8 mt	4	10
	6 – 8 mt	2	
	8 – 10 mt	2	
	10 – 12 mt	1	
	12 – 16 mt	1	

Table-1: Class Weighted

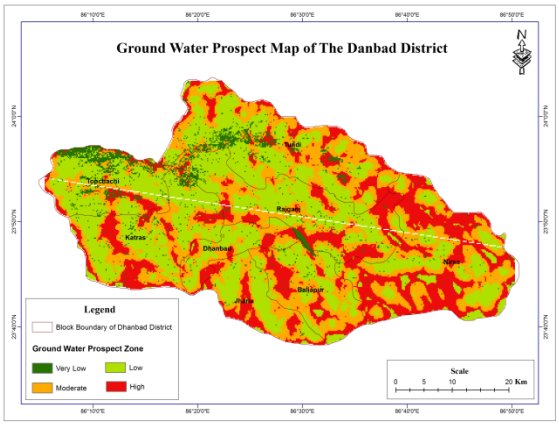

Fig -9: Ground Water Prospect Map of the Dhanbad District

6. Conclusion:

Remote Sensing & GIS has proved to be powerful and cost effective method for determining ground water potential zonation mapping in the Dhanbad district. Remote sensing & GIS technique is found efficient to minimize the time, labor and money and there by enables quick decision making for sustainable water resource management. Satellite imagery, topographic maps and conventional data were used to prepare the thematic layer of Land Use/Land cover, Slope, Drainage density, geology, hydro geomorphology and water depth map. The various thematic layer are assigned proper weighted overlay analysis integrated in the GIS environment to prepared the ground water recharge potential zone map of the study area. According to the ground water prospect map Dhanbad district is divide in to

four different zones very low, low, moderate and high. The result of present study can serve as guideline for future artificial recharge projects in the study area in order to ensure sustainable ground water utilization.

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