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Research Article

DELINEATION OF GROUND WATER PROSPECT ZONES USING REMOTE SENSING, GIS TECHNIQUES - A CASE STUDY OF BAGHMUNDI DEVELOPMENT BLOCK OF PURULIYA DISTRICT, WEST BENGAL

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ABSTRACT

The exploration, assessment and management of ground water resource has become one of the key issues as ground water forms an important component of the total water supply for drinking and irrigation purposes. Remote Sensing has been successfully used to locate prospective ground water. The present study has been undertaken in the Baghmundi block falling in Puruliya District of West Bengal State with an aerial extent of 455.12sq.km. The thematic maps such as Geology, Geomorphology, Land use/ Land cover, Slope, Lineament and Drainage map were prepared for the study area. A Digital Elevation Model (DEM) has been generated from ASTER GDEM 30 metres resolution data. The ground water potential zones were obtained by overlaying all the thematic maps in terms of weighted overlay methods using the spatial analysis tool in ArcGIS 10.1. During overlay analysis the ranking has been given for each individual parameter of each thematic map and weights were assigned according to the influence such as Geology-25%, Geomorphology-25%, Land use /Land cover -25%, Slope-15%, Lineament-5%, Stream Order -5% and find out the potential zones in terms of very good, good, moderate, poor and very poor zones with the area of 25.65 sq.km, 118.22 sq.km, 125.05 sq.km, 140.08 sq.km and 44.96 sq.km respectively. The GIS based output was validated by conducting field survey by randomly selecting wells in different villages using GPS.

The study has brought out that high groundwater potential zones are confined along lineaments and in pediment areas. The other geomorphic units like denudational hills form zones of moderate to good groundwater prospects. Dissected pediments, inselberg complex, undulating upland and buried pediment with intermountain valley are zones of poor prospects. Very poor regions occupy a small part of total study area and are mainly confined to undulating upland and residual hills.

Keywords: *GIS, Groundwater, Weightage, Thematic Maps*

INTRODUCTION

The growth of population in India increases 17.64 percent (Census of India, 2011) in last decade with more stress on agriculture sector for increasing the food grain production. It has consequently increased deforestation (Forest cover in India is 19.27 percent, Statistical Abstract of India, 2011) and demand for more water. Present availability of water resources in West Bengal is about 14.75 million hectare meter where projected demand of fresh water in the year 2025 and 2050 will be of 16.60 and 20.00 million hectare meter, respectively (Saha, 2010). The study area lies in the western part of West Bengal is chronically drought prone and faces acute water scarcity not only drinking purposes but also for agriculture. The available surface water resources are inadequate to meet the entire water requirement for different purposes. So demand for underground water has increased each and every year. The occurrence and yield potential of groundwater sanctuary are basically controlled by geology, geomorphology and structural set-up of an area (Raju, 2012). It is important to target groundwater potential zone prior to any planning for groundwater development. In recent year, the use of remote sensed data and geographic information system (GIS) application has been found increasing in a wide range of resources inventory, mapping, analysis, monitoring and environmental management. Remote sensing provides very useful methods of survey, identification, classification and monitoring several forms of earth resources, and helps in preparation of data in various temporal resolutions.

The occurrence and movement of groundwater in an area is governed by several factors such as topography, lithology, geological structures, depth of weathering extent of fracture, secondary porosity, soil, drainage pattern, landforms, land-use/land-cover, climatic conditions and interrelationship between these factor (Nagarajan and Singh, 2009). In addition, quantitative morphometric parameters of the drainage pattern also play a major role in evaluating the hydrology parameters, which in turn help to understand the groundwater situation (Krishnamurthy *et al.*, 1996). The quality and quantity of groundwater is controlled mainly by the interaction of topographical, geological, meteorological and pedological features. Therefore, a detailed hydro-geomorphological mapping of groundwater prospect zones is delineated. This delineation is possible through current spatial deposition of basic information on geology, landforms, soil, land-use/land-cover, surface water bodies, etc. This indication gives complete information on groundwater movement and localisation (Tiwari, 1993). It is obvious that groundwater cannot be seen directly from Remote sensed data; hence, its presence must be inferred from identification of surface features, which act as an indicator of groundwater (Rai *et al.*, 2005). Since delineation of groundwater prospect zone and identification of artificial recharge sites are based on the combined role being played by various factors, it is necessary to use techniques of Remote Sensing and GIS. The present study is an attempt to delineate groundwater prospect zones of Baghmundi Development Block of Puruliya district, West Bengal, through remote sensing and Geographical information system.

MATERIALS AND METHODS

Location of Study Area

The study area is bounded by 23^0 04'N to $23^0$18'N and 85^0 52'E to 86^0 12'E. The area falls in the western part of Puruliya district in the state of West Bengal and covered by survey of India (SOI) toposheet no. 73E/15, 73E/16, 73I/3 and 73I/4. The block has 144 small villages, having eight Gram Panchayats. The study area covers about 455.12 Sq. km. The study area is shown in figure 1.

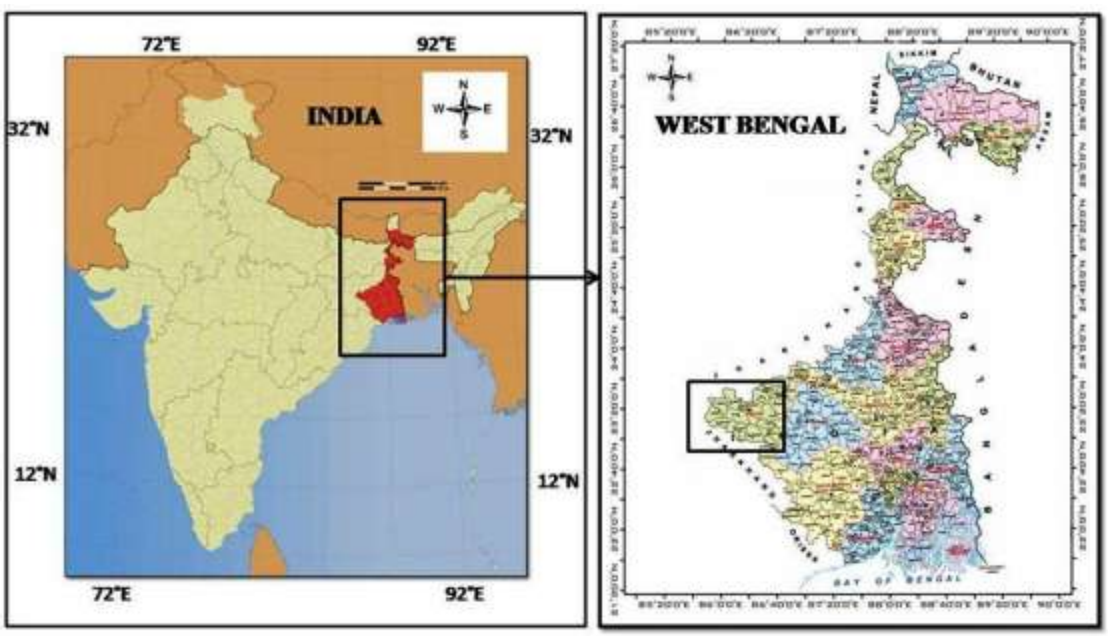

Figure1: Location of study area

Village- Wise Map of the Study Area

Out of 144 villages the maximum and minimum geographical area were found to be Burda (21.05 sq.km) and Saramchaki (0.28 sq.km) respectively (Figure 2).

Figure 2: G.P. and village level map of the study area

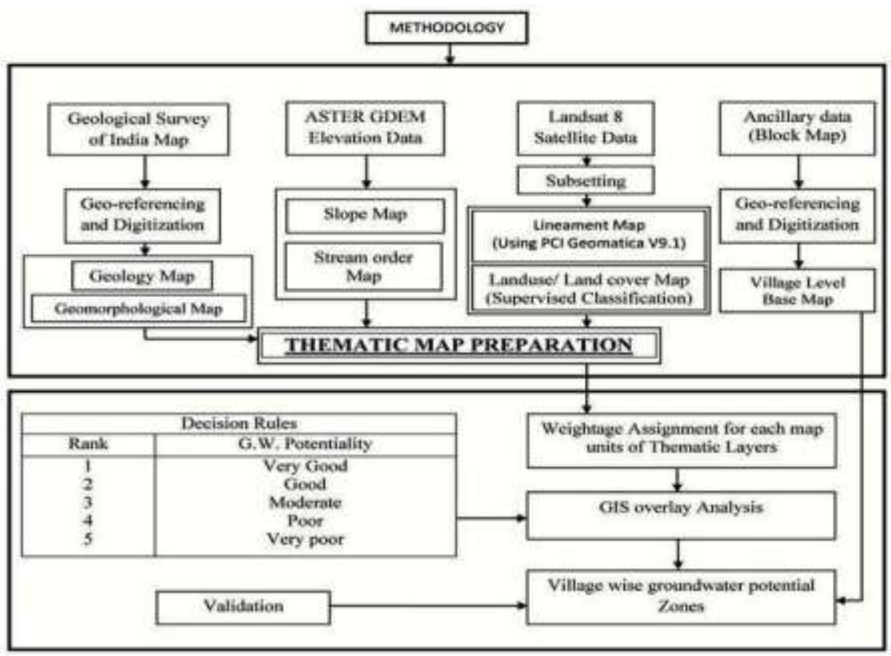

Figure 3: Methodology steps

Physiographic Characteristics

The area is mixture of hilly and valley topography, with the maximum elevation of 682 metres recorded at the Gorgaburu lying in the eastern side of the Baghmundi. The river Subarnarekha is the major river flowing through the western part of the study area. The largest reservoir of the study area is Ajodhya reservoir situated in Barriya village in Baghmundi G.P.

*Geology***:** Four major lithounits have been demarcated in the area. These are Biotite Granite Gneiss, Epidiorite, Mica Schist and Residual Soil having 289.07sq.km, 7.69sq.km, 40.06sq.km and 118.29sq.km respectively (Figure4).

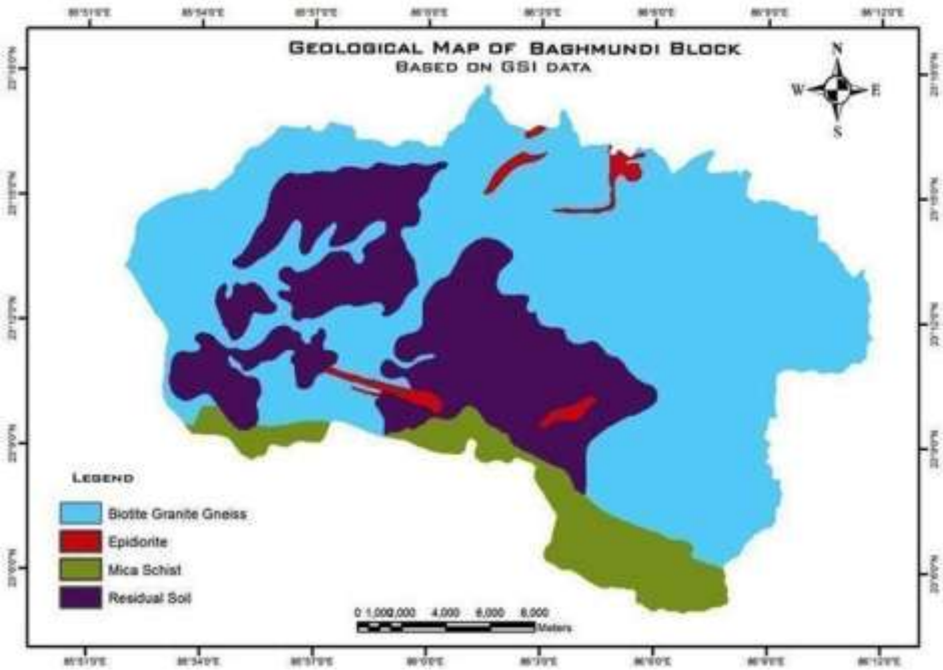

Figure 4: Geology map

*Geomorphology***:** Geomorphology is the science of studying the external expression and architecture of the planet earth. Geomorphological process is generally complex and reflect interrelationship among the variables such as climate, geology, soil and vegetation (Buol, 1973). The major geomorphic units identified in this area are Accumulation Glacis (33.33sq.km), Buried Pediment Medium (78.48sq.km), Buried Pediment Shallow (80.36sq.km), Erosional Glacis (15.65sq.km), Erosional Remnants (7.88sq.km), Laterite Uplands (1.44sq.km), Planation Surface (26.04sq.km), Structural Hills (153.40sq.km) and Infilled Valleys (56.98sq.km) (Figure 5).

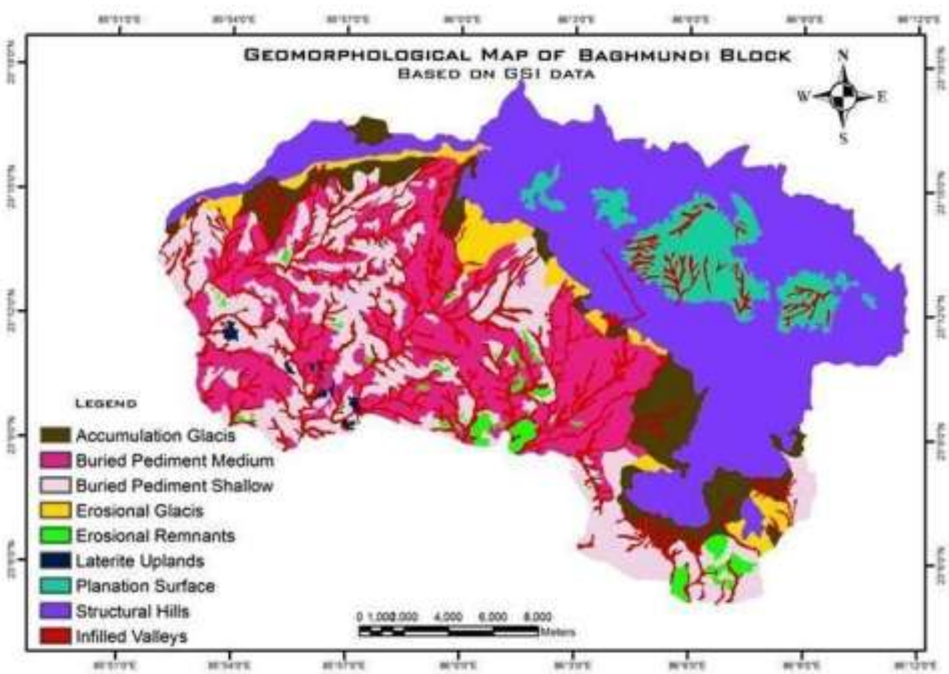

Figure 5: Geomorphology map

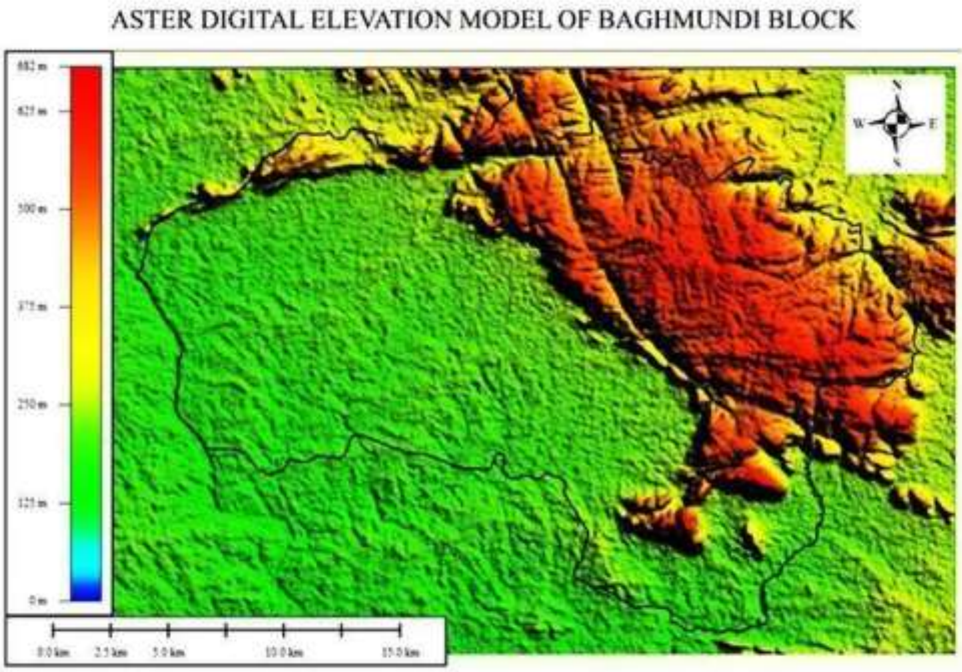

Figure 6: Digital Elevation Model (DEM)

*Slope***:** Slope is a surface feature, which is related to landforms, present material, elevation and landuse. A slope map has been prepared by using ASTER GDEM image with 30 metres resolution (Figure 7).

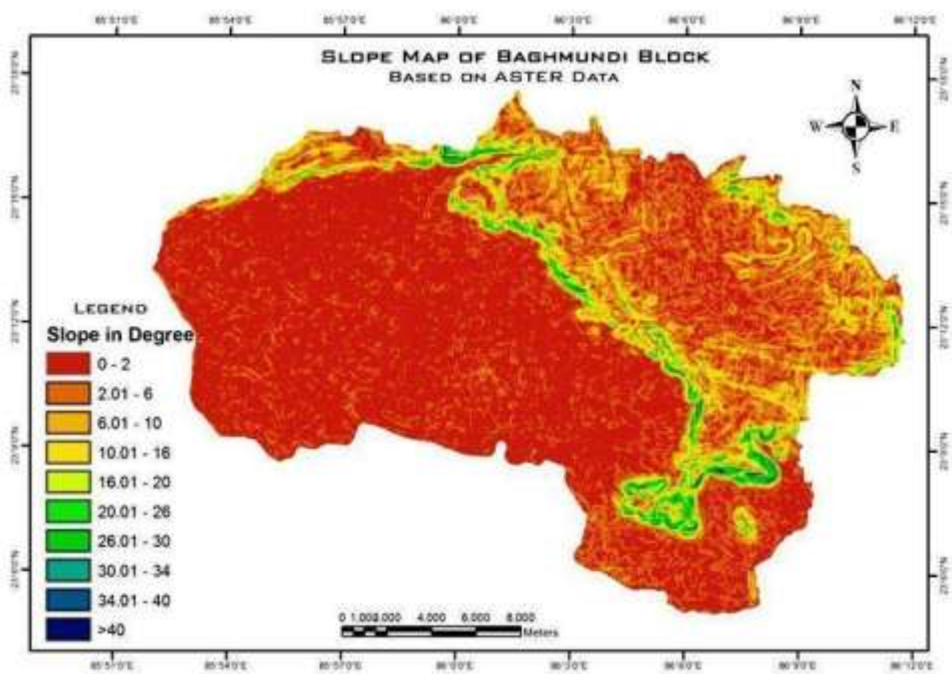

Figure 7: Slope map

Land-Use/Land-Cover: The term land cover relates to the type of feature present on the surface of the earth where as landuse refers to the human activity associated with the specific piece of land (Lillesand

and Kiefer, 1979). The study area is classified into a number of land use and land cover based on different spectral signatures of the surface features in the landsat 8 imagery. Supervised classification served as a very good helping tool for the interpretation of land use classes, the thematic map was generated by satellite imagery and digital data. The land use and land cover map thus produced from satellite data (Figure 8) is shown in figure 9. The various land use/ land-cover units thus classified in the study area are 1) Water (6.76sq.km) 2) Stress Vegetation (35.81sq.km) 3) Healthy Vegetation (112.84sq.km) 4) Built-up area (20.58sq.km) 5) Barren Land (78.21sq.km) 6) Agricultural Land (200.48sq.km).

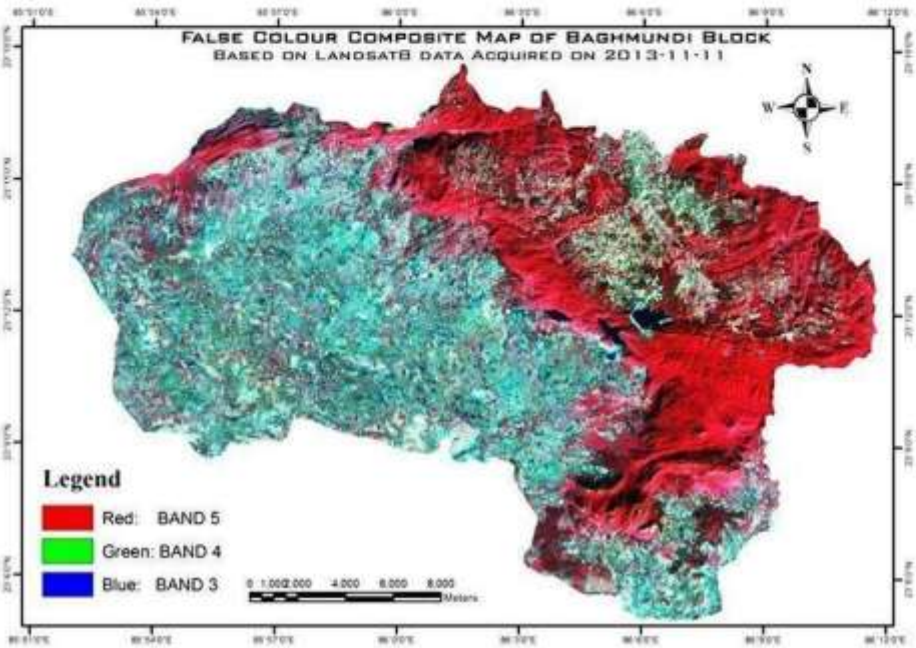

Figure 8: Satellite image

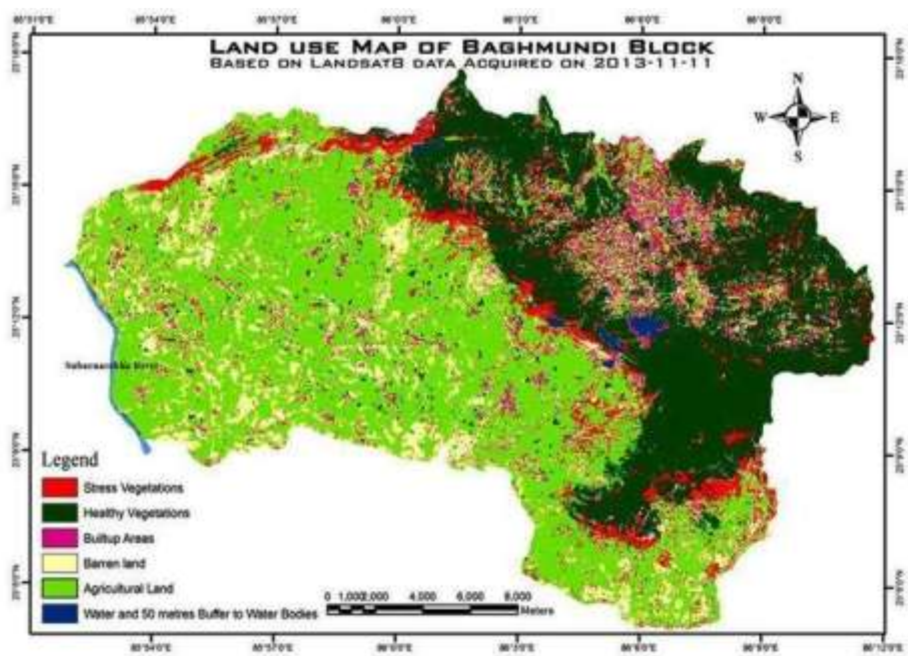

Figure 9: Land use/ Land cover map

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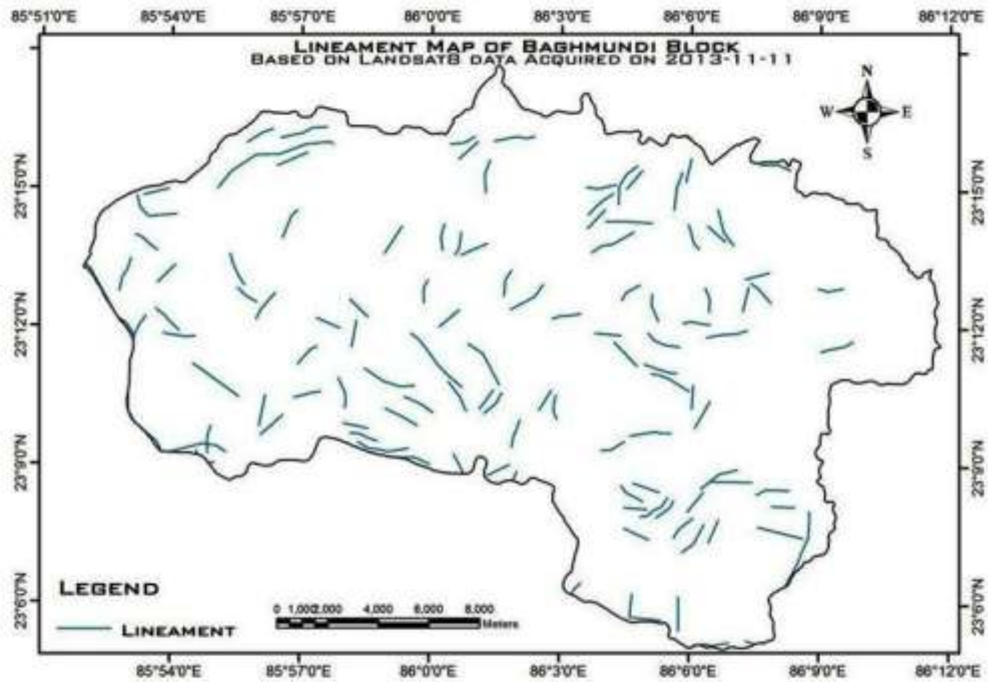

Figure 10: Lineament map

Table 1: Rank and weightage of different parameters

Sl. No.	Criteria	Classes	Category	Rank	Weights (%)
1	Geomorphology	Valley field	Very Good	1	**25**
		Buried pediment(Medium/Shallow)	Good	2	
		Planation Surface/Erosional Glacis/ Accumulation Glacis	Moderate	3	
		Erosional Remnants	Poor	4	
		Laterite Uplands/ Structural Hills	Very Poor	5	
2	Land use	Water and 50 metres buffer to water bodies	Very Good	1	**25**
		Healthy Vegetation	Good	2	
		Stress vegetation/ Agricultural Land	Moderate	3	
		Barren Land	Poor	4	
		Built-up Areas	Very Poor	5	
3	Geology	Residual Soil	Very Good	1	**25**
		Mica Schist	Moderate	3	
		Biotite Granite Gneiss/ Epidiorite	Very Poor	5	
4	Slope (in Degree) Natural Break	0	Very Good	1	**15**
		0.1-5	Good	2	
		5.1-15	Moderate	3	
		15.1-25	Poor	4	
		>25.1	Very Poor	5	
5	Lineament	Present	Very Good	1	**5**
		Not Present	Very Poor	5	
6	Stream Order	Third order	Very Good	1	**5**
		Second Order	Good	2	
		First Order	Modetate	3	
Integration Function = (Thematic Layers)		[(Geomorphology * .25) + (Land use * .25) + (Geology * .25) + (Slope * .15) + (Lineament * .5) + (Stream Order * .5)]			

Source: Nagarajan M., Singh S., 2009

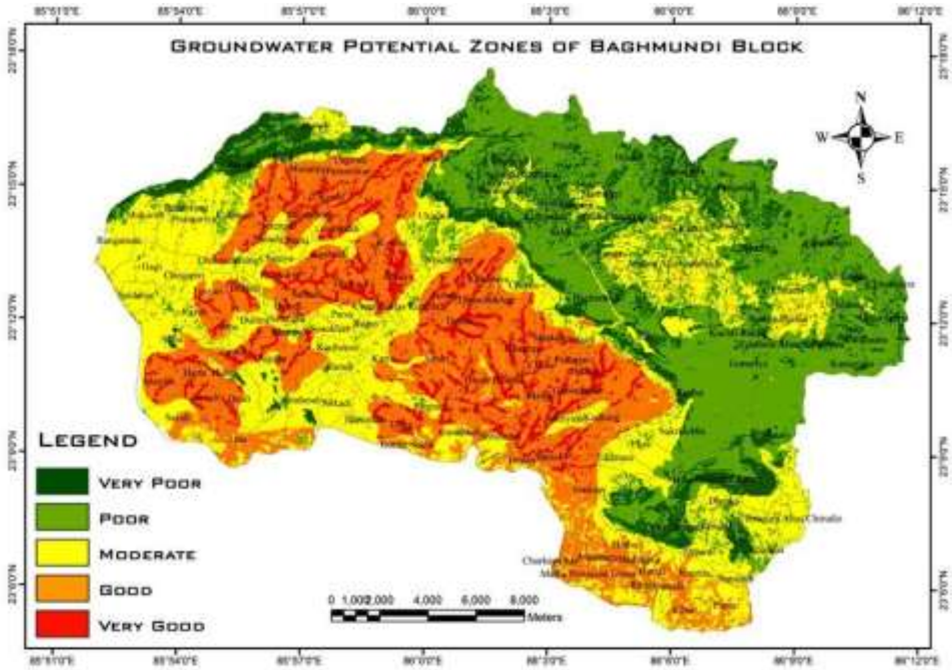

Figure 11: Groundwater potential zones

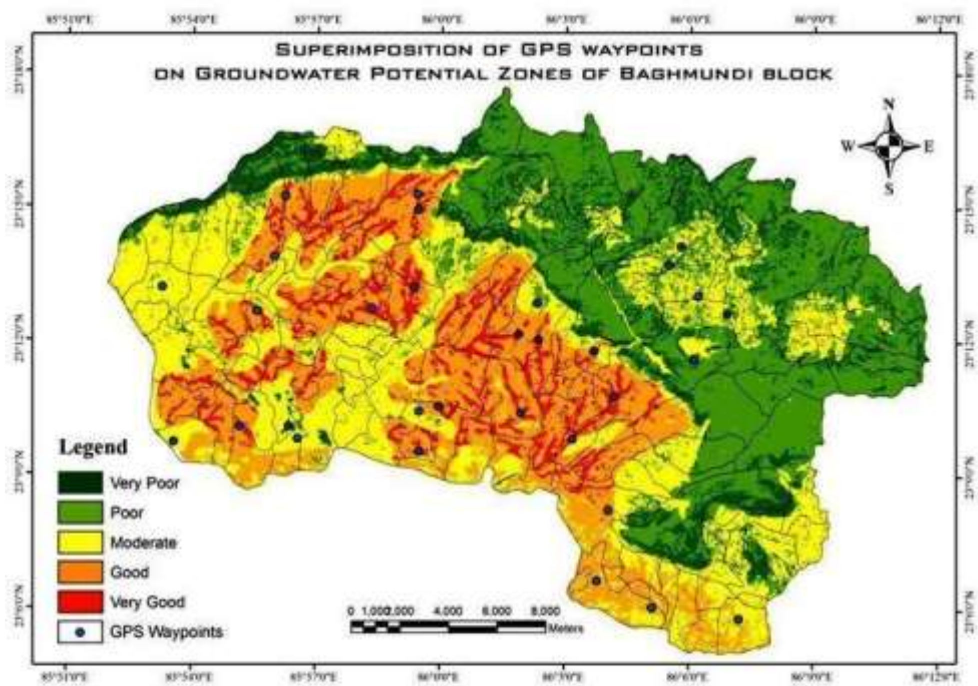

Figure 12: Validation using GPS points

*Lineament***:** In the study area, major lineaments are identified (Figure 10) from the Landsat 8 satellite data interpretation, which are surface manifestation of some structural features in the bedrock of fracture and joint developed due to tectonic stress and strain. Lineaments were identified in structural hills, pediments and buried pediment zones of the study area, mainly controlled by the stream channels.

*Drainage***:** The most important river in this area is Subarrnarekha River which is flowing through the western boundary of the block. The other important channels are Burda Nadi, Karru Nadi, Soblia Nadi,

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Turga Nadi, Kistobazar Nadi, Daurigarha Nadi and Sanka River. The Stream order map of the area was prepared, based on ASTER GDEM elevation data using ARC GIS 10.1 software.

Methodology

The methodology adopted (Nagarajan and Singh, 2009, Sarup *et al.*, 2011) in present study is presented schematically in figure 3. The various thematic maps such as Base map, Geomorphology, Geology, Land-use/cover, Lineament, Stream Order map, Slope map are prepared into the vector format using digitization in Arc GIS software. The Weight age and ranks (Nagarajan and Singh, 2009) were assigned to the themes and units depending upon their influence over recharge (Table 1). Overlay technique using Geographic Information System (GIS) have been used to delineate the Ground water potential zones.

Groundwater Potential Zoning

From the analysis the ground water potential zones in terms of very good, good, moderate, poor and very poor with the area of 25.65 sq.km, 118.22 sq.km, 125.05 sq.km, 140.08 sq.km and 44.96 sq.km respectively were obtained (Fig.11). The output groundwater potential zone map overlaid with village-wise map and the groundwater potential zones in terms of village and G.P. wise classification zones were obtained. It reveals that out of 8 Gram Panchayat Serengdih has the of 14.28% and 43.98% of its total area in very good and good zones respectively where as Ajodhya has maximum area in terms of poor and very poor zones. The distribution of area of each potential zones and G.P. wise division of area in percentage is shown in figure 13

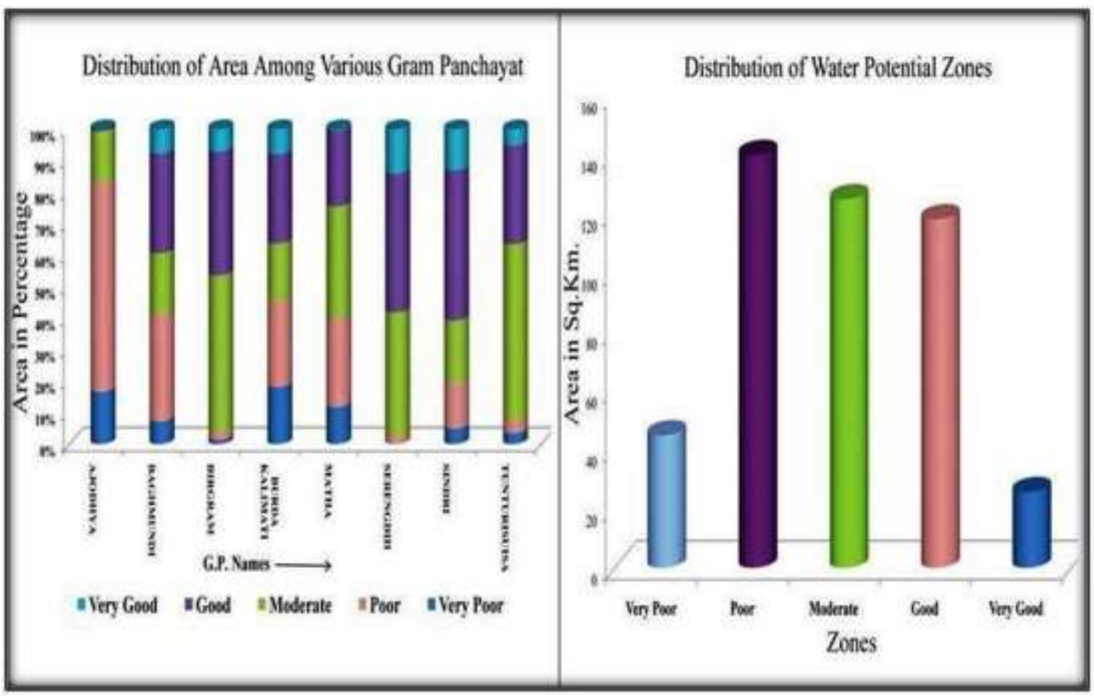

Figure 13: Potential zones distribution graph

Very Good Groundwater Prospect Zones: The major geomorphic units in this zone are infilled valleys. Major part of this zone exists in central part of the study area covering of 25.65 sq.km. Serengdih and Sindri has the maximum area cover 14.28% and 13.28% respectively with respect to their G.P. area.

Good Groundwater Potential Zones: This zone is dominated by geomorphic units like buried pediment Deep and Medium. Sindri has the maximum of 46.49% area cover where as Ajodhya has the minimum of 0.74%.

Moderately Groundwater Potential Zones: This is mainly a pediment zone, which occupies area about 125.05 sq. km. spreading mainly western part of the block. G.P. like Tunturisuisa (54.98%), Birgram (50.53%), Serengdih (39.23%) are having major area covering by this zone.

Poor Groundwater Potential Zones: Structural hills fall under poor groundwater prospect zone covering area about 140.08sq.km.which falls under the G.P. of Ajodhya (67.21%) and Baghmundi (34.98%).

Very Poor Groundwater Potential Zones: This is mainly a rocky terrain having plateau, mesa, butte, escarpment and linear ridge developed. Accordingly, these potential units have been mapped as very poor groundwater potential zone covering area about 44.96 sq.km. Because of the surface characteristics, these act mainly as runoff zone and are not suitable for groundwater exploration.

Model Validation

The village-wise groundwater potential zone maps were validated by hand- held GPS instruments. The field study was conducted in the study area, to check the five different zones. The wells randomly selected in villages from five zones to study the depth level of the ground water. The groundwater level depth was found to be normally 10-20 ft in very good zones, 20- 40 ft in moderate zones and >60 ft in very poor zones. The co-ordinates are collected using GPS in all the selected wells and incorporated in village wise groundwater potential zones map as depicted in figure 12. Although aquifer potential test is the best method for validation, but in this study it was not possible.

Conclusion

Geologically it is observed that the groundwater is mainly confined to secondary porosity i.e. fractured zone, fault, joint and weathered column. It is observed from field survey and also from various wells located in the region the hard granite gneisses act as barriers for the groundwater flow in the region. From the generated ground water resource prospect map, it is observed that high potential zones are mainly located along lineaments and in pediment areas. Alluvial fills, valley fills are good potential zones. The geomorphic units like buried pediment and denudational hills are moderate to good groundwater prospective zones. Undulating upland and buried pediments with intermountain valley, mainly confined in undulating upland, are the regions of poor groundwater prospecting zones. Very poor potential regions cover around 10% of total study area (confined to dissected pediments, structural hills, inselberg complex and residual hills).

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