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Research Article

DELINEATION OF GROUNDWATER POTENTIAL ZONES USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM TECHNIQUE: A CASE STUDY FROM ATTAPPADY HILLS, PALAKKAD DISTRICT, KERALA, SOUTH INDIA

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ABSTRACT

The objective of the study is to delineate ground water potential zones in Attappady Hills by using remote sensing and GIS technique. The various thematic maps such as Slope, Land use, Soil, Geology, Geomorphology, lineament and drainage density were prepared from SOI top sheets. These thematic maps have been overlaid in terms of weighted overlay method using spatial analysis tool in Arc GIS 9.3. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map and weights were assigned according to the influence of different parameters such as Land use (15), Geomorphology (11), Geology (17), Soil (16), Lineament Density (15), Drainage Density (14) and Slope (12).On the basis of this weight and ranking, the ground water potential zones of Attappady Hills have been delineated. From the present study it is observed that an integrated approach of Remote Sensing and Geographical Information System can be successfully used in delineating groundwater potential zones in the study area. In the study area four categories of ground water potential zones, viz., very good, good, poor and very poor have been demarcated. Major portion of the study area has poor and good prospect while a few scattered areas have very poor prospect. The very good potential areas are mostly concentrated in the south-eastern part of the Attappady due to gentle slope and distribution of forest cover.

INTRODUCTION

Generally groundwater is considered as a vital natural recourse for the reliable and economic provision of potable water supply in both urban and rural environment (Magesh *et al*, 2012). Hence it plays a fundamental role in maintaining ecological balance, human well-being and economic development (IPCC 2011). Groundwater is the potential source of water supply throughout the world (Gleeson *et al*. 2012; Basu & Van Meter, 2013; Rodell *et al*. 2009; Yeh *et al*. 2009). The increasing demand for groundwater due to expanding population size, increasing area of irrigated cultivation and economic development with less importance to the environment has mounted huge stress on its circumspect utilization (Mondal and Dalai, 2017).

The occurrence, movement, quantity and quality of groundwater are major concerns, which depend on the underlying rock formations and their structural fabric, the thickness of weathered material, the topography and climatic conditions (Singh *et al*. 2011b).

The remote sensing and GIS techniques are highly useful for identifying the potential groundwater areas (Samson & Elangovan 2015; Gumma, &Pavelic 2013). The remote sensing and GIS data can provide quick and useful information on the factors influencing the occurrence and movement of groundwater. The main factors which control the occurrence and movement of groundwater include geomorphology, lineament, geology, slope, soil etc (Rajaveni *et al*. 2017; Ibrahim-Bathis & Ahmed, 2016; Dar *et al*. 2010).

The present study incorporates a systematic integration of remote sensing and GIS data with field information to provide a rapid and cost-effective tool for delineation of groundwater potential zones in the Attappady Hills of Palakkad District, Kerala.

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Study Area

Attappady is an area classified as the first Integrated Tribal Development Block of Kerala and forms part of Mannarkkad Taluk of Palakkad District. The Attapady block is located between 10° 55' 10" and 11° 14' 19" North Latitude and between 76° 27'11" and 76° 48' 8" east Longitude, stretching from Mukkali to Anakatty (West-East) and Thazhemully to Muthikkulam (North-South), covering an area of 745 square kilometer (sq.km) in Mannarkad Taluk of Palakkad district, Kerala state, South India (Figure.1). It has a total area of 745 sq. km. spread over three Panchayats, namely Agali, Pudur and Sholayur. Attappady region is a showcase for the most vibrant and yet conflicting social and cultural ethos.

The average annual rainfall of Attappady is only around 900 mm/year. The mean maximum and minimum temperature of Attappady are 33^{0}C and 23^{0}C respectively. The Attappady region is drained by two major rivers- Bhavani and Kunthi. Shiruvani, Varagar and Kodugarapallam are the main tributaries of Bhavani river which flows to Tamil Nadu then converging with Kaveri river. Kunthi is one of the major tributaries of Bharathapuzha originating from Angindamudy of Silent valley National Park.

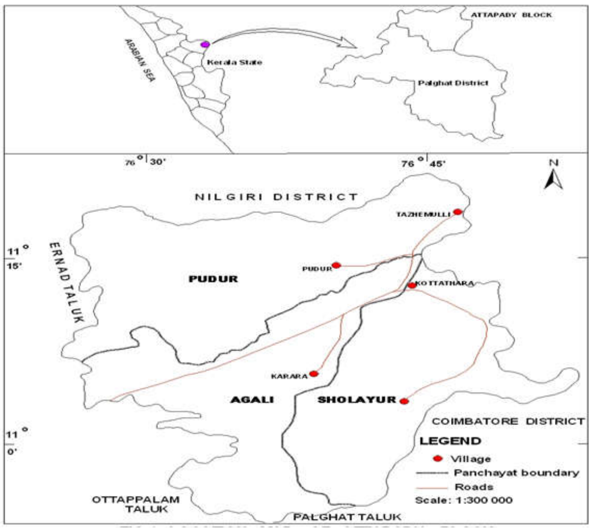

Figure 1 Location Map of Attappady

MATERIALS AND METHODS

The methodology adopted for the present study is shown in below. The base map of Attappady Block was prepared based on Survey of India topographic maps (58A/8, 58A/12, 58A/16 and 58B/9) on a 1:50,000 scale. The drainage network and contours for the study area was scanned from Survey of India (SOI) toposheets and digitized in Arc GIS 9.3 platform. The drainage density and lineament density maps were prepared using the line density analysis tool in Arc GIS. Satellite images from IRS-1C, LISS-III sensor, on a scale of 1:50,000 (geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 43 North) have been used for delineation of thematic layers such as land-use. These thematic layers were converted into a raster format (30 m 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 9.2. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned according to the influence of different parameters (Shaban *et al*., 2006). The weights and ranks have been chosen on the basis of judgment of similar ground water potential identification works carried out by researchers which are shown in Table.1

Table 1 Classification of weighted factors influencing the Ground water potential Zones

Factor	Domain of effect	Rank assigned	Weight
Land Use	Water body	1	
	Crop Land	2	
	Wetland & Marshy Land	3	
	Forest	4	
	Plantation zones	5	
	Grass land	6	15
	Land with scrub	7	
	Land without scrub and fallow land	8	
	Sandy	9	
	Barren rock	10	
	Built up	11	
Geomorphology	Structural- highly dissected	1	
	Denundational-highly dissected	2	11
	Structural- moderately dissected	3	
Geology	Migmatite & Khondolite	1	
	Pegmatite	2	
	Penisular gneissic	3	
	High grade meta sedimentary	4	17
	Charnockite	5	
	Basic	6	
	Meta and ultra basic	7	
Soil	Gravelly loam	1	
	Gravelly clay	2	16
	Clay	3	
Lineament Density	1.6-2.1	1	
	1.0-1.6	2	
	0.5-1.0	3	15
	0-0.5	4	
Drainage Density	5.2-6.9	1	
	3.4-5.2	2	14
	1.7-3.4	3	
	0-1.7	4	
Slop	0-15	1	
	15-30	2	
	30-45	3	12
	45-62	4	
	>62	5	

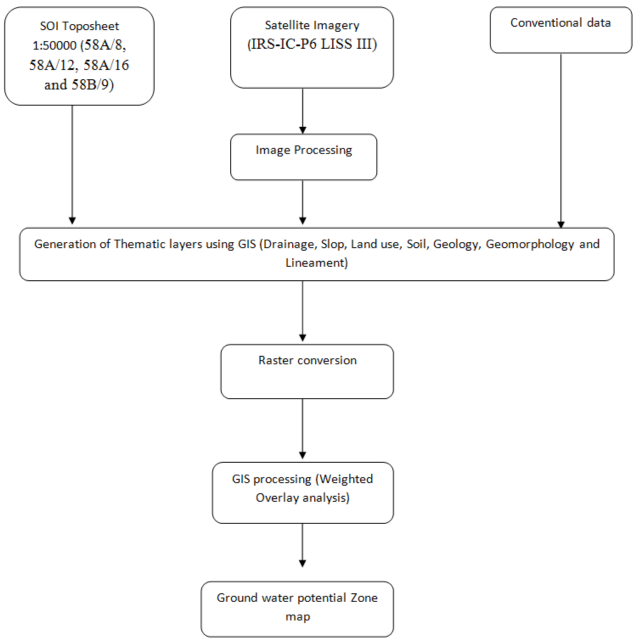

Figure 2 Flow chart for delineating Ground water potential Zones

RESULT AND DISCUSSIONS

The occurrence of ground water in an area is governed by several factors such as drainage, geology, geomorphology, land use, soil type, lineament, slope etc. In the present study, seven influencing factors of ground water such as land-use, Soil, Geology, Geomorphology, Slope, lineament and drainage are identified and thematic layers are prepared.

Drainage Density

Waikar and Adithya (2014) state that drainage basin is natural unit draining runoff water into a common point. Drainage density is an important parameter for identifying ground water potential zones. Drainage density indicates the closeness of spacing of stream channels. The type of drainage and drainage density gives the information related to runoff, infiltration, relief and permeability. Drainage density is inversely proportional to permeability. Hence the high drainage density causes less infiltration and bad ground water potential as compared to low drainage density region (Kamal *et al*., 2017). High ranks are assigned to area with low drainage and vice versa. Based on the drainage density values, study area was grouped into 4 classes as shown in Figure 4.18 and assigned very good (0-1.7 km/km^2), Good (1.7-3.4 km/km^2), poor(3.4-5.2 km/km^2) and very poor(5.2-6.9 km/km^2).Majority of the study area belongs to the category 'good' and 'poor'.

Geology

Geology is considered as one of the most important factor in predicting the ground water potential zone. The study area is underlain by crystalline rock of Archean age. Three major types of lithological units namely charnockite, migmatite and gneissic are found in the study area. Gneisses are the predominant rock type in Attappady. The migmatite and khondolite groups have more porosity for the percolation of ground water, so it has been given high weightage and basic rocks with less porosity has been given less weightage. The weights are assigned to different lithology based on their porosity and permeability. Geology map of study area is shown in Figure.4.

Geomorphology

Gupta (2003) defines "Geomorphology is the study of forms of Earth (landforms), its description and genesis”. The hydrogeomorphology in hard terrain is highly influenced by the lithology and structure of the underlying formation and is considered as one of the most important features in evaluating the ground water potential and prospects (Kumar et.al, 2008). . Geomorphology of an area depends on the structural evolution of geological formation. Geomorphology of the study area is divided into Structural- highly dissected, Denundational-highly dissected and Structural- moderately dissected. Geomorphology of study area is shown in Figure.5. Structural origin- highly dissected hills and valley is the predominant geomorphology of Attappady. Denundational origin- highly dissected type of geomorphology covers a small portion of eastern Attappady and structural origin moderately dissected type occupies the western part of the study area which is shown in green colour. Highly dissected region receives more recharge of ground water and has good prospects, so high rank was given to this type.

Land use

Land use has a significant role in the development of ground water resources of an area. It influences many of the processes in hydrological cycle viz., infiltration, evapotranspiration, surface runoff etc (Waikar and Adithya, 2014). The major land use types of study area are Crop land, Water body, Wetland & marshy, Forest, plantation, grass land, land with scrub, land without scrub and fallow land, sandy, barren rock and built up land. From the land use point of view, areas occupied by water bodies are very high sites for ground water recharge, so it has been given high weightage. Crop lands and forest lands are also good site for ground water potential. Barren rocks and built up lands are prevent the water percolation hence it is categorized as poor for ground water prospects. Figure.6. gives the details of land use of study area. Major land use category of the study area is forest and crop land. Hence in terms of land use ground water potential of Attappady is good.

Soil

Soil is an important parameter in delineating ground water potential zones. Soil of the study area is divided into three main categories namely gravelly loam; gravelly clay and clay are shown in Figure.7. Study area is predominantly covered by clay and followed by gravelly loam. A small portion of western Attappady is covered by gravelly clay. The rank for various soil categories are assigned based on the porosity and infiltration rate of the soil.

Slope

Slop is one of the most significant parameter in delineation of ground water potential zones. The higher degree of slope results in rapid runoff and increased rate of soil erosion with feeble recharge potential (Magesh *et al*., 2011a, b). Figure.8. illustrate the slope map of the study area. Study area, Attappady is categorized into steeply sloping hills. On the basis of degree of slope, study area has been classified into five slope classes such as $0\text{-}15^0$, $16^0\text{-}30^0$, $31^0\text{-}45^0$,$46^0\text{-}65^0$ and $>65^0$.

Lineament Density

Lineaments are structurally controlled linear or curve linear features, which are identified from the satellite imagery by their relatively linear arrangements (Magesh *et.al*., 2012).Lineaments is the result of fracturing and faulting, hence it is the indicator of secondary porosity and permeability. Since the presence of lineament usually denotes a permeable zone, lineament density play a significant role in identification of ground water potential zones. Areas with high lineament density are good for ground water potential zones. High rank was assigned to high lineament density area. The lineament density of study area is shown in Figure.9. Based on the lineament density values, the study area was grouped into four classes; 0-0.5, 0.5-1.0, 1.0-1.6 and 1.6-2.1.

h.Delineating Ground Water Potential Zones

The ground water potential zones of study area, Attappady Hills, Kerala, were generated through integration of various thematic maps viz., land use, drainage, slope, lithology, geomorphology, lineament and soil using geospatial techniques. The ground water potential zones of the study area can be divided into four grades namely very good, good, poor and very poor as shown in Figure.10. The ground water potential zone map demonstrates that the very good ground water potential zone is concentrated in the south-eastern part of the study area due to gentle slope and distribution of forest cover. This indicates that slope and land use play a vital role in ground water augmentation. Moreover, lithology and drainage density also play a significant role in the infiltration ability of the ground water system.

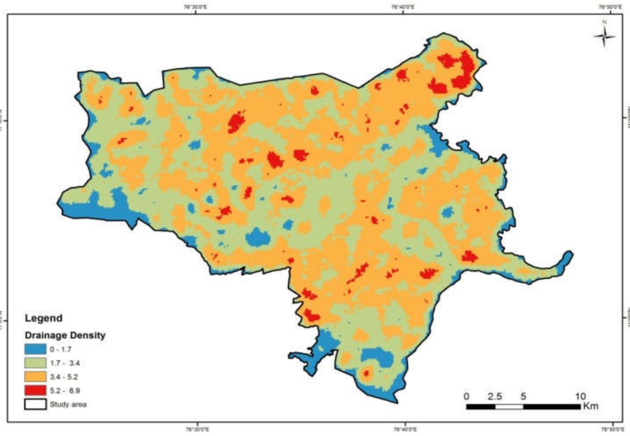

Figure 3 Drainage Density Map of Attappady

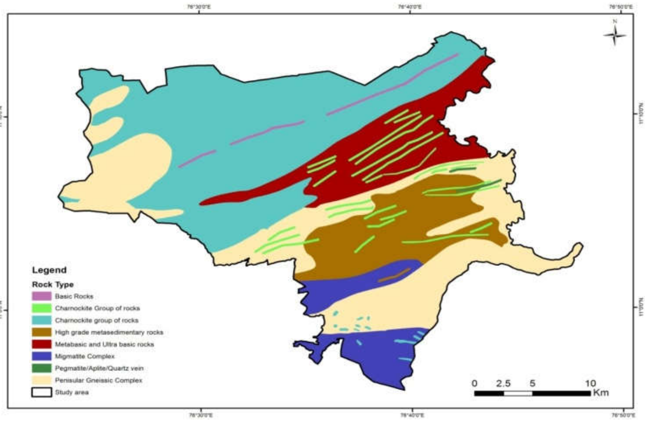

Figure 4 Geology Map of Attappady

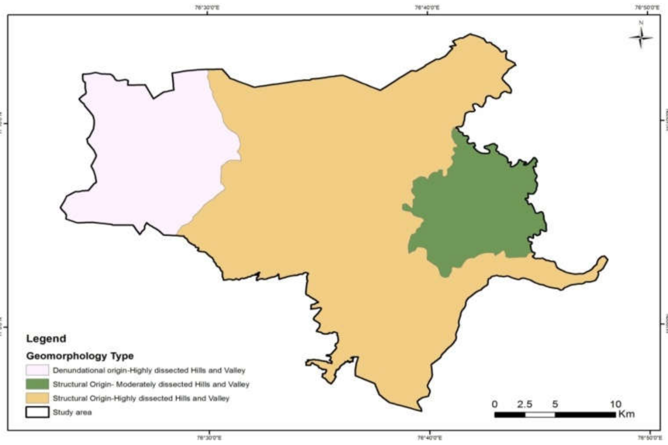

Figure 5 Geomorphology map of Attappady

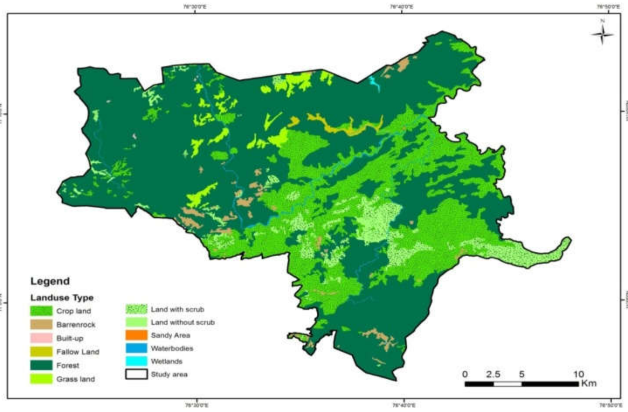

Figure 6 Land Use Map of Attappady

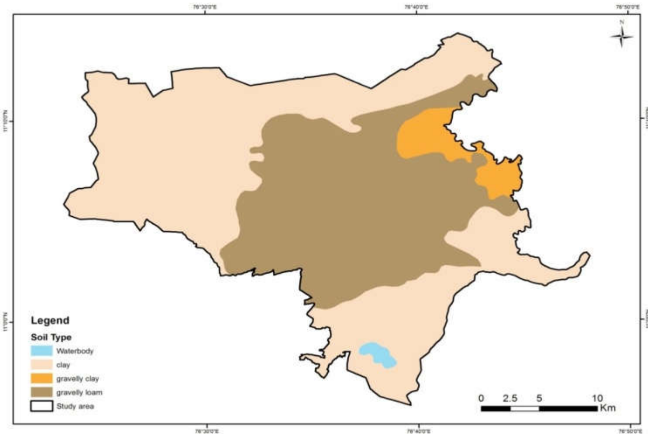

Figure 7 Soil Map of Attappady

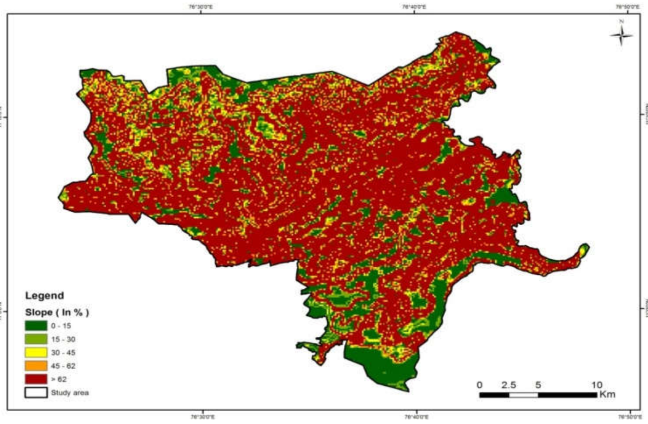

Figure 8 Slope Map of Attappady

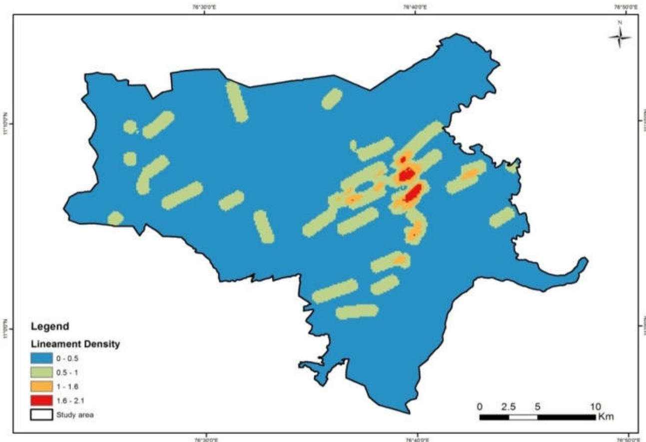

Figure 9 Lineament density Map of Attappady

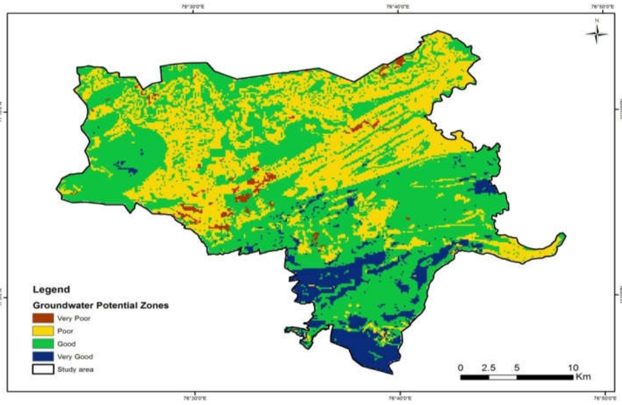

Figure 10 Ground Water Potential Map of Attappady

CONCLUSION

The present study aimed at identifying the ground water potential zone of Attappady Hills using geospatial technique. Delineating ground water potential zone in Attappady Hills of Kerala using Remote sensing and GIS technique found effective and efficient to minimize time, labour and money thereby enables decision making for sustainable water resource planning and management. According to the ground water potential zone map, Attappady Hills categorized into 4 zones namely very good, good, poor and very poor. The results of this study can be used for future ground water development and artificial recharge projects

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