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Delineation of Groundwater Potential Zones in Jalluttu Watershed using Remote Sensing and GIS

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ABSTRACT

The study aim to delineate the groundwater potential zones of Jalluttu watershed, for efficient use of available water resources. Jalluttu watershed is taken to study the groundwater potential zones using Geoinformatics. It occupies an area of 277km2. The study area is located in the eastern part of Salem and Namakkal Districts. The watershed is the part of Vellar basin. The watershed receives 800 mm of rainfall annually and has an average elevation of 964m. This study area also witnesses a rapid outgrowth of settlements and agro-based industries. It is necessary to find out the groundwater potential to support the region's growing population and agricultural activities. The work has been carried out by using the Multi-Criteria Decision Making method. There are eight themes taken (Geology, Geomorphology, Slope, Lineament density, Drainage Density, Soil Texture, Soil depth, Land use and land cover) and layers have been prepared using GIS software. For each theme weightage and ranks were applied to compute the groundwater potential index. Based on the derived statistics of ground water potential index the study area has been classified in to excellent, good, poor, and very poor zones.

1. Introduction

Groundwater is one of the valuable natural resources in the earth that is essential to sustain all human activities. It is vital not only for sustaining human life but also for the economic and social progress of a region. Groundwater is the major water source for all domestic as well as economic activities carried out by human beings. Around the world, groundwater quantity and quality is under acute pressure due to over exploitation, pollution and lack of proper management. Decrease in the level of groundwater can also be attributed to the failure of monsoon. Using remote sensing data and the geographical information system (GIS) for the exploration of groundwater resources is very helpful in assessing, monitoring, and conserving groundwater resources (Magesh et.al.2012). A study conducted on groundwater potential zones revealed that palaeo channels and alluvial plain are the geomorphologic features with excellent potential for groundwater occurrence followed by Aeolian plain (Sitender et.al 2011). Multi-criteria decision analysis has proven to be a excellent decision making tool in the management of natural resources and especially in the field of groundwater studies. (Omid et.al, 2014). Several factors such as high lineament density, high rainfall, lithology with good permeability, low drainage density etc helps in delineating the excellent groundwater potential zones (Mohammadi- Behzad et al, 2018). Since Remote sensing data are economical compared to traditional method of hydrological surveys, it has wide applications in groundwater related researches. Besides this, it is very helpful in identifying various controlling factors of groundwater occurrence sites like slope, geomorphology drainage type and patterns, landuse and landcover etc (Deepesh et al, 2010). About 35% of the world's water source is groundwater and also regarded as one major drinking water sources especially in the arid regions. (Zeinolabedini et. al, 2015). Water scarcity is severe problem faced by both rural and urban population and hence the identification of groundwater potential zones can reduce the stress on groundwater (Venkatesan et.al, 2017). Groundwater quantity can be maintained with the help of artificial recharge by the means of surface spreading, injection of water into wells through non-natural ways, increasing infiltration by changing the stream channels.(Abdul et. al, 2016). Therefore, this study will be helpful to get a deep insight for identifying and delineating groundwater potential zones.

1.1 Study Area

The Jallutu watershed is located in the eastern part of the Salem and Namakkal Districts of Tamil Nadu. The total geographical area of the study area is 277km2. Ayothiyapattinam, Pethanaickenpalayam, Panaimarathupatty, Vennandur and Namagiripettai are villages that cover the study area. The Jallutu River originates from Nainarmalai on the west and flow towards northeast and confluence with Vellar River. (Fig.1).The maximum elevation of the watershed is 964 m and minimum is 253 m .The average rainfall of the area is about 800 mm annually. The study area receives rainfall in both southwest and northeast monsoon season and supported with summer showers. Eastern part of the study area receives more than 800 mm and the western part of the study area receives less than 800 mm. The annual average temperature of the study area is 27°C. The major economic activity in the study area is agriculture.

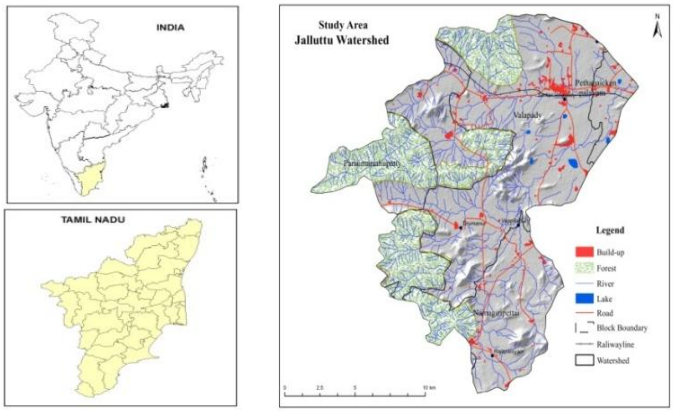

Figure 1: Study area

1.2 Methodology

The present study is an attempt to delineate groundwater potential zones of Jallutu watershed. The Open Series Map No: C44A6, C44A7 published by survey of India were used to trace the stream network of Jallutu River and its watershed has been delineated. Landuse and land cover is prepared from IRS P6 LISS IV false colour composite image of 21-02-2015.Geomorphology of the study area is prepared using satellite image. Lithological units were traced for the study area from the District mineral resource maps of Salem and Namakkal District. The slope of Jallutu watershed is prepared form Cartosat DEM. Annual average rainfall of the study area is prepared by interpolating rainfall station located around the study area and the data was collected form Department of Economic and Statistics government of Tamil Nadu. The detailed soil maps were collected from Tamil Nadu Agricultural University, the datasets were joined spatially and soil texture, soil depth maps were prepared for the study area. The above said thematic layers were assessed for their suitability of groundwater potential and respective weights were given. Further the sub units of each thematic layer were assessed and ranks are given, an each thematic layer's weight and ranks were multiplied. The weighed and ranked layers were overlaid using ArcGIS software. Products of each weight and ranks of each layer were added to in the final layer to bring out the groundwater potential index.

GWPZ= (Ws*Rs) + (Wg*Rg)+ (Wgm*Rgm) + (Wld*Rld) + (Wsd*Rsd) + (Wt*Rt) + (Wd*Rd)+ (Wlu*Rlu)

Based on mean and standard deviation of the groundwater potential index, the study area was divided into excellent, good, poor and very poor.

2. Thematic Layers

In order to understand the potential of groundwater resources in the Jalluttu watershed 8 thematic layers were chosen. The selected thematic layers role and their significance towards groundwater potential are discussed in the following sections. Further, allotted suitable weight and rank of individual layer has been given in table 1 and its spatial distribution is shown in the figures 1and 2.

2.1 Slope

Slope is an important factor in delineating the groundwater potential zones, the study area slope ranges between less than 3 degree and more than 35 degree and slope map is generated from Cartosat, Digital Elevation Model (DEM). Jallutu watershed exhibits a gentle slope towards east and the western part of the study area is under higher slope. About 50 per cent of the study area falls under less than 5 degree of slope. The ranks were given based on the rate of runoff. If runoff is high in slopes rate of infiltration is low and vice versa. Hence, higher priority is given for lower slopes in the slope layer.

2.2 Geology

The lithological composition of the study area is dominated by Charnockite (46.5 %) and Fissile hornblende –biotite gneiss (43.8 %) which indicates the study aera is highly characterized by metamorphic rocks. The following rock types include Ankerite Gneiss, Carbonite, Dunite, Pink Pegmattite, Pyroxene Granulite and Siderite-Ankerite gneiss also present in minor amount. Charnockite and Pyroxene Granulite has been ranked high followed by Pink Pegmatite while Carbonite and Dunite is ranked least.

2.3 Geomorphology

Geomorphology plays a vital role in indentifying groundwater potential zone because it is an indicator of groundwater occurrences through various geomorphic features. Geomorphic features of study area are mapped through interpreting IRS P6 - LISS IV multispectral false colour composite (FCC) image with 5.8 metre spatial resolution and Cartosat DEM. Deep buried pediment, shallow buried pediment, denudational hill and Structural hill are the geomorphic features found in the study area. Among the features deep buried pediment spreads about 40.2 %, structural hill accounts for 38.1 % and shallow buried pediment accounts for 19.8 %. Deep buried pediments ranks high score followed by shallow buried pediments. Structural hill and denudational hills were least ranked.

2.4 Land use /Land Cover

The land use and land cover map is prepared by interpreting IRS P6 - LISS IV multispectral false colour composite (FCC) image with 5.8 metre spatial resolution and survey of India topographic maps. Landuse and landcover of a study area indicates the intensity of human interference with a land surface. The eastern and southern part of the study area is occupied with crop land (22.82 %), fallow land (24.7 %) and plantations (11.2%) of the study area. Forests occupy the major part of the study area in the western part constitutes about 36 per cent of the study area. Settlements and quarries are present in the study area in a scattered pattern. In general land use of the study area shows the land is intensively used for agriculture. Plantation, crop land and fallow lands ranked with higher scores than other land use classes and quarry, land with scrub and land without scrub allotted least rank.

2.5 Drainage Density

Drainage network of the study area is digitized from topographic maps and the drainage layer is overlaid with 500m * 500m grids. The drainage density is calculated for each grid with the length of the stream segment. Higher drainage density is seen along the western and central part of the study area which is associated with structural hills. Higher drainage density has lower infiltration with high runoff hence the chance of

occurrence of groundwater is less, so higher drainage density ranked when compared to low drainage density. The low drainage density exhibits a low run off with a high infiltration hence it is placed higher than the high drainage density. The low drainage density is seen along the eastern and southern part of the study area.

2.6 Lineament Density

Lineaments of the study area are mapped form Bhuvan web map portal and compared with LISS IV FCC. Lineament density serves an important thematic layer in groundwater potential modelling. Numerous research works proved that higher lineament density have higher potential of groundwater. Higher lineament density is seen along central, southern and northwest of Jallutu watershed have high potential for groundwater occurrence. Lineament density provides the secondary porosity for water percolation (Pradhan2009). The lineament density of the study area are classified into Less than 0.5 (low), 0.5 – 1.0 (Medium), 1.0 – 1.5 (high) and More than 1.5 (very high).

2.7 Soil Texture

The soil texture is determined by the composition of sand, slit, clay and loam of a soil. The present study area is occupied by 43 per cent of sandy clay loam, sandy clay loam is found along the central part of the study area and it stretches between north and south directions. Sandy clay found in the western part of the study area and it spread about 13.6 per cent.

Sandy loam is present along the foot hills of study area, which occupies 12.3 per cent of the study area. Clay and silt clay are present along the river courses and either side of the major river course. Clay and silt clay together occupies 10.3 per cent of the study area. Soil present in an area provides a path to reach water to aquifer through infiltration process. Sandy and sandy loam soils have higher porosity than clay and silty clay soil, hence in this study higher rank allotted for sandy and sandy loam soil.

2.8 Soil Depth

Soil depth is also considered as a controlling factor for delineating of groundwater potential zones. The soil depth in the study area is categorized into Shallow (25-50 cm), Moderately shallow (50-75 cm), Moderately deep (75-100), Deep (100-150). Soil with maximum depth has been given high rank while soil in shallow depth was ranked least.

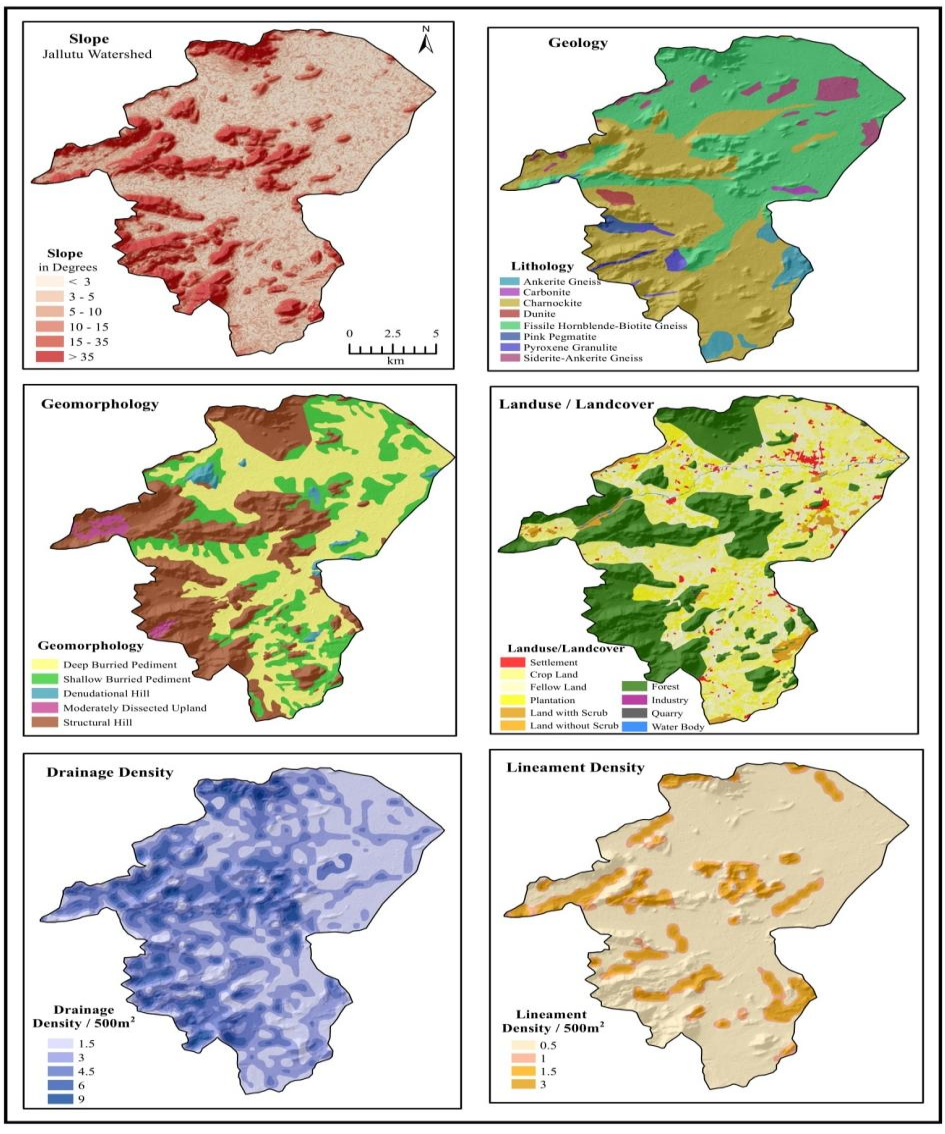

Figure 2. Thematic layers

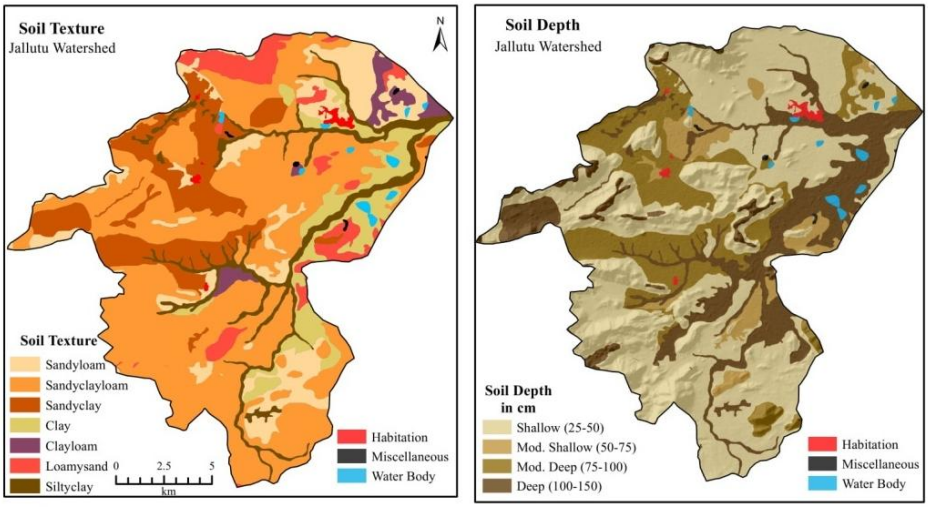

Figure 3. Thematic layers

Table:1

Weightage and Rankings given to Thematic layers

S. No	Layers	Class	Weight	Rank
1	Geology	Ankerite gneiss	0.1	10
		Carbonite		5
		Charnockite		25
		Dunite		5
		Fissile hornblende-biotite gneiss		15
		Pink Pegmatite		15
		Pyroxene Granulite		20
		Siderite-Ankerite gneiss		5
2	Geomorphology	Deep Buried Pediment	0.16	45
		Shallow Buried Pediment		40
		Denudational Hill		5
		Moderately Dissected Uplands		9
		Structural Hill		1
3	Slope	< 3.0	0.12	40
		3.0 - 5.0		20
		5.0 - 10.0		20
		10.0 - 15.0		10
		15.0 - 35.0		5
		> 35.0		5
4	Land use / Land cover	Settlement	0.12	1
		Crop Land		25
		Fellow Land		18
		Plantation		30
		Industry		1
		Land without Scrub		15
		Land with Scrub		5
		Forest		3
		Quarry		1
		River		1
5	Lineament Density	<0.5		10

		0.5 - 1.0		20
		1.0 - 1.5	0.18	30
		>1.5		40
6	Drainage Density	< 1.5	0.12	35
		1.5 - 3.0		30
		3.0 - 4.5		20
		4.5 - 6.0		10
		>6.0		5
7	Soil Depth	Shallow	0.11	10
		Mod. Shallow		20
		Mod. Deep		30
		Deep		40
8	Soil Texture	Clay loam	0.09	5
		Loamy sand		25
		Silt clay		15
		Clay		10
		Sandy loam		25
		Sandy clay		10
		Sandy clay loam		10

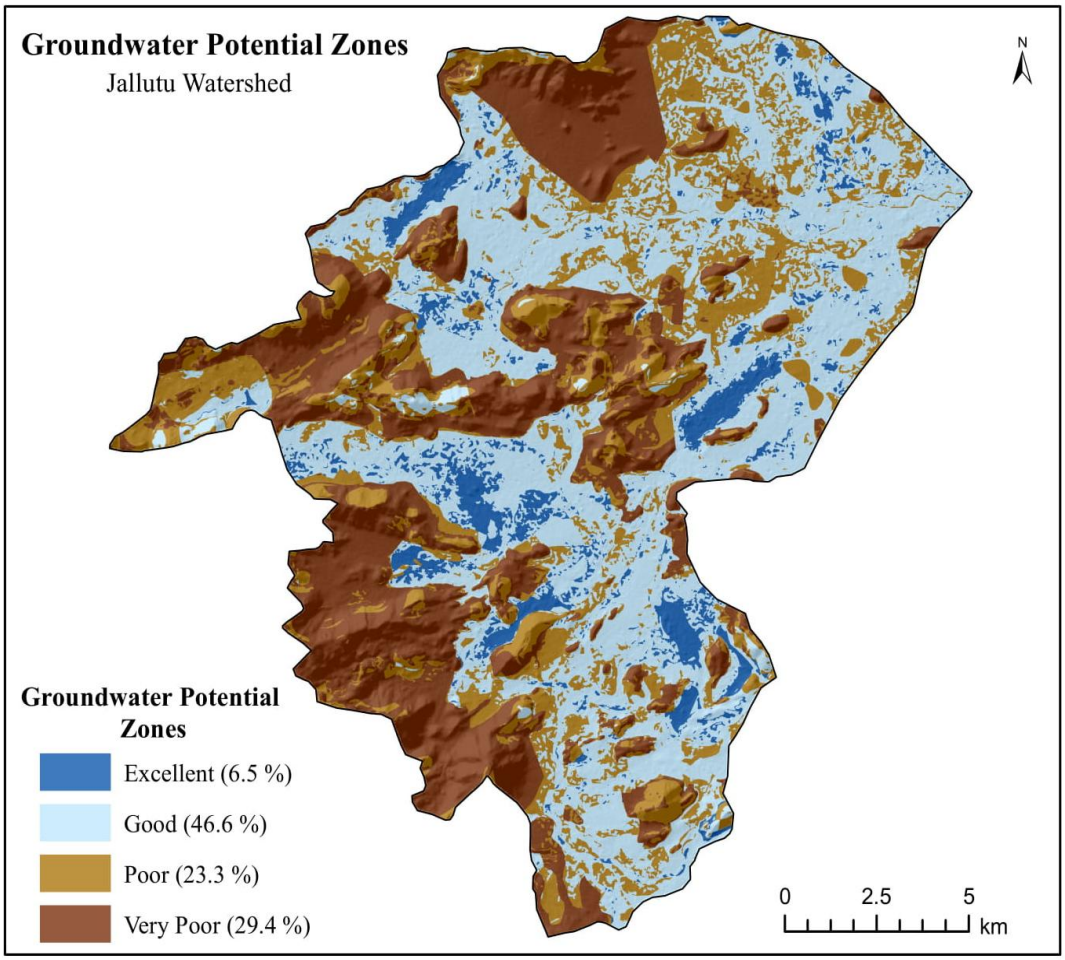

Figure 4. Groundwater Potential Zones in Jalluttu Watershed

Table.2
Classification of Groundwater Potential Zones

S. No	Class	Area (km^2)	Area (%)
1	Excellent	18.24	6.5%
2	Good	112.82	46.6%
3	Poor	64.84	23.3%
4	Very poor	89.95	29.4%

3. Results and Discussion

3.1 Groundwater Potential Zones

The groundwater potential zones of the study area were delineated through the integration various layers (Slope, Geology, Geomorphology, Land use /Land Cover, Drainage Density, Lineament Density, Soil Texture and Soil Depth). The thematic layers were weighted and their sub classes were ranked with their suitability nature of groundwater potential. The weighed and ranked layers were overlaid using ArcGIS software. Products of each weight and ranks of each layer were added to bring out the groundwater potential index. Mean and standard deviation of the groundwater potential index was taken to classify the study area into four class namely excellent, good, poor and very poor (Table 2 and Fig.4). The study reveals that 18.24 km^2 (65 %) area under excellent category, which found along middle, eastern and northwestern part of the study area. An area of 112.82 km^2 is under good for groundwater prospects. The good groundwater prospect zone found along the study area except the area occupied by structural hills along western part of the study area. Poor and very poor groundwater prospects have seen along the structural hills found along the western part, middle and northern part of the study area, It accounts an area of 64.84 and 89.95 km^2 respectively. The streams originate from the hills drain towards plain were support ample of water, similarly sandy loam, sandy clay loam provides very good infiltration along the eastern and southern part of the study area. Deep buried pediments were found in the study area facilitates the occurrence of groundwater. The anthropogenic influences were clearly evident through the land use and land cover map of the study area, in such scenario optimized usage of water is necessary to attain sustainable use of groundwater.

4. Conclusions

In this study, there were eight parameters chosen to delineate the groundwater potential of the study area. It is found that major portion of the study area comes under good category of potential zones and is observed in the study that deep buried pediment, sandy clay loam, low drainage density, high rainfall, high lineament density etc are seen as the contributing factors for occurrence of more groundwater. The geomorphology of the watershed characterized by structural hills, shallow and deep pediments are conducive for occurrence of groundwater. By analysing the land use/land, cover pattern of the area it is evident that intensive agricultural activities practiced by the people are a cause for decrease in groundwater level. About 112.82 km2 (46.6 %) of the watershed area is categorized as potential zones of groundwater. On the whole, it is observed that the watershed possess good groundwater potential zones for extraction. Since resources are scarce and demand for the same is high, proper management and utilisation is needed to maintain its availability.

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