Geo-Spatial Modelling for Demarcating Recharge Zones Using Remote Sensing and Geographical Information System (Gis) in Gangavalli Block, Salem District Tamil Nadu

KEYWORDS

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ABSTRACT *The groundwater scenario in hard rock formation is under great stress due to unbalanced groundwater developments. Due to this, the yield of the bore wells is very low and at many times it is dry. To overcome this issue, the aquifers are recharged through Artificial Recharge structures. The artificial recharge structures are constructed without considering the recharge characteristics of the area. Keeping in view, at attempt has been made to demarcate the zones for artificial recharge in the area using Remote Sensing and Geographical Information System (GIS). The zones are validated with water level data collected from the well located near to the artificial recharge structures constructed in the area.*

INTRODUCTION

Identification of suitable suite for constructing recharge structures is essential to extract benefit efficiently. Integration of information derived from the satellite data interpretation coupled with Geographical Information System makes it possible to identify the suitable structures for construction. Singh et al (1996) and Behera and Mohapatra (1996) have carried out the studies on the application of remote sensing techniques for suggesting suitable sites for soil and water conservation measures in the various watersheds in the country. Rajarajan.K (2008) was carried Analysis of Impact of Artificial Recharge to Groundwater Through Remote Sensing &GIS- A case study in Basavapura Microwater shed in Gauribidnur taluk, Kolar District, Karnataka and Rajarajan.K (2013) had demarcated areas for artificial recharge and water conservation in groundwater contaminated areas through Geographical Information System (GIS) - a case study in Mulbagal taluk, Kolar district, Karnataka. The present study aims at identification of suitable zone for constructing recharge structures through integrating multiple thematic layers generated from satellite data by using GIS spatial logical modelling.

STUDY AREA

The Gangavalli block of Salem district is lies between North Latitudes 11° 00' 30" and 11° 58'30" and East Longitudes 77° 39'0" and 78° 50'30" forming part of survey of India topographical maps Nos. 58E and I. The total geographical area of the Block is 410 Sq.km. and has 27 revenue villages and 14 panchayats (fig-1). Suvedha Nadhi draining the central part of the block is the major water course controlling the drainage in the block. The area is characterised by dentritic drainage. The Block receives the rain under the influence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to the rainfall in the Block. The southwest monsoon rainfall is highly erratic and summer rains are negligible. Rainfall data from two stations over the period from 1901-2003 have been analysed. The normal annual rainfall over the block varies from about 800 mm to about 1600 mm. It is observed that the chances of receiving normal rainfall are minimum (40-50%) around Attur in the eastern part of the block and maximum (50-60%) around Pachamalai in the western and northern parts of the block (Subburaj , 2013)
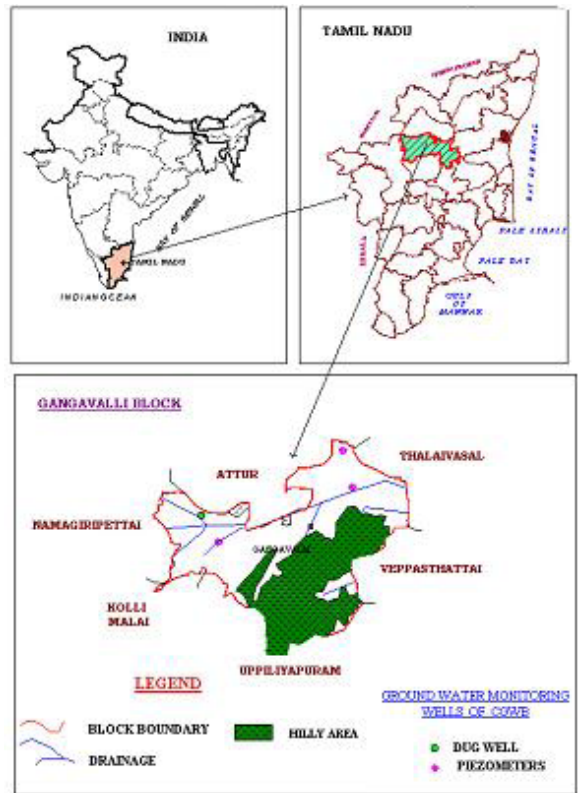

Figure 1: Location Map

METHEDOLOGY

Thematic maps containing details from geomorphology, geology and soil maps have been prepared using IRS-ID, LISS-III data. In addition to that, Weathered thickness map has been prepared using well data collected from the area. All the layers were digitised and generated as geo-spatial data using Map Info GIS. All the layers were integrated in Map Info GIS using Weighted Index Overlay Model.

Spatial Analysis of thematic maps

The thematic maps were assigned theme weight and class

weight based on the ground water infiltration capacity. Index Overlay Model (IOM) was adopted to evaluate the maps. The resultant map was reclassified into four zones according to higher values to lower values of map integration.

Geology
Geologically, the area is mainly consisting by charnockite, gneiss, mylonite and basic rocks of Archaean age (fig-2). The charnockite rock occupies in the southern parts of the area covering 63% of the total geographic area and followed by gneiss occupying 33 % of the area. Basic rocks and mylonite trending NE-SW direction covers only 4% **of the area.**
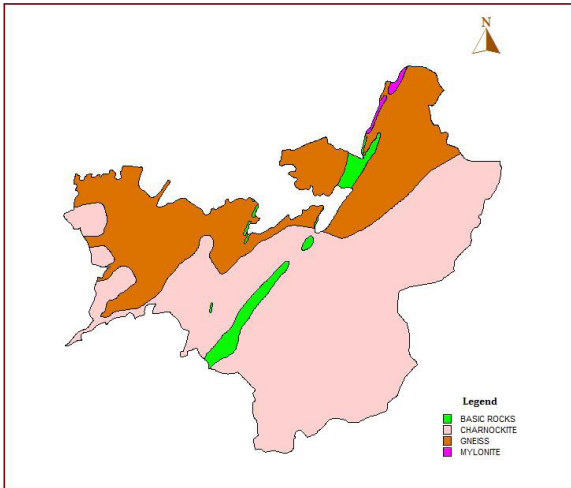

Figure 2: Geology Map of the study area

Geomorphology
The different landforms discernable on the imagery have been broadly classified into Denudational hill, dissected hill and fluvial landforms. The landforms delineated are Hills and plateau, Pediment, pediplain and valley fills (fig-3).
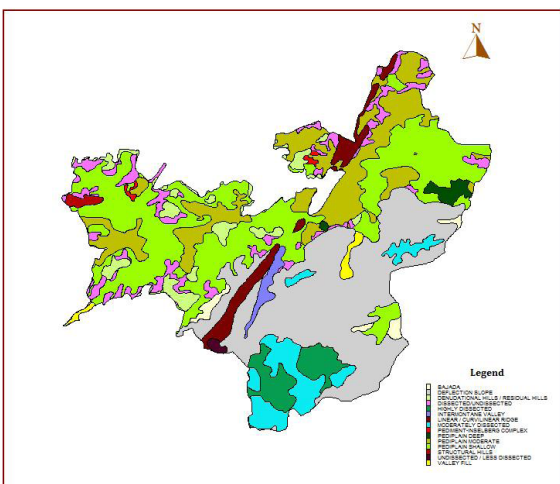

Figure 3: Geomorphology map of the study area

Hills and plateau: Hills and plateau is highly elevated hills prone for dissection and denudation. It devoid or wear very thin soil development. The landforms are undissected / less dissected, intermontane valley, structural hill, deflection slope, moderately dissected, highly dissected,

denudational / residual hill, structural hill, linear /curvilinear ridge. It covers 46.85% of the total geographic area. It acts as run-off zone.

Pediment: Pediment is gently undulating rock surface and wears a thin cover of weathered materials. It has been carved over gneissic formation exposed in the northern part of the area. Pediment zones permit poor infiltration and act as run-off zones, however the fractures, which traverse these zones, could act as good recharge zones. The landforms are bajada, pediment Inselberg complex and dissected / undissected plateaus and it covers only 7.59% of the total geographic area.

Pediplain: This landform is formed by disintegration of county rock. The landforms are pediplain shallow, pediplain moderate and pediplain deep. It is classified on basis of the thickness of the soil development. The pediplain shallow is having thickness of soil ranging from 1-5mts and the pediplain moderate thickness is ranging from 5-10mts. The pediplain deep thickness is more than 10mts. In the study area, the pediplain shallow is covering 28.49% of the total geographic area and followed by pediplain moderate covering 15.47% of the total geographic area. These landforms are falling in the northern parts of the area.

Valley fill: Valley fill has been developed mainly in the valley portions over charnockite due to deposition of unconsolidated materials by fluvial agencies. The materials are silt, fine sand and at places pebbly. The thickness of fill and weathered zones are ranging from 1 to 15 m and it act as good recharge zone.

Soil
Soil map was prepared based on visual interpretation of satellite data and classified into five classes, which are sandy soil, sandy clay, sandy loam, black soil and forest covered soil (fig-4). Sandy soil is occupied along the river course and sandy clay soil is occupied on the uplands of the area. 42% of the area is occupied by forest area soil and followed by the sandy clay covering 27% of the area. The sandy soil is covering 24 %of the area.
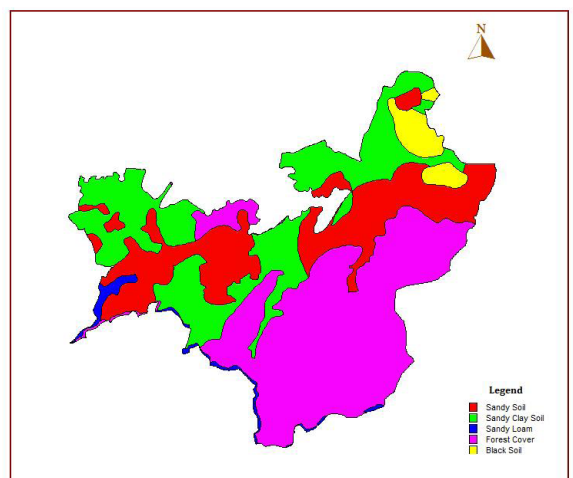

Figure 4: Soil map of the study area

Weathered thickness:
Weathered thickness map has been prepared based on the dug well data collected from the field. A total 28 nos of Dug wells were established in the area and collected

depth, weathered thickness and water level data. Based on the weathered thickness, the four classes were demarcated such as 1. 2-4m, 2. 4-6m, 3. 6-8m and 4. 8-10m. Weathered thickness 2-4mts class is covering in the southern and northwestern parts of the area. The weathered thickness 4-6m is very predominant in the area covering 45% of the total geographic areas. The weathered thickness 6-8 m is found in the eastern parts of the area, covering 225 of the area.
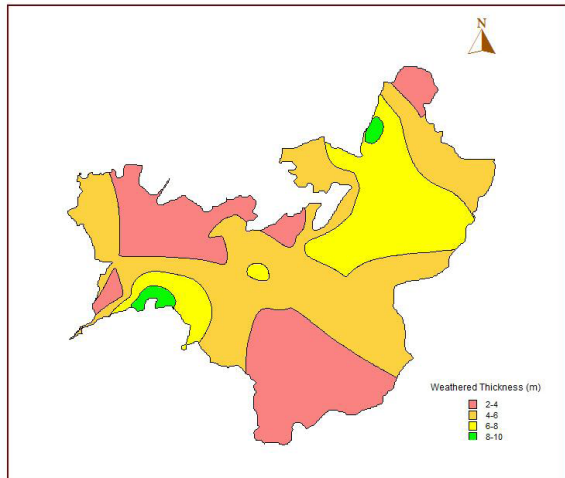

Figure 5: Weathered thickness map of the study area

TABLE-1

THEME WEIGHT AND CLASS				
Sl.No	Theme	Theme weight	Class	Class weight
1	Geology	25	Charnockite	8
			Gniess	10
			Mylonite	7
			Basic Rocks	1
2	Geomor-phology	30	Undissected / Less dissected	1
			Intermontane Valley	7
			Structural Hill	1
			Bajada	5
			Deflection Slope	1
			Denudational Hills / Residual Hills	1
			Dissected / Undissected	1
			Highly Dissected	6
			Linear / Curvilinear Ridge	1
			Moderately Dissected	5
			Pediment Inselberg Complex	1
			Pediplain deep	10
			Pediplain Moderate	9
			Pediplain Shallow	8
			Valley fill	9
3	Soil	20	Sandy Soil	10
			Sandy Clay Soil	7
			Sandy Loam Soil	1
			Forest Soil	8
			Black Soil	1
4	Weathered Thickness	25	2 - 4 m	7
			4 - 6 m	8
			6 - 8 m	9
			- 10 m	10

Unsuitable zone: This zone is influenced by hill and plateau landforms of charnockite and gneissic rock formation. This zone is occupied in forest cover soil with weathered thickness ranging from 2 to 6m. This zone is covering 40% of the total geographic area.

Poorly suitable zones: This zone is influenced by moderately and highly dissected plateau landform with the forest soil cover. Charnockites and 2-4m weathered thickness are found in this zone. This zone occupies a total of 17 % of the area.

Moderately suitable zones: This zone is highly influenced by pediplain shallow and moderate landform formed in gneissic formation with sandy soil and sandy clay soil. The weathered thickness ranging from 4 to 8 mt is occupied in this zone.

Theme weight and Class weight
Based on the infiltration characteristics of the landforms, geology, soil and weathered thickness, weights were assigned to all the classes of each theme. The weights of the each class of the theme are given between 1-10 scale. The weight for theme was also assigned to the total of 100. The weight of the theme is based on the recharge potentials of the theme. In the study area, geomorphology is given higher weight and followed by the other themes. The details of the weight assigned are given in table-1.

Recharge zones
Based on the integration of multiple thematic maps using weighted average index overlay model with help of GIS, four zones were demarcated in the area. They are unsuitable, poorly suitable, moderately suitable and highly suitable zones (fig-6).
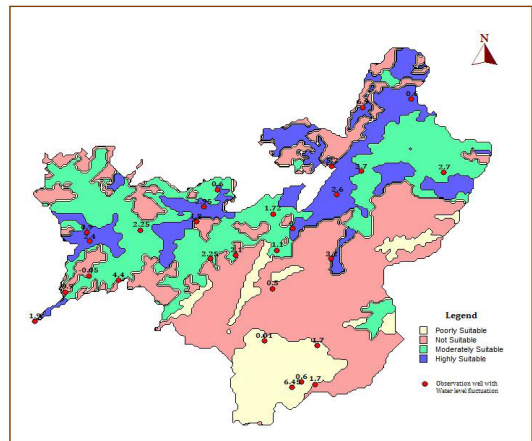

Figure 6: Weathered thickness map of the study area

Highly suitable zones: This zone is occupied in the eastern and western parts of the area. This zone is highly influenced by the pediplain moderate, pediplain deep and valley fill with weathered thickness ranging from Validation of Recharge zone Groundwater recharge structures were constructed in the area during 2006 and 28 nos dug wells were established in and around the structures to monitor the groundwater level periodically. The recharge zones are validated with groundwater level of 2009. The details of the dug well are presented in table-2.

A total of 9nos of well is falling in highly suitable zones and the groundwater level fluctuation in those well is ranging from 0.00 to 6.9 m. The difference between pre and

post monsoon water level is very less. It indicates that the groundwater recharge in this zone is very active. In the moderate suitable zones, 9 nos dug well are falling in which the water level fluctuation is ranging from -0.05 to 4.4m. The negative fluctuation is because of the damaged structures. The most of the dug well is having the water level fluctuation more than 2.00 mts. In poor suitable zones, 7 nos dug wells are falling. The water level fluctuation is ranging from 0.01 to 6.45. The most of the dug well is showing less than 2mts. In not suitable zone, 4 nos of dug well is falling. The water level fluctuation is ranging from –0.9 to 2.25m. In this zone, the water column can be raised upto 2m. It indicates that the groundwater recharge is not active.

TABLE-2

DETAILS OF THE DUG WELL,DEPTH, EATHERED THICKNESS, WATER LEVEL FLUCTUATION IN THE STUDY AREAS

Location	Depth of Dug Wells (m.bgl)	Weathered Thickness (m)	Water Level (m.bgl)		Water Level Fluctuation (m)	Water Level (m.bgl)		Water Level Fluctuation (m)
			Jul-06	Jan-07		May-08	Jan-09	
Gangavalli	23.00	5.00	8.00	11.50	-3.50	9.00	3.80	5.20
Kondayayampalli	12.44	3.00	10.75	8.60	2.15	7.30	5.50	1.80
Kondayayampalli	7.20	3.00	5.15	6.20	-1.05	5.90	5.30	0.60
Naduvalur- East	15.40	4.00	6.80	12.60	-5.80	9.20	8.60	0.60
Kondayayampalli	17.20	2.50	9.25	13.20	-3.95	10.40	N/M	N/M
Gudamali	15.40	4.00	6.80	7.90	-1.10	6.80	6.30	0.50
Thammampatti	26.90	7.00	21.90	13.55	8.35	13.00	9.00	4.00
Nagiyampatti	21.90	7.50	12.10	12.50	-0.40	12.10	6.95	5.15
Koneripatti	11.82	8.00	10.40	10.70	-0.30	6.40	3.55	2.85
Sendarapatti (MM-III)	25.00	6.00	12.90	10.25	2.65	4.15	N/M	N/M
Gudamali	9.12	4.00	6.98	8.70	-1.72	7.20	6.10	1.10
Naduvalur- West	35.10	9.00	19.70	6.50	13.20	17.00	10.10	6.90
Manmalai-1	20.22	7.00	10.10	9.70	0.40	9.00	6.90	2.10
Manmalai-11	13.40	4.5	9.50	9.80	-0.30	9.40	7.15	2.25
Odaikadu	13.60	4.00	9.00	3.80	5.20	2.90	2.30	0.60
Chinnamangalam	6.45	2.50	6.30	7.15	-0.85	3.50	1.80	1.70
Valakombai	22.70	10.00	9.60	13.50	-3.90	15.80	11.40	4.40
Ullipuram	5.60	3.30	3.80	4.50	-0.70	3.70	3.50	0.20
Chinna Nagoor	13.02	3.00	10.20	3.20	7.00	2.85	2.20	0.65
Periya Nagoor	9.98	3.30	4.38	5.50	-1.12	4.00	2.30	1.70
Mayambadi	4.00	2.00	1.22	2.20	-0.98	1.07	1.06	0.01
Odalkattu pudur	13.60	4.00	9.00	3.20	5.80	9.10	2.65	6.45
Thagarapudur	15.70	6.00	6.60	9.20	-2.60	9.00	6.05	2.95
74-Krishnapuram	18.60	6.00	9.60	10.20	-0.60	6.90	4.30	2.60
Gudamali	12.50	3.00	6.90	6.55	0.35	6.02	4.30	1.72
Othiyathoor	8.20	3.00	3.00	7.50	-4.50	6.30	2.90	3.40
Analkarapatti	9.60	7.00	7.30	6.20	1.10	6.10	6.10	0.00
Serdi	6.62	4.00	4.50	3.10	1.40	4.45	2.55	1.90
Ninankarai	5.20	3.00	4.10	6.00	-1.90	2.60	N/M	N/M
Seradi east	7.44	3.00	5.24	5.50	-0.26	5.90	5.70	0.20
Malpull	10.20	6.00	9.10	6.85	2.25	5.45	2.25	3.20
Gandhinagar	11.75	3.00	7.08	9.20	-2.12	5.20	4.30	0.90
Vasanthan nagar	12.16	5.00	9.60	9.70	-0.10	7.50	5.10	2.40
Goundampalayam	8.20	3.00	7.78	7.00	0.78	4.50	2.25	2.25
Kanaavaikadu	8.63	7.05	8.34	5.40	2.94	4.80	2.10	2.70
Tidavur (Tank)	9.25	6.00	1.40	4.23	-2.83	3.00	0.30	2.70

Conclusion

The geo-spatial data such as geology, geomorphology, soil and weathered thickness have been integrated using weighted index overlay model to demarcate suitable zones for recharge to groundwater. The zones were validated with the groundwater level of dug well located in and around the recharge structures. The zones are matching with water level fluctuation in the area. It indicates that this geo-spatial data integration model can be applied in other area where the groundwater is recharged.

Acknowledgement

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