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IDENTIFICATION OF GROUNDWATER RECHARGE ZONES AND ARTIFICIAL RECHARGE STRUCTURES FOR PART OF TAMIL NADU, INDIA - A GEOSPATIAL APPROACH

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ABSTRACT
Water is essential for the existence of all forms of life for human consumption, agriculture and industrial. This is the reason why the man has moved and settled only in areas of rich water resources. As the population has started growing and unregulated usage of surface water resources has been initiated in multiple fronts the available water is not able to cope up to human needs. So, the man has aggressively and competitively started mining the ground water reservoirs all over the world using all the possible and available modern technologies. Hence the ground water have started playing some dividend, so to replenish the extracted water from the underground reservoirs definite newer avenues are to be created, so that there exists equilibrium between the extraction and the replenishments. A large amount of rain water is lost through runoff, a problem compounded by the lack of rainwater harvesting practices (Murugiah M & Venkatraman P 2013). So, a technique of pushing the rain water into the deeper part of the aquifer system is called Artificial Recharge. The main objective of the study is to identify suitable sites for artificial recharge and also to identify the site specific mechanisms such as sites for desiltation of tanks, percolation ponds, check dams, pittings and enechelon dams etc, in the study area through Geospatial technology. To attain this Remote Sensing Technology is the good tool in mapping such geological features related to artificial recharge, due to its multispectral photo capturing capacity and repeativity coverage, where as GIS Technology got special and advanced merits, in storing archiving, manipulating, modelling and retrieving of huge amount of various spatial and non spatial data.

KEYWORDS: Groundwater recharge zones, Artificial recharge structures, Remote Sensing and Geo-Informatics.

INTRODUCTION
Artificial recharge defined as a process of induced replenishment of the ground water reservoir by human activities. Therefore, any man-made facility that adds water to an aquifer may be considered as artificial recharge (CGWB, 1994). Managed aquifer recharge is defined as the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in the corresponding increase in the amount of groundwater available for abstraction (UNEP). It is useful for reducing overdraft, conserving surface run-off and increasing available ground water supplies. Artificial recharge Provide subsurface storage and maintains the natural ground water as an economic resource. Artificial recharge has now been accepted world-wide as a cost-effective method, to augment ground water resources in areas where continued overexploitation without due regard to their recharging options has resulted in various undesirable environmental consequences. As the population increased, settlements developed into towns and cities and agriculture expanded.Techniques were developed to augment water availability by collecting and storing rainwater, tapping hill and underground springs etc. Hence, the availability of high technology like Remote Sensing (RS), Geographical Information System (GIS) need to be used and the holistic models are to be brought out to meet out the demands of the people.

REVIEW OF LITERATURE
Replenishing the groundwater aquifers through artificial recharge was carried out in various parts of the world for the last six decades. However, the importance of artificial recharge was realized in India only about four decades ago (Karanth 1963). In the recent years, many studies concentrated on application of remote sensing and GIS for

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artificial recharge (Anbazhagan 1994, PhD thesis, Anbazhagan and Ramasamy 1993 etc.,). Some of the literature describes RWH for groundwater recharge as artificial recharge (Bouwer 2002). However in much of the literature, RWH is considered part of 'managed aquifer recharge', which also includes artificial recharge, enhanced recharge, water banking and sustainable underground storage (Dillon 2005; Gale 2005).

STUDY AREA

The study area lies between 78°25'40"E to 785°7'42"E' longitude and 10°8'36"N to 10°44'19"N latitude and covering area of nearly 2084 Sq.Km (Figure 1). The area experiences different climate depending on the altitudes. Summer, Rainy, winter seasons are prominent and experience from April to June, September to December, January to March respectively. The average mean rainfall for the past 70 years (1927 – 96) is to order of 733mm in the area. Water resource depends on the nature of the rock types and the physiographic conditions. The ground water occurs under water table conditions in the weathered and the fractured zones of the crystalline rocks in the study area. The quality of water is good in major part of study area, in general and contains less than 482 ppm of dissolved solids and chloride content of about 100ppm. Number of tanks has been identified in the study area. Sub surface geological data and also the geophysical data have been collected to understand the water resources scenario.

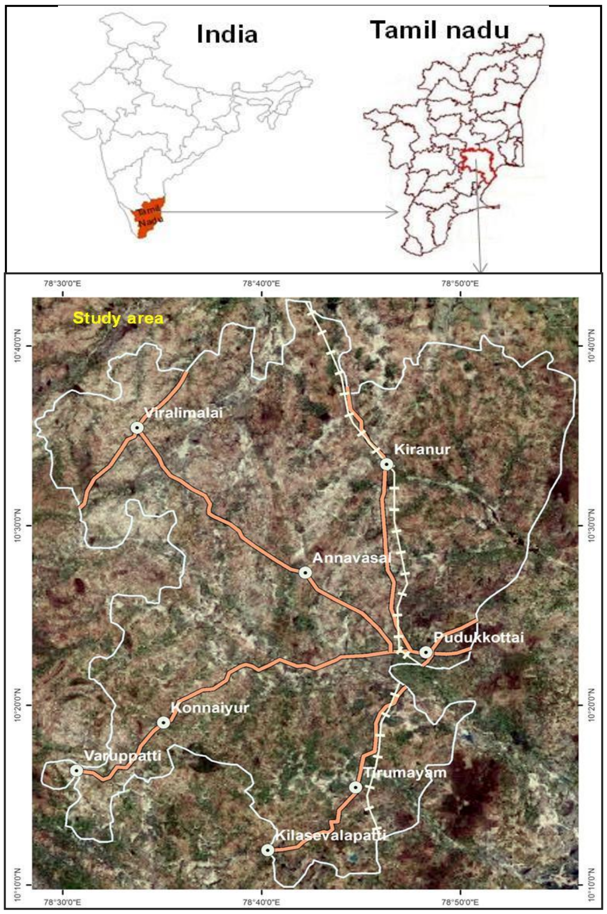

Figure 1: Study Area

OBJECTIVES:

Assessment of physiographic features like drainage systems (streams and water bodies), slope, land use /land cover, soil and geology/hydrogeology etc. and identification of suitable sites for groundwater recharges zones and artificial recharge structures through Geospatial technology.

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DATA USED

IRS 1C / 1D LISS – III FCC on 1:50,000 scale images aquire form NRSC, survey of India topographic sheets on 1:50000 scale, geophysical resistivity data collected from Public Works Department (PWD) for 117 locations and Geology map collected from geological survey of India map.

METHODOLOGY

For identification of rainwater harvesting structures in the study area different thematic layers were used from primary and secondary sources such as IRS 1C /1D geo-coded data and survey of India topographic sheets on 1: 50000 scale. From the IRS 1C / 1D LISS III geo-coded photographic products, four thematic maps have been prepared such as Structural trend line, Lineament, Geomorphology and Land use/Land cover maps. From the survey of India topographic sheets three thematic maps have been prepared such as Drainage, Slope and Tank maps. From the data collected from the public works department reports, two thematic maps have been prepared such as water level map and depth to bed rock map. From the geological survey of India reports, the geology map of the study area has been prepared. Limited field check have been carried out for confirmation of details obtained from the Remote Sensed data, GIS databases were generated for all thematic layers, these data bases were integrated and analysis was carried out for preparing artificial recharge structures. Methodology flow chart shown below (Figure 2)

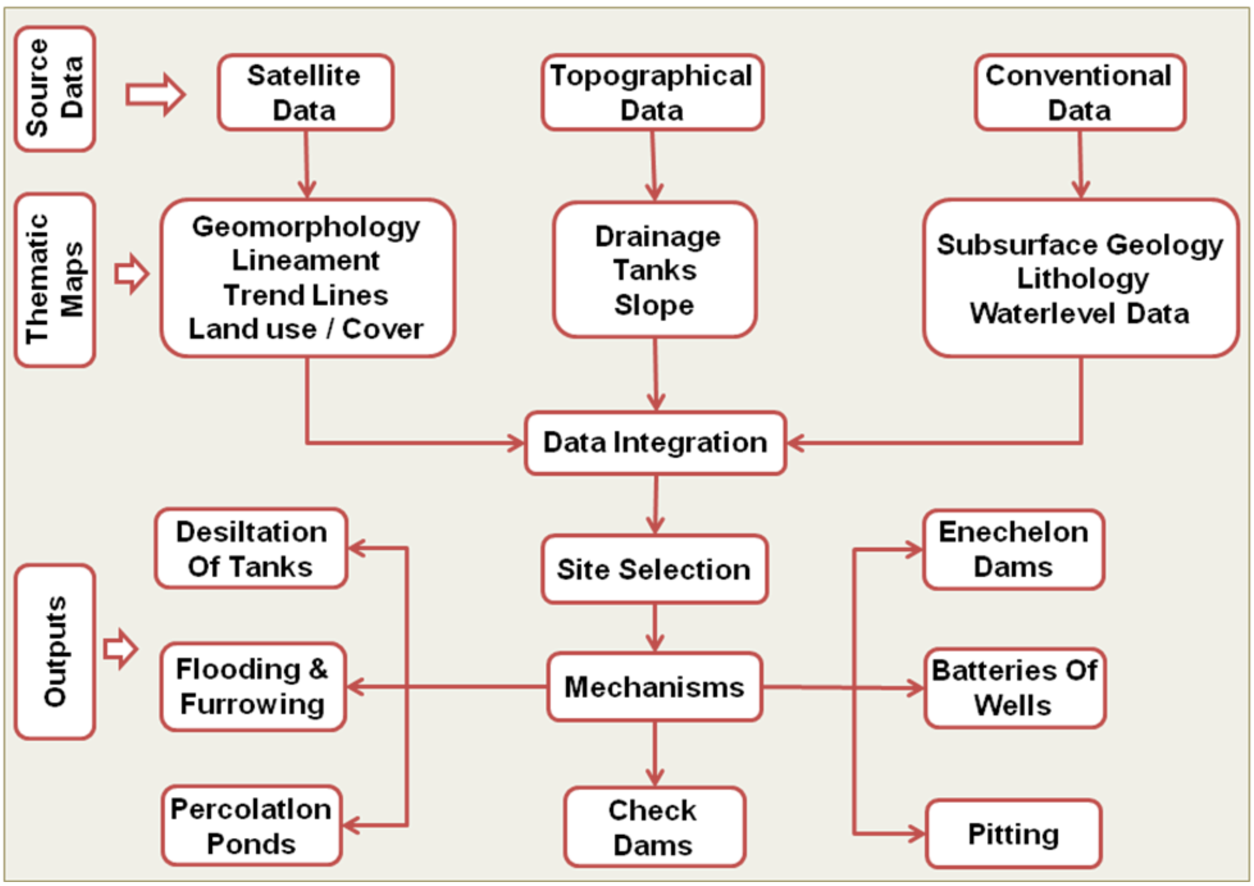

Figure 2: Methodology flow chart

RESULTS AND DISCUSSION

THEMATIC LAYERS

Any hydrological investigation and artificial recharge studies involves the preparation of number of thematic databases like geology, geomorphology, lineaments, structural trendlines, land use / land cover, slope and drainage etc. of the study area. As the main purpose of the study is the site selection for artificial recharge, it is necessary to understand the different land forms and their characteristics. Hence the reliability and dependability of ground water resources especially in artificial recharge of ground water depend on the detailed study of the above said themes. The studies in this aspect are being carried out for the past several decades through traditional conventional based surveying and mapping methods which takes a lot of time, more man power and cost. But nowadays the emerging satellite based Remote Sensing & GIS techniques have become a more efficient tools for obtaining such information with less cost and faster. In the present study, numbers of thematic maps have been prepared as shown below.

Lithology: The lithology map was prepared by using already existing geology and mineral map of the study area (geological survey of India map) and it was counter checked by the intensive field check. The study area exposes quartzite charnockite, pegmatite/quartzite veins, pink granite/granite gneiss, calc –gneiss / calc granulites /crystalline limestone and grey migmatite/hornblende-biotite gneiss-grey granulite, garnet granulite (Figure 3a).

Lineament Architecture: Lineaments are defined as linear and curvilinear features of tectonic origin, Observed to a considerable distance on the earth surface. Hobb (1912), was the first person to coin the term, subsequently many people have carried out work on the lineaments. Lineament analysis for ground water recharge in study area has considerable importance as joint/fractures and faults serve as conduits for movement of groundwater. Lineaments are observed in satellite data these lineaments normally show tonal, textural, soil tonal, relief, drainage and vegetative linearities and curvi linearities in satellite data. All these linear features were interpreted from the satellite data and the lineament map was prepared (Figure 3b).

Lineament density: The entire study area was girded into 2084 grids of 1 sq.km each. The lineament map was superimposed over the grid map and the total length of the lineaments was counted for each grid, plotted in the corresponding grid centre and contoured using Surfer software. These contours were designated as lineament density diagram. After removing the anomalous values the area falling in low, medium and high lineament density zones were demarcated.

Lineament anomaly pattern: From the shape of the lineament density contours the linearity maxima axes were drawn along the crest of the contours of elliptical shapes with maximum value in the core and successive lesser and lesser values encircling them.

Fold style: The structural trends were seen in IRS 1C / 1D LISS – III FCC on 1:50,000 scale images as long and liner features in the area. These linear structures were observed in the form of soil tone, vegetation, relief and drainage linearity and curvilinearities. A detailed satellite image interpretation was made to bring out these structural trends GIS database was prepared (Figure 3c).

Geomorphology: Geomorphology is the branch of geology concerned with the structure, origin, and development of the topographical features of the earth's surface. Landforms are the important surficial indicators to select the suitable sites for artificial recharge. So in the present, study an attempt was made to prepare detailed geomorphologic map on 1: 50,000 scale using IRS 1C / 1D LISS – III geocoded data. Each and every landform has their own physical characters hence these land forms express distinct morphometric expression of their own in the satellite images so photo recognition elements like tone, texture, shape, size, associated features etc., have been utilized in delineating the different landforms. Geomorphologically the study area consists of residual hills, Linear ridges, Inselbergs, Lower plateau (lateritic), Pediment, Buried Pedi plain deep, Buried Pedi plain medium, Buried Pedi plain shallow, Alluvial plain older, Alluvial plain younger etc, were identified in the present study area (Figure 3d).

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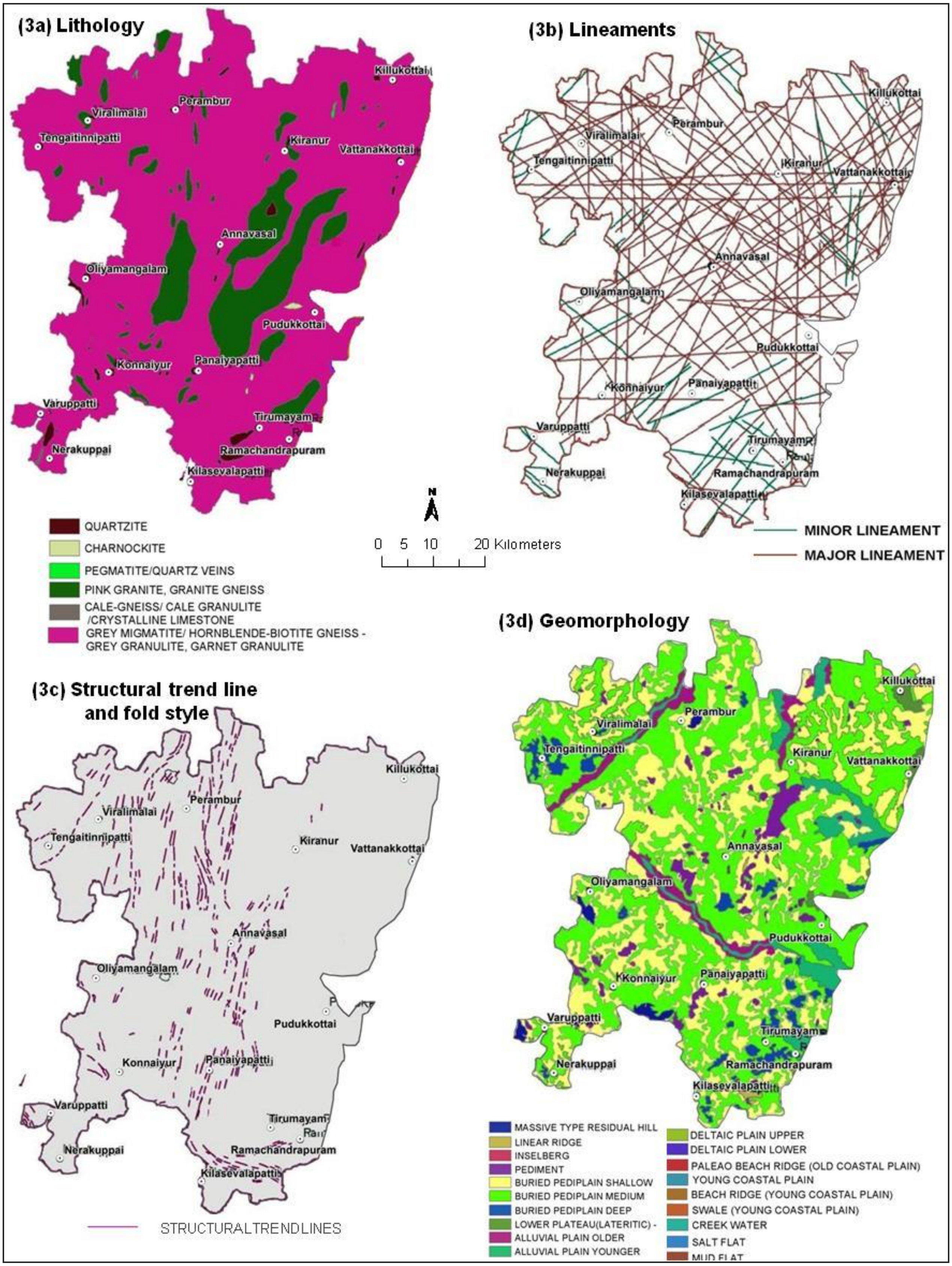

Figure 3: Thematic layers (geological related)

Land Use / Land Cover: Land use refers to "Man's activities and various uses which carried on land". Land cover refers to "Natural vegetation, water bodies, rock / soil, artificial cover and other resulted due to land transformation. Standard Land use / Land cover classification developed by NRSA (IMSD 1995) and NRIS (National Natural) resource information system has been followed. In the present study Land use / Land cover map has been prepared on 1:50,000 scale using IRS 1C / 1D LISS – III geocoded data. Land use map was prepared from satellite data using the photo interpretation elements and comparing with topographic sheets, it was further confirmed by limited field check. Different Land use / Land cover classes of the study area consists of Towns / cities, Villages, Tanks, River, Cropland, Fallow land, Plantation, Land with Scrub, Land without Scrub, Barren rocky / stony waste, Gullied / Ravenous land, Mining area, Open forest, Semi evergreen forest, Sandy area, Mud flat, Saltpans and Aquaculture land etc (Figure 4a).

Slope Morphometry**:** Slope is yet another important parameter in artificial recharge investigations. If the slope is high then there is no time given to the water to percolate downwards, instead surface runoff will be more. If the same water need percolated downwards means, the slope should be negligible or very less. Survey of India topo sheets have been used for the preparation of slope map. The contours were firstly transferred onto tracing sheet. Such contours were having an interval of 20mts on 1: 50,000 scale, then by measuring the distance between two contours, the slope was demarcated in to several categories as shown below in Table 1. In the study area major portion coming under 0-1 % of slope which indicates that the area is a plain country (Figure 4b).

Table 1. Slope categories

S.NO	CATEGORY	% SLOPE
1	Nearly level plain	0-1%
2	Very gently sloping	1-3%
3	Gently sloping	3-5%
4	Moderately sloping	5-10%
5	Strongly sloping	10-15%
6	Moderately steep to steep sloping	15-35%
7	Very steep sloping,	>35%

Drainage / Water Bodies: Drainage refers to the area whose rainfall being drained into the rivers. Drainage network helps in the delineation of water shed and for suggesting various water harvesting structures. The amount of water reaching a stream system depends upon the morphometry of the basin, total precipitation, losses due to evapotranspiration and absorption by soil and vegetation. The drainage basin morphometry throws light on the lithological and structural controls of the basin; relative runoff, recharge, erosion aspects and stage of development of basin itself. Water bodies show light blue to dark tone in satellite data. River stream and tanks have been identified and interpreted from toposheets and then compared with satellite data for minor corrections (Figure 4c).

Drainage density: The entire study area was girded into 2084 grids of 1 sq.km each. The drainage map was superimposed over the grid map and the total length of the drainage was counted for each grid plotted in the corresponding grid center and contoured using Surfer software. These contours were designated as drainage density diagram. After removing the anomalous values the area falling in low, medium and high were demarcated and GIS database was prepared.

Water levels**:** Water level of an area speaks about the availability of ground water from the surface and generally follows the topography and altitudes. Shallow water level indicates that the area had already saturated or bestowed with water whereas deeper water level indicates the poor ground water conditions. For the preparation of water level map, data has been collected from Public works department for 59 wells of 360 months. The 360 months of average annual water level data has been calculated for each location and fed into SURFER software for contouring. These contours were classified in to three zones as deep, medium, shallow (Figure 4d).

Sub Surface Geology: In the study area, geophysical resistivity survey was conducted by PWD for 117 locations and the same data was used for the analysis and detailed database generated on Sub surface geology. From the analysis we can get the data on depth to bedrock for each point for the entire study area. These locations with their depth to bedrock values are fed into the SURFER software for contouring. These contours were classified in to three zones as deep, medium, shallow.

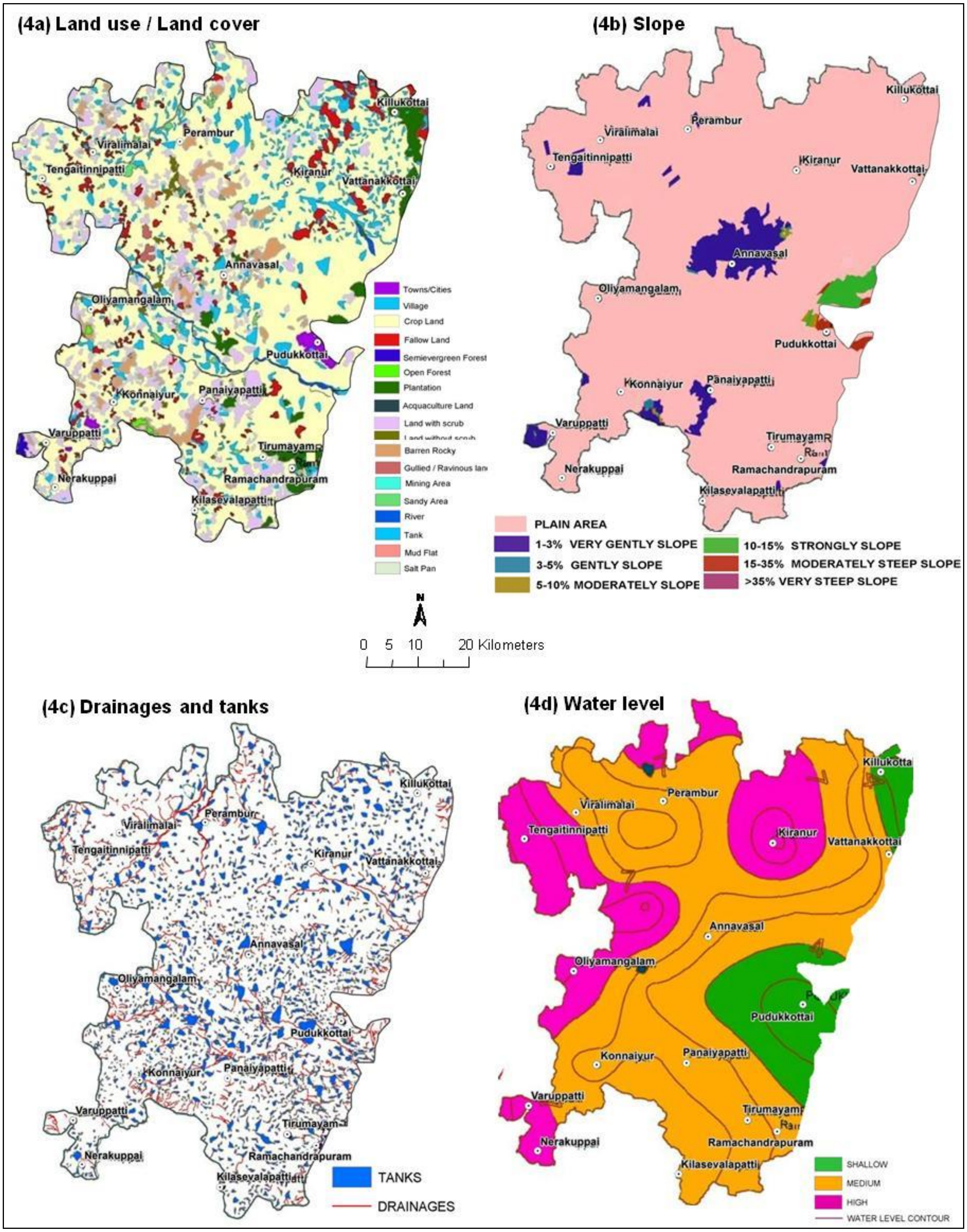

Figure 4: Thematic layers

SPATIAL MODELLING AND WATER RECHARGE

The terrain conditions play an important role in controlling the recharge, different terrain parameters such as lineament density, slope, drainage, drainage density, depth to bed rock and water level data were thematically integrated and suitable areas were identified accordingly. Scientifically selecting the suitable sites for artificial recharge, one has to identify suitable site-specific mechanisms also, in order to obtain full efficiency from such\recharge structures, such as Sites for desiltation of tanks, flooding and furrowing, percolations ponds, check dams, pitting, batteries of wells, en-echelon dams and hydrofracturing etc.

Site selection: For selection of suitable sites for artificial recharge, the zones of poros lithology, lineament density maxima, pervious geomorphic units, zones of less than 3º slope, drainage density maxima zones, Land cover like scrubland, cropland, fallow land, depth to bed rock maxima zones etc were buffered out from different maps and added using add function in GIS environment. This output was overlayed with zones of deeper water level and where ever polygons of intersection were there those areas were identified as better area for recharge (Figure 5a).

MECHANISMS FOR RECHARGE

Sites for desiltation of tanks: The map showing all the existing tanks was superposed over the map showing suitable areas for artificial recharge and wherever such already available tanks fell in such selected zones they have been recommended for desiltation (Figure 5b).

Sites for flooding and furrowing: The areas having plain slope and low drainage density are the best suitable areas for artificial recharge through flooding and furrowing. For identifying such sites, the map showing sites for artificial recharge was overlaid on drainage density and slope maps, wherever plain slope and low drainage density have coincided with artificial recharge site those areas were recommended for artificial recharge through flooding and furrowing (Figure 5c).

Sites for percolation ponds: For the percolation ponds, the area must have shallow slopes and the micro drainage catchments. Hence at the first stage, such zones were buffered out having the above terrain conditions. This map, was superposed over the priority area map wherever those were coincided those areas have been recommended for percolation ponds (Figure 5d).

Sites for check dam: The drainage map was prepared for the study area using topographic sheets. The same was analysed for drainage convergence, meeting points, only drainages satisfying above conditions were filtered out and GIS map was generated. This map was superposed over the site selected for artificial recharge and the areas of coincidence were recommended for check dams (Figure 5e).

Sites for pitting: The drainage density map was prepared for the study area. From the drainage density map, maxima areas were identified and GIS map was generated and these map overlaid on the map showing suitable sites for artificial recharge, wherever such drainage density maxima were found within these positive areas of recharge were recommended for pitting (Figure 5f).

Sites for batteries of wells: From the shape of the lineament density contours the linearity maxima axes were drawn along the crest of the contours of elliptical shapes with maximum value in the core and successive lesser and lesser values encircling them, the GIS map was generated showing these lineament density maxima axes. Then this map was superposed over the map showing the artificial recharge sites wherever the lineament density maxima axes were falling within the recharge areas sites, those areas were recommended for batteries of wells (Figure 5g).

Sites for en-echelon dam: From drainage map broad and straight drainages were identified in the study area and GIS map was generated accordingly. Then this GIS map was superposed over the map showing sites for artificial recharge map, wherever such broad and straight drainages were found within such selected sites for artificial recharge those were recommended for En –echelon dams (Figure 5h).

Sites for hydro-fracturing: With the positive areas for artificial recharge sites, the zones of coincidence of lineament density maxima and drainage density maxima were recommended for hydro-fracturing (Figure 5i).

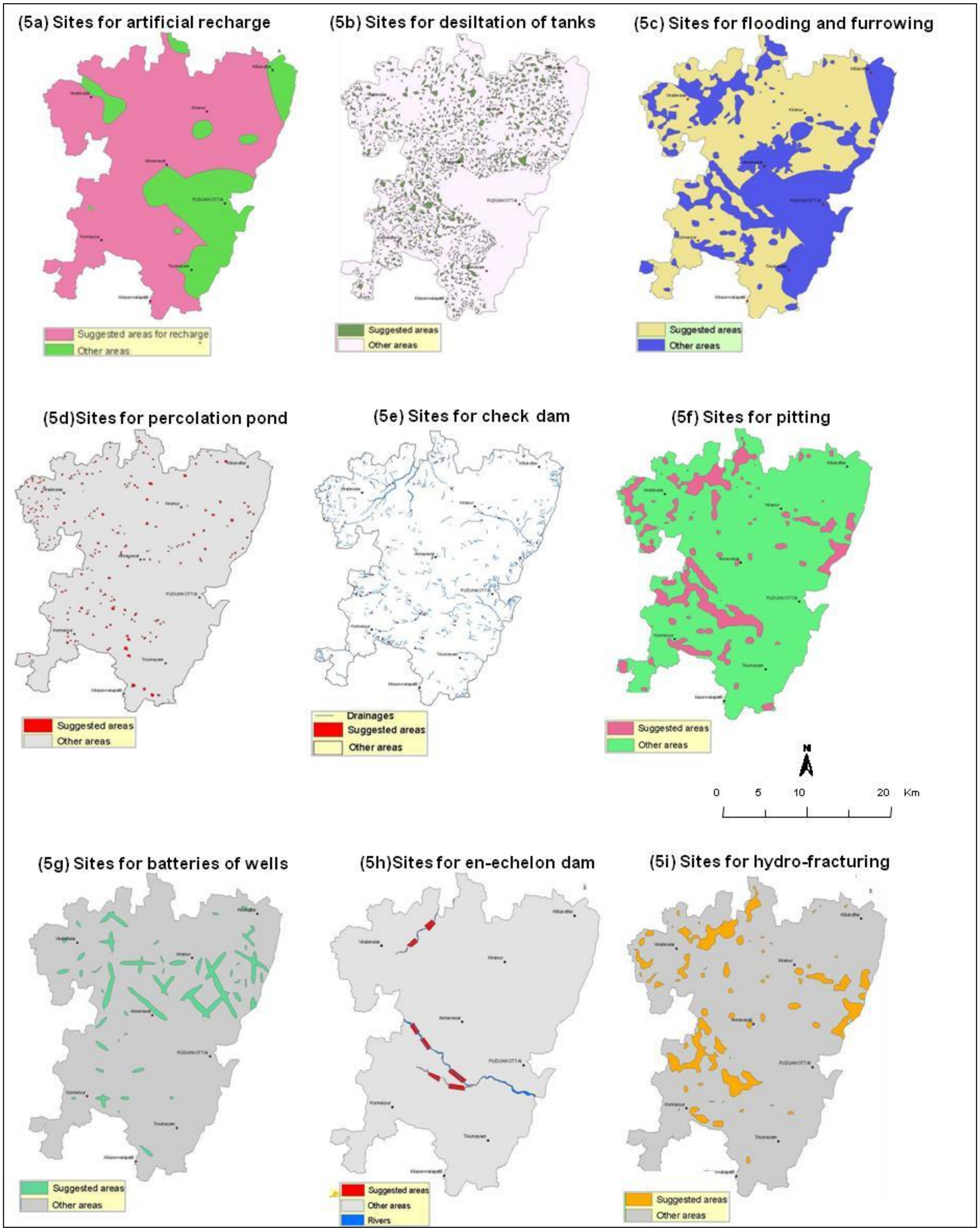

Figure 5: Mechanisms for recharge

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CONCLUSION

The present study has demonstrates that the Remote sensing and GIS techniques provide a reliable source of information on the generation of thematic information for the groundwater recharge studies. Some new genetic models were derived to identify the suitable sites for artificial recharge and to detect site-specific mechanisms to enhance the groundwater potential in the study area. The type of recharge structures suggested in the study area are site for desiltation of tanks, flooding and furrowing ,percolation ponds, check dams, pittings , batteries of wells, en-echelon dams and hydro-fracturing.

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REFERENCES

[1] Anbazhagan S. (1994). Remote Sensing based integrated terrain Analysis for artificial recharge in Ayyar Basin, central Tamil Nadu, India. Ph.D thesis. School of Earth Sciences. Bharathidasn univer sity, Tiruchirapalli.
[2] Anbazhagan S. and Ramasamy SM. (1993). Role of Remote Sensing in geomorphic analysis for water harvesting structures. Proc. Of the national seminar on water harvesting. June 25-26 at Dept. of civil engg.Regional engineering collage, Tiruchirapalli.
[3] Burrough P.A. (1986) Principles of Geographical Information System for land resource assessment, Claradone press, Oxford.
[4] Gale, I. & Dillon, P. (2005), 'Strategies for Managed Aquifer Recharge (MAR) in semi-arid areas', United Nations Environment Programme, Division of Technology, Industry and Economics, UNESCO IHP.
[5] Gary L. Prost, Remote Sensing for Geologist. A guide for image Interpretation, Gordon and Breach Science Publishers, the Netherlands.
[6] Herman Bouwer(2002),Artificial recharge of groundwater: hydrogeology and engineering, Hydrogeology Journal (202) 10:121 142, DO1 10 1007 s 10040-(MI-01 87-4)
[7] Hobbs, W. H. (1912). „Earth Features and Their Meaning: An Introduction to Geology for the Student and General Reader,‟ Macmillan Co., New York, 347.
[8] Integrated mission for sustainable development, technicalguidelines (IMSD), technical guide lines. National Remote Sensing Agency. Department of space, government of india, bala nagar, hydarabad. december 1995.
[9] Karanth K R. (1963). Scope for adopting artificial recharge in Barbar Formations. Geol. Survey. Ind., Symp. On ground water, MISC.pub, Calcutta.
[10] Lillesand TM. And Kiefer R. W (1987) remote Sensing and image Interpretation, John Wiley & sons, New York.
[11] Manual on artificial recharge of ground water (2007).Government of India Ministry of water resource, Central ground water board (CGWB).
[12] Murugiah M, Venkatraman P (2013). Role of Remote Sensing and GIS in artificial recharge of the ground water aquifer in Ottapidaram taluk, Tuticorin district, South India International Journal of Geomatics and Geosciences Volume 3, No 3, 2013 ISSN 0976 – 4380.
[13] UNEP - http://www.unep.or.jp/ietc/publications/techpublications/techpub-8e/artificial.asp.

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