International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 22 (2017) pp. 12176-12183

Revelation of Groundwater Possible Region Using Fuzzy Logic Based GIS Modeling

Geetha Selvarani Arumaikkani [1], Sivakumar Chelliah [2] and Maheswaran Gopalan [3]

[1]Professor, Department of Civil Engineering,
[2]Assistant Professor, Department of Mechanical Engineering
[3]Professor VSA School of Engineering and Management, Tamil Nadu, India.
[1,2]Vel Tech Rangarajan Dr. Sangunthala R& D Institute of Science and Technology, Avadi, Chennai, Tamil Nadu, India.
[3]NH-47, Main Road, Uthamasolapuram, Salem – 636010, Tamil Nadu, India.

[1,3]Orcid Id: 0000-0001-5779-6765, 0000-0001-8786-8301

Abstract

Water is the most crucial necessity for existence sustaining system to mankind. Within that, groundwater represents a major portion of the earth's water circulatory structure because it plays a vital resource required for drinking, irrigation and industrialization purpose. Remote sensing and Fuzzy logic based concepts have found a very wide range of applications in different fields and it provides a very precise approach for dealing with uncertainty which grows out of the complexity of human behavior and it become inevitable tools for the analysis of groundwater at various level. Fuzzy logic model is an attractive one because it is straight forward to understand and implement. And the membership functions assessed for overlay maps were mainly extracted from the field data. The benefit is that they don't need to conduct a new analysis, or change the rules, or the criteria, which saves time and effort. In fuzzy set theory membership can take any value between 0 and 1 where 0.0 represents absolute falseness and 1.0 represents absolute truth reflecting the degree of certainty with respect to some attribute of interest. The study area is covered by hard rock formations and faces acute water scarcity problem both for irrigation as well as for drinking purposes. The specific objective of this study is to develop a spatial model using remote sensing and fuzzy techniques under GIS environment to predict groundwater potential zones.

Keywords: Salem District, GIS, Groundwater, Fuzzy techniques

INTRODUCTION

Water is the elixir of life, a precious gift of nature to mankind and other species in the earth. Thus the total availability of water is fixed and the present problem is to identify the existing resources and their proper utilization. Depletion of water level in aquifers and decline in yield of well due to excessive pumping in the absence of adequate knowledge on groundwater availability are becoming a major concern across the globe [1, 2]. Remote sensing and GIS techniques can be applied for investigating groundwater resources and it has the advantage of covering large and inaccessible areas within a short span of time. Remotely sensed data from satellite provides quick and useful base line information on the factors controlling the occurrence, potential and movement of groundwater such as lithology, geological structure, geomorphology, soils, land and land cover. So it has become a handy tool in assessing and monitoring the groundwater resources. Several studies were carried out in the past two decades for identifying the groundwater potential zones using GIS and remote sensing data. The methodology proposed in the literature [3 to 13] to demarcate groundwater potential zone of an area. The present study attempts to delineate suitable locations for groundwater exploration using integrated approach of remote sensing, bore well and GIS techniques. ArcGIS 8.2 and ERDAS Imagine 8.1 software have been used for the generation and analysis of the thematic layers, such as- geomorphology, geology, lineament, slope, soil and landuse / landcover, which are assigned fuzzy membership values according to their relative contribution towards the groundwater. The fuzzy operators such as Fuzzy Product, Fuzzy Sum and Fuzzy gamma are used for factor maps integration. The final water potential map generated has been classified into categories s based on the fuzzy number obtained from map integration.

STUDY AREA

Salem district lies in the western part of Tamil Nadu, located between 11°15' - 12°00' north latitudes and 77°35' - 78°50' east longitudes. The total geographical area is about 5207 sq.kms out of which the Stanley reservoir covers an area of about 164.5 sq.kms. Salem district is well known for its mineral deposits like magnesite, bauxite, limestone, quartzite, iron ore and granite are available in this district. The population of this district according to 2011 census is 34,82,056. The districts comprises of twenty administrative blocks which is shown in Figure 1.

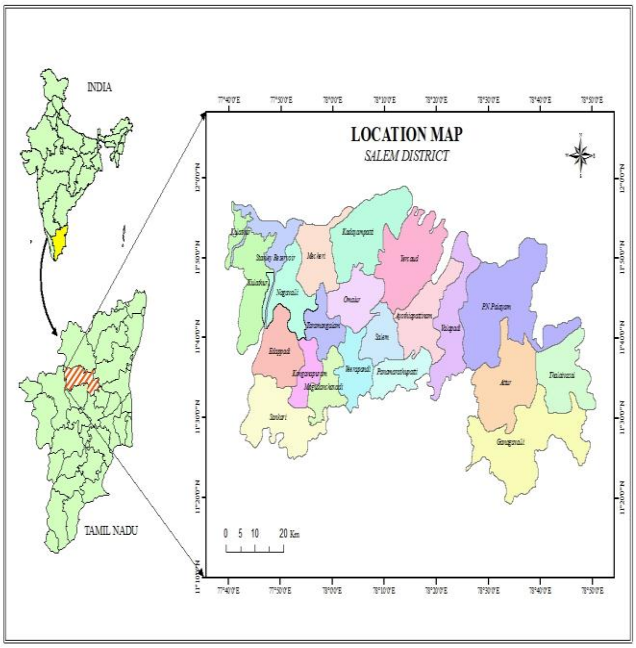

Figure 1: Location Map of the Study Area

Salem district is underlain entirely by Archaean Crystalline formations with Recent alluvial and Colluvial deposits of limited areal extents along the courses of major rivers and foothills respectively. Weathered and fractured crystalline rocks and the Recent Colluvial deposits constitute the important aquifer systems in the district. Ground water occurs under phreatic conditions in the weathered mantle and under semi-confined conditions in the fractured zones. Dug wells have traditionally been the most common ground water abstraction structures used for irrigation in the district. The yields of the open wells are low in the hill areas about 500 lpm for a drawdown of 2 m for four hours pumping, where as the open wells in the plains varies from 200 to 1000 lpm. In recent years, the declining water levels and reduction in yields of wells are being observed due to increased extraction of ground water by a large number of bore wells for irrigation purposes. The depth to water level in the district varied between 0.10 – 11.46 m bgl during premonsoon and 0.10 – 17.15 m bgl during post monsoon [14].

METHODOLOGY

In order to demarcate the groundwater possible region in the study area different thematic maps were prepared using GIS and remote sensing . The thematic map of landuse/landcover was prepared using IRS-1D LISS-III data by visual interpretation. Geomorphology, geology, soil and lineament maps were prepared on 1: 50000 scale based on the maps published by State ground and surface water resources data centre, Chennai. Drainage map and contour map of the study area was prepared from survey of India topographic maps in 1: 50000 scale. Data on existing ground water conditions for bore wells was collected from the C.G.W.B. (Central Ground Water Board).

The thematic maps like geomorphology, geology, soil, land use and land cover, drainage density, lineament density and slope of the study area was overlaid using fuzzy logic theory and the final map was prepared and finally it was validated with bore well data. The figure 2 below illustrates the methodology adopted for the present work.

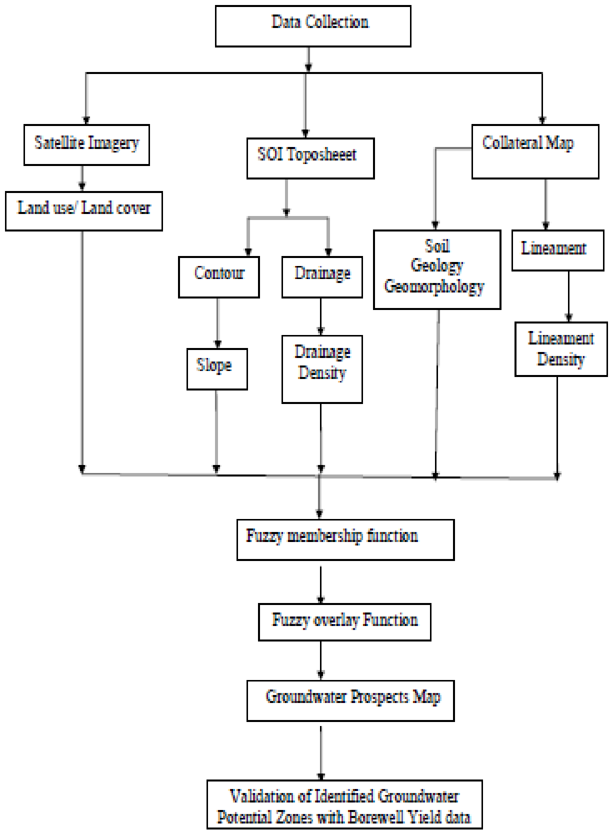

Figure 2: Methodology Adopted for the Present Work

SOIL

Thematic layer map of soil type reveals that the study area is having nine categories. They are red in situ, red colluvial, black soil, brown soil, mixed soil and soil association which are shown in Figure 3. Major portion of the district is covered by red in situ soil. Red colluvial, black soil, brown soil and soil association are covered over small areas of the district. Red soil was developed on the crystalline rocks like gneissic and granite. It was formed due to the disintegration of metamorphic and igneous rocks. Presence of iron gives red colour and it is rich in iron and aluminium. Red colluvial and red in situ are the types of red soil.

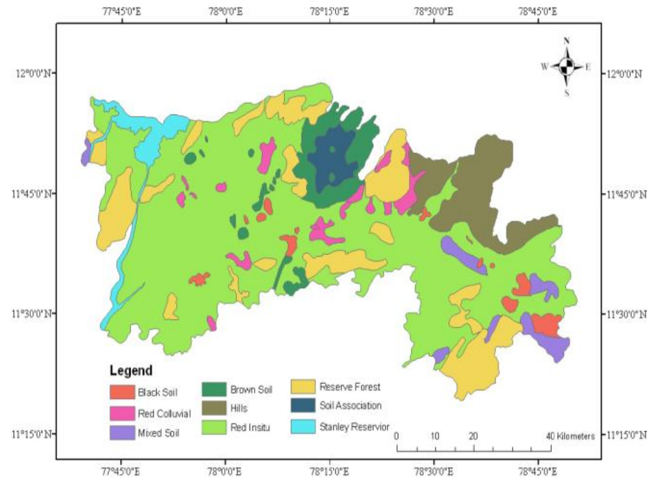

Figure 3: Soil Map of the Study Area

Geology

Geology is a science which deals with the different types of rocks units of this district are gneiss, charnockite, leptinite, amphibolites, dunite and magnesite, alluvium, calcareous gneiss and limestone, Ultra basic with magnetite and amphibole gneiss which is shown in Figure 4.

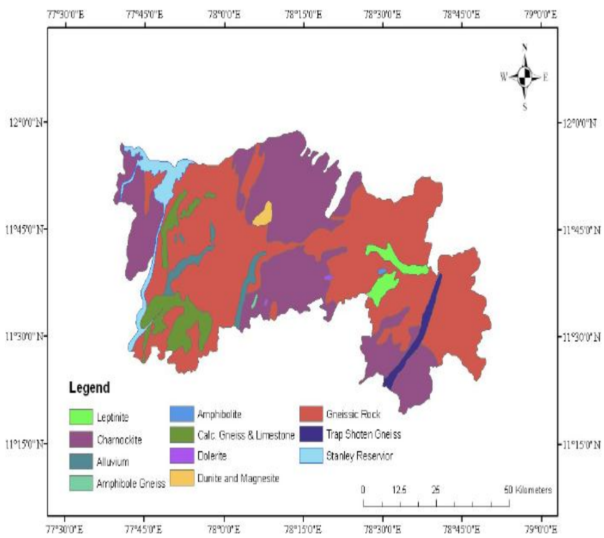

Figure 4: Geology Map of the Study Area

Geomorphology

Geomorphology indicates the land form in that particular area. The relief, slope, depth of weathered material, types of the weathered material and the overall assemblage of different landforms play an important role in defining the groundwater regime more particularly in hard rock areas and as well in unconsolidated formations [15].The study area is blessed with many hills viz. Shevaroys on north side, Kalrayan hills on north eastern side, Pachamalai hills on southwest and Palamalai hills on western side. The different land form includes structural hill, hill plateau, composite slope, bazada zone, pediment, shallow pediment and buried pediment which are shown in Figure 5. The entire district is mainly consists of shallow pediment, buried pediment and pediment. Boundary of the district is mainly covered by structural hills. Along the north and north eastern direction the district is covered by composite slopes and bazada zone.

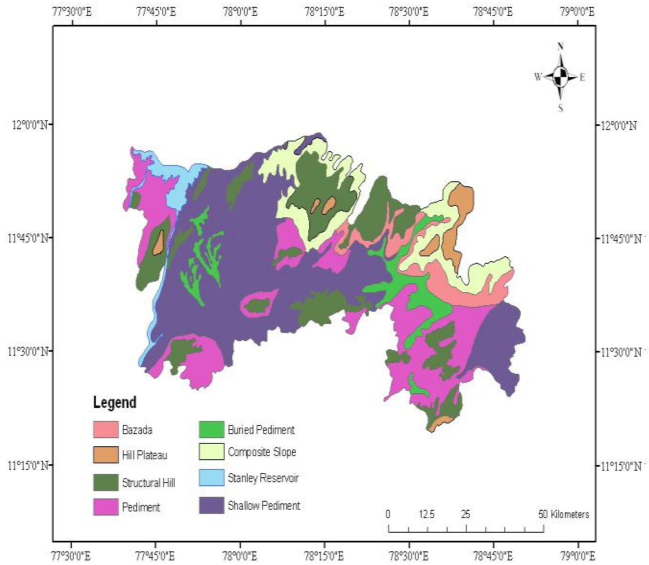

Figure 5 Geomorphology Map of the Study Area

Land Use / Land Cover

Land use/land cover plays an important role in the occurrence and development of groundwater. The land use of the study area is classified into twelve classes: Built up land, Water bodies, Crop land, Fallow land, Scrub forest Dense forest, Open forest, Gully land, Land with Scrub, Land without Scrub,Mining area and Stony waste is shown in Figure. 6.

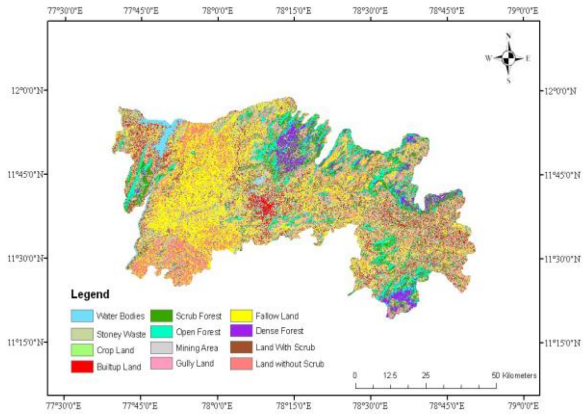

Figure 6: Land Use Pattern of the Study Area

Approximately 22.48% of the total area is covered by forest land, and 22.88 % of the area is under cultivation as agriculture land. Settlements represent 4.63 and 4.53 % area is covered by the water bodies. The remaining (45.48 %) represents Gully land, land with scrub, land without scrub, mining area and stony waste. Classification of land use for weighted analysis was decided based on the land-use type, area coverage and properties to infiltrate water, and their characteristics to hold water on the ground surface.

Drainage Density

Drainage density indicates closeness of spacing of channels as well as nature of surface material [16] . It was the measure of total length of the stream segment of all orders per unit area. It was affected by factors which control the characteristic length of the stream like resistance to weathering, permeability of rock formation, climate, vegetation etc. The drainage density indicates the relative run off of an area. Places where the density is high runoff would be more and of less drainage density run off would be less. In the study area the density ranges from 0 to 3 km/km^2 which is shown in figure 7.

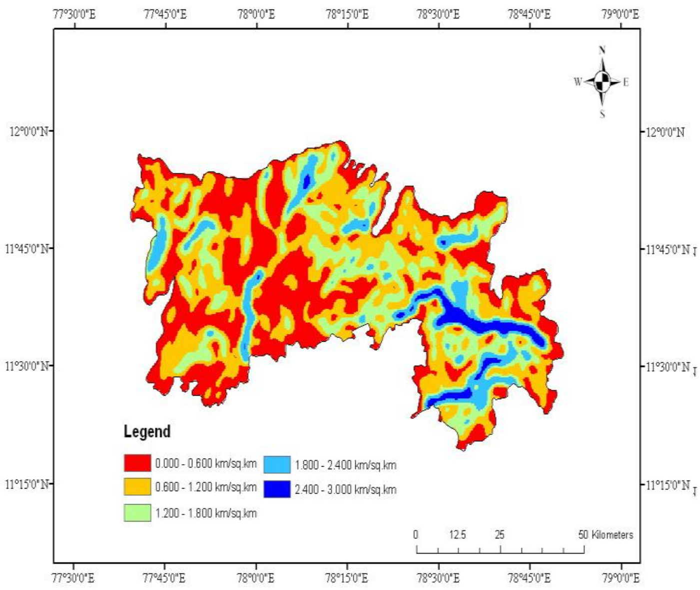

Figure 7: Drainage Density Map of the Study Area

Lineament Density

The lineament density indicates the relative infiltration capacity of an area.

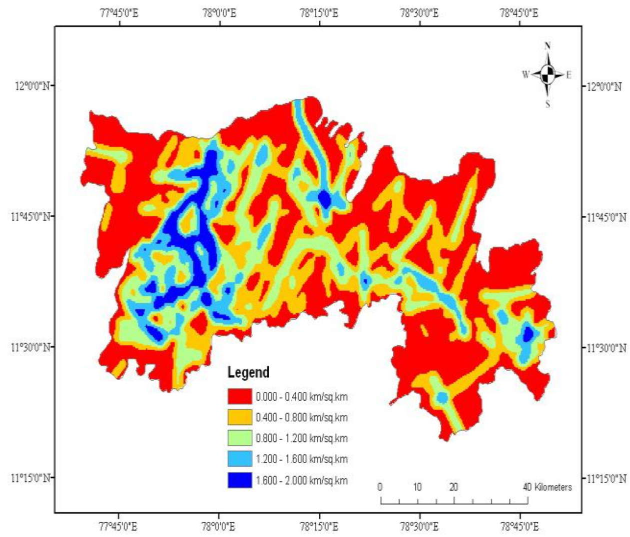

Figure 8: Lineament Density Map of the Study Area

Places where the density is high infiltration would be more and of less lineament density infiltration would be less. In the study area the density ranges from 0 to 2 km/ km^2 which is shown in Figure 8.The study area based on the lineament density was classified into five categories viz., 0-0.4, 0.41-0.8, 0.81-1.2, 1.21-1.6 and 1.61-2.0 km/sq.km. The lineament density was relatively high in west, northwest and southwest parts of the study area when compared with other areas and it was less in the east, northeast, southeast directions and around the periphery of the district. Lineament density was more in Mecheri, Nangavalli, Edappadi, Magudanchavadi and small areas in Sankari, Yercaud and Thalaivasal blocks.

Slope

Slope of an area is an indicator of the infiltration rate. The places where the slope is more, the contact period of water with surface is less and the infiltration rate will be less. In places where the slope is relatively less, the contact of water with the surface will be high and the infiltration rate will be high which results in good groundwater potential. The study area was classified into five category (which is shown in Figure7) nearly level (0-1 º), gentle slope (1.1-3 º), high slope (3.1-15 º) and the other two classes represents the hills (15.1-45 º and 45.1-87 º). The slope map of the study area reveals that the slope was high in the hilly terrain which was situated in the north, north eastern, south eastern and western part of the study area. Major portion of the district falls under nearly level category (0-1 º). Structural hills, reserved forest area and Stanley reservoir were restricted in the analysis and attributes of all thematic parameter is shown in table 1.

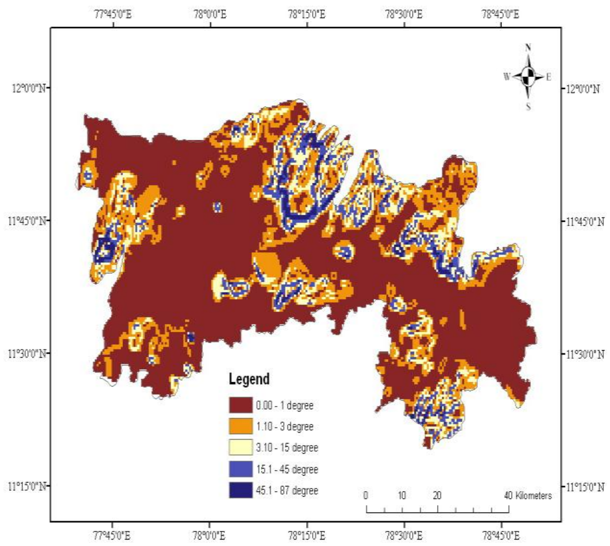

Figure 9: Slope Map of the Study Area

Table 1: Attributes of Various Thematic Map

Attributes of Soil		
Parameter	**Fuzzy Logic Rank**	**Ranking**
Red in situ	0.80	Good
Red colluvial	0.99	Very Good
Black soil	0.20	Very Poor
Brown soil	0.20	Very Poor
Mixed soil	0.20	Very Poor
Soil association	0.20	Very Poor
Attributes of Geology		
Parameter	**Fuzzy Logic Rank-**	**Ranking**
Leptinite	0.80	Very Good
Gneiss	0.80	Very Good
Amphibolite	0.20	Very Poor
Charnockite	0.60	Moderate
Alluvium	0.99	Excellent
Calcareous gneiss and lime stone	0.20	Very Poor
Amphibole gneiss	0.20	Very Poor
Dunite and magnesite	0.80	Very Good
Dolerite	0.20	Very Poor
Attributes of Geomorphology		
Parameter	**Fuzzy Logic Rank**	**Ranking**
Hill plateau	0.20	Very Poor
Composite slope	0.20	Very Poor
Bazada zone	0.99	Excellent
Pediment	0.20	Very Poor
Shallow pediment	0.20	Very Poor
Buried pediment	0.80	Very Good
Attributes of Land use/Land cover		
Parameter	**Fuzzy Logic Rank**	**Ranking**
Water bodies	0.99	**Excellent**
Mining area	0.20	**Very Poor**
Built up land	0.40	**Poor**
Crop land	0.80	**Very Good**
Scrub forest	0.40	**Poor**
Gully land	0.80	**Very Good**
Land with scrub	0.20	**Very Poor**
Land without scrub	0.40	**Poor**
Fallow land	0.80	**Very Good**
Stony waste	0.20	**Very Poor**
Attributes of Drainage Density		
Parameter	**Fuzzy Logic Rank**	**Ranking**
0-0.600	0.99	Excellent
0.600-1.200	0.80	Very Good
1.200-1.800	0.60	Moderate
1.800-2.400	0.40	Poor
2.400-3.000	0.20	Very Poor
Attributes of Lineament Density		
Parameter	**Fuzzy Logic Rank**	**Ranking**
0-0.500	0.20	**Very Poor**
0.500-1.000	0.40	**Poor**
1.000-1.500	0.60	**Moderate**
1.500-2.000	0.80	**Very Good**
2.000-2.600	0.99	**Excellent**
Attributes of Slope		
Parameter	**Fuzzy Logic Rank**	**Ranking**
45° - 87 °	0.20	Very Poor
15 ° - 45 °	0.40	Poor
3 ° - 15 °	0.60	Moderate
1 ° - 3 °	0.80	Very Good
0 ° - 1 °	0.99	Excellent

Fuzzy Logic Model

Fuzzy logic model is an attractive one because it is straight forward to understand and implement. It can be used with the data from any measurement scale and weighing of evidence is controlled entirely by the expert. The fuzzy logic model allows for more flexible combination of weighted maps and could be readily implemented with a GIS modeling language [17]. The assessment of fuzzy membership values is crucial to proper fuzzy model [18]. In a fuzzy map the associated value for each pixel (fuzzy membership value), represent both the relative importance of the thematic layers and the relative values corresponding to different parameters on the map area. In fuzzy set theory membership can take any value between 0 and 1 reflecting the degree of certainty with respect to some attribute of interest [19].

In fuzzy logic model, there are some fuzzy operators such as fuzzy AND, fuzzy OR, fuzzy algebraic product, fuzzy algebraic sum and fuzzy gama [19]. These operators are used on the factor maps which was developed based on the influence of the thematic maps and the rank of the parameters in each thematic.

Except for water resources, in other cases the operator of sum and gamma are used. The fuzzy AND is equivalent to Boolean AND and fuzzy OR is like Boolean OR [17]. The fuzzy algebraic product operator would be an appropriate combination operator for identifying suitable sites for artificial recharge, because at each location the combined fuzzy membership values tend to be very small in this operator, due to the effect of multiplying several numbers less than one [20]. So, in this research for identifying groundwater potential zones the fuzzy algebraic product was used which is shown in Figure 2. The fuzzy algebraic product is defined as

$$\mu_{combination} = \prod_{i=1}^{n} \mu_i \qquad (8.3)$$

where μ_i is the fuzzy membership function for the i-th map.

The Fuzzy Membership has been assigned to the different thematic maps (geomorphology, geology, soil, land use and land cover, drainage density, lineament density and slope) according to their categorization on the respect of ground water payment. Different classes have been given the weightage by the different experts. All the expert weightage has been converted in the fuzzy membership value according to their ranks within the range of 0-1 (Delft 2000) .The following relief structures have been taken into consideration in the present study.

RESULT AND DISCUSSION

Based on figure 10, groundwater potential is found under good category (occupies 6.12% of the study area) in few patches of northwestern side and western side of the study area. The suitable soil (red *in-situ* and red colluvial), geomorphological (buried pediment and bazada) which are present in the portion of the study area, provides favorable condition for good groundwater recharge. The predominant portion of the study area covers moderate (occupies 83.52% of the study area) due to the presence of geomorphology (pediments and shallow pediment), soil (brown soil, red *in-situ* soil and black soil) and with moderate lineament and drainage density. The groundwater potential is found under the moderate to good category (occupies 10.36% of the study area) in few patches of sides of the study area due to the presence of soil (red *in-situ* and mixed soil), geomorphology (shallow pediment, few batches of buried pediment, pediment) and geological features (gneissic, dunite and magnesite).

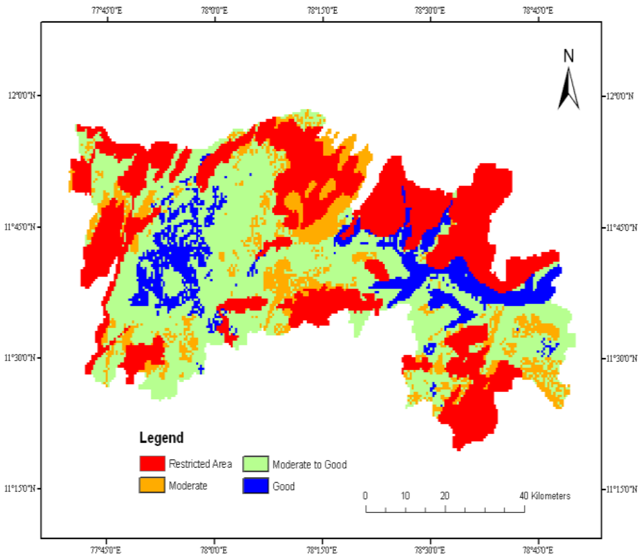

Figure 10: Groundwater Potential Zones of the Study Area (Fuzzy Logic Model)

Validation of identified groundwater potential zones with borewell data

The identified groundwater potential zones were compared with the pumping test data of 43 locations in the study area which is shown in table 8. The yield of borewells in the 43 locations ranged from 2.19 to 82 Gpm. For validation yield in the range ≥25 Gpm is taken as good, range between 2 and 25 Gpm is taken as moderate to good and range <2 Gpm is taken as moderate groundwater potential locations. The groundwater potential status (pumping rate) of each location was compared with the with output map, each correct evaluation was identified by '+' and the incorrect evaluation was identified as '−' which is shown in table 2. Out of 43 locations, four locations Karippati, Irupalli, Magudanchavadi and Kuppampatti show incorrect evaluation. Overall accuracy level of the analysis is 90.7% which is a high level of accuracy for a regional study.

Table 2: Validation of the Identified Groundwater Potential Zones

S.No	Village Name	Fuzzy Logic Model	Pumpimg Rate (GPM)	Evaluation
1	Vaikundam	Moderate	poor	"+"
2	Reddiyur	M to G	2.19	"+"
3	Ammapalayam	M to G	2.19	"+"
4	Thumbipadi	M to G	6.05	"+"
5	Vanavasi	M to G	6.05	"+"
6	Uthankatttuvalsu	M to G	6.05	"+"
7	A.kumarapalayam	M to G	6.05	"+"
8	Gangavalli	M to G	6.05	"+"
9	Kumarasamipatti	M to G	6.05	"+"
10	Korimedu	M to G	8.05	"+"
11	Semmankudal	M to G	8.89	"+"
12	Naduvalur	M to G	9	"+"
13	M.Kalipatti	M to G	10	"+"
14	Karippatti	M to G	10	"-"
15	Anuppur	M to G	10	"+"
16	Thalaivasal	M to G	10	"+"
17	Ulipuram	M to G	12	"+"
18	Pakkaliyur	M to G	12.4	"+"
19	Kattiyanur	M to G	12.4	"+"
20	Kudumalai	M to G	12.4	"+"
21	Pottaneri	M to G	12.4	"+"
22	Edanganasalai	M to G	12.4	"+"
23	Akkamapettai	M to G	12.5	"+"
24	Modikadu	M to G	16.7	"+"
25	Chandrapillaivalasu	M to G	16.7	"+"
26	Veeranam	M to G	16.7	"+"
27	Veerapandi	M to G	21.7	"+"
28	T.Pudupalayam	M to G	21.7	"+"
29	Chinna Agraharam	M to G	21.7	"+"
30	Seernganur	M to G	23	"+"
31	Muthampatti	Good	27.5	"+"
32	Irupali	Good	27.5	"-"
33	Magudanchavadi	Good	27.5	"-"
34	Vavvalthoppu	Good	27.5	"+"
35	Seshenchavadi	Good	34.2	"+"
36	Kuppampatti	Good	34.2	"-"
37	Kalleripatti	Good	35	"+"
38	Pethanaickenpalayam	Good	41.8	"+"
39	Anupoor	Good	41.8	"+"
40	Vilvanur	Good	50	"+"
41	Uthankarai	Good	56	"+"
42	Veergoundanur	Good	70.2	"+"
43	Chinnappampatti	Good	82	"+"

M to G – Moderate to Good

CONCLUSION

The present study exhibit the potential of remote sensing, GIS and fuzzy logic for segregation of groundwater potential zones which may be used for groundwater expansion and executive programmes through LISS-III data of IRS-1D satellite. Based upon the result it shows that, Moderate to good groundwater potential zones are present in almost all the blocks of the study area by integrating the thematic layers viz. drainage, slope, lineament, lithology, landuse / land cover, geology, geomorphology and soil maps on the basis of fuzzy investigation. In this study shows that 6.12 % area is good zone for groundwater potential, 10.36% area is moderate to good, and 83.25% area is moderate for groundwater potential. And this study gives the fine model to further areas for the invention and forecast of the groundwater potential who is facing in adequate water source.

REFERENCES

[1] V.R. Reddy. " Costs of resource depletion externalities: a study of groundwater overexploitation in Andhra Pradesh, India". Environmental Develoment Econonmy, 10(4), pp.533–556,2005.

[2] Krishan, Gopa.l, Lohani., A.K., Rao., M.S., Kumar., Sudhir and K.S. Takshi,. "Spatiotemporal Variability Analysis of Groundwater Level for Water Resources Development and Management in Northern Punjab, India". Journal of Environmental and Analytical Toxicology. 5(4), pp.279, 2015.

[3] Manap., M.A, Sulaiman ,WN., Ramli, MF,, Pradhan .B, Surip. N ., 2011, " A knowledge-driven GIS modeling technique for groundwater potential mapping at the Upper Langat Basin, Malaysia". Arabian Journal of Geoscience, 6, pp.1621-1637

[4] Khodaei K., and Nassery. HR., 2011,"Groundwater exploration using remote sensing and geographic information systems in a semiarid area (Southwest of Urmieh Northwest of Iran)". Arabian Journal of Geosciience, 6, pp.1229–1240.

[5] Abdalla, F., 2012," Mapping of groundwater prospective zones using remote sensing and GIS techniques: a case study from the Central Eastern Desert", Egypt. J Afr Earth Sci 70, pp.8–17

[6] Gumma, MK., Pavelic, P., 2013, " Mapping of groundwater potential zones across Ghana using remote sensing, geographic information systems, and spatial modeling," Environ Monitoring Assess, 185, pp. 3561–3579. doi:10.1007/s10661-012-2810.

[7] Sharma, Manishi, M. S. Rao, D.S. Rathore, Gopal Krishan. (2014). An integrated approach to augment the depleting ground water resource in bist- doab, region of

Punjab, India. International Journal of Earth Sciences and Engineering, 7 (01): 27-38.

[8] Preeja, K. R , Sabu Joseph., Jobin Thomas., and Vijith ,H., 2011." Identification of Groundwater Potential Zones of a Tropical River Basin (Kerala, India) Using Remote Sensing and GIS Techniques", Journal of the Indian Society of Remote Sensing, 39(1), pp.83-94.

[9] Shashank Shekhar., & Arvind Chandra Pandey., 2014,"Delineation of groundwater potential zone in hard rock terrain of India using remote sensing, geographical information system (GIS) and analytic hierarchy process (AHP) techniques", , Geocarto International , pp. 402-421.

[10] Ramu, Mahalingam B., Vinay M., 2014, "Identification of ground water potential zones using GIS and Remote Sensing Techniques: A case study of Mysore taluk – Karnataka", International Journal Of Geomatics And Geosciences ,Volume 5, No 3.

[11] Soumen Dey. 2014, " Delineation Of Ground Water Prospect Zones Using Remote Sensing, Gis Techniques - A Case Study Of Baghmundi Development Block Of Puruliya District, West Bengal", *International Journal of Geology, Earth & Environmental Sciences Vol. 4 (2) May-August, pp. 62-72*.

[12] Rajvir Singh., Anup Kumar., Chakarvarti., 2014," Remote Sensing and GIS Approach for Groundwater PotentialMapping in Mewat District, Haryana, India", International Journal of Innovative Research in Advanced Engineering, 1 to11.

[13] A. Geetha Selvarani and K. Elangovan., 'Hydrogeochemistry Analysis of Groundwater in Noyyal River Basin, Tamilnadu, India', International Journal of Applied Environmental Sciences, Vol.4, No.2, pp.211-227, 2009.

[14] Subburaj, .A ., 2008, " Scientist-D, Government of India , Ministry of Water Resources Central Ground Water Board, South Eastern Coastal Region Chennai, Technical Report Series, District" At A Glance (Salem District), District Groundwater Brochure, Salem District, Pp. 7 &8.

[15] Karanth K.R. (1987), 'Groundwater Assessment, Development and Management', Tata McGraw Hill Publishing Company Limited, New Delhi, pp. 217-228, 221, 237 and 251.

[16] Prasad, R.K., Mondal, N.C., Pallavi Banerjee., Nandhakumar, M.V., and Singh, V.S., 2007, "Deciphering potential groundwater zone in hard rock through application of GIS", Environmental Geology, Vol. 55, No. 3, pp. 467-475.

[17] Biswajeet Pradhan., Saro Lee., and Manfred F. Buchroithner.,2009, "Use of geospatial data and fuzzy algebraic operators to landslide-hazard mapping", Applied Geomatic, Vol.1, pp. 3-15.

[18] Ebadi, S., Valadanzoej, J., and Vafacinezhad, A., 2001. "Evaluation of indexing Overlay, Fuzzy Logic and Genetic Algorithm Method for Industrial Estate Site Selection in GIS Environment, Tehran, Iran".

[19] Tangestani M H (2003), 'Landslide Susceptibility mapping using the fuzzy gamma operation in a GIS, Kakan Catchment Area, Iran', In: The 6th annual International conference Map India 2003, 28 – 31, Janauary, 2003

[20] Saravi M. M., Malekian A and Nouri B (2006), 'Identification of suitable sites for groundwater recharge' In: The 2nd International Conference on Water Resources and Arid Environment' 26-29 November, 2006 at Riyadh, Saudi Arabia