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Delineation of groundwater potential zones in valagalamanda sub-watershed of Swarnamukhi river basin using remote sensing and GIS

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Abstract
The search for new groundwater resource is essential to sustained economic development in arid environment. The purpose of this study was to investigate new water sources using remote sensing and GIS methods. The thematic layers considered in this study area Geology, Geomorphology, Soil, Land use / Land cover, Drainage density, Slope, Lineament density, and Rainfall map were prepared for the study area using the IRS-P6 LISS-IV satellite imagery and conventional data. In addition, soil and drainage maps were digitized from Toposheet maps. The thematic layers were finally integrated using Arc-GIS 10.1 software to yield a groundwater potential zone map of the study area. Thus, five different groundwater potential zones were identified, namely very good, good, moderate, poor and very poor prospects covering an area of 4.97 Km^2, 131.26 Km^2, 107.81 Km^2, 26.76 Km^2&10.92 Km^2 respectively. This GIS based output result was validated using water level depth data collected from central groundwater board. Finally, it is concluded that the RS and GIS techniques are very efficient and useful for the identification of groundwater potential zones.

Keywords: Remote sensing, GIS, Thematic maps

1. Introduction

Groundwater is one of the most valuable natural resources possessed by many countries, as it is reliable in dry seasons and droughts, requires less treatment, can be tapped wherever it is needed and is less affected by catastrophic events. In arid areas, where rainfall is low and rare in occurrence, groundwater may be the only source of supply for drinking, agricultural and industrial purposes. Without proper pro-active management and protection of this resource, there is a serious risk of scarcity on an increasingly widespread basis. Under the pressure of rapid urbanization and industrialization, in the need to rapidly develop new water supply systems, there is rarely adequate attention to, and investment in the maintenance, protection and longer-term sustainability of groundwater.

In recent years, digital technique is used to integrate various data to delineate not only groundwater potential zone but also solve other problems related to groundwater. These various data are prepared in the form of a thematic map using geographical information system (GIS) software tool. These thematic maps are then integrated using “Spatial Analyst” tool. The “Spatial Analyst” tool with mathematical develop a model depending on the objective of problem at hand, such as delineation of groundwater potential zones. In recent years, many workers such as Chatterjee & Bhattacharya (1995) [7], Chandra Bose (2014) [5], Shahid & Nath (2000) [26], Goyal *et al*. (1999) [10], and Saraf & Choudhary (1998) [26] have used the approach of remote sensing and GIS for groundwater exploration and identification of artificial recharge sites. Jaiswal *et al*. (2003) [13] have used the GIS technique for generation of groundwater prospect zones towards rural development. Krishnamurthy *et al*. (1996) [16], Obi *et al*. (2000) [22], and have used GIS to delineate groundwater potential zone. Srinivasa & Jugran (2003) [24] have applied GIS for processing and interpretation of groundwater quality data. GIS has also been considered for multicriteria analysis in resource evaluation. Jacob *et al*. (1999) [14], Shahid *et al*. (2000) [26], Boutt *et al*. (2001) [3] have carried out ground water modeling through the use of GIS. Mohammed *et al*. (2003) [18] have carried out hydro geomorphological mapping using remote sensing techniques for water resource management around palaeochannels. GIS has been applied to groundwater potential modelling (Rokade *et al*., 2007; Nagarajan & Sujit Singh, 2009) [29, 13]. Therefore the overall aim of this study is to contribute towards systematic groundwater studies utilizing remote sensing, field studies, Digital Elevation Models (DEM) and Geographic Information Systems (GIS) in the assessment of groundwater resources. The specific objectives of the study are:

- To identify and delineate groundwater potential zones through integration of various thematic maps with Arc GIS 10.1.
- The validation of the model developed was made using the Groundwater Level depth data which reflects the actual groundwater potential. A comparison of this study between the water level depth data and groundwater potential zones prepared by the model was made to check the validity of the proposed model.

2. Study area

The valagalamanda watershed covers geographical area of 281.72 sq.km and located in between 13^0 43’ to $14^0$55’ North latitude and 79^0 27’ to $79^0$45’ East longitude. It is mainly situated in Chittoor district of Andhra Pradesh, India. The major part of study area is covered by Srikalahasti mandal, Yerpedu mandal, Thottambedu mandal, small area of Venkatagiri mandal. It is included in the Survey of India Topographical sheets of 57O/5, 57O/9 and57O/ 10, on a scale of 1:50,000. It is by the side of the road on way to Srikalahasti, the abode of Lord Shiva, from Tirupati, the place of foot hills of Tirumala, the abode of Lord Sri Venkateswara.

Yerpedu is easily accessible both from Srikalahasti and or Tirupati by road. It is nearer to Srikalahasti and is at a distance of about 25km west-south-west of it. It is well connected by all-weather roads from both the places, Srikalahasti and Tirupati both being the famous pilgrimage centers are well connected by the South–Central Railway and from these places number of buses belonging to Andhra Pradesh Road Transport Corporation The location map of study area, with other details, is as per figure1 below.

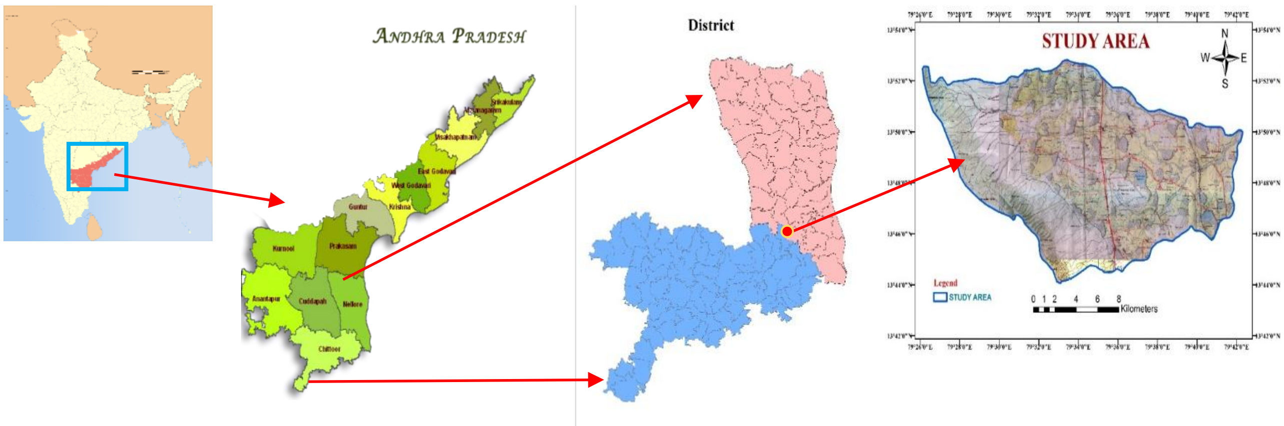

Fig 1: Location of Study Area

2.1 Data Collection

Following data were collected from various organizations for the present study

- IRS P6 LISS-IV satellite data acquired on 2012 geocoded at the scale of 1:50000 from NRSA, Hyderabad.
- Toposheets No. 57O/5, 57O/9 and 57O/10 at the scale of 1:50000 from the survey of India, Hyderabad.
- SRTM-DEM30m resolution (USGS/NASA SRTM-DEM data available from http://www.jpl.nasa.gov/srtm/)
- District geology map was collected at the scale of 1:50000 from the Geological Survey of India, Hyderabad.
- Rainfall data was collected from the state meteorological department, Chittoor district, for the period of ten years (i.e. 2005 to 2014).
- Groundwater level data was collected from Central Groundwater Board.
- Soil data was collected from Agriculture department, Tirupati.

3. Methodology

Integrated remote sensing and GIS based approach is a powerful tool for assessing groundwater potential zones based on which suitable locations for groundwater withdrawals could be identified. Methodology for preparing groundwater potential zones map in the study area is presented.

It involves in the following steps

- The methodology adopted for the present study is shown in Fig.2. The base map of Valagalamanda watershed was prepared based on Survey of India topographic maps (57O/5, 9, 10) on a 1:50,000 scale. Providing map projection system to spatial dataset. Drainage network generated in GIS environment using SRTM- DEM data.
- Satellite images from IRS P6 LISS-IV satellite, on a scale of 1:50,000 (2012 geo-coded, with UTM projection, spheroid and datum WGS 84, Zone 44 North) have been used for delineation of thematic layers such as land-use, lineament and geomorphology maps.
- The drainage density and lineament density maps were prepared using the line density analysis tool in Arc-GIS.
- The slope map was prepared from SRTM-DEM data in Arc-GIS Spatial Analyst tool.
- The Soil map was prepared from Soil map was collected from Agriculture department then it is georeferenced and cut the polygons and assessing of attributes for each layer.
- The rainfall map was prepared using the data obtained from the Indian Meteorological Department (IMD) gauge stations. These data were then spatially Interpolates a raster surface from points using a two-dimensional minimum curvature spline technique, spatial analyst tool obtain the rainfall distribution map.
- Field visits shall be carried out for checking the interpretation and for collecting the additional information, field observations shall be incorporated in various thematic maps.
- Multi influencing factor (MIF) technique shall be used for assigning weightages, ranks and scores to various themes and features class by assessing the importance of it in groundwater occurrence.
- After assigning the weightages, ranks and scores to the themes and features, all the themes shall converted to raster format using ‘Spatial Analysis’ extension of ArcGIS 10.1 software.
- While converting to raster, the scores assigned to the individual features shall be taken in the value field.
- Generation of groundwater potential zones are obtained by overlaying all the thematic maps in terms of weighted overlay method using the spatial analysis tool in ArcGIS 10.2.
- These values are imported in the ArcGIS and then obtained the yield map.

- The "Raster Calculation" option of 'spatial Analyst' extension shall be used to prepare integrated groundwater potential Zones map by adopting suitable map algebra.
- This map indicates potentiality of groundwater occurrence in the study area
- Integrated groundwater potential zones map shall have wide range of scores. This map shall be reclassified in the GIS environment using ArcGIS software to demarcate various groundwater potential zones in the study area based on certain decision rules.
- The generated output shall consist of various classes of groundwater potential zones namely Good, Moderate, and Poor Zones from groundwater potential point of view. Groundwater potential zones map generated through GIS shall be verified with the groundwater Level depth data of the study area to ascertain the validity of the model developed.
- The validation of the model developed was checked against the Groundwater Level depth data which reflects the actual groundwater potential.

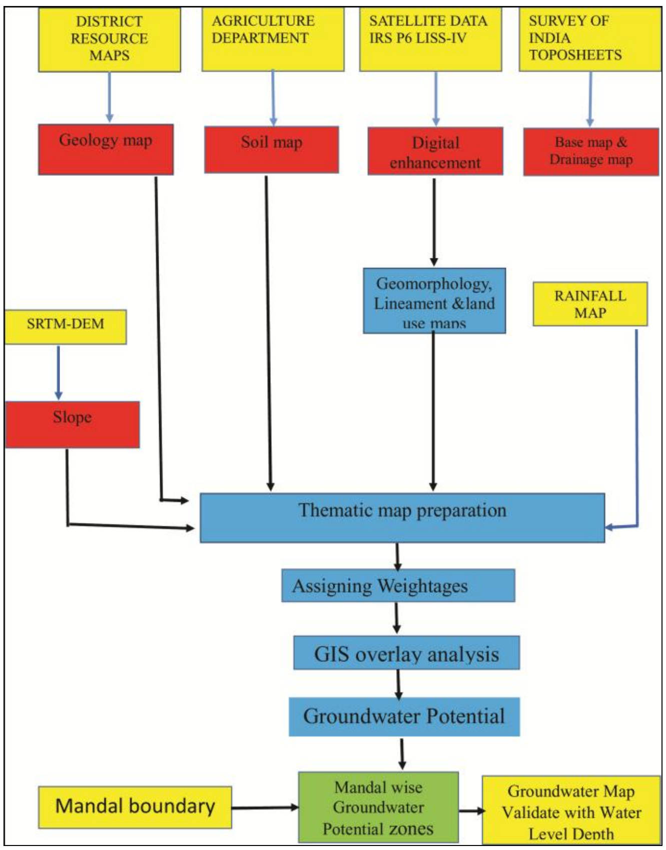

Fig 2: Flow chart for the groundwater potential zones

4. Analysis and discussions

4.1 Slope Map

Slope is an important factor for the identification of groundwater potential zones. Higher degree of slope results in rapid runoff and increased erosion rate with feeble recharge potential (Magesh *et al.*, 2012) [17]. The slope map of the study area was prepared based on SRTM –DEM data using the spatial analysis tool in ArcGIS 10.1. Slope grid is identified as "the maximum rate of change in value from each cell to its neighbors" (Burrough, 1986) [4]. Based on the slope, the study area can be divided into five slope classes. The areas having 0^0-10^0 slope fall into the 'very good' category because of the nearly flat terrain and relatively high infiltration rate. The areas with 10^0-20^0 slope are considered as 'good' for groundwater storage due to slightly undulating topography with some runoff. The areas having a slope of 20^0-30^0 cause dominating Supporting Runoff, and hence are categorized as 'fair' and the areas having a slope 30^0-40^0 cause prominent in the piedmont area which contributes more towards surface runoff are considered as 'moderate' The area having a slope of >40^0 are considered as 'poor' due to higher slope and runoff. Fig.3 illustrates the slope map of the study area.

4.2 Soil Map

Soil is an important factor which determines the amount of groundwater, the study of soil helps to find out the types and as its properties. The movement of ground water and infiltration of surface water into ground is based on the porosity and permeability of soil. The base data for the soil classification of present study has been obtained from Agriculture department, Tirupati, A.P.

The analysis of the soil type reveals that the study area is predominantly covered by red gravelly soil (in deeply buried pediments and moderately buried pediments) with red loamy soil and alluvial soil (in the flood plains) at some places red clayey soil and partly in the rock land. By extraction of various classes of soil types, a thematic map for soil was generated as per figure 4The ranks were assigned to the individual soil type, according to its respective influence of groundwater occurrence, holding and recharge as per table 3 below.

4.3 Drainage Map

A drainage basin is a natural unit draining runoff water to a common point. This map consists of water bodies, rivers, tributaries, perennial & ephemeral streams, ponds. Drainage pattern of any terrain reflects the characteristics of surface as well as subsurface formations. Valagalamanda watershed is drained by Valagalamanda and other streamlets. The drainage map is shown as Fig 5.

Drainage map of the study area has been delineated using scanned from Survey of India (SOI) toposheets 57O/5, 57O/9 and 57O/10 satellite imagery (SRTM-DEM) with digitized in ArcGIS10.1 platform. All the drainages were traced out and map was prepared. Then this drainage is super imposed with satellites images data and the changes in the drainage courses were mapped. Drainage map was prepared digitally by digitizing each order of stream as a separate layer and overlaid using ArcGIS software which gives the drainage pattern.

4.4 Drainage Density Map

Drainage density (expressed in terms of Km/Sq. Km) is defined as the closeness of spacing of stream channels. It is a measure of the total length of the stream segment of all orders per unit area. The drainage density is an inverse function of permeability. The less permeable a rock is, the less the infiltration of rainfall, which conversely tends to be concentrated in surface runoff. Drainage density of the study area is calculated using line density analysis tool in ArcGIS software. The study area has been grouped into five classes. These classes have been assigned to 'very good' (0-

1.60km/km^2), 'good' (1.60-3.80km/km2) 'fair' (3.80-5.70 km/km2), and 'Moderate' (5.70-7.80), 'poor' (7.80-12.95 km/km2) respectively. High drainage density (12.95km/km2) is recorded in the hilly parts of the study area (Fig.6). With respect to groundwater occurrence the higher drainage density is related to less infiltration of water to the ground, which in turn leads to higher run off and vice versa.

4.5 Land Use/Land Cover

Spatial data in the form of satellite imagery for the preparation of satellite image details for the study area was procured from national remote sensing Centre (NRSC), Hyderabad. The satellite imagery pertains to India Remote Sensing Satellite (IRS), Linear Imaging and Self Scanning Sensor (LISS-IV) with a resolution of 5.8m. The collected satellite imagery was geo referenced in ERDAS 8.6, then rectified and finally projected.

Land use/land cover mapping is one of the important applications of remote sensing. Land use plays a significant role in the development of groundwater resources. It controls many hydrogeological processes in the water cycle viz., infiltration, evapotranspiration, surface runoff etc. surface cover provides roughness to the surface, reduce discharge thereby increases the infiltration. In the forest areas, infiltration will be more and runoff will be less whereas in urban areas rate of infiltration may decrease. Remote sensing provides excellent information with regard to spatial distribution of vegetation type and land use in less time and low cost in comparison to conventional data. LULC of study area has been analyzed for 2012 LISS IV image. Land use/ land cover map is shown in Fig 7.And the area of various land use/land cover features are presented in Table 2.

Land use/ Land cover map have been divided into 5 categories i.e. Agricultural Land, Build-up-area, Forest, Water bodies, Waste land. In Kharif season period there is vary less irrigation area as compared to Rabi season. For agriculture purpose 39.22% is covered in the study area.

4.6 Lineament and Lineament Density

Lineaments are straight linear elements visible at the Earth's surface as a significant "lines of landscape" (Hobbs, 1904) [11]. These are primarily a reflection of discontinuities on the Earth's surface caused by geological or geomorphic processes (Clark & Wilson, 1994) [6]. Geological features that give rise to lineaments include faults, shear zones, fractures, dykes and veins as well as bedding planes and stratigraphic contacts. Geomorphic features, which appear as lineaments on the maps, aerial photographs and satellite images include streams, linear valleys and ridgelines.

In present study area lineaments are extracted from satellite image. All lineament are associated with geomorphic lineament i.e. drainage parallel. The study area is covered by major and minor lineament, magnitude varies from 0.60 Km to 3.37 Km. the lineament map is then converted into zones of different lineament density. Lineament density map is a measure of quantitative length of linear feature expressed in (Km/Km^2). Lineament density of an area has direct influence on groundwater prospectiveness of that area. In present study area with very high lineament density (3.27-4.64) having good groundwater potential whereas area with very low lineament density (0-0.60) having poor groundwater potential. The entire map classified in five categories as follow and depicted in Fig 8. The various lineament density features are presented in Table 2.

4.7 Geology

Geology is one of the major factor which plays an important role in the distribution and occurrence of groundwater. The study area is generally formed by ingenious rocks. The major rocks found in study area are Granitoids, Laterite, and Quartzite. Granitoid is a variety of coarse grained plutonic rock similar to granite. Generally granites have 1.5% porosity and 0.5-1.2% permeability. This rocks having joints and fractures, weathered interlocking texture and overlaying buried valleys which offer good groundwater potential. Quartzite is a metamorphic rock which are formed by recrystallization process. The porosity and permeability of Quartzite are <1%. The weightage were assigned based on the rock's influence in the groundwater Table 2.

4.8 Geomorphology

Geomorphology is a study of earth features and also depicts the various landforms relating to the Ground water potential zones and also structural features. Geomorphology of an area depends upon the structural evolution of geological formation. The study area comprises the features Pediment, Pediplain shallow, and most of the area covered with Pediplain shallow followed by Structural hills. Based on the importance of geomorphological features the weightage was assigned Table 2.

4.9 Rainfall Map

Rainfall is one of the major source for ground water availability through the water cycle. The amount of rainfall is not same all the places it varies based on the environment conditions of the place. The possibility of ground water is high if the rainfall is high and it is low if rainfall is low. The rainfall not only varies spatially it also varies temporally hence to determine the influence of rainfall in any region long time period study is necessary. The present study has been consider the annual mean rainfall from the year 2005 to 2014. The value of annual mean values have been plated on the respective rain gauge stations and the interpolation method spline technique has been used to find out the distribution of rainfall in the study area. Once the spatial distribution of rainfall has been found the study area has been classified into five zones based on the equal interval then the suitable weightage has been assigned for each classes in table 2.

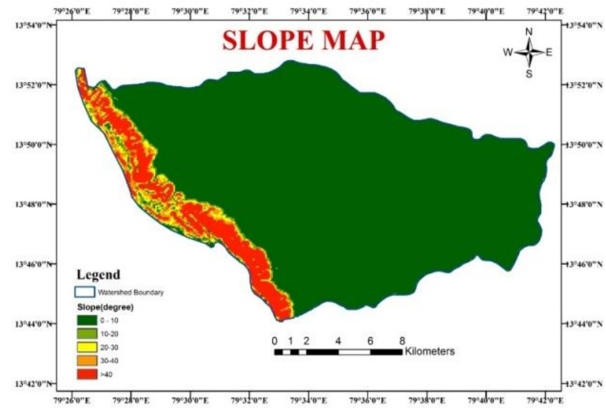

Fig 3: Slope Map of the Study Area

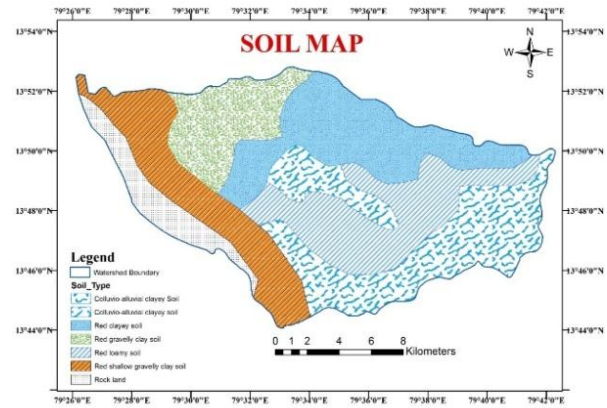

Fig 4: Soil map of the study area

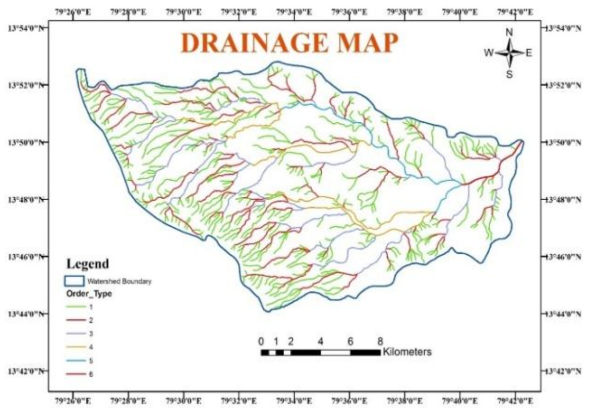

Fig 5: Drainage Map of the Study Area

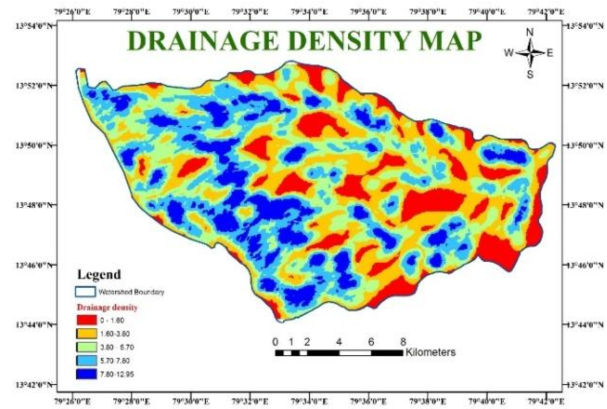

Fig 6: Drainage Density Map of the Study Area

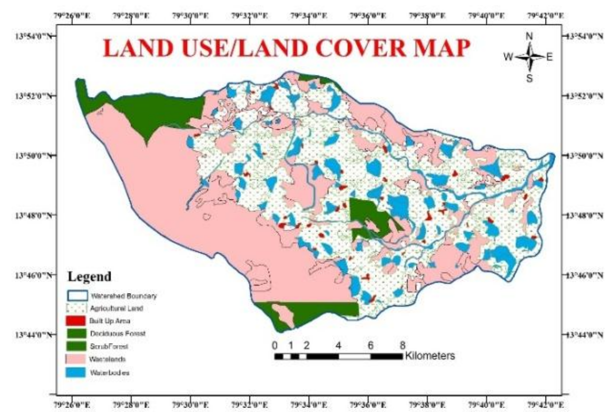

Fig 7: Land Use/Land Cover of the Study Area

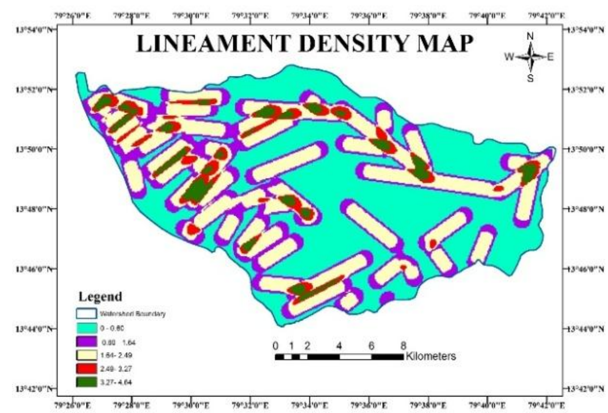

Fig 8: Lineament Density of the Study Area

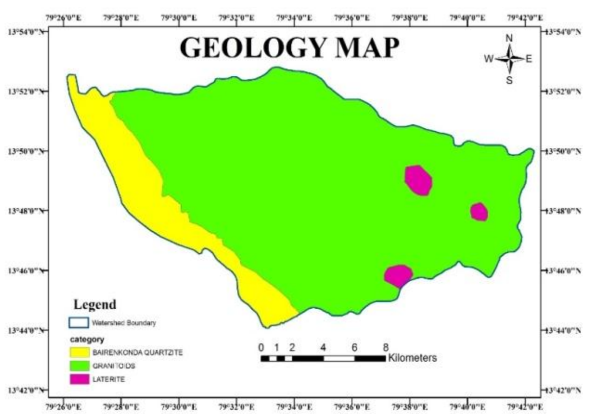

Fig 9: Geology Map of the Study Area

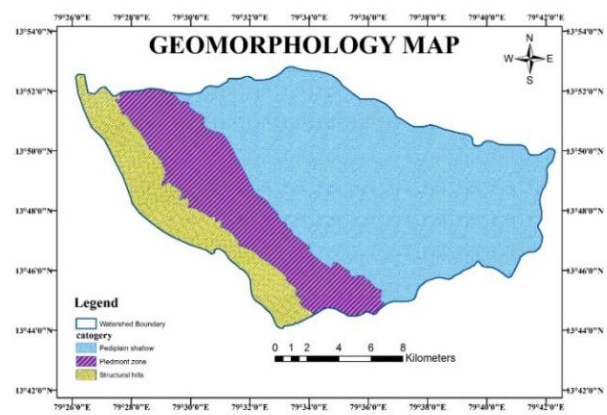

Fig 10: Geomorphology Map of the Study Area

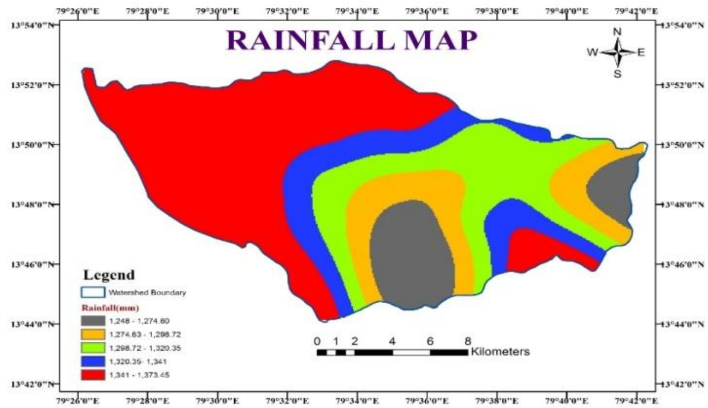

Fig 11: Rain fall map of the study area

4.10 Multi influencing factors of groundwater potential zones

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 10.1. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map, and weights were assigned according to the multi influencing factor (MIF) of that particular feature on the hydro-geological environment of the study area (Shaban *et al*., 2006) [30]. Varies influencing factors, such as geology, geomorphology, lineaments, slope, land-use, lineament, drainage, soil, and rainfall have been identified to delineate the groundwater potential zones. Interrelationship between these factors and their effect is shown in Fig 12. Each relationship is weighted according to its strength. The representative weight of a factor of the potential zone is the sum of all weights from each factor. A factor with a higher weight value shows a larger impact and a factor with a lower weight value shows a smaller impact on groundwater potential zones. Integration of these factors with their potential weights is computed through weighted overlay analysis in Arc-GIS.

4.10.1 Weightage calculation

The multi influencing factors for groundwater potential zones namely lineaments, drainage, lithology, slope, land-use, rainfall and soil were examined and assigned an appropriate weight and are shown in Table 2. The effect of each influencing factor may contribute to delineate the groundwater potential zones. Moreover, these factors are interdependent. The effect of each major and minor factor is assigned a weightage of 1.0 and 0.5 respectively (Fig 12). The cumulative weightage of both major and minor effects are considered for calculating the relative rates (Table 1). This rate is further used to calculate the score of each influencing factor. The proposed score for each influencing factor is calculated by using the formula.

$$\frac{A+B}{\sum A+B}$$

Where, A is major interrelationship between two factors and B is minor interrelationship between two factors. The concerned score for each influencing factor was divided equally and assigned to each reclassified factor (Table 5.8)

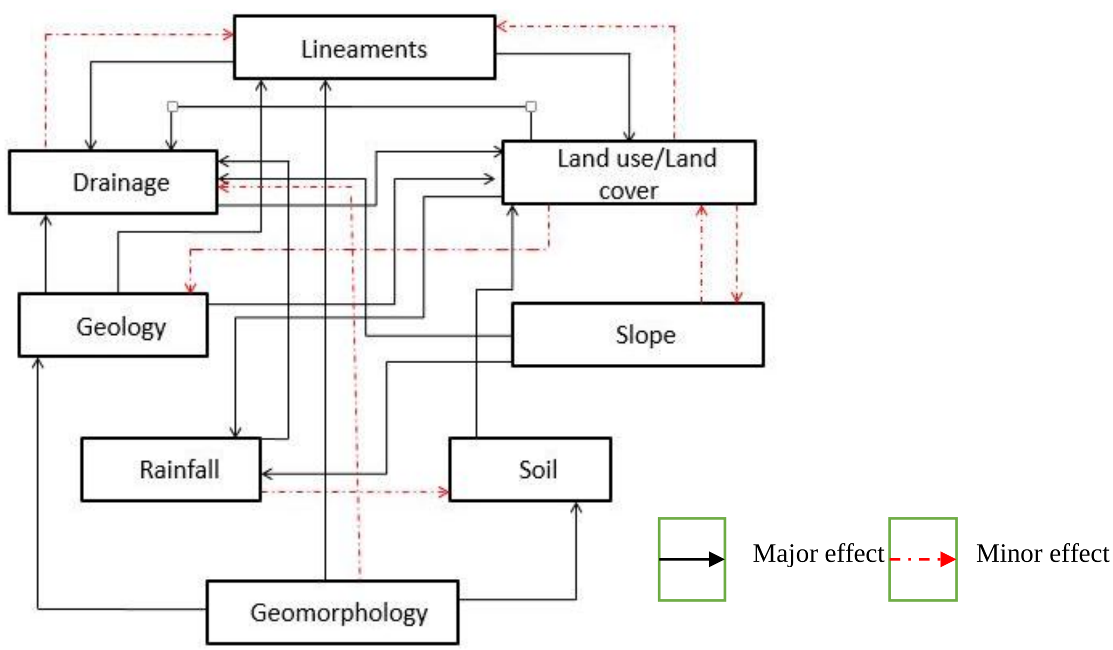

Fig 12: Interrelationship between the multi influencing factors concerning the groundwater potential zone.

Table 1: Effect of influencing factor, relative rates and score for each potential factor.

Factor	Major effect (A)	Minor effect (B)	Proposed relative rates (A+B)	Proposed weightage of each influencing factor
Lineament density	1+1	0	2	11
Geology	1+1+1+1	0	4	21
Geomorphology	1+1+1	0.5	3.5	18
Land use/Land cover	1+1	0.5+0.5+0.5	3.5	17
Drainage density	1	0.5	1.5	8
Slope	1+1	0.5	2.5	13
Rainfall	1	0.5	1.5	7
Soil	1	0	1	5
			∑19.5	

5. Demarcation of Groundwater Potential Zones of Study Area

Table 2: Weightages, Ranks and Scores for various themes in Valagalamanda Watershed

S. No.	Themes	Weightages	Feature Class	Ranks	Score
1	Lineament density	11	0-0.60	1	11
			0.60-1.64	2	22
			1.64-2.49	3	33
			2.49-3.27	4	44
			3.27-4.64	5	55
2	Geology	21	Laterite	5	105
			Quartzite	4	84
			Granitoid	3	63
3	Geomorphology	18	Pediplain shallow	5	90
			Pledmont zone	4	72
			Structural hills	2	36
4	Land use/Land cover	17	Forest	5	85
			Agricultural Land	4	68
			Waterbodies	3	51
			Built Up Area	5	34
			Wasteland	1	17
5	Drainage density	8	0-1.60	5	40
			1.60-3.80	4	32
			3.80-5.70	3	24
			5.70-7.80	2	16
			7.80-12.95	1	8
6	Slope	13	0-5.0	5	65
			5.0-15	4	52
			15-30	3	39
			30-40	2	26
7	Soil	7	Colluvio-alluvial clayey soil	5	35
			Red gravelly clay soil	4	28
			Red clayey clay soil	3	21
			Red loamy/Red gravelly clay soil	2	14
			Rock land	1	7
8	Rainfall	5	1248.00-1274.60	1	5
			1274.60-1298.72	2	10
			1298.72-1320.35	3	15
			1320.35-1341.00	4	20
			1341.00-1373.45	5	25

5.1 GIS Modeming

In order to delineate potential groundwater site in the project area, all the data sets were integrated using the model constructed in ArcGIS model builder engine the final map was produced by Weighted Linear Combination (WLC) where each class individual's weight was multiplied by the map scores and then adding the results defined by carter (1994):

$$\mathbf{S = \sum W_i X_i}$$

Where,

S=Suitability

W_i = Weight for each map score

X_i = Individual map

5.2 Groundwater Potential Zones Map of Study Area

Integration of various thematic maps of soil, land use/land cover, lineaments, drainage density and rainfall. Drainage density describing favourable groundwater zones, into a single ground water potential zones map has been carried out through the application of ArcGIS 10.1 software. Weightages ranks and scores were assigned to various themes and features classes by assessing their importance in groundwater occurrence. Weightages, ranks and scores for different themes and feature classes have been assigned considering (MIF) technique similar work carried by many researchers such as JT Chandra Sekhar, G.T Vijay Kumar (2009), M.L. Waikar, Aditya. P (2014) [19] and Magesh (2012) [17]. In this ranking I denotes 1very poor, 2 poor groundwater potential, 3 moderate, 4 good and 5 very good groundwater potential. Score of feature class for a theme is equal to product of weightages and rank.

"Raster Calculator" option of "Spatial Analysist" extension of Arc Info ArcGIS software was used to prepare integrated groundwater potential zones map by adopting suitable map algebra. The map algebra used in the "Raster Calculator" is given by

Groundwater potential zones
= (Soil) X 0.07 + (Land Use/Land Cover) X 0.17 + (Lineaments) X 0.11 + (Drainage Density) X 0.10 + (Slope) X 0.13 + (Rainfall) X 0.05 + Geology X 0.21 + Geomorphology X 0.18

Integrated groundwater potential zone map has wide range of scores. This map was reclassified in the GIS environment using ArcGIS software to demarcate various groundwater potential zones in the study area based on groundwater yield. The generated output consist of various classes of ground water potential zones namely Very Good, Good, Moderate, Poor, very poor from groundwater potential point of view.

Table 3: Areas of various Groundwater potential Zones in Valagalamanda Watershed

S. No.	Ground Potential Zones	Area(km^2)	% Total Area
1	Very Poor	10.92	3.87
2	Poor	26.76	9.5
3	Moderate	107.81	38.26
4	Good	131.26	46.59
5	Very Good	4.97	1.78

5.3 Model validation

The validation of the model developed was made using the Groundwater Level depth data which reflects the actual groundwater potential. A comparison of this study between the water level depth data and groundwater potential zones prepared by the model was made to check the validity of the proposed model. The Groundwater Level Depth data collected from the Central Groundwater Board, for Chittoor district at village level (Table 4). The co-ordinates were collected using GPS in all the selected wells and incorporated in village wise details in groundwater potential zone map as depicted in Fig 13 and Fig 14. The three zone wise wells were identified for the groundwater level depth in each zone (normally < 100 ft in good zones, 100 – 200 ft in moderate zones and >200 ft in poor zones). Very Good, Good and moderate zones were validated with available water level depth data but the poor zone of the study area was not validated because of the non-availability of data (hilly regions). The results showed that both sets of data agree with each other.

Table 4: Actual Water Level Depth data for validation of the model

S. No.	Village Name	Groundwater potential zones achieved by the model	Actual water level Depth (ft) data from CGWB
1	Mangalagunta	Very Good	40
2	Pallam	Very Good	50
3	Erragudipadu	Very Good	55
4	Pallam Peta	Good	60
5	Reddipalle	Good	70
6	Chodavaram	Good	80
7	Peddagunta Agraharam	Good	75
8	Obulayapalle	Good	78
9	Bodavaripalle	Moderate	100
10	Madamala	Moderate	110
11	Chintalapalem	Moderate	180
12	Kothuru at Chellamambapuram	Moderate	170
13	Ramanuja Palle	Moderate	185
14	Gollapalle at Venkatapuram	Moderate	180
15	Kalavagunta	Moderate	175
16	Yarlapud	Moderate	120

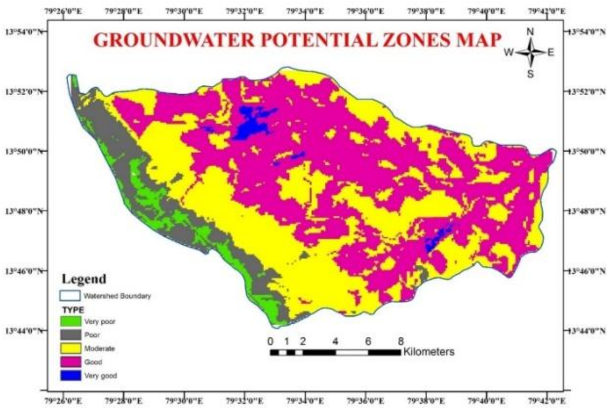

Fig 13: Groundwater potential zone Map of the Study Area

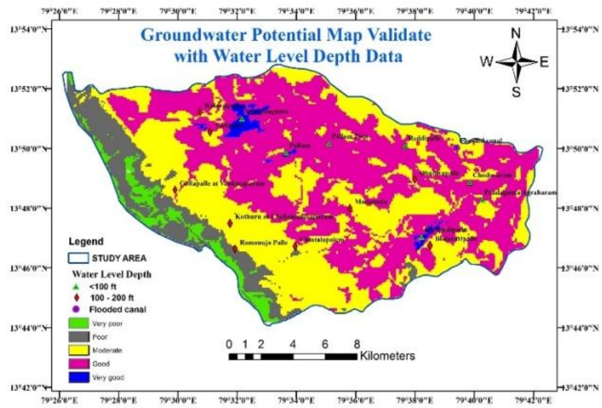

Fig 14: Groundwater Potential Map Validate With Water Level Depth

6. Conclusion

Delineating the groundwater potential zones in Chittoor district of Andhra Pradesh using remote sensing, GIS and MIF techniques is found efficient to minimize the time, labour and money and thereby enables quick decision-making for sustainable water resources management. Satellite imageries, topographic maps and conventional data were used to prepare the thematic layers of geology, geomorphology, lineament density, drainage density, slope, soil, land-use and rainfall. The various thematic layers are assigned proper weightage through MIF technique and then integrated in the GIS environment to prepare the groundwater potential zone map of the study area. According to the groundwater potential zone map, Valagalamanda watershed is categorized into five different zones, namely ‘very good’, ‘good’, moderate’ ‘poor’, and ‘very poor’. Model validation was carried out using the Groundwater Level depth data which reflects the actual groundwater potential. The results of the present study can serve as guidelines for planning future artificial recharge projects in the study area in order to ensure sustainable groundwater utilization.

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