# Identification of Groundwater Potential Zone using Geoinformatics in part of Mandakini River Basin, Chitrakoot, India

Santosh Kumar[1], Dr. Ravi Chaurey[2], Ram Moorat Singh,[3] Dr. Rakesh Dubey[4], Anoop K Patel[5]

*1 Research Scholar (RS&GIS) MGCGV Chitrakoot, Satna, MP, India*
*2 Associate Professor Geology MGCGV Chitrakoot, Satna, MP, India*
*3 Student Geology MGCGV Chitrakoot, Satna, MP, India*
*4 & 5 Consultant, MAP_IT, Bhopal, MP.*

## Abstract

*Integration of Remote Sensing data and Geographical Information System (GIS) for the exploration of groundwater has become a breakthrough in the field of groundwater, which assists in assessing, monitoring, and conserving groundwater resources. In this study, various groundwater potential zones for the assessment of groundwater availability in Satna district have been delineated using remote sensing and GIS techniques. Survey of India toposheets and Resourcersat-2 LISS-4 MX November 2017 imageries are used to prepare various thematic layers viz. Lithology, Slope, Land-Use, Structure and Lineament, Drainage, Soil, and Geology were transformed to raster data using feature to raster converter tool in ArcGIS. The raster maps of these factors are allocated a fixed score and weightage computed from remote sensing and GIS techniques. Moreover, each weighted thematic layer are statistically computed to get the groundwater potential zones. The groundwater potential zones thus obtained were divided into five categories, viz., very poor, poor, Moderate, good, and very good zones. The result depicts the groundwater potential zones in the study area and found to be helpful in better planning and management of groundwater resources.*

**Keywords** :-*Groundwater Potential Zones, Remote Sensing, Geographic Information System, Thematic maps, Mandakini River Basin.*

---

## 1. Introduction

Applications of remote sensing and GIS for the exploration of groundwater potential zones are carried out by a number of researchers around the world, and it was found that the involved factors in determining the groundwater potential zones were different, and hence the results vary accordingly. Teeuw (1995) relied only on the lineaments for groundwater exploration and others merged different factors apart from lineaments like drainage density, geomorphology, geology, slope, land-use, rainfall intensity and soil texture (Sander et al., 1996; Das, 2000; Sener et al., 2005; Ganapuram et al., 2008).

Groundwater resources are an important natural resource for its use in domestic, agriculture, and industries purposes. There has been a tremendous increase in the demand for groundwater due to increase in population, advanced irrigation practices and industrial usages. Groundwater is an significant natural resource in present day, but of limited use due to frequent failures in monsoon, undependable surface water, and rapid urbanization and industrialization have created a major risk to this valuable resource (Ramamoorthy, et al.,2014).

Remote sensing not only provides a wide-range scale of the space-time distribution of observations, but also saves time and money (Murthy, 2000; Leblanc et al., 2003; Tweed et al., 2007). In addition it is widely used to characterize the earth surface (such as lineaments, drainage patterns and lithology) as well as to examine the groundwater recharge zones (Sener et al., 2005). To understand groundwater prospects of an area, integration of different thematic layers is required. In the hard rock terrain, availability of groundwater is limited and its occurrence is essentially confined to fractures and/or weathered horizons (Krishnamurthy et al. 2000; Chandra et al. 2006; Vijith, 2007; Suja Rose and Krishnan, 2009).

## 2. Study Area

The study area is the River part of Mandakini river basin, of the Dist. Satna Madhya Pradesh spread across Utter Pradesh, India. Autonomous region and covers 1680 Sq.km. (approx.). The study area located between 24°56'09.31"N, 25°10'53.19N latitude and 80°44'23.31"E, 80°52'44.53"E longitude (approx.). length of about 46 km is a major tributary of the Yamuna River. Satna, also known as the 'Land of Red Soil', is well known for its culture values. The base of this triangle is marked by river Ajoy separating the boundary of Satna with Satna district. On the East and north, Satna district as per agro-climatic classification with the majority of soil being Kaimur Sandstone and Rewa sandstone content.

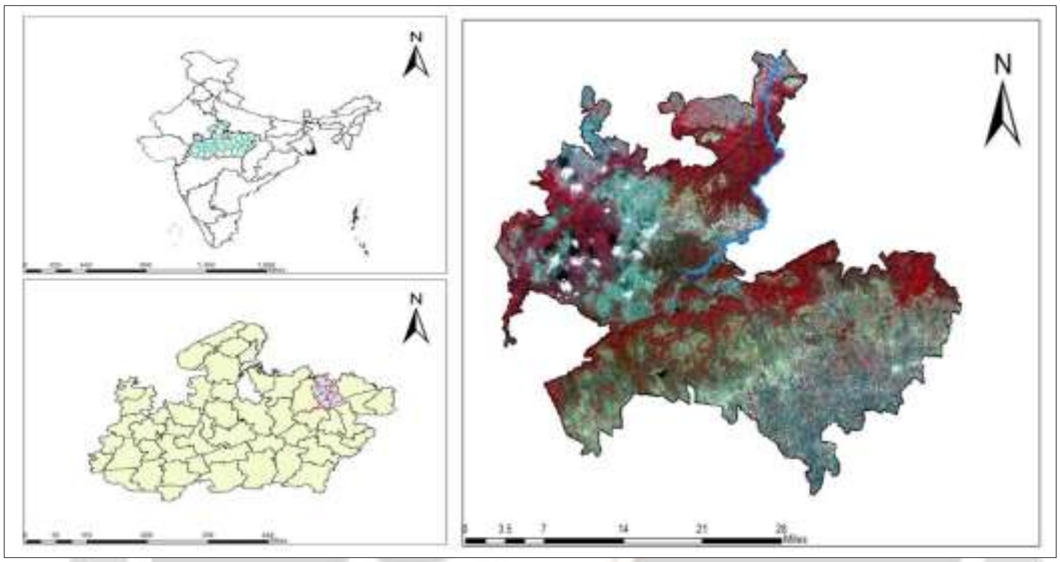

**Figure 1** Location map of study area in Mandakini river basin.

## 3. Data used and Methodology

Indian Remote Sensing satellite (IRS) P-6 LISS-4 MX data with spatial resolution of 5.8 meter is used to period of November 2017. Resourcersat-2, LISS-4 MX data of November 2017 period, in FCC form, that is, standard combination of wavelength bands 2 (0.52–0.59 µm), 3(0.62–0.68µm) and 4 (0.77–0.86 µm) and also the shortwave infrared (SWIR) have been used for mapping and preparation of maps and inventory data sheets. Elevation information is obtained from Shuttle Radar Terrain Mapping Mission (SRTM) DEM. The methodology adopted for the present study is shown in Fig. The base map of Satna district was prepared based on Survey of India topographic maps (63-C/8, 63-C/12, 63-C/16, 63-D/5, 63-D/9, 63-D/10, 63-D/13 & 63-D/14) on a 1:50,000 scale. Various thematic maps (Geology, Soil, Lineament, Land use Land cover, Drainage etc) were prepared and integrated all in Arc GIS. By assigning weightage to each theme a final map was prepared having different categories such as (i) Very Poor (ii) Poor (iii) Moderate (iv) Good and (v) Very Good. The drainage network for the study area was scanned from Survey of India (SOI) toposheets and digitized in ArcGIS 10.4 platform. The slope map was prepared from SRTM DEM data in ArcGIS 10.4 Spatial Analyst module.

Satellite images from IRS-P6, LISS-IV sensor, on a scale of 1:50,000 (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, lithology, lineament, and soil types. These thematic layers were converted into a raster format (5.8m resolution) before they were brought into GIS environment. 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 10.4. 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).

**3.1 Flowchart for groundwater potential using RS, GIS**

The methodology proposed in this study to identify and delineate groundwater potential zones using RS and GIS techniques is illustrated in Fig.8 The selected six thematic maps were integrated in the GIS environment to generate.

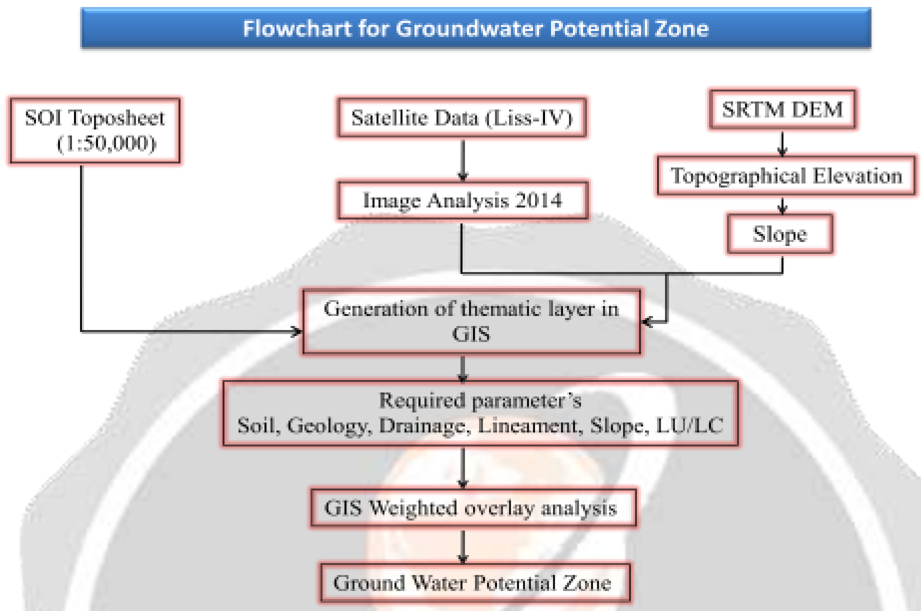


**Figure 2** Flowchart of GPZ.

## 4. Factors Influencing Groundwater

### 4.1 Lineament

Lineaments are important in rocks where secondary permeability and porosity dominate the intergranular characteristics combine in secondary openings influencing weathering, soil water, and groundwater movements. Linear faults, accompanied by the cranny, provide space for the occurrence of groundwater.

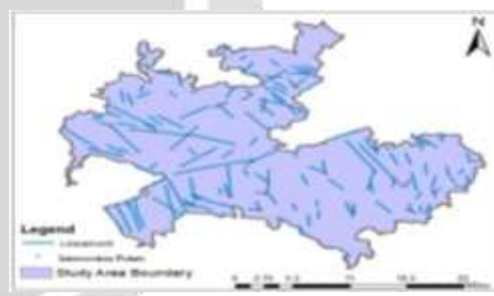


**Figure: 3** Lineament map of study area.

### 4.2 Land-use

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. 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 (Waikar and Aditya P. Nilawar, 2014). The study area shows that major portion in land use is covered by cropland kharif 192.30 sq.km, cropland rabi 501.26 sq.km, current fellow land 108.19 sq.km., scrub land 78.07 sq.km., forest land 813.87 sq. km., water bodies 27.18 sq. km., settlement covered in area 29.27sq. km.

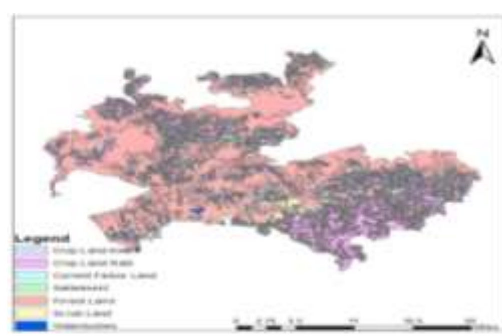


**Figure : 4** Land Use map of study area.

### 4.3 Drainage

This map is also prepared from survey of India toposheets on 1:50,000 scale. Drainage map of the study area reveals only two types of drainage patterns viz. dentritic pattern and few locations have trellies pattern. Radial type of drainage patterns are also seen at some places. According to drainage density, the study area is divided into four subclasses, i.e., Very Poor, Poor, Moderate, Good and Very Good covering an area of 617.76, 527.83, 1026.30, 299.72 and 315.98 km, respectively of the total area 2787.59 km.

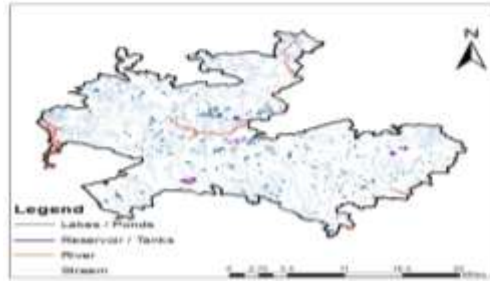


**Figure : 5** Drainage map of study area.

### 4.4 Soil

Soil is an important factor for delineating the groundwater potential zones. 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 Sandy Clay Loam soil and Sandy Loam soil (in the flood plains) at some places as shown in Surface layer is dark brown fine sandy loam. Subsurface layer is pale brown fine sandy loam. Subsoil is red clay loam and sandy clay loam.

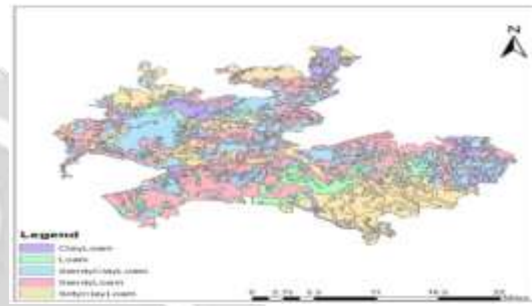


**Figure : 6** Soil map of study area.

### 4.5 Slope map

Slope is one of the important terrain parameters which are explained by horizontal spacing of the contours. In general, in the vector form closely spaced contours represent steeper slopes and sparse contours exhibit gentle slope whereas in the elevation output raster every cell has a slope value. Here, the lower slope values indicate the flatter terrain (gentle slope) and higher slope values correspond to steeper slope of the terrain. In the elevation raster, slope is measured by the identification of maximum rate of change in value from each cell to neighboring cells.

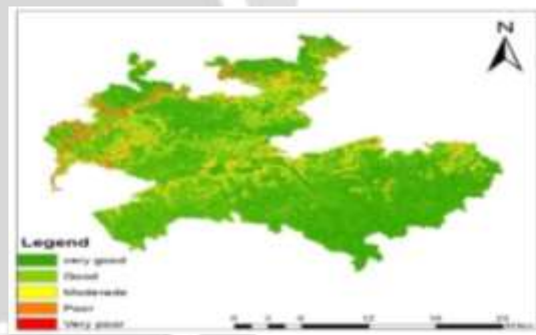


**Figure: 7** Slope map of study area.

The slope values are calculated either in percentage or degrees in both vector and raster forms, The slope amount derived from digitized contours and spot heights have shown that elevation decreases from the northern part to the southern part with slope 0º to 10º in flat and mountainous areas respectively. In the nearly level slope area (0-1) degree, the surface runoff is slow allowing more time for rainwater to percolate and consider good groundwater potential zone, where as strong slope area (10-15) degree, facilitate high runoff allowing less residence time for rainwater hence comparatively less infiltration and poor groundwater potential. The entire slope map is divided into five categories as in Table1.

### 4.6 Geology

The Vindhyan Super group has been lithostatigraphically subdivided into four groups, in stratigraphic order these are: the Semri Group, the Kaimur Group, the Rewa Group and the Bhander Group. The Vindhyan sediments show much facies variation and both horizontal and vertical gradation in lithology. Thus, areas show different lithostratigraphic succession. This aspect is well demonstrated when a comparision of lithostratigraphic area.


**Figure: 8** Geology map of study

succession is made between the eastern and western parts of the Vindhyan Basin.

The study area mainly composed of Vidhyan and then followed by Bhander shale, Granite, Kaimur Sandstone, Rewa Sandstone, Shale are distributed in the northern part. Geomorphic features play a vital role in the evaluation of surface and ground water resources. The hydro geomorphic units such as flood plain, valley fill, buried pediment is good sources of groundwater where as structural hills, pediment zone and gullied land are poor recharge zones[15] (Subagunasekar et al.2012).

**Tabel 1 Rank and weight for different parameter of groundwater potential zone in the study area**

| Parameter | Classes | Ground Water prospect | Weight (%) 100 | Rank |
|---|---|---|---|---|
| | > 1.8 | Very good | | 5 |
| | 1.8 - 3.6 | Good | | 4 |
| Lineament | 3.6 - 5.4 | Moderate | 30 | 3 |
| | 5.4 -7.2 | Poor | | 2 |
| | < 7.2 | Very poor | | 1 |
| | Nearly level (0$^0$-1$^0$) | Very good | | 5 |
| | Very gently sloping (1$^0$-3$^0$) | Good | | 4 |
| Slope Classes | Gently Sloping (3$^0$-5$^0$) | Moderate | 20 | 3 |
| | Moderately Sloping (5$^0$-10$^0$) | Poor | | 2 |
| | Strong Sloping (10$^0$-15$^0$) | Very poor | | 1 |
| | Clay Loam | Very good | | 5 |
| | Loam | Good | | 4 |
| Soil Texture | Sandy Clay Loam | Moderate | 20 | 3 |
| | Sandy Loam | Poor | | 2 |
| | Silty Clay Loam | Very poor | | 1 |
| | > 0.5 | Very good | | 5 |
| | 0.5 -1 | Good | | 4 |
| Drainage | 1 - 5 | Moderate | 15 | 3 |
| | 5 -10 | Poor | | 2 |
| | < 10 | Very poor | | 1 |
| | Bhander shale | Very good | | 5 |
| | Granite | Good | | 4 |
| Geology | Kaimur Sandstone | Moderate | 15 | 3 |
| | Rewa Sandstone | Poor | | 2 |
| | Shale | Very poor | | 1 |
| | Crop Land (Kharif/Rabi) | Very good | | 5 |
| | Water body | Good | | 4 |
| Land use/Land cover | Current Fallow Land | Moderate | | 3 |
| | Settlement | Moderate | 20 | 2 |
| | Forest Land | Poor | | 1 |
| | Scrub Land | Very poor | | 1 |

### 4.7 Verifying Groundwater Potential Zone Map

The groundwater potential zones for the study area were generated through the integration of various thematic maps viz., drainage, slope, lithology, soil, lineament and land-use using remote sensing and GIS techniques. The demarcation of groundwater potential zones for the study area was made by grouping of the interpreted layers through weighted multi influencing factor and finally assigned different potential

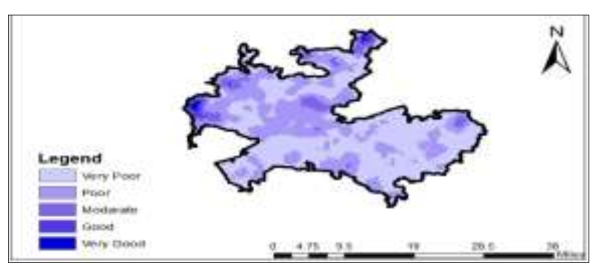


**Figure:9** Groundwater Potential Map

zones. The groundwater potential zone of this study area can be divided into four grades, namely very good, good, Moderate, poor, and very poor. The groundwater potential map demonstrates that the excellent groundwater potential zone is concentrated in the north-eastern region of the study area. This indicates that, soil type and slope plays a vital role in groundwater augmentation. Moreover, the concentration of drainage density and lineament density also helps the infiltration ability of the groundwater potential Zone map of study area.

## 5. Conclusions

Satellite imageries, topographic maps and conventional data were used to prepare the thematic layers of lithology, lineament density, drainage density, slope, soil, land-use and rainfall. The various thematic layers are then integrated in the GIS environment to prepare the groundwater potential zone map of the study area. According to the groundwater potential zone map, Satna district is categorized into four different zones, namely very good, good, Moderate, poor, and very poor. 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. This is an empirical method for the exploration of groundwater potential zones using remote sensing and GIS, and it succeeds in proposing potential sites for groundwater zones. This method can be widely applied to a vast area with rugged topography for the exploration of suitable sites.

## 6. Acknowledgement

This study was carried out as part of Ph.D. work at Madhya Pradesh Agency for Promotion of Information Technology (MAP_IT), Bhopal Madhya Pradesh by lead author Shri Santosh Kumar. Support particularly by CEO MAP_IT, Dr. Sandeep Goyal, OIC GIS & Head MP-SSDI, MAP_IT, Bhopal gratefully acknowledged for allowing us to use facilities at GIS (MP-SSDI) lab during research work. It is our sincere duty to acknowledge Dean, Head of Department and Professors at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh for their continue guidance and support during this research work.

## 7. References

[1]. Anuj Verma and U. K. Shukla, Deposition of the Upper Rewa Sandstone Formation of Proterozoic Rewa Group of the Vindhyan Basin, M.P., India: A Reappraisal Journal Geological Society of India Vol.86, October 2015, pp.421-437

[2]. Burrough PA, McDonnell RA (1998). Principles of Geographical Information Systems Oxford: Oxford University Press, p. 333.

[3]. Chi K-H, Lee B-J (1994) Extracting potential groundwater area using remotely sensed data and GIS techniques. In: Proceedings of the regional seminar on integrated application of remote sensing and GIS for land and water resource management. Bangkok, pp 64–69.

[4]. CGWB (2006). Dynamic groundwater resources of India (as on March, 2004). Central Ground Water Board (CGWB), Ministry of water resources. New Delhi: Government of India.

[5]. Deepesh Machiwal·Madan K. Jha·Bimal C. Mal, Assessment of Groundwater Potential in a Semi-Arid Region of India Using Remote Sensing, GIS and MCDM Techniques Water Resource Management (2011) 25:1359–1386.

[6]. D. Pinto, S. Shrestha, M. S. Babel, and S. Ninsawat, "Delineation of groundwater potential zones in the Comoro watershed, Timor Leste using GIS, remote sensing and analytic hierarchy process (AHP) technique," Applied Water Science, 2015.

[7]. Huajie Duan, Zhengdong Deng, Feifan Deng, and Daqing Wang Assessment of Groundwater Potential Based on

Multicriteria Decision Making Model and Decision Tree Algorithms Mathematical Problems in Engineering Volume 2016 (2016)

[8]. information system (GIS) techniques International Journal of Water Resources and Environmental Engineering Vol. 3(7), pp. 150-160, August 2011.

[9] K. A. Mogaji1, O. S. Aboyeji and G. O. Omosuyi Mapping of lineaments for groundwater targeting in the basement complex region of Ondo State, Nigeria, using remote sensing and gis.

[10]. krishnamurthy, J., Mani, A.N., Jayaram, V. and Manivel, M. (2000) Groundwater resources development in hard rock terrain: an approach using remote sensing and GIS techniques. Int. Jour. Appld Earth Obser. Geoinformatics, v.2, pp.204-215.

[11]. Murthy,K.S.R.,(2000).Groundwater potential in a semi-arid region of Andhra Pradesh—a geographical information system approach. International Journal of Remote Sensing, 21 , pp. 1867–188.

[12]. Prabu Pothiraj and Baskaran Rajagopalan , 2012, A GIS and remote sensing based evaluation of groundwater potential zones in a hard rock terrain of Vaigai sub-basin, India. Arab J Geo science . DOI 10.1007/s12517-011-0512-3.

[13]. Ramamoorthy.P.,Arjun.A.,Gobinath.K.,Senthilkumar.V.,Sudhakar.D.,(2014) Geo Spatial analysis of groundwater Potential Zone using Remote Sensing and GIS techniques in Varahanadhi Sub Basin, Tamilnadu, International Journal of Science, Engineering and Technology,Vol.2(4) pp.273-285.

[14]. S.B. Mabee, K.C. Hard castle, D.U. Wise 1994 A Method of Collecting and Analyzing Lineaments for Regional Scale Fractured Bedrock Aquifer Studies. Ground Water, Vol. 32 pp. 884-894.

[15]. Subagunasekar,M.,Sashikkumar,M.C.,2012.INT J CURR SCI ,159-162.

[16]. Suja Rose, R.S. and Krishnan, N. (2009) Spatial analysis of groundwater potential using remote sensing and GIS in the Kanyakumari and Nambiyar basins, India. Jour. Indian Soc. Remote Sensing, v.37, pp.681-692.

[17]. S. Venkateswarana and R. Ayyandurai (2015) Groundwater Potential Zoning in Upper Gadilam River Basin Tamil Nadu ICWRCOE.

*****