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Research Article

APPLICATION OF GEOSPATIAL TECHNOLOGY FOR MAPPING OF GROUNDWATER POTENTIAL ZONES IN SERCHHIP DISTRICT, MIZORAM, INDIA

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ABSTRACT
Erratic and irregular availability of surface water leads to large scale exploration for groundwater in recent times. Increasing demand for water supply necessitates the utilization of advanced and scientific techniques that are capable of saving time and money to identify the groundwater prospective. Serchhip district of Mizoram, India received abundant rainfall. However, rapid growth of human population and rapid urbanization within the district leads to acute shortage of water resources. Therefore, groundwater resources need to be utilized to facilitate this persistent scarcity of water supply. The first and foremost step in utilizing groundwater is to delineate its locations beneath the surface. The present study makes use of Geospatial technology like utilization of geographic information systems (GIS) and remote sensing data to detect the promising sites for groundwater exploration. Geospatial factors which are responsible for the occurrence of groundwater within the district were identified. Land use / land cover, slope morphometry, geomorphology, lithology, geological structures like faults and lineaments layers were generated. These thematic layers were assigned different ranks based on their relative importance in deriving the potentiality of groundwater. Different classes within each thematic layer were assigned weigthages in numerical rating from 1 to 10 as attribute values in GIS environment. Summation of these attributes values and the corresponding rank values of the thematic layers were utilize to generate the final groundwater potential map. This final map shows the different classes of ground water potential zones within the district which can be utilize for exploration and further development of groundwater resources.

Keywords: *Geospatial Technology, GIS, Groundwater, Remote Sensing, Serchhip District*

INTRODUCTION
The demand for water supply inscreases rapidly due to urbanization, growth of population and extensive uses in agricultural sectors (Choudhary *et al.,* 1996; Majumder and Sivaramakrishnan, 2014). Groundwater is one of the most vital natural resources and the largest available source of fresh water (Sharma and Kujur, 2012; Neelakantan and Yuvaraj, 2012; Kumar, 2013). Therefore, finding prospective areas for groundwater, monitoring and conserving this resource has become highly crucial for the present civilization (Rokade *et al.,* 2004; Kumar and Kumar, 2011).
In Mizoram, the amount of rainfall is reasonably high. However, shortage of water is often experienced in the post-monsoon season due to the fact that majority of the water available is lost as surface runoff. The major source of water in the state like springs also depleted during the post monsoon period (Central Ground Water Board, 2007).
Geologically, Mizoram state comprises N-S trending ridges with high degree of slopes and narrow intervening synclinal valleys, faulting in many areas has produced steep fault scarps (GSI, 2011). Hence, Serchhip district also in general, experienced acute shortage of groundwater as the monsoon rainfall is rapidly lost as surface runoff. Therefore, groundwater potential zones have to be identified so as to adopt proper measures for its conservation and development.
Few efforts were made to study groundwater prospect zones within the state of Mizoram. These include Hydrogeological mapping of Aizawl city, Aizawl district (DG&MR, 2003) and Hydrogeological mapping of Champhai town, Champhai district (DG&MR, 2004).
Advent of geospatial technology like utilization of Remote Sensing and GIS allow fast and cost effective survey and management for natural resources (Ramakrishna *et al.,* 2013). Hence, these techniques have

wide-range applications in the field of geo-sciences including groundwater prospecting (Jeganathan and Chauniyal, 2002; Anirudh, 2013). Satellite remote sensing makes it possible to analyse various ground features such as geological structures, geomorphic features and their hydraulic characteristics that may serve as indicators of the presence of groundwater (Raju *et al.*, 2013). GIS techniques can be utilize to delineation groundwater prospect zones by overlaying various geospatial data (Soumen, 2014).

Therefore, many researchers have utilized these two techniques successfully in groundwater studies (Gustafsson, 1993; Saraf and Jain, 1994; Krishnamurthy and Srinivas 1995, Krishnamurthy *et al.*, 2000). The same techniques have been proved to be of immense value not only in the field of hydrogeology but also for the development of surface water resources as well. (Saraf and Choudhury, 1999; Sharma and Kujur, 2012).

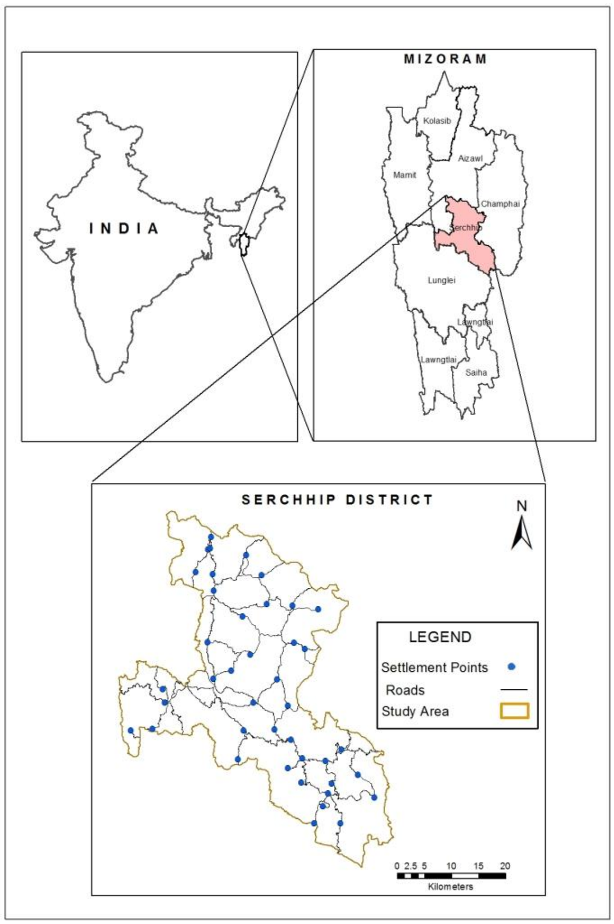

Figure 1: Location map of study area

Study Area

Serchhip district occupies the central part of Mizoram, extending more to the eastern side. It lies between 23°35'58' 82'' and 23° 00' 20' 84" N latitudes and 92° 41' 06' 00'' and 92° 40' 39' 63'' E longitudes. The total geographic area is 1421.00sq.km. and it falls in the Survey of India Topo sheet Nos. 84 A/14, 84A/11, 84 A/15, 84 E/3, 84 E/2, 84 A/12, 84 A/16 and 84 E/4.

The district enjoys a moderate climate owing to its tropical location. It is neither very hot nor too cold throughout the year. The entire district falls under the direct influence of the south west monsoon. As such the area receives an adequate amount of rainfall which is responsible for a humid tropical climate characterized by short winter and long summer with heavy rainfall. The average annual rainfall of the study area is 1688.80m (Lalzarliana)

MATERIALS AND METHODS

Data Used

Indian Remote Sensing Satellite (IRS-P6) LISS III data with spatial resolution of 23.5m was used as the main data in the present study. Indian Remote Sensing Satellite (IRS-P5) stereo-paired Cartosat-I data having spatial resolution of 2.5 m were also used. SOI topographical maps and various ancillary data were also referred in this study.

Thematic Layers

Thematic layers generated using remote sensing data like land use/land cover, slope, geomorphology, geology and lineaments can be integrated in a Geographic Information System (GIS) environment and can be utilize for delineating groundwater potential zones (Chaudary *et al.*, 1996; Kumar and Kumar, 2011). The present study utilized five thematic layers to define groundwater potentiality of the study area. The different layers are as follows-

Land use / Land cover: Remote sensing and GIS techniques can provide information for landuse mapping and play vital role in determining land use pattern (Sharma and Kujur, 2012). Land use/land plays an important role in facilitating natural groundwater recharge to the aquifers (Anirudh, 2013; Sidhu and Rishi, 2014). Forest, pastures and grasslands, and water bodies are important for groundwater recharge. Impermeable pavements and other structures due to urbanization act as obstacles to natural recharge process. Infiltration and runoff are greatly depending on land use/land cover. It is well known that recharge is high in the cultivable land and irrigated land compared to the wasteland and settlements (NRAA, 2011; Valliammai *et al.*, 2013). Considering the above facts, weightage values were assigned for the different classes of land use/land cover of the area. The different land use / land cover classes in the study area are shown in Table 1 and Figure 2.

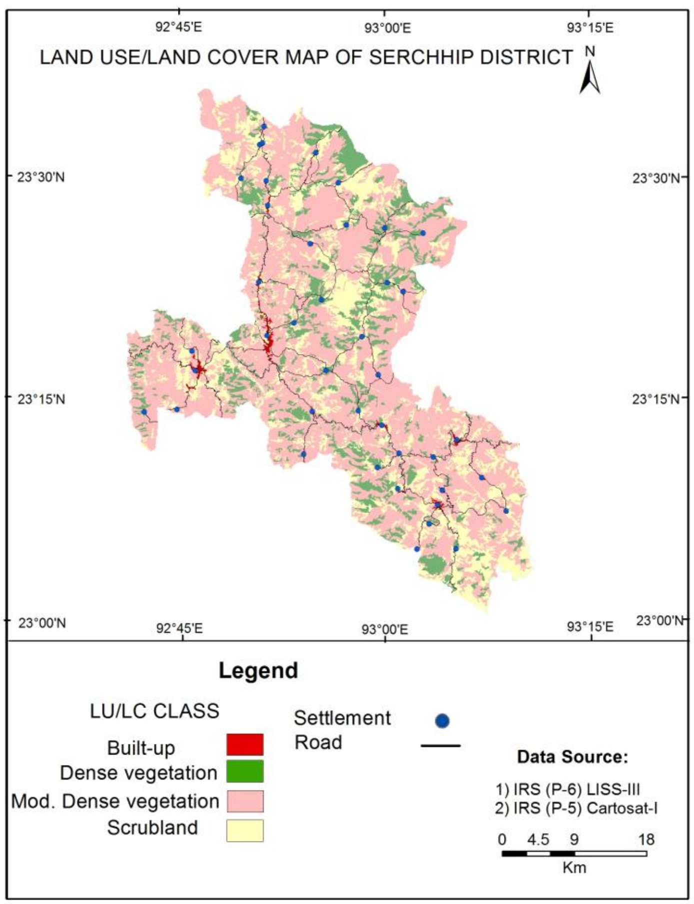

Figure 2: Land use / Land cover map of Serchhip district

Table 1: Land use/land cover area classes and area covered

Land use Class	Area (Sq.Km)	Percentage
Dense Vegetation	189.76	13.35
Moderately dense Vegetation	898.29	63.22
Scrubland	316.54	22.28
Built up	11.84	0.83
Water body	4.58	0.32
Total	**1421.00**	**100.00**

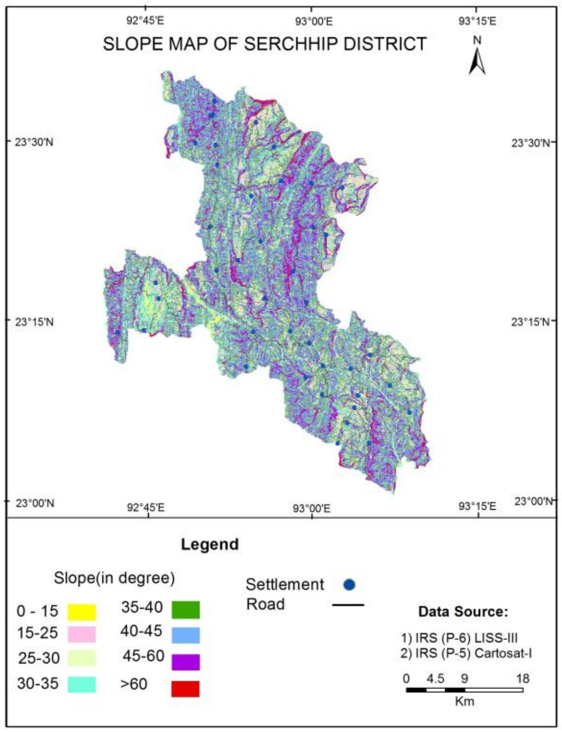

Figure 3: Slope map of Serchhip district

Table 2: Slope classes and area covered

Degree of Slope	Area (Sq.Km.)	Percentage
0-15	134.02	9.43
15-25	7.02	0.49
25-30	76.35	5.37
30-35	172.31	12.13
35-40	448.28	31.55
40-45	356.67	25.1
45-60	183.01	12.88
>60	43.34	3.05
Total	**1421.00**	**100.00**

Slope: Slope map was generated utilizing the Cartosat-I stereo-paired data in a GIS environment. The was divided into eight slope classes, viz., 0-15, 15-25, 25-30, 30-35, 35-40, 40-45, 45-60 and above 60 degrees. Gentle slope promotes water infiltration and groundwater recharge whereas steep slopes acts as a high runoff zone (CGWB, 2000; Kumar and Kumar, 2013; Al-Bakri1 and Al-Jahmany, 2013; Siddalingamurthy *et al.*, 2013). Weightage values were given in accordance with the steepness of the slope. Slope classes and area covered are given in Table 2, and the slope map is shown in Figure 3.

Geomorphology: Geomorphology is one of the most important features in evaluating the groundwater potential and prospect, and can be utilized in managing groundwater resources (Kumar and Kumar 2011; Valliammai *et al.*, 2013, Raju *et al.*, 2013). It is also highly helpful for selecting the artificial recharge sites as well (Ghayoumian, 2007).

The study area was comprises three main geomorphic units viz., structural hill, valley fill and flood plain. Structural hills were further divided into High, Moderate and Low structural hills with the elevation of above 1000m, 500-1000m and less than 500m above mean sea level respectively (MIRSAC, 2006). High elevated areas are less suitable for occurrence of groundwater and following this pattern, weightage values were given to each of the geomorphic classes. Valley fills are considered to be the best potential areas (Edet *et al.*, 1998; El-Baz, 1999). The area coverage of different Geomorphic classes is given in Table 3 and Geomophological map of the study area is shown in Figure 4.

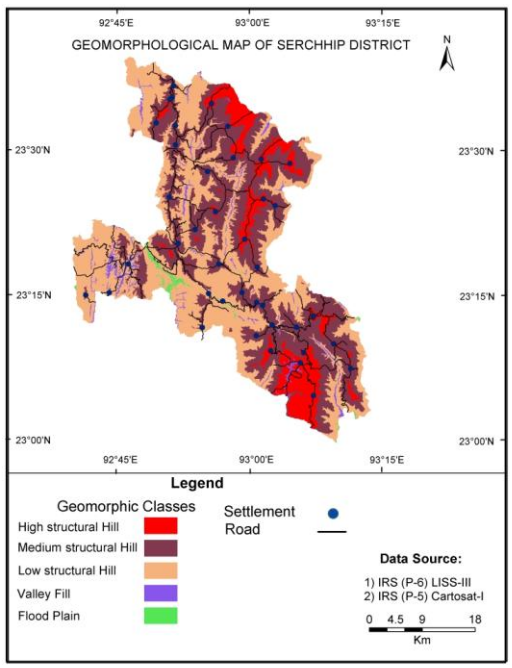

Figure 4: Relative relief map of Serchhip district

Table 3: Geomorphic classes and area covered

Geomorphic Unit	Area (Sq.km.)	%
High Structural Hill	169.65	11.94
Medium Structural Hill	568.41	40.00
Low Structural Hill	640.65	45.08
Valley Fill	33.61	2.36
Flood Plain	8.69	0.61
Total	1421.00	100.00

Lithology: Lithology of Mizoram comprises great flysch facies of rocks made up of monotonous sequences of shale and sandstone (La Touche, 1891). The study area lies over rocks of Bhuban sub-group which belong to Surma Group of Tertiary age. This sub-group was further sub-divided into Lower, Middle and Upper formations. Lower and Upper formations consist mainly of arenaceous rocks while

Research Article

Middle Bhuban comprises mainly argillaceous rock (GSI, 2011). All the three formations are exposed within the study area. Four litho-units have been established for the study area purely based on the exposed rock types namely Sandstone unit, Shale-siltstone unit, Clayey unit and Gravel, sand & silt unit.In particular, the features to be considered are geological boundaries, porosity, etc (CGWB, 2000; Al-Bakri1 and Al-Jahmany, 2013). It was considered that the unconsolidated material units offer more chance for the occurrence of groundwater. Considering all these factors, the different lithological units were assigned weightage values. The lithological units and their area covered were given in Table 4.

Geological Structure: Lineaments like faults, fractures and joints can be delineate and analyse using Remote sensing data (Kanungo *et al.*, 1995). The most obvious structural features that are important from the groundwater point of view are the lineaments (Bhatnagar and Goyal, 2012). Lineaments provide the pathways for groundwater movement and provide potential for groundwater recharge (CGWB, 2000; Sankar, 2002; Sharma *et al.*, 2012). It was observed that the rocks exposed within the study area were traversed by several faults and fractures of varying magnitude and length (MIRSAC, 2006). The geological map of the study area is given in Figure 5.

Table 4: Lithological units and area covered

Rock Types	Area (Sq. km)	%
Sandstone	703.36	49.50
Shale & Siltstone	674.66	47.48
Clayey Sand	33.70	2.37
Gravel, Sand & Silt	9.29	0.67
Grand Total	**1421.00**	**100**

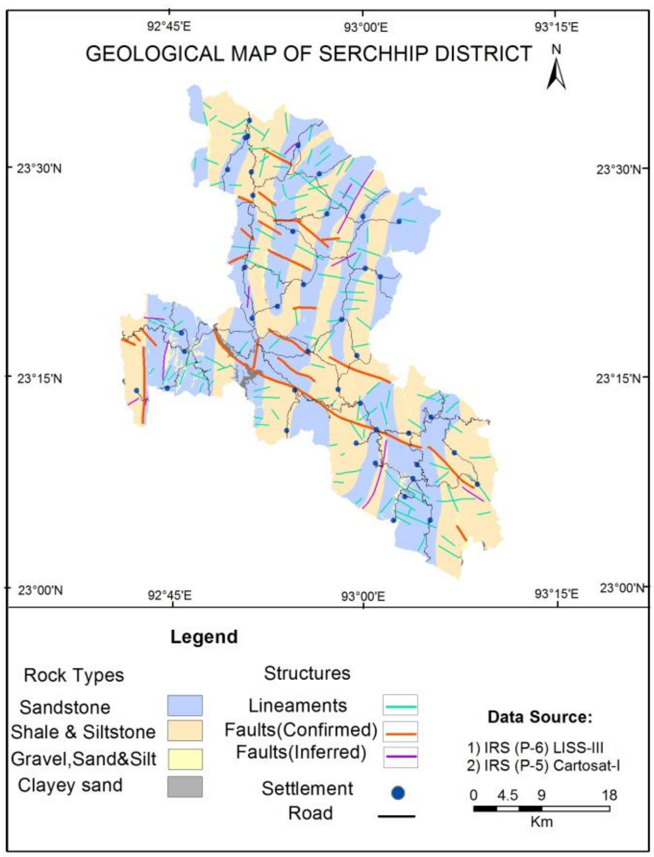

Figure 5: Geological Map of Serchhip town

Data Analysis

Geo-spatial factors like land use/land cover, slope morphometry, geomorphology, lithology and geological structure are found to be playing significant roles in demarcating groundwater potential zones within the study area. Based on their role in controlling the occurrence, storage and distribution of groundwater, all the thematic layers were assigned different ranks (Kumar and Kumar, 2011). Individual classes in each thematic layer are carefully analysed so as to establish their relation in selecting suitable areas for groundwater occurences. Weightage value is assigned for each class in such a manner that less weightage represents the least influence and more weightage having higher influence. The assignment of weightage value for the different categories within a parameter is done in accordance to their assumed or expected importance based on the *apriori* knowledge of the experts (Neelakantan and Yuvaraj, 2012; Krishna Murthy and Renuka Prasad, 2014). Limited ground information within the study area was also considered. All the thematic layers were integrated and analysed in a GIS environment using ARCINFO (10.1 version) to derive the final map. The scheme of giving weightages in the study is shown in Table 5.

Table 5: Ratings for Parameters on a scale of 1-10

Parameter	**Ranks (in %)**	**Classes/Units**	**Weight**
Lithology	20	Sandstone	8
		Shale & Siltstone	2
		Clayey Sand	9
		Gravel, Sand & Silt	5
Land Use / Land Cover	15	Dense Vegetation	8
		Sparse Vegetation	7
		Scrubland	5
		Built-up	2
Slope [in degrees]	15	0 - 15	8
		15-25	7
		25-30	5
		30-35	3
		35-40	2
		40-45	1
		45-60	1
		> 60	1
Structure/ Lineaments	25	Length of Buffer distance on	8
Geomorphology	25	High Struct. Hills	1
		Medium Struct. Hills	3
		Low Struct. Hills	5
		Valley Fill	9
		Flood Plain	9

RESULTS AND DISCUSSION

Combining all the controlling parameters by giving different weightage value for all the themes, the final map is prepared and categorised into 'Very good', 'Good', 'Moderate', and 'Poor' potential zones. The output map is generated on a scale of 1: 50,000. Various classes are described below:

Very Good

Very good zone includes valley fill, flood plains and low-lying areas. Besides, it includes the intersection of lineaments such as faults, fractures and joints. This zone usually comprises areas where unconsolidated sediments, such as gravel, sand, silt and clayey sand are deposited. These have a high potentiality of retaining water since they allow maximum percolation due to their maximum pore spaces between the grains. This zone spreads over an area of about 140.72sq. km., and forms 9.90per cent of the study area.

Good

All the remaining geologically structure controlled areas fall under the Good potential zone. Other low lying and gentle slopes areas are also included. Sandstones are generally capable of storing and transmitting water through their interstices and pore spaces present in between the grains, and are considered to be suitable aquifer. Hence, parts of areas where sandstones are exposed also come under this zone. This zone spreads over an area of about 255.48sq. km., and forms 17.98per cent of the study area.

Moderate

This zone mainly comprises areas where the recharge condition and the water-yielding capacity of the underlying materials are neither suitable nor poor. Topographically, it covers gently sloping smooth surface of the hill. Although the lithology may comprise good water-bearing rock formation such as sandstone, the potentiality is minimized by the sloping nature of the topography where run-off is maximum. In general, the moderate zone falls within the poor water-bearing rock formation such as silty shale that is, in turn, characterized by the presence of secondary structures in them. The Moderate zone is evenly distributed within the study area and covers an area of 459.35sq. km., and occupies 32.33per cent of the total study area.

Poor

This zone is mainly distributed in the elevated areas. In the area of high relief, a greater part of precipitation flows out as surface run-off, which is a poor condition for infiltration beneath the ground surface. Hence, the groundwater yield is generally assumed to be low. Unless the elevated areas are traversed by geological structures, and possess high drainage density and suitable water-bearing rock formation, their groundwater yield is generally low. The Poor zone is mainly distributed along the ridges. This zone is predominantly high in terms of aerial extend, and covers majority of the study area.This zone occupies an area of about 565.45sq. km., which is 39.79per cent of the total study area.

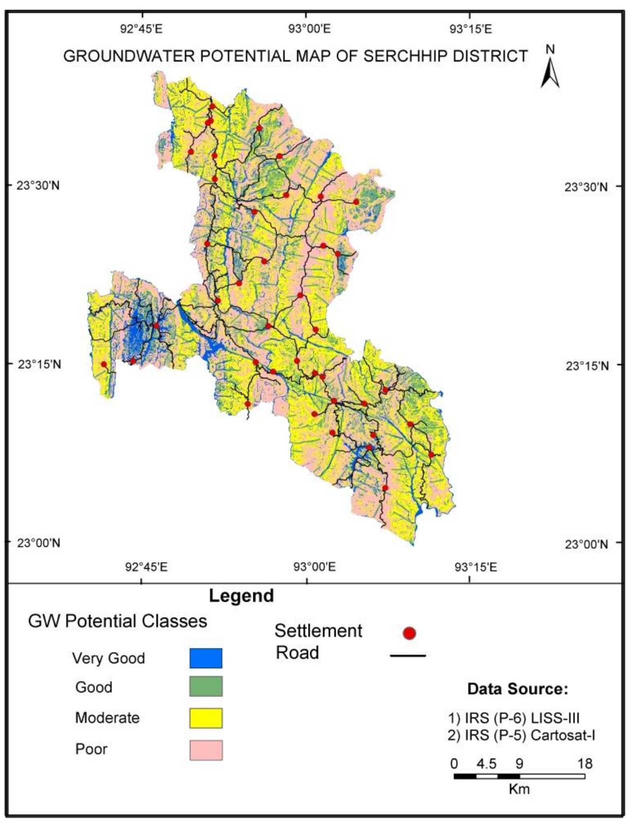

Figure 6: GW Potential Map of Serchhip town

Table 6: GW potential zones and area covered

Sl No.	Potential Zone	Area (Sq. Km.)	%
1	Very Good	140.72	9.90
2	Good	255.48	17.98
3	Moderate	459.35	32.33
4	Poor	565.45	39.79
Total		**1421.60**	**100.00**

Conclusion

The present study has proven that geospatial factors like land use/ land cover, slope, geomorphology, lithology and geological structure are directly associated with the availability of groundwater. All these vital parameters can therefore, be utilize for selecting suitable areas for groundwater exploitation. The study also shows that geospatial technologies like application of remote sensing and GIS can be used as successful tools in delineating, development and management of groundwater.

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REFERENCES

Anirudh B (2013). Remote sensing & Geographical information system based study for groundwater prospecting in hard rock terrain. *International Journal of Remote Sensing & Geoscience* **2**(1) 53.

Bhatnagar D and Goyal S (2012). Groundwater potential zones mapping through Multi-criteria analysis, a case study of sub Watershed of Katni river basin. *International Journal of Remote Sensing & Geoscience* **1**(1) 22-26.

CGWB (2007). Manual on artificial recharge of ground water. Central Ground Water Board, Ministry of Water Resources 13.

Choudhary BS, Manoj Kumar, Roy AK and Ruhal DS (1996). Application of remote sensing and Geographic Information Systems in ground water investigations in Sohna block, Gurgaon district, Haryana (India). *International Archive of Photogrammetry and Remote Sensing* **XXXI**(B6) 21.

DG&MR (2003). Detail Hydrogeological mapping of Aizawl City. Directorate of Geology and Mineral resources, Mizoram.

DG&MR (2004). Detail Hydrogeological mapping of Champhai town. Directorate of Geology and Mineral resources, Mizoram.

Edet A, Okereke C, Teme S and Esu E (1998). Application of Remote Sensing Data to Groundwater Exploration: A Case Study of the Cross River State, Southeastern Nigeria, *Hydrogeology Journal* **6**(3) 394-404.

El-Baz F (1999). Groundwater Concentration beneath Sand Fields in the Western Desert of Egypt: Indications by Radar Images from Space, *Egyptian Journal of Remote Sensing and Space Sciences* **1** 1-24.

Ghayoumian J, Mohseni Saravi, Feiznia S, Nouri B and Malekian A (2007). Application of GIS techniques to determine areas most suitable for artificial groundwater recharge in a coastal aquifer in southern Iran, *Journal of Asian Earth Sciences* **30**(20) 364-374.

GSI (2011). Geology and Mineral resources of Manipur, Mizoram, Nagaland and Tripura. Geological Survey of India, Miscellaneous Publication No. 30 Part IV **1**(2) 36-39.

Gustafsson P (1993). High resolution satellite data and GIS as a tool for assessment of groundwater potential of semi-arid area. In IXth Thematic Conference on Geologic Remote Sensing. 8-11 February, 1993 at Pasadena, California, USA.

Kanungo DP, Sarkar S and Mehotra GS (1995). Statistical analysis and tectonic interpretation of the remotely sensed lineament fabric data associated with the North Almora thrust, Garhwal Himalaya, India. *Journal of the Indian Society of Remote Sensing* **23**(4) 201-210.

Krishna Murthy BN and Renuka Prasad TJ (2014). Identification of groundwater potential zones using GIS technique in South Bangalore metropolitan region Of Karnataka, India. *International Journal of Geology, Earth & Environmental Sciences* **4**(3) 9-22.

Krishnamurthy J and Srinivas G (1995). Role of geological and geomorphological factors in groundwater exploration: A study using IRS-LISS-II data. *International Journal of Remote Sensing* **16** 2595-2618.

Krishnamurthy J, Mani A, Jayaraman V and Manivel M (2000). Groundwater resources development in hard rock terrain – an approach using remote sensing and GIS techniques. *International Journal of Applied Earth Observation and Geoinformation* **2**(34) 204-215.

Kumar B and Kumar U (2011). Ground water recharge zonation mapping and modeling using Geomatics techniques. *International Journal of Environmental Sciences* **1**(7) 1671.

Kumar CP (2013). Assessment and strategies for development potential of deeper confined aquifers in India. *Asian Academic Research Journal of Multidisciplinary* 1(8).

La Touche THD (1891). Records of the Geological Survey of India. *Geological Survey of India (GSI)* **24**(2).

Lalzarliana C (2013). Rainfall records of Mizoram. Directorate of Agriculture, Government of Mizoram 1.

Majumder A and Sivaramakrishnan L (2014). Groundwater budgeting in alluvial Damodar fan delta: A study in semi-critical Pandua block of West Bengal, India. *International Journal of Geology, Earth & Environmental Sciences* **4**(3) 23-37.

MIRSAC (2006). Natural Resources Mapping of Mamit district, Mizoram using Remote Sensing and GIS, A project report. Mizoram State Remote Sensing Centre, S&T, Planning Dept. Mizoram 28.

MIRSAC (2010). Ground water potential zonation and surface water mapping of Mizoram. using Remote Sensing and GIS. Mizoram Remote Sensing Application Centre, Directorate of S&T, Mizoram.

MIRSAC (2012). Meteorological Data of Mizoram. Mizoram Remote Sensing Application Centre, Aizawl, Mizoram 43-45.

Murugiah M and 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* **3**(3) 414.

National Rainfed Area Authority (2011). Monitoring and Evaluation of Artificial Recharge of Ground Water Programmes/Schemes/Projects in the Rainfed Regions of Maharashtra, Planning Commission Government of India, New Delhi 18.

Neelakantan R and Yuvaraj S (2012). Evaluation of groundwater using geospatial data – A case study from Salem taluk, Tamil Nadu, India, *International Journal of Remote Sensing & Geoscience* **1**(2) 7.

Raju GS, Babul KR, Siva Kumar KN and Kumar PLK (2013). Application of remote sensing data for identification of groundwater potential zones in and around Kadapa area, Andhra Pradesh, India. *International Journal of Remote Sensing & Geoscience* **2**(1) 58.

Ramakrishna, Nagaraju D, Mohammad Suban Lone, Siddalingamurthy S and Sumithra S (2013). Groundwater prospectus studies of Tattekere watershed, Mysore district, Karnataka, India using Remote Sensing and GIS. *International Journal of Remote Sensing & Geoscience* **3**(1) 6-10.

RokadeVM, Kundal P and Joshi AK (2004). Water resources Development Action plan for Sasti Watershed, Chadrapur District, Maharashtra using Remote sensing and Geographic Information System, *Journal of the Indian Society of Remote Sensing* **32**(4) 359-368.

Sankar K (2002). Evaluation of groundwater potential zones using remote sensing data in Upper Vaigai river basin, Tamil Nadu, India. *Journal of Indian Society of Remote Sensing* **30**(30) 119–129.

Saraf AK and Choudhury PR (1998). Integrated remote sensing and GIS for ground water exploration and identification of artificial recharge sites, *International Journal of Remote Sensing* **19**(10) 825–1841.

Saraf AK and Jain SK (1994). Integrated use of remote sensing and GIS methods for groundwater exploration in parts of Lalitpur District, U.P. India: International Conference on Hydrology and Water Resources, 20-22 December, 1993 at New Delhi, India.

Sharma MP and Kujur A (2012). Application of Remote Sensing and GIS for groundwater recharge zone in and around Gola Block, Ramgargh district, Jharkhand, India. *International Journal of Scientific and Research Publications* **2**(2) 1.

Siddalingamurthy S, Nagaraju, D, Sumithra S, Mohammad Subhan Lone, Ramakrishna and Lakshmamma (2013). Evaluation of groundwater resources studies of Chamarajanagar taluk, Chamarajanagar district, Karnataka, India, using Remote Rensing and GIS Techniques, *International Journal of Remote Sensing & Geoscience* **2**(4) 39-43.

Sidhu S and Rishi MS (2014). Water quality assessment of the sewage contaminated drain and its impact on the groundwater regimes a case study of North Choe Chandigarh, *Asian Academic Research Journal of Multidisciplinary* **1**(26).

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* **4**(2) 62-72.

Valliammai A, Balathanduytham K, Tamilmani D and Mayilswami C (2013). Identification of potential recharge zone of the selected watershed using Remote Sensing and GIS, *International Journal of Scientific & Engineering Research* **4**(8) 611.