Integrated watershed study to delineate ground water prospects through Remote Sensing

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ABSTRACT

This paper addressing the application of remote sensing and GIS technology for better understanding of the hydro geological parameters of the study area around Sagar town principally dominated by Deccan Volcanic rocks. The study carried out around Bewas Parkul sub-Watershed, covering 75.66 sq. Km. Area. This sub-watershed is the part of Dhasan basin notified as 2C2C6 in the watershed Atlas of India. IRS LISS IV Satellite imagery was used to prepare various thematic maps on scale of 1:10,000. The layers which have been integrated are in the strong co-relationship with each other, they are as follows land use and land cover, geomorphology, geology, hydro geomorphology, structure of the land form. The output layers helped in the identification of the potential zones for ground water prospect of the area. These maps can be further used in development and planning with some limitations due to seasonal variations. Lineaments and their intersections appear to be potential sites for the ground water, thus water tables level can also be estimated from this study. Thus an assessment can be done for the suitability towards construction of the surface reservoirs and the check dams which may help in the strengthening of the agricultural infrastructure over the study area. This even would be a major step towards controlling of the land degradation over the study region.

Keyword: - *Ground water Potential, Remote Sensing, GIS, Cartosat-1.*

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1. INTRODUCTION:

Integrated watershed study is done with the objective to explore the occurrence of ground water in a particular basin. Groundwater is said to be the natural resource which is dynamic and replenish-able in nature it plays an important role in the economic activities and in the daily life of the population. Thus ground water should be prevented from degradation and unwise exploitation. Monitoring and research have to be done more on hydro geological exploration to achieve a better understanding of groundwater systems and their dynamics. Land use are greatly influenced by the anthropogenic activities which further indirectly influences the groundwater conditions also. land use change from forests to agricultural crops as an example may have significant impacts on groundwater levels rise and fall. land use in the study area should be properly managed in a planned way so that the protection and maintenance of the groundwater systems can be taken into consideration and thereby prevent groundwater contamination. Topographical and surficial features are very important things to be kept in mind while determining the groundwater potential zones on the earth surface. Hard rocky terrain have limited ground water potential zone it is mainly confined to fractured and weathered zones. Thus it is clear that the exploration and exploitation of ground water resources require thorough understanding of geology, hydrogeology and geomorphology of the area (V.K. Srivastava et. al, 2012). Integrated analysis of the above apart from just mapping and delineation of the potential areas on small and regional scale help in determination of aquifer characteristics, flow pattern, and correlation of lithology over the study area (Sabale et al., 2009). Remote Sensing and GIS has emerged as a major tool for integration of various resources and environmental management plans, the technology is gradually getting its importance because it gives fairly accurate, updated and timely information on natural resources for planning effectively the above factors for exploration of the ground water and analyzing them. This paper attempts an overview of the application of remote sensing and GIS techniques to delineate ground water of Bewas-Parkul Sub-Watershed lying within the Dhasan basin in a methodological approach.

2. STUDY AREA

The study area includes the catchment of Dhasan river in the Sagar District and which is located in the north central part of the state of Madhya Pradesh and covers almost an area of about 78 Sq. Kms and is located between 23° 76' N to 23° 61' N latitude and 78° 53' E to 78° 64' E longitude. The Dhasan River originates from the northwest part of Sagar district , this district has a network of four main rivers namely the Ganga Basin, Ken sub Basin, Betwa sub Basin and Narmada basin and the major physiographic unit of this place consists of the Deccan trap and Bundelkhand massif in the North and the Malwa plateau in the South.The soil type of the entire district is clay loam, sandy clay loam and sandy loam. This sub watershed is a part of the Bewas Parkul Watershed. The normal annual rainfall of the study area is about 1100 mm and mainly the annual rainfall takes place during the southwest monsoon period i.e. June to September very small amount of rainfall takes place during the rest of the year. Temperature falls as low as 11ºC and reaches maximum up to 240C in the winter months of the year and in the month of May and June, the temperature goes up to 400C or at times may be even more than that. The present study area, mainly consists of the pediplain region ranging from deep moderate and shallow pediplane, there are even some more residual hills which have been subjected to erosion from several years by the river in this area. In this terrain ground water occurs under both the confined and the unconfined conditions and in the weathered zone of consolidated or unconsolidated rocks. Groundwater in such rocks circulates through the secondary openings represented by joints, cracks, fissures and such other planes of discontinuity. Above scenarios has been taken into consideration for mapping of ground water potential zones, by integrating various thematic maps, as generated from processed and enhanced remote sensing multi band data, digital elevation model (DEM) created from Cartosat data and other geo hydrological data in GIS environment.

3. DATA USED AND METHODOLOGY

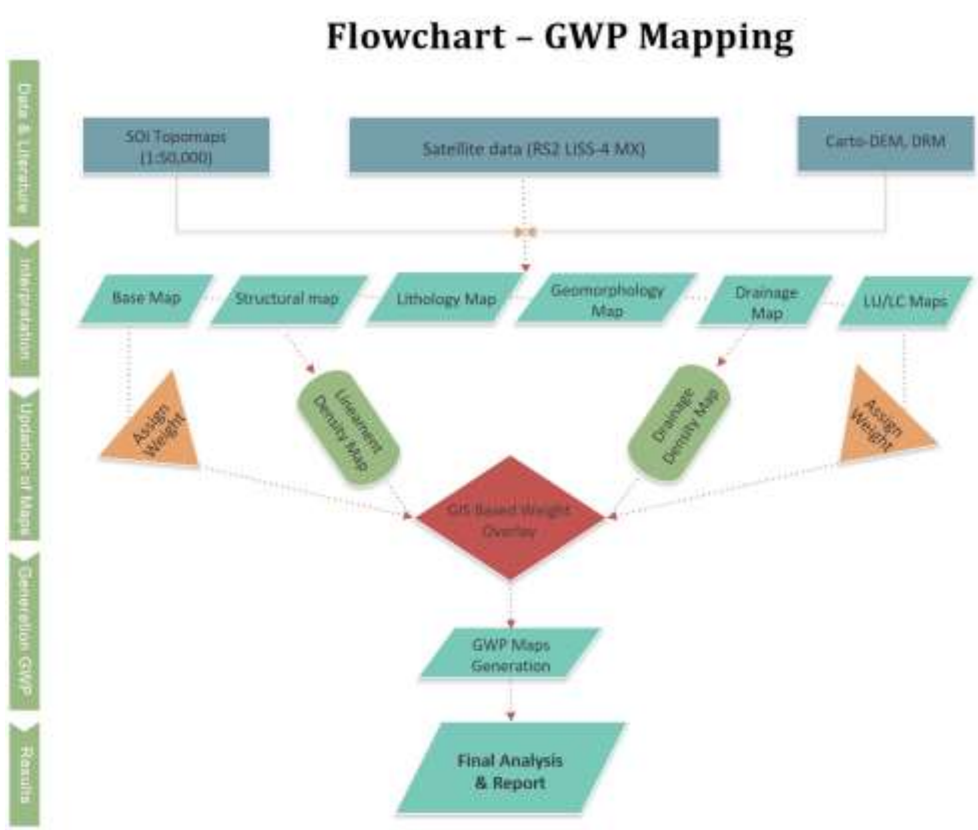

Fig -1: Methodology

4. RESULTS AND DISCUSSION:

On the basis of the integrated and weighted analysis of various thematic maps such as the geomorphological map, geological map, slope map, drainage map, lineament map and land use and land cover map Hydrogeological explorations have been conducted.

4.1 Drainage Network and drainage density map Analysis:

The structural analysis of a drainage network helps assessing the characteristics of the groundwater infiltration zones (Teixeira et. al, 2008). The drainage network depends on several climatic factors like rain. The amount of rain water plays an important role in the hydrologic cycle it forms as a source of water to the rivers and also as a source of ground water infiltration, slope of the land ,lithology of the study area helps to understand the percolation rate of the water. Surface water circulation can be considered as an inverse function of the groundwater infiltration potential zone. Thus it is quite clear that the drainage density is a very important index which has to be determined in geo-hydrological studies required for the exploration of the geo-environmental aspects. Bed rocks determine the drainage textures and the patterns of the rocks cause of the lithological characters of the study region prominently dominates the underlining rocks and their deposition structure. A drainage map of the study area has been prepared using the IRS-P6 LISS-IV on 1:50000 scale. The pattern of the drainage clearly shows that it is dendritic in nature. Dendritic drainage pattern has its stream branch in all directions and at almost any angle, resembling in plan the branching habit of certain trees. this pattern is often observed when a consequent stream receives several tributaries which in turn are fed by smaller tributaries. It is an indicative of insequent streams flowing across horizontal and homogeneous strata or complex crystalline rocks offering uniform resistance to erosion. The orders of the streams dominating in the watershed are mainly first, second and the third order. The drainage density was calculated according to the stream length per unit area of the study region as it is a better quantitative expression to the dissection and analysis of land form (K.Pareta, 2011). The drainage density of the catchment area is in the order of 1.033 square km. Since water surface circulation can be considered as an inverse function of ground water circulation the overall weight for this factor was considered as 15 (J.Teixeira, 2008).

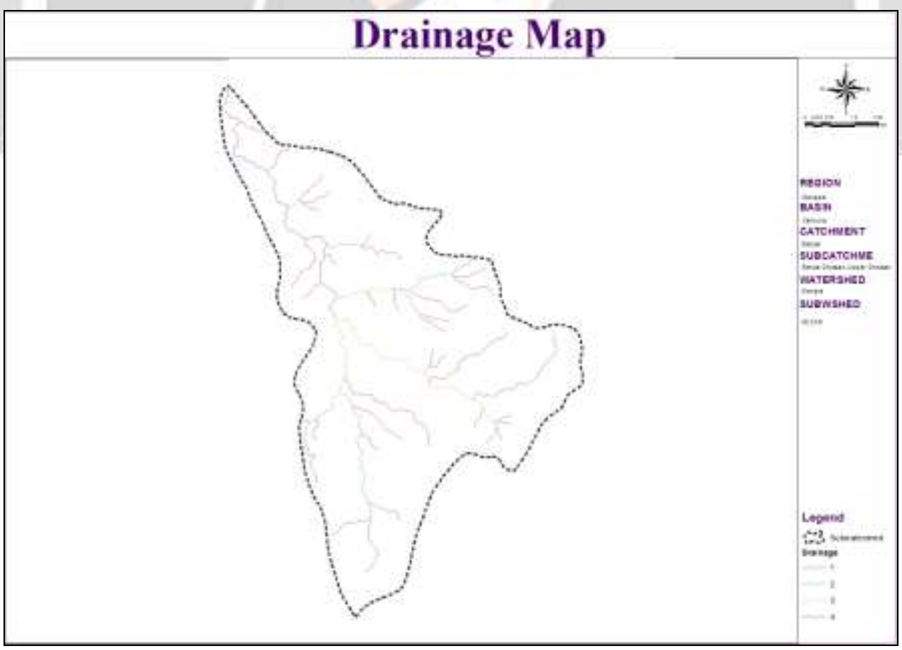

Fig -2: Drainage Map

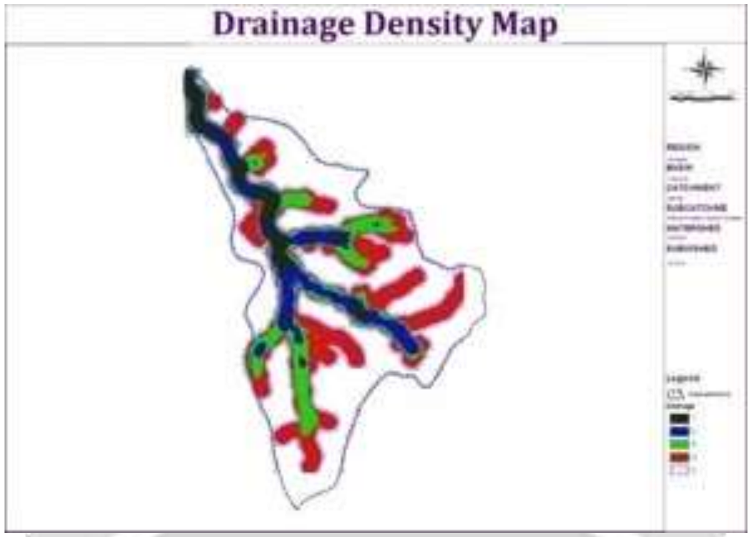

Fig -3: Drainage Density Map

4.2 Topography Analysis:

Topography in other word slope, describes the shape and the relief of the land rather it is one of the most important factors controlling groundwater infiltration rate (Jha et al 2007; Yeh et al 2008).The slope line showing the gradient of the landform is in the direction towards the border face of the watershed, the area is mainly a gentle sloping place with some undulations on the bottom part of the watershed. As we already know that slope is an effect of the geomorphological processes over the landform in the study area. Thus the major geomorphic agent ie the streams of the watershed have affected the slope of the landform. There is an inverse relationship existing between slope values at each point in the study area and the surface water in the given place, consequently the time available for the water to infiltrate (J.Teixeira, 2008). Keeping all this factor in mind we have given a weight of 20 to this particular layer.

4.3 Lithological Analysis:

Lithological analysis mainly includes the physical characteristics visible within the rock outcrop or rather the landform over the region. Thus in order to understand the groundwater conditions of the study area, a general lithological map was prepared with the help of DRM of area and IRS-P6 LISS-IV.The area is covered with the Deccan Trap Basalt, and Alluvium. The storage and the movement of ground water in these type of lithological structure formation is controlled mainly by the secondary porosity and permeability of the rock structure created due to weathering jointing and fractured rock. It is observed that the ground water occurrence is usually good along the lineaments and thereby there are trisections in the water table conditions. Since the study area lies in the Deccan Trap region it has a large spatial extents of basaltic rocks, weathered jointed, fractured and vesicular units. The alluvial deposits are mainly found all along the river courses, it is composed of fine to medium sand, silt, clay which are high potential aquifers. Thus it is quite obvious that due to presence of aquifers this region has high potential for ground water storage. As lithological factor forms one of the most important measures of the groundwater information it was considered to have a weight of 10 among all the layer.

4.4 Tectonic Lineament and lineament density map Analysis:

The Tectonic Lineament Density is commonly used in the study of the groundwater exploration as lineaments play a prominent role particularly in hard rocks. Lineaments are used to infer groundwater storage as well as its flowing path. The tectonic lineament density is well correlated with secondary porosity and transmissivity indicating zones of higher groundwater infiltration and potential circulation (Yeh et al 2008). Due to the importance of groundwater assessment based on mapping of landforms and lineaments it is often estimated from the remote sensing data the occurrence of lineaments on the surface. Lineaments are defined as linear features over the landform formed due to the geological instability of the structure extending in length may be from few kilometers to several kilometers over the landform. These linear features usually represent faults, fractures or shear zones and are identified on satellite images on the basis of tonal contrast, stream / river alignment, and differences in vegetation and knick-points in topography (K. Pareta, 2011). Lineament in study of the area from remotely sensed imagery helps in the assessment of the sub-surface fractures that may control the movement and storage of groundwater over the region (K. Pareta, 2004). Thus a lineament map has been composed from the LISS IV imagery it shows that there are mainly three major lineaments apart from other smaller lineaments in the study area the lineaments are mostly along the flow of the river beds and the linear density towards the broad base of the watershed are comparatively more than the narrow base of the watershed. The lineament mainly trends towards the North-East and South-West direction whereas the other striking North-West South-East direction over the study area. Keeping the factors in mind a score of 15 was given to this layer.

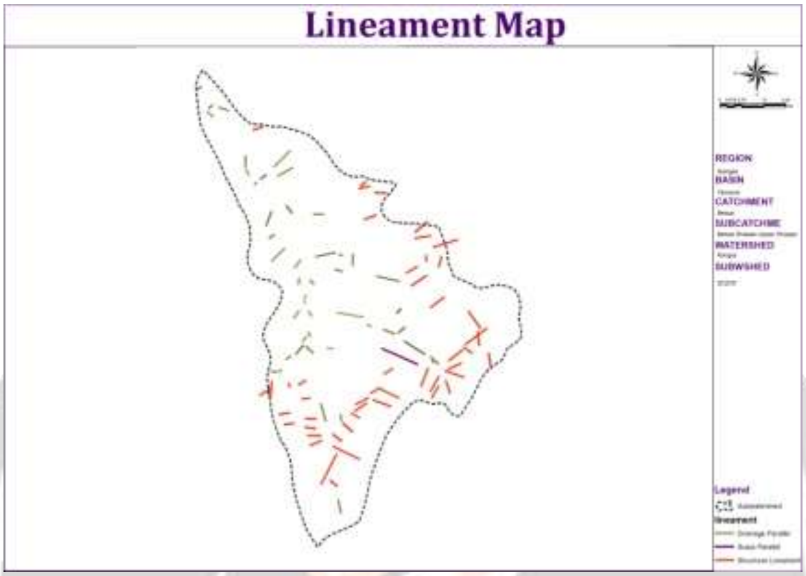

Fig -4: Lineament Map

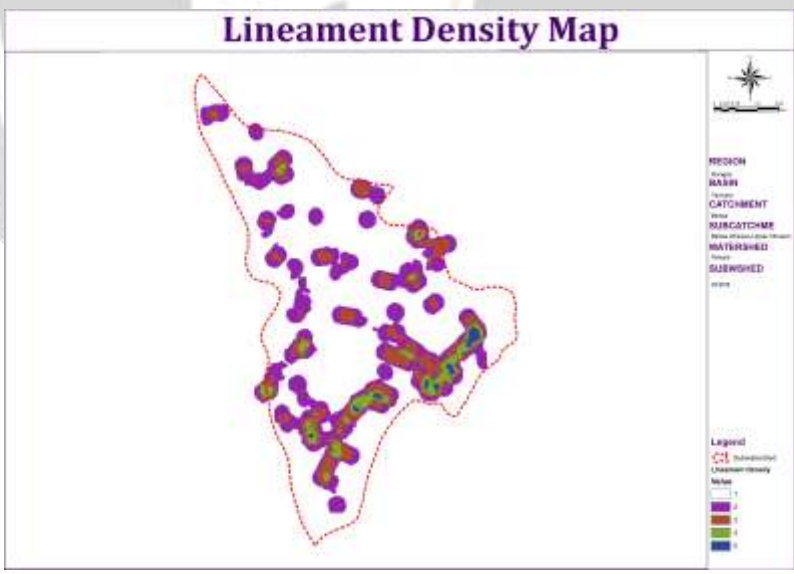

Fig -5: Lineament Density Map

4.5 Geomorphology Analysis:

Geomorphology describes the morphology of the landform in the study area by several geomorphic processes active in that region. A combined analysis of the land forms and the structural units in the study area shows mainly that there are three major structural difference in the landform. The study area consists of the plateau region with some residual hills rising in between, these are constantly being modified by the main geomorphic agent that is river flowing in this region. The residual hills have an escarpments in one side and the on the other side gentle slope. The feet of the residual hills have moderate and shallow pediplain these are mainly formed of deep alluvium brought down by the river. The central part of the watershed has a flat table like upland structure called Mesa surrounded by steep escarpments. The Mesa in the central part is a resultant of the constant activity of the river flowing in the region. It is quite evident from the description of the geomorphology of the study area that the area has undulations over it which results in the streams to have high frequency in its flow thereby influencing the surface water circulation and indirectly influencing even the ground water circulation. Thus a score of 15 is given to the layer generated from geomorphology of the study area.

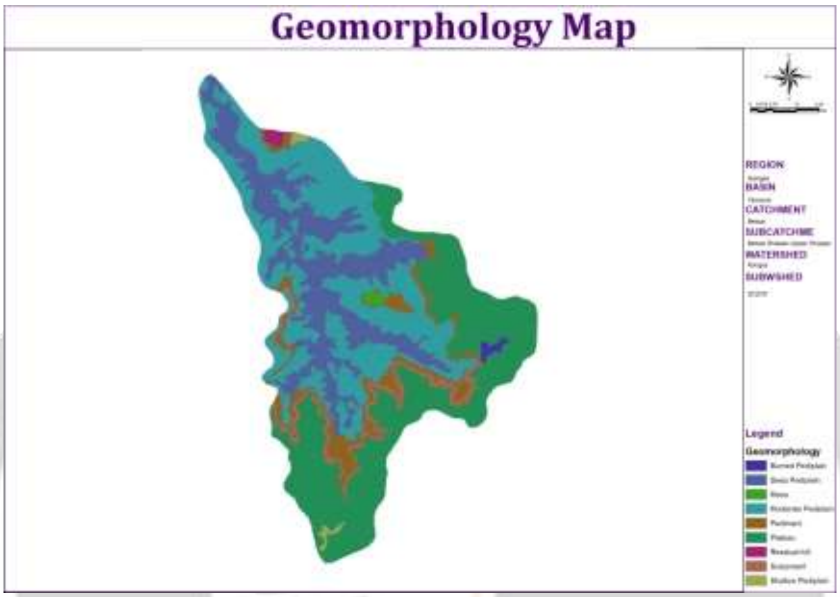

Fig -6: Geomorphology Map

4.6 Landuse and Landcover Analysis:

Landuse and landcover is the most important factor that rules out in ground water infiltration. Landcover describes the physical aspects of the study area where as land use documents how people use the natural resource of the land. Several studies on ground water exploration brought out the fact that land cover acts out as a major key factor (Sener et al 2005; Sreedevi et al 2005). Thus land is the most important natural resource, which binds all the other factors in the ecosystem. Précised and accurate information on the areal distribution of land use/land cover categories and the pattern of their change is one the most important factors for proper planning of management and utilization of land resourses of the study area. Various types of vegetation cover can benefit groundwater infiltration due to its organic decomposition of the roots helps loosen the rock and soil, making water percolation easier even at times soil organic matter increases the formation of structural aggregates resulting in hydraulic conductivity, vegetation protects direct evaporation from the soil , vegetation also delays direct runoff increasing the possibility of infiltration (Yeh et al 2008).Thus the land use pattern of any landform is a direct reflection of physical processes taking place on its surface. Keeping the above views in mind, a land use/land cover map has been prepared from IRS-P6 LISS-IV. This figure depicts that there are five major units of land cover/land use pattern in the study area, which are shown on the map. They are Agricultural Crop Land, Agricultural Fallow, Built Up, Deciduous Forest, Waste Land and Water Bodies. The overall weight considered for this factor was 15.

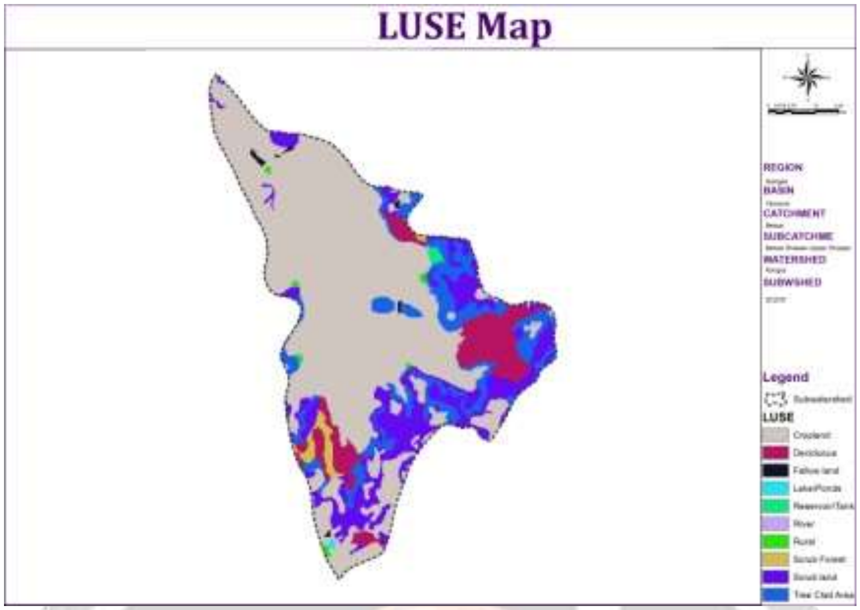

Fig -7: Landuse Map

Table -1: Weight and rank for different thematic layers of ground water potential zone

Parameters	Map weights (%)	Individual features	Rank	Groundwater potentiality
Drainage density	10	1--10	5	Very good
		11--20	4	Good
		21--30	3	Medium
		31--40	2	Poor
		41--50	1	Very poor
Slope	15	0--1	5	Very good
		1--3	4	Good
		3--5	3	Medium
		5--10	2	Poor
		10--15	1	Very poor
Geomorphology	25	Deep Pediplain	5	Very good
		Mesa	1	Very poor
		Moderate Pediplain	5	Very good
		Pediment	3	Medium
		Plateau	2	Poor
		Residual hill	1	Very poor
		Escarpment	1	Very poor
		Shallow Pediplain	4	Good
		Valley	5	Very good
Lineament density	20		1	Very poor
			2	Poor
			3	Medium

			4	Good
			5	Very good
Land use/Land cover	15	Agricultural Land-Crop Land-Kharif Crop	5	Very good
		Agricultural Land-Crop Land-Rabi Crop	5	Very good
		Agricultural Land-Crop Land-Two crop area	5	Very good
		Agricultural Land-Fallow-Current Fallow	4	Good
		Built Up-Built Up (Rural)-Built Up area (Rural)	1	Very poor
		Forest-Deciduous (Dry/Moist/Thorn)-Dense/Closed	2	Poor
		Forest-Deciduous (Dry/Moist/Thorn)-Open	2	Poor
		Forest-Scrub Forest	2	Poor
		Tree Clad Area	3	Medium
		Wastelands-Scrub land-Dense scrub	3	Medium
		Wastelands-Scrub land-Open scrub	3	Medium
		Waterbodies-Lakes/ponds-Dry-Kharif extent	4	Good
		Waterbodies-Reservoir/Tanks-Dry-Kharif extent	4	Good
		Waterbodies-River/Stream-Perennial	4	Good
Lithology	10	Basalt	4	Good

4.7 Groundwater Zonation Analysis:

Groundwater exploration being the objective of the study area authors have tried to explore the zones which are rich of groundwater or rather in one way the favorable zones of the groundwater exploration of the study area has been tried to be explored. Weighted Overlay Application in ESRI ArcGIS 9.3 have been used to explore the geohydrological condition of the study area. Several layers have been prepared in the GIS environment like the lithological structural, lineament density, drainage density, land use, geomorphological elements, and the background of the survey of India topographical maps on 1:50,000 scale and each layer have been given a weight according to its influence on the ground water. On the basis of the integration of these maps groundwater favorable zones of the study area were identified. The groundwater favorable zones are shown in Fig -8 dividing the watershed into five major zones of very poor, poor, moderate, good and very good of ground water potentiality. It has been observed that the ground water potential zone are strong along the lineament in the study area this is perhaps due to the reason that these are also the zones through which the ground water is recharged. The location of potential infiltration areas becomes perceptible when using this type of hydro geomorphological zoning maps which helps further in management and planning.

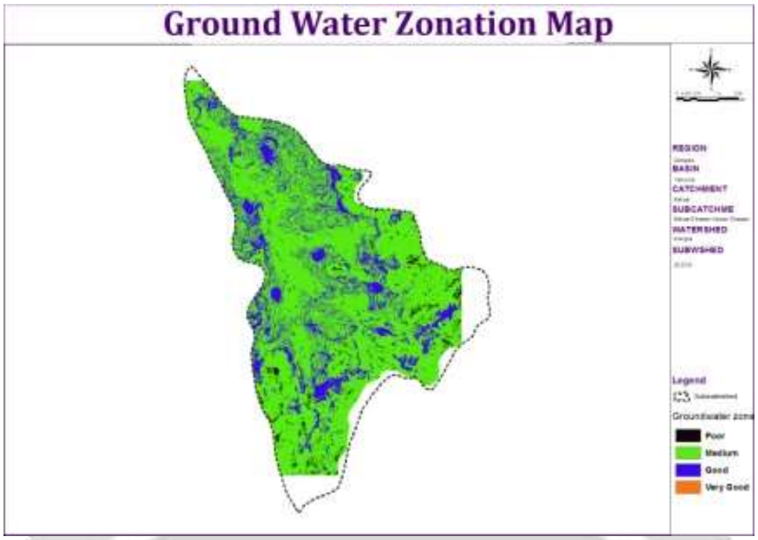

Fig -8: Ground Water Prospect / Zonation Map

5. CONCLUSION

Geo-environmental exploration has been carried out in the process of ground water exploration supported by the GIS mapping techniques. The watershed taken into consideration for the study area corresponds to basaltic hard-rock watershed and distinctive morphological and climatic features. The geodatabase has been organized into different thematic layers were connection of geomorphological and hydro-geological features within the watershed have been drawn so as to understand the ground water and surface water circulation model, and to contribute to the decision making process in different areas, like the water resources management and territory planning.

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