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Identification of Groundwater Potential Zone in Kabani River Basin using Remote Sensing and GIS

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Abstract— **Water is a major component in all living systems. Without water nothing can live on the earth. Water is becoming more and more precious as its supply continues to be scarce throught out the world. The objective of this study is to explore the groundwater availability in kabani river basin. Remote sensing data and Geographical Information System (GIS) is used to locate potential zone for groundwater in the kabana river basin. Satellite image and topographical map have been use to prepare the required thematic maps like geology, geomorphology, land use/land cover, soil, slope, lineament density, drainage density and relative relief. Geomorphology and land use/land cover map are prepared from LISS IV satellite image. With the help of toposheet roads, rivers, places, drainage and contour are digitized to prepare base map. With the help of contour, DEM is prepared. From this DEM various parameters such as aspect, slope, drainage density, lineament density are prepared. Weights and rank were assigned according to their influence based on infiltration of ground water by means of Weighted Overlay Analysis (WOA). Ground water potential zone are classified into four Groups like Very low, Low, Moderate and High.**

Index Terms— **Kabini river basin, Groundwater, Weighted Overlay Analysis, Ground water Potential Zone.**

I. INTRODUCTION

Water is essential for life and it does plays a vital role both in biotic and abiotic environment. The earth has liquid water in oceans, sea, rivers, water bodies and polar regions covered by solid water. Water in all three states makes a large contribution to the planet climate. Water vapour is a green house gas that traps energy radiated from the earth surface of the planet and helps to keep the planet warm enough to sustain the complex life in this environment. Water covers about 70 percent of earth's surface makes up about 70 percent of your mass and is essential for life. Water is essential for life. Surface water n the tropical regions are less. Therefore groundwater is the only source that people can rely during summer. Groundwater starts with precipitation that pass gradually into the ground. The amount of water that pass into the ground will vary widely from place to place, depending on the slope of the land, amount and intensity of rainfall, and type of land surface. Porous, or permeable, land containing lots of sand or gravel will allow 50 percent of the quantity of water that to penetrates into the ground and become groundwater. In less permeable areas, there may be less seepage. The rest becomes runoff or it gets evaporates. More than over half of the fresh water on Earth is stored as groundwater. Hence an attempt is made in this study to map the probable zones of groundwater potential, by integrating the land use/cover, geomorphology, slope, geology and soil parameters.

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II. STUDY AREA

Wayanad is a small hill district in Kerala with an area of 2131 km^2. The study area falls in the latitudinal and longitudinal extension of 11˚26′28″ - 11˚48′22″ N and 75˚46′38″ - 70˚26′11″ E on the Kerala. The total population of Wayanad District is 786627 as per 2001 Census. The average rainfall is about 2500mm per year. Wayanad district lies at a height of 700-2100 m above sea level, nestled among the mountains of the Western Ghats on the north-eastern part of Kerala. Its geographical area is 2131 sq. km. Some important mountains in the district are Chembra peaks, Vellarmala, Banasuramala, Brahmagiri, Kunnelipadimala and Thariodemala. Kabani river is one of the three east flowing rivers of Kerala. Kabani and its tributaries constitute a powerful river system in Wayanad. The district has three taluks viz. Vythiry, Mananthavady and Sulthan's Bathery. It is also divided into three blocks- Kalpetta, Mananthavady and Sulthan's Bathery. There are 25 gram panchayats and one municipality. Sulthan's Bathery, Mananthavady and Kalpetta are in the process of gaining urban status.

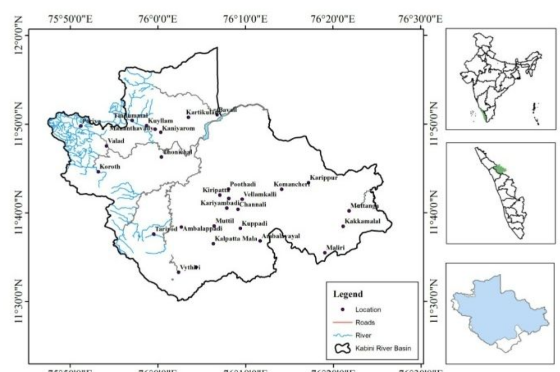

Fig 1: Base Map

III. MATERIALS AND METHODOLOGY

In order to identify the groundwater potential zones, different thematic maps on 1:50,000 scales are prepared from remote sensing data and topographic maps. Geomorphology and land use/land cover map is prepared by using LISS IV satellite image. Contour is digitized from toposheet by this DEM is prepared. By using DEM various parameters like slope, aspect lineament density and drainage density is prepared. Geology and soil map is derived from Geological Survey of India (GSI). Lineament density is prepared from hill shades which is derived from DEM using various azimuth and illumination angle. The drainage density map is created by kernel density using spatial analyst tool in Arc GIS. All the thematic layers are integrated by using Arc GIS to identify the ground water potential zone. The details of the methodology are shown in the flow chart,

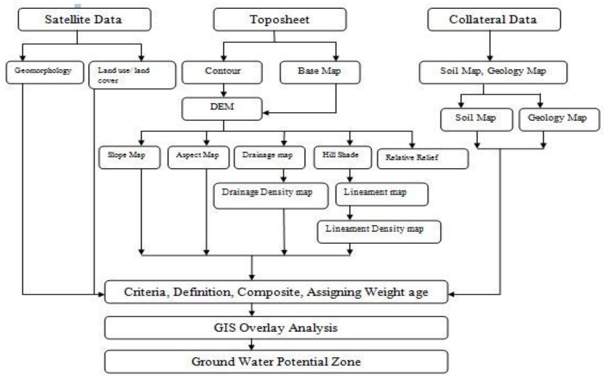

Fig 2: Flow chart of the Methodology for identification Ground water Potential Zone

IV. PREPARATION OF THEMATIC MAPS

A. Land use / land Cover

The term land use relates to the purpose the land serves, for recreation, wildlife habitat or agriculture; it does not describe the surface cover on the ground whereas land cover refers to the surface cover on the ground such as vegetation, urban infrastructure, water, bare soil. In the present study the identified land use / land cover features are agriculture lands, built-up area, hills, uplands with/ without scrub, shrubs, plantation, fallow land and water bodies.

As the settlements increases, land surface becomes impermeable. The areas having the ability to hold good amount of surface water are irrigation systems. The paddy cultivation, which was occupied by major portion of the agricultural land is a good source for continuous groundwater recharge. Generally the hill ranges has steeper slopes, the ground water prospects are less.

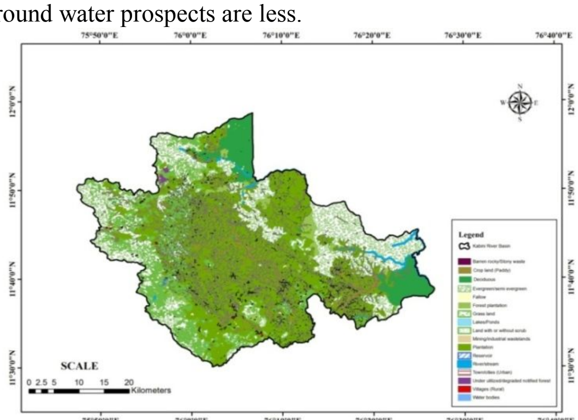

Fig 3: Land use/Land Cover Map

B. Lithology

Lithology describes the geochemical, mineralogical and physical properties of rocks. Lithology plays an important role in the distribution and occurrence of groundwater. The area has been divided into various classes such as charnockite, diorite, gabbro, ultramafites etc.. The charnockites are massive, hard, compact, fine-medium grained and black coloured and eventhough they do not have the capacity to store water but they are having large amount of lineaments, due to this the water can penetrate into the fracture and increases the groundwater potential, for this reason it has been given as higher preference when compared with diorite, gabbro, ultramafites etc.

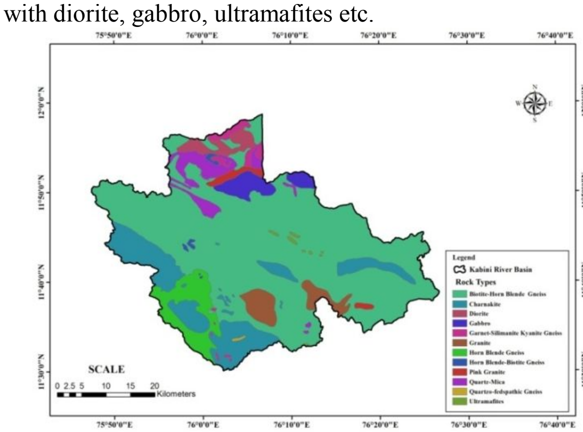

Fig 4: Lithology Map

C. Geomorphology

Geomorphology is the scientific study of the origin and evolution of topographic and bathymetric features created by physical or chemical processes operating at or near the earth's surface. In this study area geographical features that are observed are water body, flood plain, plateau, structural hill complex and denudational hill complex. Here the water bodies has higher water level, and hence it is best for having high groundwater potential. The structural hill complex that composed of composite ridges and valleys traversed by structural features and having little infiltration, and denudational hill complex are heaps of angular boulders raising abruptly from surrounding having moderate to steep slopes, therefore the groundwater prospect in this zone is considered as poor.

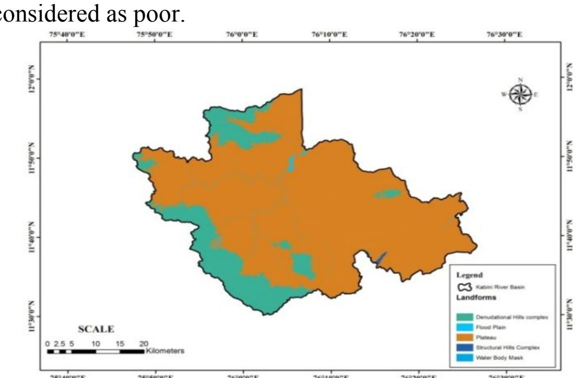

Fig 5: Geomorphology Map

D. Slope Map

The slope plays an important role in identifying the ground water potential zones. Generally slopes can be categorized as steep, moderate and gentle types. The contours are digitized using 1:50,000 scale topographical maps of Survey of India. By using the Arc GIS 3D Analyst module, the slope map has been generated. Lands with gentle slopes are capable of holding rainwater and then it can penetrate into the subsoil and further into the aquifer zones. Because of the faster gravitational flow in steeper slopes the water is prevented from infiltration.

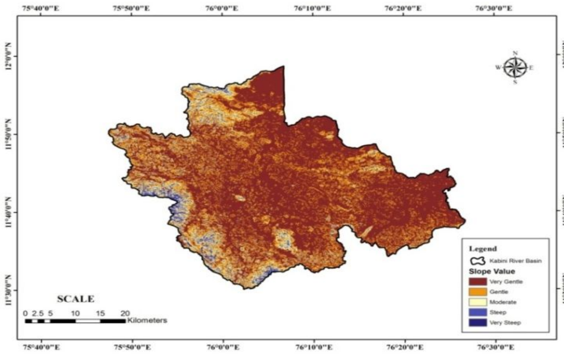

Fig 6: Slope Map

E. Soil Map

Life-supporting upper surface of earth is the soil that is the basic of all agriculture. Soils differ according to the climate, geological structure and rainfall of the area and are constantly being formed and removed by natural, animal and human activity. It is a mixture of minerals and organic constituents that are in solid, gaseous and aqueous states (Voroney, 2006). The soil for the study area reveals three main soil categories namely sandy, clay and rocky and non-soil categories. Clay consists of very fine grained material with very low air spaces, and has least infiltration rate hence it is assigned as low priority. Sandy soil has high infiltration rate, hence given higher priority for groundwater potential.

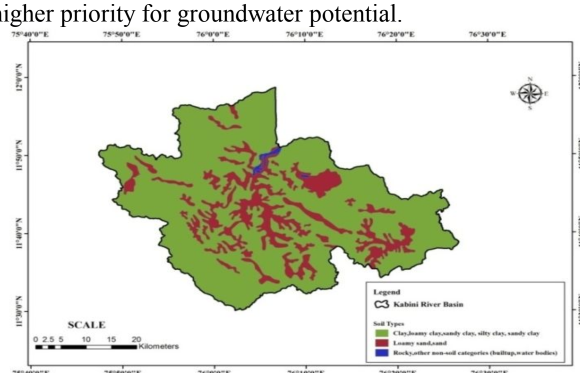

Fig 7: Soil Map

F. Lineament Density

Lineament plays a very important role in recharging groundwater in the hard terrains rock. Lineaments play significant role in groundwater exploration particularly in hard rocks. The linear features, which are relavant with faults, folds and fractures can give a clue for exploration of ore, oil and groundwater Linear features may be a geological contact/fault/ shear or fractured jointed zone. Lineament map was created from SRTM DEM with hill shades by various azimuth angle (0-360) and illumination angle (15 and 34). By using above lineament map, the lineament density was created by using Kernel density tool in Arc GIS. Polygons with higher values of lineament density will contribute greater recharge and infiltration of water to the ground. In general lineament is considered as good potential zones for groundwater targeting as they reflect high porosity and hydraulic conductivity of the underlying materials (Subagunasekar Ma and M.C. Sashikkumarb,2012)

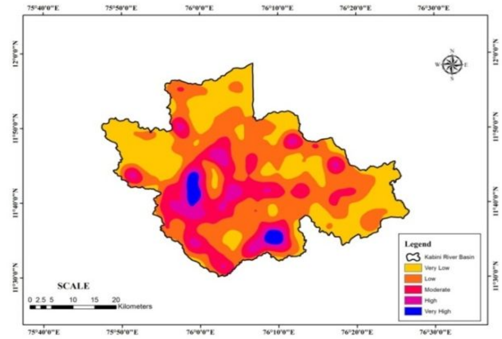

Fig 8: Lineament Density Map

G. Drainage Density

Drainage density of a basin is the total line length of the stream network divided by basin area. Drainage density is an inverse function of permeability, and therefore it is an important parameter in evaluating the groundwater potential zone. The drainage density was created by Kernel density using Spatial Analyst tool in Arc GIS. Higher the drainage density may indicates surface runoff moves rapidly from hillslopes (overland) to channel and hence indicates low groundwater potential zone. High ranks are assigned to low drainage density area and vice versa.

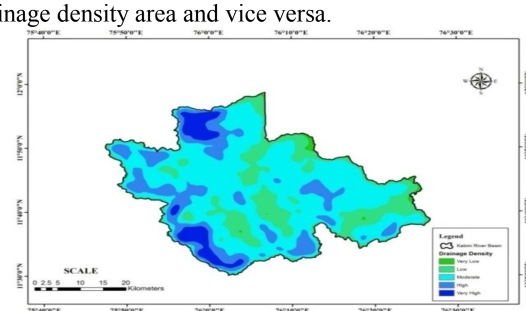

Fig 9: Drainage Density

H. Relative Relief

Relative Relief is an important parameter in evaluating the groundwater potential zone. Create a minimum elevation raster using spatial analyst tool neighbourhood focal→ statistics, given the→DEM as input same procedure for creating maximum elevation raster. In ''Raster Calculator'' use the following equation as maximum of DEM - Minimum of DEM function of map algebra tool is available in spatial analyst tool box in Arc GIS. Higher the relative relief values lower the runoff, and hence indicates high groundwater potential zone. Low ranks are assigned to low relative relief area and vice versa.

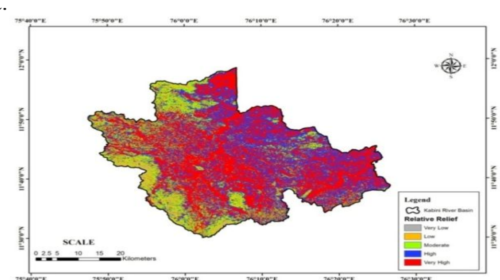

Fig 10: Relative Relief

Table1: Assigned rank and weightage for different features of various thematic layers

S. No	Parameters	Weight age	Classes	Ranks
1	Geomorphology	25	Water Body Mask Flood Plain Plateau Structural Hill Complex DenudationalHill Complex	9 6 4 1 1
2	Lithology	15	Biotite-Horn Blende Gneiss Charnakite Diorite Gabbro Garnet-Silimanite kyanite Gneiss Granite Horn Blende Gneiss Horn Blende- Biotite Gneiss Pink Granite Quartz- mica Quartz-Fedspathic Gneiss Ultramafites	1 9 1 1 1 6 2 2 1 7 2 1
3	Landuse/Cover	15	Crop land Fallow Grassland Plantation Deciduous Evergreen/Semi Evergreen Forest Plant Land with/without Scrub Mining/Industrial Land Village (Rural) Town/Cities (Urban) Lakes/Ponds Reservoir Rivers/Streams Waterbodies	9 9 9 9 6 6 6 4 4 2 2 8 8 8 8
4	Slope	15	Very Gentle Gentle Moderate Steep Very Steep	9 7 5 3 1
5	Lineament Density	10	Very Low Low Moderate High Very High	1 3 5 7 9
6	Drainage Density	10	Very Low Low Moderate High Very High	9 7 5 3 1
7	Soil	5	Clay, loamy clay, sandy clay Loamy Sand, Sand Rocky, other non-soil categories	5 9 1
8	Relative Relief	5	Very Low Low Moderate High Very High	9 7 5 3 1

RESULTS AND DISCUSSION

The ground water potential map was arrived from various thematic maps and the maps are reclassified. By assigning the weightage and ranks to the reclassified maps based on the influence of groundwater is described. Finally the weighted overlay analysis is performed in Arc GIS Software. The Table-1 describe the rank and weightage for each parameters. The output of the weighted overlay analysis is the final ground water potential zone.

CONCLUSION

Remote sensing and GIS plays a major role to identify the groundwater potential zone. By integrating various layers such as geology, geomorphology, land use /land cover, soil, slope, drainage density, lineament density and relative relief. The plateau cover 70% of the study area. The agricultural land reduce the runoff and thereby increase the infiltration of groundwater whereas in the settlement area the infiltration rate gets decreased. Higher the lineament density higher will be the availability of groundwater. In this study area about 90% of the area is having gentle slope thereby the infiltration rate is higher and the runoff is less. The loamy sand and sand are identified good for the ground water potential. By assigning weight age and ranks to each parameters the influence can be classified. In present study the basin is classified into four types normally very low, low, moderate and high potential zone.

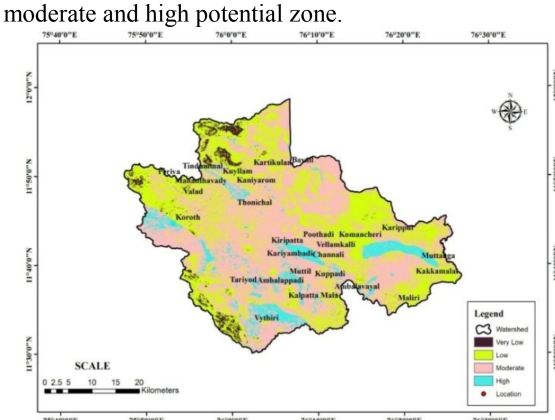

Fig11: Groundwater Potential Zone

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