

Utilization of Remote Sensing and GIS for Mapping of Natural Resource- On Water Resource Action Plan and Prioritization for Yagachi Watershed Hassan District

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ABSTRACT: Today all water resource development processes in most of the countries are based on micro watershed planning. Micro watershed is the smallest area, which acts as a comprehensive unit in the hydrological environment. For sustainable development of water resources, all planning should be based on the character of the hydrological environment of the watershed. In the study area, the geological formation consisting of quartz, schist, slate show a fine texture of drainage pattern which indicate a high potential for groundwater occurrence. In general the slope is greater than 30° thereby indicating more runoff and less infiltration. Lineaments, hydrogeomorphology and slope are the key parameters in the groundwater occurrence in the Yagachi watershed. The lineaments mapped from satellite images cut across slope categories and lithounits, thereby indicating the possibility of acting as major units for subsurface movement and linear aquifers for the storage of water. The central and southern part of the watershed areas provide good prospect for groundwater. It has been observed in the field and from the groundwater potential map that the gentler slope has more prospects for groundwater. Lineament density, lithology and drainage texture act as complementary conditions for gentle slopes.

KEYWORDS: Utilization of RS and GIS for mapping of natural resource and action plan for Yagachi watershed

I. INTRODUCTION

Water, an indispensable constituent of everyday life, is widely distributed in nature so that it may be available quickly and easily. Water system, being the life supporting factor a healthy water system, is essential for a enhance economy and a very good quality of life. However, with the increasing population and rapid urbanization trend, along with the advent of modern technologies, the usage of water has increased tremendously. Hence the need for an early rational and practical policy for the development, use the conservation of water resources for the growth of the country.

The world's total water resources are estimated at 1.36×10^8 M ha-m. Of these global water resources about 97.2 % is salt water found mainly in the oceans and only 2.8 % is available as fresh water at any time on the planet earth. Fresh water constitutes about 2.2 % of surface water resource and 0.6 % from groundwater resource. More so, of the 2.2 % of surface water, 2.15 % of fresh water is found in glaciers and icecaps and only 0.01 % of fresh water is found in lakes and streams and the remaining 0.04 % of fresh water is from other sources. Of the total groundwater stored (0.6 %) only 0.25 % can be economically extracted with the present drilling technology (the remaining being at greater depths). The importance of water resources management through adequate watershed rehabilitation and conservation is increasing. Watershed development and management is evolving as a useful mechanism to address the most common water resource problems in India. Firstly, it aims to address the problem of water availability resulting from an increased demand on a resource rendered fragile due to irregular and erratic rainfall. Secondly, watershed management is required to mitigate the effects of flood and drought and to provide a livelihood for the large number of ethnic minority groups living in the country.

Watershed is a hydrologic unit, and the term is defined as "the total area of land above a given point on a waterway that contributes runoff to the flow at that point" [1]. The watershed characteristics such as size, shape, slope, drainage, vegetation, geology, soil, geomorphology, climate and land use pattern affect the disposal of water from the watershed

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[2]. The watershed management is to protect the proper utilization of all land, water and natural resources of the watershed. The concept of watershed management is as old as the concepts of crops grown under irrigated conditions and this has led to the development of tanks and reservoirs for increasing the production to meet the demands of the overgrowing population.

II. OBJECTIVES OF THE PRESENT STUDY

To delineate groundwater potential areas, in Yagachi watershed and Systematic groundwater studies utilizing Remote Sensing, field studies and Geographic Information Systems (GIS).

The specific objectives:

Prepare thematic maps of the area such as lithology, lineaments, landforms and slopes from remotely sensed data and other data sources.

Assess groundwater controlling features by combining remote sensing, field studies.

Identify and delineate groundwater potential zones through integration of various thematic maps with GIS techniques.

Validate the result using secondary hydrogeological data

Recommendations for future work and provide guidelines for groundwater prospecting.

Methodology

The research in groundwater resources was undertaken by well-programmed and integrated approach set up on reliable methodology for data collection and review, carrying out field survey, identification, selection and evaluation of well data it was completed in three phases:

Data collection and review of previous work

Data Analysis and Interpretation

Validation of results

Climate and Rainfall

The climate of the district is agreeable. The temperature increases steadily in the beginning of March and April is the hottest month. Relative humidity is generally high in the South-West and post monsoon seasons. The skies are heavily clouded during the monsoon season and moderately clouded during the post monsoon season. During the summer season, there is slight increase in the cloudiness in the afternoons.

In October and November months, some of the depressions and cyclonic storms that originate in the Bay of Bengal cross the East Coast and move across the peninsula. The year is divided into four seasons viz.,

1. Summer season from March till the end of May;
2. South-West monsoon season from June to the end of September;
3. Post monsoon season from October to November; and
4. Cold season from December to February.

The drainage area of the district is mainly influenced by the South-West monsoon. The 101-year (1903-2003) average annual rainfall of the district is 1080.71 mm. The recorded monthly maximum and minimum rainfall of the district during the monsoon period is as follows: fig 3-1

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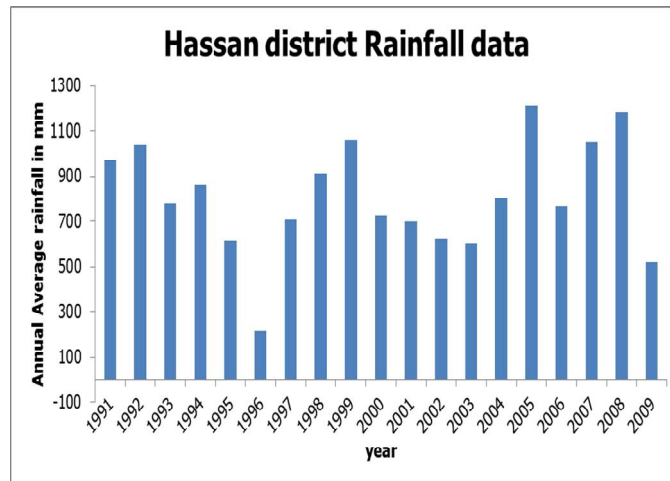


Table .1 Hassan district rainfall data

YAGACHI

The **Yagachi River** is a river in Karnataka, India. It arises in the Western Ghats near the city of Chikmagalur flows through Belur Taluk, Hassan District, where it becomes a tributary of the Hemavati River, which it enters near Gorur. The dam was constructed in the year 2001. The reservoir is situated at an altitude of 965 feet above the sea level. The length of the Yagachi dam is 1280 meters. The maximum height above the foundation of the reservoir is 26.237 meters. Capture water sports Center located near Yagachi River.

LOCATION AND STUDY AREA

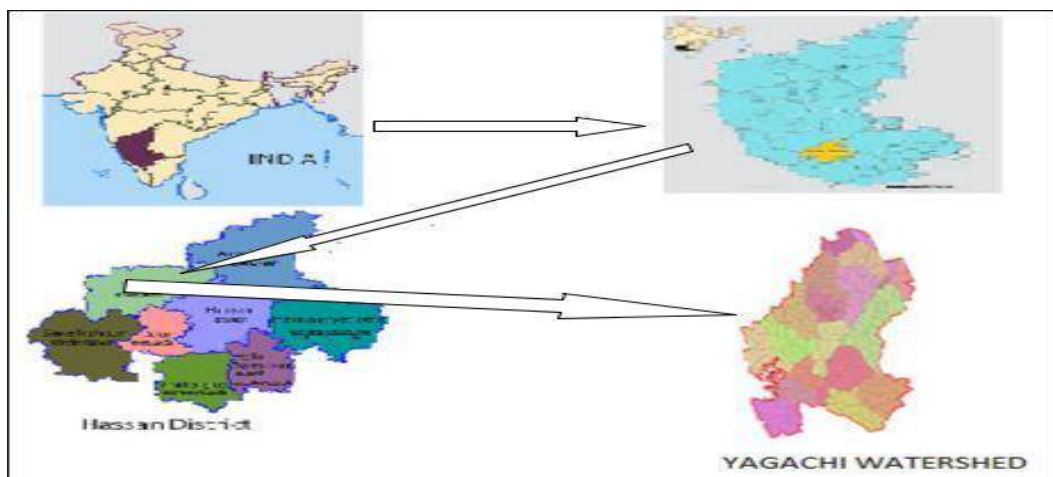


Fig. 1 Location and study area of Yagachi watershed

Hassan district situated in the south-western part of the State is having a total geographical area of 6814 sq. km. and a population of 1721669 (Census, 2001). It lies between the latitudes 12°30'39.29" to 13°13'36.5" N and longitudes 75°32'49.7" to 72°38'0.5" E. The district consists of eight taluks viz., Alur, Arasikere, Arakalgudu, Belur, Channarayapatna, Hassan, Holenarsipura and Sakalehsapura. The district is bounded on the North by Chikmagalur district, on the East by Tumkur and Mandya districts, on the South by Kodagu and Mysore districts and on the West by Dakshina Kannada district.

DRAINAGE MAP

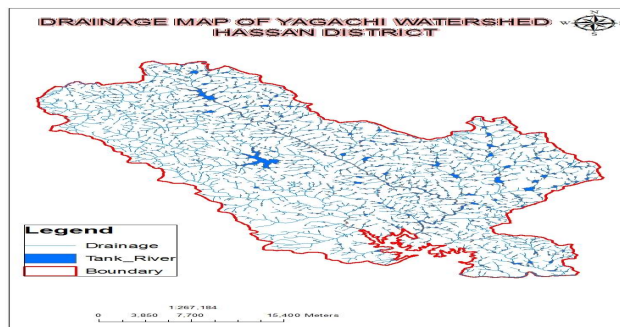


FIG.2 DRAINAGE MAP OF YAGHACHI WATERSHED

Drainage map comprise various streams and rivers that are flowing all the area. Drainage patterns and textures are dissection signatures and very important terrain recognition elements, used as criteria for identification of geological and geomorphological phenomena. The drainage pattern truly reflects the hidden structural characteristics and points out the tectonic history of an area. Drainage pattern is usually classified as Dendritic and parallel drainage pattern are recognized, which are indicative of the presence of structures that act as conduits or storage for sub-surface water. Structurally controlled drainage patterns are observed in western and eastern part of the study area.

GEOMORPHOLOGY

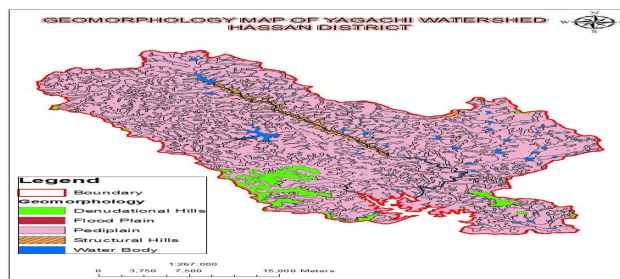


FIG. .3 GEOMORPHOLOGY MAP OF YAGACHI WATERSHED

Pediments

Gently sloping smooth surfaces of eroded bedrocks between hills and plains with veneer of detritus lithologies like granodiorite, tonalites and migmatitic gneisses constitute pediments. Fractures have played important role in their formation. These pediments are situated in the study area

Pediplain shallow

They are formed by coalescence of buried pediments, where a thick overburden of weathered materials accumulates. The intensely weathered areas of granitoids constitute these landforms. Varying thickness of shallow overburden can be observed in such areas. Weathering of the bedrocks has been initiated by fractures, joints and minor lineaments. The area covering by such land forms is huge in the study area

Pediplain moderate

Flat and smooth buried pediplain and pediment with moderately thick overburden are called pediplain moderate. Thickness of weathered material is high compare to pediplain shallow. The weathered materials are chiefly constituted by gneisses and migmatites.

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Pediplain shallow command area :-They are the pediplain shallow land forms but occurring in command area. Like in other areas, they are formed by coalescence of buried pediments where a thick overburden of weathered materials occurs to form pediplain shallow. Here the overburden is weathered material of granodiorite, tonalitic and migmatitic gneisses with varying thickness. The weathering is controlled by fracture, faults and lineaments.

Pediplain moderate command area

Flat and smooth buried pediplain and pediment with moderate thickness of overburden occurring in command area are termed as pediplain moderate command area. The lithology here is granodiorite, tonalitic and migmatitic gneisses. They are controlled by fracture and lineaments. Thickness of the weathered material is high compared to pediplain shallow command area.

Besides mapping and delineating the above land forms the water bodies have also been delineated using toposheets updated with imageries. These surface water bodies influence the surrounding bore wells and ground water recharge conditions.



FIG.4 PEDI PLAIN MODERATE 5 & 6. PEDI PLAIN SHALLOW 7. PEDIPLAIN MODERATE

Lineament

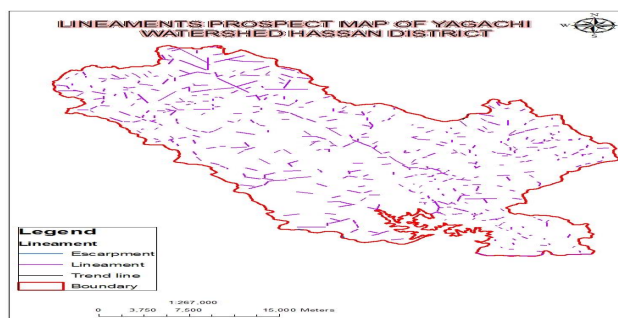


FIG 8. LINEAMENT MAP OF YAGACHI WATERSHED

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Mapping of lineaments in the study area was done by visual interpretation of various digitally enhanced single band and multi band images that involves standard band combinations, principal component analysis and directional filtering, since lineaments are the results of faults and fractures they infer that they are the zone of increased porosity and permeability, which in turn has greater significance in groundwater studies occurrence and distribution. Structural features were interpreted from satellite imagery. In the imagery they were identified on the basis of break of slope, truncation of terraces knick points, abrupt change in stream course, lithology, vegetation, texture, drainage density etc.

LITHOLOGY

Geology of the study area is quite simple comprising 80% of aerial extent by Peninsular gneisses (PGC). The younger granite occurs as isolated patches and domes. These rocks are classified as crystalline formations from groundwater point of view. The fracture/ fissure system developed along with joints and faults traversing the rocks facilitate groundwater circulation and hold moderate quantity of water. The volcano-sedimentary sequence consisting of conglomerate, orthoquartzite, quartz-chlorite schist, peliticschists, iron formations and metavolcanics are noticed (Ramakrishna and Vaidhyanadhan., 2008). The schistose rocks are poor aquifers and yield very less quantity of water of poorer quality. The joint pattern controls movement of water in the metavolcanic rocks and normally yields better quality water. The prominent schistose rocks noticed in the study area are belonging to Holenarsipura schist belt which is most important belt for mineralization in Karnataka, Dharwar Craton. Groundwater in general occurs in the water

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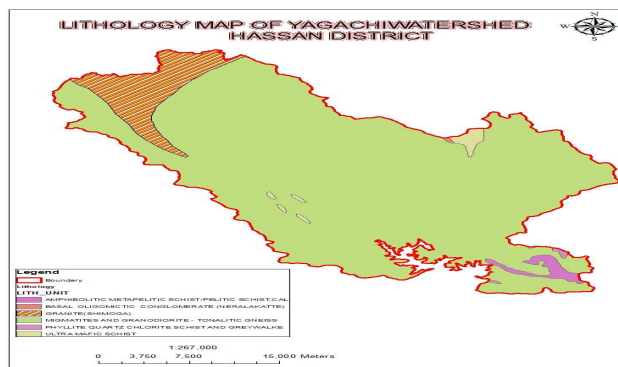


FIG.9. LITHOLOGY MAP OF YAGACHI WATERSHED

The prominent schistose rocks noticed in the study area are belonging to Holenarsipura schist belt which is most important belt for mineralization in Karnataka, Dharwar Craton. Groundwater in general occurs in the water table conditions in the weathered and also under semi-confined conditions in the deeper fractures. The major rock formations encountered are granites, gneisses, schist and quartzite (Fig.4). Low ranges of granitic hills are noticed in all taluks except Sakaleshpur.

SLOPE MAP

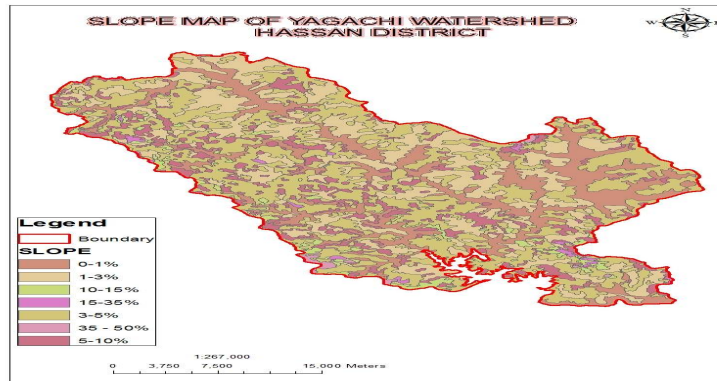


FIG 10. SLOPE MAP OF YAGACHI WATERSHED

Slope aspect and altitude map is a very important terrain parameter from land utilization point of view. For evaluating various ground features of a basin and to prepare different thematic maps slope analysis is important. In the present study slope map has been prepared on 1:50000 map based on the guidelines of All India Soil and Land use Survey (AIS & LUS, 1995) on slope categories (Table 3 and .4). Slope plays significant role in infiltration vs. runoff. Infiltration is inversely related to slope, i.e. more gentle the slope, infiltration would be more runoff would be less and vice –versa. The general classification of slope following the above guidelines is shown below:

Table 2. General slope category guideline

Sl. No.	Slope category	Slope(%)
1	1- Nearly level	0-1
2	2-Very gently sloping	1-3
3	3-Gently sloping	3-5
4	4-Moderately sloping	5-10
5	5-Strongly sloping	10-15
6	6-Moderately steep to steep sloping	15-35
7	7-Very steep sloping	> 35

For general slope analysis survey of India topo sheet in 1:50,000 scale has been used which gives 20 meter contour interval. The closely spaced contour indicate higher order slope. The slope categories are given below in the Table 3.

Table 3. Slope category of Contour spacing on 1: 50,000 (IMSD tech. guideline 1995)

Slope category	Lower and upper limit of slope percentage	Lower and upper Limit of contour Spacing
1.	0-1 %	More than 4 cm
2.	More than 1% upto 3%	More than 1.33 cm and upto 4cm
3.	More than 3% upto 5%	More than 0.8 cm and upto 1.33 cm
4.	More than 5% upto 10%	More than 0.4 cm and upto 0.8 cm
5.	More than 10% upto 15%	More than 0.26 cm and upto 0.4 cm
6.	More than 15% upto 35%	More than 0.11 cm and upto 0.26 cm
7.	More than 35%	0.11cm and less

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SOIL MAP

Soils are essential units in controlling the infiltration of rainwater and surface flow patterns. The soils display a wide diversity and are quite fertile and majority of the study area is covered by red soil. These occur in different physiographic units such as hilly region, hillocks, undulating to rolling lands, gently sloping pediments and valleys. The influence of parent material is realized in the undulating plain areas where vegetation is of scrub type (NBSS & LUP., 2013). The main soil types observed in the study area are red soil, red sandy soil, black soil, mixed soil and silty clay soil.

Red soils are observed in the western taluks derived from granites, laterites & schists. They are shallow to medium in depth and suitable for growing of coffee, cardamom, areca, paddy and sugarcane crops. **Red sandy soils** are noticed in eastern taluks derived from granite, gneisses and schists. These are shallow, loamy to sandy loamy in texture and are intermixed with coarse gravel, pebbles showing well drained but poor in moisture retaining capacity. Suitable for growing of crops.

Clay soil are deep to moderate deep, well drained which are observed in hills, ridges, undulating lands and Western ghats of the study area (NBSS & LUP., 2013). The map depicts seven types of soil textures such as Sandy clayey loamy, Sandy loamy, Fine loamy, Clay skeletal, Sandy loamy, Loamy skeletal and Gravelly clayey loamy textures (NBSS & LUP., 2013) (Fig.8). These help in proper identification of drainage properties for water developmental strategic programmes.

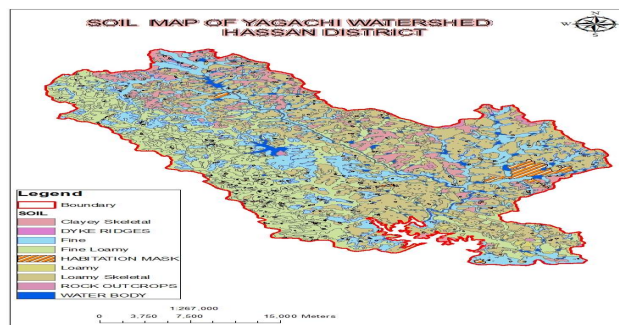


FIG.10. SOIL MAP OF YAGHACHI WATERSHED

Fine loamy texture shows very deep, well drained, dark brown to yellowish red and associated with clay loam texture observed in moderately to steeply sloping hills. Clayey skeletal texture of the soil shows very deep, well drained, red to dark red in colour and associated with gravelly clay texture noticed at foot hills and valleys. Loamy skeletal texture shows deep, well drained, brown to dark brown and associated with gravelly clay loamy texture at hillocks of the study area (NBSS & LUP., 2013).

LAND USE / LAND COVER

One of the parameters that influence the occurrence of sub-surface groundwater occurrence is the present condition of land cover and land use of the area. The effect of land use / cover is manifested either by reducing runoff and facilitating, or by trapping water on their leaf. Water droplets trapped in this way go down to recharge groundwater. Land use/cover may also affect groundwater negatively by evapotranspiration, assuming interception to be constant.

The land use/cover map of the area was readily interpreted from Landsat image by using visual interpretation, unsupervised classification, supervised classification. For identification of vegetation cover band ration of band 4 to band 3 was done. After detailed analysis the result was compared and corrected by data collected from different

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locations of Satellite remote sensing techniques are of immense value for preparing accurate land use/landcover map and monitoring changes at regular provided intervals of time.

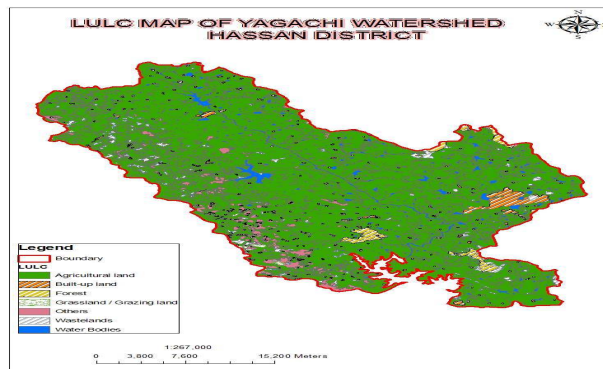


FIG.11. LAND USE LAND COVER MAP OF YAGACHI WATERSHED

GROUND WATER PROSPECT

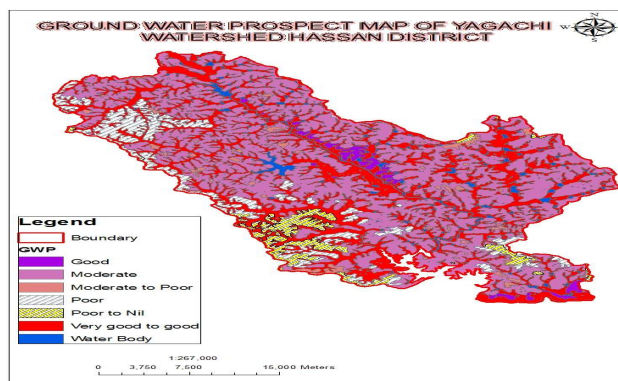


FIG.12 GROUNDWATER PROSPECT MAP OF YAGACHI WATERSHED

The delineation of groundwater potential zones by reclassifying into different potential zones; Very Good, Good, Moderate, Fair and Poor was made by utilizing the model designed using ARCGIS model builder engine. The map produced has shown that the groundwater potential of the project area is related mainly to lineaments, geology and slope. The validity of the model developed was tested against the borehole data, Although some wells exist in all groundwater potential zones, the best yielding wells lie in the very good and good groundwater prospect zone.

The model generated will help as a guideline for designing a suitable groundwater exploration plan in the future. The spatial distributions of the various groundwater potential zones obtained from the model generally show regional patterns of lineaments, drainage, landform and lithology.

Spatially the very good and good categories are distributed along areas near to lineaments and less drainage density and where the lithology is affected by secondary structure and having interconnected pore spaces. This highlights importance of lineaments, geology and hydrogeomorphological parameters in the Yagachi area.

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Areas with moderate groundwater prospects are attributed to contributions from combinations of the land use/cover, lithology, slope and landform. The low to poor categories of groundwater potential zones are spatially distributed mainly along ridges where slope class is very high, the lithology is compact/massive and far from lineaments

III. CONCLUSION

The main objective of this study area is to use GIS and Remote sensing technique for the assessment, evaluation and analysis of spatial distribution of ground water potential zones with in an area. Ground water potential zone map have been produced using eight thematic maps from satellites images, exiting data and field data. Produced ground water potential zone map were compared and validated by existing discharge data obtained from different localities of the study area. The result showed fairly significant correlation or agreement with the discharge data.

This study has shown that large spatial variability of ground water potential. This variability closely followed variability in the structure, geology, geomorphology and land use/cover in the study area. The most promising potential zone in the area is related to gneissic rock of which is affected, by secondary structure and having interconnected pore spaces, with plain geomorphic feature and less drainage density. Most of the zones with fair to poor groundwater potential lie in the massive basements unit which is far from lineaments.

This study generally demonstrates that GIS and Remote sensing techniques in combination with field data could be used for the assessments of ground water potential zones in an area with little primary porosity and low bedrock hydraulic conductivity and where hydrogeological properties are mainly determined by secondary factors fracture zones and associated weathering. It can be considered as a time and cost-effective tool for delineations and identification of high ground water potential target area.

Recommendation

Remote sensing data are powerful tools to improve our understanding of groundwater systems. Despite unable to measure hydrogeological properties directly, they provide continuous detailed terrain information and allow the mapping of features significant to groundwater development therefore it is important to incorporate them in the data collection stage of groundwater exploration works.

Since geology, geomorphology and lineament mainly control the distribution occurrence and flow of groundwater, analysis of these parameters should be supported by high-resolution terrain data and satellite

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