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Role of Remote Sensing and GIS Technique for Generation of Ground Water Prospect Zones towards Rural Development - A Case study of Hampapura, Hobli, H.D.Kote Taluk, Mysuru District.

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ABSTRACT: The explosive growth and uneven distribution of population, poor irrigation practices, rapid urbanization/industrialization, large-scale deforestation and improper land use practices have induced the depletion and pollution of both the surface and groundwater resources in India. In addition, recurrent drought further aggravates the problem of water even for drinking, especially in rural areas. In order to ensure 'Health for All, the Government of India has launched many programmes to provide potable drinking water to every settlement in the country within the next five years. In order to accomplish these tasks, the systematic planning of groundwater exploitation using modern technologies is essential for the proper utilization of this precious natural resource. On this basis, we extracted information on lithology, geological structures, and landforms, land use/land cover from remotely sensed data and drainage networks, soil characteristics and slope of the terrain using conventional methods and then integrated in a Geographical Information System (GIS) environment to depict village-wise groundwater prospect zones. Thus, a GIS-based model which takes account of local condition/variability has been developed specifically for mapping groundwater prospects. A pilot study was carried out for the Hampapura hobli, H.D.Kote taluk, a part of the Hebbala watershed, Mysuru. Information from this study could be used for effective identification of suitable locations for extraction of potable water for rural populations.

I. INTRODUCTION

Groundwater is a precious and most widely distributed resource of the earth. It is one of the main sources of fresh water availability of the globe. With increasing demand and over-exploitation of groundwater, has caused rapid water table depletion. Also a substantial quantity of rain water is going waste through surface runoff into the ocean. Hence in order to maintain the water table condition in balance and to restrict the surface water runoff going waste. Various measures for artificial recharge of groundwater can be implemented in such zones. The artificial recharge is a process by which excess surface water is directed into the ground either by spreading on the surface, by using recharge wells or by altering natural conditions to increase infiltration to replenish an aquifer [1] & [2]. It refers to the movement of water through man-made systems from surface to underground water bearing strata, where it may be stored for future use.

The Remote Sensing (RS) study along with Geographical Information System (GIS) for groundwater reflects hidden hydrological characteristics and deals with indicative elements at the surface, such as lineaments, drainage frequency, density, lithological character and land use/cover etc. It provides a better estimate and qualitative assessment of recharge potential. Remote Sensing with its advantage of spatial, spectral and temporal availability of data covering a large and inaccessible area within a short time has become a very rapid and cost-effective tool in assessing, monitoring and conserving groundwater resources. Geographical Information System is a powerful set of tools for collection, storing, retrieving, transforming and displaying spatial data from the real world for particular purposes such as feasibility study of the recharge sites. In recent years many workers such as [3] & [4], have used Remote Sensing and GIS techniques for groundwater exploration and identification of artificial recharge sites.

Artificial recharge can be used for a number of reasons: integrated water management, seasonal storage and recovery of water, long-term storage or water banking, emergency storage or strategic water reserve, short term storage, enhancement of well field production, restoration of groundwater levels, compensation for over-draft, reduction of pumping cost, stoppage or reduction of the rate of land surface subsidence and improvement of ground water quality to

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agricultural and municipal standards (Raju, et al., 1994). Artificial recharge plays a pivotal role in the sustainable management of groundwater resources. So the aims of present study is to delineate artificial recharge zones as well as to identify favorable places for artificial recharge sites using remote sensing and Geographical information system for augmenting groundwater resources in H.D Kote taluk of Mysore district. The results of this study could be used to formulate an efficient groundwater management plan for the study area, so as to ensure sustainability of scarce groundwater resources.

II. RAINFALL AND CLIMATE

Mysore district receives an average rainfall of 776.7 mm. There are 53 rainy days in the district on an average about 50% of annual rainfall occurs during the southwest monsoon period (table 2.1). The rainfall generally decreases from west to east. The coefficient of variation is around 30% in the west to above 35% in the east, indicative of consistent rainfall in the west as compared to the east. The pre monsoon rainfall is more consistent than the post-monsoon rainfall. The southwest monsoon had been normal from 1994 onwards till 1999, excessive during 2000 and deficient thereafter. The northwest monsoon is much better comparatively being excessive to normal during the recent past. Over all on an annual basis, there are more normal to excessive rainfall years than deficient ones. While during 1997, 1999, 2000 and 2005, the district received Excess rainfall, 1998, 2001, 2002, 2003 and 2004, it was Normal and only during 2006, the district received Deficient rainfall. The average minimum and maximum temperatures vary from 34 to 21.4°C in April to 16.4 to 28.5°C in January. Relative humidity ranges from 21 to 84%. Wind speed ranges from 7.9 in October to 14.1 kmph in July. Annual potential evapotranspiration is 1533.5 mm. The PET less than the monthly mean rainfall during the months of July, September and October in different taluks, thereby indicating availability of water surplus for recharge to ground water.

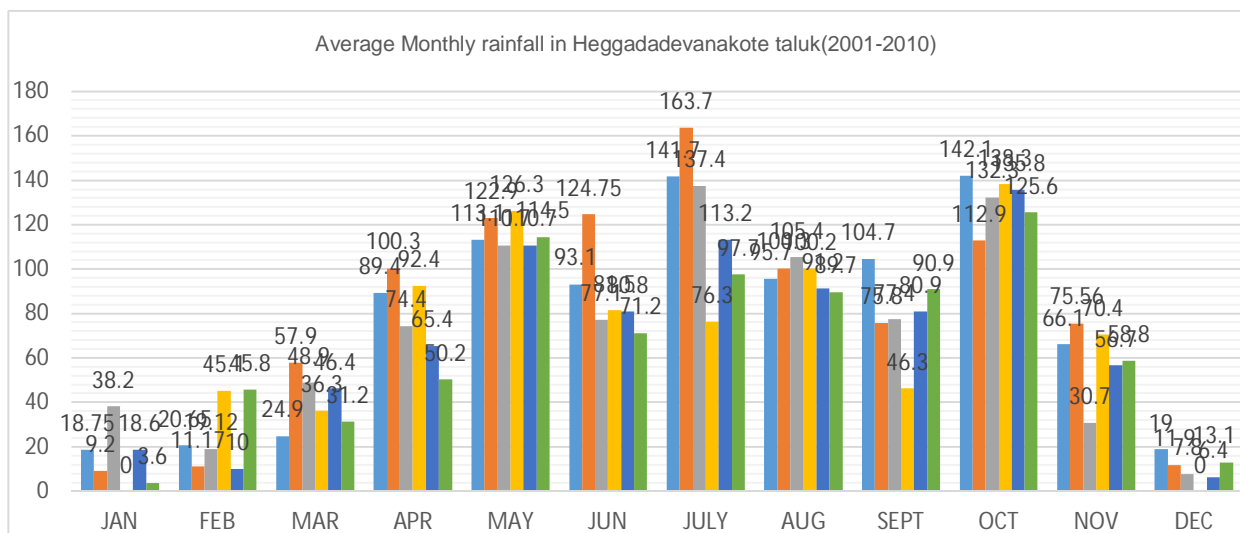


FIG.1 RAIN FALLDATA OF H,D,KOTE TALUK

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Study area

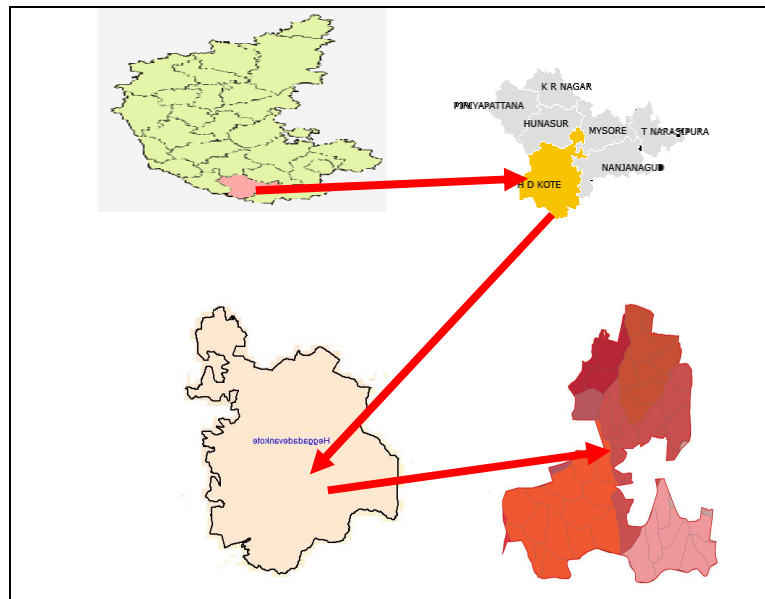


FIG 2. STUDY AND LOCATION

OBJECTIVE

Following are the generation of objectives for present study:

- Preparation of drainage map using topomap and updating with the missing drainage using Pan+Liss merged data
- Preparation of slope map, gradient study with respect to surface water dynamics and groundwater infiltration.
- Geophysical study and integrating it with imagery study for identifying groundwater potential zones
- Categorization of micro watersheds within the main watershed for water resource management planning

Methodology:

Data collection : Different data products required for the study include SOI TOPOSHEET bearing number—57D/3 on 1:50,000 scale data of using pan+liss III GEOCODEDE Satellite imagery and remaining needful data from different organization (govt. or as well as other agencies) and other data rain fall data and demography data etc. have been adopted.

Reference data : The spatial data used consists of reference data containing of maps prepared by different government, organization , which are the key source for the reference. The reference data or maps used in this study and the source are specified.

MAP NAME	SORCE ORGANIZATION
• TOPO MAP	SOI (survey of India)
• SATELLITE DAT	RAMANAGARA
• GEOLOGY/LITHOLOGY MAP	GIS (Geological Society of India)
• SOIL DATA	AGRICULTURE DEPT.
• HYDROGEOLOGY	CGWB/SGWB

The step by step procedure for preparing the hard copy Delineation of the study area from the area from toposheet obtained from SOI. Conversion of master data to vector formation of the baseline digital map preparation of thematic map by visual interpretation. Creation of the baseline data by digitizing the map and digital database is prepared using auto cad software, Preparation of the baseline digital map (hard copy) Preparation of thematic map by visual

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interpretation. Preparation of thematic map from SOI toposheet and thematic map like geology, lineament pattern, drainage network, soil, land use/land cover, geomorphological units and their interpretation for surface flow and groundwater accumulation prepared on the visual interpretation of satellite image in conjunction with the existing map/literature. Field visits for checking the interpretation collecting the additional information Incorporation of field observation in the thematic maps. Integration of above thematic maps and preparation of ground water potential map Incorporation of corrective/modification based on the collection data Final output generation using GIS SOFTWARE.

ROAD NETWORK

The important network mainly the distribution of metalled and unmetalled roads and railways have been demarcated using 1:50,000 scale SOL topo map and updated with satellite imagery in order to understand the connectivity of various habitations. The locations of villages, towns, hamlets are also mapped, incorporating the village boundaries, accessibility is an indicator of the level of socio economic development and depends on the transport network that exists.

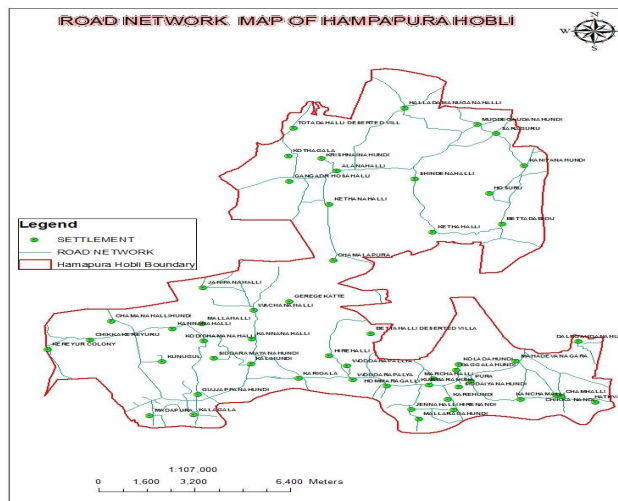


FIG.3 ROAD NETWORK MAP OF HAMPAPURE HOBLI

LITHOLOGY

The area consists of amphibolite schist as basement overlaid by hornblend-biotite gneissic, charnockite, quartzite, and granite belonging to Archean to lower Proterozoic -Younger basic dykes and pegmatite have intruded all these lithological units at places. Recent alluvium deposits are noticed along the valleys. charnockite shows medium grey tone and medium to coarse texture in tone and medium to coarse texture.

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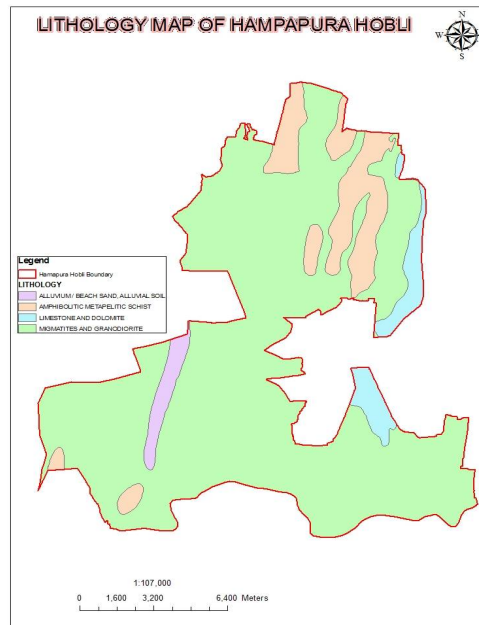


FIG -4: LITHOLOGY MAP OF HAMPAPURA HOBLI

DRAINAGE

Drain is a natural depression of the natural surface. It's a vertical, horizontal and length of depression depends on bedrocks, topography, geological structure and the nature of the soil etc., many other factors like slope, rainfall and vegetation etc., also contribute for the development of a drain. The study area is represented by dendritic to sub dendritic type of drainage pattern. The dendritic drainage pattern is the most common drainage pattern characterized by branching or tree like drainage pattern.

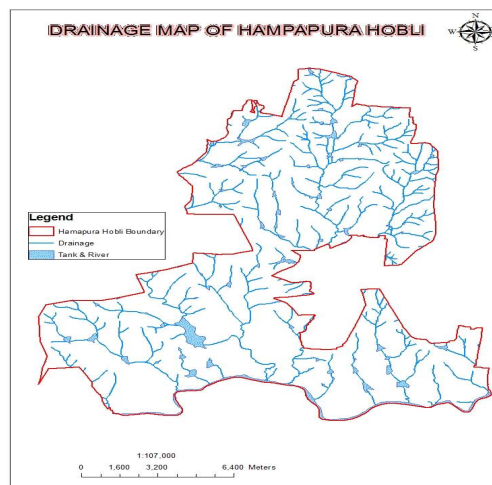


FIG-5 DRAINAGE MAP OF HAMPAPURA HOBLI

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Drainage network in the present study was prepared by toposheet and Pan+LISS merged data, in which the spatial resolution of the data is 5.8m. For this interpretation keys like tone, texture, pattern and association were used. After visual interpretation of the drainage map of the study area, it was scanned and digitized using Arc Map 10 and ERDAS IMAGINE and finalized after field validation for the doubtful drainages. The drainage of the study area is shown in Map

LINEAMENT

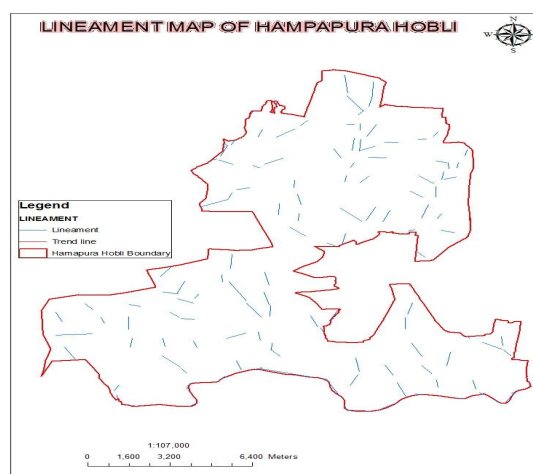


FIG -6: LINEAMENT MAP OF HAMPAPURA HOBLI

A lineaments is defined as a large scale linear structural features, such features may represents deep seated faults , masters and joints sets, drainage lines and boundary lines of different rock formations. The study of lineaments has become an important part in analyzing the structure and tectonics aspect of any area .Lineaments provide the pathways for groundwater movement and hydro geologically very important (sankar, 2002). Lineaments are important in rocks where secondary permeability, porosity and inter granular characteristics together influence groundwater movements. The lineaments intersection areas are considered as good ground water potential zones. The combination of fractures and topographically low grounds can also serve the best aquifer horizons(Rao,1992).In the study area lineaments have been identified on images through visual interpretation by comparing spatial variation in tone, color, texture ,associations,etc.25m area on either side of lineaments and intersection of lineaments are considered to be favorable for accumulation of ground water .The study area is travelled by numerous lineaments .Fractures oriented along NS-SE,NNW-SSE, and E-W directions .It is believed that these lineaments might have been resulted due to plate movements and tectonics in region.

III. CLASSIFICATION OF LINEAMENTS

Numerous efforts have been made by various researchers to classify lineaments on the basis of their origin, magnitude or mode of expression. Classification based on magnitude (length) reflects their nature, significance and origin. In addition to this, lineaments can be classified with regard to their groundwater potential. Depending upon their deposition, lineaments are classified into three categories as below.

Class 1-High yielding lineaments

Class 2-Moderately yielding lineaments

Class 3- Low yielding lineaments

The lineaments that extend across stream courses and in the proximity of alluvial and colluvial areas have been classified as class 1 or High yielding lineaments. The lineaments dissecting Pedi plain and pediments at low lying areas

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have been classified as class 2 or moderately yielding lineaments. The lineaments in higher elevation and denudation hills have been classified as class 3 or low yielding lineaments.

The lineaments of the study area have been classified based on the above classification and are shown in the map no.. A major segment of the river flows along class 1 lineaments and the direction of the flow is strongly controlled by the lineaments are noticed in the central part of the study area, apart from this there are some other channel courses following the lineaments. Lineaments belonging to class second are common. Class 3 lineaments are characteristics of hilly areas of the southern part of the study area. The concept of lineament density has been evolved by considering the total length of the lineament to the basin area. A high value of this parameter can be related to the possibility of high recharge and large scale availability of ground water in the area. The lineament density can be taken as index of fracturing in the area.

LAND USE LAND COVER

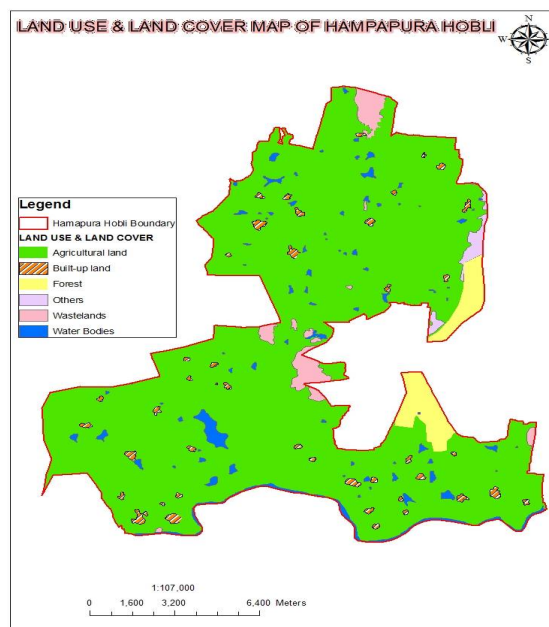


FIG-7: LAND USE AND LAND COVER MAP OF HAMPAPURA HOBLI

The general land use of an area depicts an idea of overall areal utilization of resources, natural or cultural. Land use describes as the land used for the different purpose such as agriculture, settlements or industry, whereas land cover refers to the material such as vegetation, rocks and water bodies that are present on the surface (Anderson et. al., 1972). The land use map of the area is prepared by using satellite imagery and are classified as water body, agriculture, forest, and wasteland and built up land in Map. The high resolution satellite data such as LISS III data and LANDSAT ETM are good source to provide Soil is defined as the top layer of the earth's crust. It is formed by mineral particles, organic matter, water, air and living organisms. It is in fact extremely complex, variable and living medium. It is usually differentiated into horizons from mineral and organic constituents of variable depth which differ from the parent material below in morphology, physical properties and constitutions, chemical properties and composition and biological characteristics. The interference between the earth, the air and water, soil is non-renewable resource which performs may vital functions: food and other biomass production, storage, filtration and transformation of many substances including water, carbon, and nitrogen

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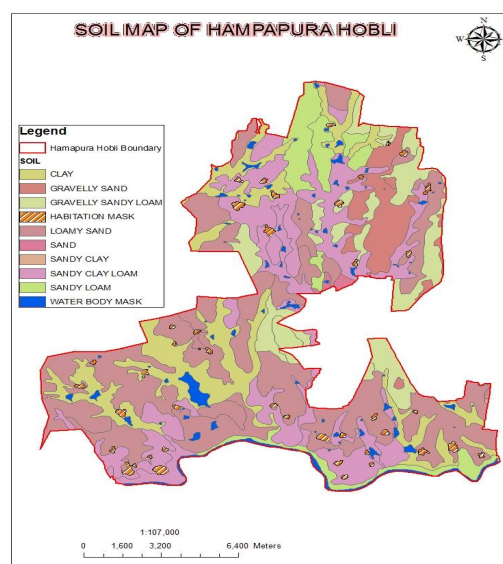


FIG -8: SOIL MAP OF HAMPAPURA HOBLI

. Soil has a role as a habitat and gene pool, serves as a platform for human activities, landscape and heritage and acts as a provider of raw materials. These functions are worthy of protection because of their socio-economic as well as environmental importance. Soils play an important role in the accumulation of ground water. Soil structure and texture which are controlled by the percentage of sand, silt and clay play a dominant role in ground water infiltration.

Five factors that effect the soil formation are parent material, climate, organism topography and time. It is the accumulation of loose weathered material that covers much of the land surface of earth. Soil varies in depth, composition, age, color and texture. Although its chief component is weathered rock, a true soil also contains water, air, bacteria and decayed plant and animal materials. Soil that forms directly from the bedrock beneath it is residual soil. If the soil forms from the material that was transported to the location by erosion, it is transported soil. Over exploitation of ground water resource and in effective tapping of surface runoff which effect agriculture economy and increase the wastelands. Hence, it is essential to control the excess runoff to recharge the deep aquifer through innovative and cost effective soil and water conservation measures.

Soil plays an important role in augmenting the recharge of groundwater and also in determining the quality parameters. The study area consists of sandy loam, Red sandy loam, Red loam and black and mixed loam. The depth of soil varies from place to place i.e. from few centimeters to meters

RED LOAM : Red loam develops under moonsonic, medium dry climate over acidic to intermediate parent rock. Red, reddish brown and deep yellowish brown soils in the area occupy the northern part of the study area. The thickness varies from 1-7m and also could be classified into deep, medium and shallow type based on color and texture.

SANDY LOAM This soil type is normally made up of sand along with varying of silt and clay. Sand particles are often larger and more solid than other types of particles found in soil and for this reason there is normally more room for water to move freely through it. Sandy loam soils are made of approximately 60 percent sand, 10 percent clay and 30 percent silt particles.

RED SANDY LOAM Red sandy loam forms the major type of soil and occupies the largest area in the south western part of the study area. In contrast to red loam these soils do not contain larger admixtures of sand particles. The thickness varies from 1-5m. These also could be classified in similar manner as those of red loam based on color and texture.

BLACK AND MIXD LOAMThe type of soil mostly occupies the south eastern part of the study area. Mostly these types of the soil are clayey, high porous with rich plasticity. They have a variable thickness between 1-3m. Infiltration capacity of these soils is very high in the beginning and drastically gets reduced with time.

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SLOPE

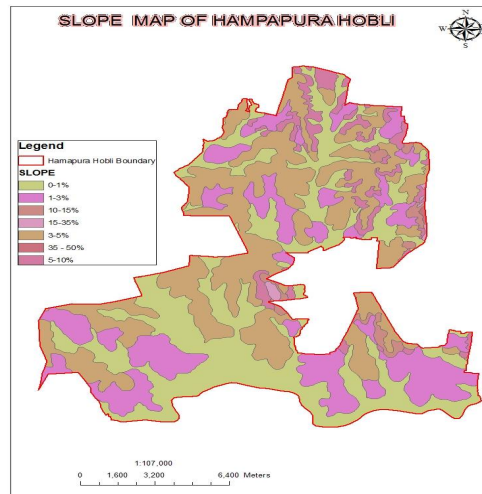


FIG -9: SLOPE MAP OF HAMPAPURA HOBLI

Heggadadevanakote taluk is an undulating land with igneous and metamorphic rock of precambrian age. The general elevation of the area ranges from 700-950meters AMSL. The higher elevations are observed in the southern part of the study area. slope of the area is the vital element in detemining the water table elevations. The slope map was digitizes on a 1:50,000 scale base map. The slope of the study area ranges between 0-35%. The area having 0 to 1% slope fall into the 'very good' category because of the nearly flat terrain and relatively high infiltration rate. Most of the study area (70%) falls under this category. The areas with 1 to 3% slope are considered as 'good' for underground storage due to slightly undulating topography with some runoff. The areas having slopes of 3 to 5% cause relatively high runoff and low infiltration, and hence are categorised as 'moderate'. The fourth (5-10%) and fifth (10-30%) and (>35%) categorised are considered as 'poor' due to higher slope and runoff.

GEOMORPHOLOGY

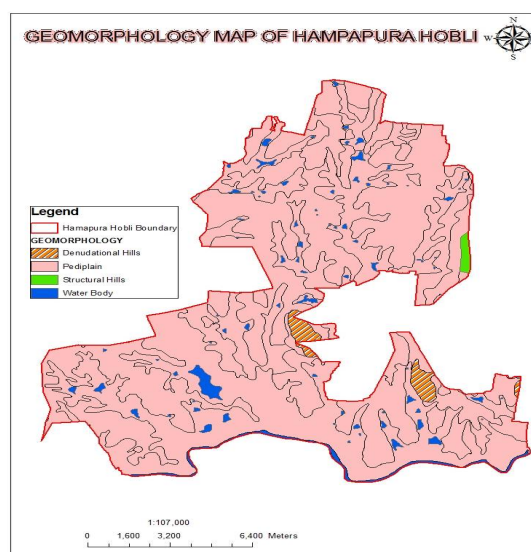


FIG-10. GEOMORPHOLOGY MAP OF HAMPAPURA HOBLI

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IV. DISTRIBUTION OF GEOMORPHIC UNITS

Hills

Hills in the area are divided into denudational hills, residual hills and structural hill. Escarpment line with rugged tops often mark denudational hills and are exposed as isolated pockets in the southern part of the study area. These are mainly composed of charnokite, hornblend-biotite, gneisses, and quartzites and are mostly covered with the forest leaving no common tonal characteristics for their identification. However these rock bodies could be identified from their massive size and dome to elliptical shape. The rugged topography in this region is due to erosion of hills to plain regions leaving behind the rock exposed.

Residual hills

Residual hills are the products of the process of peneplanation, which reduces the original mountain masses into a series of scattered knolls standing on the pediplains. The hills which are having more resistant formation stand out prominently to differential erosion and weathering, The occurrence of these hills is controlled by different lithological composition, distribution and spacing of joints and fractures (Thornbury, 1969). Residual hill of the area is generally identified by grey tone and coarse texture and due to dark reddish colour in the standard false colour composite with radial drainage pattern. Residual hills are mostly found in the southern part of the study area as isolated pockets and occasionally these are covered with the forest.

Structural hills

Structural hills of the area are the linear or arcuate hills exhibiting definite trend lines and pelitic schists rocks. These are structurally controlled with complex faulting and criss-crossed by numerous joints/fractures, which facilitate some infiltration and occurrence of groundwater.

Weathered Pediments

These are gently sloping undulating surface with or without a veneer of weathered/soil materials, often dotted with rock outcrops and are occurred as a narrow strip adjoining to hills at relatively elevated zones (Ghose, 1993) has attributed, the pediments are generally appear in the grey tone having rugged texture on false colour composite images.

Weathered pediplains

Pediplains are highly undulating plains of large aerial extent and are often dotted with rock outcrops. These are the result of continuous process of peneplanation with intensive weathering under semi arid climatic conditions. Based on the weathering, pediplains in the area are further classified as, pediplain moderately weathered (PPM), pediplain shallow weathered under irrigated command (PPSC) and pediplain shallow weathered (PPS). PPM occurs normally along the prominent and is fracture streams, which controlled the valley course. PPSC and PPS occur at relatively elevated regions with the valley respectively. these appeared as bright red in the imagery. irregular dissected portions with moderate erosion are noticed at places.

Valleys

These units recognised as valley fill shallow (VFS) developed due to transported and or weathered materials in the valley areas and are normally controlled by lineaments. The thickness of VFS varies between 15 to 30m and display dark red to bright red tone on false colour composite images.

GROUND WATER PROSPECT

The hydro geomorphology maps are prepared using satellite data with limited field surveys, geological, geomorphological, structural and hydrological aspects have been studied to evaluate ground water prospects. The geological details like lithology/rock types and structural trend lines were delineated using geological maps and satellite data and incorporated on hydro geomorphology maps to arrive at ground water potential zones. The ground water prospect map depicts zones which are very good to good, good to moderate to poor to nil and also indicates sites for recharging aquifers and water harvesting structures

IV. DEVELOPMENT THROUGH WATERSHED

Watershed management plan plays very important role in the development of agrarian sectors. The natural resources, when developed can meet the requirements of ever increasing population, and also ensure sustainability. Such resources should be studied based on geology, geomorphology, groundwater, soils, forest, land use, and agriculture pattern. In the present study 2/3 of the area is under rain fed crops pattern.

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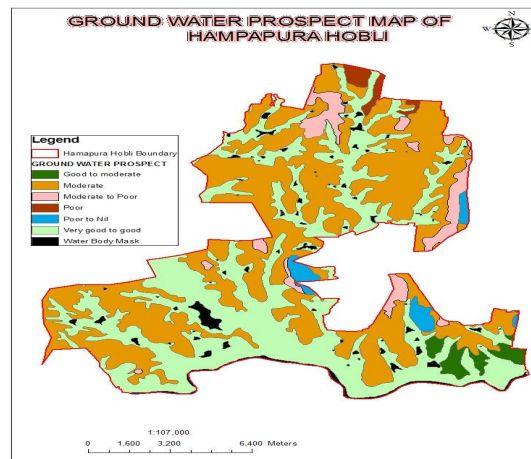


FIG-.11 GROUND WATER PROSPECT MAP OF HAMPAPURA HOBLI

Due to non-uniform distribution of the rainfall and the failure of the crops, the agricultural sector has suffered its worst, and in this direction watershed management assumes greater importance and provides solution for sustainable development. In this regard the Dry Land Development Board (DLDB) and Watershed Development Board (WDB) of Karnataka state have taken up joint ventures in parts of the state, by, making use of Remote Sensing and GIS techniques. From thus point view different thematic maps of the study area have been prepared and water resource action plan have been suggested. The study area has been divided into 37 Micro watersheds .

V. CONCLUSION

The main objective of this project 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 targeted rural development area.

RECOMMEND

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 there fore it is important to incorporate them in the data collection stage of groundwater exploration works.

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Despite various satellite data with different spectral and spatial resolutions coupled with digital image processing techniques help to produce detailed maps, ground verification is crucial to increase the accuracy of the interpretation results. The result obtained from this study should be supported by subsurface data obtained from geophysical study.

Detailed image interpretation was carried out and various thematic maps were prepared. GIS images were generated using ERADSA 8.6 and ARC GIS 9.3 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 imagery.

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