Ground Water Potential Zone Mapping, Using Remote Sensing and GIS Application for Ayyarahalli Sub Watershed, Mysore, District

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***Abstract*— Present study area is facing shortage of water for domestic, irrigation and industrial purpose, because of the inadequate surface water resource the demand for ground water resource is increasing every year to meet this growing demand. It is essential to identify the ground water potential areas through scientific approach and using various thematic maps, (i.e. base map, hydrogeomorphological, geological structure, drainage, slope, land use and land cover and ground water prospect zone maps). The maps were prepared using remote sensing data along with existing maps. The ground availability of the study area is classified into very good, good, moderate, poor and nil zones. Thus, the study also proves that remote sensing and GIS when synergistically used provide ample scope for the integration of spatial and non-spatial data that can be successfully adopted to systematic approach which helps in deciphering the probable potential zone of ground water exploration in the study area in a more scientific and unbiased manner.**

***Index Terms*— ground water potential zones, Remote sensing and GIS.**

I. INTRODUCTION

Water is an essential community of mankind. The world total water resources are estimated to be $1.378/10^8$ million hectare meter. Out of this, nearly 97.2% is saline water and 2.8% in fresh water that is in the form of glacial, streams, lakes and ground water occupier. The ground water gets its replenishment from meteoric precipitation. At present nearly $1/5^{th}$ of the total water consumption in the world is by ground water resources. India is one of the major agricultural countries with more than 70% of the population depending on agriculture which is dependent on monsoon which is not uniform over the years. Nearly three fourth of the cultivable land in India is dependent on mansoon, which is contributing nearly 42% of the total production from agriculture. The productivity of any crop mainly depends on two natural resources, land and water in addition to management practices. Therefore the conservation of these two natural resources is essential for the sustainability of rain fed agriculture. This could be done using the watershed methods. The concept of watershed for development is gaining importance over the years. (Dept. of Wasteland Development, [1] & [2]. Hydrogeology has been an area of the biggest beneficiary of remote sensing. It has enhanced our understanding of local, regional, lithological, structural and geomorphologic features more clearly. Thus providing a better insight into surface and sub-surface dynamics of water and its utilization and management [3], [4] and [5].

Importance of the study area: The study area is Ayyarahalli, one of the sub-watershed which comes under Yennahole watershed (4D4B1) (which lies in Bay of Bengal region, Cauvery basin, Stanley Reservoir to Krishna Rajasagar catchment and left above Shimsa sub-catchment in Mysore district). The total area of the Ayyarahalli sub-watershed is 463.910 hectares, which again has two mini-watersheds namely Ayyarahalli and Yandanahalli and ten micro-watershed they are Bhugatahalli, 4B3E3G1a Chikkanahalli, 4B3E3G1b, Vajamangala, 4B3E3G1c, Varuna- 4B3E3G1d, Yandanahalli 4B3E3G2a, Choranahalli 4B3E3G2b. Jantagalli, 4B3E3G2c Marigaudanahalli, 4B3E3G2d Masamabyinahalli, 4B3E3G2e, Ayyarahalli, 4B3E3G2f. The geographical location of the study area falls between 12^0 16" 34' N Latitude and 76^0 44' 62'E longitude. For effective monitoring and management of any natural resource many methods are adopted. In this direction, groundwater prospect in an area is controlled by many factors such as geology, geomorphology, drainage, slope and depth of weathering, presence of fractures, surface water bodies, canals and irrigated fields [6]. Slope for example is one of the factors that control the rate of infiltration of rainwater into the subsurface and could therefore be used as an index of groundwater potential evaluation. In the gentle slope area the runoff is slow allowing more time for rainwater, to percolate, whereas high slope area facilitate high runoff allowing less residing time for rainwater hence comparatively less infiltration. In one way or the other, each of the listed factors contributes to groundwater occurrence. This is
especially true in hard rock terrains, including the study area. These factors can be interpreted or analyzed with GIS using RS data, [7] GIS as a defined is '' a powerful of tool for collecting, storing, retrieving as well as transforming and displaying spatial data from the real world for a particular set of purpose'' This range of map analysis operations to be undertaken in support of groundwater potential zonation of an area. Hence suitable techniques need to be developed for mapping prospective zones. The systematic approach of understanding the terrain characteristics at the regional level and then going for detailed mapping will help in improving the quality of information and its applicability to appraise the surface and subsurface water dynamics. Apart from mapping, the updating and modification of the existing geological and hydrogeological maps will also be very helpful. The present study is one such effort to employ the remote sensing and GIS techniques to study a small river basin (watershed) in the hard rock terrain of southern Karnataka from the point of

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appraising the surface and subsurface water movement, the control of geology and geomorphology over it and other influencing factors associated with them.

II. MATERIAL USED AND METHODALOGY

The area (Fig, 1) of interest lie in the watershed 4B3C as codified by the National Institute for Soil Survey and Land Use Planning (NISS&LUP) and further classified as sub, mini and micro watersheds using classification made by KSRSAC. The drainage layers were digitized (auto cad 2000, Erdas8.5 and arc map 8.12) using SOI toposheets (1976) and were updated/corrected using LISS III + PAN merged imagery of 1:12,500 scale (Dec.2000).

Watershed Delineation:- Many data used in this paper has been procured from different research and institutions. The rainfall data has been collected from the statical department, Mysore. Population data has been collected from Census of India.

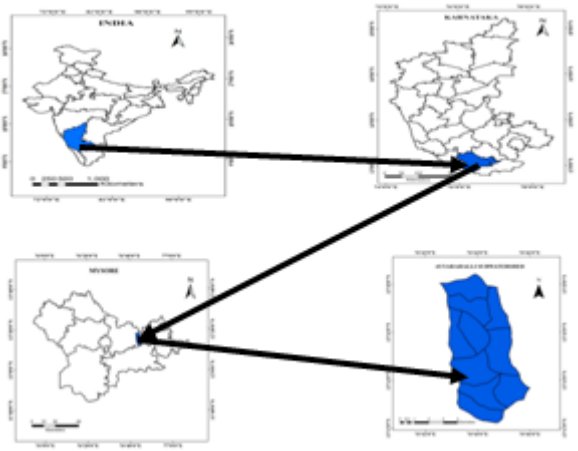


Fig.1: Location study area map:

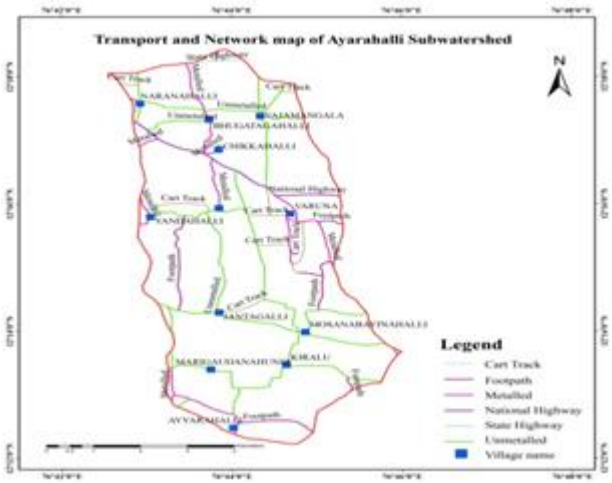


Fig.2: Base map of Ayyarahalli sub watershed

Base map is one of the important reference map for the preparation of thematic maps. Base map helps in locating the study area and gives an account of all the permanent features existing in the area of interest with the required positional accuracy The following features are extracted from the source data, as independent layers :- 1. Roads 2. Railways, Water bodies, Canals, 5. Settlement, 6. Farm House, 7. Cross Drainage Structure, Major Landmarks, Administrative Boundaries, etc.

Fig.3: Drainage of Ayyarahalli sub watershed:-

Drain is a natural depression of the land surface. It's 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 dendtritic to subdendritic type of drainage pattern. The dendtritic drainage pattern is the most common drainage pattern characterized by branching or tree like drainage pattern. Drainage net work in the present study was prepared by toposheets and Pan + Liss merged data, in which the spatial resolution of the data is 5.8 m 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 AutoCAD MAP 2000 and ERDAS IMAGINE and finalized after field validation for the doubtful drainages.

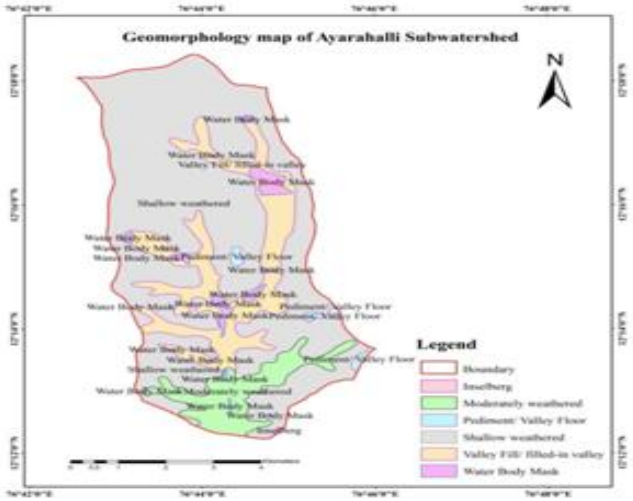


Fig.4: Geomorphology

Geomorphology is the science of the landforms and their systematic study is important to interpret them as signatures of the past and ongoing geological processes. These geomorphic features have great bearing on water resources of

any area. The rainfall pattern is a strongly influencing factor in the landform evolution and as well in hydro geomorphology. Rainfall pattern is also key for evaluating the terrain for water replenishment, storage and losses. Obviously critical and intelligent rainfall pattern analysis is vital for predicting droughts, cycles of surplus rainfall and runoff pattern, which are all ultimately necessary for comprehensive planning of any watershed. Geomorphology of the study area is as fallows

Pediments: - Gently sloping smooth surfaces of eroded bedrocks between hills and plains with veneer of detritus lithology like granodiorite, tonalites and migmatitic gneisses constitute pediments. Fractures have played important role in their formation Fig.5. The Pediments are gently sloping, smooth rocky surfaces exposed between hill and plain with thin covering of thin soil. They are characterized by rugged or undulated topography. Undulated plains with small hills and mounds, which survived the denominational process from pediment inselberg complex region of the area. The ground water prospect in this unit is poor Fig.5

Pediment inselbergs:-They are isolated low relief hills surrounded by gently sloping smooth bed rocks. As the dominant lithology is the area is granitoids, these pediment inselberg complex lithology composed of granodiorite, tonalitic and migmatitic gneisses. These are controlled by structure like joints, fracture and lineaments.

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

Pediplain moderate:-Flat and smooth buried pediplain and pediment with moderately thick overburden are called pediplain moderate

Valley fills:-The valley fill shallow are mainly composed of sands, sills, clays and rock fragments. They are very limited to lateral spread in the Gneiss terrain. This unit mainly observed in and around study area and very good for ground water prospect.

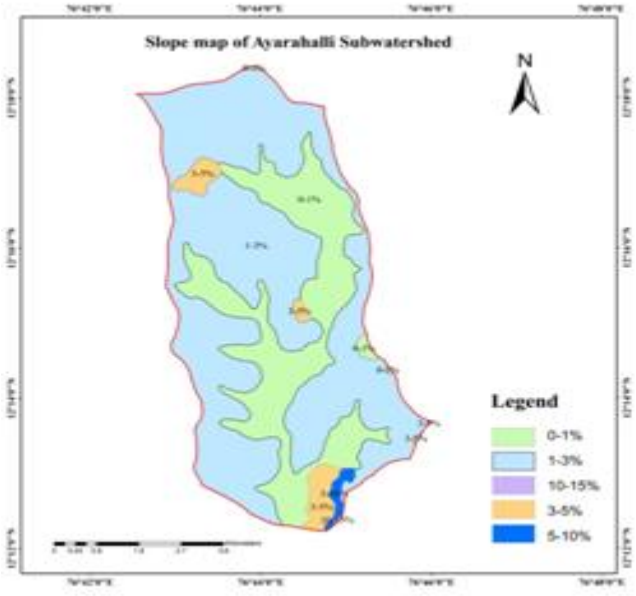


Fig.5: Slope of Ayyarahalli sub watershed

Slope aspect and attitude are important terrain parameters used for land capability and irrigability assessment, formulating soil and water conservation measures etc, the map has been prepared based on the contour information available on 1:50,000 SOI topo maps. The slope values were grouped into seven classes viz nearly maps based on the guidelines of All India Soil and Land use Survey (AIS & LUS, 1995) on slope categories (Table 1). The general classification of slope following the above guidelines is shown below, For general slope analysis survey of India Toposheets is 1:50,000 scales 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. 1and 2.

Table 1: Slope category based on AIS and LUS

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

Table 2: 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

Fig.6: Lithology of the study area

Lithologically, study area is mainly made up amphibolites, ultramafics and younger dykes are belonging to surgur groups of rocks, gneisses is predominant lithology. They are part of the Peninsular Gneisses, which are predominant in the southern part of Karnataka. Amphibolites and ultramafics are noticed as enclaves within the gneissic rocks. Besides the different rock types, drainage pattern. Joints, fissure, fracture and different lithological boundaries have been studied. Demarcation of lineament in different areas and their relation to rock types and lithological contacts has also been studied. Similarly different litho boundaries have also been recognized.

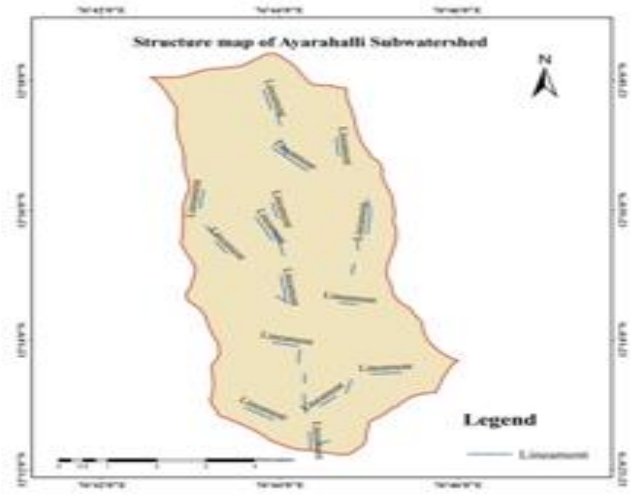


Fig.7: Lineament map of Ayyarahalli sub watershed

Lineaments are structurally controlled linear or curvilinear features, which are identified from the satellite imagery by their relatively linear alignments. Lineaments represent the zones of faulting and fracturing resulting in increased secondary porosity and permeability.

Fig.8: Ground water prospect map of the study area

Hydro geomorphology of the study area is represented in Fig.8. and the data in Table 3. Geomorphic unit-wise ground water prospect zones and their subsurface phenomenon are represented its identification and location are based on indirect analysis of some directly observable terrain features like geological structures, geomorphic features and their hydrologic characters. Remote sensing has also helped for better observation and more systematic analysis of various geomorphic units. Individual geomorphic unit are described in

Table 3: Ground water prospect of hydrogeomorphic unit

Map Symbol	Geomorphic Unit	Structure	Description	Ground water Prospect
RH	Residual hill	Joints, fractures, Lineaments	residue like small hills.	Poor to nil
PD	Pediment	Sometimes Fracture Controlled	Gently sloping, Smooth surface of erosional bedrock	Moderate to poor
PI	Pediment Inselberg	Controlled by joints, fracture lineaments etc.	Isolated low relief/hill bedrock	Moderate to poor
PPS	Pedipla in shallow	Joints, fracture Lineaments etc.	pediments marked by a large area and shallow soil depth	Moderate to poor varies with lithology and structure
PPM	Pedipla in moderate	Joints fracture lineaments etc	------‘’--------	------,,----------
PPMC	Pedipla in moderate	Joints fracture Lineaments Etc.	Colaescene of pediments marked by a large area and moderate recharge	Good to moderate varies with underlying Lithology, Structure and sometimes good to very good
DYKE	Dyke	Dyke	It is the discordant type of Igneous body having wall type of structure	Acts as a ground water barrier water is available on the upstream of the dyke
LINEAMENT		Lineament	represents joints, fracture, Shear zones	Good to very good

Wasteland:- Wastelands may be described as degraded land which can be brought under vegetative cover with reasonable effort and which is currently under unutilized land. This land is deteriorating due to lack of appropriate water and soil management or on account of natural causes. Wastelands can result from inherent/imposed constraints such as by location, environment, chemical and physical properties of the soil or financial or management constraints. This class includes settlement, land with scrub, water bodies. Using remote sensing and GIS techniques the study area is classified into different categories from the point of utility and natural cover, as double crop, kharif, plantations, fallow land, barren rocky land with scrub, tank.

Fig.9: Wasteland map of Ayyarahalli sub watershed

Water body:- Water body is an area of impounded water, aerial in extent and often with a regulated flow of water. It includes man-made lakes / tanks besides natural lakes, rivers and streams. Tanks are the natural or man-made enclosed water body with a regulated flow of water.

Fig.10: Land use and land cover

These features are medium/smaller in aerial extent when compared to reservoirs with limited use. Based on the observations on the satellite image in all the three seasons, tanks may be differentiated into tank (dry) and tank (water spread).

III. CROP LAND

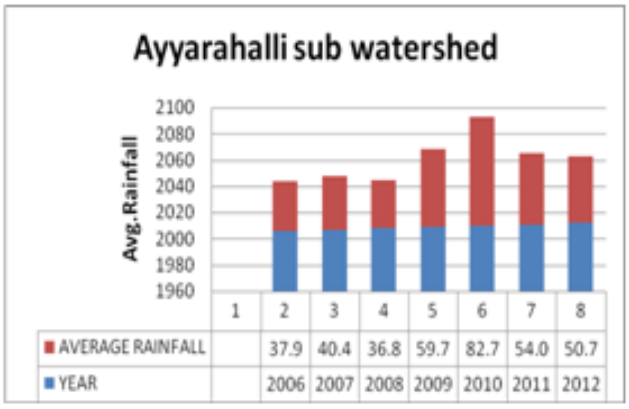
Land with scrub: This sub-class is found usually at relatively higher topography like uplands or high grounds with scrub. These lands are generally prone to degradation or erosion. These exclude hilly and mountainous terrain. It is noticed in all sub-watersheds

Barren rocky: -Stony waste may be defined as the rock exposures of varying lithology often barren and devoid of soil cover and vegetation. They occur amidst forest hills as openings or scattered as isolated exposures or loose fragments of boulders or as sheet rocks on plateau and plains, in almost all parts of the study area. Stony wastes have been observed in all the sub-watersheds

Fallow land: : It is described as agricultural land, which is taken up for cultivation but is temporarily allowed to rest, un-cropped for one or more seasons. These lands are particularly those, which are seen devoid of crops at the time when the imagery is taken of both seasons. In the present study

Agricultural land: - It is defined as the land primarily used for farming and for production of food, fiber, and other commercial and horticultural crops. It includes crop land, fallow and agricultural plantations.

Climate and rainfall:- Mysore taluk receives rainfall from south-west monsoon. This taluk enjoys more or less salubrious climate of Bangalore. The climatic condition is congenial for industrial development.. Actual rainfall received in Mysore taluk during 2004 was 748.5m.m. The agricultural operation is dependent mostly on canal irrigation due to perennial rivers in the taluk.



Fig,11: Rain fall data

IV. CONCLUSION

The present work was taken up in order to appraise the area hydrologically by employing remote sensing and GIS techniques, as these techniques would provide quicker, more precise and holistic view of any basin. The data most commonly available for groundwater study are geological, geomorphological and hydrological information. In this study we attempted to identify groundwater potential zones using remote sensing and geographic information system techniques in the area. To demarcate the groundwater availability of the area, various thematic maps such as, base map, lithological map, geological structural map,

geomorphology map and hydrological map were prepared from remote sensing data. Topographic maps, geology maps and hydro geomorphology maps were prepared using Arc GIS and ERDAS software and these maps are integrated for preparing groundwater prospects map. The hydrogeomorphological units such as valley fill and pediplain are prospective zones for groundwater exploration and development in the study area. Presence of faults and lineaments in the study area enhance the potential of these units and generate level of success.

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REFERENCE

[1] **India Soil & Land Use Survey.** Watershed Atlas of India, All India Soil & Land Use Survey, Ministry of Agriculture and Cooperation, Govt. of India.1990

[2] **Department of Wasteland Development**, Guidelines for Watershed Development, Ministry of Rural Areas & Employment, Govt. of India.1997

[3] **Moore.I.DGrayson, R.B.and Ladson.A.R.,** "Digital terrain modeling is review of hydrological, Geomorphological and biological Application" (Eds.Beven,K.J and More,I.D),John Wley, Chichester,1977,pp.7-31

[4] **Cathryn Turton.**"Enhancing livelihoods through participatory watershed development in India. Sustainable livelihoods research paper" 131. Overseas Development institute London.U.K. Printed by Kussel press .Nottinghom referenced on the public domain websites,2000, pp. 1-28

[5] **Prakash S.R.** Identification of groundwater prospective zones by using remote sensing and geo-electrical methods in and around Saidnagar area, Dakar Block, Jalaun district, U.P., J. Indian Soc. Remote Sensing, Vol. 21(4), 1993, pp. 217-227.

[6] **Chaudhary B.S., Kumar M., Roy A.K and Ruhal D.S.** Application of remote sensing and geographic information systems in ground water investigations in Sohna block, Gurgaon District, Haryana (India),In: International Archives of Photogrammetry and Remote Sensing Vienna, XXXI (part B6), 1996,pp. 18-23.

[7] **Ravindran, K.V.** Drainage morphometry analysis and its correlation with geology, geomorphology and ground water prospects in Zuvari basin, South Goa, using remote sensing and GIS. Proc, Nal Sym-Remote sensing for natural resource with special emphasis on water management, held at pune during Dec.4-6,1997,pp.270-296.

[8] **Jain, P. K.** Remote sensing techniques to locate ground water potential zones in upper Urmil River basin, district Chatarpur-central India. *J Ind Soc Remote Sens. Vol.* 26, No. 3, 1998 pp. 135–47.

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