Identification of Ground Water Potential Zones Using GIS And Remote Sensing Techniques: A Case Study of Yavatmal Taluka – Maharashtra

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Abstract- *India is blessed with numbers of rivers and streams which acts as prime source of water for all type of uses such as drinking, irrigation and industrial. But, there are some regions where these rivers don't flow which results in no or less drinking and irrigation water for survival. So, here ground water plays a vital role to fulfil the demands of the lives residing away from the rivers and their streams. This study is carried out to analyse the ground water potential zones in Yavatmal Taluka.*

The study is based on the secondary data, which is collected from concern department and through internet. The parameters have been consider for the study are drainage density, elevation, geomorphology, land use and land cover, rainfall pattern, slope gradient and soil texture. The selected parameters have been prepared and classified in GIS environment, then weightage for each parameters and its classes have been assigned using Hierarchical Process, then weighted overlay analysis in ArcGIS used to find out the result. The result of study has been compared with the collected sample data to assess the accuracy of result. The comparison of study's result and the collected sample data has given 90 per cent accuracy.

Keywords- Hierarchical process, Weighted Overlay Analysis, potential ground water zone, GIS and RS.

I. INTRODUCTION

India is country with numbers of rivers and streams which acts as prime source of water for all type of uses such as drinking, irrigation and industrial. But, there are some regions where these rivers don't flow which results in less drinking and irrigation water for survival. So, here ground water plays a vital role to fulfil the demands of the lives residing away from the rivers and their streams. The study of groundwater plays an important role since it can be main source for drinking, irrigation and industry use if proper study is done for the same. In recent times remote sensing and geographic information system technique is proved to be a cost effective and time saving tool to produce valuable data on geomorphology, geology, land use land cover, slope, lineament density, drainage density, etc. which helps to decipher groundwater potential zones. There are different perspectives of groundwater studies which have been done by several researchers based on their purpose, in recent times, many researchers such as Chaudhary et al. (1996), Rajat C. Mishra et al. (2010), Dr. Jyoti Sarup et al. (2011) have used the approach of remote sensing and GIS for identification of groundwater potential zones and exploration of groundwater with locating the artificial recharge sites. Akram Javed et al. (2009), Narendra et al. (2013) have used remote sensing and GIS techniques for delineation of groundwater potential zones.

Additional to this researchers had studied to find groundwater level fluctuation using temporal water depth data (Vijaya Kumar, 2006), and properties of groundwater to find out the quality of it (Ranjana 2009, Yadav 2012). The Present study is conducted to explore the potential zones of ground water availability using remote sensing and GIS technologies. The study conducted by Kamaraju 1996 and Sajikumar 2013 provide proofs for GIS and RS techniques which are best suitable method to find out the potential ground water zones as well as it can reduce the time and cost and human power (from / than) the traditional methods. For the analysis of potential ground water zones totally different and important parameters have been considered for the study such as, drainage density, elevation, geology, geomorphology, land use and land cover, slope and soil pattern. Each parameters have been classified, and weightage for each classes have been given based on the Hierarchical Process decided from different researcher get the final results.

Integrated approach of remote sensing and GIS can provide the appropriate platform for convergent analysis of divergent datasets for decision making in not only mapping

and planning of groundwater resources but also management of groundwater resources for its efficient and cost effective use for a region or state. This study is aimed to develop and apply integrated method for combining the information obtained by analysing multi-source remotely sensed data in a GIS environment for better understanding the groundwater resource for a watershed in Yavtamal district, Maharashtra, India

II. STUDY AREA AND METHODOLOGY

The study area is one the taluks in Yavtamal district in Maharashtra, which is also headquarters of district. The geographical extension of the study area is (Latitude of 20.15degree to 20.50 degree and Longitude of 77.90 degree to 78.40 degree) which consists of 1060 km2 geographical area. The calculated average rainfall data shows that, the rainfall ranges from 900 mm to 1000 mm, and major part of the study area has covered by black soil. The surface of study area maximum covered by agricultural activities which is 80 per cent of total study area and built-up land use areas are seen highly in and around the Yavtamal city which comprises of five small towns.

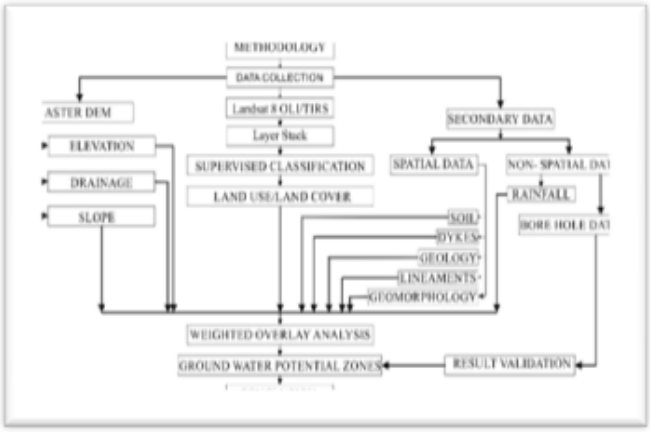

Figure 1: Methodology for the study

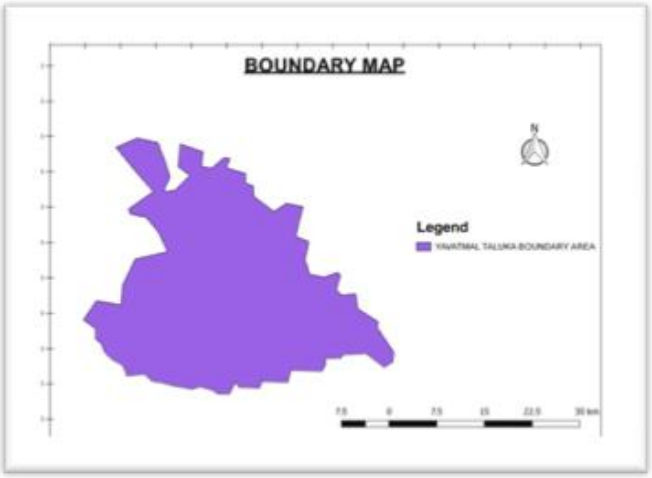

Figure 2: Map showing the study area

The study has been conducted based on the secondary data which have been collected from concerned department. The study has considered different parameters for the groundwater level assessment as mentioned in introduction. The elevation data has been downloaded from ASTER GDEM and this has been used as base to create the elevation and slope, then using the elevation data the drainage network has been created. The Landsat 8 satellite data downloaded from earthexplorer.usgs.gov has been used to find out the land use and land cover pattern of study area. The spatial data such as soil, dykes, geology, lineaments, geomorphology and rainfall were collected from remote sensing and GIS platform, Bhuvan. The collected rainfall data had been collected from metrological department. Once the error reification of each parameters were over, the analytical hierarchical process has been used to rank the weight of each parameters, which basically depends on various literature survey.

III. ANALYSIS AND DISCUSSION

As mentioned in the methodology the selected parameters have been created using GIS techniques and it has been ranked based on the hierarchical process from literature survey. The detailed discussion of each parameters is following.

3.1 Drainage density

The density of drainage is one of the factors which plays the major role in Potential groundwater zones. The water runoff will be high if the density of drainage is high so the infiltration of water into ground would be less, whereas low the drainage density area's surface-water runoff will be less so the infiltration of surface water into ground will be high. For the present study the stream data has been created from the aster DEM and this data have been compared with the stream data which collected from department of mines and geology. The corrected streams data have been used to find out the drainage density of study area.

By extraction of drainage density features, a thematic map generated, classified into four zones according to their respective drainage density, which is as per figure 3 below. The ranks were assigned to the individual slope class, according to its respective influence of groundwater occurrence, holding and recharge, as per table 1 below.

Table 1: Ranking for drainage density

Sr. No.	Drainage density (in Km/ sq. km.)	Description	Ranking (In word)	Ranking (In number)
1	0 to 0.5	Low density	Good	1
2	0.5 to 1.0	Moderate density	Moderate	2
3	1.0 to 1.5	High density	Poor	3
4	1.5 to 2.0	Very high density	Poor	3

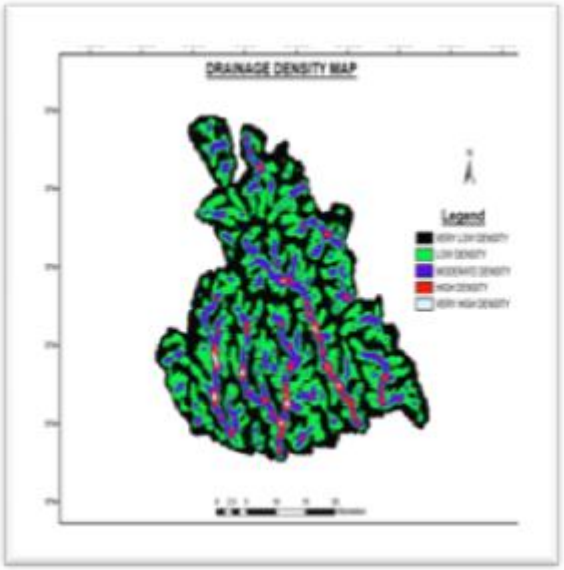

Figure 3: Drainage density map

3.2 Elevation

Water tends to store at lower topography rather than the higher topography. Higher the elevation lesser the ground water potential and vice versa, for the present study elevation data having 30 meter spatial resolution has been created based on the ASTER DEM. The study area's elevation ranges between 280 meters to 450 meters from the mean sea level, this values have been classified equally into classes and weightage for each class have been assigned.

3.3 Geomorphology

Geomorphology is a study of earth structures and also depicts the various landforms relating to the Ground water potential zones and also structural features. Geomorphology of an area depends upon the structural evolution of geological formation. The study area comprises the features denudational pediment complex and most of the area covered with moderately dissected lower plateau followed by hills, Settlement, Rivers/Stream and reservoirs. Based on the importance for Geomorphological features the weightage was assigned.

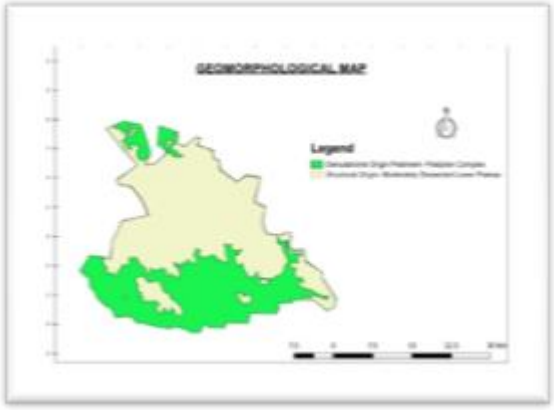

Figure 4: Geomorphological map of the study area.

3.4 Land use and Land cover (LU/LC)

Due to anthropogenic activities the land surface has been modified enormously in the recent years. The surface covered by vegetation like forests and agriculture traps and holds the water in root of plants whereas the built-up and rocky land use affects the recharge of groundwater by increasing runoff during the rain, so it is necessary to study what kind of features are covered the study area's land surface. The Landsat 8 satellite image has been used for the study to find out the land use and land cover of study area. The supervised classification method has been used with level – I classification. The result of the study found the study area covered by six different classes such as agricultural land, forest, built-up, water body, waste land and others. The weight assigned based on water logging and runoff properties of LU/LC.

Table 2: Ranking for land use land cover

Sr. No.	Land use land Cover	Ranking (In word)	Ranking (In number)
1	Agricultural	Good	1
2	Urban Built up	Poor	3
3	Scrub Land	Poor	3
4	Rural Built up	Moderate	2
5	Waste land	Poor	3
6	Wet land	Good	1
7	Waste land (rocky)	Poor	3

Land use land cover features control the occurrence of groundwater with variety of classes among itself. Remote sensing data and GIS technique provide reliable, accurate baseline information for land use land cover mapping, which plays vital role in determining land use pattern and changes therein on different times. The effect of land use land cover is manifested either by reducing runoff and facilitating, or by trapping water on their leaf. By extraction of various classes of land use land cover, a thematic map was generated as per figure 5 below.

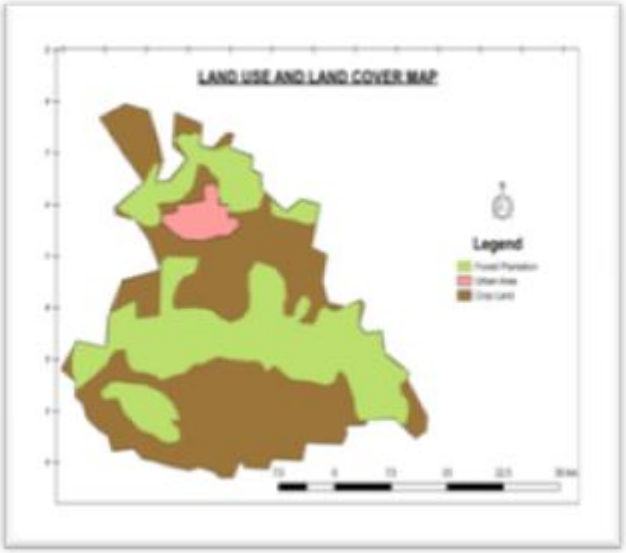

Figure 5: Land use land cover map for the study area.

3.5 Rainfall

Rainfall is one of the major source for ground water availability through the water cycle. The amount of rainfall is not same all the places it varies based on the environment conditions of the place. The possibility of ground water is high if the rainfall is high and it is low if rainfall is low. The rainfall not only varies spatially it also varies temporally hence to determine the influence of rainfall in any region long time period study is necessary. The present study has been consider the annual mean rainfall from the 50 years data from IMD, Pune. The value of annual mean values have been plated on the respective rain gauge stations and the interpolation method has been used to find out the distribution of rainfall in the study area. Once the spatial distribution of rainfall has been found the study area has been classified into zones based on the equal interval then the suitable weightage has been assigned for each classes.

3.6 Slope

The precipitous terrain causes rapid runoff and does not store water easily. Slope of any terrain is one of the factors allowing the infiltration of groundwater into subsurface. In the gentle slope area, the surface runoff is slow allowing more time for rainwater to percolate, whereas, steep slope area facilitates high runoff allowing less residence time for rainwater to percolate and hence comparatively less infiltration. The slope map of the study area is derived from ASTER DEM 30 m and slope of the study area is classified into five classes, which is as per figure 6 below.

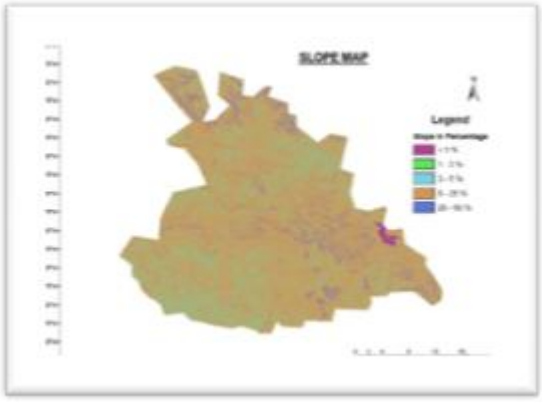

Figure 6: Slope map

The ranks are assigned to the individual slope class, according to its respective influence of groundwater occurrence, holding and recharge, as per table 3 below.

Table 3: Ranking for % slope

Sr. No.	Slope (%)	Description	Ranking (In word)	Ranking (In number)
1	< 1	Nearly levelled	Good	1
2	1 to 3	Gently sloping	Good	1
3	3 to 5	Moderate sloping	Moderate	2
4	5 to 25	Strongly sloping	Poor	3
5	25 to 90	Steep sloping	Poor	3

3.7 Soil

Soil is the one of the primary factor which determines the amount of groundwater, the study of soil helps to find out the types and as its properties. The movement of ground water and infiltration of surface water into ground is based on the porosity and permeability of soil. Therefore the study of soil is important to determine the amount of ground water of any place. The base data for the soil classification of present study has been obtained from National Bureau of Soil Survey and Land Use Planning, Maharashtra. The result of soil classification found that, the study area has Regur soils as major soil. Regur soils are black in colour and are also known as black cotton soils. They are well-known for their ability to retain moisture. These soils have moderate effect as a controlling factor for groundwater occurrence and recharge potential for this study area.

Figure 7: Soil map of the study area.

Table 4: Ranking for soil types

Sr. No.	Soil type	Ranking (In word)	Ranking (In number)
1	Alluvium	Good	1
2	Regur	Moderate	2
3	Mountain	Poor	3

3.8 Weighted overlay

Overlay analysis is a multi-criteria analysis wherein analysis can be carried out with complex things for finding out certain theme with the help of assignment of rank to the individual class of feature and then assigning weightage to the individual feature considering its influence over theme. All the thematic maps were converted into raster format and superimposed by weighted overlay method, which consists of rank and weightage wise thematic maps and integration of them through GIS. Integration of thematic maps for carrying out multi-criteria or overlay analysis in GIS environment was done using ArcGIS software.

Table 5: Ranks and weightages of parameters for groundwater recharge potential zones

Sr. No.	Groundwater recharge potential factor	Classes	Rank	Weightage (%)
(1)	Slope	< 1%	1	20
		1 to 3 %	1	
		3 to 5 %	2	
		5 to 25 %	3	
		25 to 89 %	3	
(2)	Soil	Alluvium	1	20
		Regur	2	
		Mountain	3	
(3)	Geomorphology	Valley	1	25
		Pediplain	2	
		Plateau	3	
		Structural hill	3	
(4)	Land use land cover	Agricultural	1	25
		Wetland	1	
		Rural built up	2	
		Scrub land	3	
		Waste land	3	
		Urban built up	3	
		Waste land rocky	3	
(5)	Drainage density	0 to 0.5 (Low)	1	10
		0.5 to 1.0 (Moderate)	2	
		1.0 to 1.5 (High)	3	
		1.5 to 2.0 (Very high)	3	

IV. RESULTS

Overlay analysis is carried out, using weighted overlay analysis tool provided in the ArcGIS software, to integrate various thematic maps viz. geomorphology map, soil map, slope (%) map, land use land cover map, drainage density map and lineament density map, which are being very informative and plays important role in the study for groundwater recharge potential zones of study area. The various thematic maps were assigned with different weightages of numerical value to derive groundwater recharge potential zones. On the basis of weightage assigned to these maps and bringing them into the function of spatial analyst for integration of these thematic maps, a map indicating groundwater recharge potential zones is obtained, which is as per fig. 8 below. This map has been categorized into three zones viz. ‘poorly suitable’, ‘moderately suitable’ and ‘most suitable’ from groundwater recharge potential point of view.

For more realistic evaluation, the result of study has been compared with the collected sample data to assess the accuracy of result. The comparison of study's result and the collected sample data has given 90 per cent accuracy.

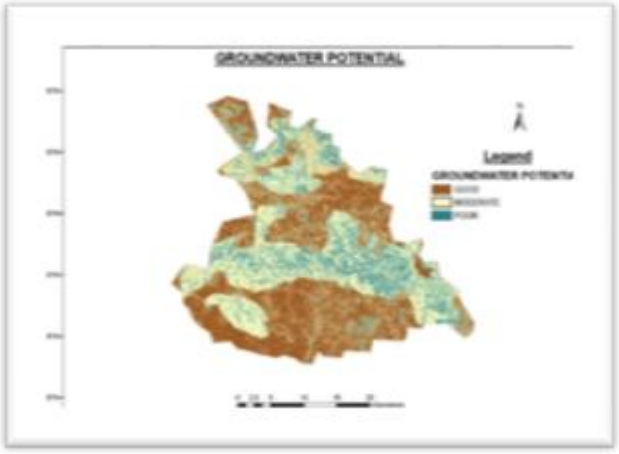

Figure 8: Groundwater Potential zones of Yavatmal Taluka, Yevatmal, Maharashtra.

V. CONCLUSION

The study of identification of ground water potential zone in Yavtamal Taluk depicts that, vast area has been covered by good followed by poor potential zone, whereas moderate potential zone is available at town area. To validate the result of present study sample locations ground water data have been collected, then these data have been correlated with the result of study. The result of correlation between study result and sample data has given 90 per cent of accuracy. Therefore based on the result and accuracy the study suggest these method would be suitable for exploring potential ground water zones. The occurrence and recharge of groundwater in the study area is prominently controlled by the geomorphology, soil type, land use land cover and slope (%) as revealed from GIS analysis. Remote sensing and GIS technique used to integrate various thematic maps proves to be very important to map the groundwater occurrence and movement for recharge potential mapping and management plan on a scientific basis. Overall result demonstrates that the use of remote sensing and GIS technique provides powerful tool to study groundwater resources and design a suitable exploration plan for recharge of groundwater in study area. The integrated groundwater potential zones map for the study area has been categorized into three zones viz. 'poorly', 'moderately' and 'good', on the basis of the ranks and weightages assigned to different features of the thematic maps. From this study it is observed that remote sensing and GIS technique can be used effectively to delineate groundwater potential zones map, which can be used for improvement in the groundwater exploration and holding for the study area and later on may be for various purposes like identification of location of structures for artificial recharge, locations of new tube wells and efficient groundwater management for betterment of the society. The study also recommends the use of GIS technology with RS data for the further study of ground water, which can minimize the cost, time, human power with higher accuracy.

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