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Research paper

Multi criterion Analysis for Ground water Potential Zones along River Gostani and surroundings of Visakhapatnam, Andhra Pradesh, India.

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Abstract

The present study is to make an analysis of the groundwater potential zones along Gostani river and the nearby areas. The data is collected from the field concern department and through internet to make a study. For the study seven parameters have been taken into consideration like geology, geomorphology, drainage, slope, soil, land use / land cover and lineaments. Thematic maps prepared and reclassified under Geographical Information System (G.I.S) environment. Weightage for each theme and its classes have been allocated by making use of weighted overlay analysis and then Analytical Hierarchical Process in Arc G.I.S. so as to find out the result.

Keywords: *Analytical Hierarchical Process; Groundwater potential zones; Remote sensing and G.I.S; Weighted Overlay Analysis*

1. Introduction

Groundwater study is valuable as it happens to be main source for drinking, irrigation and industrial usage throughout the world. Several researchers made different perspectives of groundwater studies basing on their purpose especially the study of physical and chemical properties of groundwater. Groundwater potential zones are delineated integrating water level fluctuations making use of G.I.S. and Remote Sensing (R.S.) techniques and proved that multi-disciplinary approach is better than the traditional methods. Seven parameters have been taken into account such as, geology, geomorphology, slope, soil, drainage, lineaments and land use/ land cover for the analysis of groundwater potential zones. Each parameter is given a weight age factor found on the Saaty's Analysis hierarchical process. [1].

Base flow/groundwater exploration in the river bed being carried since 1942 through Boni water works by Visakhapatnam Municipal Corporation, Bheemunipatnam municipality, Vizianagaram municipality, several Rural Water Supply schemes and few industries. As a result, back waters from the sea encroached upstream by about 1.0km than the usual since the year 2000. Water yields in all the above said schemes get reduced to less than 50% during summer 4 months indicate the over exploitation of groundwater in the river bed. Water being released for every 15 days during summer to recharge the river bed from Thatipudi surface storage reservoir for sustainability of the water supply schemes (Fig.2).

2. Study Area and Methodology

The area of study is part of Gostani river basin covering in topo sheet Gostani basin area falls in topo sheet 65 O/5 within the geographical coordinates between N17º50´ and N18º00´ latitudes and E83º15' and E83º30´ longitudes. The river originates in Anantagiri hills flow through Borra caves. Gostani means udd of a cow which represent the stalactites/ stalagmite of limestone caves of Borra. A reservoir is constructed across the river near Thatipudi village and its maximum storage capacity is 4.0 TMC. About 2.0TMC being used for irrigation from this reservoir and 1.0 TMC to Visakhapatnam municipality. In the remaining amount some quantity being release to the downstream of the reservoir to recharge the river bed for about 30km length where number of infiltration wells, galleries and groins for sustainability of urban and rural water supply schemes[2]. Thus the available surface and groundwater being used from the storage reservoir and river bed potential. But still about 68% of groundwater potential available for future in Vizianagaram district (Fig.1).
In the year 1980 Thomas L. Saaty introduced Analytic Hierarchy Process (AHP) process. Dealing with composite conclusion making AHP is an productive mechanism. If set priorities so as to make the best decision besides it may aid the decision maker. The best decision is to be made by a set of alternative options and a set of estimation criteria if the AHP takes into consideration. Based on the pairwise decision makers of comparisons the criteria, then the AHP made a weight for each ranking criterion. When the weight is higher than the more importance is given to the corresponding criteria for the class or map [3]. The AHP assigns a score to each option according to the decision makers pair wise

comparisons of the options based on that criterion for a fixed criterion. With respect to consider the criterion when the better the performance signify the higher the score.

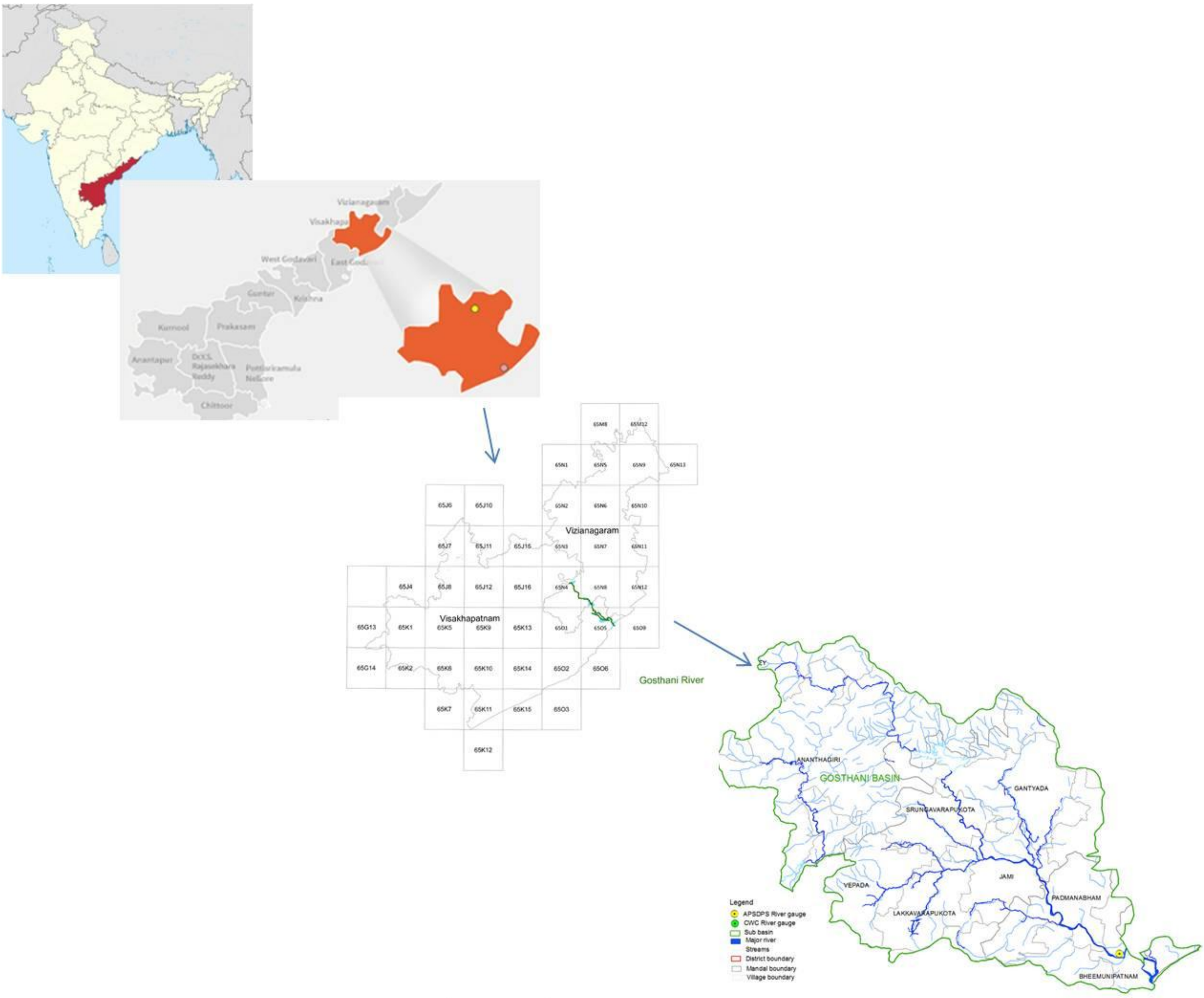

Fig. 1 Study area and river gostani

2.1. Objectives of the Study

Recognition of groundwater potential zones integrating remote sensing data through geomorphology, geology, lineaments, land use land cover, drainage, soil, slope, with help of index overlay method in G.I.S.

3. Preparation of Thematic Layer

A parameters were selected as specified in the methodology and have been created using G.I.S. techniques and ranked basing on Saaty's Process of Analytical Hierarchical. The elaborate discourse of parameter wise is as follows.

3.1. Drainage

Drainage is mapped from topo sheet of 1:50,000 scale (Fig. 3) that include first order to 4th and 5th order. Drainage density is an indication of surface/ subsurface water potential. Drainage density is high means surface runoff is more and subsurface infiltration would be less and vice versa. [4].

3.2. Geology

Geology take part an important role in dissemination and phenomenon of groundwater. Geology of the area consists of metamorphic rocks of Archaean origin. Khondalite, Charnockite and Quartzite are the dominant and has different weathering and water holding nature. Weightage factors are assigned based on the weathering, fracturing and water holding capacity of the rocks (Fig. 3).

3.3. Geomorphology

Geomorphology makes evaluation of land structures. In addition to which delineates the diverse landforms and structural features related to groundwater accumulation and permeability. Major land forms comprises the features like pediment, inselbergs and pediplain which covers most of the area and is classified as pediplain moderate and pediplain shallow. It is followed by structures hills, residual hills, denudational hills, flood plain and rivers/stream [5]. Weightage factors were assigned based on the importance for geomorphological features (Fig. 3).

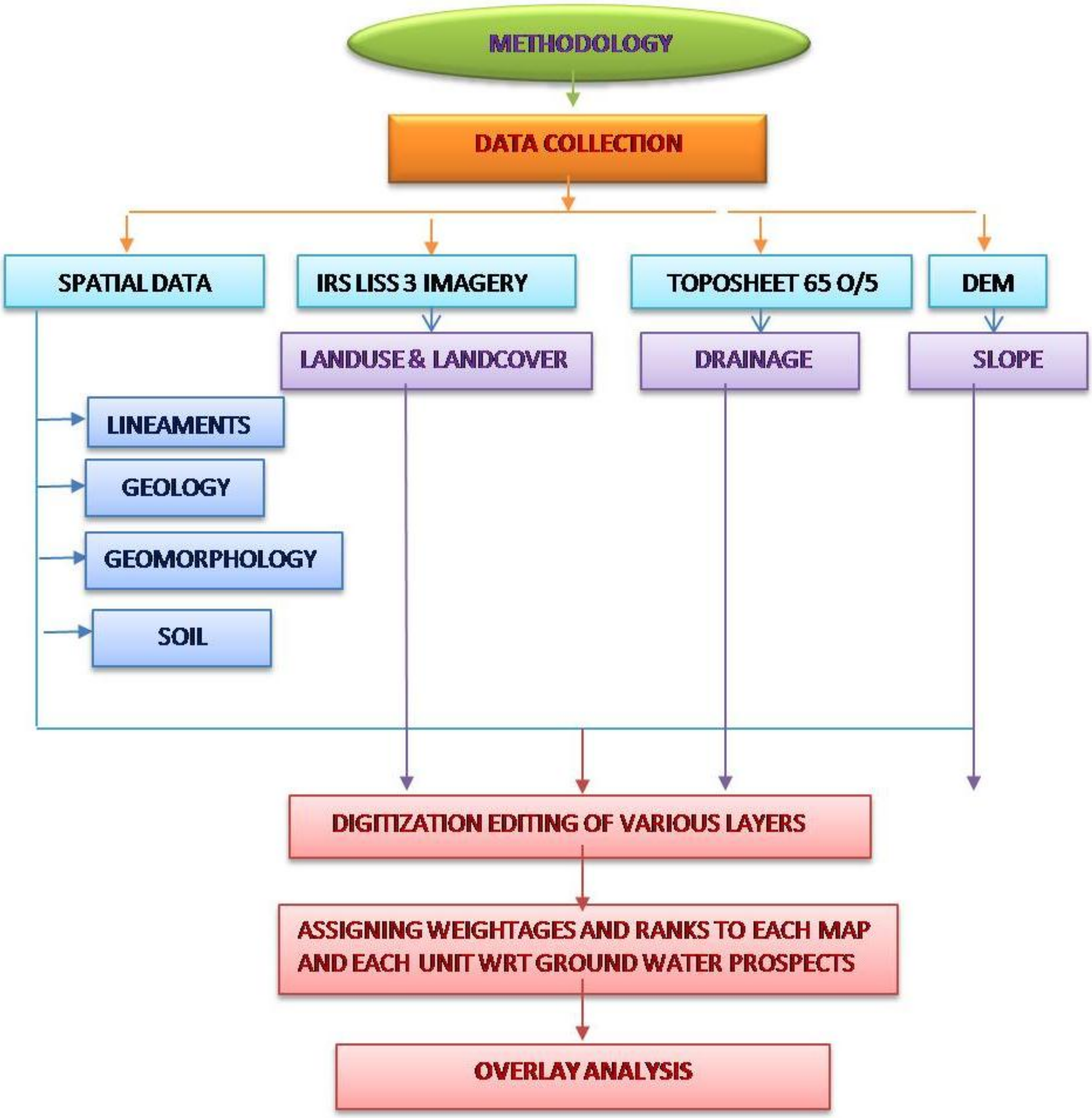

Fig. 2 Methodology for Mapping of Ground Water Potential Areas

3.4. Lineaments

Lineaments are the linear features of tectonic origin. A lineament may be a fault/ fracture, master joint, a long and linear geological formation, They are identified as long narrow straight course of streams, vegetation and may be the result of faulting and fracturing province of enlarged porosity and permeability in consolidated rock areas. Weightage was given based on the importance for lineaments features (Fig. 3).

3.5. Land use and Land cover (LU/LC)

Landsat-8 satellite images are used for the landuse/ landcover mapping. The study area categorised as water feature, forest, built up, agricultural land, waste land and others as shown in Fig. 3. Weight age factors are assigned based on the infiltration capacity of the soil.

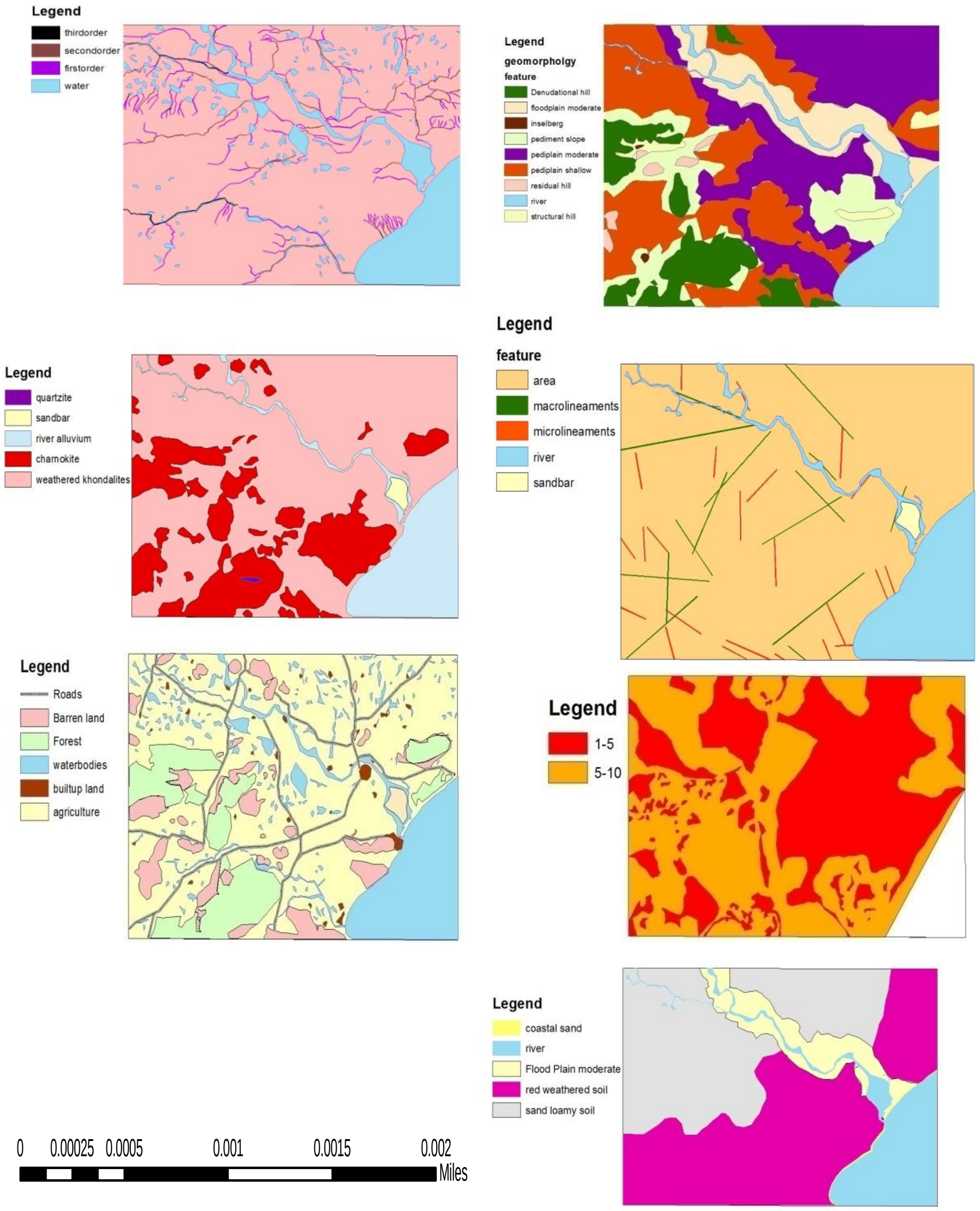

Fig. 3 Drainage, Geomorphology, Geology, Lineaments, Landuse/Landcover, Slope and Soil

3.6. Soil

Soil is one of chief factors as it determines the amount of groundwater recharge as well soil erosion. The types and its properties of soil acquire by the examination of soil. Base line data of the soil classification has been procured from the National Bureau of Soil Survey. Three types of soils such as river alluviam, red loamy and sandy loamy soils have been identified in which river alluvium has maximum infiltration capacity. Weight age factors are assigned as per the soil infiltration capacity (Fig. 3).

3.7. Rainfall

Even though the groundwater recharge depend on many factors, amount of rainfall is the key when estimating the quantity. Intensity is another important factor to allow the rainwater percolation into sub soils. However, average annual rainfall of the study area is more than 1000mm shows that the area comes in the category of high rainfall region.

3.8. Slope

Distribution of rainfall into surface and subsurface flows depend on the slope of the terrain other than the landuse, soils and intensity of rainfall. Seven categories of slopes have been identified Slope determines the remarkable effect on infiltration, the run-off is more immediate effect on surface water. Slopes are reclassified into 4 classes and given the weight age factors as per the category (Fig.3).

4. Database Organization and Overlay Analysis

Overlay analysis is one of the spatial G.I.S. operations. It integrates spatial data with assign data. Attributes are information about each map feature. Overlay analysis does this by integrating information from one GIS layer with another GIS layer to derive or infer an attribute for one of the layers. The output layers are shown in Fig. 4.

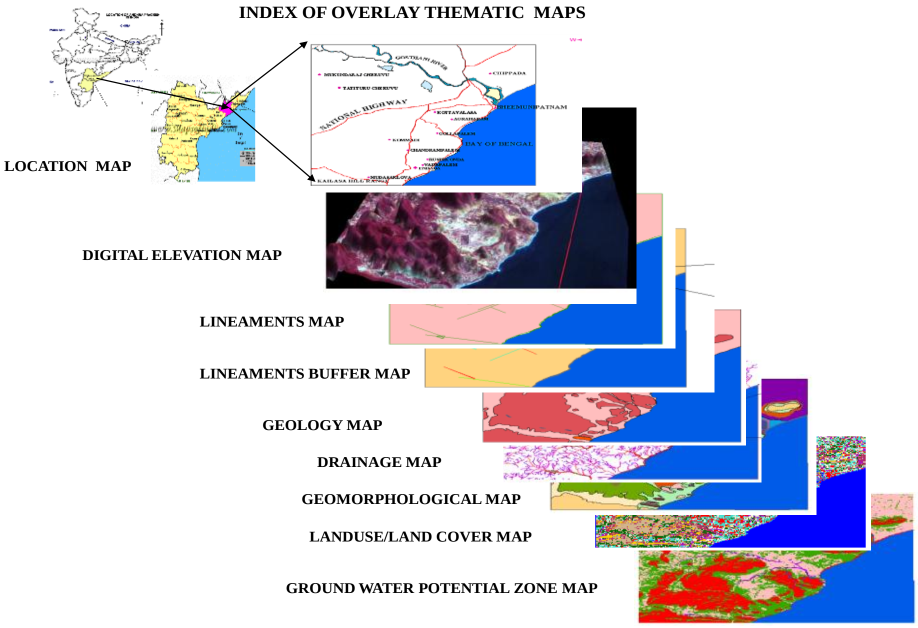

Fig. 4 Index overlay thematic map

4.1. SAATY'S Analytical Hierarc

Thomas L Saaty in the year of 1980 introduced this process. It is an effective tool for dealing with complex decision making and helps the decision maker to set priorities and make the best output It helps the decision maker to set priorities and make the best decision. The AHP takes into consideration a set of evaluation criteria and a set of alternative options among which the best decision is to be made. The AHP generates the weight for each evaluation criterion according to the decision makers pairwise comparisons of the criteria [6]. The higher the weight the more important the corresponding criterion. Next the AHP assigns a score to each option, for a fixed criterion according to the decision makers pairwise comparisons of the options based on that criterion With respect to consider the criterion when the better the performance signify the higher the score [7].

Secure the ranking thereby determing global score for each option and finally the AHP integrates the criteria weights and the options scores. The given option of a global score is with respect to all the criteria which obtained from a weighted sum of the scores. Of the parameter based on the importance of this, the procedure of assigning weightage for parameter wise and classes is shows in the table 1. The worth 9 in the table display maximum importance while 1/9 shows the minimum importance and 1 signify the equal weight of a parameter or a class. Each parameter in the study has been classified based on these weightage criteria [7]. The weightage assigned for selected 9 parameters for the evaluation was display in the Table 2.

Table 1: Continuous rating scale of Saaty's Analytical Hierarchical process

1/9	1/7	1/5	1/3	1	3	5	7	9
Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme
				Equal				
← Less Important					More Important →			

Note:1/8,1/6,1/4,1/2,2,4,6,8 if more number of classes exist

4.2. Index Overlay

The parameters have been assigned as mention in Tables 3 to 9. Then the tool 'Feature to Raster' is used to convert all features to raster. The parameters display in Table 2. Then weightages are assigned to each parameter and its respective subclasses in attribute table [8]. Then the tool 'Look up' is used to select each parameter and its respective subclass to determine weights to perform overlay analysis using formula

$$S = \frac{\sum(S_{ij} W_i)}{\sum W_i}$$

where S=weighted score for an area object

W_i=weighted score for i th input map

S_{ij}=score for j th class of the i th map,

the values of j depending on class actually occuring at current location

Table 2: Derivation of map weights according to Saaty's AHP process

S.No	Influencing Factor	Satty's scale	Satty's scale in Decimal	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	Geology	1	1	38.8	39
2	Geomorphol-ogy	1/2	0.5	19.4	19
3	Lineaments	1/3	0.33	12.8	13
4	Drainage	1/4	0.25	9.7	10
5	Soil	1/5	0.20	7.7	8
6	Slope	1/6	0.17	6.8	7
7	LU/LC	1/8	0.125	4.8	5
	Sum=		2.575		

Table 3: Derivation of Geology map class weights according to Saaty's AHP process

S.No	Influencing Factor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing Value
1	*Geology*	Weathered Khondalite	Very High	1	66.66	67
		Hard Khondalite	Moderate	1/3	22.22	22
		Quartzite		1/6	11.11	11
			Sum=	1.5		

Table 4: Derivation of Lineaments map class weights according to Saaty's AHP process

S. No	Influencing Factor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	*Lineaments*	Micro Lineaments	High	1	83.33	83
		Macro Lineaments	Low	1/5	16.67	17
			Sum=	1.2		

Table 5: Derivation of Slope map class weights according to Saaty's AHP process

S. No	Influenc-ing Fac-tor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
		1-5	High	1	83.33	83
1	*Slope*	5-10	Moderate	1/5	16.67	17

Table 6: Derivation of Geomorphology map class weights according to Saaty's AHP process

S.No	Influencing Factor	Classes	Ground Wa-ter Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	Geomorphology	Residual Hill	Very Low	1/5	4.6	5
		Structural Hill	Very Low	1/5	4.6	5
		Denudational Hill	Very Low	1/5	4.6	5
		Inselberg	High	1/5	4.6	5
		Pediplain moderate	Very High	1	23.25	23
		Pediplain shallow	Very High	1	23.25	23
		Piedmont Slope	High	1/2	11.6	12
		Floodplain moderate	Very High	1	23.25	23
			Sum=	4.3		

Table 7: Derivation of Drainage map class weights according to Saaty’s AHP process

S.No	Influencing Factor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	*Drainage*	First Ordered	High	1	65.35	65
		Second Ordered	Moderate	1/3	21.56	22
		Third Ordered	Low	1/5	13.07	13
		Sum=		1.53		

Table 8: Derivation of Soil map class weights according to Saaty’s AHP process

S.No	Influencing Factor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	*Soil*	River alluvial	High	1	65.35	65
		Red weathered	Moderate	1/3	21.56	22
		Sandy loam	Low	1/5	13.07	13
			Sum=	1.53		

Table 9: Derivation of Land use/Landcover map class weights according to Saaty’s AHP process

S.No	Influencing Factor	Classes	Ground Water Availability	Satty's scale	%Influence= (Satty's scale/Sum*100)	Relative Influencing value
1	*Land Use/ Land Cover*	Forest	Very High	1	43.8	44
		Agriculture	High	1/2	21.9	22
		Waterbody	Moderate	1/3	14.47	14
		Builtup land	Low	1/4	10.96	11
		Waste Land	Very Low	1/5	8.77	9
			Sum=	2.28		

This has been categorized into five results as very low, low, moderate, high and very high based on the output of overlay analysis, which was illustrated in Fig. 5.

The ranges of weightage values for ground water potential are below:

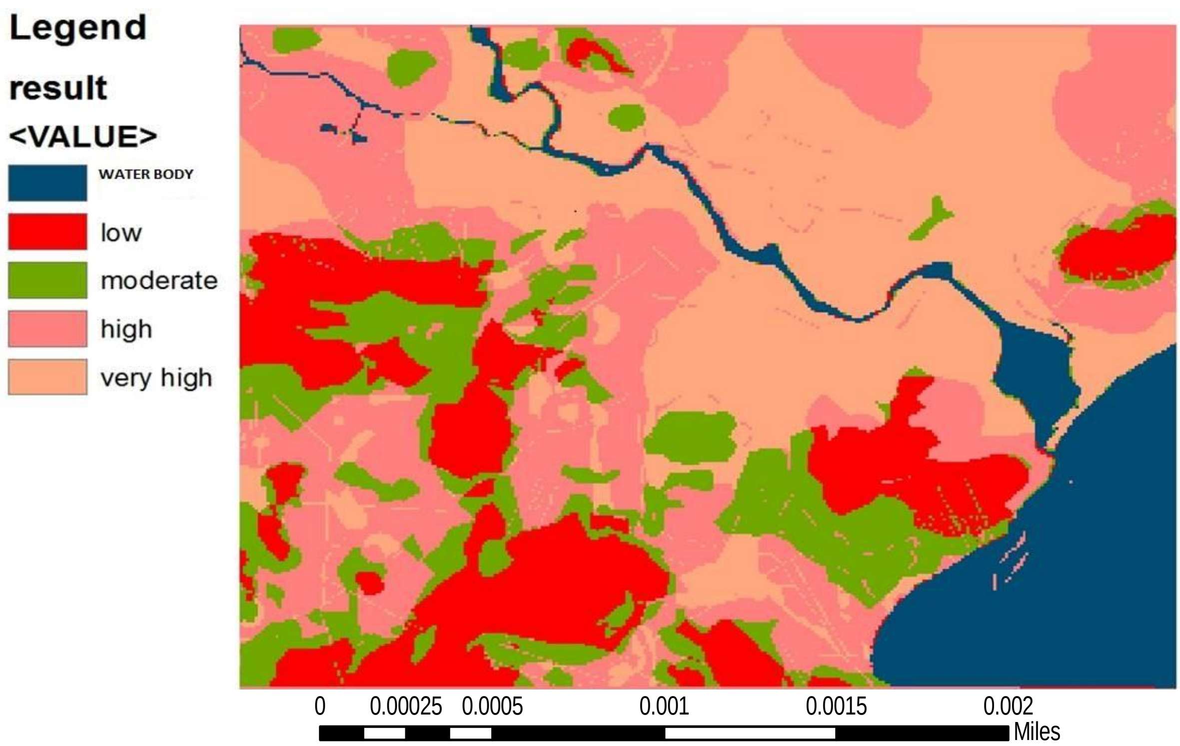

Fig. 5 Groundwater Potential zone map of study area

5. Conclusions

The wide area is envelope by very high potential province followed by high, moderate, low, very low potential province which signifies the study of identification of groundwater potential zone along river Gostani and sourrounding area.

The utilization of G.I.S with R.S.data for the further study of groundwater which can reduce the time, cost, human power with high accuracy which also proposes the investigation.
From the output map the following important observation can be made. The entire area is divided into six zones of groundwater potentiality, which are

- Very Good groundwater potential zones found in following areas: Bhandrayyapeta, majjibeta, kurapali, lakshmipura, vijayaramapuram, lingavalasa, maddipeta, krishnamajupeta, allupeta, kondaragupeta, bangarajupeta, polepalle, silapeta, jinapeya, rangapalem, ragalingapeta, kummaipalem, mamididipalem, mummivaripalem, bonni, pandragg, peddachamayavalasa, tagarapuvalasa, kondapeta, kottapeta, chittivalasa, santapeta regions
- Good groundwater potential zones found in Chippada, nammivanipalem, chinni kovulavada, narasayyapeta, amaam, gollapalem, dollipeta, kokavanipalem, erravanipalem, paradanipalem, gummidivanipalem, sontyam, mindivanipalem, palavalasa, dukkovanipalem, mattamidipalem, nagarapupalem, anantavaram, gollapalem, sirlapalem, mukundapuram, bandarupuram, archakunipuram, dokamdri, allupeta, kondarajupeta, bonganudjupeta regions.
- Moderate groundwater potential zones found in geomorphologically residual hill and structural hills regions and geologically hard khondalite rocks
- Low Good groundwater potential zones found near foot hills and geomorphologically pediment zones which are mostly associated with the thin layer of weathered zones.

Acknowledgement

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