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Assessment of Groundwater Potential using GIS in Cheyyeru Sub Basin, Chittoor, Andhra Pradesh.

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Abstract:

A morphometric analysis with the combination of GIS and Remote Sensing is conducted to find out the groundwater potential zones in Cheyyeru sub-basin, Chittoor, Andhra Pradesh with an aerial extent of 487.87 SqKm. The main stream of the basin is of third order and drainage patterns of sub basins are mostly of dendritic and parallel type. The watershed is divided into three sub basins for calculating the groundwater potential zones by using DEM (digital elevation model) which acts as the source to generate LULC, Slope, Soil map and River map in GIS. These thematic maps of Geomorphology are converted to raster format and analysis is done in the GIS, after which the results are used for compact factor analysis where they are reclassified with a 1 to 4 scale, representing poor, moderate, good, and very good zones of Groundwater potential. The groundwater potential map shows prioritized sub-basins. The groundwater potential map supports the statistical analysis indicating the presence of groundwater potential zones in W2 and W1 sub basins.

Key words: Ground water potential, Land degradation, Geographical information systems (GIS), Remote sensing (RS)

1. Introduction

Watersheds and its management have become a major focus of resource management in countries around the world. Much of this interest is the result of land-use practice that has led to increased soil erosion. Recently there has been increase in number of reports warning of high levels of soil erosion and detoriation of major watersheds. Sediment is building up in reservoirs and stream beds resulting in reduced irrigation and power production while increasing the incidents and severity of flooding. For example, Bowonder et al., report a 60 percent loss in the storage capacity of nizamsagar reservoir in telangana due to severe soil erosion in the upper small watershed (Bowonder et al, 1985). The actual rate of sedimentation was 25 times the original assumed rate the impact of such soil erosion is felt by rural people throughout the watershed to reduce incomes as well as inadequate supplies of wood and clean water, has dramatically increased the potential for erosion and downstream damages. These watershed problems are especially acute in developing countries where growing populations are exerting intense pressure on increasingly scarce land and water resources. Most of the people in these areas live and work on the land. So, as rural populations increase, land formerly formed extensively are now being formed more intensively, while formerly follow lands, usually more susceptible to erosion, are being cultivated.

The practices required to reduce these losses by protecting small watersheds from degradation are well recognized. However, the management of watersheds have been largely unsuccessful, partly because the concentration has been almost exclusively on biophysical aspects such as slope, soil texture, and vegetative cover, without proper regard for socioeconomic aspects. For successful project implementation, economic, social, political and institutional considerations are paramount.

Description of the study area: Cheyyeru sub basin is located in parts of Pileru, kalikiri and sodam mandals and occupying an area of 487.87 Sq km of Gundloor, Doddipalle and Thatiguntapalevillages in Chittoor District and is situated between the stretches from 13°38’20”North Latitudes and 78°48’14”East Longitudes and covers an area of 48788.81hactares(487.97 sq kilometres), with respect to the survey of India Toposheet number 57K/10, 57K/13, 57K/14 NE on a scale of 1:50,000 scale. The location map of the Cheyyeru sub basin is as shown in the figure 1.1.

The area experience humid tropical climate and the summer months are very hot and the mercury level rises to +42°Celsius. Winter months are pleasant. Winter months are ideal for agricultural field work. Rainfall is generally scanty. The average rainfall per annum is 753.55 mm.

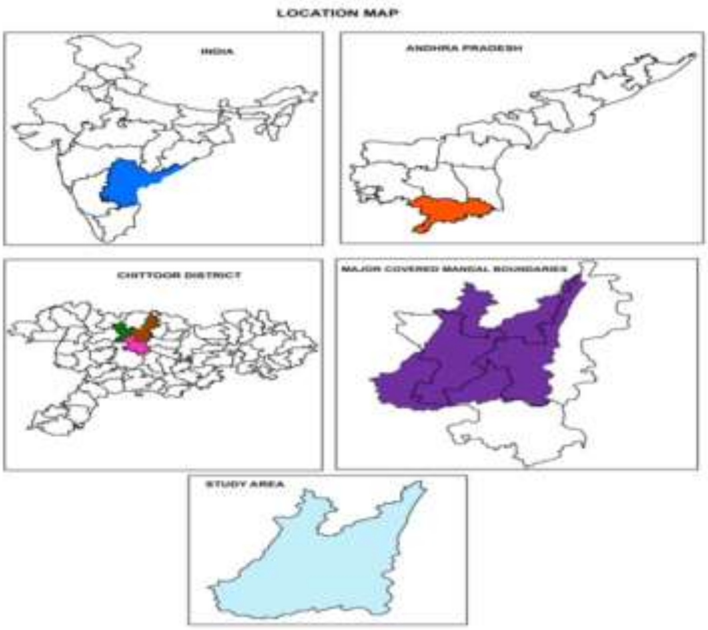


Fig. 1.1: Location map of the Cheyyeru Sub basin

The main goal of this study was to determine and evaluate the groundwater potential zones in Cheyyeru sub basin with qualitative approach using GIS techniques and to give some suggestions to take some measurements against to soil erosion and to make sustainable use of land resources.

2. Morphometric analysis and prioritization of ground water potential zones

The morphometric analysis and prioritization of micro watersheds of Cheyyeru sub basin is based on the integrated use of Remote Sensing and GIS techniques. The SOI toposheets on 1:50,000 scale were georeferenced and the Landsat TM imagery was rectified using the toposheets. The watershed so selected was downloaded into database in the form of image file. Later the same is imported into the ArcGIS, it is then georeferenced and projected as per the spatial data available. The study area boundary was delineated and its drainage pattern was mapped using Dem of study area in ArcGIS 10.2.2 environment.

2.1 Basin parameters

Morphometric analysis of a drainage basin provides a quantitative description of the drainage system. The geometry of the basin is formed by continuos flow through stream courses over a period of time and is a function of stream length, slope, roughness and size, shape slope and infiltration capacity of the basin, which contains linear, areal and relief parameters.

2.1.1 Linear Parameters

Stream number, stream order, stream length, mean stream length, stream length ratio, and bifurcation ratio are the linear parameters considered in the analysis.

2.1.2 Areal Parameters

The aerial aspects include various morphometric parameters like drainage density (D_d), drainage texture (T), stream frequency (F_s), elongation ratio (R_e), circulatory ratio (R_c), form factor (F_f), and length of overland flow (Lo).

2.1.3 Relief parameters

Relief parameter for drainage basin analysis, depends on the elevation difference between the highest and lowest point of a region. The relief measurements like basin relief (R), relief ratio (Rr) and ruggedness number (Rn) are used for analysis in this study.

2.2 Prioritization of groundwater potential zones

Prioritizing is nothing but giving the ranks for the sub-basins of ground water potential zones. It is done by compact factor analysis which is a mathematical analysis by using the values of morphometric parameters. The groundwater potential zones identification of micro watersheds Cheyyeru sub-basin was carried out through compact factor analysis of morphometric parameters.

2.3 Morphometric analysis of groundwater potential zones

Morphometric analysis is found to be an important study in the river basin evaluation, watershed prioritization and natural resources management. Drainage basin morphometry describes its surface characteristics and provides information regarding the region's topography and underlying geological structures. Morphometric characteristics of a watershed indicate its formation and development since all hydrological and geomorphic processes occur within the configuration of the basin surface and there by determines the shape and dimension of the landform. Remote Sensing with GIS has been proved to be an efficient tool in delineation of drainage patterns and basin prioritization as it provides effective solutions to overcome most of the problems of land and water resources planning. The chapter deals with the determination of morphometric parameters of Cheyyeru sub basin using RS and GIS techniques and prioritization of groundwater potential zones in the basin through compact factor analysis. The morphometric analysis and prioritization of sub basins of Cheyyeru sub basin on the integrated use of Remote Sensing and GIS techniques.

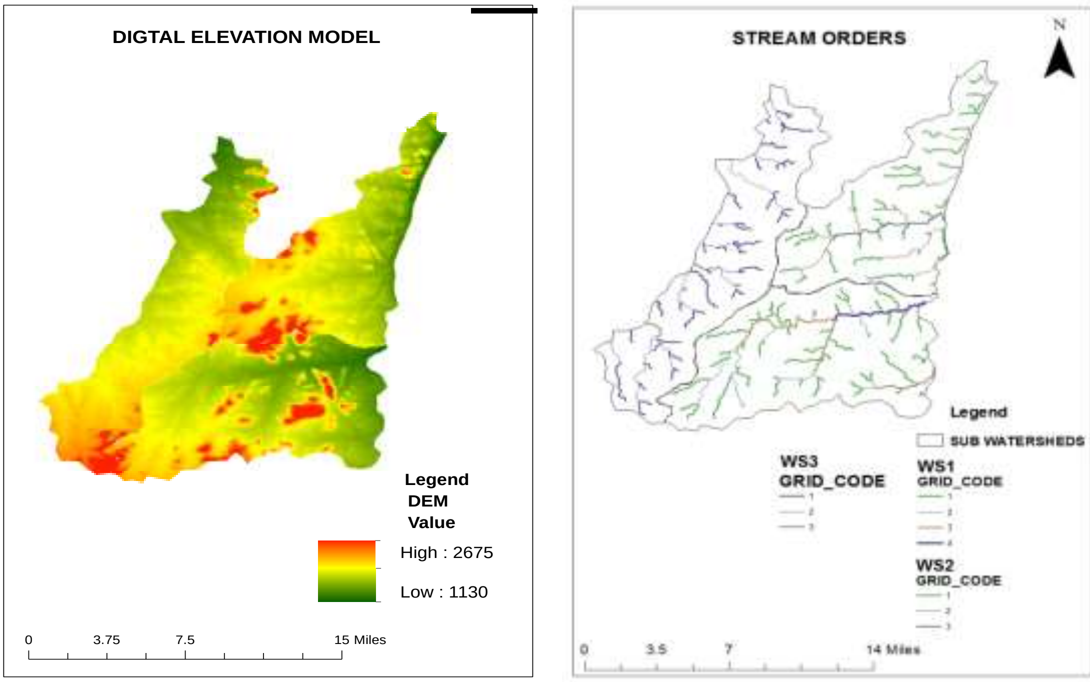
2.3.1 DEM of study area

The most common digital data of the shape of the earth's surface is cell based digital elevation models (DEMs). This data is used as input to quantify the characteristics of the land surface. Digital elevation model is taken from the SRTM 30M data. The DEM of the study area shows the elevation between 1178m to 310m.

2.3.1.1 Stream ordering

It is a method of assigning a numeric order to delineate a stream network, by using this method identification and classification of types of streams is done, based on their number of tributaries. Some characteristics of streams can be inferred by simply knowing their order.

1. Basin creates a raster delineating all drainage basins.
2. Fill, fills sinks in a surface raster to remove small imperfections in the data.
3. Flow accumulation creates a raster of accumulated flow into each cell. A weight factor can optionally be applied.
4. Flow direction creates a raster of flow direction from each cell to its steepest down slope neighbour.
5. Stream order assigns a numeric order to segments of a raster representing branches of a linear network.
6. Stream to fracture tool converts a raster representing a linear network to features representing the linear network.



(a) **(b)**

Fig 2.1 (a)&(b) DEM and stream order map of study area

2.4 Basin parameters

Morphometric analysis of a drainage basin provides a quantitative description of the drainage system. The geometry of a basin is formed by continuous flow through stream courses over a period of time and is a function of stream length, slope and roughness and, shape, slope and infiltration capacity of the basin.The drainage network of Cheyyeru basin was digitized from Dem of study area in ArcGIS 10.2.2 environment with RS data. The drainage pattern of the basin varied from dendric at higher elevations to parallel in the lower elevations. Indicating the homography in texture and lack of structural control of geological formations. Further, the pattern is characterized by a tree or fern like pattern with branches that intersect at acute angles.

2.5 Linear Parameters

The stream order (u) of the various streams was obtained using Strahler's classification. The number of streams (Nu) and corresponding lengths of streams (L) were obtained using GIS software. The other linear morphological parameters considered for the study include bifurcation ratio (Rb), mean stream length (Lu) and mean length ratio (R_L).The stream segments at the outlets of sub basins W_2 and W_3 are of 3rd order while for W_1 sub basin is of 4th order as shown in figure 6.6. It is likewise seen that the quantity of streams diminishes as the stream order builds observing Horton's law of stream numbers (Horton, 1945).The total number of streams, bifurcation ratio, stream length, and mean stream length and stream length ratio are as shown in table 2.2 & 2.3.

Table 2.2:Number of Streams and Bifurcation Ratios

Sub basin	**Total number of streams (Nu)**				**Total Nu**	**Bifurcation ratio (R_b) ($\frac{Nu}{Nu+1}$)**			**Mean R_b**
	1	2	3	4		1/2	2/3	¾	
W_1	92	24	27	18	161	3.83	0.88	1.5	2.07
W_2	56	32	16	*	104	1.75	2	*	1.25
W_3	81	42	3	*	126	1.93	14	*	7.965
TOTAL	219	98	46	18	391	**Mean**			3.761

from Table 2.2, it was seen that there are 219 streams are of first order, 98 streams are of second order, 46 streams are of third order, and 18 streams are of fourth order. It was seen that fundamental bifurcation proportion is high for W3 (7.965) and low for W2 (1.25). The higher Rb for W3 sub basin might be because of huge varieties in frequencies between progressive orders demonstrating the developed geology. The mean Rb of Cheyyeru sub basin was seen to be 3.761 showing that the sub basin is less influenced by auxiliary aggravations with drainage pattern, very little affected by geographical structures.

Table 2.3: Stream Lengths and Stream Length Ratio

Sub basin	**Stream length L_u (Km)**				**Total L_u Km**	**Mean stream length L_{sm}**				**Mean stream length ratio R_L**		
	1	**2**	**3**	**4**		**1**	**2**	**3**	**4**	**2/1**	**3/2**	**4/3**
W_1	0.86	1.11	0.84	0.476	3.288	0.0093	0.046	0.031	0.0264	1.29	0.75	0.56
W_2	1.18	1.02	0.70	*	2.9	0.0211	0.032	0.044	*	0.86	0.69	*
W_3	0.76	0.97	1.53	*	3.26	0.009	0.023	0.510	*	1.27	1.57	*

From the Table 2.2 it was seen that, the stream length proportion demonstrates the surface stream attributes of the basin. A decline in the stream length with increment in stream order for W1 to W3 sub basins was watched. The mean stream length proportion between the floods of various orders of the investigation zone changed from 0.75 to 0.56. This change might be attributed to variation in slope and topography.

2.6 Areal Parameters

The basic parameters of sub basins viz., length (L), perimeter (P) and area (A) are shown in Table 2.2

Table 2.4: Basic Parameters of Sub Basins

Sub basin	**Basin Area A, $(Km)^2$**	**Basin length, L (Km)**	**Perimeter P (Km)**
W1	183	16.16	68.96
W2	143.6	15.15	67.58
W3	161.1	9.730	84.37

The areal parameters for the basin namely drainage density (Dd), stream frequency (Fs), drainage texture ratio (T), circulatory ratio (Rc) are as shown in table 6.3.

Table 2.5: Areal parameters of sub basin

Sub Basin	**Drainage density D_d**	**Stream frequency F_s**	**Drainage texture T**	**Elongation ratio R_e**	**Circulatory ratio R_C**	**Form factor F_F**
W1	0.0180	0.8798	0.0158	0.4547	0.4833	0.7008
W2	0.0202	0.7242	0.0146	0.3560	0.3949	0.6256

W3	0.0202	0.7821	0.0158	0.3205	0.2843	1.7016

From Table 2.5, it was seen that Dd of sub basins of the investigation region ran between 0.0180 to 0.0202. Low estimations of Dd of sub basins demonstrate the presence of coarse drainage structure, exceptionally safe and penetrable sub soil with thick vegetated spread low relif. Fs of sub basins shifted between 0.7 to 0.8. Low Fs esteems show an extremely coarse drainage structure with low help and high infiltration limit and, the presence of great locales for groundwater recharge. The drainage surface (T) of the sub basins differed from 0.0146 to 0.0158. Low T esteems demonstrate extremely coarse drainage surface. Re under 0.7 of sub basins W1, W2, W3 show elongated state of sub basins. Rc under 0.5 of W1, W2, W3 show elongated sub basins with moderate elongation, low runoff and high subsoil permeability. Low Ff values of sub basins indicate elongated shape resulting in longer flow duration with flatter peak leading to more groundwater recharge.

2.7 Relief Parameters

The relief parameters such as relief ratio (R_r) and ruggedness number (R_n) are shown in Table 2.6.

Table 2.6: Relief Parameters of Sub Basins

Sub basin	Basin relief R (m)	Relief Ratio Rr	Ruggedness number Rn
W1	479	0.2964	0.0086
W2	648	0.4277	0.0131
W3	418	0.4296	0.0084

From the Table 2.6 it was observed that the relief ratio of sub basins ranged between 0.29 to 0.43. Lower values indicate gentle slope. R_n values varied between 0.008 to 0.013 for the sub basins. Low relief ratios and ruggedness numbers of sub basins indicate the existence of promising groundwater zones.

From the morphometric analysis of linear, areal and relief parameters of sub basin indicate that W_3 possess high bifurcation ratio with short streams. It is less elongated with high frequency causing less infiltration rate, moderate drainage density and low ruggedness number.

3. COMPACT FACTOR ANALYSIS

The groundwater potential zones identification of sub basins of cheyyeru sub basin was brought out through minimal factor examination of morphometric boundaries. The smaller factor examination of morphometric boundaries was done to organize sub basins based on groundwater possible accessibility. Rank of 1 to 4, speaking to poor, moderate, great and generally excellent likely zone, were utilized to rank the straight, areal and help boundaries, in light of their commitment towards groundwater. Higher position shows the more noteworthy level of groundwater energize structures. The normal position estimation of the boundaries of the sub basin shows its minimal factor. The reduced variables 1 to 4 speak to poor to excellent classes of groundwater possible zones. The positions appointed and minimal elements registered for the sub basins are introduced in Table 3

Table 3.1: Groundwater potential availability for corresponding compact factor

Sub basin	**Rank**										**Compact factor**	**Groundwater potential availability**
	Linear parameter		**Areal parameter**						**Relief parameter**			
	R_b	R_l	D_d	F_s	T	R_e	R_c	F_f	R_r	R_n		
W_1	2	2	3	1	2	1	1	2	3	2	1.9	**Moderate**
W_2	3	3	2	3	3	2	2	3	2	1	2.4	**Good**
W_3	1	1	1	2	1	3	3	1	1	3	1.7	**Poor**

From the Table 3.1 it was observed that higher compact factors of 2.4 of W_2 of sub basin indicate good groundwater potential. The sub basins W_1 and W_3 with compact factors 1.7 and 1.9 respectively fall in poor to moderate groundwater potential zones. The groundwater potential zones map is as shown in Figure 3.2.

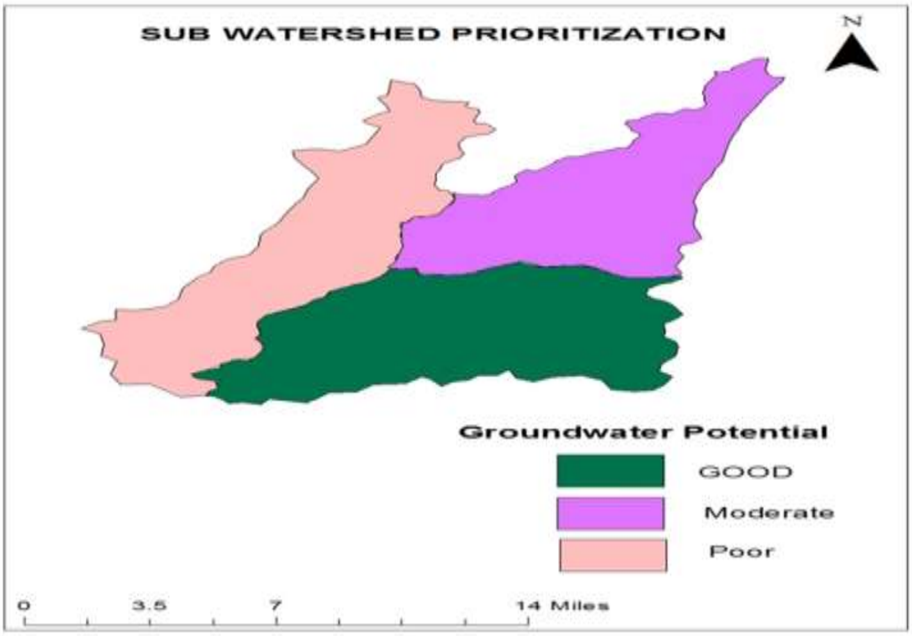


Fig: 3.1Groundwater potential zones of Cheyyuru basin

The observations are as follows:

1.Based on the slope map the slopes of the study area are divided into seven classes 1,2,3,4,5,6,7. These are nearly level, very gentle slope, gentle, moderately slope, moderately steep slope, steep slope, and very steep slope.

2. Four soil mapping units were identified in this watershed.

3. By using morphometric analysis groundwater potential zones have been identified and it was known that Sodam has very good GW potential, Pileru has moderate GW potential, and Kalikiri has poor GW potential.

4. Conclusion

The purpose of the study is to determine and evaluate the groundwater potential zones in Cheyyeru sub basin with qualitative approach using GIS techniques and to suggest few measurements for sustainable use of land resources.

1. It was observed that W2 (Sodam region) sub-basin with compact factor 2.4 indicates good groundwater potential.
2. Also observed that W1(Pileru region) sub-basin with compact factor 1.9indicates moderate groundwater potential.
3. Also observed that W3(Kalikiri region)sub-basin with compact factor 1.7 indicates poor groundwater potential.

This study is helpful for water resources planners and farmers to indicate potential areas for development and can be implemented in other parts of the country too. Further studies can be done on groundwater hydro chemistry and its suitability for domestic and irrigation purpose. Also can be studies on the groundwater recharge amount and its relation to precipitation amount.

5. References

[1] NemikaKumari and AkhouriPramod Krishna, Department of Remote Sensing, Birla Institute of Technology (BIT) Mesra, Ranchi, Jharkhand, India Geospatial Techniques Based Assessment of Groundwater Recharge Site Suitability.

[2] Prioritization of mini watersheds based on Morphometric Analysis using Remote Sensing and GIS techniques in a draught prone BargurMathursubwatersheds, Ponnaiyar River basin. India Sethupathi A.S 1, Lakshmi Narasimhan C 2, Vasanthamohan V 3, Mohan S.P 4. International journal of geomatics and sciences Volume 2, No2, 2011.

[3] V.S.S. Kiran and Y.K. Srivastava Check Dam Construction by Prioritization of Micro Watershed, using Morphometric Analysis as a Perspective of Remote Sensing and GIS for Simlapal Block, Bankura, W.B. [7] Abha Mishra, D.P.Dubey and R.N.Tiwari Morphometric Analysis of Tons basin, Rewa District, Madhya Pradesh, based on watershed approach.

[4] Watershed Morphology of Highland and Mountain Ecoregions in Eastern Oklahoma Dale K. Splintera; Daniel C. Dauwalterb; Richard A. Marstonc; William L. Fisherb.

[5] Prioritization of Sub-watersheds based on Morphometric and Land Use Analysis using Remote Sensing and G1S Techniques AkramJaved .MohdYousufKhanday .Rizwan Ahmed.

[6] Morphometric Analysis of Tons basin, Rewa District, Madhya Pradesh, based on watershed approach Abha Mishra, D.P.Dubey and R.N.Tiwari Department of Geology, Govt. P.G. Science College. [14] GIS model-based morphometric evaluation of Tamiraparani sub-basin, Tirunelveli district. Tamil Nadu, India N. S. Magesh& N. Chandrasekar Received: 28 November 2011 /Accepted: 31 October 2012 /Published.

[7] A GIS morphometric analysis of hydrological catchments within Makkali Metropolitan area, Saudi Arabia Koshak.N 1, Dawod.G 2 1 Center of Research Excellence in Hajj and Omrah, Umm Al-Qura University, Makkah, Saudi Arabia.