Demarcation of Ground Water Potential Zones using Remote Sensing and GIS Applications

Sunandana Reddy Machireddy[1], Navyatha C[2], Neelakanteswara Reddy N[3], Srinidhi H[4], Mahesh Naik N[5], Madhu Kumar B[6]

[1*]Associate Professor, Rajeev Gandhi Memorial College of Engineering & Technology (Autonomous),
Nandyal, Andhra Pradesh, India.
[*]Corresponding Author: machireddynanda@gmail.com

[2]Assistant Professor, Rajeev Gandhi Memorial College of Engineering & Technology (Autonomous),
Nandyal, Andhra Pradesh, India.
putloorinavyatha@gmail.com

[3,4,5,6]UG Student, Rajeev Gandhi Memorial College of Engineering & Technology (Autonomous),
Nandyal, Andhra Pradesh, India.
neelakanteswarreddy7893@gmail.com

Abstract*: *Now-a-days, due to the high demand of water for the human needs, groundwater sources are drastically extracted and causing to least the source. The entire Yearly furnish is contributing from the utmost resource called Groundwater. Globally, groundwater is extracting primarily for the purpose of agricultural fields, domestic and for industrial water supply. Majority of the surface water is in the form of saline water which is not useful for the needs of human beings for their daily needs. Very less amount of fresh surface water is existing on the ground surface. To compensate the needs, it is essential to identify, extract and manage the groundwater which is available at different levels at different areas of the globe. Proper planning is required for the extraction of groundwater using updated technologies for using and maintaining of natural resources like water resources. The prime strive of the selected project area is to map out potential groundwater regions in the Pendlimarri Mandal of Kadapa District by using Geospatial Technology. The main impartial target of the work is to select appropriate methods and assessment criteria of the technology to identify the potential underground demarcations in geographic information system environment with help of ArcGIS software. To demarcate zones of groundwater potential, various key parameters called geology, lineament density, LU / LC, geomorphology, groundwater depths, slope and drainage pattern were prepared by utilizing remote sensing data and secondary data which can collect from concern departments. The thematic layers are to be finally integrated by using weighted overlay analysis of spatial analyst tools of data management tools of ArcMap software to delineate underground water prospects regions output layout of the project. Disparate groundwater prospects levels were categorized, from the range excellent to poor including very good, good and moderate in between. At last, decided that that the applications of geoinformatics are essential and effectively applied for the demarcation of potential zones of groundwater.

***Keywords*: Remote Sensing, GIS, Groundwater, Weighted Overlay Analysis, Integration.**

(Article history: Received: March 2022 and accepted May 2022)

I. INTRODUCTION

Eco-diversity and mankind are completely reinforced from one of the dominant natural resources called groundwater. It is highly required to preserve the natural resource from the epidemic area along with proper maintenance in the form of resource management to serve living organism and eco system. Groundwater exists underneath the surface of the earth in fractured zones of geological formations and in the pore spaces of the soil [1]. The predominate underground water sources are precipitation and snowfall towards surface of the earth, which leads to partial infiltration into deeper levels of the subsurface. Even one third portion of earth is being covered by water only 2% of water is freshwater which is in the form of glaziers and groundwater. As we supposed to use only groundwater [2]. In the different continents, 30% of people are completely depending on underground water for their drinking purpose and is the dominant provenance for the case of fresh water, which increases its over dependency due to increasing dependence of groundwater leads to over exploitation of resource. Both GIS and remote sensing are contemporary techniques for the identification of ground water potential zones of any region. It is a very high temporal resolution technique, easy to interpret data using images through visual interpretation, spatial modelling and analysis are commonly applying tools or functions of the geographic information system. Societal and economic measures can be analyzed much effectively using geographic information system. The present study results that the integration of multi layered mapping features were integrated from function and techniques of geospatial technology which solves many mapping problems and shows precise outcomes. Remote sensing images out to be a very powerful tool and source for groundwater potential zone identification in any area [4]. Underground prospect regions can be effectively demarcated by considering the integrated thematic layers which are prepared using input satellite image. The different thematic features which we are considering in the study are drainage density, geology, geomorphology, Land use/Land cover lineament, slope and groundwater depth. The seven features are integrated by Weighted Overlay analysis of spatial analyst tools. Demarcation of underground water prospects regions is essential in utilization and development of water resource management systems [5]. It boosts in the improvement of practices of irrigation and leads towards development of agricultural economy and drastically reduce the scarcity of water. Geospatial technologies are great techniques for integrating and modelling for the solutions using geospatial data [6]. Geospatial technology be in the service of pilot archive system to recognize the conditions of the under groundwater. It helps in systematic integration of data for exploration & region's demarcation. Underground water recognition and management became systematic due the advancement of remote sensing and geographic information system. Groundwater severs as an equalizer of streamflow. Groundwater is ultimate source available in the aquifer system. It may be moving lazy according to the characteristics of aquifer formation in the form geological types. In the both rural and urbanized areas the only major source of drinking water is groundwater. Remote sensing and GIS tools with latest advancement are playing vital role in the natural resource management. Water resource management strategies are effectively managed [7].

II. METHODOLOGY

The main motto of this project is to establish effective groundwater investigations and demarcation of the zones of prospects by using Remote Sensing and Geographic Information System.

Pendlimarri Mandal of Kadapa District is selected as case study to apply the applications and to demarcate the prospects zones. Total area of the mandal is 1069.86 km^2. Pendlimarri Mandal is bounded between latitude and longitude ranges 14° 12' N to 14° 33' N, 78° 27' E to 78° 48' E. The predominant geological rock types of the area are sedimentary rocks. The drainage pattern was observed as sub dendritic to dendritic pattern. The average annual precipitation of Pendlimarri Mandal is around 550.31mm. The temperature of the area ranges from 21^0 C and 44^0 C in summer season. Altitude of the of the Mandal is 137m above MSL. The location map is depicted in the below figure (Fig. 1).

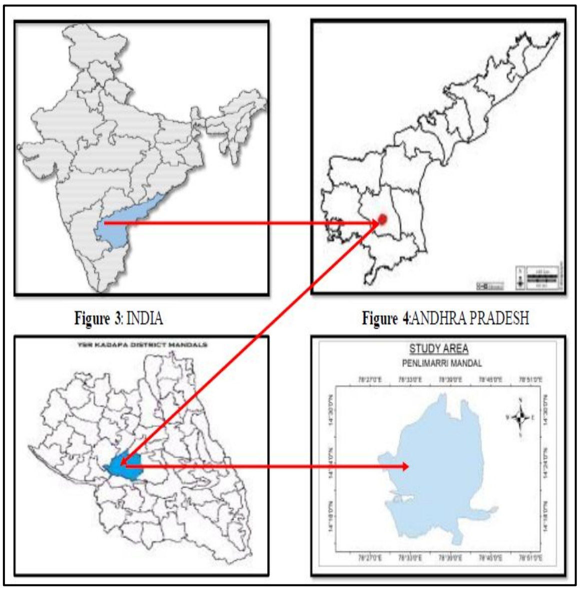

Fig. 1. Location map of the study area

Methodology of the present research project is mainly to interpret potential areas related to the natural resource called groundwater with help of interpreting influencing thematic layers by utilizing interpolation, integration and spatial analysis techniques of geospatial technology including image classification. Primary step involves in the creation of database using SOI toposheet and other ancillary information and geological information of the study area to effectively extract the same using satellite image [8]. Geospatial technology is applied to extract different themes which are influencing the groundwater system. Hydrogeological characteristics are properly investigated by understanding the land details and available information. Groundwater existing levels were collected through field survey. With help of information from open wells, reports from farmers and bore wells, groundwater depths were collected. By using these depths along with spatial location, groundwater depth zonation map was prepared by applying IDW method of spatial technology. In the next order, SRTM digital elevation model one arc sec data was used to derive contours and slope patterns, where slope is one of the primary influencing factor in the groundwater resource management [9]. Drainage discharge pattern map was also generated using DEM by applying hydrology tools of spatial analysis of GIS. Drainage lines of the mandal were automatically extracted by means of flow direction and flow accumulation tools [10]. These drainage line were later converted into drainage density raster with help of density operations for the total area. Process the methodology is shown in figure (Fig. 2).

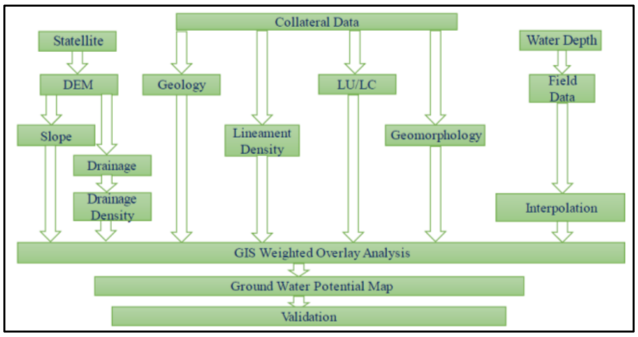

Fig. 2. Flowchart of the Methodology

Another process involves, satellite data to extract the information of different classes related to groundwater systems. Image analysis techniques ware used to classify the image according to the specific theme. Supervised classification was used to create various key parameters. All the thematic data in the form of separate layers are extracted using satellite image analysis. All these themes were integrated using applications of GIS and demarcated potential zonation map of groundwater was generated with help of weighted overlay analysis technique of spatial analysis method of GIS [11]. In the current research, geology, slope, drainage density, geomorphology, lineament density, groundwater depths and land use / land cover were considered and equal weightages were assigned as thematic layers to demarcate groundwater zonation potential mapping of the study area.

III. RESULTS AND DISCUSSIONS

A. *Geology*

Permeability and porosity of rock formations along with other characteristics are playing key role in the movement, occurrence and depth level of underground water. Differences with respect to different areas are due to the existing rock characteristics. Based on image interpretation and other ancillary data from district profile data, the lithological types are interpreted and validated with Bhuvan web data by using ArcGIS. The geology of the study region comprising of several lithology of igneous, metamorphic and sedimentary Origin. Independent weightages were assigned to each rock type, established on the influencing parameters for the case of potential regions of underground water. Top priority was assigned to shale/tuff and dolomite followed by flaggy limestone, limestone and with others rocks respectively.

The major portion of study area consist of dolomite 370.827 sq.km (34.66%), chert 0.582 sq.km (0.054%), flaggy limestone 47.568 sq.km (4.44%), Granite 138.849 sq.km (12.97%), limestone 7.675 sq.km (0.717%), quartzite/arkose with conglomerate 393.248 sq.km (36.75%), shale/tuff 85.48 sq.km (7.985%) and river 20.339 sq.km (1.90%) respectively. Details of geology map is shown in the figure (Fig. 3).

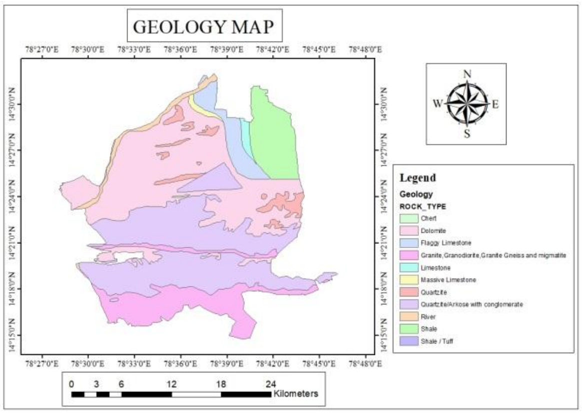

Fig. 3. Geology Map of the Study area

TABLE I. GEOLOGICAL CLASSES

S.NO	TYPE OF ROCK	AREA (Sq.km)	AREA (%)	WEIGHT CLASS	PROSPECT
1	Shale	85.422	7.98	1	EXCELLENT
2	Shale/ Tuff	0.058	0.005	1	EXCELLENT
3	River	20.339	1.90	1	EXCELLENT
4	Dolomite	370.827	34.66	2	VERY GOOD
5	Flaggy Limestone	47.568	4.44	2	VERY GOOD
6	Limestone	7.675	0.71	2	VERY GOOD
7	Chert	0.582	0.054	3	GOOD
8	Massive Limestone	5.293	0.494	3	GOOD
9	Quartzite	35.791	3.341	3	GOOD
10	Quartzite/Conglomerate	357.457	33.41	3	GOOD
11	Granite	138.849	12.97	5	POOR

B. *Slope*

In the demarcation of groundwater potential zonation, slope plays vital role, as it is most important key parameters. Slope is nothing but lateral space of the imaginary contouring lines. Due to the inclined slope, trespasser of the surface water is straight distressed. The slope categories were demarcated through SRTM digital elevation model with one arc sec data which is having 30 m resolution in GIS environment [12].

Slope degrees are extracted by deriving contours from elevation model. Various slope classes are demarcated as excellent, very good, good, moderate and poor from the ranges 0-1, 1-3, 3-5, 5-10, >10 respectively. Giant preference was assigned to leveled lateral surfaces and subsequently next slope ranges from gentle to steep slope categories. Slope classes are highlighted in the given figure (Fig. 4).

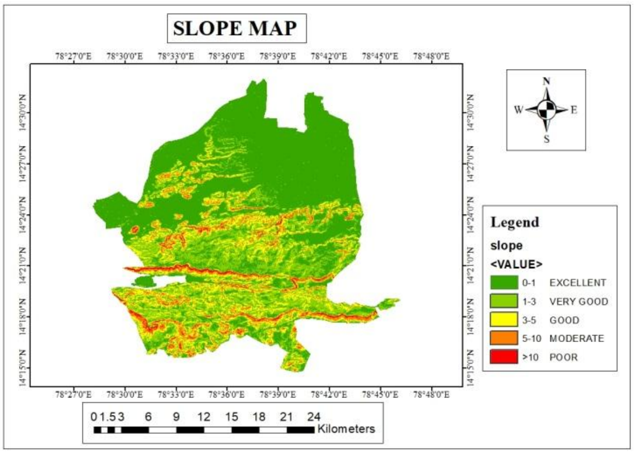

Fig. 4. Slope map of the study area

TABLE II. SLOPE PERCENTAGES

S.No.	SLOPE VALUE	WEIGHT CLASS	PROSPECT
1	0-1	1	EXCELLENT
2	1-3	2	VERY GOOD
3	3-5	3	GOOD
4	5-10	4	MODERATE
5	>10	5	POOR

C. Drainage & Drainage Density

The drainage network of the catchment is naturally draining component of discharge of the rainfall towards an isolated location point. The drainage pattern system includes rivers, streams, tributaries, water bodies and ponds etc. The network of drainage pattern assists in the watershed delineation and give the complete picture of topographic information of the study area. Permeability, percolation and discharge details are able to understand and estimate through drainage pattern and density of drainage. Fine textured drainage patterns are formed due to the impervious rocks and coarse drainage pattern are formed due to porosity and high permeability. Sometimes, multiple catchment areas may be connected due to secondary structures like fold, fault and lineament. Customary truth is that the delicate regions are favourable zones for the occurrence of the groundwater. The aspects of the surface as well as subsurface hydrological formations are highly reflects by the pattern of drainage system. Character of material of the surface and compactness of arrangement of passage media are designating by the density of the drainage pattern, accordingly furnish a quantitative estimate of median length of drainage of the total catchment area. It is also noted that little density of the drainage caused due to high permeability soils which are huge impenetrable below the thick cover of vegetation, where little height due to broad spectrum of climatic conditions and geology of the area. With the high topography and the scanty vegetative cover along with impermeable subsurface strata, the density of the drainage is resulted as huge amount of the area. The fine texture of the drainages and coarse texture of the drainages are developed due the huge density of the drainage and least density of the drainage respectively. The discharge in the area along with infiltration of the rainfall data are characterizing by the influence of drainage density of the same area. The entire drainage map is divided into five categories such as Excellent, Very good, Good, Moderate & Poor. Drainage density map is shown in the figure (Fig. 5).

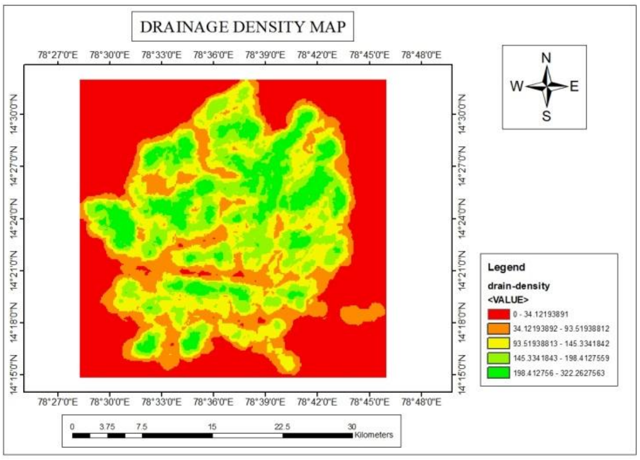

Fig. 5. Drainage Density Map

TABLE III. DENSITY RANGES OF DRAINAGES

S.NO	DENSITY RANGE	WEIGHT CLASS	PROSPECT
1	0-34.12	1	EXCELLENT
2	34.12-93.51	2	VERY GOOD
3	93.51-145.33	3	GOOD
4	145.33-198.41	4	MODERATE
5	198.41-322.23	5	POOR

D. Lineament and Lineament Density

Lineaments are major trend lines flowing in the form of direct linear components which hare existing on the surface of the earth. These are outstanding objects of topography like secondary structures called faults, joints and fractures and are the fruitful systems or zones for the exploration of minerals and natural resources management including improvement and management of groundwater. All the linear features of the surface geology which are existing on the surface were considered as lineaments like dykes, bedding planes, fractures and faults. Along with such linear components, vegetation lineation and linear valleys which are clearly appearing in the input satellite image. Lineament map was prepared using landsat-8 image by following above approach. Density of lineament map was prepared using line density tool of ArcGIS on the prepared lineament extents of the area. Area’s lineament density map was categorized as different zones from high to poor using spatial analyst tool of ArcGIS [13]. High density class is considered as potential zone for the case of demarcation of potential groundwater zone and least densities are unsuitable zones of groundwater availability. This resulted output discloses the probable for acquiring the potential zones of groundwater of the study area. Existing of well and linear fractured structures are indications for the aquifer system in the analysis of zonal scale of the study. Lineaments in the form of density leads to have hydraulically conductive and maximum porous. Underground water access is also anticipated through the indication of breadth of weathering area, which is actually controlling the sources. The mineralogical veins and ridges and dykes are also running in straight manner, leads to have lineament. Details are shown is figure (Fig. 6).

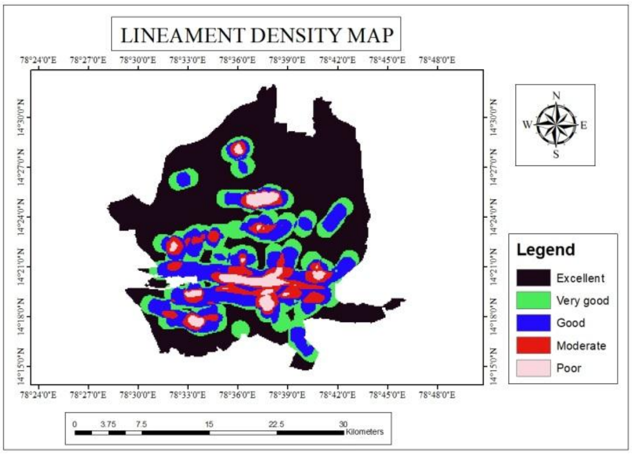

Fig. 6. Lineament Density Map of the study area

TABLE IV. LINEAMENT DENSITY CLASSES

S.NO	LINEAMENT DENSITY RANGE	WEIGHT CLASS	PROSPECT
1	0-0.45	1	EXCELLENT
2	0.45-0.97	2	VERY GOOD
3	0.97-1.57	3	GOOD
4	1.57-1.98	4	MODERATE
5	1.98-2.33	5	POOR

E. *Land use / land cover*

In the provisions to improve and increase the groundwater availability, the infiltration capacity of the surface water to be drastically increased. This can be done only through the existing nature of the land use / land cover of the particular area. Hence, land use / land cover plays vital role in the groundwater management. Landsat-8 satellite image with spatial resolution of 30 m was used to extract the categories of land use / land cover classification system using supervised classification of image analysis of ArcGIS. The categories of land use and land cover are rural residential areas in the form of built-up area, water bodies including river area and streams, agriculture area, forest land and rocky exposure along with other features with extents spatially. Which are tabulated in the below table (Table.5). Agricultural crop patterns are mostly depending on the availability of the source called groundwater and seasonal rainfall due to the dry seasonal conditions. The dominant crop types which are harvesting in the River Papangi basin of the case study are banana, tomato, paddy, groundnut, sunflower etc., From the image interpretation element techniques all the features are classified and identified one the satellite image of Landast-8. Thematic classification is derived using supervised classification techniques of image classification of GIS [14]. The land features were identified with help of basic elements like shape, shadow, size, tone, texture, pattern and association. For example, the agricultural land demarcated based on its shape as rectangular with help of texture and tone. Bluish light and fined textures with define size and shape were treated as residential areas. Plantation of Forest land category was demarcated which is in red to light red and brown tone with thin moderate texture with different sizes and different shapes. Broad texture and with tone of dark brownish blue were observed for the case of rock exposure. Weightages were assigned for the integration according to the groundwater influence of this theme. LU / LC map is shown in the below figure (Fig. 7).

TABLE V. LU / LC CLASSES

S.NO	TYPE OF LAND	AREA (sq.km)	AREA (%)
1	Agriculture land	149.988	14.01
2	Forest area	173.74	16.31
3	Open area	114.580	10.70
4	Rock	221.030	20.65
5	Settlement	173.130	16.18
6	Vegetation	151.482	14.15
7	Waterbody	85.669	8.00

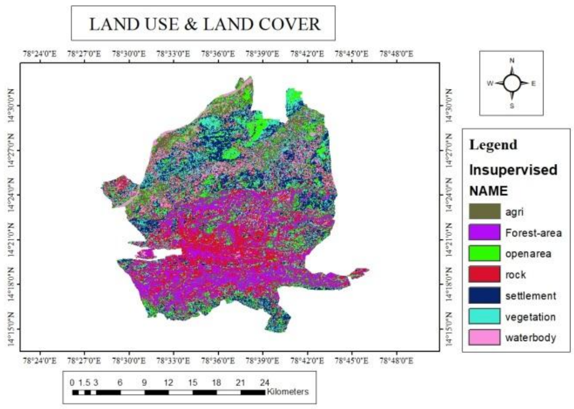

Fig. 7. Land Use / Land Cover of the study area

F. *Geomorphology*

Systematic learning of various landforms and operations to structure the same is called Geomorphology. Geomorphic attributes offer outstanding demonstration of underground water availability, development and movement. In the development and planning activity, vegetation, water and soil are playing vital role along with the study of geomorphology. Evaluations of structures of formations of geology are major factors to form geomorphological formations. Based on the groundwater importance, the landforms were categorized to demarcate the resource.

In Pendlimarri Mandal, geomorphological variations were categorized as waterbody, bajada zone, pediment pediplains, moderate and low dissected hills and valleys of structural as well as denudation origin. Major dominating landforms are denudational hills and pediplains. Geomorphological classes are depicted in the figure (Fig. 8).

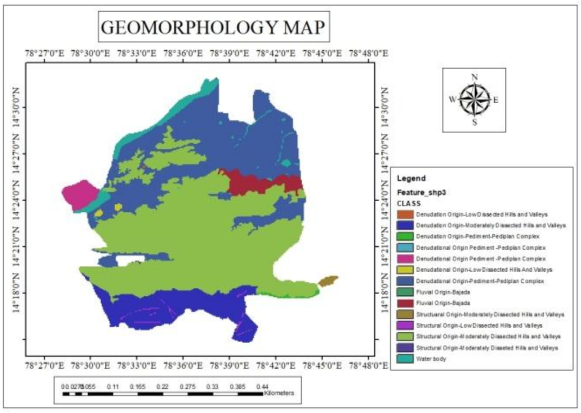

Fig. 8 Geomorphology Map of the study area

TABLE VI. GEOMORPHOLOGY CLASSES

S.NO	DESCRIPTION	AREA (sq.km)	AREA (%)
1	Waterbody	35.708	3.33
2	Fluvial origin Bajada	30.272	2.28
3	Denudation origin-Pediment Pediplan	356.323	33.30
4	Structural origin Moderate & Low dissected hills and valley	121.935	11.39
5	Denudation origin Moderate & Low dissected hills and valley	526.432	49.20

G. Groundwater levels

Present existing groundwater levels are proving huge understand levels on the groundwater table level. Hence, groundwater existing levels were collected from the field through open and bore wells from the different corners of the study. These levels are also playing decisive part in demarcation of potential sectors of underground water. Primary priority was given to the locations with low depth from the surface level and least priority was given to huge depth value from the top surface of the earth. Stochastic technique for multidimensional intercalate along with identified dissipated locations is Inverse Distance Weighting Interpolation method.

Depth ranges were generated using interpolation method where continues values were assigned to the total unknown area using known point locations. This data is also called continues surface data with ‘z’ value. Groundwater depth levels were identified for the total area using IDW method based on known point values. Same output map was classified as different zones according to the influence of groundwater. Details are shown in the below figure (Fig. 9).

TABLE VII. GROUNDWATR DEPTH RANGES

S.NO	DEPTH RANGE	WEIGHT CLASS	PROSPECT
1	51.87 - 110.32	1	Excellent
2	110.32 – 168.77	2	Very good
3	168.77 – 227.23	3	Good
4	227.23 – 285.68	4	Moderate
5	285.68 – 344.13	5	Poor

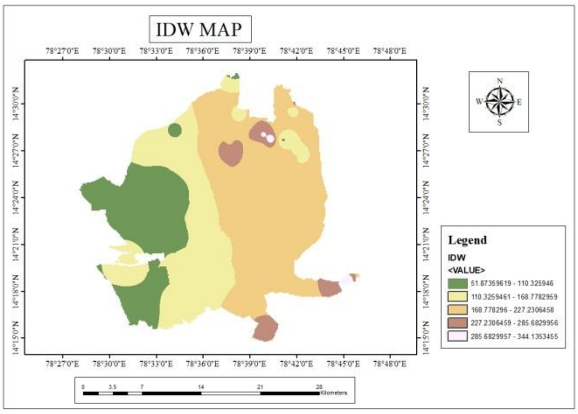

Fig. 9. IDW Map of the study area

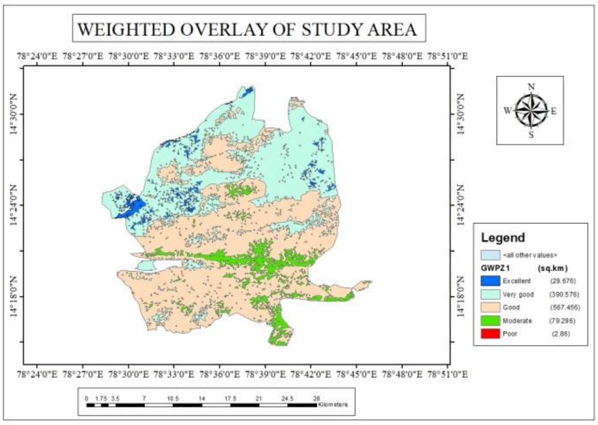

Fig. 10. Groundwater Potential Zones Map of the study area

H. Analysis of Weighted Overlay

Weighted overlay analysis of spatial analysis of geospatial technology has applied to integrate all the thematic features in the form of overlay operation to derive prospects regions of underground water.

Before analysis of weightage overlay, various zones are considered from highly suitable to poor with common coding for all the thematic features. Weightages have given based on the influencing factors of groundwater availability. All the features were reclassified into raster based on weighted ranks. Ranks of uniform for all the themes, so that it is very convenient to do integration analysis. All the six key parameters called, the drainage density, geology, lineament, LU/LC, groundwater depth and geomorphology were considered with uniform weightage with 15% except the slope, which is considered as least with 10%.

Unique codes in the form of ranks were assigned to all the thematic features ranging from high priority to poor based on influencing factors related to underground water. Each and every thematic layer was reclassified as new raster with the values called uniform ranks. Reclassified images are the input parameters for the overlay operation using spatial technology. The high category was assigned to areas with greatest potential and least assigned to the low potential area features uniformly to all the layers.

Weighted overlay operation was performed by integrating all the themes by assigning approximately uniform weightages to all the themes. The integrated output generated based on ranks assigned to the individual themes.

The prospects and weightages are shown in the table. Detailed potential zones map is shown in the below figure (Fig. 10).

TABLE VIII. WEIGHTAGES

Parameter	Classes	Groundwater prospect	Weight (%)
Geology	Shale Shale/ Tuff River	Excellent Excellent Excellent	
	Dolomite Flaggy Limestone Limestone Chert Massive Limestone Quartzite Quartzite/Conglomerate Granite	Very good Very good Very good Good Good Good Poor	15
Drainage density range	0-34.12 34.12-93.51 93.51-145.33 145.33-198.41 198.41-322.23	Excellent Very good Good Moderate Poor	15
Lineament density range	0-0.45 0.45-0.97 0.97-1.57 1.57-1.98 1.98-2.33	Excellent Very good Good Moderate Poor	15
Land use/ Land cover	Agriculture land Forest vegetation Forest area Open area Rock Settlement Vegetation Waterbody	Good Very good Very good Moderate Poor Good Very good Excellent	15
Geomorphology	Waterbody Fluvial origin Bajada Denudation origin-Pediment Pediplain Structural origin Moderate & Low dissected hills and valley Denudation origin Moderate & Low dissected hills and valley	Excellent Excellent Very good Good Moderate	15
Groundwater depth	51.87 - 110.32 110.32 – 168.77 168.77 – 227.23 227.23 – 285.68 285.68 – 344.13	Excellent Very good Good Moderate Poor	15
Slope	0-1 1-3 3-5 5-10 >10	Excellent Very good Good Moderate Poor	10

TABLE IX. GW PROSPECTS ZONES

PERCENTAGE OF ZONES AREA				
S.NO	NAME OF ZONES	VALUE	AREA [sq.km]	PERCENTAGE [%]
1	EXCELLENT	1	29.676	2.77
2	VERY GOOD	2	390.576	36.51
3	GOOD	3	567.456	53.04
4	MODEARATE	4	79.296	7.41
5	POOR	5	2.86	0.27
TOTAL AREA			1069.864	100

IV. CONCLUSIONS

The research study shows that a spatial technique of geospatial analysis is extensively beneficial for the identification of the prospects map of underground water areas. Various strategies were applied to demarcate the potential underground water pockets. Now a day, Groundwater targeting is a challenging task and which is demarcating by using many techniques and systems. These systems have their own merits as well demerits in the work progress and process. Among, geospatial technology proved to be an outstanding method with effective system for demarcation of ground water prospects regions in the Pendlimarri Mandal.

Landsat-8 images with 30 m spatial resolution with the aid of geospatial technologies are highly fruitful for interpretation of groundwater prospects of the study area by considering various thematic parameters in the form of separate layers like lithology, landforms, density of drainage pattern, lineament, land use & land cover, slope and groundwater depths. The study discloses that the combined integrated separable layers and groundwater depths offers first-hand knowledge to the authorized agencies and policy makers for sustainable development in the water resource development mainly in groundwater development and management.

The derived solution of research work was categorized into different ranks ranging from excellent to poor underground water prospects regions which are depicted in the figure (Fig. 10). Around 53% of the area comes under category good and 36% of area comes under very good potential zone. Hence, in the present study, need to develop various strategies and implementation of suitable measures like artificial recharge structures where potential groundwater zones are ranked with moderate and poor. Geospatial technologies are playing crucial important, efficient role in the development of natural resources called groundwater exploration by means of its latest trends and spatial analyst tools.

ACKNOWLEDGMENT

Authors would like to acknowledge the Management and Principal of Rajeev Gandhi Memorial College of Engineering & Technology (Autonomous), for their support and encouragement to do this project and providing the facilities. Authors are also extending warm greetings for the stake holders who supported and helped in this work.

REFERENCES

[1] S. R. Machireddy, “Delineation of groundwater potential zones in South East part of Anantapur District using remote sensing and GIS applications,” *Sustain. Water Resour. Manag.*, vol. 5, no. 4, pp. 1695–1709, 2019.

[2] P. Mohana and S. Muthusamy, “Use of earth observation images and GIS techniques for groundwater exploration in hard rock terrain,” *J. Geogr. Cartogr.*, vol. 4, no. 2, pp. 27–35, 2021.

[3] M. L. Waikar, and A. P. Nilawar, “Identification of groundwater potential zone using remote sensing and GIS technique,” Int. J. Innov. Res. Sci., Engg. Techn., vol. 3, no. 5, pp. 66–75, 2014.

[4] L. Yeshodha, H. N. Rajkumaraand, and S. Arunachalam, " Modelling of Groundwater Potential Zone Using Remote Sensing and GIS, Krishnagiri District,Tamil Nadu, India," *J. Env. Res. Dev.*, vol. 5, no. 1, 2010.

[5] D. Machiwal, M. K. Jha, and B. C. Mal, "Assessment of groundwater potential in a semi-arid region of India using remote sensing, GIS and MCDM techniques," *Water Resour. Manage.*, vol. 25, no. 5, pp. 1359–1386, 2011.

[6] A. Jothibasu, A. Venkatesan, and S. Gunasekaran, "Potential Groundwater Accumulations Assessment in Drought Prone Area using Remote Sensing and GIS Technology," *Int. J. Adv. Remote Sens. GIS*, vol. 6, no. 3, pp. 2080-2087, 2017.

[7] S. R. Machireddy, J. Sada Sivudu, and P. Rajesh, "Application of Geo-Spatial Technologies in Identification of Groundwater Potential Zones", Int. J. Sci. Adv. Res. Techn., vol. 4, no. 1, pp. 230-235, 2018.

[8] Q. S. W. Ali, D. Lal, and J. Ahsan, "Assessment of groundwater potential zones in Allahabad district by using remote sensing & GIS techniques," *Int. J. App. Res.*, vol. 1, no. 13, pp. 586-591, 2015.

[9] C. S. Agarwal, and P. K. Garg, "Textbook on Remote Sensing in Natural Resources Monitoring and Management". Wheeler Publ., 2000.

[10] I. A. Mary, T. Ramkumar, and S. Venkatramanan, "Application of statistical analysis for the hydrogeochemistry of saline groundwater in kodiakarai, Tamilnadu, India," *J. Coast. Res.*, vol. 278, pp. 89–98, 2012.

[11] S. S. Asadi, P. Vuppala, and M. A. Reddy, "Remote sensing and GIS techniques for evaluation of groundwater quality in municipal corporation of Hyderabad (Zone-V), India," *Int. J. Environ. Res. Public Health*, vol. 4, no. 1, pp. 45–52, 2007.

[12] H. Basavaraj and R. Nijagunappa, "Identification of Groundwater Potential Zone using Geoinformatics in Ghataprabha basin, North Karnataka, India," *Int. j. geomat. geosci.*, vol. 2, no. 1, pp. 91–109, 2011.

[13] S. K. Jose, R. Jayasree, R. S. Kumar, and S, Rajendran, "Identification of Ground Water Potential Zones in Palakkad District , Kerala Through Multicriteria Analysis techniques using Geoinformation Technology," *Bonfring Int. J. Ind. Engg. Manag. Sci.*, vol. 2, no. 1, pp. 62–68, 2012.

[14] S. Kaliraj, N. Chandrasekar, and N. S. Magesh, "Identification of potential groundwater recharge zones in Vaigai upper basin, Tamil Nadu, using GIS-based analytical hierarchical process (AHP) technique," *Arab. J. Geosci.*, vol. 7, no. 4, pp. 1385–1401, 2014.

AUTHOR PROFILES

Dr. M. Sunandana Reddy has completed his master's degree in Remote Sensing & GIS and Doctorate degree in Water Resources Development using Geospatial technologies. The author is currently working as Associate Professor in RGM College of Engineering & Technology (Autonomous). His research interests include applications of geospatial technologies in various natural resources and other allied engineering areas including disaster management. He has vast experience in geospatial analysis.

Mrs. C. Navyatha has completed her master's degree in structural engineering and pursuing her doctoral research in concrete technology at Satyabhama Institute of Science and Technology. Presently she is working as Assistant Professor in Civil Engineering, RGM College of Engineering & Technology (Autonomous), Nandyal.

N. Neelakanteswara Reddy is a B. Tech Civil Engineering graduate student of. RGM College of Engineering & Technology (Autonomous). He has hands-on experience in applying RS & GIS in various areas of civil engineering fields.

H. Srinidhi is a B. Tech Civil Engineering graduate student of. RGM College of Engineering & Technology (Autononous). She has hands-on experience in applying RS & GIS in various areas of civil engineering fields.

Mahesh Naik is a B. Tech Civil Engineering graduate student of. RGM College of Engineering & Technology (Autonomous). He has hands-on experience in applying RS & GIS in various areas of civil engineering fields

Madhu Kumar is a B. Tech Civil Engineering graduate student of. RGM College of Engineering & Technology (Autonomous). He has hands-on experience in applying RS & GIS in various areas of civil engineering fields