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Groundwater Potential Zone Identification of Karwi Area, Mandakini River Basin, Uttar Pradesh Using Remote Sensing and GIS Techniques

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ABSTRACT: *The paper deals with identification of the groundwater potential areas in parts of Mandakini River Basin, Chitrakoot district, Uttar Pradesh. Based on the integrated studies, it has been observed that the lithology, geomorphology, lineaments, slope, soil and land use/land cover was generated from Modis, Landsat ETM + data and Survey of India, toposheet nos. 63D/13, 63C/16, 63C/15, 63G/2 and 63G/3) on 1:50,000 scale and integrated data with raster based Geographical Information System (GIS) to identify the groundwater potential zones. The examination of satellite images, topographic maps supported by ground truth survey revealed that the area has a network of interlinked subsurface features. For surface water resources and ground water resources, the proper evaluation of water potential helps in additional exploration at optional level. For the formulize of proper management programme, a reliable and up to date information about various factors, viz. size and shape of river basin, topography, soil, slope, elevation and their characteristics, land use/land cover, and drainage parameters are required. The integrated map generated was further classified according to spatial variation of the ground water potential. Six categories of groundwater potential zones availability namely excellent (26.19%), very good (32.42%), Good (23.20%), moderate (0.48%), Poor (1.89%) and very poor (15.83%) were identified and delineated. In this system used a subsistence plan for optimum development of the water resources and for finding solutions for different management problem related to natural resources. The final result represents the favorable groundwater potential zones information could be used to reduce the water shortage and quality risks for public health.*

KEYWORDS: *DEM, GIS, Groundwater Potential Zone, Land use, Remote Sensing, Slope, Water Resource.*

I. INTRODUCTION

Groundwater has an important role in the environment: it replenishes streams, rivers, and wetlands and helps to support wildlife habitat; it is used as primary source of drinking water and also in agricultural and industrial activities. Water is an essential, valuable component next to oxygen and acts as an elixir of the life. It occurs in different forms and its subsurface occurrence is commonly known as the ground water. Ground water is the earth’s largest accessible storage system, which is the only substitute of surface water supply. The ground water resource constitutes a part of the dynamic hydrological cycle. Around the world, groundwater resources are under increasing pressure caused by the intensification of human activities and other factors such as climate changes. Reductions in groundwater stores have implications for the water cycle because groundwater supplies the baseflow in many rivers and it supports evapotransiration in high water table regions. Groundwater begins with rain and snow melt that seeps or infiltrates into the ground. The amount of water that infiltrates into the ground varies widely from place to place according to the type of land surface cover. In porous surface material such as sand or gravel, 40 to 50 percent of the rain and snowmelt may infiltrate into the ground. Infiltration into less porous surface material may range from 5 to 20 percent. The remainder of the rain and snow melt runs off the land surface into streams or returns to the atmosphere by evaporation. Infiltration into the ground is also strongly influenced by the season of the year. Evapotranspiration (which includes evaporation from open water bodies and bare soils, and transpiration from plants) is greater during the warm months. During cold months, the ground may be frozen, hindering water seepage, and evapotranspirration is less (Lyle S. Raymond, “What Is Groundwater - New York State Water Resources Institute, Cornell University).

Water in the basin arrives in the form of precipitation a part of the hydrologic cycle. Some precipitation returns to the atmosphere, having been intercepted by vegetation and evaporated from the surface of level and branches. More is lost to evaporation from the ground surface and transpiration by plants. In arid and Simi-arid climates all of the precipitation may be consumed in this way of the most way of the time, basin run-off occurs only occasionally, following intense storms.

Where precipitation exceeded losses to evapo-transpiration, the excess water makes it way through the drainage systems. However, water may be stored in lakes, soils and as ground water to considerable periods before it eventually arrives at the outlet, or basin channels, as basin run-off. Development in various fields such as agriculture, industry and urbanization in the different countries particularly in India. This has lead to increase in the demand of water supply mostly from exploration of ground water resources. In hard-rock semi-arid terrain that occupies almost two-third of India, ground water is the largest fresh water resource. The purpose of present study search to the probable sites of ground water potential zone in the inter-drainage areas to provide a complete picture of the area. For a proper visualization and study the influence of subsurface detail and its effect on the geomorphological and hydrogeological status of the basin area, a three dimensional picture is essential. The use of spatial analysis, DEM for 3D visualization and terrain draping, slope map, thematic map overlays can be very helpful interpretation of satellite data. Since, most of the geological features extend deep down into the earth, as well as across it, the three dimensional spatial nature of geological features needs special attention. The subsurface geomorphology, morphology of the basin and the tectonics are the factors, which effect of the sedimentation pattern and guided, the channels of Yamuna river system. Geophysical methods are conventionally employed for ground water potential zone through there are several methodologes to locate and map the occurrence and distribution of ground water. The advent and new technologies development of , such as remote sensing with its advantage of spatial, spectral and temporal availability of data have proved to be useful for quick and useful baseline information about the factors controlling the occurrence and movement of ground water like geomorphology, geology, drainage pattern, lineaments, slope etc.(Bobba et al. 1992; Meijerink, 2000).

Remote sensing provides land resource data in the form of digital magnetic types and in different bands of the electromagnetic spectrum. Availability of such a data in different bands makes it very useful for delineation of the ground water potential distinctly. Ground water potential zone mapping both by visual interpretation and digital analysis is possible by satellite remote sensing techniques. The variation of ground water potential zone categories can be expanded or reduced to any degree and be made more responsive to the information the user needs. Information on ground water resource availability in the form of map and statistical data is very useful for spatial planning, development and management and utilization of land of agriculture, Pasture, Urban, Environmental studies, forestry and economic production etc. The timely accurate and upto date information on ground water resource can be obtain from various remote sensing satellite on a cost effective basis at the shortest possible time. The excellent reviews of remote sensing and gis technology in ground water hydrology are presented in Farnsworth et al. (1984), Waters et al.(1990), Shahid and Nath (2002); Singh and Prakash (2002), Vijith (2007) Prasad, et al. (2008) have attempted to delineation of ground water prospects zone . Integration of remote sensing and gis have proven to be an efferent tools in groundwater studies (Krishnamurthy et al; 1996, Sander 1996), satellite data serves as primarilmanary inventory method to understand the ground water prospects / condition and gis enable integration management of multi thematic data.

A point of view, present study is the is a principal source of water for domestic and drinking purposes and most of people depend on dug/ tubwell for use of daily needs. Hence, the present study is an attempted to identify and under stands ground water potential zones of Mandakini river basin, in a part of Uttar Pradesh, Chitrakoot district, North Central India by an integrated approach of remotelly sensed data, GIS, fields and lab technologies.

II. STUDY AREA

The present study focused to evaluate the ground water potential zone of Mandakini river basin part of Uttar Pradesh. Mandakini River basin originate from near by Sati Anusuiya of Satna district Madhya Pradesh and flows for some distance and come in to Chitrakoot district of Uttar Pradesh, and falls in Yamuna river near by Rajapur village. The study area is confined to latitude 24°55' N to 25°30' N and longitude 80°47' E to 81°10' E (Survey of India Toposheet No 63D/13, 63C/16, 63C/15, 63G/2 and 63G/3) on 1:50,000 scale and covering a total area of 1033.59 km^2

(Figure 1). Mandakini river basin of the unique topography, geology, climate, and agricultural activities in the study area, the major concern and warrants attention of groundwater problems in Bundelkhand region. Hence, the abundance, pathways and sourcing of various ground water potential zones should be systematically looked into for their suitability for water supply of drinking and irrigational purposes.

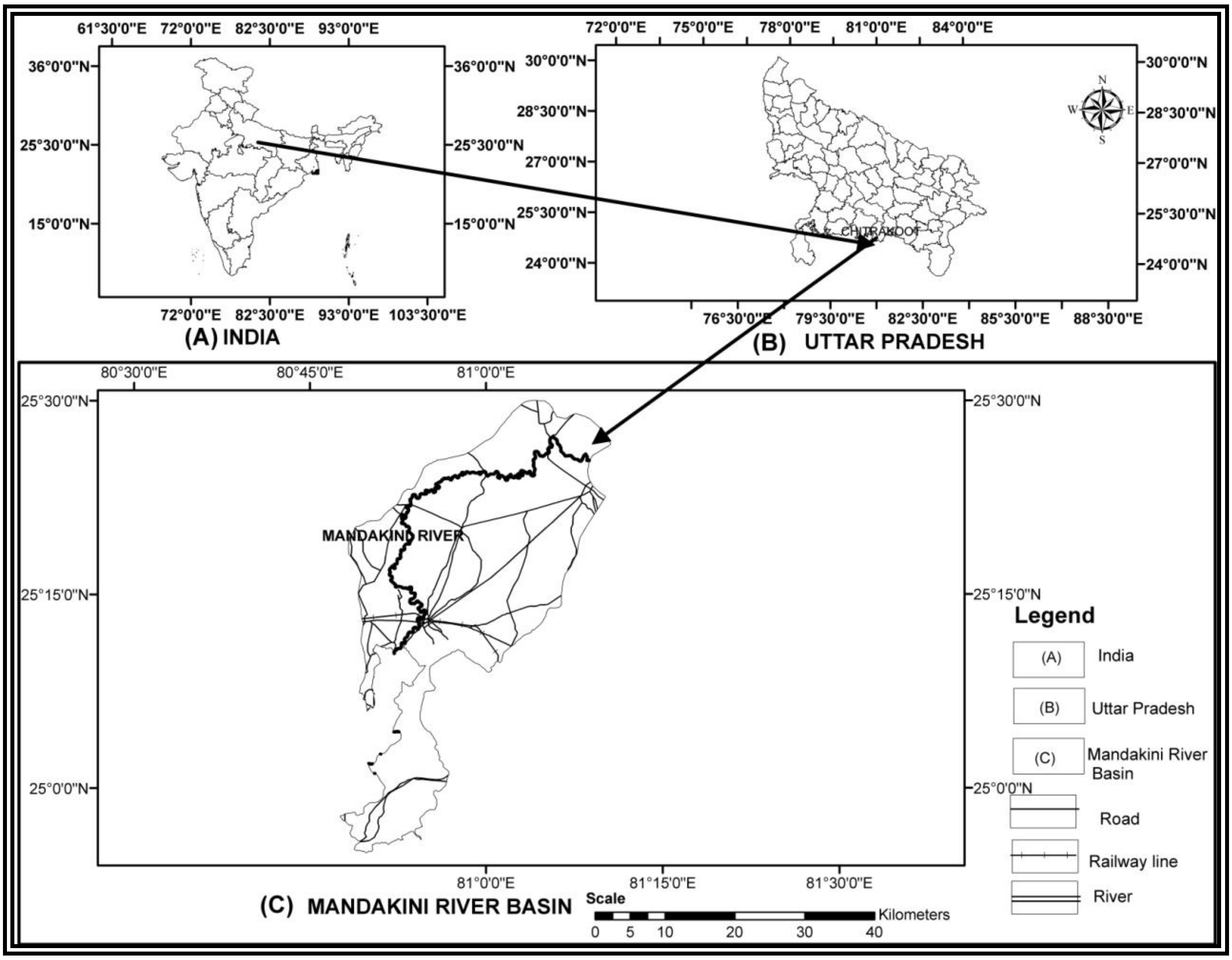


Fig.1. Location map of the Mandakini River Basin

2.1. Geological Setting : Mandakini River basin is rocks of the Vindhyan Super group dwell in part of Chitrakoot district, Uttar Pradesh. The Chitrakoot region is an area confined to an unevenly condensed succession of Semri group strata resting unconformably upon Bundelkhand granites (Narain, 1960). Mandakini river basin has been litho strata graphically divided into two groups namely the Semri, the Kaimur in ascending order. The Semri group is traditionally designated as the lower Vindhyan whereas the Kaimur groups are referred to as Upper Vindhyans. The Mallet, (1889) has worked out following geological successions of the study area: (Table:1).

Table 1: Geological successions of the study area (after, Mallet, 1889).

Quaternary-Recent and sub-Recent: Alluvium (clay, kankar etc.)
Algonkian {-Upper Vindhyan: Kaimur Sandstones
{-Lower Vindhyan: Limestones
---------------------------------Unconformity---------------------------
Archean- Bundelkhand Granite

The Tirohan limestone is the youngest lithostratigraphic unit of this group, containing phosphoritic chert stromatolites, *Jurussania* (Krylov), which are extensively exposed in isolated hillocks of the Chitrakoot area in a part of Uttar Pradesh, India. The fossiliferous localities lie at the area relative scarcity of fossils prior to ~543 Ma and with the explosion and radiation of the better-known, morphologically complex populations, the earliest appearance of animal remains is yet to be understood.

(Veeru Kant Singh et al., 2011

III. MATERIAL AND METHODOLOGY

In the present study, Data acquired for the comprised topographic map and satellite imagery details. For mapping the extent of the Mandakini river basin as it stood at the 1971 level, Survey of India Topographic map 63D/13, 63C/16, 63C/15, 63G/2 and 63G/3 was used, along with Modis, Landset and SRTM data (Modis Terra scene is r12c28 17 March 2012, Landset ETM^{+} scene path 142, Row 042 and 043, 1st October 2005 and 22 February 2006 and SRTM scene SRTM_fB03_n025e080 and SRTM_fB03_n025e081) is made freely available under NASA sponsored Global Land Cover Facility (GLCF). For Landset, Modis and SRTM satellite data was used for preparation of different themes.

The various thematic maps like a geomorphology, lithology, soil, landuse/land cover, slope, drainage, lineaments were prepared and verified by ground truth surveys. The various types of thematic layers are used in geographic information system to prepared of the ground water potential zone map. This theme guidelines prepared by National remote sensing Agency (NRSA, 1995) were made use for preparation of various thematic maps and final ground water potential map. The weighted overlay analysis technique has been employed to determine to ground water potential zone map. The weightages of individual themes and feature score were prioritized depending upon their suitability to hold ground water (Table 2).

Table 2: Weightages of individual themes and feature class scores assigned by multi criteria evaluation (MCE) technique used for groundwater prospecting

S.No.	Thematic layers	Map weight (wt)	Individual features	Feature score (Wi)
1.	Landuse/Land cover	20	Crop Land	9
			Forest/Plantation	7
			River/Water Body	9
			Open Land	5
			Hills	2
			Settlements	1
			Waste Land	3
2.	Soil	10	Loamy	7
			Silty Loam	5
			Clay Loam	3
			Exposed Rock	2
3.	Slope	20	0-1	9
			1-3	9
			3-5	7
			5-10	6
			10-15	4
			15-35	3
			> 35	1
4.	Geomorphology	35	Striped Plain	9
			Pediplain	8
			Pediment	4
			Flood Plain	4
			Channel Bar	3
			Plateau (Sedimentary)	2
			Hills	1
5.	Lithology	15	Alluvium Sand	9
			Thick bedded/Massive Sand Stone	2
			Granite/BGC	1
			Thin bedded sand stone/Quartzite	1
			Shale with sand stone bands/ Lenses	1

This process involves raster overlay analysis and is known as multi criteria evaluation techniques (MCE), of several methods of available for determining interclass/intermap dependency, a probability weighted approach has been adopted that allow a linear combination of probability weightage of each thematic map (Wt) and different categories of derived thematic maps have been assigned scores (Wi), by assessing the importance of it in ground water occurrence. The total weights of the final integrated map were derived as sum or product of the weights assigned to the different layers according to their suitability. The maximum value is given to the feature with highest ground water prospects and minimum being to the lowest potentially features. Spatial analyst extension tools of Arc GIS 9.2 was used for converting the features to raster and also are final analysis. In this method, converting to raster, the score assigned to the individual features were taken in the value field.

Then, the individual themes were normalized by dividing themes weightage by 100. The "Raster Calculator" used to prepare the integrated final ground water potential map (GPM) of the area. The map algebra (ESRI 2007), used in the raster calculator is (Eq.1),

GPM = (Landuse/Land cover) x 0.20 + (Soil) x 0.10
+ (Slope) x 0.20 + (Geomorphology) x 0.35
+ (Lithology) x 0.15 --(1)

The Arc tool box in Arc GIS 9.2 to use of spatial analyst extension is major role of this analysis. In this study the total weights of the final integrated map were derived as sum or product of the weight assigned to the different layers according to their suitability.

IV. RESULT AND DISCUSSION

The different type of thematic data derived of the analysis for ground water potential zones and result of the composite map obtained in (Figs. 1, 2, 3, 4, 5, 6, 7 and 8) are discuss below in details:

4.1. Geomorphology : The geomorphic imprints can be considered as surface indicators for identification of subsurface water conditions. Geomorphic surface indicator/ landforms have been classify as tectonic and structural landforms. The geomorphology is well depicted in satellite images. False colour composites of the original bands and principal component images have been used for the interpretation of the geomorphic features. Geomorphic features and structural details from Satellite images were interpreted for identifying ground water and facilitated the location of recharge zones and ground water conditions. Various geomorphic features have been identified in the image using remote sensing keys.

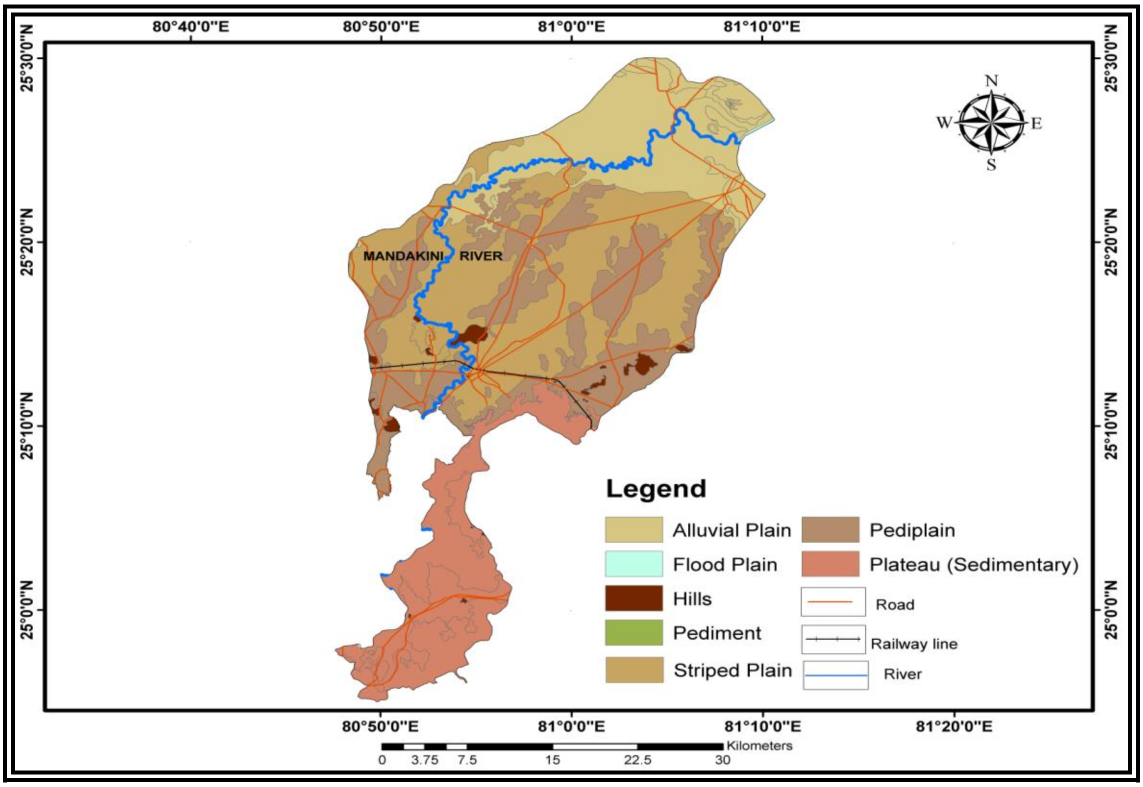


Fig.2 Geomorphological map of the Mandakini river basin part of Uttar Pradesh

Geomorphic unit of the study area have been identify an basis of satellite data and followed by ground truth verification. Two types of landforms occupy in the study area of Mandakini river basin part of Uttar Pradesh. First type of denudational landforms (Hill, Plateau) and other second types of fluvial landforms of Alluvial plain, Pedi Plain, Striped Plain, Flood Plain etc. The quantitative analysis of Mandakini river basin carry out with the help of research literature, decipher geology, satellite data and field visits/surveys. So the distinguish of different types of landform features of the area. For example- Alluvial plain, Pedi Plain, Striped Plain, Plateau etc. the observebd of the Alluvial plain are good excellent potential zone of the basin.

4.2. Slope : Slope is a rate of change of elevation and considered as the principal factor of the sacrificial water flow since it determines that gravity effect on the water movement. The slope is directly proportional to runoff and ground water recharge will be laser in the area with steep slope. The water flow over the gently undulating plains is slow and adequate time is available to enhance the infiltration rate of water to the underlying fractured aquifer. The slope was estimated from aster satellite data, Using in Arc GIS 9.2 software of 3D Analyst tools. The slope was estimated from the digital elevation model (DEM).which was obtained from the contour in the topographical map.

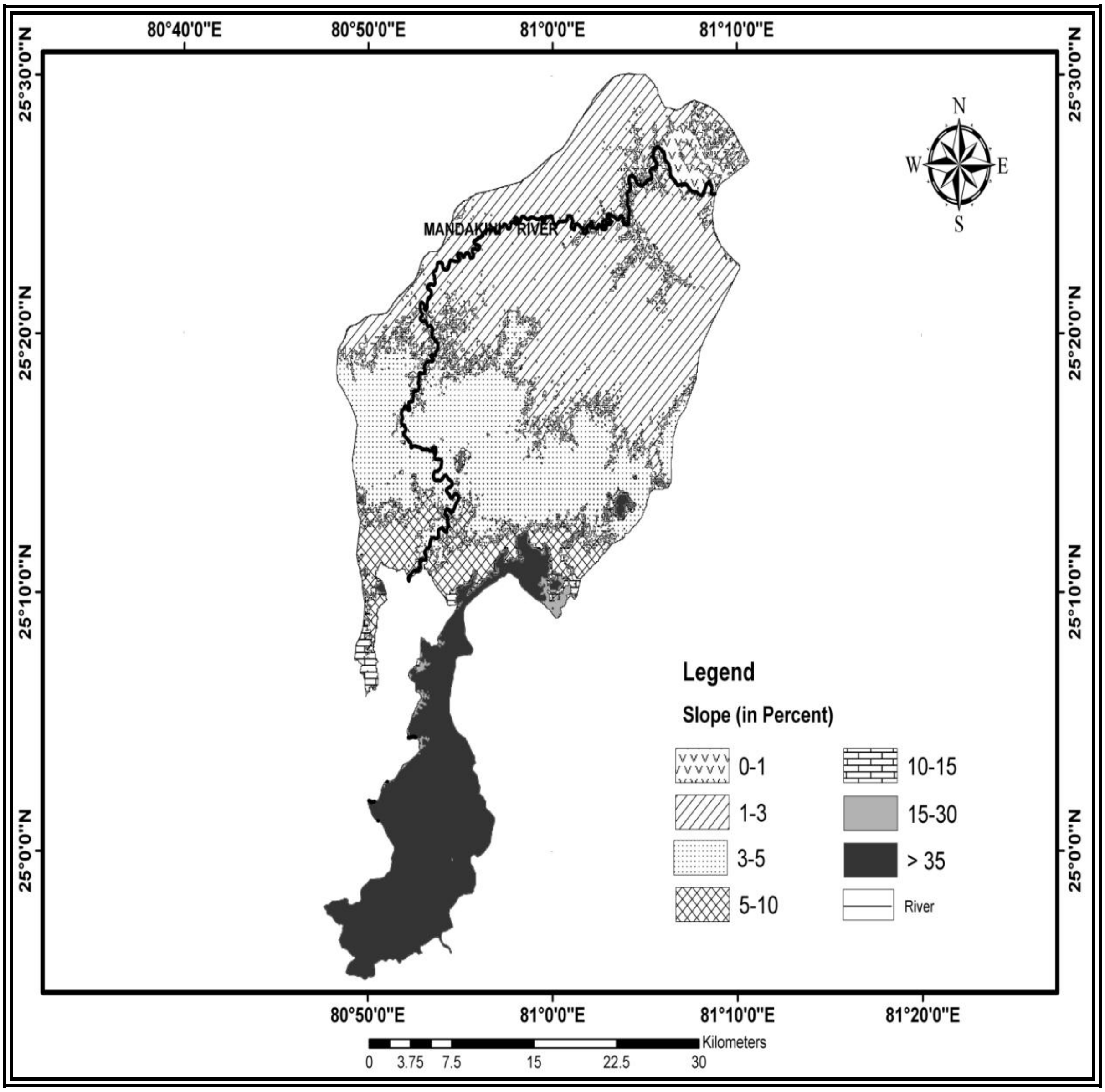
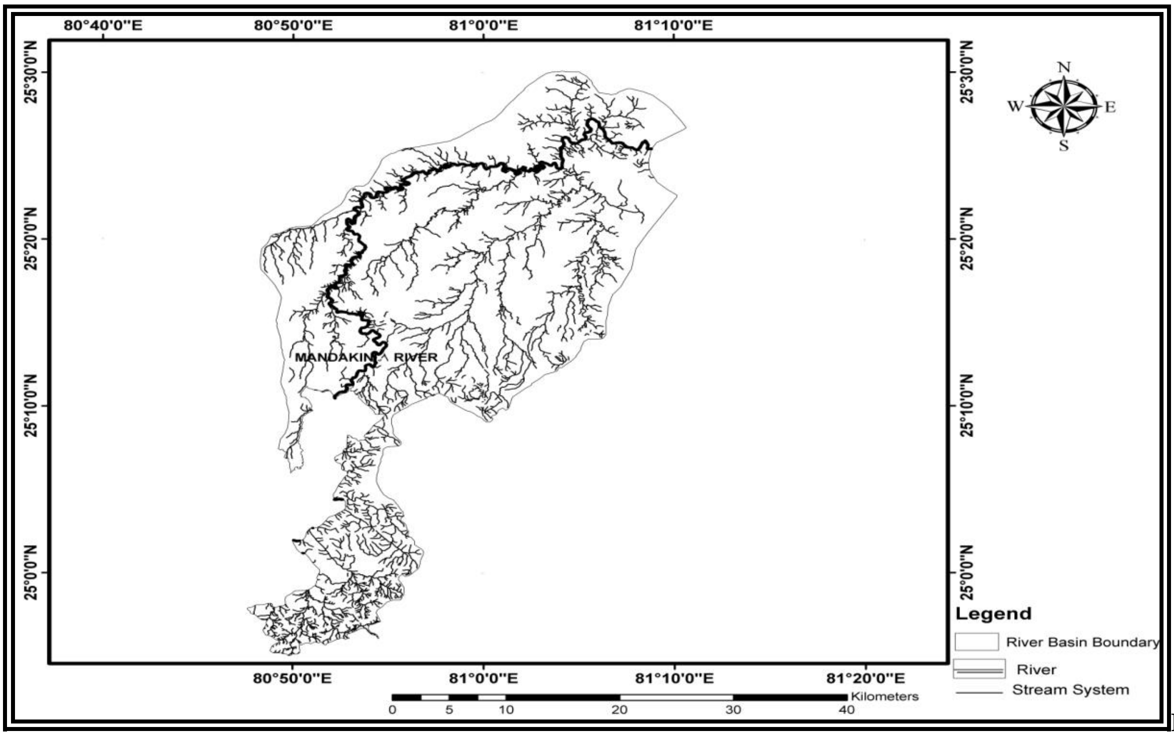


Fig. 3 Slope map of the Mandakini river basin part of Uttar Pradesh

The identify slope category (in percentage) was classified into seven classes and varies from 0 to 1 % is nearly level, 1-3 % is very gently sloping, 3-5 % is gently sloping, 5-10 % is moderately sloping, 10-15 % is strongly sloping, 15-35 % is moderately steep to steep slope and > 35 % is very steep slope of the study area. slope map is a major role of ground water recharge.

4.3 Drainage : Mandakini River is the main river with complete drainage system, draining there water to the whole area and responsible for agro-economic growth, biodiversity, habitation and livelihood. The Mandakini river basin a complete drainage system is found, 1st order to the main river. The drainage pattern of the area is dendritec and drainage texture of the study area is medium. The inter related nature of land and water resource calls for a holistic approach toward for urban and rural areas development and watershed management.



Fi g.4 Drainage map of the Mandakini river basin part of Uttar Pradesh

The development of stream segments is affected by slope and local relief and these may produce difference in drainage density from place to place. This drainage system is expressive for river basin and watershed management. The drainage system is formed with different streams and streamlets.

4.4. Soil :A synoptic view of the Satellite imagery provide excellent information on soil aspects areas. Based on visual interpretation of satellite data, all the above information to be derived and mapped. Percent of the sand, silt, clay is called that soil texture. The Mandakini river basin in a part of Uttar Pradesh interpreted of satellite data of soil texture in three types of silty loam, clay loam and loam and other area is exposed rock in the study area.

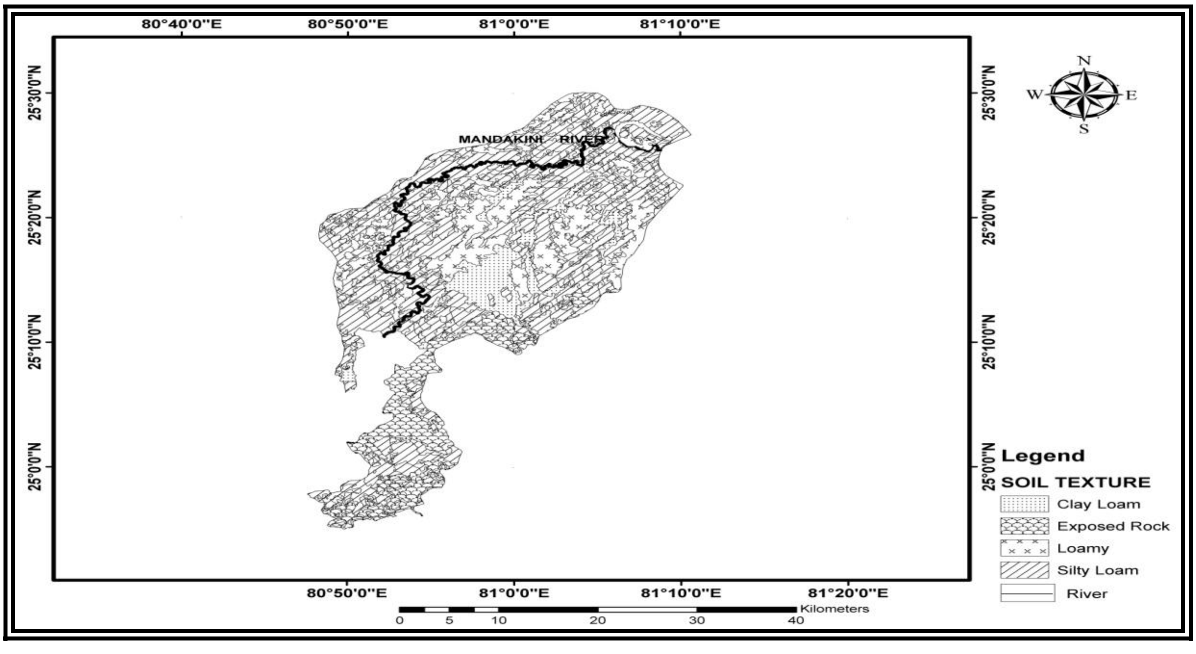


Fig. 5 Soil map of the Mandakini river basin part of Uttar Pradesh

The better soil texture is loamy, moderate soil texture is silty loam, poor soil texture is clay loam and exposed rocks is nill of the infiltration of the water. The infiltration rate on depends on the grain size of soil. Soil of Mandakini river basin in a part of Uttar Pradesh vary to their depth, texture, drainage and degree of erosion from the high land to low land region. This map is a most important role of the ground water recharge zone map.

4.5. Land use/ Land Cover : Realizing the important of Land use /Land cover in Ground Water Potentiality, Land use /Land cover was prepared using geocoded MSS images used and field data. The various Land use /Land cover classes delineated by employing the slandered methods of visual interpretation and the identified features includes Agriculture land, forest/plantation, waste land, hills, settlement, Fallow/open land road network and River/water bodies. In this majority of the area was used for scrubs land followed by Agriculture land.

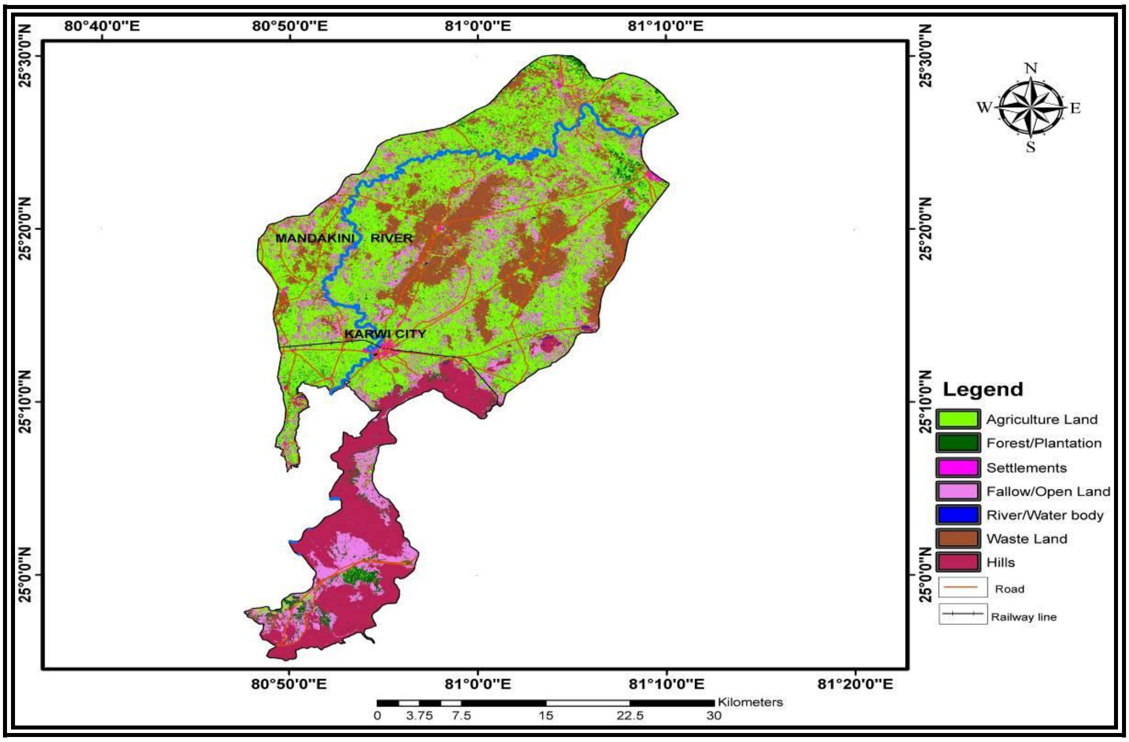


Fig.6 Land use/Land cover map of the Mandakini river basin part of Uttar Pradesh

The area under various Land use/ Land cover category with the study area computed and shows in the Table No-3 based on visual interpretation techniques and maps are shows in figure no -6.

Table-3: Land use/Land cover Statistics Based on Visual Image Interpretation

Sl. No.	Class Name	Area (in Ha)	Area (in %)
1	Hills	13571.45	13.13
2	River/Water body	171.02	0.17
3	Forest/Plantation	5884.42	5.69
4	Agriculture Land	44125.55	42.69
5	Waste Land	22437.65	21.71
6	Fallow/Open Land	16521.57	15.98
7	Settlements	647.74	0.63
8	**Total**	**103359.39**	

The Mandakini river basin in a part of Uttar Pradesh satellite data classified total area of 103359.39 ha. In this area classified of satellite data obtained to Agriculture land of 42.69%, forest/plantation 5.69%, fallow/open land of the15.98%, hills area of 13.13%, river/water body area of the 0.17%, Waste Land 21.71% and settlement area of the 0.63% of the interpreted of satellite data.

4.6. Ground water potential zones : For the Basin area was conducted with objective to delineate the areas with promising ground water zones and composite map of groundwater potential zone summarized of the results. In this study process involves raster overlay analysis and is known as multi criteria evaluation techniques (MCE), which gives linear combination of portability weight for different themes taken for the study. The integrated final map (Fig. 7) has generated to the distribution of ground water potential zones provide an insight into the management of ground water resources. The map has been categorized into six zones namely very poor to excellent groundwater potential zones. The area under various Ground water prospects zones category with the study area computed and shows in the Table No-4 based on thematic layers integration techniques and maps are shows in figure no -7

Table 4: Predictable Potentiality Statistics of the Mandakini River Basin part of Uttar Pradesh

Sl. No.	Class Name	Area (in Ha)	Area (in Percent)
1	Very Poor	16358.75	15.83
2	Poor	1950.75	1.89
3	Moderate	491.5	0.48
4	Good	23979	23.20
5	Very Good	33507	32.42
6	Excellent	27072	26.19
7	**Total**	**103359**	

Out of the total area, 16358.75 ha were classified for very poor potential zone, 1950.75 ha is poor potential zone, which accounts for almost 17.72% of the total area. Moderate potential zone occupy 0.48%, while good potential zone accounts 23.20% of the area. the very good potential zone occupy 32.42% and excellent zone 26.19% of the basin. Field check has been made through the yield data of dug wells and tube wells which satisfy the above analysis.

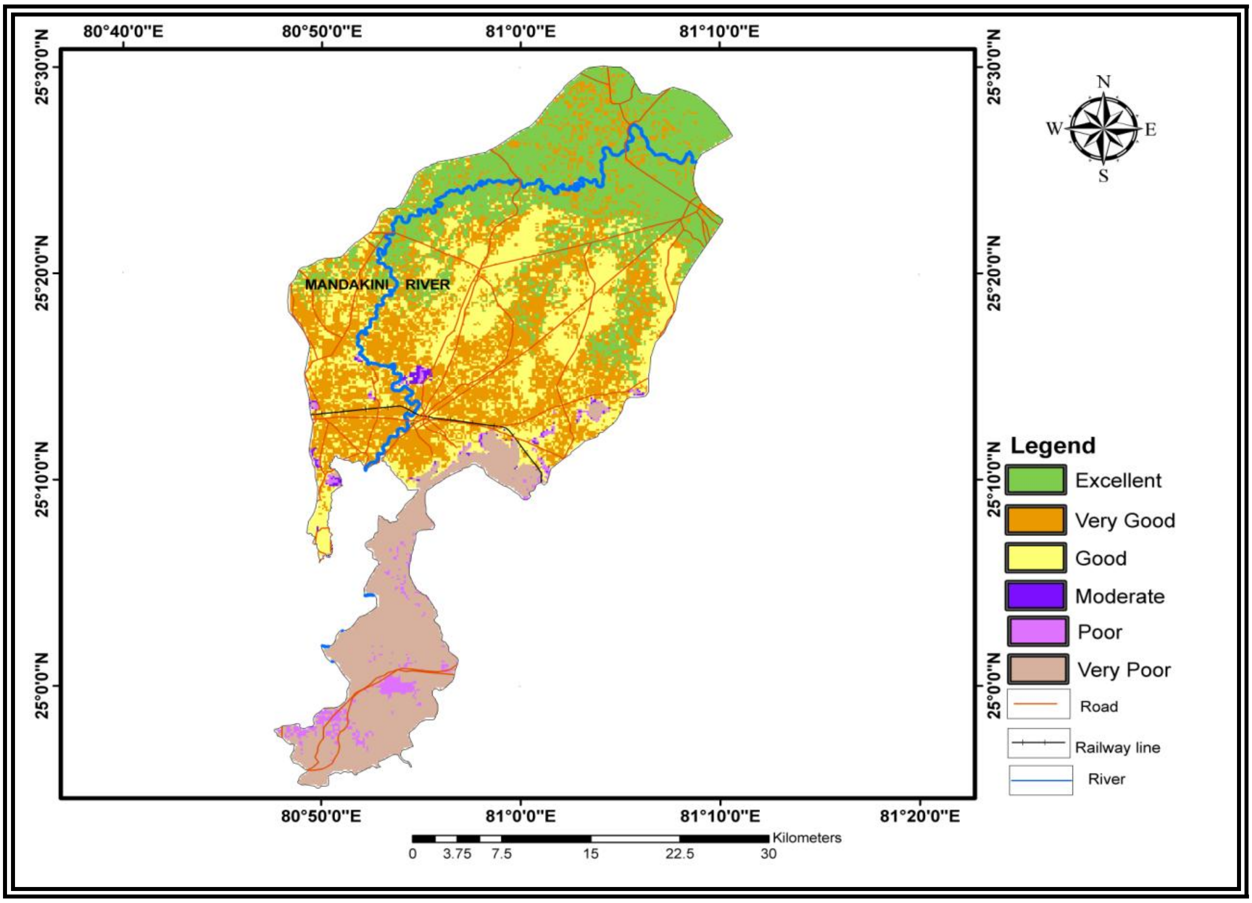


Fig.7 Ground water potential zones map of the Mandakini river basin part of Uttar Pradesh

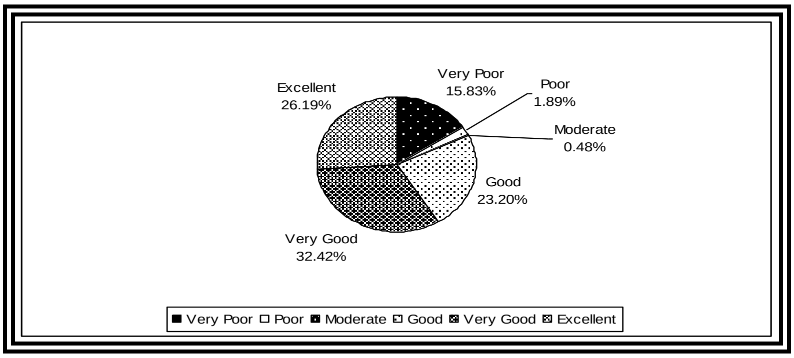


Fig. 8 Geographical Representation in Ground water potential Zones

This technology used effectively and economically in analysis and inventory, for basin area development and management of water resources. In this investigation can be integrated into Mandakini river basin area management plan aimed at improving the life style of humans and protecting the natural environment. These form a complete water potential zones system which provieds a expressive role in agriculture, rural and urban areas development of basin. It has been observed from ground water potential that the gentle slope has more potential for ground water

V. CONCLUSION

In the present study, an attempt has been made to generate Ground water potential zones map through multi criteria evaluation techniques using the raster based GIS analysis and also to assess the continuous variation of ground water prospects availability of the area. The integrated groundwater potential zones map has been categorized into six classes on the basis of the cumulative weightage to different features of the thematic maps. The total area of ground water prospects zones is 103359.00 ha. and excellent ground water potential zone area is 26.19% of the total area. The field survey has been made through the data of dug wells and tube wells which satisfy the above analysis. Therefore, appropriate management interventions and amicable salutations for drinking water supply, irrigation tubwells, wells of basin better developments and management need to be initiated without further delay.

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