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DELINEATION OF GROUNDWATER POTENTIAL ZONES AROUND PARAS THERMAL POWER PLANT USING REMOTE SENSING AND GIS TECHNIQUES

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Abstract: In this study, an attempt has been made to understand the hydrogeological behavior of Paras thermal power plant so as to delineate the groundwater potential zones around Paras thermal power plant using remote sensing and GIS techniques. The weathered layers and fractures are the main sources of groundwater supply in basaltic rock of the watershed. As a result, the extent of weathering and fracture characteristics decide its hydraulic conductivity and other properties. In all the dug wells and bore wells in the basaltic terrain reflect the presence of aquifer in the weathered and fractured basalts. The aquifers on the basis of permeability, potential and extent of aquifers, are categorized into i) extended and shallow aquifers with intergranular porosity and permeability, and with moderate to high potential (alluvial horizons); ii) limited and shallow aquifers with fracture and/or porosity and permeability, and with moderate potential (highly fractured and weathered basalt); and iii) limited and shallow aquifers with intergranular and fracture porosity and permeability with low potential (massive basalt). The results demonstrate that the jointing, resulting from cooling and from movement, is common in the upper part of each basalt flow while the original crust of the flow was itself broken and jointed. The joints were often filled subsequently either with clay produced by weathering or by mineralization from silica- and lime-rich groundwater but where not obliterated they provide much of the permeability of the Deccan basalts; the rest is being provided by the present-day weathering mantle. In this study an attempt has been made to correlate the lava flows in different locations particularly with the help of natural gamma and resistivity logging, there is little continuity of water-bearing levels, a yielding horizon in one well-being essentially barren in another only tens of meters away. The shallow aquifer is a bit better and full development of its resources will provide 60 mm to be used between the end of one monsoon and the start of the next. Of the 40, 20 mm is presently lost to base flow during October and November immediately following the monsoon and before the winter crop is planted. With present agricultural practice this 20 mm will continue to run to waste and only the remaining 30 mm is available for irrigation. Half of this is already pumped from open wells or from the rivers. The aquifers have transmissivity of 30–400 m^2/day but they are very local and prolonged pumping always gives evidence of this in falling water levels. The regional transmissivity is only 3 m^2/day. Storativity is thought to be 10^{-5}.If drilling is stopped at 40 m the yield expectation is 255 m^3/day per well; deeper drilling gives expectation of only 4 m^3/day per 10 m of drilling. These are averages: in fact of the thirty holes drilled, thirty gave negligible yield; in six of the twelve holes which met aquifers deeper than 50 m the water was unsuitable for irrigation. Because of poor recharge and low Storativity, the deep aquifers do not offer much replenishable yield.

Keywords: Hydrology, Paras Thermal Plant, groundwater potential, aquifers, potential fractures

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INTRODUCTION

In the context of many developing and under developed countries, about 80 percentage of population who reside in the rural areas rely on the natural resources for day-to-day livelihood. This implies that more the degradation, higher the poverty and hence the health problems connected with poverty. This demands an appropriate management tools to be implemented on the affected areas. Analysis and assessment tools like GIS along with Remote Sensing have proved data to be very efficient and effective and hence very useful. Watershed is a region (or area) delineated with a well-defined topographic boundary and water outlet. It is a geographic region within which hydrological conditions become concentrated within a particular location, for example, a river or a reservoir, by which the watershed is drained. Within the topographic boundary or a water divide, watershed comprises a complex of soils, land forms, vegetation, and land uses. The terms watershed, catchment, and basins are often used interchangeably. Watershed management implies the judicious use of all the resources i.e. land, water, vegetation, in an area for providing an answer to alleviate drought, moderate floods, prevent soil erosion, improve water availability and increase food, fodder, fuel, and fiber on sustained basis.

Water management, both in its conservation and controlaspects, has significantly benefited from satellite remote sensing inputs that has become an effective tool for a number of applications related to water resources development and management. Besides inventorying of surface water resources through mapping of water bodies, remotely sensed data enable us to study various hydrological processes and thereby water balance with reasonable accuracy. Watershed assessment needs an approach that can handle complex problems but is easy to implement, that is flexible but consistent, that can be applied at different spatial scales, and that can readily be translated into easily communicated descriptions related to management decisions.

In order to combat the frequent recurrence of drought in the States, Drought Prone Area Program (DPAP) was introduced during the year 1975, as a Centrally Sponsored Scheme (CSS) with matching states hare of 50:50 and adopted the watershed approach in 1987. The Drought Prone Area Program concentrated on non-arable lands. Drainage lines for in-situ soil and moisture conservation, agro-forestry, pasture development, horticulture and alternate land use were its main components. Integrated Wasteland Development Program (IWDP) was introduced during 1992 with 100% central assistance. The Integrated Wasteland Development Program made a forestation and soil &moisture conservation in waste lands under Government or community or private control as its predominant activity, without much focus on saturation of complete micro watershed and participation of people. All the area development programs like DPAP, IWDP and Desert Development Program (DDP) were implemented through recommendations of Dr. Ch. Hanumantha Rao's Committee.

Study Area

The study area, Paras is located in Akola district of Maharashtra at latitude-20.68043 and longitude-77.52193. It is 269 km South West of Nagpur. For the purpose of administrative conveyance, the district is divided into seven Tahsils and Panchayat Samities (Fig.1 and Fig.2). According to the 2001 Census, there was 542 Gram Panchayat for the purpose of Rural Development. The main crops grown in the district are Jawar, Wheat, Cotton, Tur, Mung. The two main rivers of the district are the Purna and the Penganga, the other less important rivers being the tributaries of these two rivers. They are the Katepurna, Shahanur, Morna, Mun, Nand, Man and Uma, which are the tributaries of the Purna, and the Adan, the Arna and the Pus which are the tributaries of the Penganga

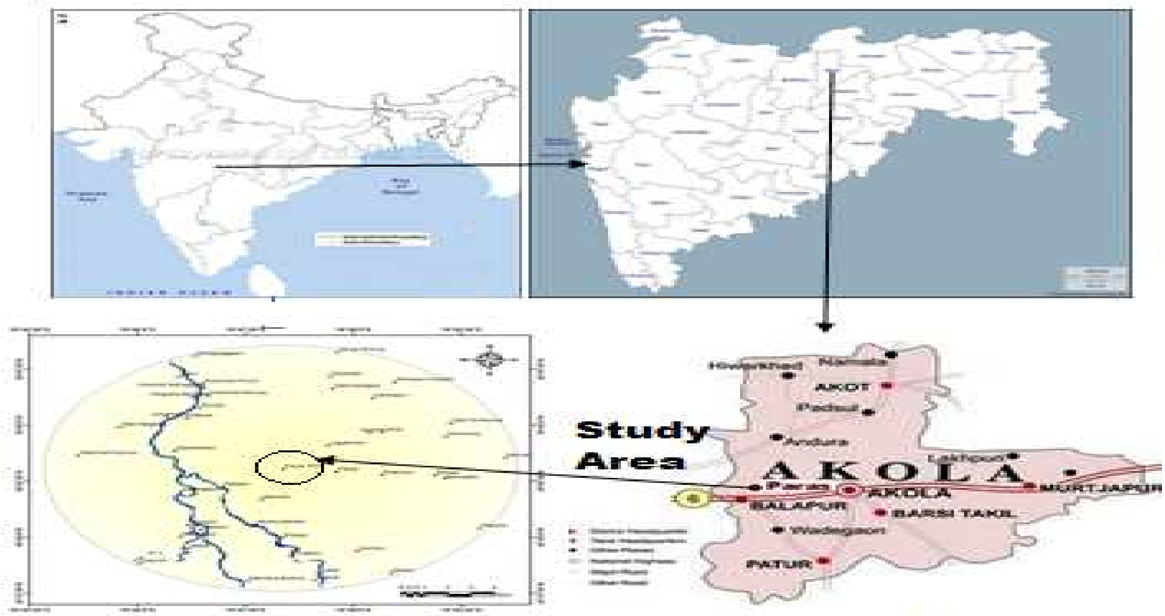

Fig.1 Location map of the study Area

Fig.2 Satellite imagery of the Paras Power plant located in Akola district of Maharashtra

Drainage analysis:

Mun River is the major river passing through the study area which is a tributary of Purna River. The Mun river rises in the northern Ajanta scarps of the Chikhli tahsil of Buldhana district and flows east through the Ghatbori reserve forest area to enter the district of Akola. It is joined by a right bank tributary, the Uttavli, also rising in the scarps in Buldhana district and joining the Mun at the foot of the scarp near the village Pimpalkhuta after which the combined flow-northwards is fed by another stream the Vishwamitri rising on a similar scarp within the district and flowing north. After the confluence, the river flows through a flat alluvial country making-curves and graceful meanders; it flows past the township of Balapur; to the immediate north of Balapur, it is joined by a left bank-tributary, the Mas river, and another 6 km further downstream by a fairly long source stream, the Nirguna river and its tributary the Bordi river, both of which rise in the Medshi and Pathar reserved forest sections of the ghat country and flow north. After its confluence with the Bhuikund, the Mun is crossed by the Bombay-Nagpur railway line over a bridge which is south-east of Nagjhari railway station. In its lower course, the Mun makes excellent meanders and oxbow lakes in wide plains; its immediate banks are highly gullied. It joins the Purna river near the village of Khajikhed on its left bank. It forms for quite some distance the boundary between the Buldhana and Akola districts.

Climate

The climate of this district is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season. The year may be divided into four seasons. The period from about the middle of November to the end of February constitutes the winter season. The summer season extends from March to June. This is followed by the south-west monsoon season which extends up to the end of September. October and November constitute the post-monsoon season

Rainfall

The average annual rainfall of the district is 846.5 mm (33.33"). The rainfall during the monsoon months constitutes about 85 per cent of the annual rainfall, July being the rainiest month. During the fifty year period, 1901 to 1950, the highest annual rainfall amounting to 150 per cent of the normal occurred in 1949, while the lowest annual rainfall which was only 45 per cent of the normal occurred in 1920. In the same fifty year period the annual rainfall in the district was less than 80 per cent of the normal in ten years, two of them being consecutive

Temperature: Temperature rises rapidly after February till May which is the hottest month of the year. In May, the mean daily maximum temperature at Akola is 42.4 °C and the mean daily minimum temperature is 27.5°C. The heat in the summer season is intense during the day and the nights are comparatively tolerable. During the period from April to June, on individual days, the day temperature raises up to about 46° or 47°C. With the arrival of the south-west monsoon in the district by about mid-June there is an appreciable drop in the day temperature and the weather becomes pleasant. After the withdrawal of the monsoon the day temperature increases gradually and a secondary maximum in day temperature is reached in October. However, night temperature decreases progressively after September. Both day and night temperature decreases rapidly from October till December, which is the coldest month in the year.

Humidity:

Except during the southwest monsoon season when the humidity is between 60 to 80 percent, the air is generally dry over the district. The summer months are the driest when the relative humidity is even less than 20 percent in the afternoons on many days.

The aim of the present study is to usage-informatics to demarcate the watershed for suggesting various ways for the management along with detailed hydro-geological studies including identification of ground water potential zones within the study area associated with the drainage and slopping/elevation pattern based on the geography of the area.

Remote sensing and GIS

The term GIS was first coined in the early 1960s by Roger Tomlinson (Cop pock and R hind 1991)during his work with the Canada Land Inventory (CLI). At that time, a system was needed to analyze the data collected by the CLI to support the development of land management plans for rural areas of Canada.(David M. Theobald,2007). Digitizing in GIS is the process of "tracing", in a geographically correct way, information from images/maps. Digitizing is the process of converting features on a paper map into digital format digitizer can be used in conjunction with the editing tools in ArcMap to create new features or edit existing features on a digital map. Digitization is process of making an electronic version of a real world object or event, enabling the object to be stored, displayed and manipulated on a computer, and disseminated over networks and/or the www. But before digitization, the map must be geo-referenced.(Manjula et. al, 2010).

Geo-referencing

There is a great deal of geographic data available in formats that cannot be immediately integrated with other GIS data. In order to use these types of data in GIS it is necessary to align it with existing geographically referenced data, called geo-referencing. The process of geo-referencing relies on the coordination of points on the scanned image (data to be geo-referenced) with points on a geographically referenced data (data to which the image will be geo-referenced). By "linking" points on the image with those same locations in the geographically referenced data you will create a polynomial transformation that converts the location of the entire image to the correct geographic location. (Manjula et. al, 2010)

Geo-processing: A GIS operation used to manipulate data stored in a GIS workspace. A typical geo-processing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geo-processing operations are geographic feature overlay, feature selection and analysis, topology processing, and data conversion. Geo-processing allows for definition, management, and analysis of information used to form decisions.(Jill McCoy, ESRI, 2001-2004)

DEM (Digital Elevation Model) map:

A DEM is a gridded array of elevations. In its raw form it is an ASCII, or text, file. In a DEM, elevations are sampled at regular intervals in the x and y dimensions. The whole process of making a DEM map involves various steps like interpolating elevations, creating a DEM from interpolated elevations, downloading and formatting the DEM, performing raster analysis on a DEM and creating derivative data from DEMs.(Joe Wheaton, 2010).

Slope map

The incline, or steepness, of a surface is known as slope that can be measured in degrees from horizontal (0–90), or percent slope (which is the rise divided by the run, multiplied by 100). A slope of 45 degrees equals 100 percent slope. As slope angle approaches vertical (90 degrees), the percent slope approaches infinity. The slope of a TIN face is the steepest downhill slope of a plane defined by the face. The slope for a cell in a raster is the steepest slope of a plane defined by the cell and its eight surrounding neighbors. Slope can be represented in two units:

a) **Degree slope**-One method for representing the measurement of an inclined surface. The steepness of a slope may be measured from 0 to 90 degrees.

b)**Percent slope-**A measurement of the rate of change of elevation over a given horizontal distance, in which the rise is divided by the run and then multiplied by one hundred. A 45-degree slope and a 100-percent slope are the same (GIS Dictionary, ESRI).The step by step process of slope map preparation was known by going through the literature of 'Using ArcGIS Spatial Analyst'(Jill McCoy and Kevin Johnston, ESRI, 2001).

The methodology used for demarcation of watershed of an area was base map preparation, contour map preparation, geo-referencing, digitizing and editing, DEM preparation, calculation of slope and slope map preparation, FCC preparation, ground truth preparation, unsupervised classification of land use/land cover along with the Supervised Classification of land use/land cover characteristics of wastelands.

Methodology

Thematic layers for GIS analysis were prepared by image processing of the raw data using sources like thematic layers for GIS analysis were prepared by image processing of the raw data using sources like multispectral Imageries *(ETM+), RADAR (SRTM)* data, GSI Maps and SOI Toposheet. A special emphasis was laid on the development of action plan for land and water resources management mainly based on the land use/ land, cover, geomorphology and slope of the area. From the final output of these themes generated; recharge wells, percolation tankand check dams are recommended for the study area, mainly to control sedimentation from the catchments. The flow chart showing the methodology used in the study area in given in Fig.3. To increase the groundwater recharge and vegetative cover to control soil erosion, various action plans like construction of recharge structures, a fforestation etc has been proposed. The methodology adopted in this study includes satellite data processing using ERDAS 9.1 Image processing software, layers like slope, DEM, were extracted from SRTM RADAR Data which was used in the analysis for creating the action plans, layers like lineaments through visual interpretation and land use/ land cover through hybrid classification were extracted which was highly useful for the hydrology based analysis.

Digitization of Maps

From the SOI toposheet and GSI maps the layers such as drainage, geology, lineaments, soil, and geomorphology etc., digitized were used for weighted overlay analysis as well as suitability analysis. From the line features like lineaments and drainage, their densities per unit area weremapped for overlay analysis and water resource action plan.

Analysis

Based on the above mentioned criteria these layers were integrated and used according to requirements of the analysis. Two types of analysis were carried out namely, weighted overlay analysis for groundwater potential, suitability analysis for land resource development.

The SOI topo sheets have been converted to digital maps by scanning and the scanned data were stored in JPEG (Joint Photographic Expert Group) format. This format was used since the size of the data in this format can be reduced to a large extent without losing quality. The data was scanned at 200dpi resolution. The image quality was further enhanced by adjusting the brightness and contrast of the image in Adobe Photoshop. After scanning the data was ready for further processing on Arc GIS.

ArcGIS software has been utilized in this study which gives the power to visualize, explore, query, and analyze data geographically. In this project ArcGIS has been used to display raster map, digitizing different features and querying the data for finding the attributes for any feature on map. ArcGIS Spatial Analyst is a tool which helps in analysis and understanding of spatial relationships in our data. Reclassify tool has been used to reclassify different data and raster calculator has been used for overlay analysis and calculation of final results.

Registration:

In order to provide a common scale to all data and for all measurements, maps and image has to be registered with each other. First, SOI toposheets has been geo-referenced using ArcGis software. Universal Traverse Mercator (UTM) 1984 has been selected as the projection system six ground control points distributed over whole area, whose latitude and longitude is known have been manually selected from toposheet . The basic procedure for geo-referencingis to move the raster into same place as target data by identifying the series of ground control points that link location on the raster with locations in target data in map coordinate. After creating enough links a first order transformation has been used for registering with RMS error of 0.51 which is good for registration. Resampling is performed by nearest neighbours assignment to give a final geo-referenced map. After geo-referencing the base map, remote sensing image is registered with the base map using the same technique by taking four points which are easily identifiable in both toposheets and image.

Digitization:

For all GIS work, ArcGIS has been used. After geo-referencing the SOI toposheets was opened in ArcGIS and remote sensing image in GEOMATICA 10.2 and finally used in background for on-screen digitization. For working in most GIS software, mainly the vector data is needed. In digital map, the spatial data are depicted using the topology. Topology is a mathematical procedure for explicating spatial relationship as list of features e.g. an area is defined by arc comprising its borders and an arc is defined by form and nodes and its left and right polygons. Topological relationship is build from simple elements: nodes(simplest element), arc (set of connected nodes) and area (set of connected arcs). In ArcGIS different features is digitized in different layers. By digitizing raster data is converted in vector format. A topology was also created for each feature. In ArcGIS the features are digitized in three modes: point, polyline and polygon, depending upon the type of feature and scale of map. Depending upon the characteristics of the feature, attributes have been defined as such as national highways, roads(major, minor) have been digitized as polyline, while villages has been digitized in point, contour in polyline, drainage in polyline and river in polygon. Attribute table has been attached with each of the features. The attribute table in case of contour comprises of polyline No., id no., FID(field) and altitude.

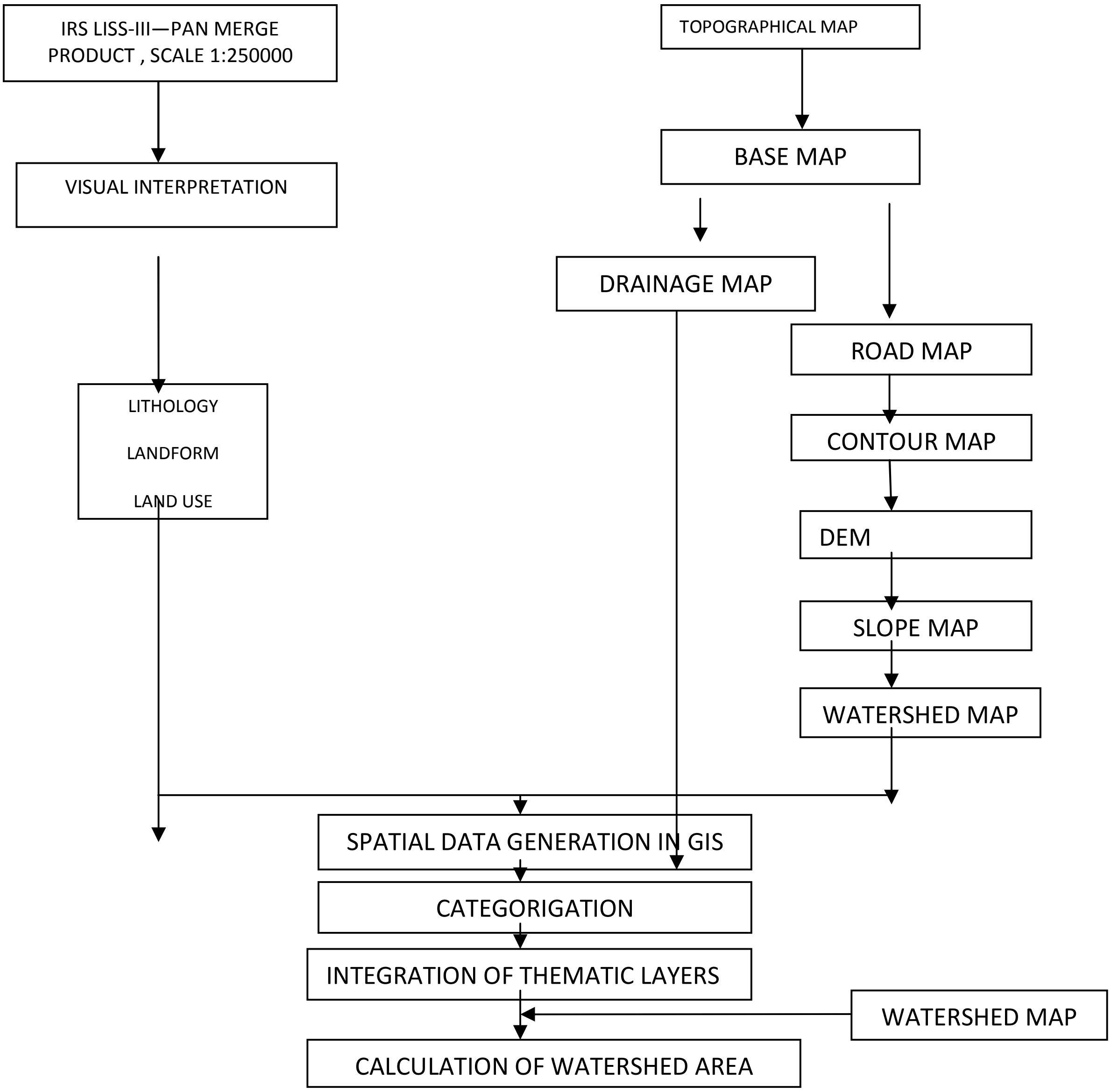

Fig 3: flowchart showing the methodology used in the study area

Satellite imageries:

The spatial resolution and the spectral bands in which the sensor collects the remotely sensed data are two important parameters for any land use survey. IRS P6 LISS III data offers spatial resolution of 23.5 m with the swath width of 141 x 141 km. The data is collected in four visible bands namely green (Band 2) (0.52-0.59μ), red (Band 3) (0.62-0.69μ), near Infrared (NIR) (Band 4) (0.77-0.89μ), Short wave infrared band (Band 5) (1.55-1.75μ) with orbit repeat period of 24 days (three days revisit). The shapes, sizes, colors, tone and texture of several geomorphic features are visible in IRS data. Four spectral bands provide high degree of measurability through band combination including FCC generation, bands rationing, classification etc. These features of the IRS data are particularly important for better comprehension and delineation of the land use classes. Hence, IRS P6 LISS-III data has been used for land use mapping.

The digital image processing was performed on PCI GEOMATICA 10.2 System on high-configured computer. This software package is a collection of image processing functions necessary for pre-processing, rectification, band combination, filtering, statistics, classification etc. Apart from contrast stretching, there are large numbers of image processing functions that can be performed on this station. Arc Map 10 is used for final layout presentation.

Generation of contour map

Contours are polyline that connects points of equal value of elevation. The elevation points were prepared from toposheets 13, D14, D10 and D9 on a scale of 1:25000 collected from Survey of India (SOI). The collected toposheets were scanned and registered with tic points and rectified. Further, the rectified maps were projected. All individual projected maps were finally merged as a single layer. The contours were digitized with an interval of 10m. The contour attribute table contains an elevation attribute for each contour polylines. The contour map was prepared using Arc Map of ArcGIS 10. Contour map is a useful surface representation as they enable to simultaneously visualize flat and steep areas, ridges, valleys in study area.

Generation of digital elevation model (DEM)

A DEM is a raster representation of a continuous surface, usually referring to the surface of the earth. The DEM is used to refer specifically to a regular grid of spot heights. It is the simplest and most common form of digital representation of topography. The Digital Elevation model for the study area was generated from the Tin.For example, if the direction of steepest drop was to the left of the current processing cell, its flow direction would be coded as 16.**Generation of flow accumulation**

The result of Flow Accumulation is a raster of accumulated flow to each cell, as determined by accumulating the weight for all cells that flow into each down slope cell. Cells of undefined flow direction will only receive flow; they will not contribute to any downstream flow. A cell is considered to have an undefined flow direction if its value in the flow direction raster is anything other than 1 (East), 2(South-East), 4 (South), 8 (South-West), 16 (West), 32 (North-West), 64 (North), or 128 (North-East). The accumulated flow is based on the number of cells flowing into each cell in the output raster. The current processing cell is not considered in this accumulation. Output cells with a high flow accumulation are areas of concentrated flow and can be used to identify stream channels. Output cells with a flow accumulation of zero are local topographic highs and can be used to identify ridges.(Fig.4).

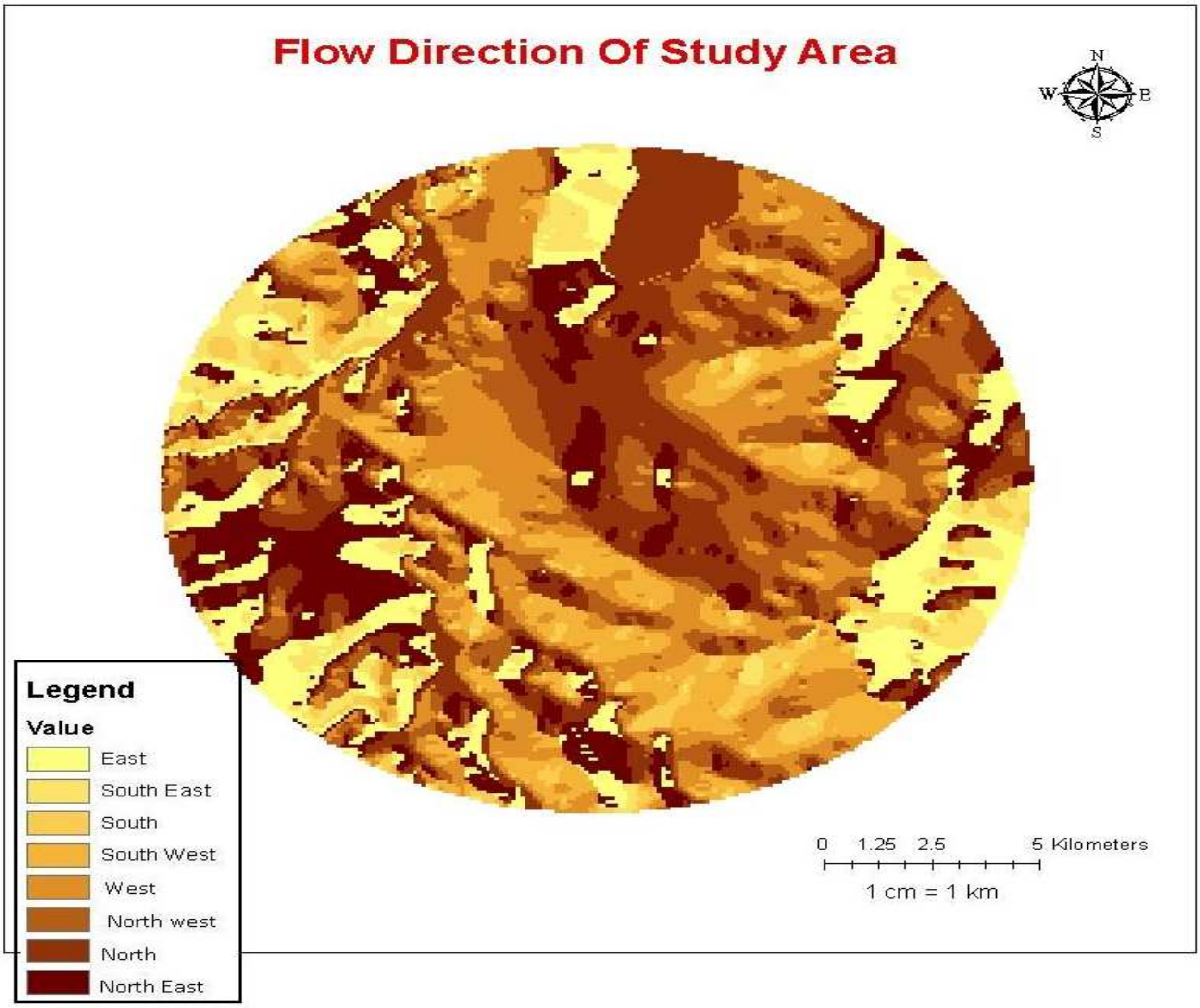

Fig. 4 Flow direction map of the study area

Generation of slope map and watershed:

The Slope function in ArcGIS 10 calculates the maximum rate of change between each cell and its neighbors. Every cell in the output raster has a slope value. The lower the slope value indicates the terrain is flatter and the higher the slope value, the steeper the terrain. The output slope raster was calculated in both percent of slope and degree of slope. Slope map was prepared from the DEM.(Fig.4).Watershed of the study area was demarcated using the software ArcGIS. Drainage pattern was taken as the input data.The slope map of the study area has been prepared using remote sensing and GIS analysis which indicates the presence of five different slope classes in the area of investigation (Fig. 5).

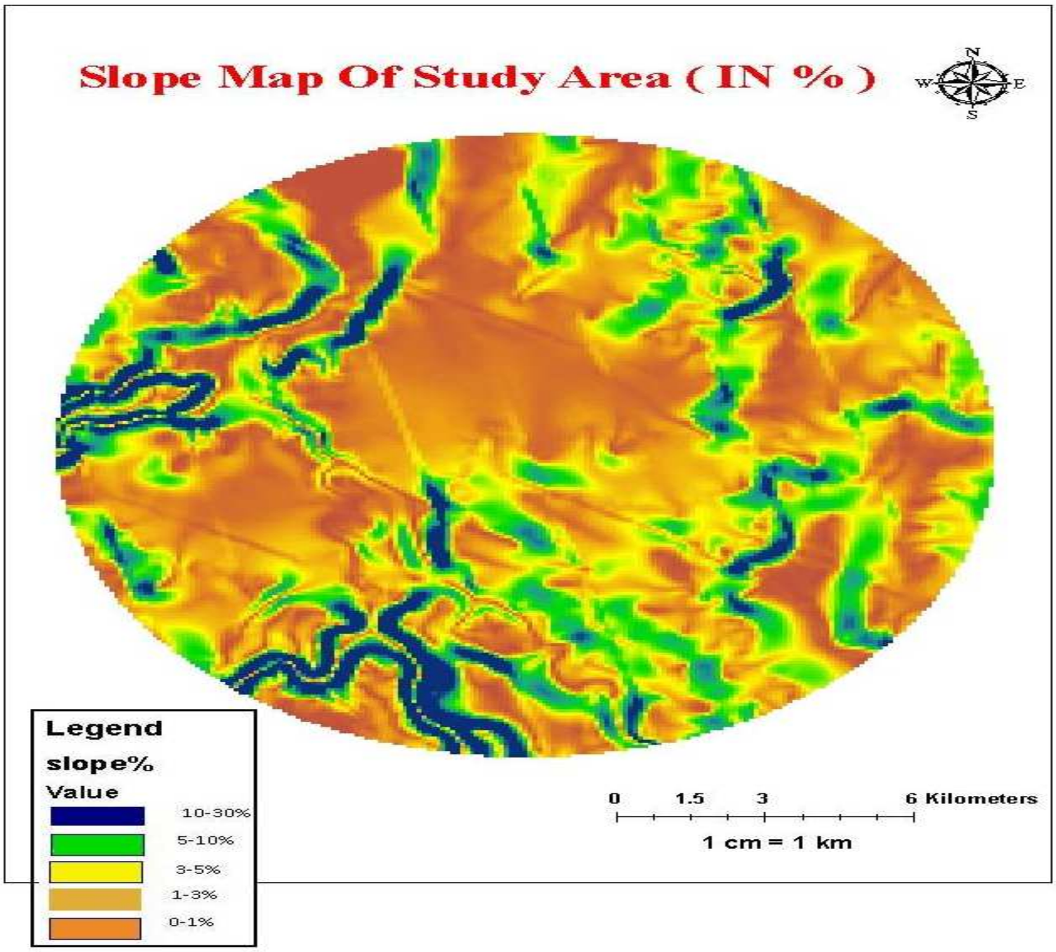

Fig. 5 Slope map of the study area

Land Use/ Land Cover map:

The topographic maps namely D13, D14, D10 and D9 on a scale of 1:25000 were collected from Survey of India. The collected topographic sheets were scanned and registered with tic points and rectified in Arc map of Arc GIS 10 Further, the rectified maps were projected and merged together as a single layer. The present study area of Paras watershed was delineated in GIS environment. Spatial data in the form of satellite imagery for the preparation of Land use/Land cover details for the study area was procured from National Remote Sensing Centre (NRSC). The satellite imagery pertains to Indian Remote Sensing Satellite (IRS) P-6, Linear Imaging and Self Scanning Sensor (LISS –III) with a resolution of 23.5m. The collected satellite imagery was geo-referenced in GEOMATOCA 10.2, then rectified and finally projected. Study area has been classified for Land Use / Land Cover into five classes viz, Crop land, fallow land, river, barren land and settlement in each sub area based on NDVI values generated.

Watershed management

It has been estimated that about one-third of India's lands suffer, in one way or another, from severe degradation. Rendered unproductive by the destructive forces of wind and water erosion or by salinity and water-logging, these vast stretches of land have been abandoned and neglected, while foodproduction centres on a few fertile pockets.According to the 1985 Report of the National Remote Sensing Agency in Hyderabad, 53.3 million hectares of land are to be considered as wastelands. The situation has not improved since and more recent figures put the number at 69 million hectares. The drylands and marginal lands, where for ages millets and pulses were grown, have suffered the most in the last three decades. Small and medium farmers, unable to make ends meet and drawn to the ever-growing cities, gradually left these lands to the destructive forces of wind and water erosion. Keeping in mind the situation of land degradation watershed development has become the main intervention in natural resource management in India. Watershed development programme not only protect and conserve the environment, but also contribute to livelihood security. The key characteristics of a watershed that drive management approaches are the integration of land and water resources, the causal link between upstream land and water use and downstream impacts and externalities, the typical nexus in upland areas of developing countries between resource depletion and poverty, and the multiplicity of stakeholders. Watershedmanagement approaches need to be adapted to the local situation and to changes in natural resource use and climate. The study area was divided into five classes based on FCC land use/land cover procured by RS software GEOMATICA 10.2.The area and percentage area of each classes depicted in the study area is given in table 2. Watershed management map has indicated the presence of five distinct groups in the study area (Fig. 6)

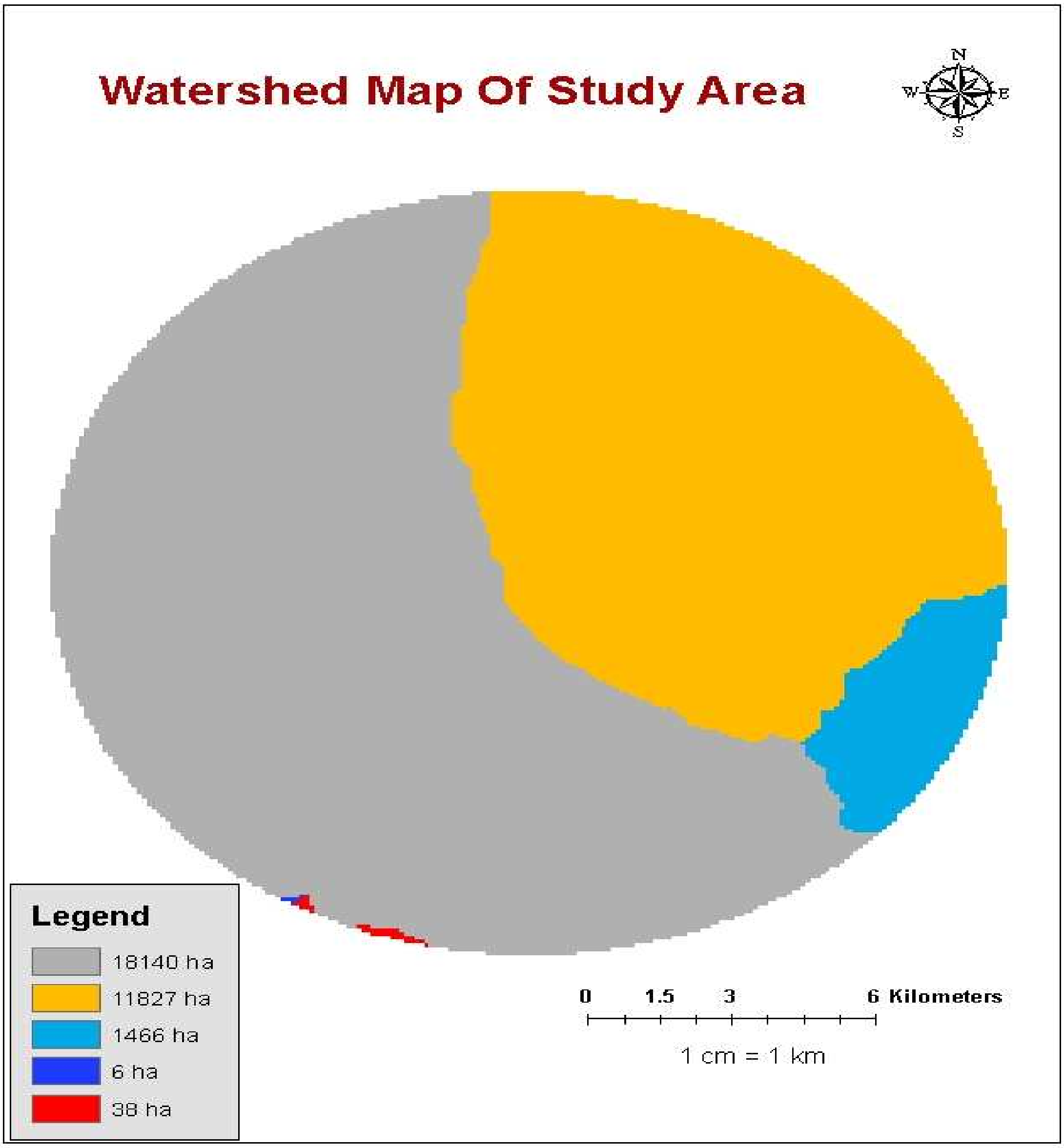

Fig.6 Watershed map of the study area

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Ground Potential zones map:

The thematic maps of soil, Hydro-geomorphology and Landuse/Land cover prepared for the study area. The Digital Elevation Model (DEM) has beengenerated from the 20 m contour interval contour lines derived from SOI toposheets. Slope maphas been prepared from DEM. These vector maps have been converted into raster format usingconversion tool in GIS environment. Further, these raster maps have been reclassified. Thesereclassified maps have been overlaid in terms of weighed overlay method using Toposheets and Thematic Maps: Relevant toposheets in 1:25000 scale of the Survey of India and land-use map in 1:25000 scale published by the National Atlas and Thematic Mapping Organization (NATMO) were used for registration of the satellite data. These were also used as collateral data in the digital analysis and classification of the satellite data for the preparation of the groundwater potential zones (Fig.7).

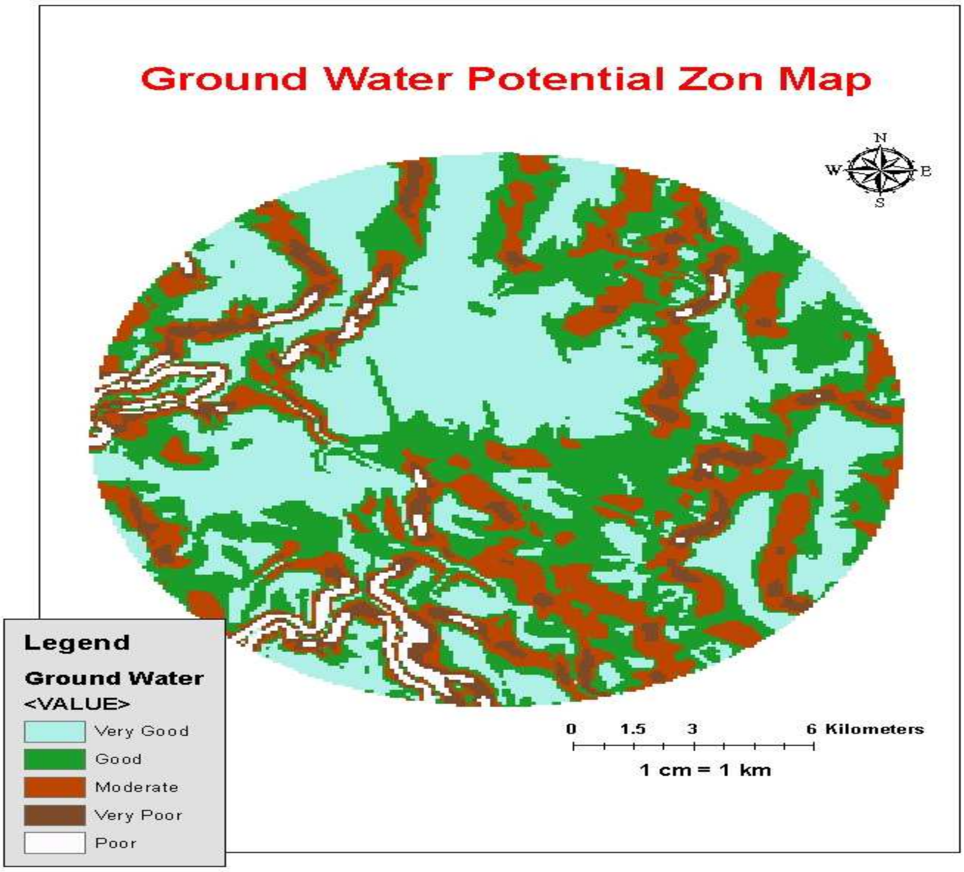

Fig. 7 Groundwater potential zone map of study area

Table. 2 The area and percentage area of each classes depicted in the study area

Classes	Area in sq. Km	Percentage area
Agricultural Land	62.02	19.75
FallowLand	102.08	32.49
WasteLand	72.43	23.06
Water Body	46.31	14.78
Settlement	31.16	9.92
Total	**314**	**100**

Summary and conclusions

Three major watersheds were identified in the area. The area occupied by the largest watershed is 18,140 Ha and it falls under the Sub-watershed category which covers around 57.72% of the area under study, the second watershed has an area of 11,827 Ha and this also falls in the sub-watershed categoryand covers around37.63 % of the study area, the third watershed has an area of 1466 Ha and falls in the category of Micro-watershed occupying about4.66 %of the study area. There are two small watersheds having an area of 6Ha and 38Ha respectively falling in the category of Mini-watershed and covers around 0.13% of the study area. DEM is the 3-D presentation of the surface derived by the interpolation of contour map. It represents x, y and z-axes in pixel size of the order 23.5 meters. The altitude or z axis ranges from 260 meters to 310 meters above sea level Digital slope was derived from DEM on pixel size of order 23.5 meters. Digital Image Processing was done using various modules available in ArcGIS 10. TheSatellite image obtained from IRS P6 LISS II on January 2011 was processed and then unsupervised classification as well as supervised classification was done. The supervised classification of the image was done using ground truth, maximum likely-hood classifier. The following classes such as agricultural land, fallow land, wasteland, river and settlement were identified from cluster image. The area on both side of river has steep slope. The gullied land is seen on the left bank of the river in the downstream region of the Watershed area. In this region the ridge to valley width is higher than anywhere else. The slope is moderately steep around the river. It has been classified into 0-1%, 1-3%, 3-5%, 5-10%, and 10-30%. Groundwater potential zones were identified on the basis of slope of the area. Five classes' i.e. very good, good, moderate, poor, very poor, were identified. Most of the area comes under very good and good ground water potential zones. The area which has 0-1% slope has very good ground water potential due to nearly flat terrain, area having 1-3% slope has good ground water potential due to slightly undulating topography and some run-off, area with 3-5% slope has moderate ground water potential because these areas have relatively steep slope leading to high run-off, areas with 5-10% and 10-30% slope has poor ground water potential due to steep slope and higher run-off. The stony waste is extended in the source area. The slope in this area is very steep. The causative agents can be reel erosion, which removes the topsoil layer in the lower pediments on gently clopping areas. The underlying exposed rock is predominantly basaltic. The association of the stony waste can be drawn with uncontrolled tree felling in the upland. It indicates the alarming rate of deforestation. A little hilly structure is seen in the South-East Region. A river flows through the study area contributing to the largest watershed (Sub Watershed category) and hence a good groundwater potential zone. Most of the area has good groundwater potential zone because of relatively undulating topography and green vegetation/agricultural land of the area. The elevation varies from 260m to 310m above mean sea level. There are mainly two types of soil found in the study area, namely-Medium Black and Deep Black soil. The crops grown are Cotton, Pulses, Jawar, Oil seeds. Three major watersheds are identified covering 18, 140 Ha (57.72% of the study area), 11, 827 Ha (37.63% of the study area) and 1466 Ha (4.66% of the study area).Current fallow is distributed in large proportion. It is mainly loose soil and is exposed to heavy rainfall on onset and withdrawal of the monsoon. It thus causes the loss of soil and contributes to formation of wasteland like gullied areas and also the upland without grassland. Due to heavy rainfall, the eroded parts and also the grit act as erosive tool. These scrape the gullies in its course downstream. In the upstream, the management aspects like grassing, plantation and afforestation arelargely practiced.

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