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# Groundwater Regime Of Paras Thermal Power Plant Using Remote Sensing And Gis Techniques With Emphasis On Environmental Impact Analysis

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**Abstract:** In this study, an attempt has been made to understand the hydrogeological regime of the Paras thermal power plant using remote sensing and GIS techniques with emphasis on environmental impact analysis. In this study an attempt has been made to understand the groundwater potential in Deccan basalts of the Mun river basin exposed around the Akola district in Maharashtra by utilizing various geological, geophysical and hydro geological techniques. 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. The results demonstrate the presence of various geomorphic landforms such as plateau top, mesa, butte, moderately dissected middle plateau, highly dissected upper plateau, low dissected plateau, upper bazada-shallow zone, alluvial plain younger-eroded, deep alluvial plain-order, alluvial plain-order eroded, habitation, mask and water body mask. As a results, the mean lengths and length ratio; differ greatly from one order to the next within the same basin. This fact leads to the conclusion the segments of stream system cover a wide range dimension of structural and lithological control and especially in the segments of order 3, 4, 5 and 6. The analysis reveals that the influence of drainage morphometry is very significant in understanding the landform processes, soil physical properties and erosional characteristics. An average of the five bifurcation ratios is close to 4.3 which is good representative value for the series. The study demonstrates that remotely sensed data and GIS based approach is found to be more appropriate than the conventional methods in evaluation and analysis of drainage morphometry, landforms and land resources and to understand their inter-relationships for planning and management at river basin level. Because of poor recharge and low Storativity, the deep aquifers do not offer much replenishable yield. This study has certainly helped in understanding the groundwater regime of the region for sustainable development.

**Key words:** Groundwater, remote sensing, GIS, environmental analysis water quality.

## INTRODUCTION :

Space based earth observation system have become an essential part of any study on natural resources of a country. Numerous studies carried out in India and others pasts of the world have proven that remote sensing are the most important tool for identification and management of natural resource. This is mainly because of its inherent advantage like synoptic viewing capability multispectral nature of the data and repetitive coverage of some area and seal time coverage of inaccessible area apart from remote sensing, there is another important tool which is widely used in the scientific area for various type of analysis this is the geographic information system (GIS) which is an organized collection of computer hardware, software and geographic data designed to efficiently capture, store, manipulate, analyze and display all forms of geographically referred information. GIS is an interdisciplinary tool, which has application in various field such as geography, geology, urban planning, etc. Structural geology is the study of architecture of rocks insofar as it has resulted from deformation. Tectonics and tectonic geology are terms that many consider to be synonymous with structural geology. Structural geology is concerned primarily with the geometry of the rocks whereas tectonics deals with the forces and movements that produced the structure. The movements that affect solid rocks result from forces within the earth, causing folds, joints, faults and foliation. Since time immemorial environment and development are going together as two wheels of a cart. These two aspects are the determinants of human welfare and prosperity. However, history is witness to the fact that many a times development is done at the cost of environment and its quality. It directly reflects on productivity and hence on the economic development.

In the context of many developing and underdeveloped 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 thence 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 are such that water becomes 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.

**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). 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.

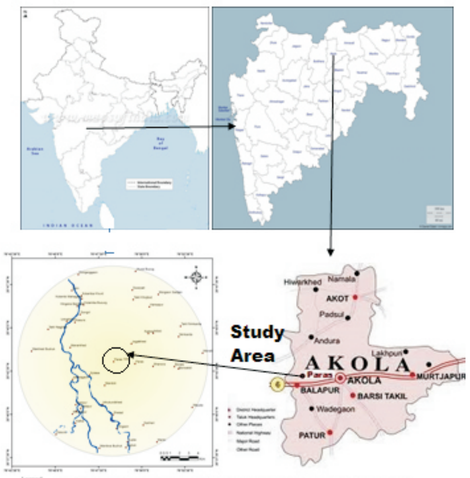


**Fig.1 Location map of the study Area**

**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 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.

**Geology of the area**

The Akola region is bounded on the north by the southern foot-hill of the Gavilgarh range which, in turn forms a part of the Satpuda range of hills, whereas, on south, it is bounded by the Ajanta and Satmala hills. Another range comprising of steep hills runs across the middle of the southern tahsil; but for the above abruptly rising hills, the entire district is more or less a fertile alluvial tract drained by the Purna, Katepurna, Adan and Penganga rivers. The entire district remains geologically unmapped but for the inspection of a few particular sites carried out by the officers of the Geological Survey of India for studies on ground water problems and suitability of dam sites. The trap covers a major part of the study area and is characterized by basalt lava flows which are generally dark grey, hard and compact. The tops of individual flows are usually vesicular and zeolitic whilst the middle zone is fairly compact and non-zeolitic. Amygdalloidal, porphyritic, or glomeroporphyritic textures are noticed locally. The vesicles are filled by secondary minerals like zeolites, quartz, calcite or some earthy or ferruginous material. Well developed columnar joints and spheroidal weathering are characteristic features of the massive basalts. Weathered zeolitised traps occur in the river beds and bluish grey, soft volcanic ash beds are encountered locally. The basalts are composed of laths of plagioclase felspars (andesine to labradorite), augite, pigeonite, glass, and minor amounts of opaque ores.

**Generation of contour map**

Contours are poly line 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 Arc GIS 10. Contour map is a useful surface representation as they enable to simultaneously visualize flat and steep areas, ridges, valleys in study area. The contour map of the study area has been prepared to understand the physiographic distinctions in the study area which can be broadly divided into basaltic lava flows and alluvial plains. (Fig 2).

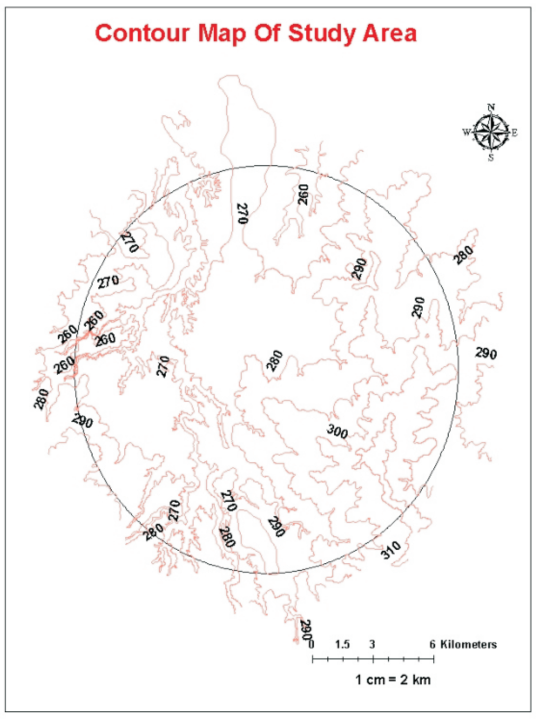


**Fig. 2 Contour map of the study area**

**Drainage pattern:**

The 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. (Fig.3).


Fig. 3 Drainage map of the study area

**Characteristics of watershed**

All characteristics of watershed related to soil type, vegetation etc. affect the disposal of water. The various parameters like size helps in computing parameters like precipitation received, retained, drained off. Different shapes based on morphological parameters like geology and structure, eg. pear, elongated etc. Physiography signifies the lands altitude and physical disposition and the slope controls the rainfall distribution and movement. The climate decides the quantitative approach. The type of drainage pattern determines the flow characteristics and so the erosion behavior. The vegetation provides information of species gives a sure ground for selection plants and crops. The geology and soils determines size, shape, physiographic, drainage and groundwater conditions. Soils, derivative of rocks are the basic to greenery whereas the hydrology is the basic to final goal of growing greenery in a watershed. It helps in quantification of water available. The hydrogeology deals with the availability of groundwater. The socio-economic and statistics on people and their health, hygiene, wants and wishes are important in managing water.

**History of Evolution of Watershed Concepts:**

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 state share 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 afforestation 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.

**Watershed development**

Man and his environment are interdependent. The changes in the environment directly affect the lives of the people depending on it. A degraded environment means a degraded quality of life of the people. Environmental degradation can be tackled effectively through the holistic development of the watershed. A watershed provides a natural geo-hydrological unit for planning any developmental initiative. Watershed is a geo hydrological unit or piece of land that drain at a common point. A watershed is defined as any spatial area from which rain or irrigation water is collected and drained through a common point. The watershed and drainage basin are synonymous term indicating an area surrounded by a ridge line that is drained through a single outlet (Fig.4). Water management, both in its conservation and control aspects, 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

*Healthy flood-plains which are well vegetated slow the flow of water andallow it spread & soak in effectively. Vegetation cutoffs & does not underground spongeleading to healthy practice.*

*Water spreads over flood -plains with poor vegetation and channelize along resulting in runoff and soil erosion leading to unhealthy practice*

**Fig.4 Schematic diagram showing the healthy and unhealthy practices of watershed development**

**Watershed resource management**

The main principles of watershed management based on resource conservation, resource generation and resource utilization are utilizing the land based on its capability, protecting fertile top soil, minimizing silting up of tanks, reservoirs and lower fertile lands, protecting vegetative cover throughout the year, in situ conservation of rain water, safe diversion of gullies and construction of check dams for increasing ground water recharge, increasing cropping intensity through inter and sequence cropping, alternate land use systems for efficient use of marginal lands, water harvesting for supplemental irrigation, maximizing farm income through agricultural related activities such as dairy, poultry, sheep, and goat forming, Improving infrastructural facilities for storage, transport and agricultural marketing and improving socio-economic status of farmers. (Anita V. Nayak, 2009). Physiographically the study area can be classified into Geomorphological studies have demonstrated the presence of five distinct landforms namely shallow dissected plateau, moderately dissected plateau, highly dissected plateau, undulations and valley fills. The shallow dissected plateau is characterized by the presence of thick weathered mantle ranging from 6 to 10m with less dissection, and intersecting lineaments indicating a potential storage zone. The depth to water level ranges from 15- 25 m bgl. The safe yield in the open dug wells various from 40-85m/d with sustained discharge of over 4 hours indicating phreatic and confined to semi confined aquifer conditions. The moderately dissected plateau occurs along the fringes of steep scarps indicating moderate thickness of the weathered horizons showing 2-6m. The bed rock is shallow and depth to water level various from 4-9m bgl with moderate water bearing horizons depending upon the placement of interflow zone suggesting the recharge nature and higher hydraulic potential. The highly dissected plateau is characterized by the presence of compact and massive lava flows showing intricate network of dissection. The availability of groundwater is scare due to negligible weathered mantle except where the top portion is either altered or due to the presence of vesicular horizon, which may retain some groundwater. The undulating plains represent potential groundwater horizons due to the availability of aquifer zones

**Digital elevation model of the study area**

Digital Elevation Models (DEMs) are a type of raster GIS layer. Raster GIS represents the world as a regular arrangement of locations. In a DEM, each cell has a value corresponding to its elevation. The fact that locations are arranged regularly permits the raster GIS to infer many interesting associations among locations: Digital Elevation Model (DEM) is a raster of elevation values. Rasters represent the world as regular arrangements of pixels (cells). Rasters lend themselves to systematic analysis of the relationships among places and their properties. For example, a Raster GIS can calculate many useful derivatives of elevation, such as: slope or aspect -- the direction of slopes or visibility -- what is visible from a spot. Synthetic hill shade calculated from a DEM is a great way to create visualizations of terrain with other semi-transparent themes. DEMs can also be used to create 3-D scenes or to create contour which may be exported to CAD programs.

Triangulated Irregular Network (TIN) is a set of adjacent, non-overlapping triangles computed from irregularly spaced points with x/y coordinates and z-values. TIN models are used to provide better control over terrain slope, aspect, surface areas, volumetric and cut-fill analysis and generating contours. The TIN's vector data structure is based on irregularly-spaced point, line and polygon data interpreted as mass points and break lines and stores the topological relationship between triangles and their adjacent neighbors. Mass Points are irregularly distributed sample points, each with an x/y location and a z-value, which are used as the basic elements to build a TIN. Each mass point has important, yet equal, significance in terms defining the TIN surface. Ideally, the location of each mass point is intelligently chosen to capture important variations in the surface's morphology (Fig.5).

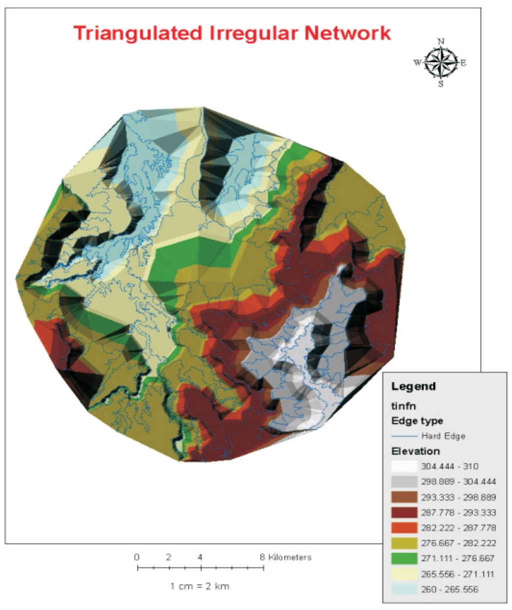


**Fig. 5 Triangulated Irregular Network**

One of the most powerful applications of DEMs is adding synthetic hill shading to maps so that the map reader may see the relationship between terrain and other things you may be mapping. Digital Elevation Models are data files that contain the elevation of the terrain over a specified area, usually at a fixed grid interval over the "Bare Earth". The intervals between each of the grid points will always be referenced to some geographical coordinate system. This is usually either latitude-longitude or UTM (Universal Transverse Mercator) coordinate systems. The closer together the grid points are located, the more detailed the information will be in the file. The details of the peaks and valleys in the terrain will be better modeled with small grid spacing than when the grid intervals are very large. Elevations other than at the specific grid point locations are not contained in the file. As a result peak points and valley points not coincident with the grid will not be recorded in the file (Fig.6).

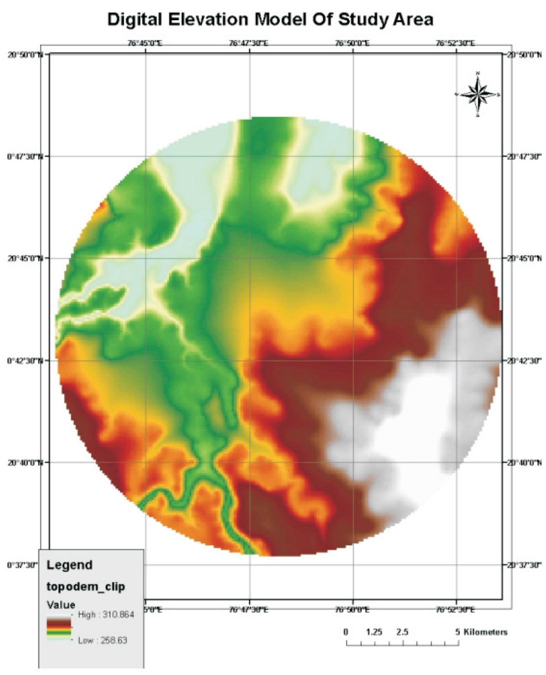


**Fig. 6 Digital Elevation Model of the study area**

**Environmental impact analysis**

The degradation of environment in the fragile Indian sub-topical eco-system is basically attributed to increasing biotic pressure, absence of adequate investments and appropriate management practices, high rate of Population growth and high incidence poverty in rural areas, over-exploitation of national resources, the break-down of traditional institutions for managing common property resources and failure of new institutions to fill the vacuum and faulty land use practices. The significant consequences are soil erosion & land degradation, depletion of natural resources, lower productivity, groundwater depletion, shortage of drinking water, reduction in species diversity, increase in the extent of wastelands. The major aspects of the watershed project related to environmental impact analysis includes soil & moisture conservation measures like terracing, bunding, trenching, vegetative barriers etc, rain water harvesting activities like farm ponds, percolation tanks, check-dams etc. planting & sowing of multi-purpose trees, shrubs, grasses, legumes and pasture land development, encouraging natural regeneration, promotion of agro-forestry and horticulture, measures needed to disseminate technology, training, extension and creation of a greater degree of awareness among the participants, encouraging peoples' participation, livelihood activities for asset-less people and production system and micro-enterprise.

**Reclassified land use and land cover pattern**

Remote sensing techniques, including the use of conventional aerial photography, can be used effectively to complement surveys based on ground observation and enumeration, so the potential of a timely and accurate inventory of the current use of the Nation's land resources now exists. At the same time, data processing techniques permit the storage of large quantities of detailed data that can be organized in a variety of ways to meet specific needs. Concepts concerning land cover and land use activity are closely related and in many cases have been used interchangeably. The purposes for which lands are being used commonly have associated types of cover, whether they be forest, agricultural, residential, or industrial. Remote sensing image-forming devices do not record activity directly. The remote sensor acquires a response which is based on many characteristics of the land surface, including natural or artificial cover. The interpreter uses patterns, tones, textures, shapes, and site associations to derive information about land use activities from what is basically information about land cover. The demand for standardized land use and land cover data can only increase as we seek to assess and manage areas of critical concern for environmental control such as flood plains and wetlands, energy resource development and production areas, wildlife habitat, recreational lands, and areas such as major residential and industrial development sites.

**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.

Land use and land cover (LULC) information is an important component influencing watershed modeling with regards to hydrology and water quality in the river basin. In this study, The study findings has revealed that the Land cover in Mun basin has changed significantly as a result of disturbances due to encroachment from farmers, fuel-wood collection and fires spreading from lowland areas. Degradation of the catchment has affected the flow characteristics in the basin as observed from increase in surface runoff and decreasing base flow (Fig. 7).

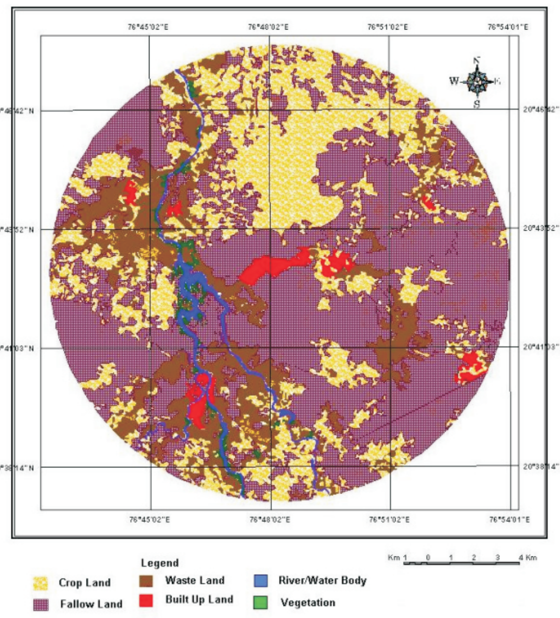


**Fig. 7 Reclassified land use and land cover map of the study area**

**SUMMARY AND CONCLUSIONS**

Digital image processing, integrated with GIS is a good way to analyze changes in an environment. Human intervention and natural hazards as factors of environmental changes can be assessed through Remote Sensing and GIS. In the present study it was found that direction of human movement, population growth trend and settlement area expansion trend/direction are to be considered when analyzing the effects of human intervention. It is suggested that a prediction model can be developed and tested to evaluate the present methodology. 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 category and 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. The Satellite 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%, 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 are largely practiced.

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