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UPPER BETWA RIVER WATERSHED MANAGEMENT AND DEVELOPMENT PLAN USING REMOTE SENSING AND GIS

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ABSTRACT

Watershed management involves management of the land, water and biological resources of a region. In the study Upper Betwa Watershed basin has been taken under investigation. During study complete inventory on geology, hydrogeomorphology, land-use, land-cover and the structural units contained in the watershed basin has been prepared. LANDSAT ETM+ Satellite data and DRM is used to demarcate hydrogeomorphological landforms and lineaments to evaluate groundwater potential of the study area. Land-use land-cover (LULC), geological and lineament maps have been generated from satellite data, with the help of ArcGIS and ERDAS imagine processing. Upper Betwa Watershed basin is occupied mostly by hard rocks and half of the portion in the study area is covered mainly by both wet and dry cultivation. The major geomorphic units identified in the study area are extremely rugged, hilly and undulating topography, comprising scattered and elongated hills, parallel linear ridges, flat plateau etc. Land-use land-cover mapping shows that most part of the watershed basin is occupied by agricultural land and forest area. Field observations showed that ground water occurs under unconfined conditions with varying water table shallow to deep depth.

KEYWORDS: Watershed basin management, Landsat, ETM data, Hydrogeomorphological and Structural landforms, GIS Processing.

INTRODUCTION

Watershed management is a practice of conserving soil, water, and biological resources using scientific principles, traditional and systems knowledge and local resources with an objective of increasing crop productivity. It involves rational utilization of land and water resources for optimum production with minimum hazards to national resources. It essentially relates to soil and water conservation in the watershed which means land use according to land potential, protection of land against all kinds of deterioration, building and maintaining soil fertility, conserving water for farm use, proper management of water for drainage, flood protection, sediment reduction and increasing productivity for all kinds of land uses (Tejwani, and Tideman as cited in Das, 1998). Use and management of water resources in sustainable manner is very important in modern age due to regular increase in water crises. Remote sensing and GIS techniques are very helping tools for gathering, analyzing and manipulating the data for the watershed management. The greatest advantage of using remote sensing data for watershed management is its ability to generate information in spatial and temporal domain. Watershed management program requires a large quantity of data from various sources which is only possible with the help of remote sensing and GIS. Remote sensing data also provides excellent information with regard to spatial distribution of vegetation type and land use in less time and low cost in comparison to conventional data. Hence, identification and quantization of these features are important for generating a groundwater potential model of an area. Currently groundwater is gaining more attention due to drought problem, rural water supply, irrigation project and low cost of development it requires. Despite the extensive research and technological advancement, the study of groundwater has remained more risky, as there is no direct method to facilitate observation of water below the surface. Its presence or absence can only be inferred indirectly by studying the geological and surface parameters. Remote sensing and Geographic information system (GIS) tool can open new path in water resource studies. Analysis of remote sensing data along the survey of India (SOI) topographical sheets and collateral information with necessary ground truth verifications help in generating the baseline information for groundwater targeting. Identification of groundwater occurrence location using remote sensing data is based on indirect analysis of directly observable terrain features like geological structures, geomorphology and their hydrologic

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characteristics. Application of GIS and remote sensing can also be considered for multi criteria analysis in resource evaluation and hydrogeomorphological mapping for water resource planning and management.

In the study, Upper Betwa watershed basin is proposed for assessment, development and management of water resources in the catchment area. Water resource development in the Betwa basin has focus on drinking water supply, irrigation and hydropower. In Upper Betwa river basin there are two major multipurpose projects namely Rajghat and Matatila. The region, though historically important, continues to be highly underdeveloped due to poor management of irrigation facilities. The rainfall is scanty, uncertain and unevenly distributed land degradation has taken place and may further increase due to continuing deforestation. Water resource of the catchment area, are under great stress due to large scale utilization of water for agricultural purpose. The basin is saucer shaped with sand stone hills around its periphery and clays underlain by Deccan trap basalts (Pandey et al. 2008a). The climate of the Upper Betwa basin is characterized by hot summer and mild winter. The air is mostly dry except during the south west monsoons. The basin lies in medium rainfall zone. Most of the rainfall is received from June to October constituting about 92% of the annual rainfall. The average rainfall of the basin is 1138 mm. The maximum and minimum monsoon rainfall values are 1400 mm and 800 mm respectively.

MATERIAL AND METHODS

Study area and data source

The area under investigation comprises upper parts of Betwa river basin. Betwa river is one of the major river originated from Barkheda village in Raisen district, M.P. rising at an elevation of about 576m. It is a southern tributary of the Yamuna River which in turn is a tributary of the Ganga River. Raisen district is situated in the central part of Madhya Pradesh and lies mostly on the plateau and partly in the Narmada valley. The watershed basin covering the Obedullahganj block of the Raisen district of M.P, which is highly industrialized and the water resources are also contaminated due to improper disposal of municipal, urban and industrial wastage. The study area falls in survey of India (SOI) toposheet No. 55 E/8,12, 55 F/5,9 and lies between 22^0 51' to 23^0 64' North latitude and between 77^0 20' to 77^0 45' East longitudes. The watershed forming the upper part of river Betwa, hence it is named as upper Betwa watershed. The area bounded in the North West by Sehore and Bhopal district.

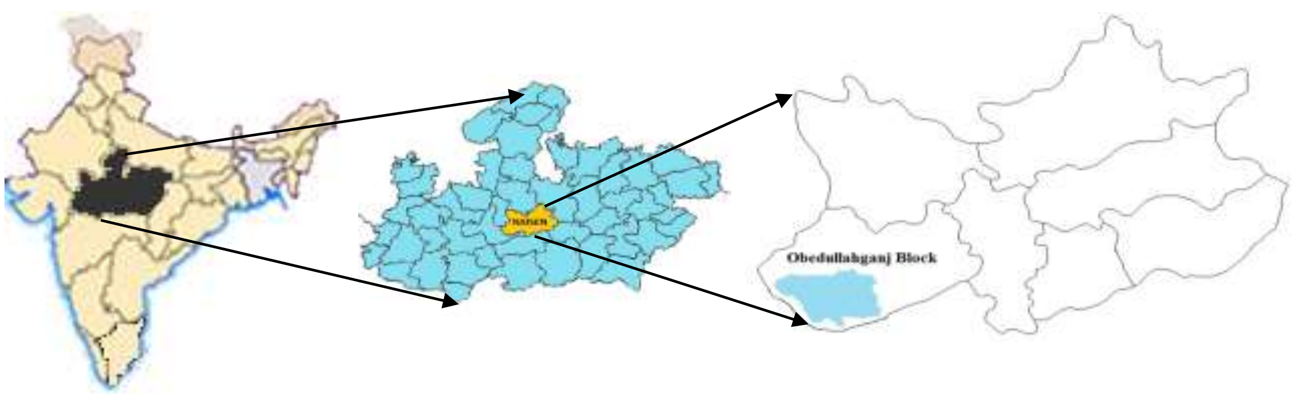

Fig.1: Location map of the study area

During the field study, complete inventory on geology, hydrogeology, hydro-geomorophological and water bearing formations have been prepared. For generation of thematic maps such as geological, hydro-geomorphological, lineament, land-use, land-cover DRM and LANDSAT-7, ETM+ the geo-coded 1:5000 scale satellite imagery was used. Basic image characteristics like tone, texture, shape, color, associations, etc were used, along with field parameters such as topography, relief, slope factor, surface cover, soil and vegetation cover were considered while delineating hydrogeomorphic and lineament maps. The survey of India (SOI) toposheets No. 55 E/8, 12, 55 F/5, 9, 55E/12, of scale 1:50000 have also been used for the preparation of base map (Fig.6) and drainage map (Fig. 4) of the study area. Identification and delineation of various units on the thematic maps are based on the color, tone, texture, size, pattern and association. All these thematic maps are also verified during the field checks. The thematic details thus finalized are transferred to the base map prepared from survey of India toposheets (SOI). Satellite imageries of LANDSAT-7, ETM+ sensor data downloaded from online available data sources (glcf/landsat/etm/data) made mosaic in ERDAS Imagine software. The image carries various types of information which has been extracted by the techniques of digital image processing with the help of ERDAS Imagine software. Then it has been integrated in GIS platform for proper understanding of surface features and processes. Various image enhancement techniques have been applied to LANDSAT data to extract information on geology, geomorphology, land use, structural features and vegetation cover (Jenson and Domingue, 1988).

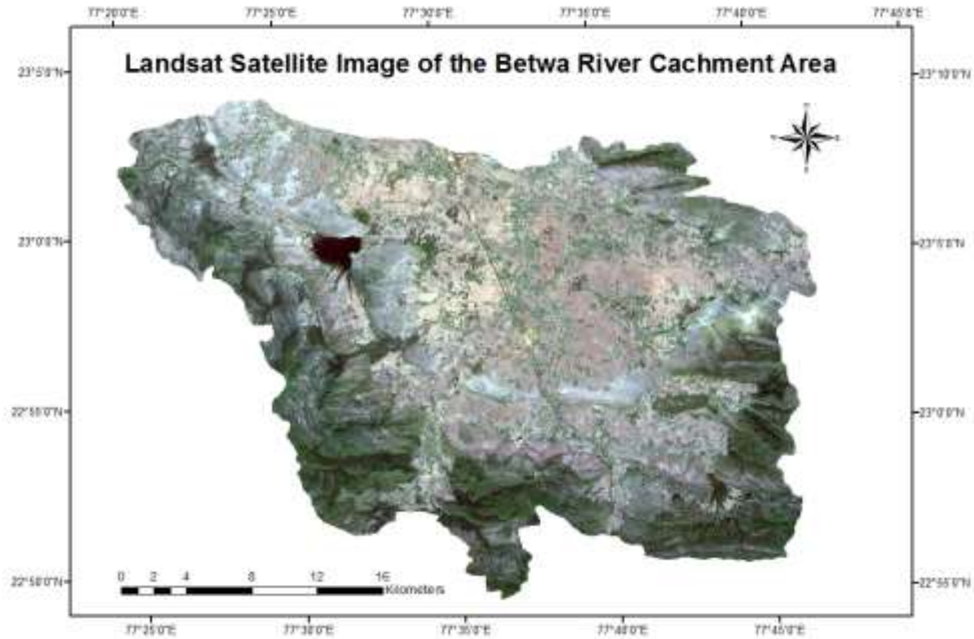

Fig.2: Satellite image of the study area

GEOLOGY

Geologically, the area is occupied by litho-assemblages of various geological formations ranging in age from the Archaean to Quaternary period. The northern part of the area is composed essentially of variegated granite and granite gneisses with enclaves of meta-sediments and meta-basics belonging to the Bundelkhand Granitoid Complex. These are intruded by NNE-SSW to N-S trending huge quartz reefs and dolerite dyke swarms. The Gneissic-Granitic suite of rocks are overlain by ENE-WSW trending volcano-sedimentary sequence of the Bijawar Group and intra-cratonic, orthoquartzite-carbonate sequence of the Vindhyan Super group in the middle parts. The lacustrine Lameta Group of rocks and the overlying flood basalt of the Deccan Trap Province cover the Bijawar Vindhyan rocks at various levels in southern and south eastern parts of the area. Soil and alluvium of the Quaternary-Recent period is mostly confined along the banks of the major rivers.

HYDROGEOLOGY

In Deccan Basalt terrain groundwater occurs under phreatic conditions in the exposed lava flows and under semi confined conditions in the flows at deeper level. Lithological constraints indicate that groundwater is present in the pore spaces of the vesicular basalt and in the joint and fracture portions of massive parts of the flows. The primary porosity in the basalts is associated with the vesicles, developed due to the escape of volatile and gases when the lava erupts on the surface as a lava flow. The groundwater in the study area therefore is restricted mostly to the zones of secondary porosity developed in these rocks due to fractures, joints and weathering. From the hydrogeological point of view, the frequency and extent of jointing, fracturing and the flow contacts and weathering along them are the most significant parameters imparting permeability and porosity for forming suitable groundwater reservoirs in the Deccan basalt.

WATER LEVEL DEPTH

In oct. (2015) field visit has been done in the study area during field survey water level has been measured in bore and dug wells at various locations in the study area with the help automatic water level recorder. Based on field measurements the average depth to water level in the study area has been recorded, ranges from 3 to 33m below ground level. Shallow water level of less than 6 m has been recorded at Bhojpur, Nimkheda, Asapuri, Bhawardeep

Industry, Bamnai, Delawadi. Depth to water level between 6 to 9 m (bgl), has been recorded at Bishankhedi, Markasiya Gotampur. Deepest water level above 10m have been reported from Nurganj(16m), Diwatiya (19), Premtalao(23) and Dahod(33) bgl showing in (Table.1).

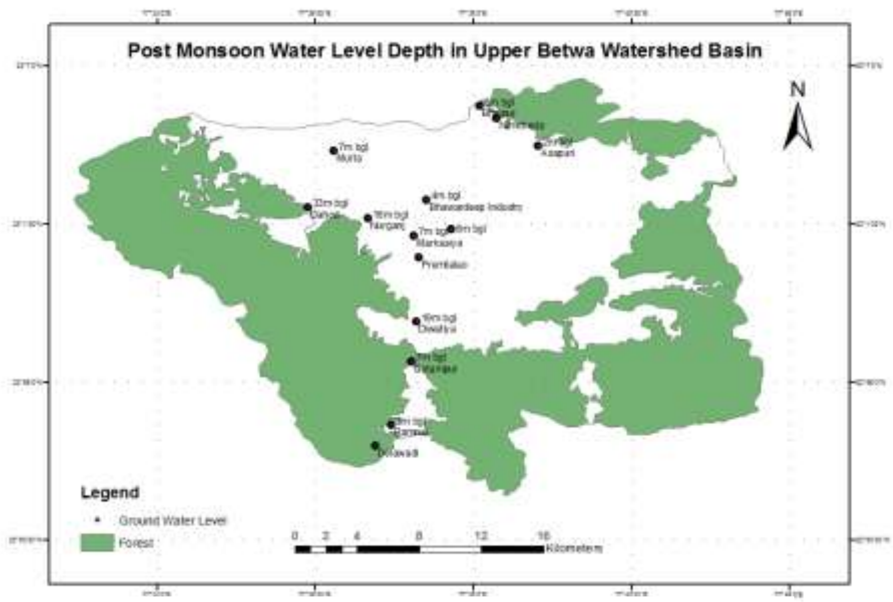

Fig.3: Map showing Post-monsoon water level depth

Formation	Location Name	Water level depth in (m) bgl
Basalt	Bhojpur	3m
	Nimkheda	5m
	Asapuri	2m
	Bishankhedi	6m
	Bhawardeep Industry	4m
	Nurganj	16m
	Premtalao	23m
	Markasiya	7m
	Dahod	33m
	Murla	7m
	Diwatiya	19m
	Gotampur	7m
	Bamnai	3m
	Delawadi	4m

Table1: Post-monsoon water level depth (Oct.2015)

GEOMORPHOLOGY

In present study Landsat-7, ETM+ images and SRTM DEM has been used for general geomorphic mapping in ArcGIS platform and various landforms were clearly identified by digital image processing and enhancement techniques. Principal Component analysis specially felt very informative tools for identification of geomorphic units present in the area of study. In general, entire study area is characterized by extremely rugged, hilly and undulating topography, comprising scattered and elongated hills, parallel linear ridges, flat plateau etc. The geomorphic units identified in the study area are shown in geomorphologic map.

DRAINAGE AND DRAINAGE DENSITY MAP

A drainage basin is a natural unit draining runoff water to a common point. This map consists of water bodies, rivers, and tributaries, perennial & ephemeral streams. The study area is fourth order basin joining the rivers, tributaries based on topography depicted in (Fig.5). Drainage network helps in delineation of watersheds. Drainage density and type of drainage gives information related to runoff, infiltration relief and permeability. Dendritic drainage indicates homogenous rocks, the trellis, rectangular and parallel drainage patterns indicate structural and lithological controls. The coarse drainage texture indicates highly porous and permeable rock formations; whereas fine drainage texture is more common in less pervious formations. Major faults, lineaments sometimes act as conduits connect two or more drainage basins. Flow of groundwater along these week zones is an established fact. Drainage pattern reflects surface characteristics as well as subsurface formation (Horton, 1945).

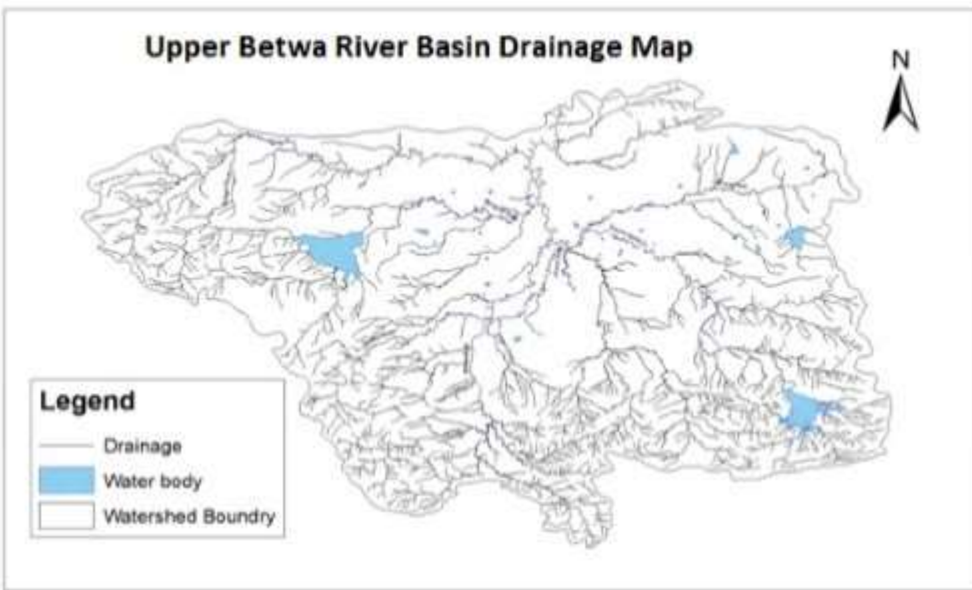

Fig.4: Drainage Map of Upper Betwa River Basin

Table2: Drainage density category

Class	Km/Km2	Drainage density category
1	0 - 1.2	Very Low
2	1.2 - 2.4	Low
3	2.4 - 3.6	Moderate
4	3.6 - 4.8	High
5	4.8 - 6	Very High

LINEAMENT ANALYSIS AND DENSITY

Lineaments are the linear features on the surface of the earth, which may be an expression of the underlying geological structures. Typically, the lineaments may be surface manifestations of fault-aligned valleys, a series of faults, fold-aligned hills or indeed a combination of these features. Their origins may be radically different due to the differing tectonic processes involved. Often the lineaments are developed in a systematic patterns and a systematic analysis of the lineaments provide information about the tectonic history of particular region (Sethupathi, et,al. 2012). Therefore, a detailed lineament study is carried out under present investigation. Here, the lineaments are mapped using Landsat ETM+ images and SRTM DEM relief maps. The main advantage of ETM+ is that the panchromatic band can be used to have an image with the resolution of 15 m, after the process of image fusion. The method of intensity–hue–saturation (HIS) is applied to enhance the resolution of LANDSAT ETM+ image bands 3, 4 and 5, which is reported to have smallest spectral error (Schowengerdt, 1997). The ETM+ images thus obtained are used for identification of the lineaments in the study. Then suitable logical weights are assigned to each unit of thematic maps and integrated in GIS using the spatial overlap method to delineate groundwater potential zones.

Class	Km/Km2	Lineament density category
1	0 – 0.34	Very Low
2	0.34 – 0.99	Low
3	0.99 – 1.57	Moderate
4	1.57 – 2.11	High
5	2.11 – 2.69	Very High

Table.3: Lineament density category

LAND USE LAND COVER MAPPING

Land use/land cover mapping is one of the important applications of remote sensing. Land use plays a significant role in the development of groundwater resources. It controls many hydrgeological processes in the water cycle viz., infiltration, evapotranspiration, surface runoff etc. surface cover provides roughness to the surface, reduce discharge thereby increases the infiltration. Land use land cover map (Fig.5) showing various land use classes of the watershed basin. In the map categorization of land-use and land-cover been made on basis of different land use land cover classes. The distributional pattern of these land use, land cover classes of the watershed basin has been evaluated shown in percentage wise (Fig.7). The land use land cover distribution is showing that, in the watershed basin agriculture covering 35% of area and forest land covering 58% surrounding the watershed basin. Open scrub covering 6% and water body covering 1% of the watershed basin.

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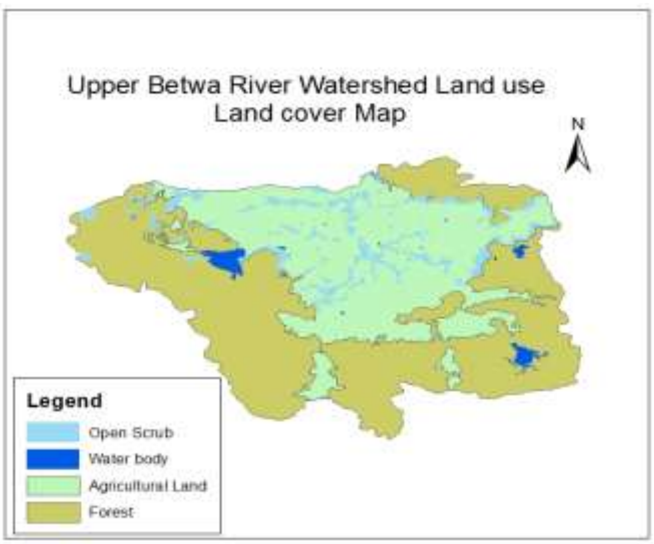

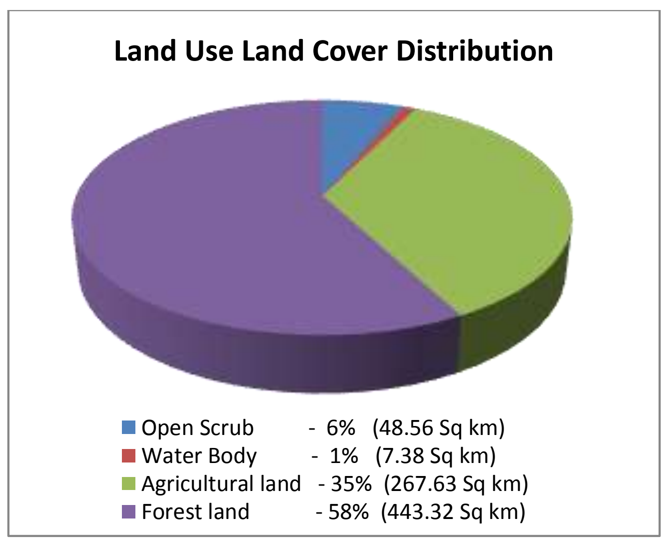

Fig.5. Land-use Land-cover map and their distribution pattern of Upper Betwa River Basin

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Fig.6: Base Map of Upper Beta River Basin

RESULTS AND DISCUSSION

Maps generated by using of LANDSAT ETM+ Satellite data, toposheets, DRM of geology, geomorphology, land-use land cover (LULC), base map and lineament with the help of ArcGIS and ERDAS imagine processing. Satellite remote sensing data has been used in the study for the in the delineation of different hydrological and structural units that have capability of water storage and discharge in the watershed basin. The identification of various litho units and structural features on satellite data has been made with the help of image interpretation keys. These maps are delineating different hydrogeomorphological and structural units having the potential of water storage and discharge capability. Data base of water bearing structures have been prepared, to evaluate the groundwater potentiality of the watershed basin. Lineament mapping of the watershed basin is showing the sign of good groundwater availability in the watershed basin. It denoting the suitable groundwater recharges and discharge zones, where groundwater providing structures like dug well/bore wells, pumping wells etc can be executed. Also base map and drainage density map has been prepared using toposheets No 55E/8, 12, 55F/5 and 55F/9 of scale 1:50,000. Drainage map showing the study area is fourth order basin joining the rivers, tributaries based on topography depicted in (Fig.5). Drainage network also helps in delineation of micro-watersheds. Landsat Satellite data supporting with DRM, and toposheets has been used to delineate the different features contained in the watershed basin. Land-use land-cover mapping showing that watershed basin is surrounding by forest area covering 58% and agriculture land covering 35% area. In the forest areas, infiltration will be more and runoff will be less whereas in urban areas rate of infiltration may decrease due to interception of rainfall by settlements. The structural units like lineaments showing the area have good potentiality of water storage capacity. On the basis of geology the catchment area is containing hard rock formations sandstone and basalt formations. As per their hydrological characteristics of basalts is impermeable, but due to intensive weathering and development of secondary porosities, cavities and fractures (cracks, joints) they become capable for water holding. Therefore, we can suggest executing the ground water providing structures.

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REFERENCES

[1] Jenson, S.K and Domingue, J. O. (1998). Extracting Topographic Structure from Digital Elevation Data for Geographic Information System Analysis
[2] Production system planning for natural resource conversation in a micro-watershed.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

[3] Horton, R.E. (1945). Erosional development of streams and their drainage basins: hydrophysical approach to quantitative morphology. Bulletin of the Geological Society of America 56, 2 75-3 70

[4] Schowengert (1997). The effect of natural network structure on a multispectral land-use/land-cover classification. Photogrammetric Engineering and Remote Sensing.

[5] Sethupathi A.S, Lakshmi Narasimhan C, Vasanthamohan.V. (2012). Evaluation of hydrogeomorphological landforms and lineaments using GIS and Remote Sensing techniques in Bargur – Mathur subwatersheds, Ponnaiyar River basin, India. International Journal of Geomatics and Geosciences Volume 3, No 1, 2012.

[6] Pandey, R.P, S. K. Mishra, R. Singh, K. S, Ramasastri, (2008a). Stream flow Drought Severity Analysis of Betwa River System (India), Water Resources Managment. 22:1127–1141.