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A GIS based approach to study changes of water use pattern of Swarnarekha watershed of Gwalior and adjoining areas in Madhya Pradesh

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Abstract*— In the present study the issue of temporal changes of surface water use pattern has been evaluated by identifying hydrological features and water use of a very important watershed of Swarnarekha River nurturing the major urban area of Gwalior and adjoining areas of Madhya Pradesh using multi-spectral satellite and latest GIS technologies. The satellite images of Landsat 7 (2003), LISS III (2009) and Landsat 8 (2014) have been analyzed for the change detection of features. Images with high classification accuracies have enabled demarcating the changes in water spread areas successively with time from the year 2003 to 2014. The pattern of major drainage lines show that the majority of water requirements of Gwalior are met by the river Swarnarekha. The catchment of the river covers around 250 sq km. This includes urban areas of Gwalior, nearby villages and small settlements. Thus the precipitated water moves overland through surface drainage lines and through the vadose zone to contribute to this river. A gradual temporal change in the water spread area has been noticed. The surface detention of rain water indicates that there is a decrease in hydraulic conductivity of the soil causing depletion of subsurface storages. However, the low drainage density and moderately fine drainage texture indicates the presence of permeable soil strata. The surface water reservoir of Gwalior is Khiraoli, the hydrological state of which is studied by the aid of remote sensing and GIS techniques, it shows that the water spread areas has decreased from the year **2003 to 2014 and the distribution pattern of water has changed.**

Keywords— ***Wateruse, pattern, hydrological, landsat, GIS***

I. INTRODUCTION

The major aim of the present study was to present the temporal hydrological conditions, and the wateruse pattern of Swarnarekha watershed of Gwalior and adjoining areas with time. The information on changes has been deduced by using multi-temporal and multi-spectral satellite data through the utilization of GIS techniques. Changes have been mainly found in wetland conditions of the watershed region. Moreover, the change detection studies, through GIS, for urban expansion, land degradation, deforestation; climatic changes, etc show that it has direct effect on water use pattern and in economic and social issues of the region. The inflow and outflow of water in a wetland through interaction with available site features is referred to as wetland hydrology [1]. The hydrological cycle shows the pattern of interactions between land, water and surrounding atmosphere. Wetlands are found in many parts of the country, from higher altitudes like the Himalayas to the Deccan plateau, from rain-forest to western desert areas. The study of temporal changes of various phenomena by GIS helps in understanding the underlying processes and thus enables modelling of the dynamics of features [2]. In order to understand the nature of physical processes, the temporal and spatial data are combined in relevance to reveal the cause and effect relationships of features, which provide precise and accurate predictions. There is always a requirement of landuse/ landcover classification of the areas in context of planning and management of resources, it may be natural or manmade. The reliable georeferenced information is sought for providing basis for sustainable development of land resources in rural and urban contexts. Some basic areas are employment, transport, agriculture, environment, housing and recreation. An important aspect of classifying the landforms as per classes is the estimation and the distribution of different types of landforms which in turn can support the exploitation of water resources of a catchment. To specify a catchment there requires establishing the surface rainfall-runoff relationship, stream flow pattern and also the area affected by the flood water of the stream. Amongst this category there stand the wetlands. Studies reveal that spatial distribution of wetlands can be obtained by optimal combination of existing spatial datasets [3]. The farming and agricultural lands can be evaluated and estimated based on the resource availabilities like water

Volume 3 Issue V, May 2015
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and soil types, channel flow and drainage system which may enable temporal prediction [4, 5]. A study suggests that the effects of wetland and water quality/quantity extend over large distances due to adjacent landuse [6]. There have been studies of effects of urbanization on water resources potential and its associated problems for the development and sustainable water management [7,8,9]; and the solution for achieving sustainability by assessing ground water resources potential has been presented [10].

In the present study area, the mean annual runoff ranges from 200 to 300 mm/year; the change in the value of runoff is affected by the type of cultivation adopted in the region. A DEM model is used here to determine the surface runoff and demarcate the catchment area. It is observed in certain areas that the forest lands have been converted to agricultural lands. This has decreased the water storage capacity of nearby areas both in quality and quantity. Accordingly, the present study provides information on the effective changes in the wetland of the reservoir and the water cover of the area. It is observed here that the complete watershed of Swarnarekha is losing water resources day by day and this is evident from the overall analysis of the water availability in the watershed of the Swarnarekha river flowing from the uphills of the southern regions of Gwalior to the southern parts of Morena, feeding many scattered settlements and parts of the Gwalior city equally. Also it is found that anthropogenic activity like increase in urbanisation of Gwalior district caused a direct effect on water quality and affected the local water cycle. Especially in the arid and semi-arid regions of Gwalior, the increase in urbanisation has created water scarcity problems which lead to poor conditions of drainage systems, both natural and man-made. Also an attempt has been made to develop a prediction equation, on the basis of regression study, to find the future distribution pattern and the temporal changes of areal extent of different features.

II. METHODS AND MATERIALS

A. Study Area

The Swarnarekha River is feeding the urban sprawl of Gwalior city of Madhya Pradesh. From historical point of view, it is the banks of this river where the queen of Jhansi, Lakshmibai, died after she lost the battle with the British troops. The river has its own historical and scientific value and is essential for most part of water supplies and groundwater recharge of the surrounding areas.

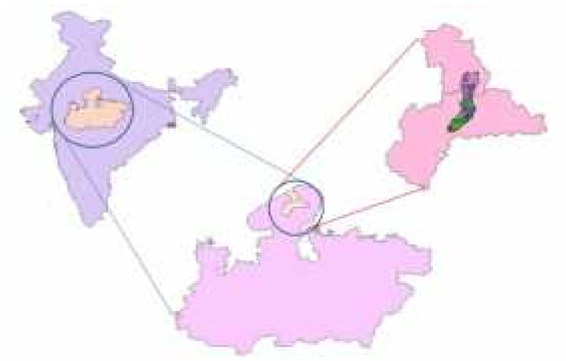

Fig. 1: Location of the study area, the Gwalior district.

The river originates in the hilly regions of Gwalior district and Meanders through to the lower reach of another district called Morena located adjacent to the Gwalior district (Fig. 1). The river originates approximately 2165 metres south to the city of Gwalior and ends about 22110 metres north from the city. On its path, it routes through various landforms and landcover regions, covering stretches of agricultural lands and patches of urban lands distributed across the borders of the two districts. The river traces its path between the co-ordinates 26°11’10” N to 26°26’35” N and 78°11’10” E to 78°06’57” E with an elevation ranging from 180 m to 250 m. The catchment area of the river covers about 280 sq km. The path of the river is inconsistent as it is a seasonal river which basically is dependent on the precipitation of the area. Serving a population spread of apparently more than 780 sq km, the river is often subjected to over exploitation and resource mobilization. The study reveals that the population increase and decrease in agriculture lands is related directly to changes in water resources volumes.

B. Image Processing

For digital image processing, the software’s like ArcGIS 10.2 and ERDAS Imagine 14 were used on the raw satellite images of landsat 7 (2003), LISS III (2009) and landsat 8 (2014) for extracting information. Landsat 8 has a total of 12 bands including the layer for quality and thermal. It also includes operational land imager (OLI) and thermal infrared sensor (TIRS). The standard band composition for natural colour is red, green and blue (popularly called as 4, 3, and 2). However, the standard false colour composite is the short wave infrared 1 (SWIR1), near infrared (NIR) and red bands (popularly 6, 5, 4). The pan corrected band provides a resolution of 15 m. The rest of the bands 1 to 9, i.e. coastal aerosol to cirrus have 30 m resolution each. The Thermal infrared bands (TIRS; band 10 and band 11) are of 100 m but are re-sampled to 30 m for delivered data products. The raw image was layer stacked in using layer stacking algorithms and the stacked image was geo-rectified. This process was accomplished using manual GCP entries from keyboard. The survey of India topo-sheets were also referred to for the process.

C. Datasets

Multi-temporal datasets of landsat were used for this study. The sensors include Enhanced thematic mapper Plus (ETM+), Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The resolution of the sensors is 30 m and Panchromatic 15 m. The ETM+ band collects one of the two gain settings being low or high for the increased radiometric sensitivity and dynamic range. An additional band 6 collects data at 60 m for both low and high gain for all the scenes. The approximate scene size is 170 km (N-S) by 183 km (E-W). The TIRS bands are acquired at 100 m which are re-sampled to 30 m. The images were projected to Universal Transverse Mercator, World geodetic system 84 (UTM WGS84). The first order polynomial transformation was adopted and re-sampling was based on nearest neighbour. Thus final images after geo-rectification obtained were matched with the topo-sheets for any unconformity which was not detected.

D. Classification

The points have been identified, through visual image interpretation, as for considering the signature for DN values of the classes. The signature files have aided in the classification of the Landsat 7, LISS III and Landsat 8 images. Signature for all the mentioned classes were recorded and About 20 signature samples were taken for each class evenly distributed all over the image amongst all the signature classes which were recorded. Supervised classification was performed based on these signatures. The multi level decisions for the classification were based on parametric signatures. The minimum distance rule was considered for the classification. This is basically the spectral distance between the measurement vector for the pixel considered and the average mean vector for each signature. Thus based on these signature values classes are generated. The classes generated in this study are basically dependant on water for their sustainability. Delineation of the study area was done using shuttle radar topography mission digital elevation model (SRTM-DEM), Fig. 2. The watershed was modelled using the same data. The watershed boundary which is “foot-shaped” is a persistent one and shows certain important characteristics. The directional property of the shape suggests the flow of the water channels from the southern part of the study area which is indeed the higher (hilly) region towards the northern part the lower valley region of the basin.

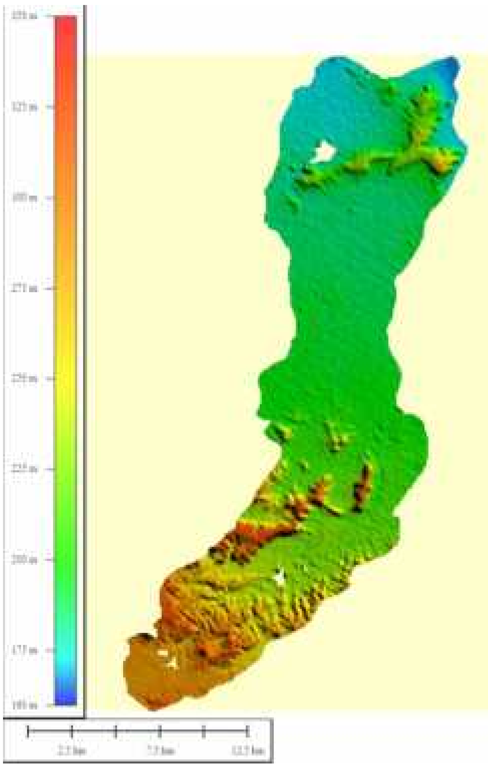

Fig. 2: Digital elevation model representation of the complete catchment area.

Volume 3 Issue V, May 2015
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International Journal for Research in Applied Science & Engineering Technology (IJRASET)

E. Extraction of Water Area

To generate the accurate area values, the classified raster was converted into vector topology so as to make precise measurements. The DEM (Fig. 2) was used to generate the aspect and slope of the study area (Fig. 3 and Fig. 4). The down slope direction of the maximum rate of change in value from each cell to its neighbours was extracted. The values of the output raster are generally the compass direction of the slope direction. This further enables to identify the gradient, i.e. the rate of maximum change in the elevation value, from each cell of the raster surface for the study area. The slope of the area varies from very gentle to steep. For the hydrological change detection analysis, image overlaying and statistical method comparisons were done.

III. RESULTS AND DISCUSSION

A. Characteristics of Khiraoli Reservoir

The overall catchment area is about 280 sq km. The catchment area under study contains vast stretches of agricultural fields, wastelands which are unproductive, water bodies like canals, streams, river, built-up area which pertain to urban area, settlements, commercial area, airport, elevated hilly regions, dense forest, etc. There are many small scattered type settlements near the reservoir. The catchment area of Khiraoli reservoir has been shown in Fig. 1. The drainage was used and change detection was done after image overlaying. The Comparative analysis shows that the area is facing water problems because over a time period of eleven years the hydrological parameters have changed. The water boundaries extracted were overlayed which pertained different time periods. The changes were prominent in terms of area under the categories of agricultural lands, water and vegetation lands.

B. Aspect of the Region

The study area shows high aspect which basically refers to the direction to which a mountain slope faces. The aspect map is an important parameter to understand the impact of sun on local climate can be understood through the aspect mapping of the area. West facing slope showing hottest time of the day in the afternoon and in most cases a west-facing slope will be warmer than sheltered east-facing slope. The distribution of vegetation type of area is effected by the aspect of the area. The aspect map derived from SRTM DEM (Fig. 2) represents the compass direction of the aspect. 0_ is true north; a 90_ aspect is to the east (Fig. 3). The Gwalior basin showing east-facing slopes and therefore, these slopes have higher moisture content and higher vegetation compare to west facing slope.

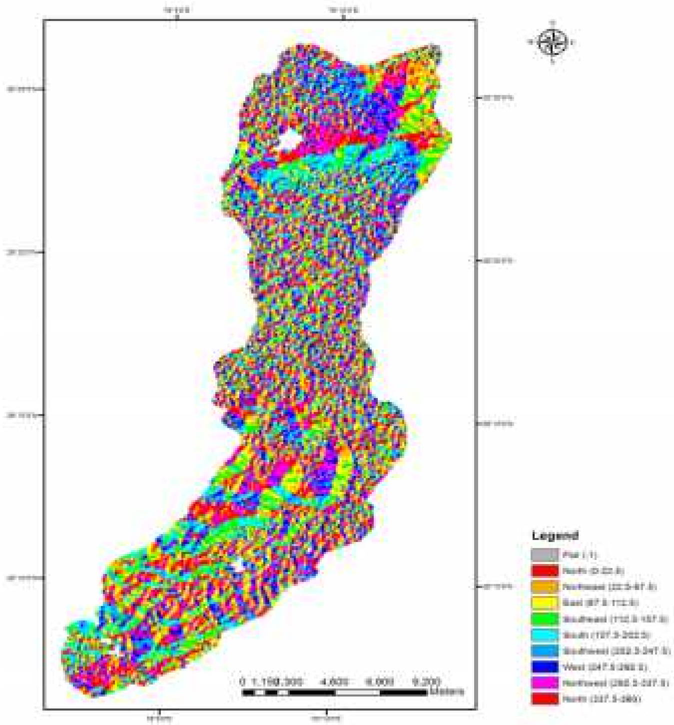

Fig. 3: Aspect map of the complete study area.

C. Slope of the Area

The slope of the region derived from Fig. 2 varies greatly in the southern region of the study area where the region is hilly and contains dense forest (Fig. 4). The slope gradually decreases from south to north and lowers to about 160m in the extreme north. The maximum area lies within 200m to 250m which almost contains the agricultural lands. The slope shows that any amount of water shall gradually drain from the southern region to the northern region, thus the Gwalior city shall in time face problems regarding water availability. The slope distribution suggests that the water availability and groundwater storage is best suitable in the north and north-eastern parts of the study area. However it also brings about a serious issue of run-off in the higher regions like the southern parts specially the Gwalior city which is a home to a large number of populations. The urbanisation shall in due course face acute water shortage problem for drinking and daily use consumption as slope hinders sustained water availability.

D. Climatological and Hydrological Conditions of Gwalior District

Gwalior district has a temperature range of one degree centigrade (in winter) to 48 degree centigrade (in summer months). The average annual rainfall is around 780 mm. The highest rainfall was measured in the year 1990 which was 1311 mm. The lowest value dates back to 2007 being 441 mm. The hydrological conditions of the reservoir greatly depend on anthropogenic activities and the climatic conditions of the area. The use of remote sensing and GIS greatly helped in estimating the areal extent [12] of surface water. Thus it helps in estimating the changes in areas of water regimes.

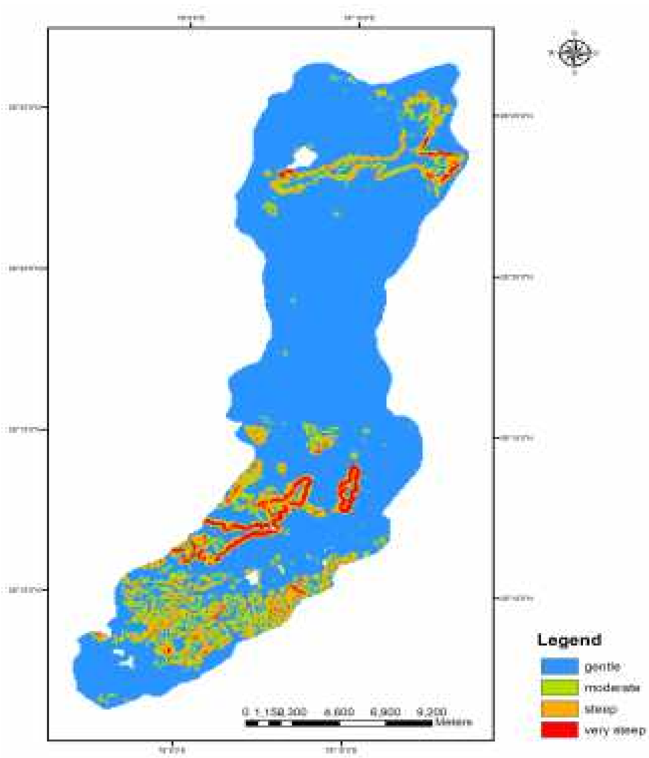

Fig. 4: Slope map of the complete catchment area.

During the period 2009-2014 the district Morena has experienced a maximum of 499 mm of rainfall in August 2013 and a low of 0.1mm in April 2011. However, there are few windows in which the rainfall did not occur and the total rainfall at many places has been recorded as null. In 2009 the highest rainfall was recorded as 274.4 mm whereas in 2013, it was 499 mm. The temperature pattern of the district has a rising trend which rose upto 36.8°C in October 2000 and low of 6.9°C in December 2000 (source: IMD, Pune). The reservoir is fed by the Swarnarekha River which originates from various small channels and tributaries of the hilly regions of the Gwalior district. The wetland area has increased to a large extent. In 2007 the area was completely under agricultural land. A very small portion was used to store water for irrigation purposes. In comparison to 2009, the scenario has changed surprisingly in 2010 and most of the agricultural land in the area has been utilized for water storage and the wetland area has increased considerably. The water storage is deep which suggests a large amount of water accumulation. The water level shows slight variation in the year 2014 in terms of colour. This is because of decrease in water level in the reservoir. This clearly suggests that there has been excess usage of water from the reservoir.

The decrease in the water level could be due to many reasons. The unwise extraction of water from the ground and thereby its consumption for agricultural purposes, household activities, industrial utilization has not only made an impact on the surface

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

water availabilities but encroachment of agricultural land is also responsible for it. The increase in urban sprawl is placing a tremendous stress on the existing water resources and thus depletion of groundwater storages due to poor hydraulic conductivity of soil imposes surface water accumulation which in time is decreasing slowly. The poor hydraulic conductivity and a large surface runoff would slow down the process of groundwater recharge, thus posing a serious threat to the conservation of subsurface water. In dry seasons, the wetland area of the reservoir is utilized by the farmers. This reduces the storing capacity often during the monsoon seasons.

E. Geological Setting of the Study Area

The Gwalior group of rocks is divided into two formations, viz, Morar formation and Par formation. This rock overly the Vindhyans group and is the youngest rocks in the region [11]. The intra-cratonic Gwalior basin is present on the northwestern fringes of granitic Bundelkhand massif. The Gwalior litho-units rest over Bundelkhand granite. These comprise of basal arenaceous Par formation overlain by volcano-sedimentary sequences of Morar formation consisting of ferruginous shale with bands of chert, jasper and limestone. The predominant rocks comprise of sandstone, shale, quartzite, doleritic dykes and alluvium (Fig. 5). The weathering has occurred mainly in shale, sandstone and alluvium deposits. These are an aggregation of

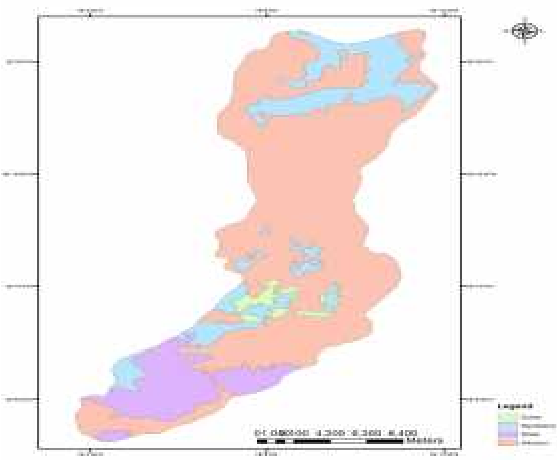

Fig. 5: Map showing geological set up of the study area.

medium-to-coarse-grained unconsolidated materials which form the principal groundwater reservoirs in the area. The thickness of this weathered zone is generally greater in the northern portion. In general, two to three water-bearing strata occur within a depth of 100 m. The thickness of each of these strata varies between 10 and 30 m. The area is covered by alluvium, which form

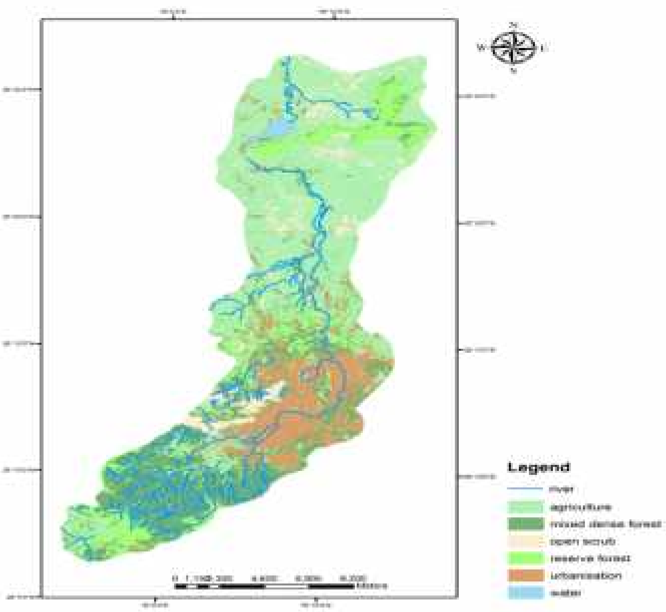

Fig. 6: Map of the study area also showing the drainage channels (laid over LULC).

the most extensive aquifer in the area, underlain by sandstone and shales and the occurrence of groundwater in different formations varies with the rock type. The water-yielding capacity of rocks largely depends on the extent of fracturing, openness, size of fracture, and nature of the inter-connections between fractures.

F. The Drainage Pattern

A drainage system is a pattern formed by streams, rivers and lakes within a particular basin, governed by certain factors like topography of the land, rock type (which can be hard or soft in nature) and the gradient of the land. These drainage basins form the basis for the watersheds of a region. A drainage basin is a kind of topographic region wherefrom a stream receives its run-off and groundwater flow.

The drainage pattern of the study area is dendritic in nature which is most commonly found drainage patterns in India (Fig. 6). Such patterns have many contributing streams which join in due course to form tributaries of a river and these channels develop from the slope towards the terrain whereas the tributaries meet at low angles and are randomly branched in a tree-like pattern. One of the major characteristic features of a dendritic drainage pattern is that they form and develop in areas of considerable or vast presence of impervious and non-porous rock. The study area has a vast distribution of channels but most of them remain dry for most part of the year. The reservoir is mainly drained by the river Swarnarekha. The river drainage pattern is basically dendritic in nature. The river flows from south to north and traces an almost linear path. The complete river path has various channels and tributaries which join the main stream at its initial stages. The significant overall water inflow is contributed by precipitation during monsoons. The elevation can be visualised by the digital elevation model of the study area as shown in Fig. 2. The drainage pattern of the study area is as shown in Fig. 6, where the drainage lines meet and converge much at the initial level but however follow a linear path and become consistent at a later stage.

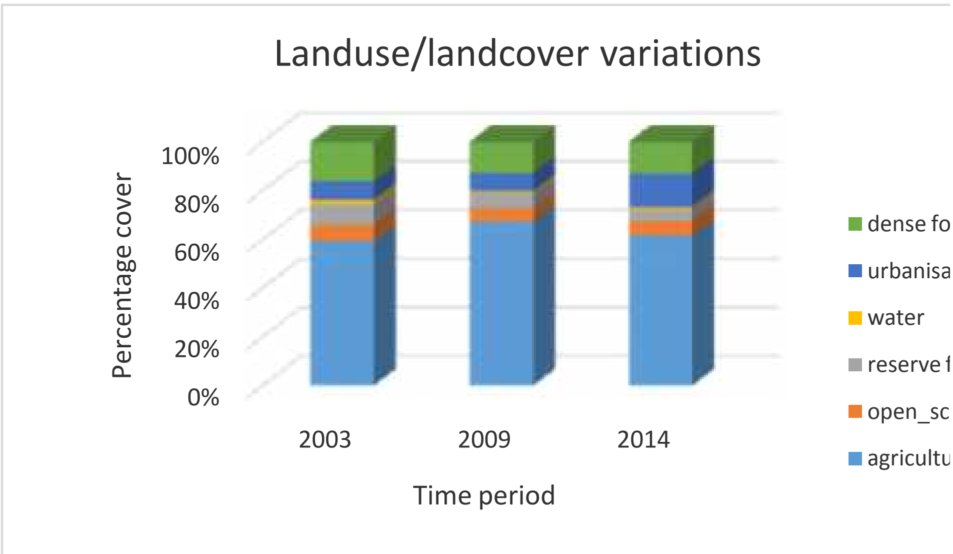

Fig. 7 – Areas of the Landuse/Landcover in percentage for several features (parameters).

G. The Status of Water Use in LULC

The classification of landuse and landcover areas with hyperspectral images provides precise information on areal extent of features of a catchment [13]. A detail study of landuse and landcover of the study area, i.e. the Gwalior and adjoining districts of Madhya Pradesh has been carried out for the years 2003, 2009 and 2014. The relative areas of the landuse/ landcover in percentage for several features, e.g. agriculture, open shrub, reserve forest, water, urbanization and the dense forest areas are shown by bar diagram in Fig. 7. The corresponding numerical values are shown in Table I. It shows that the water spread area was 1.5% of the total landcover in the year 2003 and depleted to 0.83% in 2009 and then to 0.82% in 2014; whereas the agricultural land is covered by about 55-60% with maximum in 2009 and the forest has covered consistently to about 15-18% of the total land cover area.

H. Change Detection Analysis

The change detection has been an integral part of this study as the agricultural and water areas have changed their boundaries a lot which could be observed by the comparing the imageries taken from the year 2003 to 2014. The standard change detection is

Volume 3 Issue V, May 2015
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facilitated by the current algorithms which compute the differences between the images of 2003, 2009 and 2014 at a particular threshold. This includes representations of features in different gray scale values which highlight changes. The statistics of the area derived after separate classification of the images for all the years lead to define the total effective change that occurred positively. Change determination has been done with thematic temporal overlaid imageries. The Khiraoli reservoir has a water spread area of 2182340 sq m. A significant change can be observed by the differences in water spread areas of the region. Another change that could be witnessed is in terms of reduction in the area of reserve forest. This change is accompanied with increase in agricultural lands in the same vicinity and surrounding areas. The total drainage length is equal to 264350 metres. After the renovation of the reservoir during the period of 2008-2009, the surplus amount of water was available for the nearby agricultural lands. The Figs. 8a, 8b and 8c show the temporal variations of the water spread areas of the reservoir from the year 2003 to 2014.

The land use pattern of the area is changing slowly in years and this has been interpreted from satellite imageries of different time periods. The growing size of settlements like the Gwalior city and small dwellings developing in the nearby regions of the river Swarnrekha poses a threat over the water recharge in the region. The wastewater and sewage discharge results in siltation and sedimentation of the reservoir. This affects the overall storage capacity of the reservoir and the potability of water due to deterioration of water quality. Moreover, the importance of the reservoir lies in the fact that many nearby areas and settlements like Bharrad, Kharagpur, Gulendra, Indurakhi, Madrai, Bijaypura, Baraipura, Mehtoli, etc utilize the water from the river channel and the reservoir. Thus the depletion of surface water and ground water has disturbed the balance due to the excessive use of water in many forms by the people.

(a) 2003

(b) 2009

(c) 2014

Fig. 8: Temporal images of Khiraoli reservoir, Gwalior.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

I. The Hydrological Changes

The catchment of the river covers around 250 sq km. This includes urban areas of Gwalior, nearby villages and small settlements. Thus the precipitated water moves overland through surface drainage lines and through the vadose zone to contribute to this river. The pattern of major drainage lines (Fig. 6) show that the majority of water requirements of Gwalior are met by the river Swarnarekha. A gradual temporal change in the water spread area has been noticed; the results of the changes pertaining to the numerical figures, the water covered area has decreased from 4421080 sq m (in 2003) to 2489740 sq m (in 2014) this is a significant change that 1931340 sq m reduction. This is due to the excess water consumption and depletion in the catchment area. The urban area has risen from 23049800 sq m to 30476500 sq m in spread area. This is also significant in the sense that the increase in urbanisation has put a stress on water resources which directly caused to reduce the water resources potential. The agricultural land has decreased from 200172990 sq m (in 2009) to 181540990 sq m (in 2014). This is another indicator for the lack of water resources of the region as observed in 2014. The open scrub has decreased from 19729800 sq m (in 2003) to 17048300 sq m (in 2014) due to the mere fact that the area has been utilised for construction work, built up area and mining which is a leading industry in the basaltic region of the study area. It is obvious from the observed depletion of resources during the period 2003-2014, as shown in Table I, the resources utilised and/or consumed at a similar rate persistently would produce adverse effects on water resources in the near future. It was found from the hydrological studies, by the aid of remote sensing and GIS techniques that the water spread area has increased at the earlier stages due to the construction of the surface water Khiraoli reservoir and the available drainage waters from wells. However, in the interval of time, the distribution pattern of water has changed and the water spread area decreased due to the unavailability of inflows of sufficient volume of water. The lots of surface detention of rain water indicate that there is a decrease in hydraulic conductivity of the soil causing depletion of subsurface storages. The study of satellite imageries suggest that the level of water in the reservoir has decreased too. This could be easily identified from the multispectral images of the reservoir area (Fig. 8a, 8b and 8c) which show a faded light greenish colour which depict low water depth.

TABLE I

THE CHANGE IN THE AREAS (in SQ.M.) OF DIFFERENT FEATURES DURING THE PERIOD FROM THE YEAR 2003 TO 2014

Class_Names	Area (sq m)		
	2003 From Landsat 7 Image	2009 From LISS III Image	2014 From Landsat 8 Image
Water	4421080	2597370	2489740
Open_scrub	19729800	15826700	17048300
Urbanization	23049800	21955000	30476500
Forest	72187100	70700000	70600000
Agriculture	176216000	200172990	181540990

The Swarnarekha watershed with low form factor (0.211) and an elongated shape indicates its flatter peak of flow for long period. The major channels especially of the first and second order are most often visible with higher density in the southern region where the slope declines more than the northern part. Hence the water accumulation is mostly in the central part of the study area where the soil is composed of alluvium. The low drainage density and moderately fine drainage texture indicates the presence of permeable soil strata; which supports percolation and is having moderate to good permeability. At some places the surface detention of water indicates the presence of less permeable sub-soil. The surface runoff is a major cause of denudation which leads to erosion and thereby siltation and change in the river course is occurring. The present study area shows a drainage density of 2.018 km/sq. km. This denotes low drainage density suggesting there is not much relief change in the area and permeability of subsoil is considerably high and there is good vegetation cover. Optical imageries study of the area also suggests that the area has good vegetation in terms of trees and especially agricultural lands in addition to reserve forests and dense forests. Further the rock type is also a factor determining the drainage density; the study area consists of alluvium, shale and sandstone with lower region close to the Gwalior basin as granite (Fig. 6). The vertical stratum of the soil suggests a possible presence of parts of granite in the bed region. Alluvium is the main cause of the low drainage density. The HI value of the watershed is estimated to be 0.5, which according to the threshold limits ($0.3 < HI < 0.6$) given by Strahler (1952) indicates the landscape of the area is relatively stable and still developing. It can also be noted from the curve that the medium integral value represents the early youth stage of the watershed with the landscape undissected (i.e. in the stage of inequilibrium).

IV. CONCLUSION

The hydrological studies of the Khiraoli reservoir have been carried out by the aid of remote sensing and GIS techniques. The multispectral satellite images of landsat 7, LISS III and the recent landsat 8 for the years 2003, 2009 and 2014, respectively with high classification accuracies has proved very effective in demarcating the water spread area changes in years. The above study clearly demarcates the trends in the water spread area of the reservoir from the year 2007 to 2014. The water spread area first increases due to accumulation of water, improper groundwater seepage and better precipitation conditions. Thereafter, the water spread area has decreased from 2003 to 2014 due to anthropogenic activities. The negative impacts on water resources, particularly on groundwater were due to increase in urbanization have decreased agriculture land areas. Hence from this study it can be concluded that unwise consumptions of water and human activities like unplanned and heavy infrastructure, built-up areas should be controlled check at regular intervals so that they do not extend any damage to the balance of the water resources, which in turn could harm the societal growth. The area has been marked as considerable drought prone zone by the state government and considerable actions have been planned to restore its water balance effectively. The residents of the area must be educated and well informed so as to use the water resources wisely and effectively and to prevent any misuse and overexploitation of groundwater. It is felt that to meet the requirements of adequate water balance of the catchment, the appropriate rainwater harvesting approaches are to be adopted.

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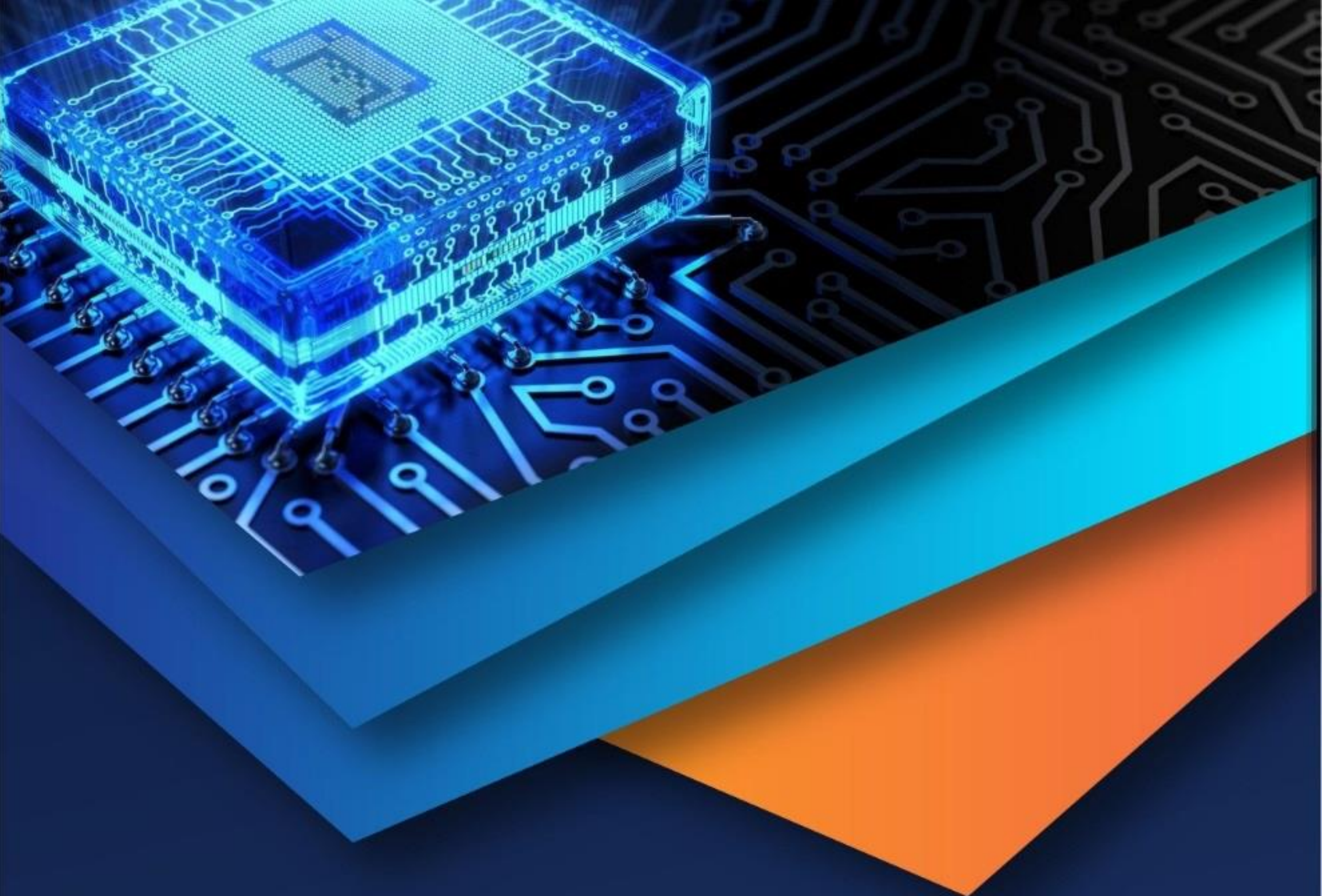

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