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Identification of Landuse Pattern Change in parts of Bundelkhand Craton, India, Using Remote Sensing and GIS

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Abstract
The Bundelkhand craton in India is composed mainly of hard and compact rocks and this area also falls under rainfall deficient region. So it is quite difficult to demarcate any water prospective zones. In the present study the area chosen are of parts of Uttar Pradesh (U.P.) and Madhya Pradesh (M.P.). The satellite images of the same region have been taken into consideration for the changes happened during the last fifteen years from 2000 to 2015. The drainage theme has been digitized and georeferenced. The two images were classified and the landuse classes identified are water body, barren lands and settlements, agricultural lands and rugged terrain with vegetation. The changes occurred have been detected through visual analysis, classified and computed area wise. Comparison tables have also been identified using the classification. The results and discussion have been mostly focused on the amount of changes and possible reasons behind that.

Keywords: *Bundelkhand craton, satellite image, change detection, land use map, classification.*

Introduction

Hardrocks (plutonic, metamorphic rocks) form part of the basement of the continents and, as such, occupies large areas throughout the world. Bundelkhand craton is the northmost craton of the Indian shield, which is concealed under the Indo-Gangetic Alluvium extending in the north up to Himalaya, separated from the Satpura mobile belt (CITZ) in the south and the Aravalli craton in the west by the Proterozoic Vindhyan basin.The largest single Purana basin i.e., Vindhyan basin trends in ENE direction having sickle shape, situated in the Bundelkhand Craton.The enclave suite of supra-crustal rocks within orthogneiss, granite with associated quartz reefs and rare felsic volcanics and mafic dyke swarms are the main components of the Bundelkhand craton. The vast Vindhyan basin wraps around Bundelkhand granite and covers the exposed area of 60,000 km^2. The reefs are spectacular landmarks in the Bundelkhand craton. These emplacements of NE-SW trending giant quartz reefs along brittle to ductile shear zones probably mark the end stage hydrothermal activity related to granitic plutonism. The Quartz reefs have a larger hydrogeological potential as these lineaments enhance weathering and increases connectivity and storage. The Vindhyan ranges give rise to some major tributaries of Ganga and Yamuna e.g. Son river, Betwa river, Dhasan river etc. The Betwa contributes around 50% of the water available in Bundelkhand upland and plain sub regions and the Ken contributes around 25%. Betwa rises from the Vindhyan ranges in Bhopal district at an elevation of around 1300 feet above mean sea level and meets the Yamuna in Hamirpur district. The major tributaries of Betwa are Dhasan, Jamini and Binarivers. Construction of weir and canals began in Bundelkhand in the late 1880s, as the water scarcity measures and to serve the irrigation purposes. There are combination of 7 dams, weirs and canal systems on the Ken, and 19 dams and canal systems on the Betwa. There are also 11 dams on tributaries of the Betwa. The Matatila dam on the Betwa river was the first major project taken up after Independence. Rajghat dam is also constructed on Betwa river. Other smaller dams in this area named after the rivers they obstruct, include the Jamini dam, Rohini dam, Sajnam dam, Shahzad Dam and Govind sagar dam which is constructed across the river Shahzad. Remote sensing is without doubt the backbone of hydrogeological reconnaissance in areas of the world where the coverage of the detailed geological maps and field data is insufficient (Hoffman and Sander, 2007). Remote sensing and GIS can prove useful tools in defining the spatial and temporal changes along rivers, lakes, water reservoirs etc. and in ground water exploration. A number of papers have been published in hydrogeology among them many surfacial features are derived from satellite images for delineation of groundwater in the hard rock terrain and identification of artificial recharge site (Saraf and Choudhury ,1998). Lineaments identification is an important step for the ground water exploration (Gustafson and Krásný, 1994).The quartz reefs in the Bundelkhand region are major lineament features present which are buff and milky white and is monomineralic rock. At places they are intruded by veins and stringers of milky white quartz and quartz-epidote rock. The reefs are highly jointed. Several dolerite dykes are also present in the area which are trending NW-SE, however, a few trend N-S and E-W (Goyal and Jain, 1972-73). Land use/land cover changes, as well as the vegetation cover change, have been well recognized as some of the most important indicators for global and regional environmental changes (Meyer and Turner, 1994; Saraf et al. 2001, Lindquist et al., 2008) The main objective of the present research is to utilize GIS and remote sensing applications to access the reservoir induced vegetation changes, in the past 15 years. Using the LANDSAT 7 ETM+ data of the years 2000 and 2015 for the concerned area, and to evaluate the changes in the vegetation cover caused by the water reservoir formed by the construction of the dam on the rivers, streams and by other reasons.

Materials and methods

Study area

The area is located between latitude 24°30’-25°N and longitude 78°- 78°30’E covering an area of approx. 2,500 sq. km. (Fig. 1). The climate is sub humid and it is characterize by a hot dry summer and a cold winter, about 91%of rainfall takes place from June to September.

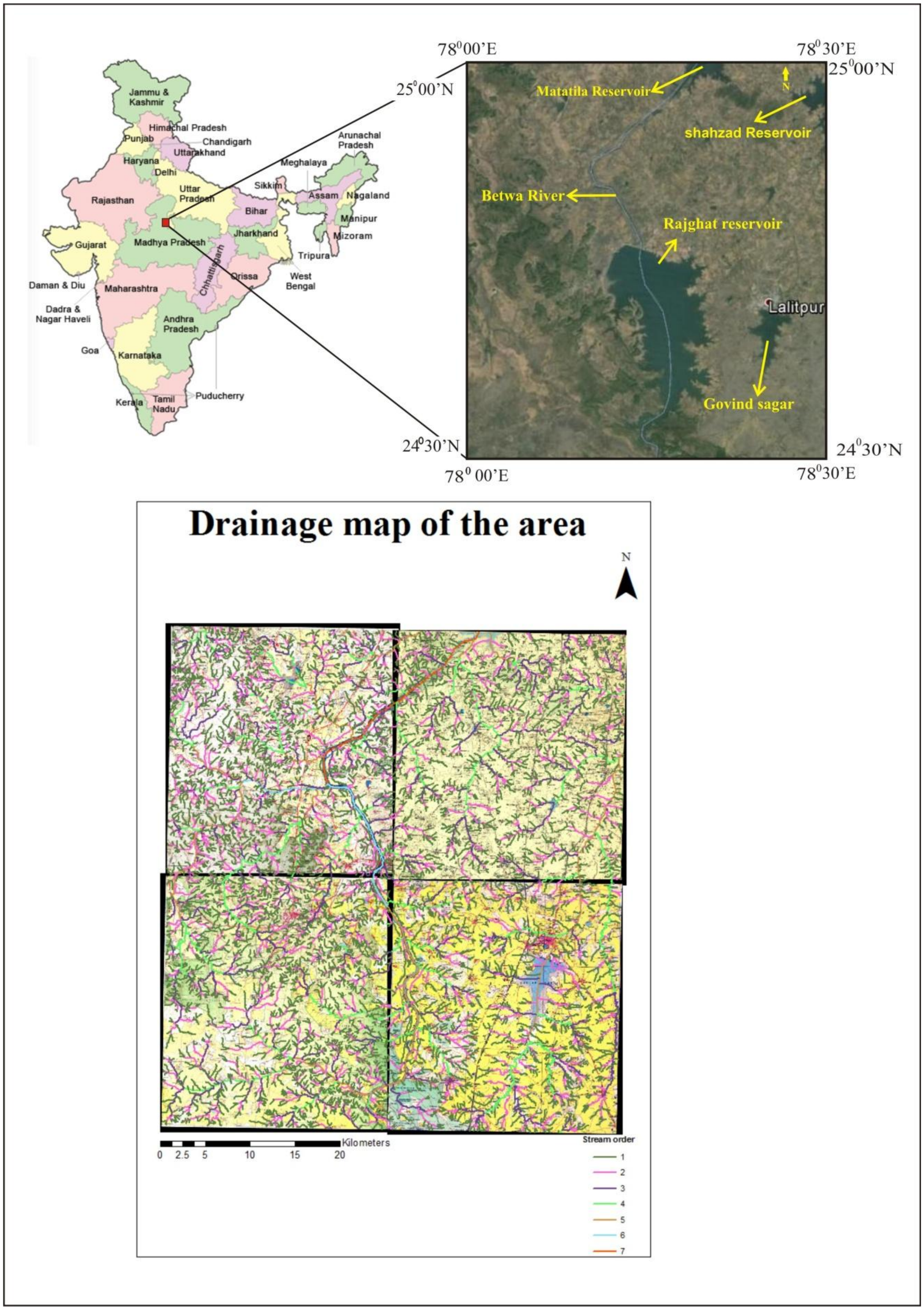

Fig.1: Location map of the study area

Geological set-up

The area mostly occupies a major part of the Bundelkhand craton in the north and the traversed by Vindhyan ranges in north-west south-east periphery. In the lower southern part Deccan traps could be traced and these are generally 'aa' type horizontal flows. Granitoids cover about 80% of the area and in the lower part the Vindhyan shale and sandstone could be noticed (Fig.2). The basement in the Bundelkhand craton consists mainly of highly deformed grey TTG gneisses, mafic and ultramafic rocks, quartzites, banded iron formation, schists and calc-silicate gneiss (Sharma and Rahman, 2000; Mondal et al., 2002). The Bundelkhand region was cratonized by 2500Ma. The spectacular landmark of Bundelkhand are the holocratic intrusive quartz reef which are developed in the brittle –ductile shear zones (Rodday et al.,1995). A NW-SE trending swarm of mafic dykes of dolerite and gabbro are also characteristic feature of the Bundelkhand (Ramakrishnan and Vaidyanadhan, 2010). The ground water occurs in these crystalline rocks along the joints, fracture and other weak plains under the water table conditions. The Vindhyan Kaimur ranges are also exposed on the north western flank of the image the major rock type in this area are mainly quartz arenitic sandstone intercalated by shales. The general startigraphic succession of the Bundlekhand Craton is given in Table 1. These sandstones are massive and compact which make them bad aquifers, only weathered product and joints present on the surface level forming potential aquifers.

Table 1: Stratigraphic succession of the Bundelkhand Craton (After S.P. Singh *et al.* 2007)

	Rock types
Vindhyan Supergroup (1400-1700 Ma)	Lower vindhyan limestones and dolomites, quartzites, Kaimur sandstones and shales, Rewa sandstones and shaless, Bhander carbonates
Bijawar/Gwalior group (1800-1600 Ma)	Sandstones, quartzites, micaceous quartzites, meta basites, ferruginous shale and sandstones, BHJ, limestones and dolomites
Mafic emplacement (2000-1800 Ma)	Dolerites, gabbro, lamproites, quartz veins and reefs, granites
Late phase granitic emplacement (2300-2000 Ma)	Quartz reef, Granitoids, Pegmatites, diaspore and pyrophyllites
Bundelkhand Granitoids (2600-2500 Ma)	Leucogranite, biotite granite, hornblende granite, hornblende- biotite granite
Bundelkhand metasedimentaries and metavolcanics(3000-2600Ma)	BMQ, rhyolite, andesite, rhyodacite, quartzite, micaceous quartzite, chlorite schist, talc schist, pyroxenite, gabbro, peridotite, calc silicate
Bundelkhand Gneissic Complex (>3300Ma)	Granite gneiss, Calc silicate, gneisses, quartzites, garnetiferous gneiss, sillimanite-cordierite gneiss, amphibolites, TTG

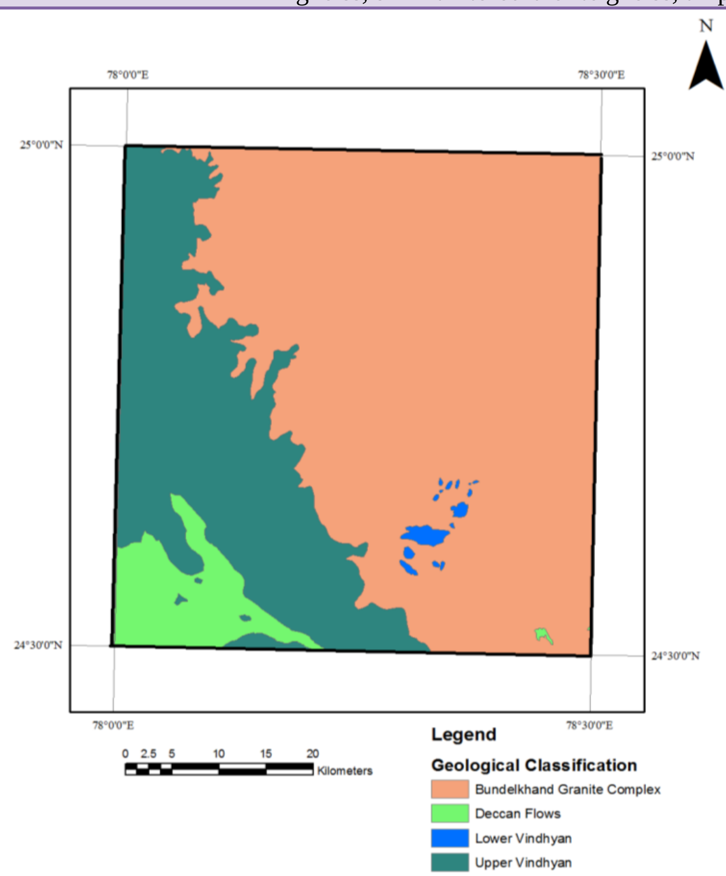

Fig. 2: Geological map of the studied area

Rivers and reservoirs

Main river flowing through this area is Betwa river, which rises from Vindhyan ranges in Bhopal district at an elevation of around 1300 ft. above sea level and meets Yamuna in Hamirpur district. The river has 14 principle tributaries out of which 11 are completely in Madhya Pradesh and 3 lie partly in Madhya Pradesh and Uttar Pradesh which includes Jamini, Khurahai, Orr, Maikua , Belnanadietc. Matatila Dam is a noteworthy project on the Betwa river. It has been extensively used for drinking, irrigation, fish culture and generating electricity. Rajghat dam made of Betwa River takes care of irrigation facilities of both Uttar Pradesh and Madhya Pradesh. Govind Sagar reservoir located near Lalitpur district headquater is made across Shahzad river which is again a tributary of Betwariver. Jamni river also has many tributaries including Sajnamnadi, Utarinadi, Baraiyanala etc. Small weirs are also made to obstruct several rivers in the region. Small natural lakes are seen in the area which formed due to secondary porosity developed by quartz reef present in the Bundelkhand Granites.

Data and Methodology

Image pre-processing

River channel and reservoirs has been extracted from the Survey of India (SOI) toposheet no. 54L/1, 54L/2, 54L/5 and 54L/6 on the scale of 1:50,000 using Arc Map 9.3. In the next processing, two clear, cloud free (<20%) LANDSAT 7 ETM+ SLC on (1999-2003) and SLC off (2003- present) images of path 145 and row 43 from date 4 February 2000 and 19 February 2015 was downloaded from Earthexplorer.usgs.gov. The 2015 image was rectified using ERDAS 9.2.Geological map from Geological Survey of India (GSI) of toposheet 54/L on the scale of 1:63,360 were used for the assessment of the rock type influencing the water resources in the region.

Image Classification

The Landsat ETM+ data of spatial resolution 30 meters was classified using ERDAS 9.2 on the classes of (1) Water bodies (2) barren lands and settlement (3) heavy vegetations and (4) agricultural lands. Both the images are of pre-monsoon time. This study adopts the remote sensing technique to monitor the changes induced by the reservoir in last 15 years. A technical flowchart for this research is given below

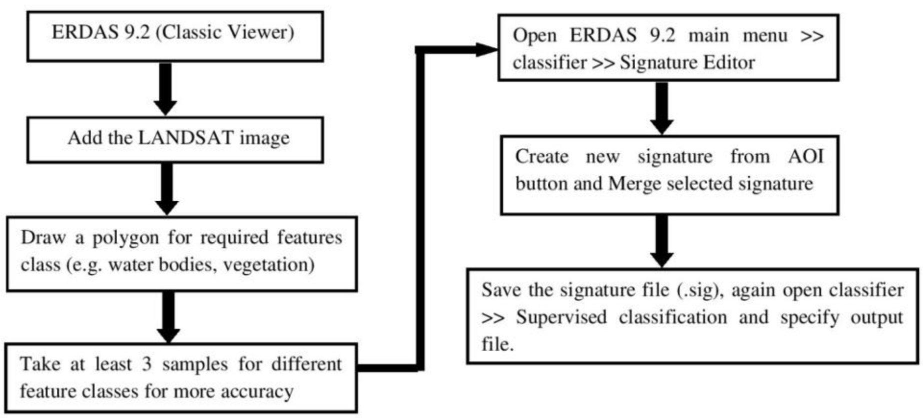

Fig 3: Flowchart of the methodology

Results and Discussion

The final land use classification tables (Table 2 and Table 3) consist of 4 classes and considerable changes have occurred in 15 years. The total area of the studied region is approx. 2500 sq. km. In 2000, water bodies were covering 168.00 km^2 of the total area but in 2015 it declined to 154.75 km^2. The heavy vegetation on the Kaimur ranges also decreased from 1243.75 to 620.25 km^2 which is about 24.94% decline. The spatial extent of agricultural land, however, changed drastically from 795.50 km^2 in 2000 to 1442.5 km^2 in 2015 due to water resource availability. Although, the extent of barren land and settlement has declined from 292.75 km^2 to 282.5 km^2.

The present study has used Landsat 7series ETM+ standard FCC of 30 meters resolution. For the change detection technique two different dates of satellite images have been used. First image is of date 4 February 2000 and second image is of date 19 February 2015. The changes in the land use patterns have been studied, compared and analyzed.

Four different land use classes have been identified in both the images. The classes are 1) Water Bodies, 2) Rugged terrain with vegetation, 3) Agricultural Lands and 4) barren lands and settlements (Fig. 4). The barren lands and Settlements have been kept within single class as their spectral signatures are quite similar for the visual analysis while classifying the satellite images. In reality both Settlements and Barren Lands show light grey to yellowish tone which comes out as light blue color in the satellite images (in standard FCC).

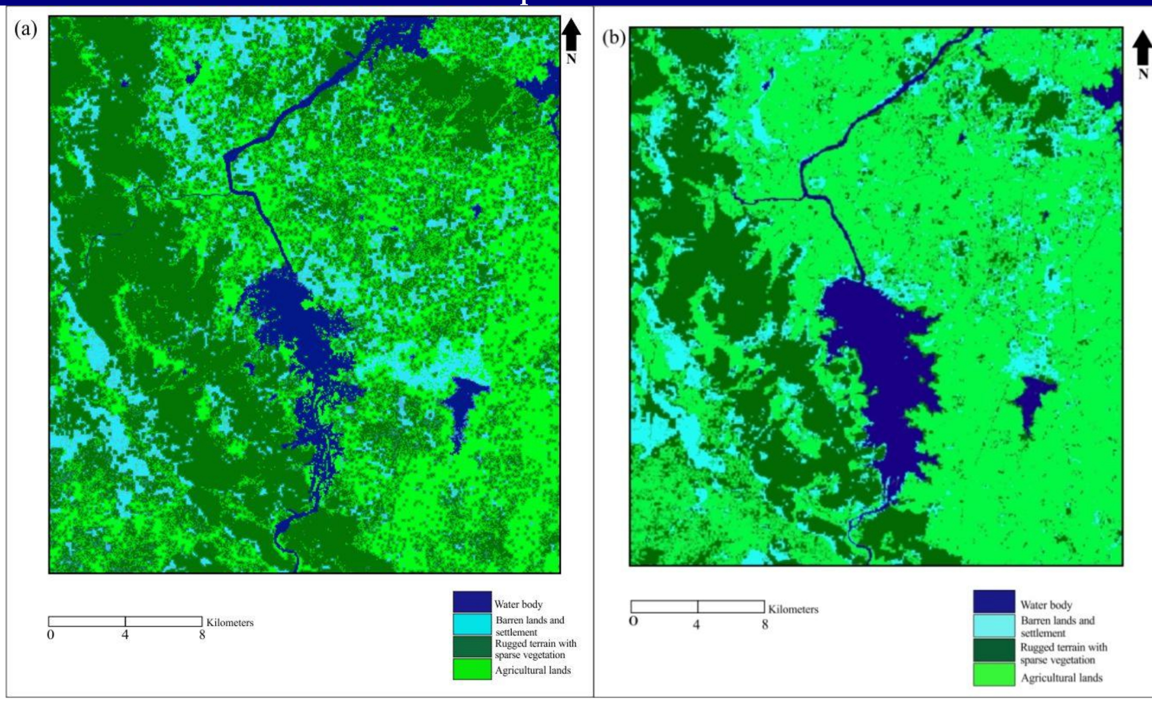

Fig. 4: Illustration of the changes in the land use and land cover (LULC) of the studied area in (a) February 2000 and (b) February 2015

Table 2: Land use and land cover patterns in 2000

Land cover type	2000 (Area in %)	2000 (Area in km$^{2)}$
Water bodies	6.72	168.00
Rugged terrain with vegetation	49.75	1243.75
Agricultural land	31.82	795.50
Barren land and settlement	**11.71**	**292.75**
Total	**100.00**	**2500.00**

Table 3: Land use and land cover patterns in 2015

Land cover type	2015 (Area in %)	2015 (Area in km^2)
Water bodies	6.19	154.75
Rugged terrain with vegetation	24.81	620.25
Agricultural land	57.70	1442.5
Barren land and settlement	11.3	282.5
Total	**100.00**	**2500.00**

While classifying the images the study area is comprising of 3 Reservoirs namely, Rani Laxmibai Sagar (locally known as Rajghat Reservoir), Govind Sagar and Shahzad reservoir. The Southern portion of Matatila reservoir is also present at the northern most part of the study area. After comparing the two landuse images it seems that there is a slight decrease in the area coverage of water body class. This has happened because the Rajghat reservoir has increased in its size, the Matatila reservoir has shrunk. Hence, few square km area of water body has decreased in class 2015.

Coming to the next class, the rugged terrain with vegetation has been decreased drastically during the last 15 years. From the GSI Quadrangle map, it has been observed that the rock types present in the area are mostly of Upper Vindhyan (Kaimursandstones). Though sandstones are good reservoir of water because porosity and permeability but physiographic of the Vindhyan in this area are rugged hills with elevation up to 550 meters. So if the rainfall occurs the rain water actually flows along the slope of the hills and accumulated at the foothills. So the water recharge has mostly taken place at the base of the hills. Hence, there is decrease in the area of this Vindhyan terrain in the study area. Agricultural lands have got a major boost during last 15 years. The loss in Vindhyan terrain is actually a gain for the agricultural lands. The increase in the area of the agricultural lands is due to two reasons: (1) the agricultural lands are mostly present at the base of the Vndhyans and geomorphologically they are flat terrains. Hence, anything after the rainfall

all water they flow along the slope and accumulated at the base. (2) The agricultural lands are present over the Bundelkhand Granitic Complex which are heavily weathered and shattered which produced suitable soil for the agriculture. The Groundwater recharge is a prime factor as this area does not fall under heavy rainfall zone, so the artificial recharge is very much necessary over here and that actually depicts through the increase in agricultural lands from 2000 to 2015.

Two major towns are present in the study area these are (1) Lalitpur and (2) Chanderi. In between these two Rajghat is also having a moderate size colony due to Betwa River Board office. The Barren lands and Settlements have minor changes in last 15 years and that definitely confirms that barren lands have actually decreased and Settlements have slightly increased.

Conclusion

From the present work it is very evident that there are significant positive changes have taken place during the year 2000-2015. The agricultural lands have been increased by a sizable portion owing to the good amount of recharge by the reservoirs present in the area. The water body may have shown a slight decrease in area but that actually corresponds to the minor shrinking of the area of Matatila reservoir may be due to silt deposition. The barren lands have also decreased marginally. The major improvement is due to the rugged terrain which has actually been converted to the agricultural lands. Hence, the greenery of the area and the potential to hold water into the soil has enhanced greatly. The water has been recharged underground and the evidence of that can be seen over the ground in terms of agriculture and other forms of vegetations.

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