Land Cover/ Land Use Classification and Associated Image Characters in A Rainfed Watershed Based on Geospatial Techniques

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Abstract— The present study aims to find out the land cover/ land use of a rainfed watershed in Lalitpur district of Uttar Pradesh. The total area of the watershed is 995.86 Km^2. The watershed falls in central Bundelkhand region in Uttar Pradesh. In this study, IRS P6 LISS III satellite data was used to create a land cover/land use (LC/LU) map of the watershed using the visual image interpretation techniques. Twelve land cover/land use (LC/LU) classes were identified using standard false colour composite (FCC) image. It has been found that the watershed is predominantly occupied by agricultural land (cultivated land and uncultivated land) contributing to more than 80% of watershed area. The watershed generally depicts moderate to high runoff characters.

Index Terms— IRS P6 LISS III, Land cover/ land use, Spectral Signature, Visual Interpretation

I. INTRODUCTION

Knowledge of land cover /land use (LC/LU) is important for planning and management of natural resources for sustainable development of man and environment. Spatial variability in distribution of land resources and changes brought in it due natural processes; human activity and interaction with other biological forms continuously modify these resources. LC/LU is therefore subjected to continuous change and will be dynamically changing due to natural causes (earthquakes, volcanic eruption, upliftment of the land due to magmatic activity/rejuvenation of the land/river course, flood and droughts) or due to anthropogenic activity, considered a major cause during recent decades (Mengistu and Salami, 2007; Javed and Khan, 2012).

Terms Land cover/land use (LC/LU) may appear synonymous and have been used interchangeably but these are separate entities and needed to be discussed separately (Dimyati et. al, 1996). Whereas the term *Land cover* relates to the physical characters of the earth surface like pervious or impervious land, vegetation, waterbodies, landforms etc., the term *Land use* strictly relate to the human activity or the function associated with a particular piece of land.

Land cover / Land use (LC/LU) studies based on ground surveys are expensive, labour intensive and tedious. Remote sensing and GIS facilitate such studies by allowing constant monitoring and analysis of the periodical changes for larger areas simultaneously. Substantial improvement in the remote sensing techniques for LC/LU mapping and monitoring with the development of sophisticated tools for the analysis of spatial and non-spatial data has multitude the ability to quantify the various attributes of the ecosystem (Kasturirangan, 2001; Ramachandra and Kumar, 2004). Images can be either classified using the object based image classification where image pixels of a particular digital number values (DN) values are assigned a specific category. The image generated usually have "salt and pepper" appearance and is of rough textured which could be due to either heterogeneous landscape or sudden jump of one category DN values to another category DN values. (Chen et al., 2012; Zhang et al., 2014). However, the visual interpretation technique involves detailed mapping, which is tedious but comparatively more accurate as in case of fuzzy boundaries by considering mean distance from the fuzzy area. The accuracy achieved in maps generated by visual interpretation techniques is relatively high (Zhang et.al. 2014) in comparison to supervised, unsupervised and object based image classification methods (Fallati et. al., 2017).

II. STUDY AREA

Study area falls in Lalitpur district of Bundelkhand region of Uttar Pradesh between Latitude 24° 11' N to 25° 13' N and Longitude 78° 11' E to 79° 0' E. Lalitpur district is bounded in the north by Jhansi district of Uttar Pradesh, in the east by Tikamgarh and Chattarpur district of Madhya Pradesh, in south by Sagar and in the west by Guna and Shivpuri districts of Madhya Pradesh. The geographical area of the district is 5039 Km^2. It is divided into three Tehsils namely Talbehat, Mandawara and Mahrauni, which have been further divided into six developmental blocks namely Bar, Talbehat, Jakhaura, Birdha, Mahrauni, and Mandawara.

The watershed spreads over a geographical area of 995.86 Km^2 in the eastern half of Lalitpur district and partially covers Bar, Birdha, Mahrauni and Mandawara blocks. It is bounded by '24°18' 31.61" N to 24° 54' 6.21" N latitudes' and "78° 26' 24.52" E to 78° 44' 30.79" E longitudes', falling in Survey of India toposheet numbers 54 L/6, 54 L/7, 54 L/9, 54 L/10 and 54 L/11. River Jamni and Betwa flows through and around the district, which becomes completely dry to partially dry in several places during summer season as most of the tributaries are rain fed. The study area comprises of a crystalline basement with the Banded gneissic complex as the basement rock. The soils are locally named Rakar and Parwa/ Rakar soil is red gravelly/sandy soils containing quartz, microcline, orthoclase etc., very shallow-to-shallow, low in organic content, low water retention and water holding capacity and excessive permeability. Whereas Parwa soils are light brown to yellowish brown textured soil, with shallow depth due to presence of hard impervious subsurface in the form of calcium carbonate which forms an assured source of nutrient availability .

The climate in the district is typical subtropical climate with severe summer and cold winter with an average annual rainfall of 846.73 mm displaying three distinct seasons of summer, monsoon and winter

III. MATERIALS AND METHODS

Survey of India (SOI) topographic maps pertaining to 54 L/6, 54 L/7, 54 L/9, 54 L/10 and 54 L/11 on 1:50000 scale were used for base map preparation. IRS P6 LISS III data of 5th March 2015 with band combination of 4, 3, 2 and a spatial resolution of 23.5 meter was used for generating an standard false color composite (FCC) (Fig. 2). All the data sets were rectified using the ERDAS imagine software. The toposheets were registered by putting the XY coordinates values as ground control points. The satellite imagery bands were first layerstacked in ERDAS imagine software using the raster toolbox module to produce a standard FCC. The image was then georeferenced using the map to map registration and was projected to Universal Transverse Mercator (UTM) projection and world geodetic system 84 (WGS84) as datum. Visual image interpretation technique based on the photographic elements such as tone texture, shape size, pattern, association and field knowledge has been used to identify the various LC/LU categories. The image was clipped to the watershed extent and various LC/LU categories were digitized using the polygon tool in Arc Map 10.2 software.

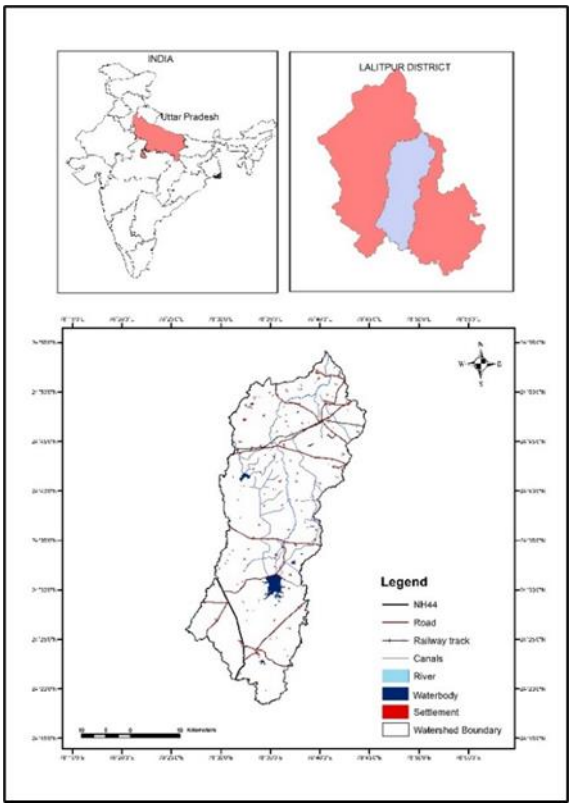


Fig 1: Location map of the watershed

IV. RESULTS AND DISCUSSION

Visual interpretation is a useful technique, which involves the same principle as of identifying features on the aerial photograph with the help of tone, texture colour, shape, pattern and association (Lillisend and Keifer, 2004). The automated classification of LISS III data could be erroneous because of the presence of only four bands in the visible and NIR region, which may not result in better classification. The main purpose of the present analysis was to study the pattern of LULC change in the Sajnam watershed and asses its hydrological impacts on the runoff generation. The IRS data analysis led to the identification of and delineation of following categories of LULC: (i) Cultivated land (ii) Uncultivated land (iii) Dense forest (iv) Open Forest (v) Open Scrub (vi) Waterbody (vii) River (viii) Dry waterbody (ix) Settlement/ built-up (x) Wasteland (xi) Stone Quarries (xii) Industrial Land (Fig 3).

With the help of extensive ground truthing and google earth image a detailed information on spectrally recognized signatures of IRS P6 LISS III standard false color composite (FCC) for various LC/LU categories have been tabulated (Table 2).

i. Cultivated Land (CL): Cultivated land occupies approximately 582.14 Km^2 (58.45%) geographical area of the watershed and is the most dominant land use class. It shows bright red to dark pinkish tones on image depicting various stages of the growth of the crop plants. The texture of the cultivated land at a zoom of 1:50000 was smooth to rough which may be attributed to the small rectangular shaped fields (Fig 4(i)).

ii. Uncultivated Land (UC): Uncultivated land covers a geographical area of approximately 246.79 Km^2 (24.78%). It exhibit bright bluish tone, smooth texture at 1:50000 zoom scale, noncontiguous pattern and irregular shape (Fig 4(ii)). During ground truthing it was found that the uncultivated land are mostly bare soil without any mulch or root cover from previous crops and are closely associated with the cultivated land.

iii. Dense forest (DF): Dense forest covers a geographical area of 16.88 Km^2 (1.69%) and is confined to high relief regions. The area with tree canopy cover of more than 40% is classified as dense forest. It is confined to slopes of the Vindhyan Plateau in the south and generally exhibit dark red/ brown to brownish green tones, rough texture at 1: 50000 zoom scale (Fig 4(iii). The dense forest category shows association with moderate slope on the plateau, and a well-defined boundary outline.

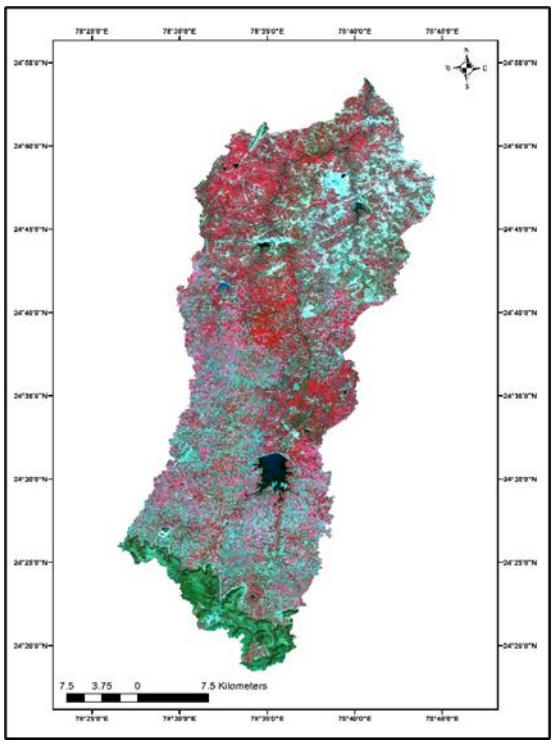


Fig 2: Watershed clip from standard FCC IRS P6 LISS III 2015 image

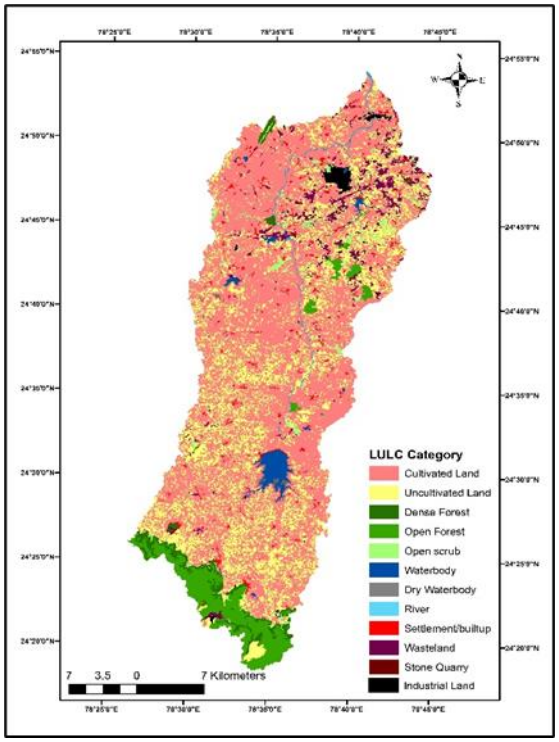


Fig 3: Lc/lu map derived from standard FCC

iv. Open Forest (OF): Open forest occupies a geographical area of 55.12 Km^2 (5.3%) and is associated with moderate relief. A vegetation canopy cover between 10%- 40% is categorized as open forest. In a standard FCC it exhibit brownish greenish tone, moderately rough texture when zoomed to 1:50000 scale and the texture would become rough on increasing the zoom. The open forest area are shown by well-defined boundaries as they are protected forest and are associated with dense forest and open scrub area (Fig 4(iv)).

v. Open scrub (OS): Open scrub covers a geographical area of approximately 20.88 Km^2 (2.09%). Formation of open scrub is attributed to either degraded forests or degraded agricultural area with boulders and varying percentage of shrub cover, occupied with rocky knobs and boulders and sometimes exposed BGC and were showing dark bluish green tones with the greenish tones increasing with the increasing vegetation. The scrub density is varying in the scattered open scrub area in the watershed possibly due to grazing. The texture of the open scrub areas is moderately rough when zoomed to 1:50000 scale with irregular shape and association with the uncultivated land and stream network (Fig 4 (v))

vi. Waterbody (WB): Waterbodies occupies 13.63 Km^2 (1.36%) area of the watershed the majority of which is contributed by the reservoirs in the watershed. It is difficult to identify the water class pixels at the boundary region of water body due to spectral mixing as land and water boundaries are not sharp. Sometimes, shallow water bodies can be mistaken for soil and saturated soil can be mistaken for water pixels along the periphery (Sarkar and Jain, 2008). Waterbodies generally appear in dark black to dark blue to blue tones depending upon the depth of water and show smooth texture 1:1000 zoom scale and hence are very smooth contiguous pattern and irregular shape with well-defined boundary outline (Figure. 4(vi)).

vii. Wasteland: The wasteland in the study area exhibits bright yellowish to white tones and high reflectance. Wasteland has irregular pattern, fuzzy boundaries, and frequent association with cultivated land, uncultivated land, industrial land, and stone quarry areas. (Fig 4(vii)).

viii. Industrial Land: The industrial land category was identified in 2015 with the development of a thermal power plant and implementation of solar panels under government scheme. The industrial land shows bright blue tone similar to urban settlement/ built-up with regular shape, well defined boundaries and pattern (Fig 4(ix)).

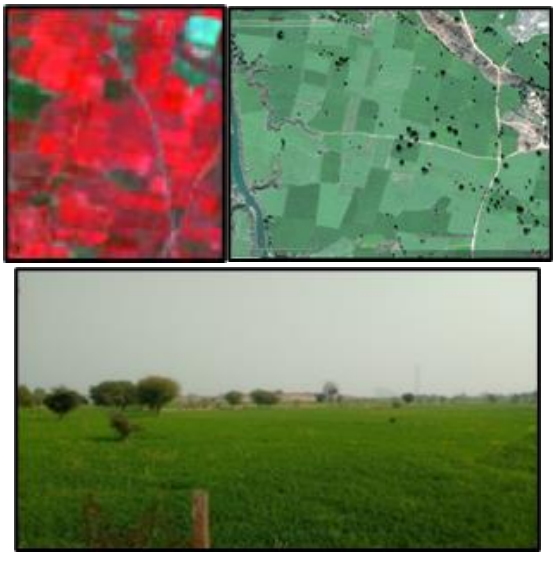
Table 1: LC/LU statistics from IRS P6 LISS III 2015 data

LEVEL I	LEVEL II	2015	
	LULC Category	Area (Km^2)	Area (%)
Agricultural land	Cultivated Land (CL)	582.148	58.457
	Uncultivated(UC)	246.795	24.782
Forest	Dense forest (DF)	16.886	1.696
	Open Forest (OF)	55.127	5.536
	Open scrub (OS)	20.889	2.098
Wetlands	Waterbody (WB)	13.632	1.369
	Dry Waterbody (DWB)	3.674	0.369

	River (R)	3.687	0.370
Built-up land	Settlement/built-up (S)	15.950	1.602
	Stone Quarry (SQ)	0.882	0.089
Wasteland	Wasteland (W)	28.907	2.903
Built-up land	Industrial land (IL)	7.278	0.731
	Total	995.856	100.000

ix. Stone Quarry: The stone quarry can be identified on the satellite with the tones similar to that of wasteland due to overburden and exposed rock surfaces. The stone quarry exhibits bright blue tone, smooth texture, well defined shape and boundary outline, associated with open scrub and overburden dump (Fig.4 (x)) .

x. Dry waterbody: The areas under dry waterbody category were those areas, which are exposed due to receding water level in the ponds and reservoirs and comprise of alluvium flats and muds with comparatively higher moisture content. They exhibit greyish green to bluish green tones, irregular pattern and are associated with the periphery of waterbodies, cultivated land and uncultivated, land.



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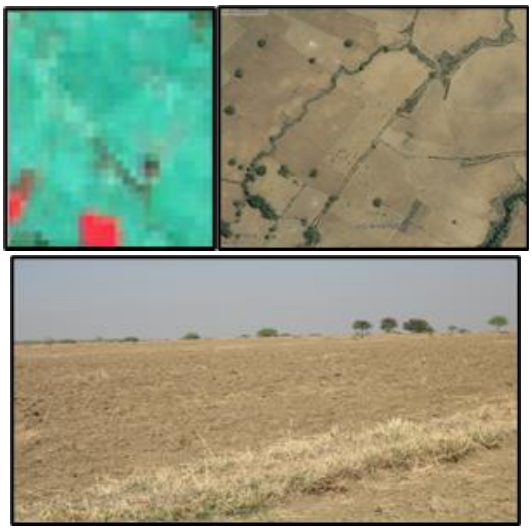

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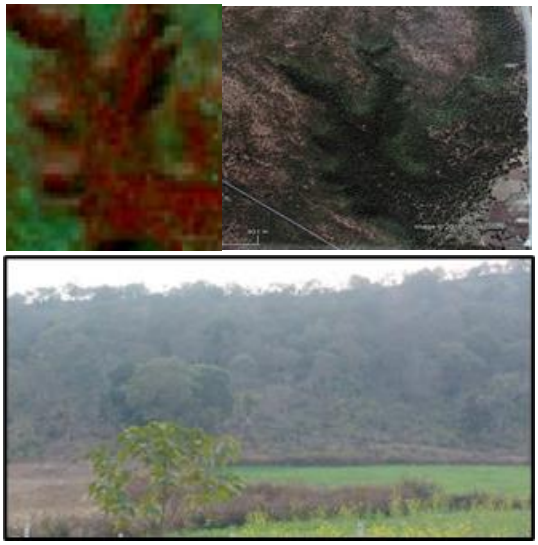

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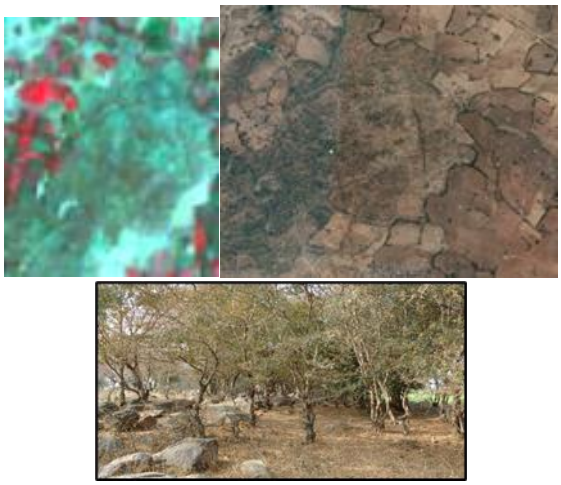

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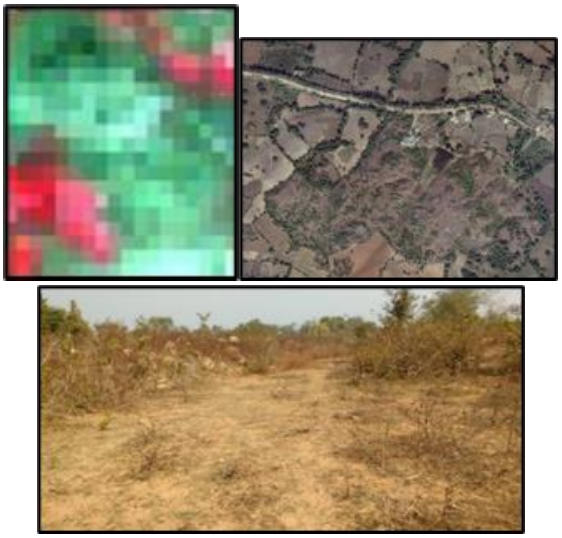

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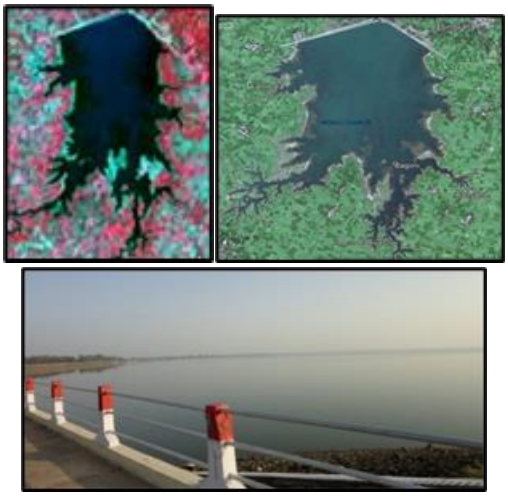

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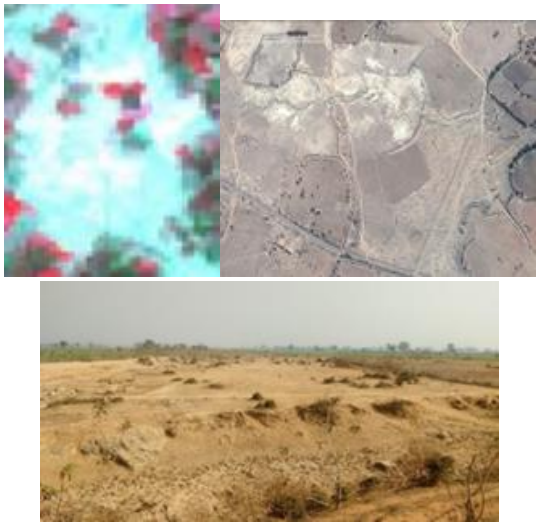

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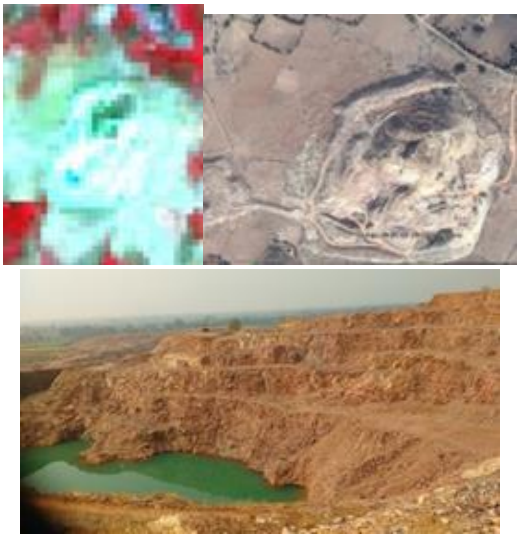

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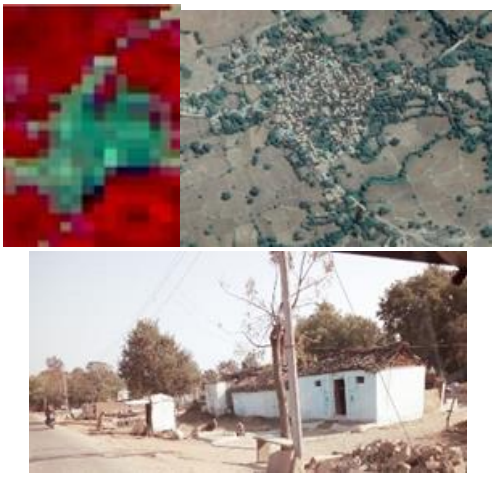

(x)

Fig 4: Spectral signature various LC/LU categories (A) satellite Image, (B) Google earth image and its corresponding(C) field photograph for categories : (i) CL (ii) UC (iii) DF (iv) OF (v) OS(vi) WB(vii) WL (viii) IL (ix) SQ (x) S

xi. Settlement/ Built- up: The settlement and built-up land in the study area is scattered throughout the watershed in the form of villages and towns. It has been found during the field visit that most of the settlements are rural and comprises of mud houses and thatched roof. The settlements/built up were easily identified through visual interpretation of the image by studying the tones, texture and association on the image. It exhibit cyan blue color with rough/blocky texture (due to rectangular houses of varying heights and irregular settlements), distinct but regular pattern, and association with network of roads .

xii. River: The main Sajnam River was easy to identify on a false colour composite due to presence of water and was exhibiting bluish to black tones, and was linear in shape, pattern, and meandering through its natural course with no sharp turning differentiating it from canals and other waterbodies.

Table 2: Spectral characters of the various LC/LC categories in the watershed

LULC Class	Tone	Texture	Pattern	Shape
Cultivated Land	Bright red to dark pink	Smooth	Well shaped field	Regular-Sub regular
Uncultivated Land	Bluish/greenish grey	Smooth	Well shaped and contiguous	Rectangular to slightly regular
Dense Forest	Dark red/ brown to brownish green	Rough texture due to canopy cover	Linear	irregular
Open Forest	Light Red	Medium	Contiguous-Non contiguous	Irregular
Open Scrub	Dark green to dark greenish blue	Medium to rough	Scattered and non-contiguous	Irregular
Water body	Black-Blue	Smooth	Contiguous	Well-defined
Dry water body	White/light brown	Fine	Well-defined	Variable
River	Bluish black	Smooth	Linear	Strolling/slightly meandering
Settlement/ built up	Cyan blue	Coarse/ blocky	Rectangular	Regular
Wasteland	Bright white to bright light blue	Smooth	Non-contiguous	Irregular
Stone quarry	Whitish cyan	Rough-uneven	Scattered	Regular
Industrial land	Bright bluish white to white	Smooth	Contiguous	Well -defined

CONCLUSION

Indian remote sensing satellite (IRS) data was used for image classification by visual interpretation method based on image interpretation elements such as tone texture, shape, pattern, association etc. The Land use categories identified were settlements, industrial land, cultivated land, uncultivated land, stone quarry. The land cover categories in the watershed are Open forest, dense forest, open scrub, waterbodies, dry water waterbodies, rivers and wasteland. The predominance of agricultural land constituting 828.944 Km^2 (83.23%) indicates the main economic activity in the watershed is the farming. The remaining LC/LU categories together occupies approximately 17% geographical area of the watershed. Presence of reservoir indicate the need of storing water for irrigation, recreation and domestic purposes. It also indicate that watershed seldom faces water shortages specially during the hot summer season. Therefore, the present land use can be modified to enhance the water infiltration capacity of watershed.

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