CLASSIFICATION AND ASSESSMENT OF LAND USE LAND COVER IN BARA TAHSIL OF ALLAHABAD DISTRICT USING SENTINEL-2 SATELLITE IMAGERY

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KEYWORDS; LULC; Sentinel-2; Maximum Likelihood Classifier; Unsupervised; Principal Component technique.

ABSTRACT

Regional development of any region depends upon the current Land use land cover (LULC) pattern. By providing raw data in the form of satellite images Geospatial technology is helpful for mapping and area estimation of Land cover on temporal and spatial basis. The present study has carried out in geospatial platform using Erdas Imagine v 2014 and ArcGis v 10.2.2 softwares. Multi-temporal Sentinel-2 satellite imagery is the primary data source for extracting thematic layers of LULC. LULC map of National Remote Sensing centre, topographic map and Google earth images along with field surveys are the ancillary database. In the present work, an attempt has been made to classify the Sentinel-2 satellite imagery (10 m resolution in VNIR band) into various land cover. Maximum Likelihood classifier, unsupervised classifier and Principal Component technique, derived band stacking etc. has been tried to extract pure classes of LULC i.e. water-bodies, sand area, fallow-land, rocky and stony wasteland, and cropland. Built-up layer is extracted by digitization due to mixing of built-up classes with fallow land and wasteland. Tree cover and scrubs layer is extracted from isodata classified image due to spectral mixing of this class with water locked cropland. Thus final map compares current LULC classes between the Jasra and Shankargarh block of study region.

1. INTRODUCTION

Accurate LULC analysis is essential for natural resource conservation, wasteland reclamation and efficient use of cropland in the backward region. Land cover refers to areal existence of natural or physical resources like cemented settlement whereas Land Use shows the main purpose using that land cover e.g. cemented settlement can be used for residential, industrial, and commercial or transport purpose. “The existing land use pattern is resultant of various factors like physical characteristics of land, climatic conditions, the institutional setting and resources investment potentiality and economic aspiration of local people etc. Thus a close study of present land use pattern and its temporal nature will provide a vision for planning and shift in the existing land use system” (Agrawal, 2013). It is also useful for planners to evolutes the possibilities and limitations of further spatial development to avoid or restrict undesirable trends of land exploitation to adjust the forms of land use to the land capability and to direct the expansion of intensive land utilization into suitable areas (Nageswar Rao and Vaidyanathan, 1990). The challenge of this research paper was to generate accurate LULC map in Bara tahsil, where spectral similarity among LULC (i.e. long fallow land and rocky and stony wasteland, built-up and fallow land, water body and built-up etc.) was common due to having heterogeneous landscape

(Thakker, et al. 2014). Therefore different classification algorithm is applied i.e. MKL, multi-temporal NDVI, PCA and digitization to get pure classes of LULC and to increase accuracy level of classification.

2. STUDY AREA

Bara tahsil consists of Jasra and Shankargarh development block represents transition zone between the plain of the Yamuna and uplands of the Vindhyan region, located in the south west of Allahabad district of Uttar Pradesh of India. It lies between the $25^0$2'30''- $25^0$22'30'' N latitude and $81^0$31'- $81^0$50' E longitude with total extent of 729.45 km^2. The plains of Yamuna and Tons have low elevation (-7-33 m) than the North-western part of Bara tahsil which is occupied by rocks of Kaimur group, have highest elevation ranging from 46 m to 129 m. The study area has tropical monsoon type of climate characterized by cool dry and invigorating winter and scorching and dusty summer. Temperature ranges from 8.93^0 C to 41.48^0 C and maximum rainfall occurs during monsoonal period (240.82 mm). It is a backward region endowed by low agricultural productivity and stone quarrying and ceramic industry due to the presence of red sand stone, glass sand, and quartz minerals belongs to the Vindhyan super group (GSI, 2001). The population statistics of study region disclose that 51.22 % population of tahsil Bara is supported by development block of Jasra in spite of having only 25.11 % area of tahsil of Bara rather than development block of Shankargarh which covers 47.82 % area of tahsil of Bara.

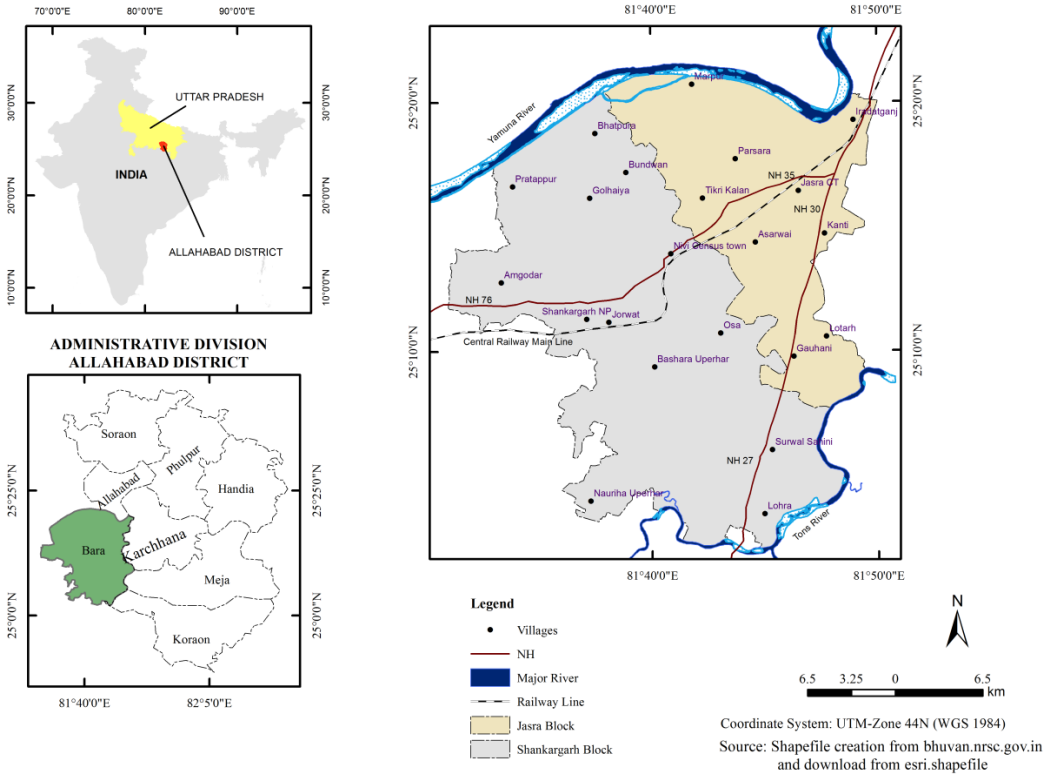

Figure 1. Location Map of Study Area

3. MATERIALS AND METHODS

3.1. Data Used

1. Toposheet of Survey of India; G44P11, G44P12, G44P15 and G44P16 (1:50 K scale)
2. L1C product of Sentinel-2 is major data source for extracting LULC (Year-2017,tiles; T44RNN & T44RNP, Blue, Green, Red, NIR and SWIR 1 and SWIR 2 band (BGRNSS bands) composed satellite image dated 23 February 2017, resolution- 10 m and 20 m).
3. Google Earth Image is used for defining classes of reference points of LULC.
4. ArcGIS v 10.2.2 and ERDAS IMAGINE v 2014 is used for image processing and analysis.
5. GPS Garmin e-trex 10 is used for the field verification.

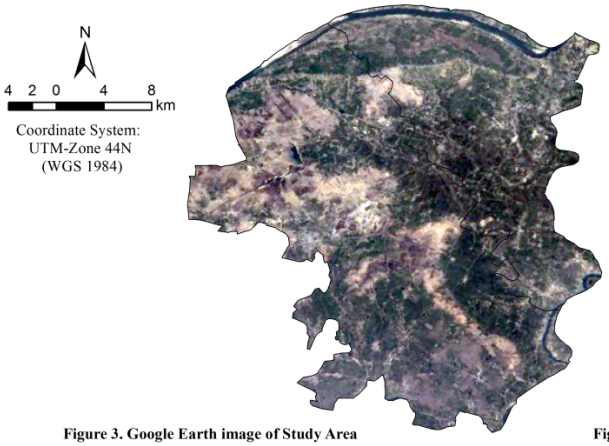

Figure 3. Google Earth image of Study Area dated 29 March 2017

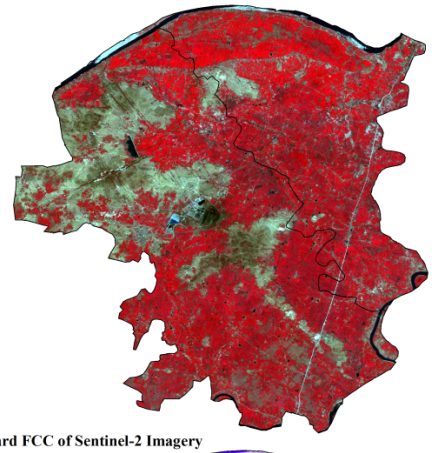

Figure 4. Standard FCC of Sentinel-2 Imagery dated 23 February 2017

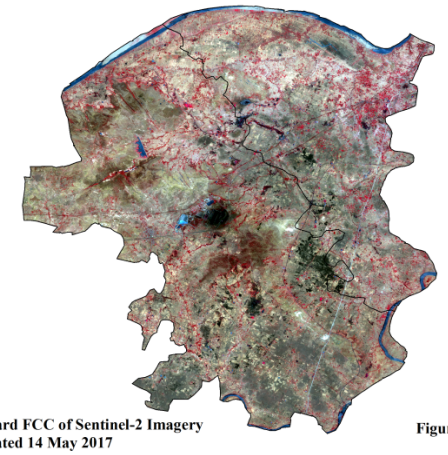

Figure 5. Standard FCC of Sentinel-2 Imagery dated 14 May 2017

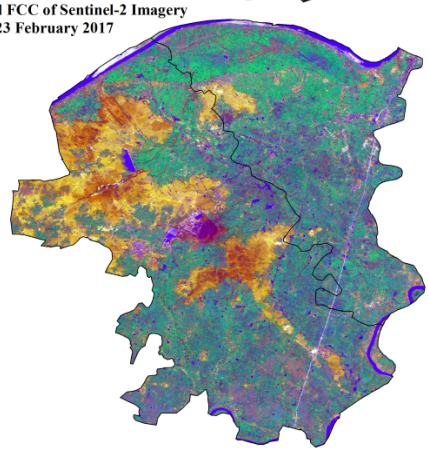

Figure 6. Principal Component (1,2,3 PC) Imagery dated 23 February 2017

3.2. Training Site Selection and Sepeability Analysis

All the satellite images brought under UTM projection (44N) and datum WGS 1884. Histogram Equalization, Standard Deviation stretch, True Colour Composite (TCC), False Colour Composite (FCC), and temporal NDVI technique is used for better visual interpretation of satellite images. Total 265650 pixels are selected for classification containing 7

LULC classes based on visual interpretation keys like tone, texture, size, shape, pattern, association etc. (Table 1). Sepearbility analysis among 7 LULC classes is done by mean plot of digital number across 6 bands i.e. Blue, Green, Red, NIR, SWIR 1 and SWIR 2 in scatter diagram (Figure 6) and through Transformed Divergence parameter (Table 2

Table 1. Number of Training Pixels Selected in Each LULC Classes over Sentinel-2 satellite imagery (dated 23 February 2017)

LULC Classes	Number of Training Pixels
Cropland	11639
Fallow land	14468
Rocky and Stony Wasteland	111222
Tree Cover and Scrubs	1568
Water body	43863
Built-up	30512
Sand area	40010
Total	265650

TD is a statistical parameter for measuring signature distance between two classes based on covariance-weighted distance. Larger TD values indicate greater statistical distance between training classes and higher the probability of correct classification of classes (Lillesand and Kiefer, 2007). The scale of TD ranges from 0 for completely overlapping classes to 2000 for completely separated classes (Jensen, 2005). The value close to 2000 or between 1900 to 2000 shows best separability and between 1700 and 1900 indicates fairly good separability. The TD value less than 1700 shows poor class separability. Mostly built-up and vegetation classes are mixed with other classes having low TD value in all bands. This thing is also observable in the scatter plot. Built-up area having similar tone as rocky and stony wasteland and fallow-land but different texture is mixed with rocky and stony wasteland and fallow land.

Figure 6. Spectral Seperability among Training Pixels of LULC Classes

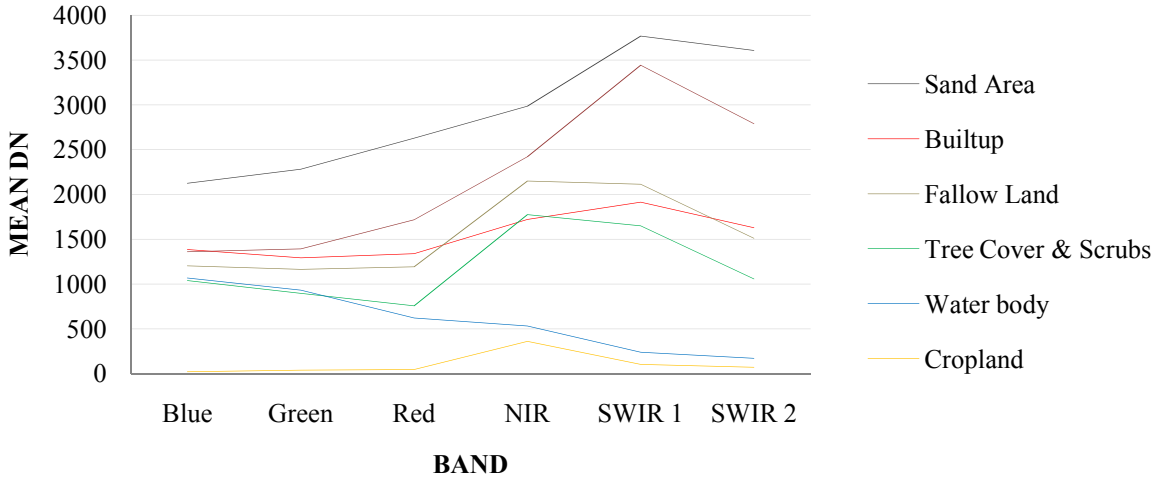

Table 2. LULC Class Pairs and their respective TD (Transformed Divergence) value in Red, NIR, SWIR1 & SWIR 2 Band

Class Pairs	Red	NIR	SWIR 1	SWIR 2
Cropland & Water body	1126	2000	2000	2000
Fallow land & Built-up	1944	1649	1646	1355
R & S Wasteland & Tree Cover & Scrubs	2000	2000	2000	1355
Built-up & Tree Cover & Scrubs	2000	523	2000	2000
Fallow land & R& S Wasteland	2000	1242	2000	2000

3.3. Classification Algorithm

In the present study Principal Component Analysis (PCA) and Maximum likelihood classifier (MKL) is used for LULC classification. MKL quantitatively evaluates both the variance and covariance of the category spectral response patterns, and probability of the pixel value belonging to particular class when assigning a class to unknown pixel. If the result is only one class, it is assigned to that class. If it either does match the signatures, or matches more than one, it is assigned a class based on the Mahalanobis distance. The Mahalanobis distance assigns classes based on their closeness to the spectral signatures (Lillesand and Kiefer, 2007).

PCA has applied on RNSS bands stacked image to transform correlated dataset into a substantially smaller set of uncorrelated variables that represents most of the information of stacked dataset. It reduces data redundancy, data dimensionality (e.g., number of bands) and increases spectral contrast. PC 1, PC 2 and PC 3 account for the vast majority of the variance found within the dataset, it can be possible to set the original bands aside, and the remainder of the image enhancement or classification process can be performed using just these three PC images (Table). Therefore, first four PCs representing 99.85 % information used as input for MKL classifier. This image is classified into 87 classes representing 5 type of LULC. By using recoding method 87 classes were merged into five classes; water bodies, sand area, cropland, fallow land, rocky and stony wasteland. Signature of tree cover and scrubs is identified through analysis of multi-temporal NDVI stacked images (Oct. 2016-May 2017) having constant NDVI value (0.3-0.7) and Isodata classifier is performed on the Sentinel 2 image dated 14 May 2017 having Blue, Green Red, NIR and SWIR 1 band combination, when no crops were found on the field. NDVI (normalized difference vegetation index) derived from NIR and red band reflectance provides a reliable estimation of the amount and vigour of vegetation because it is strongly related to the photosynthetic activity. The success of the NDVI is due to its reliability in detecting vegetation as well as in its simplicity in terms of computation and interpretation. Manually digitized AOI of built-up area is generated from the Google earth. Both tree cover and scrubs and built-up layer are overlaid on the classified image to get the pure land cover classes. This classification method was adopted when MKL classifier performed on RNSS bands satellite image (23 Feb. 2017) has not given pure classes of LULC (Thakker, et al. 2014).

Table 3. Principal Component Analysis on 6 Bands of Sentinel-2 Data

Input Bands	Blue	Green	Red	NIR	SWIR 1	SWIR 2
Band Means	1160.012	1104.303	999.921	2630.777	1909.745	1311.963
SD of Bands	177.599	229.217	413.927	628.603	714.967	720.66

PC Layer	Eigenvector Matrix						Percent of Eigen Values
PC 1	0.867	-0.004	1.753	-0.457	1.94	2.439	75.54029
PC 2	0.539	0.071	1.029	0.004	0.792	-1.084	21.62489
PC 3	0.27	0.005	0.277	0.265	-0.249	0.048	2.447843
PC 4	-0.068	0.333	0.019	-0.005	-0.009	0.003	0.234338
PC 5	0.088	0.025	-0.042	0.082	0.015	0.002	0.119
PC 6	0.046	0.006	-0.002	-0.05	-0.005	-0.002	0.033642

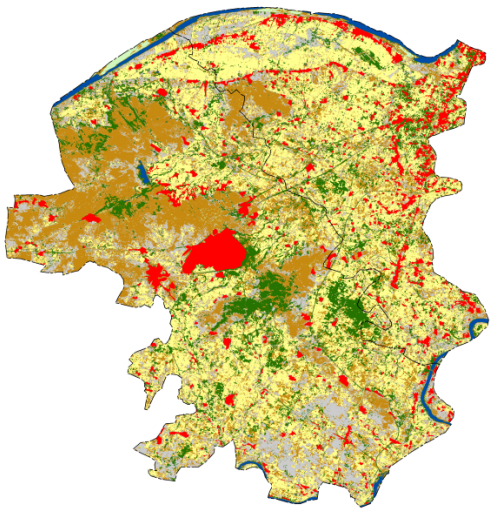

Figure 7. LULC classification with high accuracy produced from MKL classified PCA and LULC overlaid image (i.e. built-up, tree cover & scrub)

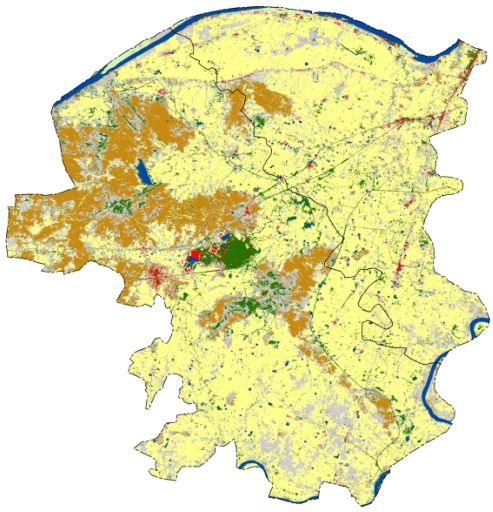

Figure 8. LULC classification with Low Accuracy produced from MKL classified multi-spectral image (i.e. Blue, Green, Red, NIR, SWIR1, and SWIR 2 bands)

Table 4. Error Matrix resulting from Classified Image

Classified Data	Reference Data								
	Tree cover & Scrubs	Built-up	Cropland	Sand area	Water body	R & S Wasteland	Fallow land	Classified Total	User`s Accuracy (DT/ RT)
Tree cover & Scrubs	133	2	84	2	3	3	12	239	55.65
Built-up	2	89	5	0	1	14	17	128	69.53
Cropland	23	1	561	0	1	4	31	621	90.34
Sand area	0	2	0	13	0	2	1	18	72.22
Water body	3	1	0	0	37	0	1	42	88.09
Wasteland	6	7	20	8	7	354	112	514	68.87
Fallow land	9	7	18	1	3	25	266	329	80.85
Reference Total	176	109	688	24	52	402	440	1891	
Producer`s Accuracy (DT/ CT)	75.57	81.65	81.54	54.17	71.15	88.06	60.45		
Overall Accuracy	76.84% {1453/1891* 100(Diagonal Total/Grand Total)}								
Kappa Coefficient	83.73 % {(Grand Total-Diagonal Total)-(Row*Column)/(Row*Column)^2 - (Row*Column)} GT= 1891, DT= 1891, Row*Column= 837268 (239*176)+ (128*109)+(621*688)+(18*24)+(42+52)+(514*402)+(329*440)								

3.4. Accuracy Assessment

Microsoft Office Excel 2007 is used for accuracy assessment. Accuracy assessment is validated through kappa coefficient and Error matrix containing overall accuracy, user`s accuracy and producers accuracy i.e. classes of the reference data is compared with the classified data. Total 1891 reference points are selected by the stratified random sampling method and their reference class is determined by overlaying KML layer on the Google earth. The overall accuracy and kappa coefficient for the PC containing MKL classified and built-up, tree cover & scrubs overlaid image was 76.84 % and 83.73 % respectively. However overall accuracy calculated from the BGRNSS band composite MKL classified image was only 67.56. The low accuracy of the classified image is result of spectral similarity between some pairs of LULC classes.

4. RESULTS AND DISCUSSION

Geospatial approach not only provides the classification method for the classification of LULC but their accuracy is also measured. Table 5 presents the detailed account of statistics of the area of each LULC in Jasra and Shankargarh block in February 2017. Figure 7 spatially depicts the present scenario of LULC in the Bara tahsil and compares their distribution in Jasra and Shankargarh block.

4.1. Cropland

Standing crops are captured as cropland on the date of satellite overpass and appear in the variations of red tone with varying shape and size in contiguous to non-contiguous pattern over standard FCC satellite imagery. Cropland is the major part of LULC which constitutes about 32.81% (23934.75ha) total area of Bara tahsil. 41.98 % (10540.67 ha) of total area of Jasra and 28.00 % (13390.05 ha) of total area of Shankargarh block are comes under cropland category. Cropland area is more in the Jasra block due to presence of Loamy soil in the alluvium plain of the Yamuna.

Table 5. Distribution of LULC in Bara Tahsil in 2017 (Area in hectare)

LULC Classes	Jasra Block		Shankargarh Block		Bara tahsil	
	Area	%	Area	%	Area	%
Tree cover and Scrubs	2991.92	11.92	6337.35	13.25	9329.23	12.79
Built-up	2449.34	9.75	2767.93	5.79	5218.22	7.15
Cropland	10540.67	41.98	13390.05	28.00	23934.75	32.81
Sand area	121.76	0.48	282.47	0.59	405.25	0.56
Water body	519.74	2.07	510.14	1.07	1031.22	1.41
Rocky & Stony Wasteland	4796.34	19.10	15369.87	32.14	20171.73	27.65
Fallow land	3689.61	14.69	9161.29	19.16	12854.60	17.62
Total	25109.38	100.00	47819.10	100.00	72945.00	100.00

4.2. Fallow land

Fallow land is the sub-class of cropland according to Anderson classification system. About 17.62% (12854.60 ha) of TGA of Bara tahsil comes under this category, in which Jasra and Shankargarh accounts for 14.69 % (3689.61ha) and 19.16 % (9161.29ha) respectively. However in the supervised classification both the current fallow and long fallow are intermixed. Current fallow-lands are un-cropped during the agricultural year under consideration as on the date of satellite overpass during all the cropping season whereas long fallow land are un-cropped for two to five agricultural years from the base year" (NRSA atlas, 2011). This land needs planning consideration because more than twelve thousand hectare of Bara tahsil are lying fallow and these land are distributed in the southern villages of Shankargarh block; Nauriha Uperhar, Pahari Kalan, Deora and Lohra etc.

4.3. Rocky and Stony Wasteland

On standard FCC image rocky and stony wasteland appears in dark brown to light brownish and white tone having discriminative boundary with other LULC except scrubs and long fellow land on standard FCC image In the study region rocky and stony wasteland comprises degraded land due to salt and sand accumulation, rock exposure, shallow and skeletal soils, erosion prone land and the land affected by sand stone quarrying activities in the study region. This is the second largest LULC class of Bara tahsil which constitute about 27.65 % of TGA (20171.73ha) in which 15369.87ha (32.14 %) is extended in Shankargarh.

4.4. Built-up

Land resource which is used for settlement purpose (buildings, transport etc) comes in the category of built-up land. However in the study region this area is extended over small entities and scattered around water body, in the field, distributed in a narrow belt along the transport network etc. is not easily identifiable over the satellite imagery having 10 m spatial resolution. In the study region they appears in bluish green, grey and white tone having regular and irregular shape and scattered to cluster and linear pattern on the standard FCC image. The built-up area is more in Jasra block (9.75 %) than Shankargarh (5.79%) due to plain region extension, soil resources suitability for crop cultivation and water resource availability.

4.5. Tree Cover and Scrubs

Tree cover appears in the standard FCC image in dark red to red tone having coarse texture, regular to irregular shape and contiguous pattern. Scrubland appears in greenish blue to green and light yellow tone on FCC image. 12.79 % area (9329.23ha) of study region is covered with tree cover and scrubs. The notified forest boundary area only extended in Shankargarh like Osa, Bajuddi, Janwan, Lakhnauti, and Baghla reserved forest occupying by Shisham (north Indian Rosewood) and Khair (Acacia) trees. Due to deciduous type of vegetation the trees shed their leaves from October to February. Whereas scattered trees are distributed upon the agricultural land, along water body and among the built-up land in both block. Scrubs are distributed in the rocky and stony wasteland.

4.6. Water bodies

Water body appears in light blue to dark blue and black tone with smooth to mottled texture and contiguous, linear and dendritic texture on the standard FCC image because Land cover comprises with surface water either impounded in the forms of ponds, lakes and reservoirs or flowing as streams, rivers, canal etc are come in this category (NRSA atlas). Total 1031.22 ha (1.41%) area of Bara tahsil comes under surface water bodies in which 519.74ha (2.07%) and 510.14 ha (1.07 %) spread over the area of Jasra and Shankargarh respectively.

4.7. Sand area

River deposited sand area appears in white to light blue tone and smooth texture on standard FCC image found along the dry beds of river and their tributaries. Seasonal or decade increase in the sand area shows depleting water resources from their beds. Total 405.25 ha (0.56%) area of study region comes under this category in which 121.76 ha (0.48%) and 282.47 ha (0.59%) extended in Jasra and Shankargarh block along Yamuna and Tons river respectively.

CONCLUSION

In the study region Sentinel-2 satellite data has potential for LULC mapping and spatial database generation which are helpful for taking efficient planning decisions. However other freely available satellite data i.e. Landsat series and LISS 3 data have two limitations in the study region. First their low spatial resolution is not efficient for accurate mapping of built-up land, vegetation cover and scattered wasteland and second change detection analysis in LULC cannot be performed in above LULC classes. Although Current scenario of LULC along with changing pattern of LULC helps in making local development strategies and reducing regional disparities. In the present study principal component analysis and MKL method along with raster overlaying classification algorithm provides better classification accuracy than only MKL classifier. However principal component analysis with factor loading matrix function of eigen value, eigen vector and variance, used as kernel for spectral enhancement of PCA image led to blurring of image hence raw image of PCA is used as input for MKL classification.

ACKNOWLEDGEMENT

Author Miss Deeksha Mishra is indepthly acknowledged University Grant Commission (UGC), New Delhi for providing financial support through NET-JRF Fellowship scheme; Training Division, National Remote Sensing Centre (NRSC), ISRO, Hyderabad for giving training opportunity in Geospatial Technologies and its applications; Prof. B.N. Singh and Prof. A. R. Siddiqui for their valuable time and useful and practical suggestions.

REFERENCES

1. Agrawal, D.K., 2013. Handbook of Agriculture. Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research (ICAR), New Delhi, pp.260-261.
2. Anderson James R. Hardy, E.E., Roach, J.T., 1976. A Land Use and Land Cover Classification System for use with Remote Sensor Data. Geographical Survey Professional Paper 964.U.S. Government printing office.
3. Jensen. J.R., 2005, Introductory Digital image Processing: a Remote Sensing Perspective (3rd ed.). Pearson Publication, USA, pp 365-66.

4. Lanorte, A. et al.,2015, On the Use of the Principal Component Analysis (PCA) for Evaluating Vegetation Anomalies from LANDSAT-TM NDVI Temporal Series in the Basilicata Region (Italy),Computational Science and its Applications 2015, part IV, Springer International Publishing, Switzerland, pp.204-216
5. Latif, S., 2016.Quartimax Rotational Principal Component Analysis for Land Use and Land Cover Classification, International Research Journal Vol. 4, April (2016).pp. 9-16.
6. Lillesand, T.M., Kiefer R.W. et al, 2007. Remote Sensing and Image interpretation. (5th ed.). JohnWiley & Sons, New York, pp. 558-559, pp. 570-571.
7. NRSA, April 2011, Land Use/Land Cover Atlas of India based on Multi-temporal Satellite Data of 2005-06.Land Use Division, National Remote Sensing Centre, ISRO, Dept. of Space, Govt. of India, Hydearbad, pp.11-19.
8. Ramachandran, R.M. & Reddy C. S., 2016. Monitoring of Deforestation and Land Use Changes (1925–2012) in Idukki district, Kerala, India using Remote Sensing and GIS, Journal of Indian Society of Remote Sensing 45(1), (February 2017) , pp.163–170.
9. Reddy, S. and Dadhwal V.K., et al, 2016. Assessment of Land Cover Change Hotspots in Gulf of Kachchh, India Using Multi-Temporal Remote Sensing Data and GIS, Journal of Indian society of Remote Sensing, 44(6), (December 2016) pp. 905–913.
10. Thakker , A. et al. Land use Land cover classification of Remote Sensing Data and their derived products in a Heterogeneous Landscape of a Khan-Kali Watershed , Gujarat. Asian Journal of Geoinformatics, Vol.14, No.4, pp.1-2.