Land Use Change Detection of Yamuna River Flood Plain Using Geospatial Technique

Nehal Ahmad, Saif Said, Naved Ahsan

Abstract--- The present study intends to quantify the changes and transformations in features classes of Yamuna River Flood Plain in Delhi. ERDAS imagine 9.2 and Terrset geospatial software were used for image processing and quantitative assessment, transformation, gain and loss, contribution o net change and spatial trend analysis. The Landsat 8 (2018), TM (2000) and MSS (1989) images were acquired for assessing LULC change detection using Maximum Likelihood Classifier. LULC classification was achieved with kappa coefficient and overall accuracy for Satellite images of MSS (1989), TM (2000) and Landsat 8 (2018) as 0.781, 0.892 and 0.804and 86.00%, 92.31%, 86.00% respectively. Analysis reveals the addition of built up area up to 25% from year 2000 onwards and loss in dense forest from 40% to 30%. Vegetation areas recorded a reduction of 15% from 1989 to 2000. Spatial trend reveals the qualitative vulnerability of vegetation classes during the study period. During 1989-2000, dense forest, vegetation and water classes contributed maximum to settlement class and during 2000-2018 an interchange of dense forest and vegetation was witnessed. The study provides an insight to the sustainable planning and management of the river ecosystem that is affected by population expansion.

Keywords: Land use land cover, Change detection, MLC algorithm, geospatial techniques, Terrset, Yamuna River.

I. INTRODUCTION

A precise land use and land cover map is critically necessary for sustainable resource utilization and for modeling and analyzing the land as a holistic system (Ahmad et al., 2012). The exercise of satellites data for the mapping of land use was widely appreciated in the last decade by researchers (Beuchle et al., 2015). Analysis of the data creates impressions of human interaction and nature towards land use evolution thereby, assisting in identifying the optimal land cover (Ghebrezgabher et al., 2016). Changes in flood plain of Yamuna River along Delhi due to anthropogenic involvement in unplanned manner have shaped the fragile ecosystem whilst posing a severe environmental threat to the surrounding areas (Zanetti et al., 2018).

With the advancements in geospatial techniques, monitoring, mapping and modeling of land use cover has afforded a way to enhance the capacity in decision making towards sustainable development and management of an area involving low cost and higher accuracy (Wu et al., 2017). However, concerns over land form classification accuracies have been addressed by various researchers

detecting change of flood plains in varied environments. Image classification techniques based on algorithms provides satisfactory results subject to condition of large the sample size. However, in Maximum likelihood classification (MLC), training sample per pixel signature file is created from the real ground information for clustering of those pixels having maximum likelihood of the digital numbers (DN) falling in a particular land use class (Afify, 2011; Butt et al., 2015b). Landsat images offer relatively precise analysis of change detection for supervised classification performed using maximum likelihood classifier (Lv, Z et al., 2017).

The Land Change Modeler (LCM) in TerrSet is used for map change analysis and spatial trend analysis for a relatively stable land cover which requires relatively low data with dynamic utility (Mishra, V.N et al., 2014;Yasmine Megahed et al.,2015). Based upon transition potential modeling, change prediction and change analysis, future land use land cover can also be predicted with the historical change of maps (Krishna Rajan et al., 2018).

This study intends to appreciate the Land cover changes over a period of 30 years by utilizing Landsat images and employing MLC via supervised classification scheme and Land Change Modeler (LCM) in TerrSet. The study furnishes an insight towards understanding the changing trends that constitutes a crucial prerequisite for efficient interdisciplinary policies leading to sustainable regeneration of an ecologically fragile flood plain.

II. MATERIALS AND METHOD

Study Area

The study area stretches 22 km flood plain of Yamuna River flowing along Delhi state entering at Wazirabad barrage and exiting at Okhla barrage confining within geographical coordinates from 77° 10′ 00″ E to 77° 20′ 00″ E longitude and 28° 32′ 00″ N to 28° 43′ 00″ N latitude and extending an study area of 51.15 km^2 (Fig. 1). The topography of the area is gently sloped in southwestward direction bounded between semi meandering river course coupled with straight and curved paths. The climate encountered by Yamuna River flowing along Delhi extend

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from humid to semi arid with most of the precipitation occurring during the monsoon season (June to September). Yamuna River enters Delhi near Palla (28°50'00"N, 77°12'00"E) and leaves Delhi 4 km downstream of the Okhla barrage near village Jaitpur (28°31'00"N, 77°20'00"E).

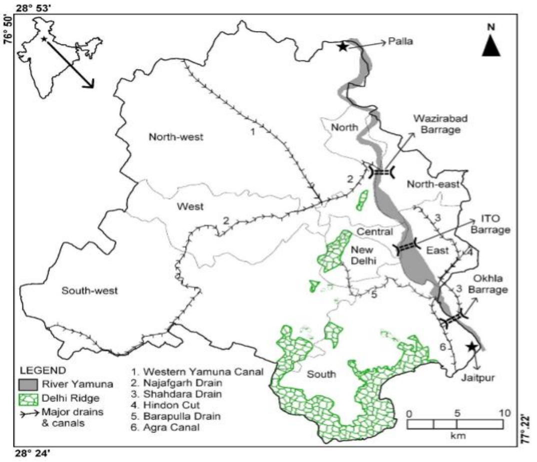

Fig. 1 Location map of the Study Area

Data Used and Image Processing

Satellite images from Landsat-2 MSS, Landsat-5 TM and Landsat 8 OLI-TIRS were acquired from united states geological survey web portal for the year 1989, 2000 and 2018 all having spatial resolution of 60m, 30m and 30m respectively. While acquiring the images, suitable scales were considered so as to get cloud free imageries. Fig. 2 illustrates the broad overview of methodology employed for the assessment and evaluation of change and transformation in features within the study area.

ERDAS imagine 9.2 were used for image dispensation, layer stacking, masking, extracting AOI, supervised classification, and accuracy assessment and confusion matrix creation.

Methodology for Land Use Land covers Change

MLC algorithm was employed on three Landsat images acquired during the period from 1989 to 2018 in ERDAS Imagine Software. The base area for the study scene was prepared by Google Earth Pro and used to extract the study area. The MLC algorithm uses the spectral signatures of training site samples from field survey with the help of GPS. The DN values of pixels corresponding to the color tones were chosen as criteria to train the given data set. A polygon was drawn to individual training sites with a number of pixel collections and at least 40 to 60 samples for each feature class viz. water, Vegetation, Dense forest area, Settlement and barren land were drawn and saved as a signature file (.sgs extension). Before classification, feature space technique was executed for correction of misclassification or overlapping to the training set data (Gurgel et al., 2017; Lv, Z et al., 2018). During process of feature extraction, a minimal confusion in clustering was ensured with the availability of satisfactory spectral signature (Butt et al., 2015a, López-Serrano et al., 2016).

Finally signature file containing training samples for all feature classes was used for the supervised classification. Ground truth data along with Google Earth Pro were applied for the verification of generated land use and land cover cover map for the year of 1989, 2000 and 2018. USGS – LULC II classification endeavors distinct feature definition to differentiate discrete classes belonging to common category by providing suitable attributes (Mosammam et al., 2017). The magnitude of the land use and land cover change, percent change and annual rate of change was obtained from Eq. 1 to 3 respectively (Kamrul Islam et al., 2018).

Magnitude of Change = Changes in current year - changes in previous year (1)

%Change = Magnitude of Change/Base year magnitude ×100 (2)

Annual rate of Change = (Final year – Previous year)/ Duration (3)

Where, base year magnitude is the current year of consideration for change detection. Duration in Eq. 3 was obtained by taking difference between the respective years under consideration i.e. for 1989-2000(duration=11 years) and 2000-2018 (duration=18 years).

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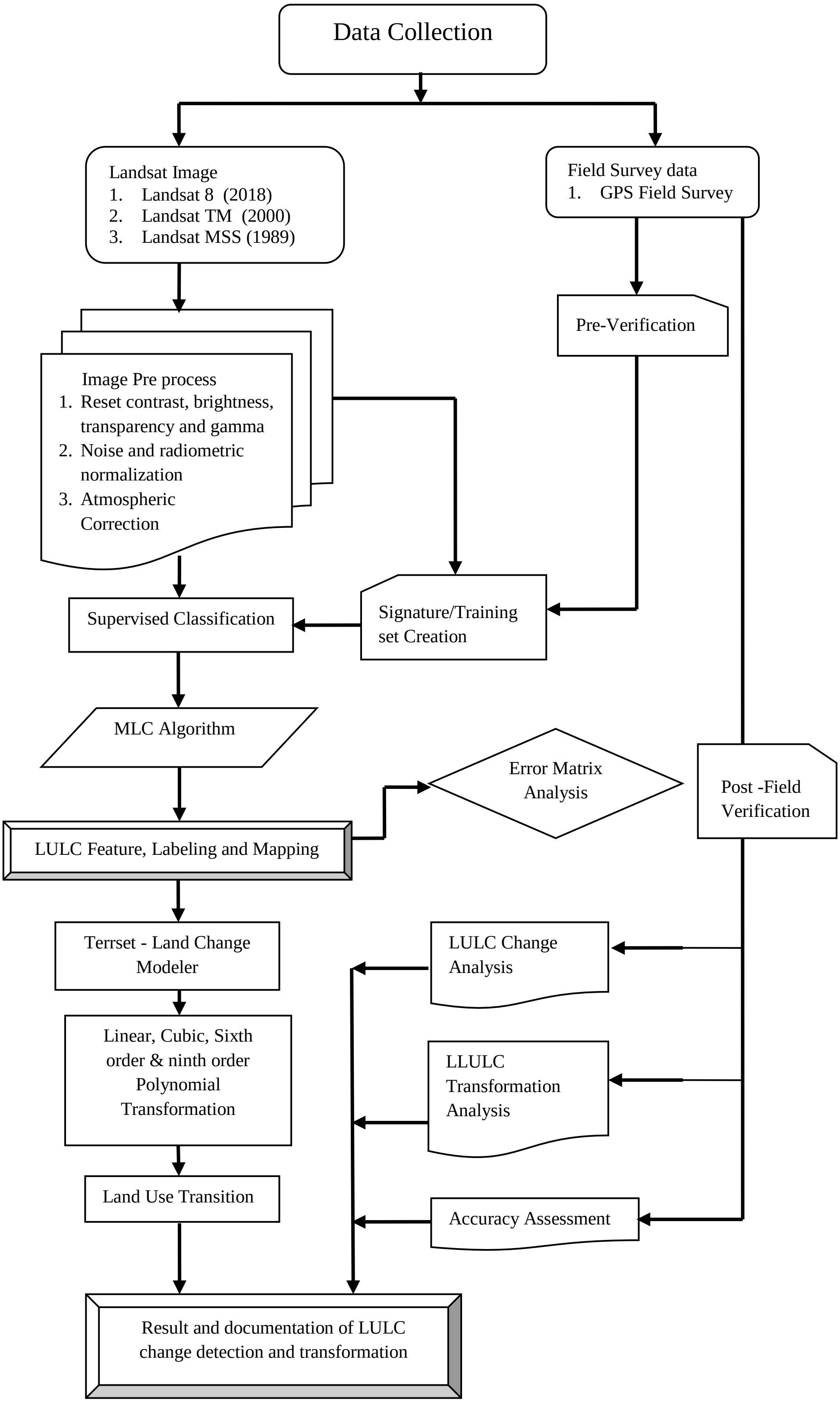

Fig. 2 Methodology adopted for LULC change detection assessment.

Methodology for Spatial Trend and Change maps

Terrset geospatial Idrisi software for ecological land change modeler and sustainability was used to assess spatial trend change analysis with linear, cubic, sixth and ninth order polynomial transition trends of different feature classes into settlement class. The analysis of spatial trend change provides a generalized pattern of land use feature classes. Higher the numbers (red colors), more likely to be changed than lower numbers (darker green to blue colors). Polynomial trend fits a smooth surface by a mathematical function to accommodate the actual topography of the surface.

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Accuracy Assessment

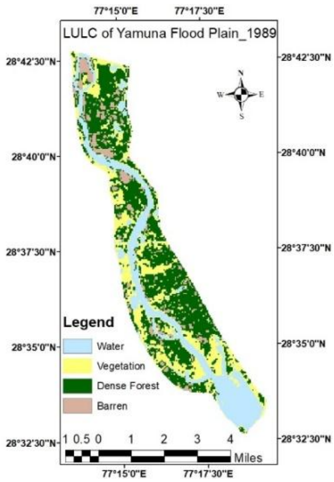
Accuracy assessment of supervised classification performed on images of years 1989, 2000 and 2018 was carried out using ERDAS Imagine software. Pixel based random points from within the classified images were collected that were considered as reference values and the same were assigned into different classes by the user. Error matrix and kappa statistics were generated through identification of correct points as classified values. Kappa coefficient matrix is calculated as per Afify, 2011.

$$K^{\wedge} = \frac{P_o - P_c}{1 - P_c} \quad (4)$$

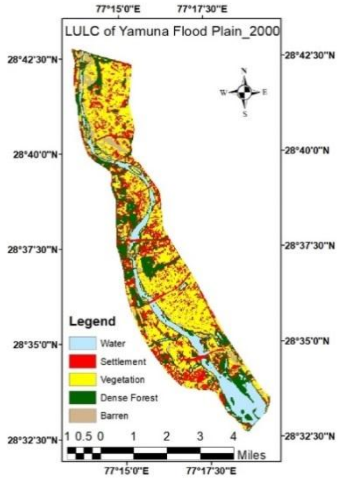
Where, P_0 = Proportion of trial of observed agreement pixel in ith row and column in the error matrix, Pc = Proportion of trial of agreement by chance expected of ith row and column in the error matrix.

III. RESULTS AND DISCUSSION

Supervised classification scheme was employed to MLC algorithm for generating LULC maps of study area by utilizing Landsat MSS, TM and Landsat 8 images of assessment years 1989, 2000 and 2018 respectively shown in Fig. 3a,b and c. Land forms within the area of study were classified into five feature as; water, Settlement, Vegetation, Dense Forest and Barren. Changes in land forms were evaluated with overall accuracies of 86.00%, 92.31% and 86.00% with kappa coefficient as 0.781, 0.892 and 0.804 respectively.



(a)



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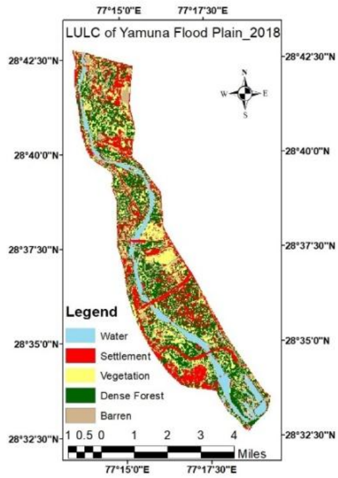

(c)

Fig. 3 LULC map of the study area for the assessment year (a) 1989, (b) 2000 and (c) 2018.

Assessment of LULC maps derived from supervised classification using MLC algorithm for change detection and transformation of feature classes is categorically summarized in Table 2, 3 and 4. Analysis reveals no areal extent of settlement class within the study area during the year 1989, however, built up class grew to 12.15 km^2 and a significant loss of dense forest into vegetation was also witnessed during 1989 to 2000.

Table 1 Distribution of LULC in km^2 and Percentage from 1989 to 2000

LULC class	1989		2000		2018	
	Area of Land Use (km^2)	Percentage Area of Land Use	Area of Land Use (km^2)	Percentage Area of Land Use	Area of Land Use (km^2)	Percentage Area of Land Use
Water	12.85	25.12%	6.52	12.75%	5.52	10.79%
Settlement	0.00	0.00%	12.15	23.75%	13.19	25.79%
Vegetation	12.60	24.64%	20.57	40.22%	12.19	23.83%
Dense Forest	20.96	40.97%	9.83	19.22%	15.15	29.62%
Barren	4.74	9.26%	2.08	4.07%	5.10	9.97%

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LULC change between 1989 and 2000

Duration from 1989 to 2000 observed large scale changes of dense forest and vegetation area and a large scale settlement surfacing on the flood plains amounting to 25% of the total land use area was also observed reflecting high rate of infiltration of migrants from neighboring states in search of livelihood (Table 2). The demographic alteration in the region signifies a stimulus of economic up rise in terms of wide scale infrastructural development with a lesser priority towards the ecological threat to the fragile river corridor. However, a moderate decline of 4.52% in the water bodies along with the forest and vegetation class that too shrank substantially to 19% with an annual rate of 4.82% which is consequential of the aforesaid fact.

Fig. 4(a) depicts the net change and contribution of land use classes during 1989 to 2000. A maximum gain of settlement and loss of dense forest is recorded during 1989-2000. Fig. 5(a) depicts the transition into settlement of land use classes during 1989 to 2000 which further depicts the concentrated anthropogenic activity within the yamuna river flood plain.

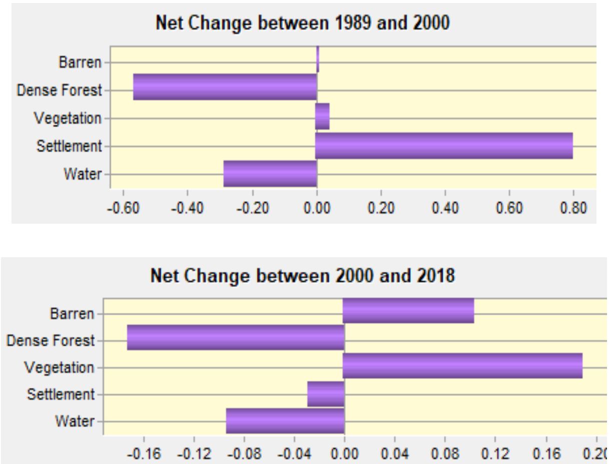
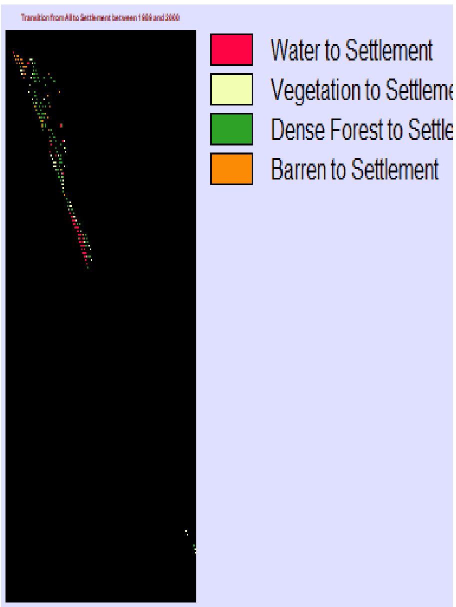


Fig. 4 (a) Net Change of LULC Class between 1989-2000 (b) Net Change of LULC Class between 2000-2018



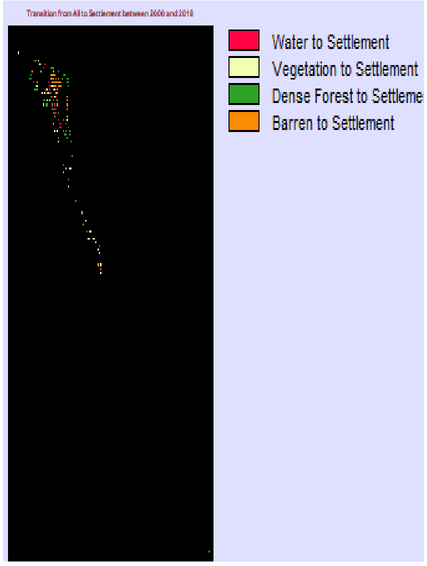


Fig. 5 (a) Transition into Settlement between 1989-2000 (b) Transition into Settlement between 2000-2018

LULC change between 2000 and 2018

Agricultural area witnessed decline during the assessment period from 2000 to 2018 from 40 % of total area to 25% at a rate of 2.07% (Table 2) on account of wide scale job opportunities in construction firms hiring inhabitants as unskilled laborers thus pressuring quit farming practices. Built-up area recorded no change during the period owing to stringent policies adopted by the state Govt. towards regeneration of the severely deteriorated river flood plain. Forest areas exhibited marked increment from 19% to 30 % at a rate of 3.2% on account of green Yamuna action plan, an initiative taken up by National Green Tribunal (NGT) for reviving the deteriorated ecological habitat of the area.

Fig. 4(b) depicts the net change and contribution of land use classes during 2000 to 2018. A maximum gain of vegetation and loss of dense forest is recorded during 2000 to 2018. Fig. 5(b) depicts the transition into settlement of land use classes during 2000 to 2018 which further depicts the concentrated anthropogenic activity within the yamuna river flood plain.

LULC transformation during 1989 to 2000

Assessment period from 1989 to 2000 detected maximum transformation of water body to dense forest and vegetation class to a magnitude of 3.32 km^2 and 1.98 km^2 respectively. The transformation of vegetation in terms of gain and loss was observed highly associated with the dense forest amounting to 11.99 km^2 and 4.17 km^2 respectively which signifies a balancing fulcrum between forest and food requirement (Table 3).

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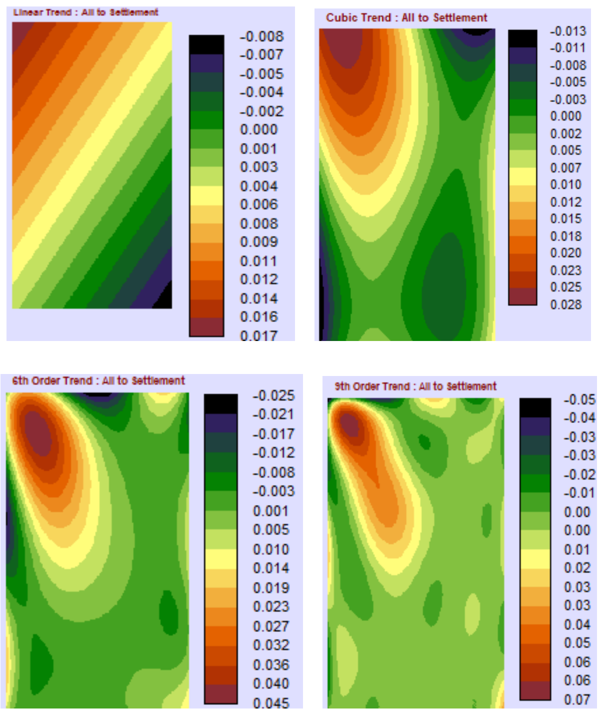
Table 2 LULC Transformation during the Assessment Period from 1989 to 2000

LULC class		Water	Settlement	Vegetation	Dense Forest	Barren	Area of LULC gain (km^2)	Land Use Area (km^2)_2000
Land Use Area (km^2)_1989	**Water**	**12.85**	0	0.62	0.35	0.11	1.08	6.52
	Settlement	1.71	**0**	3.69	5.94	0.81	12.15	12.15
	Vegetation	1.98	0	**12.61**	11.99	2.81	16.78	20.57
	Dense Forest	3.32	0	4.17	**20.95**	0.53	8.02	9.83
	Barren	0.4	0	0.34	0.86	**4.74**	1.6	2.08
	Area of LULC loss in km^2	7.41	0	8.82	19.14	4.26	39.63	51.15

(Note: the diagonal value represents area of Land use in 1989; the column represents the net loss of Land use into other feature class and row shows the net gain of LULC from other feature classes, LULC area in succeeding year is the summation of LULC of preceding year with net gain minus net loss of LULC).

A significant transformation of barren to dense forest class was observed as 0.86 km^2 in terms of gain and 2.81 km^2 loss. In the late 1980's and early 1990's, a massive construction of various structures embarked along the river segment that included Okhla barrage (1986), ISBT flyover (1990) and NH 24 flyover (1994) imposing establishment of construction units and labor settlements on flood plains thereby resulting in the massive makeshift of the already existing Built-up area.



(d)

Fig. 6 Spatial Trend analysis between 1989-2000 (a) Linear Trend Analysis – All to settlement (b) Cubic Trend Analysis – All to settlement, Barren to settlement (c) 6th order Trend Analysis – All to settlement (d) 9th order Trend Analysis – All to settlement

Fig 6 depicts the spatial trend analysis between 1989 to 2000. Fig 6 a depicts the linear trend , Fig 6 b shows the cubic trend , Fig 6 c shows the 6th order trend and Fig 6 d shows the 9th order trend analysis between all to settlement. It is further revealed that dense forest and vegetation has maximum transformation into settlement where as barren contributed minimum to settlement.

LULC transformation between 2000 and 2018

Assessment period from 2000 to 2018 witnessed (Table 4) the transformational gain and loss of vegetation class was observed to be highly interlinked with the dense forest class amounting to 11.99 km^2 and 4.17 km^2 respectively. Also, conversion of dense forest into vegetation class in terms of gain and loss was recorded as 4.17 km^2 and 11.99 km^2 respectively and bearing a surplus loss of 5.94 km^2 to built-up area. Likewise, a substantial transformation of barren land to forest and vegetation class in terms of gain and loss was observed as 0.86 km^2 and 2.81 km^2 respectively. Transformations during this assessment period are associated to commencement of large scale construction phase along the river stretch utilizing appreciable agricultural and forest land for dumping and crushing waste construction material and having been left thereafter.

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Table 3 LULC Transformation during the Assessment Period from 2000 to 2018

LULC class		Water	Settlement	Vegetation	Dense Forest	Barren	Area of LULC gain (km^2)	Land Use Area (km^2)_2018
Land Use Area (km^2)_2000	**Water**	**6.52**	0.32	0.29	1.11	0.05	1.77	5.52
	Settlement	0.44	**12.15**	5.04	2.02	0.64	8.14	13.19
	Vegetation	0.82	3.14	**20.57**	2.4	0.56	6.92	12.19
	Dense Forest	1.32	3.53	7.24	**9.83**	0.5	12.59	15.15
	Barren	0.19	1.39	2.01	1.38	**2.08**	4.97	5.1
	Area of LULC loss in km^2	2.77	8.38	14.58	6.91	1.75	34.39	51.15

(Note: the diagonal value represents area of Land use in 2000; the column represents the net loss of Land use into other feature class and row shows the net gain of LULC from other feature classes, LULC area in succeeding year is the summation of LULC of preceding year with net gain minus net loss of LULC).

Fig 7 depicts the spatial trend analysis between 2000 to 2018. Fig 7 a depicts the linear trend analysis, Fig 7 b depicts the cubuic trend analysis, Fig 7 c depicts the 6th order trend analysis and Fig 7 d depicts the 9th order trend analysis between all to settlement. It is further revealed that vegetation has maximum transformation into settlement.

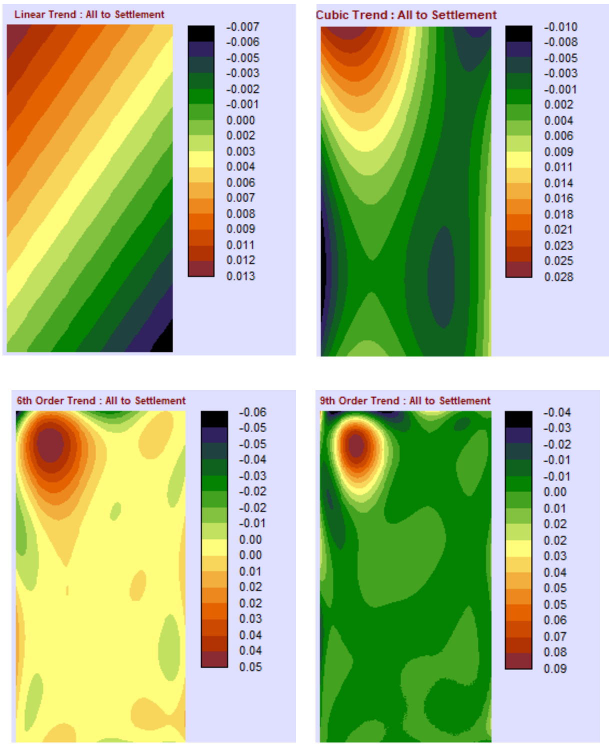

Fig. 7 Spatial Trend analysis between 2000-2018 (a) Linear Trend Analysis – All to settlement (b) Cubic Trend Analysis – All to settlement (b) 6th order Trend Analysis – All to settlement (c) 9th order Trend Analysis – All to settlement

Accuracy Assessment

The kappa coefficient and Overall accuracy for Satellite images of MSS (1989), TM (2000) and Landsat 8 (2018) were evaluated as 0.781, 0.892 and 0.804 and 86.00%, 92.31%, 86.00% respectively (Fig. 8 (a)). Fig. 5 **(b)** depicts the variation of producer and user accuracy for different classes for the year of assessment 1989, 2000 and 2018. Maximum producer and user accuracy for the year of assessment 1989 is 100.00%, 92.86% for dense forest and minimum producer and user accuracy is 62.5%, 62.5% for vegetation. Likewise for the year of assessment of 2000, maximum producer and user accuracy is 100.00%, 100.00% for water, settlement and vegetation and minimum producer and user accuracy is 80.00%, 75.00% for dense forest.

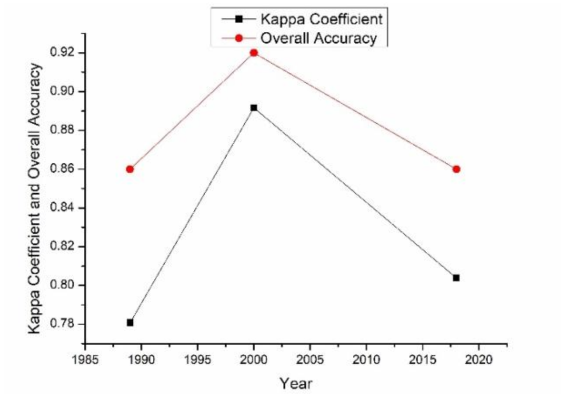

Fig. 8 (a) Kappa coefficient and Overall accuracy for the image of 1989, 2000 and 2018.

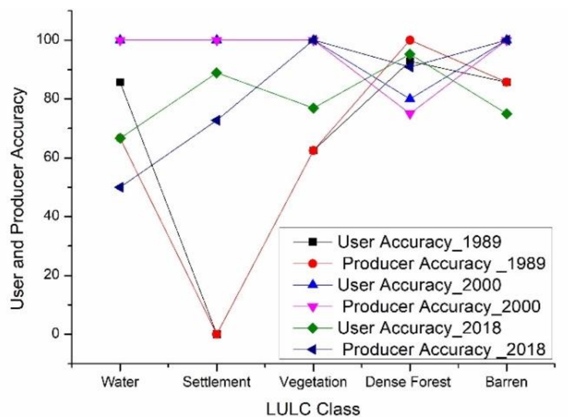

Fig. 6 (b) User and Producer Accuracy for the image of 1989, 2000 and 2018.

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CONCLUSIONS

Socioeconomic activities and land use expansion posing vulnerability to an area can very well be evidenced through time series change detection of land use along with interpretation of change. Geospatial techniques provides an effective platform to assess, examine and organize the land use and land cover changes and its relative transformation from one feature class to another and vice versa. This study reflects the land use land cover change and transformation of flood plain area of River Yamuna along Delhi, NCR was analyzed using satellite images of 1989, 2000 and 2018. ERDAS Imagine and IDRISI Terrset software for land change modeler were used for image processing, quantification and transformation with gain and loss and net contribution of feature classes. The development of built-up area up to 25 % of total area within the study period and loss of 10% in dense forest with fluctuation in vegetation and water class was observed. The spatial trend change analysis of land use modeler reveals a more rampant land use during 1989 to 2000 as compared to 2000 to 2018 which reflects an outline of change. The land use modeler further reveals the specific zone of transformation and gain and lost due to various anthropogenic activities. Overall accuracy, producer's accuracy and kappa statistics was found to be satisfactory for all the images. This study insights an strategic roadmap to sustainable land use planners and manager for an efficient river supervision. The selection of images with higher resolution, without cloud cover or with the same percentage of cloud cover and similar temporal aspect could best be utilized for the better result in overall accuracy and kappa statistics.

CONFLICT OF INTEREST

It is hereby declared that that author and co-author do not carry any conflict of interest regarding the possible publication of this manuscript.

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REFERENCES

1. Afify, H.A., 2011. Evaluation of change detection techniques for monitoring land-covers changes: a case study in new Burg El-Arab area. Alexandria Eng. J. 50, 187–195
2. Ahmad, A., and Quegan, S., 2012. Analysis of maximum likelihood classification on multispectral data. Applied Mathematical Sciences, 6(129), pp. 6425-6436.
3. Beuchle, R., Grecchi, R.C., Shimabukuro, Y.E., Seliger, R., Eva, H.D., Sano, E., Achard, F., 2015. Land cover changes in the Brazilian Cerrado and Caatinga biomes from 1990 to 2010 based on a systematic remote sensing sampling approach. Appl. Geogr. 58, 116–127. http://dx.doi.org/10.1016/j.apgeog.2015.01.017.
4. Butt, A., Shabbir, R., Ahmad, S.S., Aziz, N., 2015a. Land use change mapping and analysis using Remote Sensing and GIS: a case study of Simly watershed, Islamabad, Pakistan. Egypt. J. Rem. Sens. Space Sci. 18, 251–259.
5. Butt, A., Shabbir, R., Ahmad, S.S., Aziz, N., Nawaz, M., Shah, M.T.A., 2015b. Land cover classification and change detection analysis of Rawal watershed using remote sensing data. J. Biol. Environ. Sci. 6 (1), 236–248.
6. Ghebrezgabher, M.G., Yang, T., Yang, X., Wang, X., Khan, M., 2016. Extracting and analyzing forest and woodland cover change in Eritrea based on landsat data using supervised classification. Egypt. J. Remote Sens. Space Sci. 19, 37–47. http://dx.doi.org/10.1016/j.ejrs.2015.09.002.
7. Gurgel, R.S., Farias, P.R.S., & Oliveira, S.N. (2017). Land use and land cover mapping and identification of misuse in the permanent preservation areas in the Tailândia Municipality – PA. Semina Ciências Agrárias, Londrina, 38(3), 1145–1160.
8. Kamrul Islam et al., 2018 Land use classification and change detection by using multi-temporal remotely sensed imagery: The case of Chunati wildlife sanctuary,Bangladesh The Egyptian Journal of Remote Sensing and Space Sciences 21 (2018) 37–47
9. Krishna Rajan, D. Understanding the Drivers Affecting Land Use Change in Ecuador: An Application of the Land Change Modeler Software. Available online: https://www.era.lib.ed.ac.uk/handle/1842/3740 (accessed on 17 September 2018).
10. López-Serrano, P.M., Corral-Rivas, J.J., Díaz-Varela, R.A., Álvarez-González, J.G., López-Sánchez, C.A., 2016. Evaluation of radiometric and atmospheric correction algorithms for aboveground forest biomass estimation using landsat 5 TM data. Remote Sens. 8, 1–19. http://dx.doi.org/10.3390/rs8050369.
11. Lv, Z.; Shi, W.; Zhou, X.; Benediktsson, J.A. Semi-automatic system for land cover change detection using Bi-temporal remote sensing images. Remote Sens. 2017, 9, 1112.
12. Mishra, V.N.; Rai, P.K.; Mohan, K. 2014. Prediction of land use changes based on land change modeler (LCM) using remote sensing: A case study of Muzaffarpur (Bihar), India. J. Geogr. Inst. Jovan Cvijic SASA 2014, 64, 111–127.
13. Mosammam, H.M., Nia, J.T., Khani, H., Teymouri, A., Kazemi, M., 2017. Monitoring land use change and measuring urban sprawl based on its spatial forms: the case of Qom city. Egypt. J. Remote Sens. Space Sci. 20 (1), 103–116. http://dx. doi.org/10.1016/j.ejrs.2016.08.002.
14. Wu, T.; Luo, J.; Fang, J.; Ma, J.; Song, X. Unsupervised object-based change detection via a Weibull mixture model-based binarization for high-resolution remote sensing images. IEEEGeosci. Remote Sens. Lett. 2017, 15, 63–67. DOI:10.1109/LGRS.2017.2773118
15. Zanetti, M.; Bruzzone, L. A theoretical framework for change detection based on a compound multiclass statistical model of the difference image. IEEE Trans. Geosci. Remote Sens. 2018, 56, 1129–1143

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