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The Analysis of Land Use Land Cover Changes Using Geo-informatics and Its Relation to ChangingPopulation Scenariosin Barasat Municipality in North Twenty Four Parganas, West Bengal

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Abstract: *The scenarios of land use land cover of any urban area is significantly shown with the representation of land use land cover maps and different indices such as NDVI, MNDWI, NDBI, BUI. The changes of land use land cover is a common fact in the urban area at present. The rapid increasing of population is one of the most significant factors of land use land cover changes. The present study shows such types of LULC changes and its relation to population changes with the selected objectives and methodologies. In the present study, mainly secondary databases and geo-informatics are used for completion of the study. Here, the change of LULC in the study area is represented with the same LULC maps and index values. Besides, the population changes of changing situation of LULC is also correlated and justified with analysis of variance and significance test of correlation-regression analysis. The overall result shows that the land use land cover is changed rapidly in the period of 1990 to 2000 and 2016 in a progressive way in the case of built-up areas (percentage values of area under settlement are 10.313, 34.0505, 56.9974 respectively) and in a regressive way in the case of non-built-up areas (percentage values of areas under water bodies is 42.466, 15.7728, 14.3585, under vegetation is 26.614, 16.4874, 14.3099, under barren land is 18.454, 17.5605,0respectively).In the case of fallow land, the percentage of area is firstly increased in 2000 (area is 16.1288 %) than 1990 (2.1526%) and then decreased in 2016 (14.3342%). Finally, the correlations in between the NDVI, MNDWI, NDBI and NDBI are significant where $p<0.01$. Besides, the relationships of population with water bodies, vegetation, barren land, fallow land and settlement are not significant with the value of p which is greater than 0.05 with 95 % of confidence level.*

Keywords:*LULC changes, Index values, population change, interrelationships, significance test*

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I. Introduction

The land use land cover of an urban area generally denotes different types of physical and anthropocentric two dimensional uses of land. Basically, in an urban area most of the land is used for building up residential and commercial areas. In the present situation the human-oriented land use and land cover in an urban area have been changed dramatically due to the heavy expansion of urban population and residential area. Such, in a city the degree of land use land cover changes of urban area is determined by multivariate factors as the expansion of municipal area, increasing city population, increasing the number of settlements sprawling residential area, commercial area and transport networks. But in an urban arena, the most affective factors on land use land cover changes are rapid increasing of population and residential area as well as substituting usage of urban land by the city-dwellers.

In the context of the study some specified literatures related with the LULC (Land use land cover) changes detection through geo-informatics and its relation to population increase has been reviewed here. Morara, MacOpiyo, and Kogi-Makau, (2014:192) [1] postulated that “Land use and cover changes resulted in increase in riverine vegetation and woodlots”inKajiado County in Kenya.Dolui, Das and Satpathy(2014:8)[2]stated that “Continuous growth of urban area is responsible for changing land use land cover pattern of any urban centre” likeMidnaporeMunicipality.Ashraf(2014:16782)[3] researched that, “The knowledge of Land cover/Land use change pattern is very handy to get into the reality of anthropogenic pressure and dynamics of demography” of Patna Municipal Corporation.Sen(2015, 31)[4]postulated that“City limits are continually shifted outwards due to explosive growth Mobility within the city needs to be addressed to tackle these issues of rapid urbanization and to suggest best possible method of developing transport network” in Barasat Municipal area.Okamoto Sharifi, Chiba and Yoshihiro (2014:29)[5]mentioned in their paper with investigating urbanization in ‘Vientiane, the Laotian capital city, and its vicinity’ with the intention with addressing ‘the relationship between urbanization and land use.’ In their study Erener,Düzgün, and

Yalciner(2012: 385)[6]used detailed temporal satellite data and information systems to detect land use land cover change.Das (2016: 2466)[7]focused on researching the land use land cover change detection by urban modelling and associated methodologies.Reis(2008:6188)[8] applied 'firstly supervised classification technique to Landsat images acquired in 1976 and 2000' and then GIS to investigate LULC change in Rize, North-East Turkey.' The results indicate that severe land cover changes have occurred in agricultural (36.2%) (Especially in tea gardens), urban (117%), pasture (-72.8%) and forestry (-12.8%) areas has been experienced in the region between 1976 and 2000.Satiprasad (2013: 1)[9]examined in his paper that the 'urban LULC changes that have been taken place in Howrah city, India, for the last two decades due to the rapid urbanization. This work mainly emphasizes on understanding of LULC change detection analysis using LANDSAT (MSS in 1975, TM in 1989, and ETM+ in 2000) and LISS-III (2009) high resolution imagery for the 34 years' time span.' In the context of the research of 'Land Information System', Wani and Khairkar (2011:110)[10]mentioned in their study that 'Land Information System' is essential for monitoring land resources and detecting the Land use land cover changes.Gupta and Roy (2012:1014)[11]simply justified that the land use land cover change related classification in Burdwan Municipal area is multi-categorized and accurate with 83.01% average and 76.47% overall.Herold,Couclelis and Clarke (2005: 369)[12] in their paper analysed 'a framework combining remote sensing and spatial metrics aimed at improving the analysis and modelling of urban growth and land use change.'

Urban land use and land cover changes its characteristics depend on some indicators of various uses of land such as water bodies, vegetation coverage, agricultural usage, built-up area, arable land, vacant land, waste land or fallow land as such. Some literatures of 'Index' based methodologies are mentioned here. In their study Bhatti, and Tripathi, (2014:1)[13]applied the NDBI 'to the newer Landsat-8 Operational Land Imager (OLI) data was examined during' the study in Lahore, Pakistan and a new method for built-up area extraction has been proposed'.According to Xu (2006:3025) [14] "The MNDWI is more suitable for enhancing and extracting water information for a water region with a background dominated by built-up land areas because of its advantage in reducing and even removing built-up land noise over the NDWI."Szabó, Gacsi, and Balazs (2016:194) [15] researched about 'specific features of NDVI, NDWI AND MNDWI AS reflected in land cover categories' using LANDSAT ETM^+data.Li. Et al. (2017: 1) [16] mentioned in their study that "This study demonstrated that the proposed method was an accurate and reliable option to extract the bare land, which led to a promising approach to mapping urban land use/land cover (LULC) automatically with simple indices."Kaimaris, and Patias (2016: 1844) [17] used BUI as a new index in their study and 'Its comparison with other indexes takes place in the urban, suburban and agricultural area of a Greek city, and its effectiveness is tested in four other cities (in Greece and Palestine) on Greek city' 'based on the combination of the bands of LANDSAT ETM^+: RED (band 3), $SWIR_1$ (band 5) and $SWIR_2$ (band 7).'Ahmed, (2012:557) [18] detected the 'change in vegetation cover using multi-spectral and multi-temporal information for District Sargodha, Pakistan' using NDVI and associated Index 'derived from Landsat ETM^{+}' and 'multi-spectral MODIS' datasets. Moreover the literatures on the relationship status in between population changes and LULC changes are reviewed as follows.Mundhe, and Jaybhaye (2014:50) [19]suggested about the land use land cover change due to 'Urbanization' which is the 'method of urban areas growth, which result in population growth, increase of built-up area.'Ningal, Hartemink, and Bregt(2008: 117)[20]mentioned in their study that 'The relation between human population growth and land use change is much debated.' In this study they 'present a case study from Papua New Guinea where the population has increased from 2.3 million in 1975 to 5.2 million in 2000. Since 85% of the population relies on subsistence agriculture, population growth affects agricultural land use.' Estes (2012:155) [21] established a relationship in their study in between 'Land-cover change and human population trends in the greater Serengeti ecosystem from 1984–2003.'Ouedraogo, et al. (2010: 453) [22] found out the progressively change (conversion) of forest land to cropland with the shift of population and its density. Also, ' This paper assessed the impact of such increased population on land use change in the attracting zones from 1986 to 2006' by using 'Satellite images' 'to measure changes in land cover types over time and national population Census data were used to examine the population dynamics over the same time.' Moreover, Poiyakov, and Zhang (2008:694) [23] found that population accessibility and growth plays an effective role 'development of rural lands and transition between agricultural and forestry uses, but also influence changes between forest types' in West Georgia between 1992-2001.

The present study is structured and determined with the basic conceptualization of thespatio-temporal changing states of land use land cover in a municipal area as well as the correlation in between the degree of urban expansion and land use land cover changes. The geo-informatics such as Remote Sensing and Geographical Information System techniques are implemented to detect the temporal changes of land use and land cover scenarios. Besides, the temporal changes of population expansion and its relationship with land use land cover changes have been calculated and represented with correlation –regression, analysis of variance and significance test. The details of the techniques are mentioned in 'Databases and methodology' section. Besides, On the basis of the detailed literature review it is mentioned that the land use land cover change detection and urban expansion related studies are familiar fact to the researchers. Here, in the present study only the pre-reviewed methodologies are implemented to detect thespatio-temporal urban expansion and changes of land use land cover in the study area as well as find out the degree of those changes near about the three decades (1990-2016) in the study area.

II. Objectives

The objectives of the study area are as follows.

1. To detect the different dimensions of land use land cover changes of the study area.
2. Identifying different indices of land use land cover changes in the study area in the period of 1991-2016.
3. Tress out the relationship between population changes and land use land cover changes in the study area

III. Study area

Barasat Municipality is selected as identifying the land use land cover changes and urban expansion. This municipality (Barasat), a part of Kolkata Metropolitan Development Authority is situated under Barasat I Community Development Block in North Twenty Four Parganas district. Barasat is the district head quarter of North Twenty Four Parganas district and a Class I city populated with 278435 persons (Census of India, 2011) [24] and the total residential and non- residential area are divided into 35 words with a population density of 8216 persons/sq.km (as on 2011) and the growth rate in the city population between 1991 and 2011 was 125.5%. (Mentioned in Mukherjee and Ray, 2017:21-22)[25]The major transport networks such asNational Highway 34;Jessore Road as such cross through the town, Sealdah-Bongaon Branch line create connection of Barasatwith the capital of West Bengal and the surrounding districts.

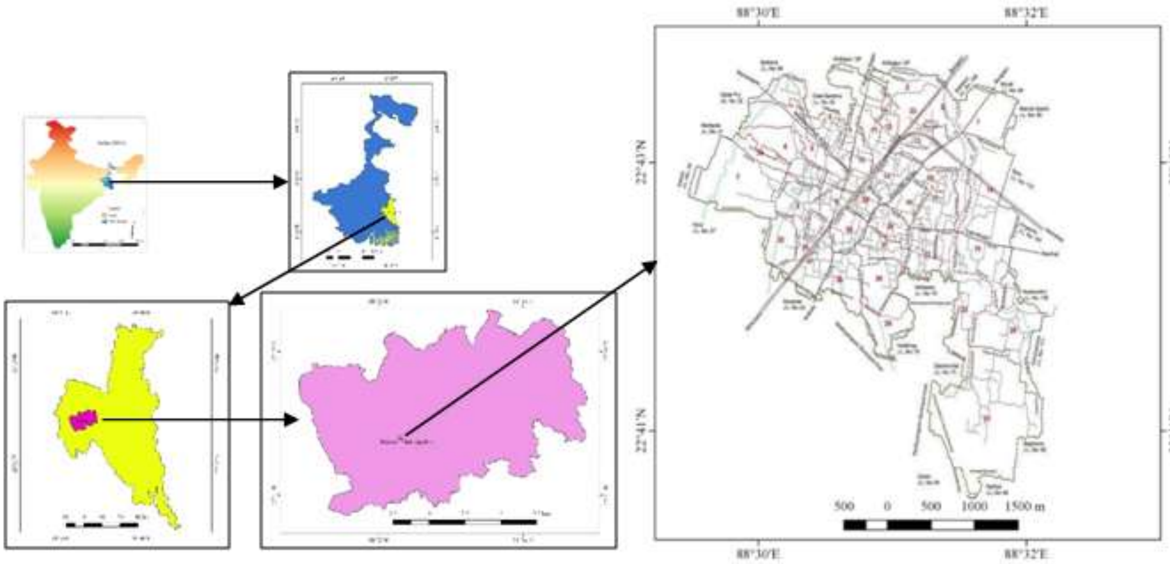


Figure 1: location map of the study area

The rapid expansion of population and residential area in this municipality create significant changes of land use and land covers. As the city is one of the fastest growing city of West Bengal, the rate of land use land cover change in this city is mentionable. Thus, the municipality contributing as a part of KMDA is selected as the study area to detect mainly the relationship of rapid urbanization and land use land cover changes as its effects.

IV. Database and Methodology

The study has been mainly conducted with secondary databases, geo-informatics and statistical analysis. The details of the methodologies are followed below.

4.1 Image processing

For the purpose of detection LULC changes, the LULC classification maps have been created in the prescribed software named Quantum GIS (version: 2.18). The multispectral images of LANDSAT (details are mentioned in the Table 1) are used to prepare of LULC classification maps.

Table 1: Details of satellite imageries used in the study

Serial Number	Date of imagery	Satellites/ Sensors	Reference System/ Path/Row
1	14/11/1990	LANDSAT 5:Thematic Mapper (TM)	WRS-2/138/44
2	17/11/2000	LANDSAT 7: Enhanced Thematic Mapper Plus (ETM+)	WRS-2/138/44
3	13/11/2016	LANDSAT 7: Enhanced Thematic Mapper Plus (ETM^+)	WRS-2/138/44

(Source: United States Geological Survey, 2016)[26]

Next 'To get the composite images, different types of bands and stacking are performed of all the collected images content. Some image improvement techniques like data scaling and histogram equalization are also performed on each image to improve the image quality' (Mentioned in Dolui, Das and Satpathy, 2014:10) [2].

4.2 ROI creation and Macro classes

After the completion of preprocessing some specified ROIs () have been created, considering the reflectance variability of LULC classes. The selected macro-classes of land use land cover are identified, such as: 1. Water bodies, 2. Vegetation, 3. Barren land, 4. Fallow land, 5. Settlement. Then training areas are selected considering more than three of the training data of each LULC for better performance of classification.

4.3 Classification Algorithm

The remotely sensed classification is performed by 'Maximum Likelihood Classification' algorithm and after the satisfaction with 'classification preview', the actual classifications are performed.

4.4 Land use land cover maps and classification reports

After the performance of semi-automatic classification in QGIS, the output classification images and areas of each classes of LULC from 'post processing - classification report' are collected for further analysis and interpretation.

4.5 Index values

Different indices values are calculated for the better performance of detection LULC changes in the study area, such as.

'Normalized Difference Vegetation Index (NDVI) (Rousse et al., 1973)[27]is most commonly used significant indicator to monitoring vegetation condition, especially vegetation health condition. The NDVI images are calculated for 1990, 2000 and 2016 from visible Red (0.63-0.69 μm) and near-infrared (0.78-0.90 μm) by using the following mathematical formula:

NDVI = (NIR – RED) / (NIR + RED)

In case of Landsat-5 and 7 it was the band-3 (Red) and band-4 (NIR), respectively.

Normalized Differential Water Index (NDWI) byMcFeeters (1996) [28] is an index to extract water bodies from satellite imagery. It is performed by the following formula,

NDWI= (Green-NIR) / (Green+NIR)

In the case of Landsat-5 the used bands are band-2 (Green) and band- 4(NIR) and of Landsat-7 those are band-4 (NIR) and band-5 (SWIR).

'If a MIR band is used instead of the NIRband in the NDWI, the built-up land should have negative values. Based on this assumption, the NDWI is modified by substituting the MIR band for the NIR band' (Xu, 2006: 3027). [14]The modified NDWI (MNDWI) was introduced byXu (2005)[29] and can be expressed as follows:

MNDWI= (Green-MIR)/ (Green+MIR)

In the case of Landsat-7 those are band-2 (Green) and band-5 (SWIR)

Normalized Difference Build-up Index (NDBI) byZha, Gao and Ni (2003) [30] is used to extract built-up features and have indices range from -1 to 1. It is performed through the following formula.

NDBI= (MIR-NIR)/ (MIR-NIR)

In the case of Landsat-7 those are band-5 (SWIR) and band-4 (NIR)

Build- up Indices are calculated for detect the built –up and non-built –up areas. It is performed by the following formula,

BU=NDBI-NDVI

In contrast to the binary output of the original technique proposed by Zha, Gao and Ni (2003), [30] a continuous image, BU, was produced through this modified approach in which a higher value of a pixel indicated a higher possibility that it indicated a built-up area.This methodology was modified and improved by He et al. (2010)[31] (mentioned in Bhatti and Tripathi, 2014: 15). [13]

4.6 Statistical techniques

Moreover different statistical techniques are used to analyse the interrelationships in between the population changes and LULC changes.

Arithmetic means are calculated to find out the average indices values each of the calculated Indices of the years 1990, 2000 and 2016.

Here, Mean= $\frac{\sum \alpha}{n}$

Where,

α Is the individual value of items

'n' is the number of terms in the distribution

To find out the degree of changes from 1990 to 2016 correlation analysis (Pearson, 1901)[32]and linear regression model (Galton, 1894;[33] Pearson, 1896[34]) have been used.

To find out the correlations in between the percentage of changes of each criteria of land use land cover (1990-2016) Pearsonian formula of 'r' (Pearson, 1901)[32]have been used.

$$r=\frac{n\Sigma xy - \Sigma x.\Sigma y}{\sqrt{n\Sigma x^2-(\Sigma x)^2}\sqrt{n\Sigma y^2-(\Sigma y)^2}}$$

Where,

r= Correlation Co-efficient

x= Independent variable

y= Dependent variable and

n= No. of observations

The Formula for linear Regression, $Y_c = a + b\ X$

Where, Y_c is a predicted value of Y (which is the dependent variable)

a is the 'Y intercept'

b_1 is the change in Y for each 1 increment change in X

X is an X score (Independent variable) for which a value of Y is predicted

Moreover the analysis of variance is implemented to find out the significance value of correlations

The 'F' value in the one-way ANOVA (Fisher, 1925) [35] is calculated through the following formula,

$$F=\frac{Explainedvatriance}{Unexplainedvariance}$$ Or,

$$F=\frac{Between-groupvariablity}{Within-groupvariability}$$

The 'Explained variance', or 'Between-group variability' is

$$\sum_{i=1}^{K} ni(\bar{Y}i.-\bar{Y})^2/(K-1)$$

Where,

$\bar{Y}i.$ Denotes the sample mean in the i^{th} group

$ni$is the number of observations in the i^{th} group

$\bar{Y}$denotes the overall mean of the data

And K denotes the number of groups

The 'Unexplained variance' or 'Within-group variability' is

$$\sum_{i=1}^{n}.\sum_{j=1}^{ni}(Yij-\bar{Y}i.)^2/(N-K)$$

Where,

*Yij*is the j^{th} observation in the i^{th} out of *K* groups and *N* is the overall sample size.

This *F*-statistic follows the *F*-distribution with *K-1*, *N-K* degree of freedom under the null hypothesis.

The test of significance (Fisher, 1925[36] following Student, 1908[37]) test has been adopted to observe the relationship either significant or not.

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

Where,

t= Value of Significance

r= Correlation Co-efficient

r^2= Coefficient of determinants and
n= No. of observations

V. Results and Discussion

5.1 Land use land cover changes

The changes of LULC in Barasat municipality are detected by the following fig. 2-4.

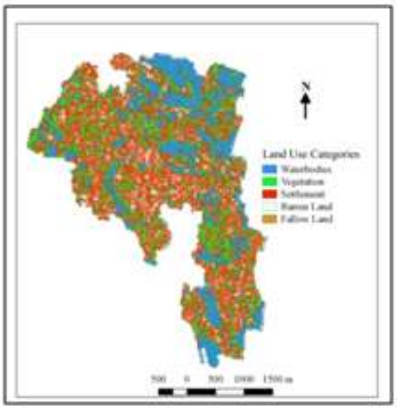


Figure 2: LULC map of 1990

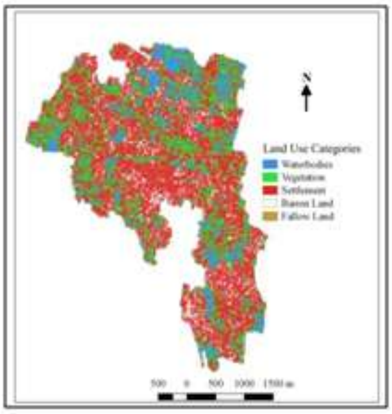


Figure 3: LULC map of 2000

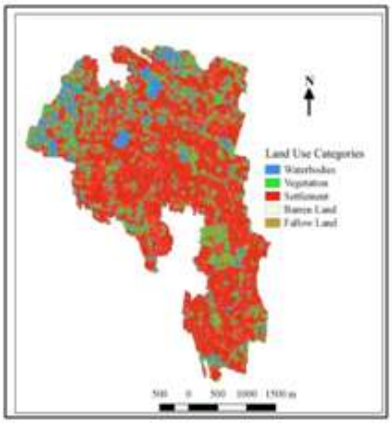


Figure 4: LULC map of 2016

The fig. (2-4) show the Land use land cover situations of Barasat Municipality in the year of 1990, 2000 and 2016 respectively. The five categories of LULC in this urban unit are under the consideration. Here, the fig. (2-4) show 42.4658% area of water bodies, 26.6145% area of vegetation, 10.3131% area of settlement, 18.4540 % area of barren land and 2.1526% area of fallow land in 1990 respectively. Besides, the percentages of area of water bodies, vegetation, settlement, barren land and fallow land are 15.7728, 16.4874, 34.0505, 17.5605, and 16.1288 in 2000 and 14.3585, 14.3099, 56.9974, 0, 14.3342 in 2016 respectively. The details representation of the percentages of areas under the LULC classes are represented in the fig. (5-7) below.

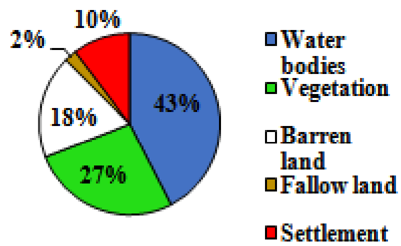


Figure 5: Area under LULC classes in 1990

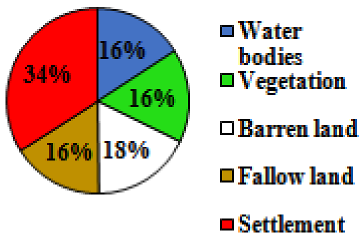


Figure 6: Area under LULC classes in 2000

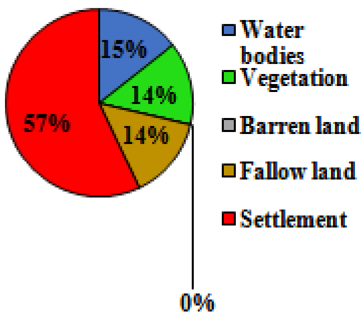


Figure 7: Area under LULC classes in 2016

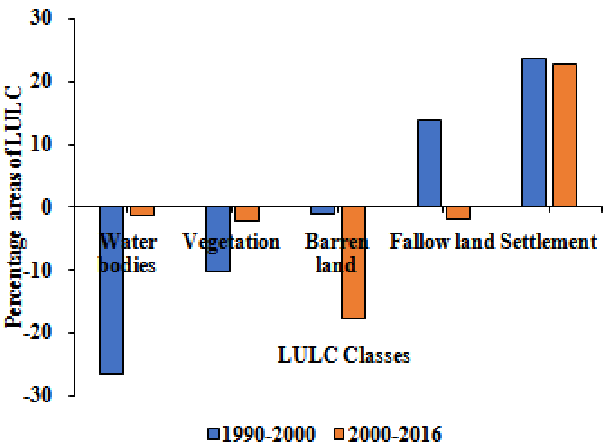


Figure 8: Land use land cover changes (1990-2000 and 2000-2016)

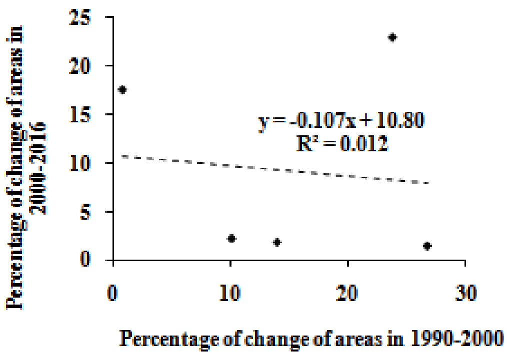


Figure 9: Relationship of LULC changes of 1990-2000 and 2000-2016

The changes occurred in the three years' time span (1990, 2000 and 2016) overall show (in the fig. 8) that the changes of water bodies area is -26.6932% in 2000 in respect of 1990 and then -1.4144 % in 2000 in respect of 2016. In the case of vegetation coverage the changes are -10.1266% in 2000 and -2.1775 in 2016. The area of barren land has been changed -0.8935% in 2000 and -17.5605 in 2016. The changes of area of fallow land and settlement are 13.9762% and 23.7375% in 2000 and -1.7946% and 22.9469% in 2016 respectively. So, it is clear that the changes of built-up area (settlement) is positive in the both years (2000 and 2016) and comparatively rapid than the non-built-up areas (water bodies, vegetation, barren land and fallow land) in the study area.

The linear trend in the scatter plot in the fig. 9 shows the low negative correlation (value of r is -0.1095) in between the changes of area of overall LULC from 1990 to 2000 and from 2000 to 2016. This type of relation shows that the changes of land use and land cover in the municipality is negatively decreased an in the case of overall changing situations but the rate of changes is very gradual.

5.2 Determination of the changes of Index values

Different indices are calculated to determine the values of changes of different LULC. Here Normalized Differential vegetation index (NDVI), Modified Normalized Differential Vegetation Index (MNDWI), Normalized Differential Build-up Index (NDBI) and Build-up Index (BUI) are calculated and represented.

5.2.1 Analysis of the changes of vegetation density

The Normalized Differential Vegetation Indices are calculated and represented in the following figures 10-12 in the year of 1990, 2000 and 2016. The fig. 10-12 show the values of NDVI which vary from very low (-0.114, 0.5938, -0.9526; dominant with water) to very high (0.136, 0.6611,-0.9429; dominant with vegetation) in the year of 1990, 2000 and 2016 respectively. Here, the variations of higher to lower indices of vegetation coverage are highly ranged in the year of 1990 than the respective years.

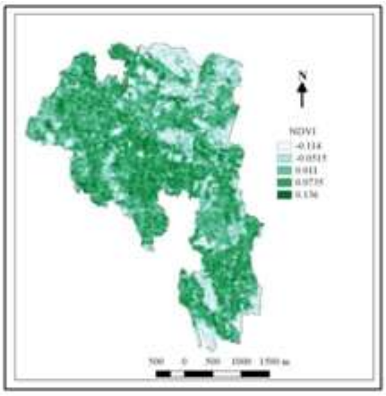
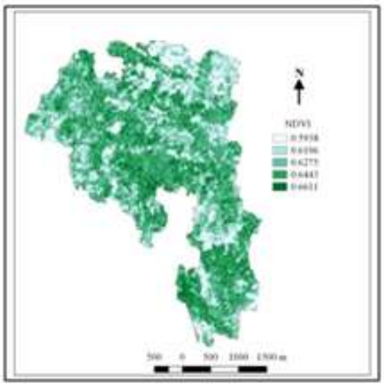
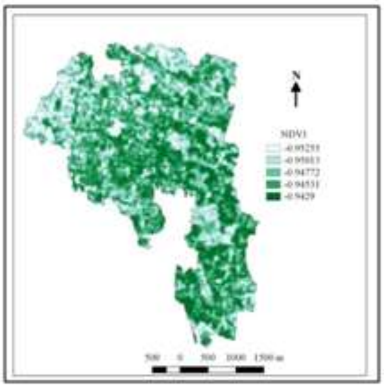




Figure 10: NDVI of 1990 **Figure 11:** NDVI of 2000 **Figure 12:** NDVI of 2016

5.2.2 Determination of the changes of Modified Normalized Water Index

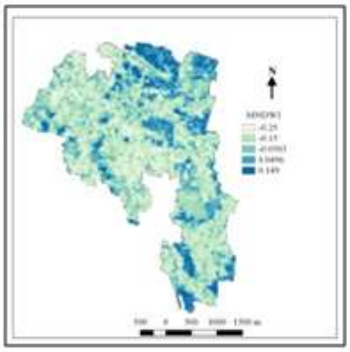
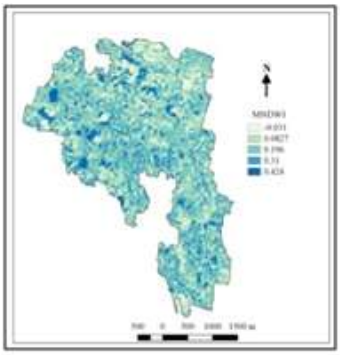
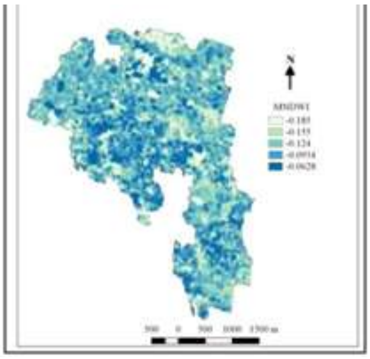




Figure 13: MNDWI of 1990 **Figure 14:** MNDWI of 2000 **Figure 15:** MNDWI of 2016

The Modified Normalized Differential Water Indices are calculated and represented in the following fig. 13-15 in the year of 1990, 2000 and 2016. Here, the values of MNDWI vary from very low (-0.25, -0.031,-0.185; dominant with non-water bodies) to very high (0.149, 0.424, -0.0628; dominant with water bodies and marshy land) in the years of 1990, 2000 and 2016 respectively. Here, the variations of higher to lower indices of water bodies are highly ranged in the year of 2000, then 1990 than the respective year.

5.2.3 Changes of Built-up areas

To determine the changes of built-up area Normalized Differential Build-up Index and Build-up Index have been calculated and represented below (in the fig. 16-18).

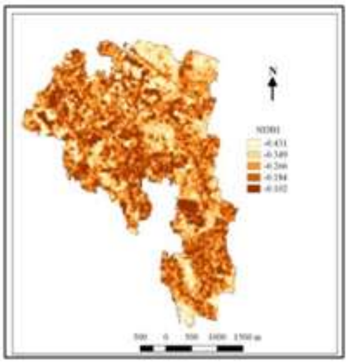


Figure 16: NDBI of 1990

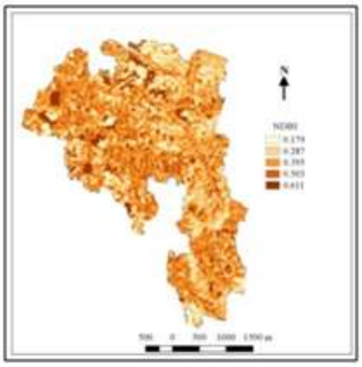


Figure 17: NBVI of 2000

Figure 18: NDBI of 2016

The Normalized Differential Built-up Indices are calculated and represented in the following fig. 16-18 in the year of 1990, 2000 and 2016. Here, the values of NDBI vary from very low (-0.431, 0.179,-0.219; dominant with non-built-up areas, changes shown in the fig. 16-18) to very high (-0.102, 0.611,-0.029; dominant with built-up areas, changes shown in the fig. 16-18). Here, the variations of higher to lower indices of built-up areas are highly ranged in the year of 1990, then 2000 than the respective year.

Besides, the Buildbuilt-up Index (BUI) has been calculated here in the year of 1990, 2000 and 2016. The index varies from very low (-0.317, 0.4148, 0.7336; non-built-up area) to very high (-0.238, 0.0501,-0.9139; highly built-up area). Here, the variations of higher to lower indices of built-up areas are highly ranged in the year of 1990 than the respective years and also the changes of built-up area is clearly shown in the fig. 19-21 that the red colored areas are highly spread and accumulated in the map (fig. 21) of 2016 than the map of 2000 (fig. 20) and 1990 (fig. 19).

Figure 19: Built-up area in 1990

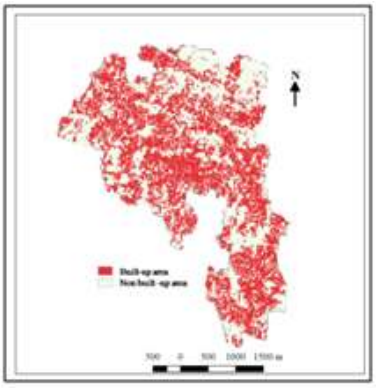


Figure 20: Built-up area in 2000

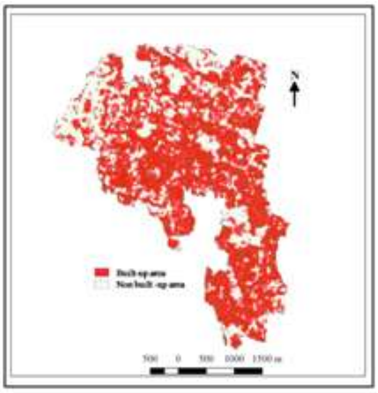


Figure 21: Built-up area in 2016

5.3 Situation of changing population scenarios and degree of LULC indices

Barasat municipal area is a highly populated city. Being an important inclusion of KMDA (Kolkata Metropolitan Development Authority) area the population is highly increased in this municipality. The population scenarios of 1991, 2001 and 2011 of Barasat has been represented in the fig. 22 below. This fig. shows that the population of this city is 10266 in 1991, 231521 in 2001 and 278435 in 2011. This situation reveals that the population is in an increasing way in this municipality.

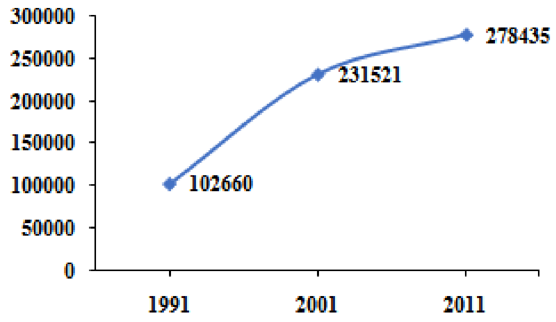


Figure 22: Population changes in Barasat Municipality (1991-2011)

Table 2: Correlation matrix of the Index values of LULC

Correlations					
		NDVI	MNDWI	NDBI	BUI
NDVI	Pearson Correlation	1	1.000**	1.000**	-.999**
	Sig. (2-tailed)		.000	.000	.000
	Sum of Squares and Cross-products	.007	.022	.022	-.011
	Covariance	.002	.006	.005	-.003
	N	5	5	5	5
MNDWI	Pearson Correlation	1.000**	1	1.000**	-1.000**
	Sig. (2-tailed)	.000		.000	.000
	Sum of Squares and Cross-products	.022	.066	.065	-.032
	Covariance	.006	.017	.016	-.008
	N	5	5	5	5
NDBI	Pearson Correlation	1.000**	1.000**	1	-1.000**
	Sig. (2-tailed)	.000	.000		.000
	Sum of Squares and Cross-products	.022	.065	.063	-.031
	Covariance	.005	.016	.016	-.008
	N	5	5	5	5
BUI	Pearson Correlation	-.999**	-1.000**	-1.000**	1
	Sig. (2-tailed)	.000	.000	.000	
	Sum of Squares and Cross-products	-.011	-.032	-.031	.015
	Covariance	-.003	-.008	-.008	.004
	N	5	5	5	5
**. Correlation is significant at the 0.01 level (2-tailed).					

(Calculated by the authors)

Here, the different land use land cover indices has been set up under the correlation matrix. The Table2 shows the correlation values (r) among the NDVI, MNDWI, NDBI and BUI which signify a highly positive relationship (r=1.000) between NDVI and MNDWI, highly positive relationship (r=1.000) between NDVI and NDBI, highly negative relationship (r= -0.999) between NDVI and BUI, highly positive relationship (r=1.000) Between MNDWI and NDBI, highly negative relationship (r= -1.000) between MNDWI and BUI and highly negative relationship (r= -1.000) between NDBI and BUI. The above relationships are significant with the value of $p<0.01$ with (N-2) degree of freedom.

5.4 Relationship in between the population changes and LULC changes

To establish the relationship in between the population changes and LULC changes, the correction values, analysis of variances and significance tests have been adopted.

Table 3: Model summery of regression analysis of the relationships between population and land use land covers

	Model Summary			
Depended variables	R	R Square	Adjusted R Square	Std. Error of the Estimate
Water bodies	-.977	.954	.908	4.800
Vegetation	-.996	.991	.982	.872
Barren land	-.736	.542	.084	9.962
Fallow land	.929	.863	.726	3.978
Settlement	.968	.937	.875	8.268
	The independent variable is population.			

(Calculated by the authors)

Here, in the correlation-regression model, the value of correlations (R), R squares, adjusted R squares and standard error of the estimates of land use land cover area (three years values of LULC in percentage mean) water bodies, vegetation, barren land, fallow land and settlement with the population (population is in percentage) are shown in the Table 3. Those signify the relationships are negative in the case of the relation of water bodies, vegetation, and barren land with population and positive in the case of fallow land and settlement with population respectively. The linear trends of the relationships are negative in the case of the relationship in between population and water bodies, vegetation and barren lands well as positive in between the population with fallow land and settlement shown in the fig. 23 (a-e) below. The above discussion justify that there negative changes of non-built-up areas (except fallow land)and positive changes of fallow land and built-up areas (settlement)in the respect of population are occurred in the study area.

Table 4: Analysis of variance of the relationships between population and land use land covers

	ANOVA					
Dependent variables		Sum of Squares	df	Mean Square	F	Sig.
Waterbodies	Regression	478.484	1	478.484	20.771	.138
	Residual	23.036	1	23.036		
	Total	501.520	2			
Vegetation	Regression	85.466	1	85.466	112.297	.060
	Residual	.761	1	.761		
	Total	86.227	2			
Barren land	Regression	117.332	1	117.332	1.182	.473
	Residual	99.242	1	99.242		
	Total	216.573	2			
Fallow land	Regression	99.821	1	99.821	6.307	.241
	Residual	15.827	1	15.827		
	Total	115.648	2			
Settlement	Regression	1021.458	1	1021.458	14.941	.161
	Residual	68.364	1	68.364		
	Total	1089.823	2			
	The independent variable is population.					

(Calculated by the authors)

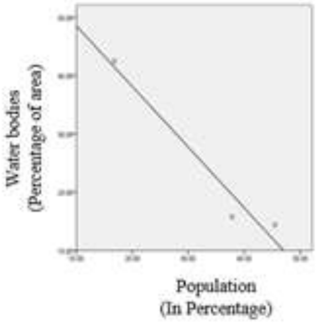
In the Table above (Table 4) shows the results of the analysis of variance (ANOVA)with the 'F' statistics which justify the relationship of water bodies, vegetation, barren land, fallow land and settlement with the population with the value of *p* of 'F' statistics, (N-1) degree of freedom and 95 percent of confidence level. Here, the relationships are not significant ($p>0.05$) shown in the above Table 4.

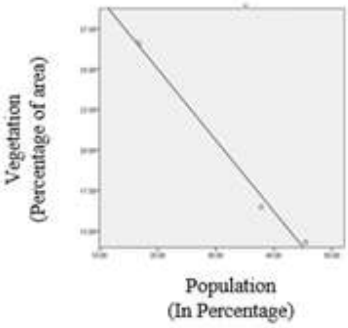
Table 5: Coefficients and significant test of the relationships between population and land use land covers

	Coefficients					
Depended variables		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Water bodies	population	-1.041	.228	-.977	-4.558	.138
	(Constant)	58.902	8.103		7.269	.087
Vegetation	population	-.440	.042	-.996	-10.597	.060
	(Constant)	33.804	1.473		22.951	.028
Barren land	population	-.516	.474	-.736	-1.087	.473
	(Constant)	29.190	16.819		1.736	.333
Fallow land	population	.476	.189	.929	2.511	.241
	(Constant)	-4.979	6.716		-.741	.594
settlement	population	1.521	.394	.968	3.865	.161
	(Constant)	-16.918	13.959		-1.212	.439
The independent variable is population.						

(Calculated by the authors)

In the above Table 5 shows the values of significant test with (N-2) degree of freedom and 95% of confidence level. The results justify the relationship of water bodies, vegetation, barren land, fallow land and settlement with the population is not significant (p>0.05).





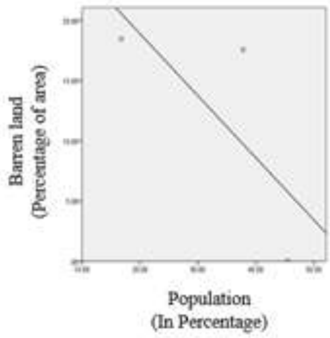
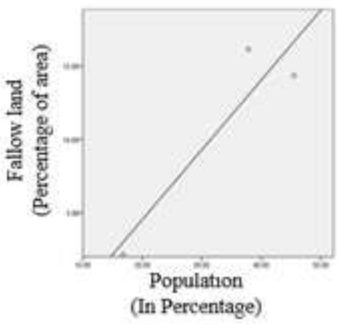


Figure 23 (a): Relationship between population and water bodies **Figure 23 (b):** Relationship between population and vegetation**Figure 23 (c):** Relationship between population and barren land



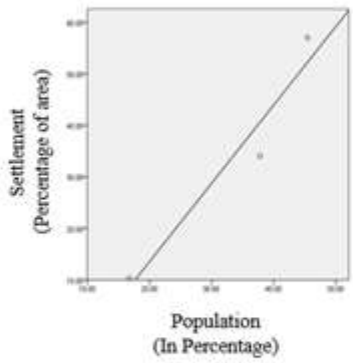


Figure 23 (d): Relationship between population and fallow land**Figure 23(e):** Relationship between population and settlement

Figure 23 (a-f): Relationships in between population and different LULC categories in the study area

VI. Conclusion

Land use land cover changes in Barasat Municipal area is in a changing situation from 1990 to 2000 and 2016. The overall results show that the built-up area in this city is rapidly increased and due to the rapid increasing of built-up area the non-built-up areas are decreased such as the area under water bodies, vegetation, barren land and fallow land is increased. The representation of NDVI, MNDWI, NDBI and BUI expresses the changes of LULC is in decreasing way in the case of non-built-up area such as water bodies, vegetation and increasing way in the case of built-up area such as settlement. The population increasing trend in the study area is justified with the regression analysis which shows that the increasing population in this municipality tends to increase and decrease but the values are not significant. Thus the overall discussion ultimately explores that Barasat Municipality is under the rapid increasing of its population situations and the LULC of built-up area is in more increasing way than the non-built-up areas at this present situation.

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