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Research Article

AN ASSESSMENT OF REGIONAL PATTERN OF POPULATION INDUCED LAND-USE AND LANDCOVER CHANGES DURING LAST DECADE IN NCR OF INDIA

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ABSTRACT
In the current study analyses the Land-use and Land cover (LULC) changes due to rapid urbanization and their association with population growth in the National Capital Region (NCR) of India. Gridded population data obtained from Socioeconomic Data and Applications Center, 2016 (SEDAC) for NCR and resampled with Arc-GIS software. Spatio-temporal pattern of resampled population data revealed that rapid increase of human population in the south-west and north-east zone of studied area during 2000-2015. The investigation of LULC changes has been carried out during last decades (2003-2014). A well-known parametric Maximum Likelihood Classifier algorithm (MLC) was employed for supervised spectral signature extraction of all Landsat images for district five LULC classes such as Built-up area, Water body, Green vegetation, Rocky area and Blank land.After classification results showed that the significant changes have occurred in LULC type spatio-temporal pattern in between 2003 to 2014. Area cover by Built-up area, Green vegetation and Water body are significantly increase by 101, 70 and 30 % respectively while the Rocky area and Blank land decreased by 67% and 4%, respectively. For stabilizing the association ship between population growth and LULC changes over studied area through GIS platform applying intersection (overlying) technique. Results showed significant spatio-temporal changes in LULC type especially Built-up area with spatial and temporal pattern of population growth during studied period in NCR region.

Keywords: *LULC· Maximum Likelihood Classifier ·Spatio-Temporal Pattern Population ·NCR*

INTRODUCTION
In the recent decades, rapid urbanization occurred due industrial and service based economic developments along with corresponding increase of population. During urbanization processes massive LULC changes occurred according to human needs which leads to losses of vegetation cover, agricultural area and habitat destruction (Dewan and Yamaguchi, 2009; Yin *et al.*, 2011; Lasanta and Vicente-Serrano, 2012; Vorovencii, 2015; Ward *et al.*, 2016). Less than 3% of total earth's land surface is covered by cities which is residence of more than half (54%) of global human population (Liu *et al.*, 2014; United Nation, 2014). The increasing pace of global urbanization induced LULC changes influences the net productivity, biodiversity and meteorological parameters (temperature, humidity etc) at local, regional and global arena (Liu *et al.*, 2006; Han and Xu 2013; Zhang *et al.*, 2013; Balcik, 2014; Mohan and Kandya, 2015; Wang *et al.*, 2016).
National Capital Region (NCR) is a one of the fastest growing region in India by economic and population growth is situated in northwestern region of Indo-Gangetic plain. As per the 2014-15 economic survey, GDP (Gross Domestic Product) grown up by 78% as compared to the 2009-10. According to census-2011, a decadal growth of population is 21.2% in between 2001 to 2011. The fast growing economy and population induced enormous alteration of a pristine natural landform composition or Land-use and Land cover (LULC) change in entire NCR.
In the present paper, we have tried to find out the population induced spatio-temporal change in LULC during 2003-2014, using satellite data in the NCR of India. Three prominent objectives of the present Chapter are: firstly, quantification of spatio-temporal changes of five classified major LULC types occurred during 2003 to 2014 from multispectral band data of Landsat images. Secondly, applying GIS-based modeling approach for evaluating spatial and temporal changes of satellite derived population in

studied area during 2000-2015. Thirdly, we have established correlation between spatio-temporal patterns of population growths with expanding urban area pattern in studied region.

Study Area

The study area, National Capital Region (NCR) of India is geographically situated in between latitude 28^0 $10^{'}$ $00^{"}$N to 29^0 $00^{'}$ $00^{"}$ N and longitude between 76^0 $50^{'}$ $00^{"}$ E to77^0 $35^{'}$ $34^{"}$ E (Figure 1) and altitude lies between 213 and 305 m above msl. It is surrounded by Indo-Gangetic alluvial plain in east and north, the Thar Desert in the west and by Aravali Hill range in the south. Meteorologically NCR is lying in the composite climatic zone with annual rainfall of 714 mmwhere 3/4th rainfall occurs in July to September months. Annual temperature experiences high 40-45 °C during the summer months (May-June) and 4-5 °C in winter months of December-January. NCR is a one of the fastest growing region in India by economic and population growth. As per the 2014-15 economic survey, GDP (Gross Domestic Product) grown up by 78% as compared to the 2009-10. According to census-2011, a decadal growth of population is 21.2% in between 2001 to 2011. The rapid population growth has accelerated urbanization which resulted in intensive changes of LULC types in studied area.

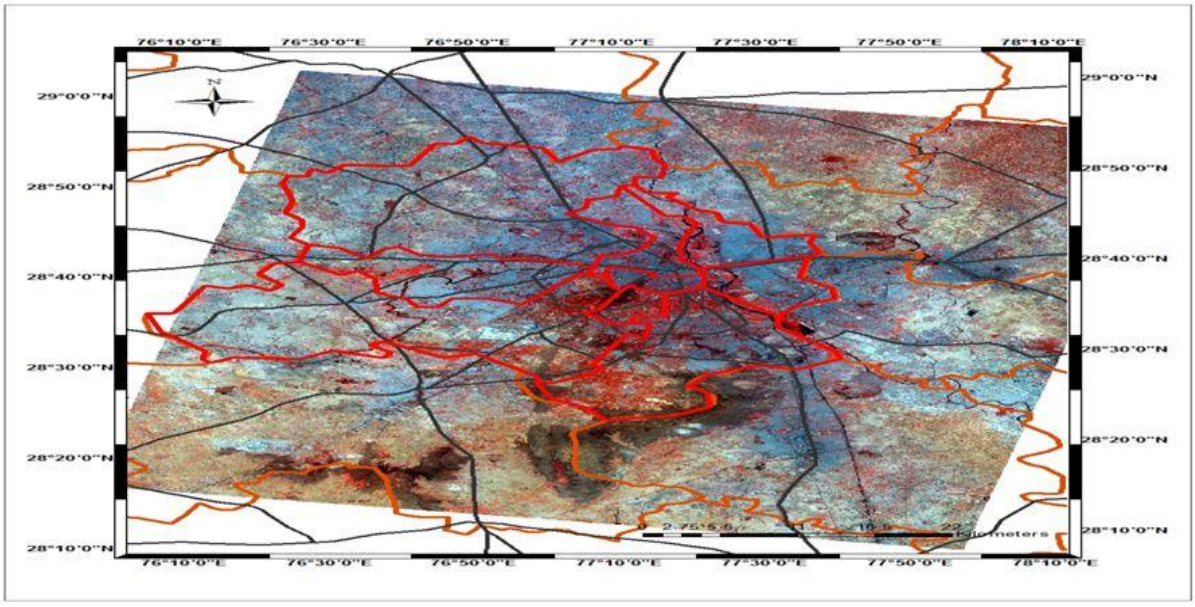

Figure 1: Map Showing the Study Area in FCC Image of Landsat of National Capital Region of India

MATERIALS AND METHODS

Data Processing and Methodology

Data Sources

Two different Landsat L_1T data Landsat 7 ETM^+ for 10 May 2003 and Landsat 8 OLI for 16 May 2014) have been taken from USGS online archived GLOVIS (http://glovis.usgs.gov/) for NCR of India. Landsat images are one of the most suitable data for analysis of LULC changes over time because fine spatial resolution in VR, NIR, SWIR and TIR spectral bands. The toposheets of Delhi-NCR region having 1:50000 m scale has taken from Survey of India (SOI) outlet for accuracy assessment of supervised classification.

We also obtained gridded population estimate spatial resolution approx. 1 km (30 arc-second) from SEDAC (Socioeconomic Data and Applications Center, 2016) http://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count/data-download. The GPWv4 (Gridded Population of the World Version 4) consist of human population count estimate based on national censuses and population register worldwide for the five-year interval since 2000 to 2020. The population

count grids contain total no of person per grid cell allocating by gridding algorithm utilizing 12.5 million sub-national and national administrative units.

Data Preprocessing

Landsat images are processed as absolute radiance using 32-bit unit floating point then convert to 16-bit integer (Digital Number unit) value in level 1 product (Landsat 7 and 8 Handbook). The conversion of integer value to original 32-bit unit floating point spectral radiance has been done by scaling factor allocated in metadata file of each band data in ENVI (Band Math tool) software.

Image Classification and Accuracy Assessment

A well-known parametric Maximum Likelihood Classifier algorithms (MLC) was employed for supervised spectral signature extraction of both images data. In each composite bands, image 100 ROI (Region of Interest) were chosen to establish each LULC type having all spectral signature adequately represented in the training statistics.

Five distinct LULC types (Built-up area, Water body, Green vegetation, Rocky area and Blank land) were identified in all three images acquired at above prescribed date (Table 1). The rocky area situated at south to central ridge covered by sparse scrub vegetation showed distinct spectral signature identified in individual LULC class. The urban areas are composed of road, building and all types of impervious surfaces. The blank land included dry land, agricultural land, landfill site etc.

Table 1: Major LULC Types in NCR

LULC Type	Abbreviations	Descriptions
Built-up Area	BA	Impervious surfaces (Road, Commercial and Residential area etc)
Water Bodies	WB	River, Drainage system and Wetland
Green Vegetation	GV	Forest, Roadside tree, Farmland tree, and green vegetation around water bodies.
Rocky Area	RA	Ridge area and Sparse scrub vegetation
Blank Land	BL	Dry land, Open un-vegetated land, Bare soil and Agricultural land

Accuracy assessment procedure has been carried out with assigned ancillary data such as digitized toposheet of NCR taken from SOI for 2005 and field survey. The detection of LULC changes over the studied time period has been carried out using a post-classification differentiation method by randomly selecting 10000 points in each classified image. Gridded population estimate at 1km spatial resolution is resampled onto 30 m for overlaying with LULC map created in Arc-GIS software. We have adopted overlaying technique between population map and LULC map for analyzing population induced spatio-temporal changes of LULC in NCR region.

RESULTS AND DISCUSSION

Spatial and Temporal Pattern of Human Population

Gridded population estimate at 30 m spatial resolution is manually classified into five classes on the basis of no of person per grid cell. Five classes as Sparse, Lower, Moderate, Higher and Highest density consist of <500, 500-1500, 1500-2500, 2500-3500 and >3500 people per grid cell respectively. The spatial and temporal pattern of human population in 2000 and 2015 has been sheen in Figure 2 (a and b). We can observe in Figure 3 percentage of total area cover by different population density class as 30 in Sparse, 22.42 in Lower, 12.24 in Moderate, 17.31 in Higher and 17.95 in Highest in 2000. In 2015 Highest density class cover 39.14 percentage of total area and other class Sparse (23.46), Lower (19.74), Moderate (6.18) and High (11.48) percent. Area cover under Moderate and High density class in 2000 has been covered by Highest density class in 2015. We have seen here Highest and High density class of population dominated in central and north-east to southwest region of studied area in 2000, which have been change to predominantly Highest class cover in 2015. Spatial and temporal change in population can

be observed in Figure 4. Here, we observed enormously increases in population in during 2000 to 2015, particularly in extended urban agglomeration of Delhi-NCR.

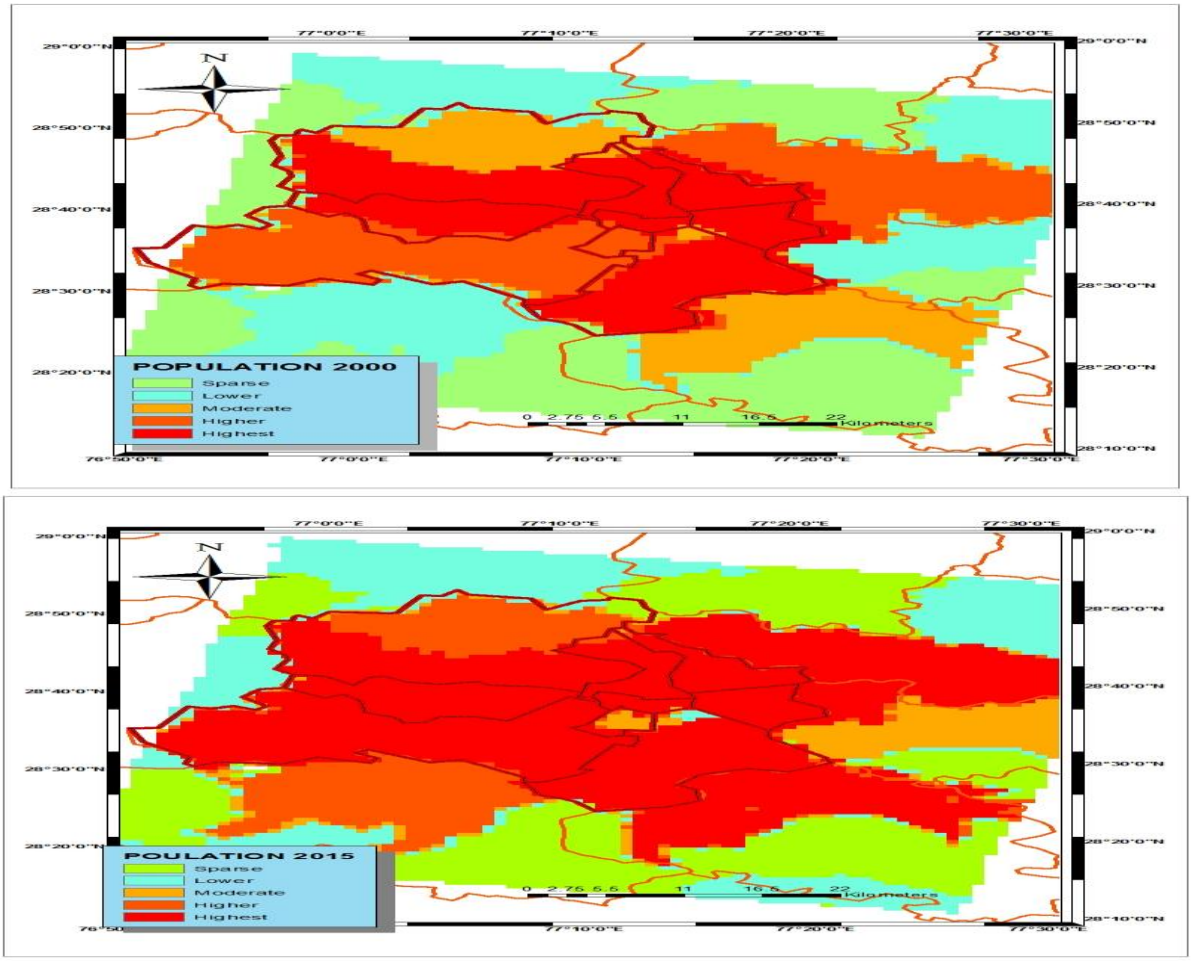

Figure 2 (a and b): Spatial Pattern of Population in NCR during 2000-2015

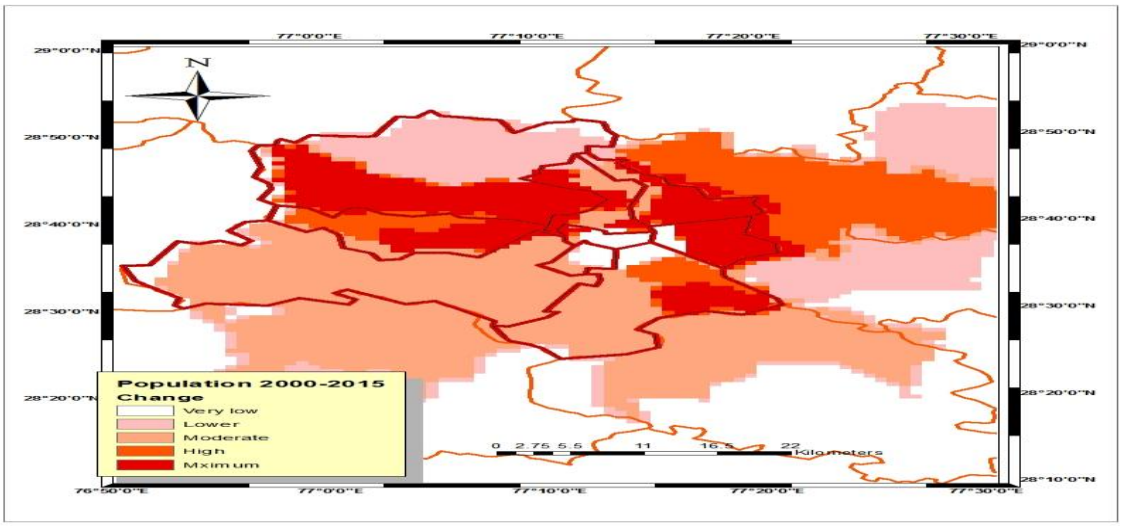

Figure 3: Spatial and Temporal Pattern Changes of Population in NCR during 2010-2015

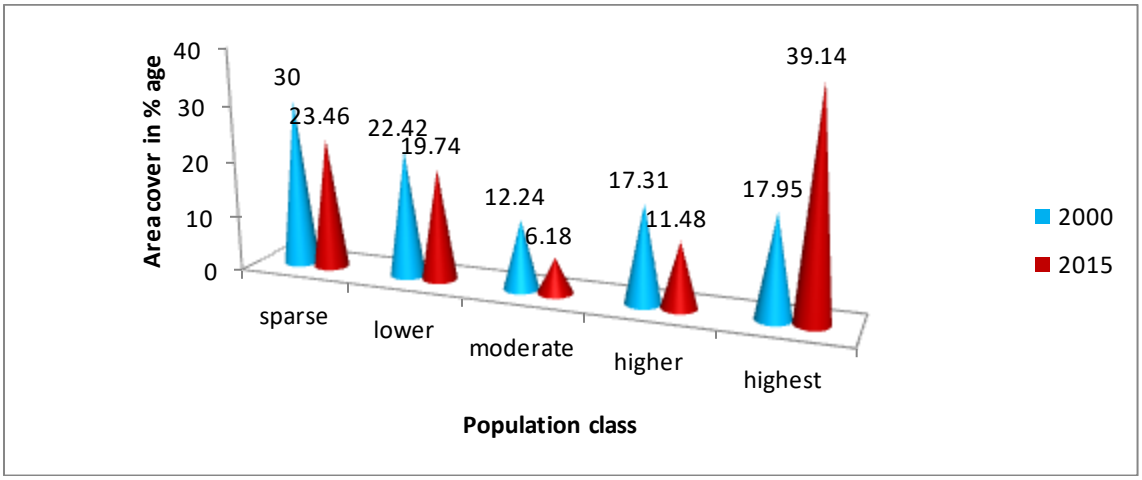

Figure 4: Area Lies under Different Population Density Class during 2000 and 2015 in NCR

Spatial and Temporal Change of Different LULC

For the present study, May month has been selected because in this month, generally cleaner (cloud free) atmosphere and high air temperature exists which is suitable for studies related to surface phenomenon via satellite observation. Spatial pattern of distinct LULC type in between 2003 and 2014 has shown in Figure 5 (a & b) in NCR of India. On the analysis, it was found that during the period 2003 and 2014, the built-up area expands from 5.84% to 11.78% (almost double) this expansion has occurred in mainly in east, north-west, south-west and south-east direction (periphery of city center). The green vegetation area has grown from 8.72 to 14.83% primarily in central and south ridge area during the period 2003 to 2014. Rocky area has decreased from 12.99 to 4.19 % (almost 1/3) in between 2003 to 2014 period because of rapid expansion of urban built-up area and conversion of sparse scrub vegetation into green vegetation due to artificial plantation and natural process in studied area. Blank land and water body contribution were 72.04 % and 0.39 %, respectively during 2003 which changed to 71.67 % and 0.51% during 2014, correspondingly (Figure 6). Blank land has been converted into built-up area in periphery mainly in east and north-east direction which is mostly agricultural land and fallow land. In south, south-west and west direction buildup area has developed at cost of rocky area (ridge area) and dry non-arable land (desert land).

Green vegetation zone has expanded in rocky area due to conversion of scrub into green vegetation in central and southern ridge area in NCR. Composition of LULC in north-eastern part has been gradually changed from sparse scrub vegetation in 2003 to built-up area, blank land and green agricultural land area during 2014. Overall, significant increase has been noticed from 2003 to 2014 with Area cover by Built-up area, Green vegetation and Water body are significantly increase by 101, 70 and 30 % respectively while the Rocky area and Blank land decreased by 67% and 4%, respectively. Summary of the composition of major LULCs change occurred over past 11years is depicted in Figure 7.

As superimposing the population map (Figure 2 a & b) with LULC map (Figure 5 a & b) respectively, we observed that similar spatial pattern follow in highest density population class and built-up area changes in LULC map. Figure 4 showed as area covered by highest density class increasing by 118.05% during 2000-2015, following similar trend of built-up area increases aproximately101.71% (Figure 6) in between year 2003 and 2014.

Our study show the rapidly growing human population is primary driver for land use and land cover changes in recent era in regional and global scale. LULC changes induced alteration in local and regional climatic parameter such as surface temperature (Weng *et al.*, 2004; Cavan *et al.*, 2014). Urbanization increase the impervious surface at the cost of natural land cover type such as green cover land, rocky area, agricultural land etc. While increase the efficiency of shrinking agricultural land by applying advance agricultural technique such as enormous use of fertilizer, pesticide and plant breeding (Trewavas, 2002).

This change in agricultural practice has resulted in alteration of nutrient cycle and contamination of surface and ground water in regional and global scale (Smil, 1997).

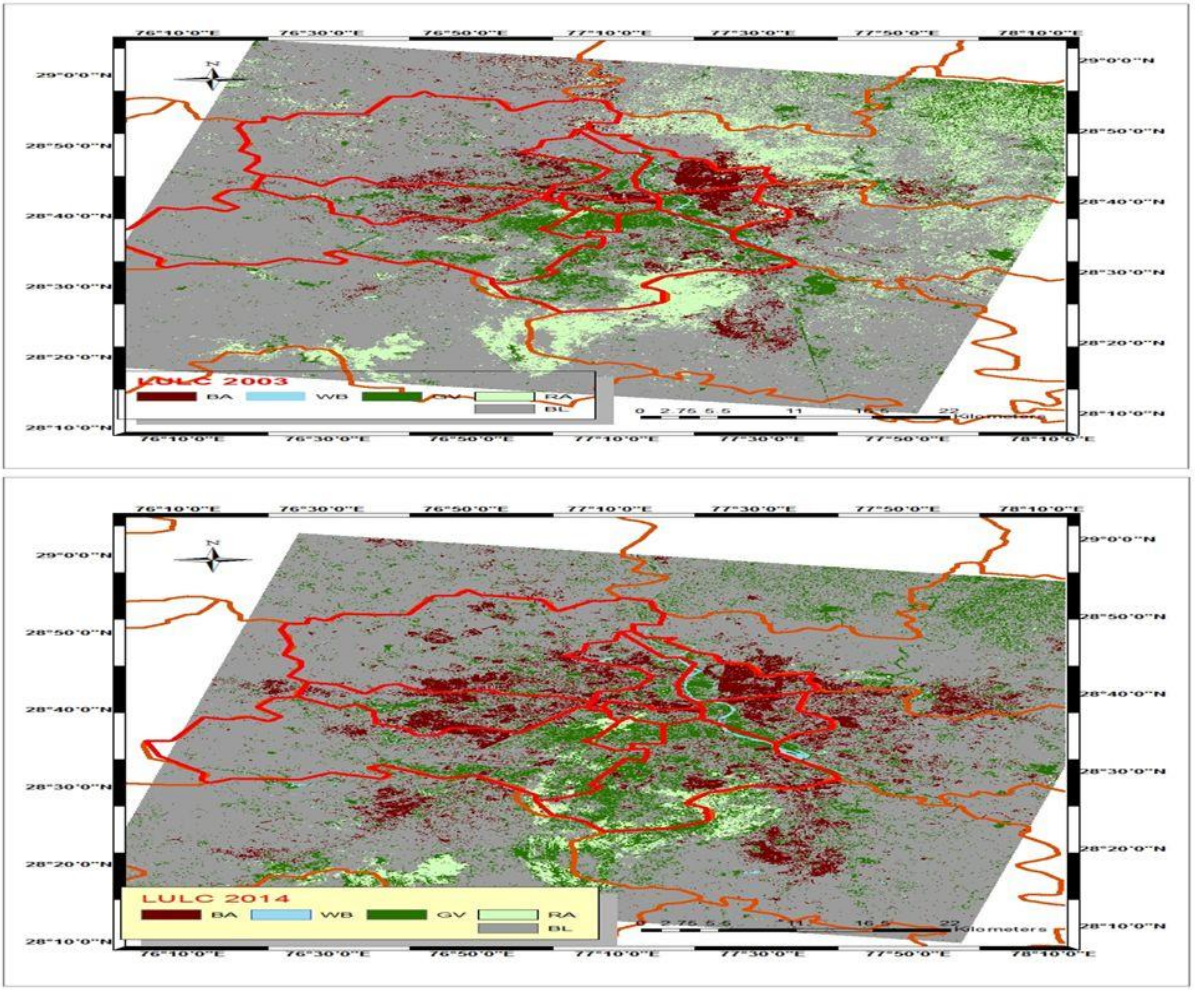

Figure 5 (a and b): Spatial Pattern of LULC in NCR during 2003-2014

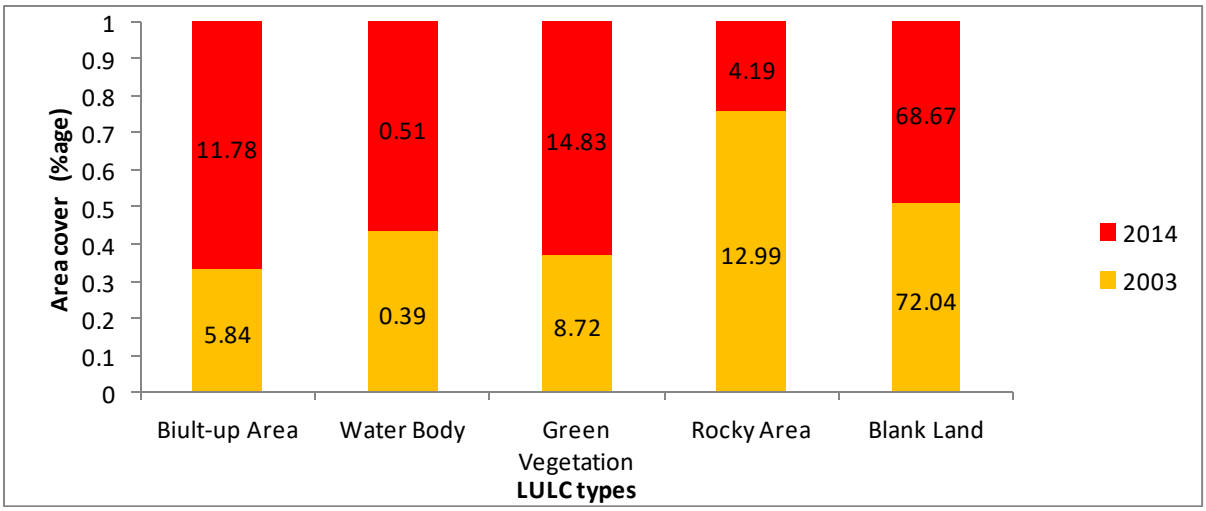

Figure 6: Area Lies under Different LULC in Percentage during 2003 and 2014

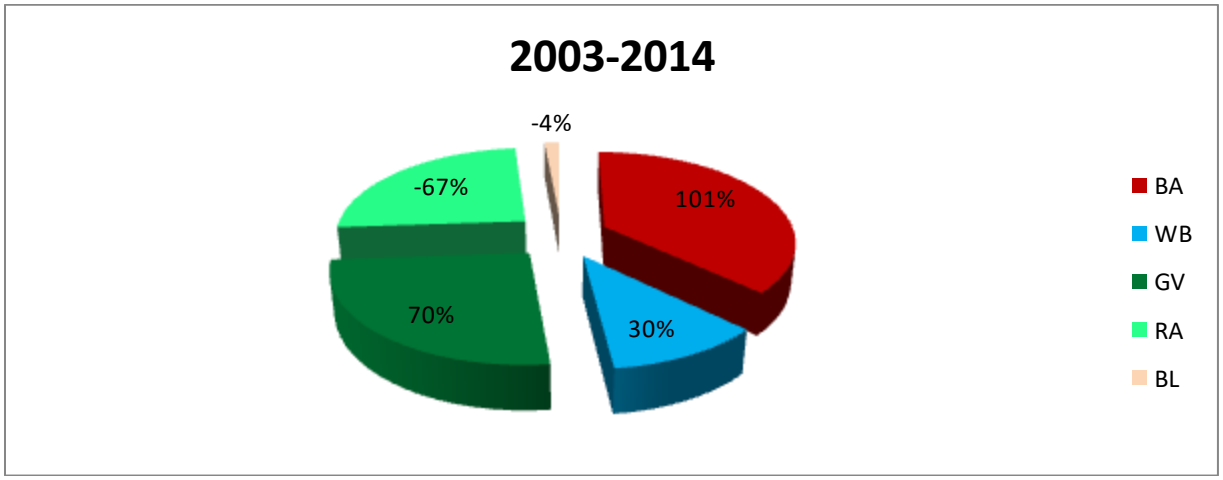

Figure 7: Changes Occurred in Total Area Cover by different LULC in between 2003 and 2014 in NCR

Conclusion

In the present study, we have derived many conclusions; Firstly, enormous changes occurred in spatial pattern of human population changes in NCR during 2000-2015. Percentage of total area cover by different population density class decreases as Sparse by 21.8%, Lower by 11.95%, Moderate by 49.50% and High by 33.67% where Highest density class increases by 118.05% during 2000-2015. Secondly, we are profoundly detected spatio-temporal pattern of land use and land cover changes in the studied area during period in 2003 to 2014. It is found that there is coherent increase in Built-up area by 101% and Green vegetation cover area by 70% at the cost of ridge area (rocky area) and Blank land area decreases by 67% and 4% of total area cover.

Thirdly, we observing similar spatial and temporal pattern follow by built-up area and highest density population class during study period. The present study is the first comprehensive work which comprises both satellite retrieved population and LULC analysis in the NCR of India. It may provide better understanding of urbanization phenomenon with corresponding change in population with LULC policy makers and urban planners. For future studies, there is need for the availability of long term data for population with higher resolution for LULC composition analysis for better understanding and future prediction of urbanization through modeling approaches.

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