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URBAN SPATIAL GROWTH AND LANDUSE CHANGE DETECTION ANALYSIS OF ALIGARH CITY, UTTAR PRADESH, INDIA USING HIGH RESOLUTION REMOTE SENSING DATA, GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND GLOBAL POSITIONING SYSTEM (GPS) TECHNIQUES

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Abstract:
Use of High Resolution temporal satellite imageries and Geographical Information System (GIS) provide us present and past status of extensions and Landuse change in oukskirts of urban centres. The present paper is an attempt to analyze the temporal urban growth and landuse change of Aligarh city using Survey of India Topographical Map surveyed in 1971 and IKONOS satellite data of various time periods from 2004, 2009 and 2014. The result shows that in 1971 the urban built-up land of the city based on SOI Topographical Map was 2224.6555 hectare, based on interpretation of IKONOS satellite imagery of 2004, 2009 and 2014 , the urban built-up area of the city is 4724.7614 hectare in 2004, 5872.6774 hectare in 2009 and 7059.8875 hectare in 2014 respectively. This has increased to 2500.1059 hectare in a period of 33 years from 1971 to 2004 and in the period from 2004-2009 and 2009-2014 it has increased by 1148 hectare and 1187.211 hectare respectively. Agricultural land, Orchard/Plantations and water bodies to built-up (urban) has been calculated in GIS and it has been observed that there is a tremendous increase in the built-up urban area. The loss of prime arable land, orchard/plantation and water bodies has been converted in to built-up urban land. The digital database created for urban growth and landuse change of Aligarh city, Uttar Pradesh, India using multi-date data in Arc-GIS software would be very useful for urban development authorities, planners, decision makers for better landuse planning and management for proposed landuse programmes.

Keywords:
Urban Growth; Urban Growth; IKONOS Satellite High Resolution Image; Landuse Change; GIS & GPS Techniques.

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1. INTRODUCTION

Almost developing countries of the world are facing the problem of ever increasing population because of their basic needs in urban-rural areas. Migration of population from rural to urban areas in search of employment and better facilities in all sectors are ever putting pressure on our land, water and biological resources in urban periphery. In developing countries, the trend of urbanization in India is also very fast that's why our country is going to loss their agricultural dominant identity and it is closed to 7933 urban local bodies as per Census of India, 2011. Uttar Pradesh, the largest populated state in northern part of India has around 20 crores of total population with 724 urban local bodies as per Census Data of 2011. The change in urban environment in state of Uttar Pradesh is very fast. To assess and monitor present and past status of urban growth and landuse change, multi-date satellite imageries, coupled with Geographical Information System (GIS) and Global Positioning system (GPS) are very useful and it has proved a vital tool for preparation and analysis of urban growth and landuse change map. Batty, M. 1996. Xu, H. 2008, Gopalan, A.K.S. 2009, Bhatta, B. 2009, Patkar, V.N.,2003, Xu, H. 2008, suggested that from the years high resolution remote sensing data have been successfully utilized for urban land use and infrastructure mapping and it has been considered a necessary element for monitoring and modelling for understanding the earth as a system. Imdad and Janki, 2007, has suggested that for effective landscape planning, it is necessary to know the landform transformation process and pattern in mixed urban-rural landuse on periphery of cities. Urban regional planners require nearly continuous acquisition of data to formulate governmental policies. These policies and programme might range from social economies and cultural domain to the context of environmental and natural resources planning. In this connection role of urban planning agencies is very important and there is an increased need for these agencies to have timely accurate, authentic and cost effective data of various forms. In this research paper an endeavor has been made to create a digital database for urban growth and land use change for Aligarh City, Uttar Pradesh, using Arc- GIS software, would be useful to Aligarh Development Authority for better landuse planning and management. This is the first study on urban Growth and landuse change using temporal high resolution data of IKONOS Satellite in GIS and no any literature is available for the study area.

2. OBJECTIVE

The broad objective of the present study is to prepare detailed urban spatial growth map, landuse/landcover and change map, land transformation of Aligarh city using Survey of India topographical maps and IKONOS satellite 1m resolution data in Geographical Information System (GIS) techniques.

3. STUDY AREA

The Aligarh city and its environs are selected for study. It lies between the latitude 27^0 53' N and longitude 78^0 4' E (Fig.1). Aligarh is the historical city in state of Uttar Pradesh, India is located in the central region of the state. The population density of the city is 1815 person per sq km. The provisional total population of Aligarh City as per Census of India, 2011 is 9, 11,223.

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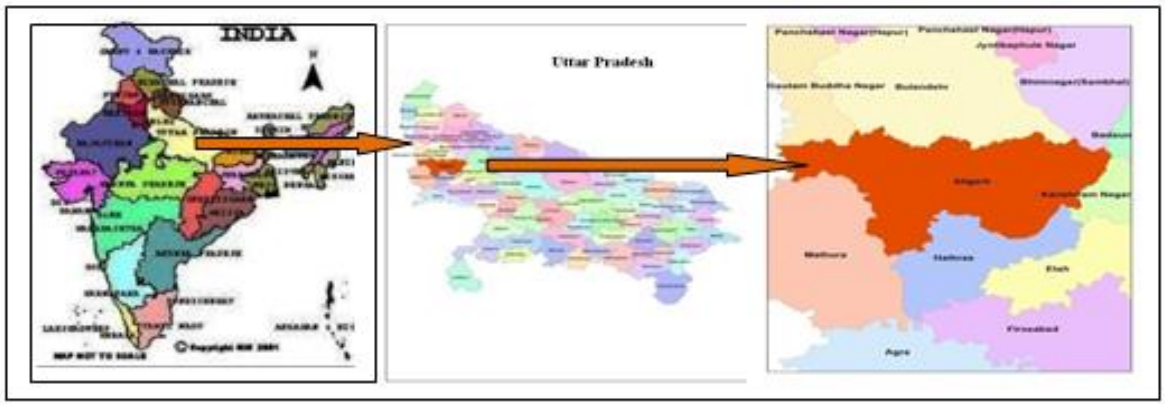

Figure 1: Location Map of Study Area

4. MATERIALS & DATA USED

The following dataset has been used to meet out the set objectives -

- Survey of India topographical map sheet No. 53 I/7 of Aligarh city & its environs on 1:25,000 / 1:50,000 scales surveyed in 1971.
- Guide map of Aligarh city on 1:20,000 scale.
- IKONOS Satellite (Google Earth) 1m resolution data of 2004, 2009 & 2014.
- Ground truth/ field data collected using Global Positioning System (GPS).
- Census of India population data- 2011.

Software & Equpment

- ArcGIS software 10.1 V
- GPS Mobile Mapper 10.0 V

5. METHODOLOGY

To meet the set objective of the study area, at first road/transport network map was prepared using Survey of India topographical map corresponding to study area. Primary road-state/national high way and major roads and canals have been prepared as polygon feature, whereas minor roads of the city were delineated as linear feature. IKONOS satellite's 1m spatial resolution data of 2004, 2009 and 2014 has been used for study area to update the road/transport network. Urban spatial growth map was demarcated based on S.O.I. topographical map sheets surveyed in 1971 & IKONOS satellite data of 2004, 2009 & 2014 and status of growth for different period has been calculated in Arc-GIS software. Landuse/landcover and land transformation and change map for the study area has been prepared using S.O.I. topographical map sheet No. 53 I/7 and IKONOS Satellite data of 2004, 2009 and 2014. Each and every urban spatial growth/ layers was superimposed to know the status of spatial growth in different years from 1971 to 2014. Landuse/landcover and land transformation area estimation has been calculated for each every layeyes. Ground truth/field survey was carried out using Global Positioning System (GPS) to know the locational extent of different Landuse/landcover categories and field information has been incorporated before finalization of maps.

Statistical Method: The statistical methods applied for present study are mentioned below:
The comparative study on land use / land cover assist in identifying the trend and percentage of changes between 2004 to 2009 and 2009 to 2014 in achieving this the first task was to develop the tables showing the area in hectare and percentage of change between 2004 to 2009 measured in given each and every land use/ land cover categories. The change of percentage is to determine the trend of change can be calculated by dividing observed changes by the sum of changes

1) Percentage Area = $\frac{Area\ of\ category\ in\ hectare}{Total\ Area\ in\ \text{Hectare}} \times 100$
2) Overall change in Category (2009 to 2014) = Change in Category of 2014 – Change in Category 2009.
3) Percentage Change (Trend) = $\frac{Observed\ change}{Sum\ of\ changes} \times 100$

6. RESULT AND DISCUSSIONS

The results and discussions related to urban spatial growth, land use / land cover change and land transformation in the present study are discussed under the following sub sections.

URBAN SPATIAL GROWTH, RATE AND DIRECTION

Urban sprawl is an extension beyond the municipal limit. It has been observed that outward expansion of urban areas in India poses a threat to the land use pattern and limited land of the city gets used, the ever increasing demand creates pressure on surrounding fertile vulnerable lands in and around the city causing faster rate of land conversion from agricultural land and others land to urban use. In the absence of any planning policy, Subudhi, AP et.al 1998 suggested that the quantum and direction of waves depends upon various centripetal and centrifugal forces working from city and adjoining area. This results in uncontrolled expansion of city as well as problem of providing basic public services and facilities. Urban Development Authorities/Municipal Government has the power to manage the sprawl issues in terms of will and ability.

The growth of urban area over a period was determined by computing the area of all the settlements from topographical map sheet of 1971 and this area has been compared to the area obtained from the interpreted satellite imagery for the built up urban area. Since the sprawl is characterized by an increase in the built-up area along the urban and rural fringe, this attribute gives considerable information for understanding the behavior of such sprawls. This is also influenced by parameters such as population density and population growth rate etc.

Table 1: Urban Spatial Growth Rate & Percentage per Annum

Year	Data	Area (Ha.)	Sprawl Growth (Ha.)	Growth %	Growth (Ha.) Per Annum
1971	SOI Toposheet	2224.6555	---	---	---
2004	IKONOS Data	4724.7614	2500.1059	112.3816	75.76

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2009	IKONOS Data	5872.6774	1148.00	24.2957	229.6
2014	IKONOS Data	7059.8875	1187.211	20.2158	237.442

In 1971 the city grew in concentric manner, after 1971, IKONOS satellite's imageries of 2004, 2009 and 2014 have also been used to create vector layer to monitor the growth of city through overlaying of these vector layers of three time period data, the area for 1971, 2004, 2009 and 2014 has been calculated in GIS, which is 2224.6555 hectare in 1971, 4724.7614 hectares in 2004, 5872.6774 hectares in 2009 and 7059.8875 hectares in 2014 respectively. Spatial growth (Ha.), per annum growth (Ha.) and percentage of growth has also been calculated, which is 2500.1059 ha. (75.76 ha) per annum between the years of 1971 to 2004 at an interval of 33 years, similarly, Spatial growth , per annum growth and percentage of growth has also been calculated between the period of 2004 to 2009, which is 1148 ha and between the year 2009 to 2014, it is 1187.211 ha respectively. It has been observed from Fig.-2 and Table-1 that the city has grown mainly towards south to south west and marginally in east direction with most of the prime agricultural land and vegetative area getting constructed into built up land and between the periods of 2004 to 2009 a remarkable growth of 229.6 ha. (24.2957%), and 237.442 ha per annum(20.2158%) has been calculated respectively as compared to 75.76 ha per annum between 1971 to 2004, and percentage growth and per annum growth for the period is 112.3816% (3.39% per annum) in 33 years. Similarly, spatial growth, per annum growth, percentage growth and per annum percentage growth has been calculated for the period of 2004 to 2009 and 2009 to 2014 which is 4.8% and 4% per annum respectively. The urban growth in present study is defined as consisting of all urban land uses i.e. built-up- residential, industrial, institutional/utilities, commercial etc. The present study considers only the physical factor influencing under spatial growth i.e. road/ transport network distance from city core. The demographic / socio-economic factors have not been considered.

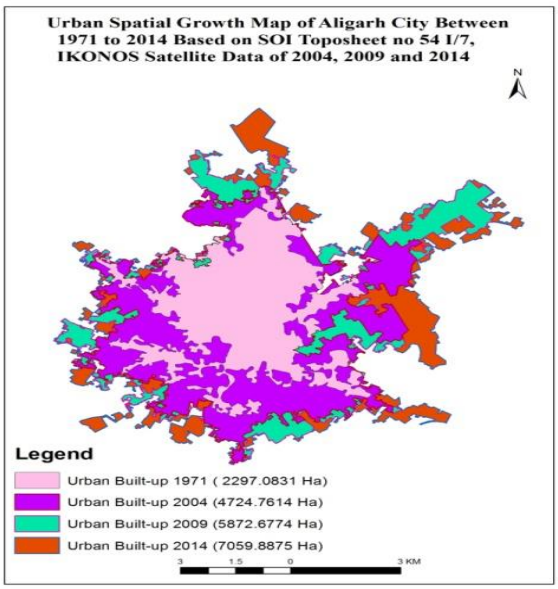

Figure 2: Urban Spatial Growth Map of Study Area from 1971 to 2014

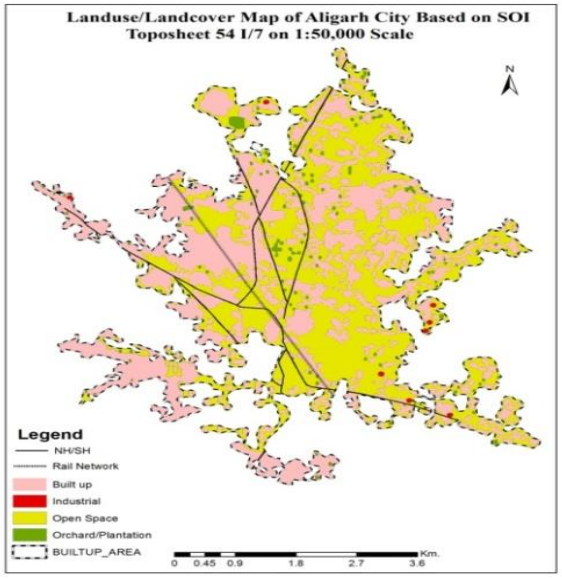

Figure 3: Landuse/Landcover Map of Study Area based on SOI Toposheet of 1971

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Landuse / Land cover (1971)

The urban land use / Land cover map of Aligarh city for year 1971 using SOI topographical map sheet no 53 I/7 has been prepared , and four land use/land cover categories identified and mapped using Arc- GIS software . It has been shown in Fig.-3 & Table-2 that they are built -up, industrial, open space and orchard/plantation. These landuse / landcover categories are occupying Built-up1048.5693 ha (47.134%), industrial area 5.1894 ha (0.2333%), open space 1131.8319 ha (50.8768%) and orchard/plantation 39.0648 ha (1.7559%).

Table 2: Landuse / Landcover Statistics of Study Area (1971)

S.No	Class Name	Area in Ha.	Percentage (%)
1	Built up	1048.5693	47.134
2	Industrial	5.1894	0.2333
3	Open Space	1131.8319	50.8768
4	Orchard/Plantation	39.0648	1.7559
	Total	**2224.6555**	**100**

Landuse / Land cover (2004)

The urban land use/ Land cover map of Aligarh city for year 2004 based on IKONOS Satellite imagery has been prepared and 11 land use/land cover categories identified and mapped using Arc GIS software. It has been observed from Fig.-4 & Table-3 that the different landuse categories in study area are occupying the space as agriculture land 96.735ha (2.0474%), built up 3558.963 ha (75.3257%), orchard/plantation 57.3335 ha (1.2134%), open space 735.3739ha (15.5642%), ponds/lakes 92.1774 ha (1.9509%), canal/distributaries 2.1803 ha (0.4614%), national highway/state highway 66.1402ha (1.3998%) and major road 35.5506 ha (0.7524%), parks 62.563 ha (1.3241%), industrial area 5.6737 ha (0.12%) and commercial 12.0708 ha (0.2554%) respectively.

Table 3: Landuse / Landcover Statistics of Study Area (2004)

S.No	Class Name	Area in Ha.	Percentage (%)
1	Agriculture Land	96.735	2.0474
2	Built up	3558.963	75.3257
3	Canal/Distributaries	2.1803	0.4614
4	Open Space	735.3739	15.5642
5	Orchard/Plantation	57.3335	1.2134
6	Ponds/Lakes	92.1774	1.9509
7	NH/SH	66.1402	1.3998
8	Major Road	35.5506	0.7524
9	Park	62.563	1.3241
10	Industrial	5.6737	0.12
11	Commercial	12.0708	0.2554
	Total	**4724.7614**	**100**

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Landuse / Land cover (2009)

The urban land use/ Land cover map of Aligarh city for year 2009 has been prepared based on IKONOS Satellite imagery and 11 landuse / landcover categories identified and mapped using Arc GIS software. They are agriculture land and occupying the area as 109.6952 ha (1.8678%), built-up 4841.9845 ha (82.449%), canal/distributaries 3.381 ha (0.0575%), orchard/plantation 58.1662 ha (0.9904%), park 63.7906 ha (1.0862%), open space 561.8952 (9.5679%), ponds/lakes 95.1517 ha (1.6202%), national highway/state highway 71.301 ha (1.2141%) , major road 40.7315 ha (0.6935%), industrial area 14.5083 ha (0.247 %) and commercial area 12.0722 ha (0.2056%) respectively (Fig.-5 & Table-4).

Table 4: Landuse / Landcover Statistics of Study Area (2009)

S.No	Class Name	Area in Ha.	Percentage (%)
1	Agriculture Land	109.6952	1.8678
2	Built up	4841.9845	82.449
3	Canal/Distributaries	3.381	0.0575
4	Open Space	561.8952	9.5679
5	Orchard/Plantation	58.1662	0.9904
6	Ponds/Lakes	95.1517	1.6202
7	NH/SH	71.301	1.2141
8	Major Road	40.7315	0.6935
9	Park	63.7906	1.0862
10	Industrial	14.5083	0.247
11	Commercial	12.0722	0.2056
	Total	**5872.6774**	**100**

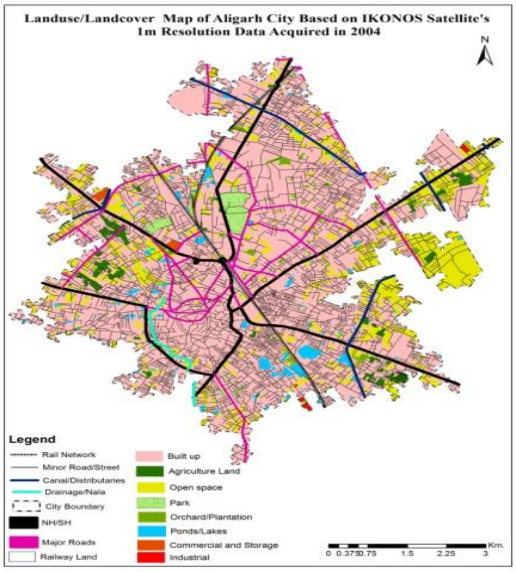

Figure 4: Landuse/Landcover Map of Study Area Based on IKONOS Satellite Data of 2004

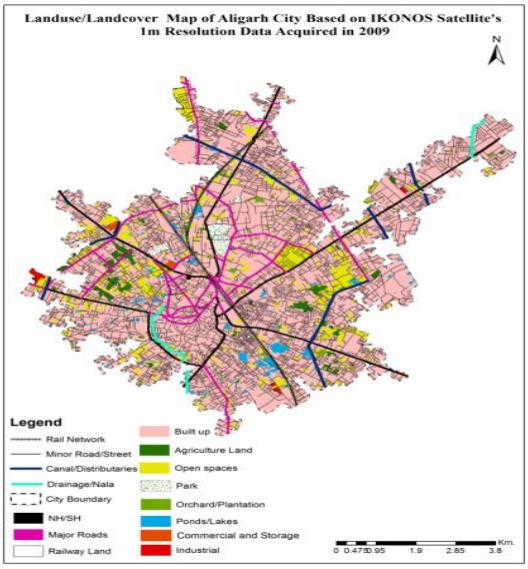

Figure 5: Landuse/Landcover Map of Study Area Based on IKONOS Satellite Data of 2009

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Landuse / Land cover (2014)

The urban land use/ Land cover map of Aligarh city has been prepared based on IKONOS Satellite imagery of 2014 and 11 landuse / landcover categories identified and mapped in satellite data using Arc- GIS software (Fig.-6 & Table-5). These different categories in study area occupy the area under agriculture land 160.4544 hectare (2.2727%), built-up 6177.2283 ha (87.4975%), canal/distributaries 7.3893 ha (0.1046%), orchard/plantation 54.7667 ha (0.7757%), park 61.2636 ha (0.8678 %), open space 239.5696 ha (3.3933%), ponds/lakes 77.7372 ha (1.1011%), national highway/state highway 78.6706 ha (1.1143%) ,major road 48.6563 ha (0.6891%), industrial area 126.9081 ha (1.798%) and commercial 27.2434 ha (0.3859%) respectively.

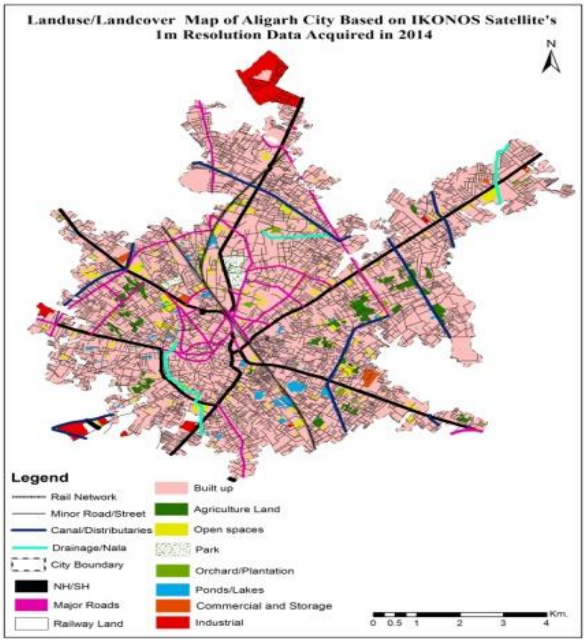

Figure 6: Landuse/Landcover Map of Study Area Based IKONOS Satellite Data of 2014

Table 5: Landuse / Landcover Statistics of Study Area (2014)

S.No	Class Name	Area in Ha.	Percentage (%)
1	Agriculture Land	160.4544	2.2727
2	Built up	6177.2283	87.4975
3	Canal/Distributaries	7.3893	0.1046
4	Open Space	239.5696	3.3933
5	Orchard/Plantation	54.7667	0.7757
6	Ponds/Lakes	77.7372	1.1011
7	NH/SH	78.6706	1.1143
8	Major Road	48.6563	0.6891
9	Park	61.2636	0.8678
10	Industrial	126.9081	1.798
11	Commercial	27.2434	0.3859
	Total	**7059.8875**	**100**

Land Transformation between 2004-2009

From the results obtained for land transformation between years 2004 to 2009. It has been observed that the area of agriculture land is 12.9602 ha and trend of change has been observed as (1.029%). Table-6 shows the trend of changes of other landuse categories as built-up (urban area) has been increased 1283.02 hectare (110.76%), canal/distributaries 1.2 hectare (0.01%) and the area of open space has been decreased to -173.48 hectare (-15.1124%), Orchard/ Plantation 0.8327 hectare (0.0725%), ponds/lakes 2.9743 hectare (0.25%), national highway/state highway 5.1609 hectare (0.4495%), major road 5.1809 hectare (0.4513%), park 1.2276 hectare (0.1069%), industrial 8.8346 hectare (0.7696%) and commercial is 0.0014 hectare (1.2%) respectively.

***Table 6*:** Land Transformation Statistics of Study Area between 2004-2009.

S.No.	Class Name	2004 (Area in Ha.)	2009 (Area in Ha.)	Change in area (2009-2004) (Ha.)	Trend Change %
1	Agriculture Land	96.735	109.6952	12.9602	1.029
2	Built up	3558.963	4841.9845	1283.02	110.76
3	Canal/Distributaries	2.1803	3.381	1.2	0.1
4	Open Space	735.3739	561.8952	-173.48	-15.1124
5	Orchard/Plantation	57.3335	58.1662	0.8327	0.0725
6	Ponds/Lakes	92.1774	95.1517	2.9743	0.25
7	NH/SH	66.1402	71.301	5.1609	0.4495
8	Major Road	35.5506	40.7315	5.1809	0.4513
9	Park	62.563	63.7906	1.2276	0.1069
10	Industrial	5.6737	14.5083	8.8346	0.7696
11	Commercial	12.0708	12.0722	0.0014	1.2
	Total	**4724.7614**	**5872.6774**	**1147.92**	**100**

Land Transformation between 2009-2014

The result obtained for land transformation and landuse pattern change between years 2009 to 2014 are summarized in Table-7, which shows that the statistics under different landuse / landcover categories as agriculture land between years 2009 to 2014 is 50.759 ha (4.2755%) and built-up (urban area) has been increased 1335.2 ha (112.469%), canal 4.0083 ha (0.337%), national highway/state highway 7.3696 ha (0.6207%), major road 7.9248 ha (0.6675%), industrial 112.4 hectare (9.4675%) and commercial is 15.171 hectare (1.277%) and it has been observed from Table-7 that open space, orchard/ plantation, ponds/lakes and parks area has been decreased to -322.33 ha (-27.14%), -3.3995 ha (-0.2863%), -17.415 ha (-1.4668%) and -2.527 ha (-0.2128%) respectively.

Table 7: Land Transformation Statistics of Study Area between 2009-2014.

S.No.	Class Name	2009 (Area in Ha.)	2014 (Area in Ha.)	Change in Area (2009-2014) (Ha.)	Trend Change %
1	Agriculture Land	109.6952	160.4544	50.759	4.2755
2	Built up	4841.9845	6177.2283	1335.2	112.469
3	Canal/Distributaries	3.381	7.3893	4.0083	0.337

4	Open Space	561.8952	239.5696	-322.33	-27.14
5	Orchard/Plantation	58.1662	54.7667	-3.3995	-0.2863
6	Ponds/Lakes	95.1517	77.7372	-17.415	-1.4668
7	NH/SH	71.301	78.6706	7.3696	0.6207
8	Major Road	40.7315	48.6563	7.9248	0.6675
9	Park	63.7906	61.2636	-2.527	-0.2128
10	Industrial	14.5083	126.9081	112.4	9.4675
11	Commercial	12.0722	27.2434	15.171	1.277
	Total	**5872.6774**	**7059.8875**	**1187.2**	**100**

Since 1971 to 2014, in span of 43 years various residential colonies at Aligarh city has been developed due to launching of different residential/ commercial- market area schemes by Aligarh Development Authority (ADA), U.P. Housing Board & many cooperative housing societies/ private builders and the area occupied by these colonies has been transformed into built up urban area permanently. During 2004 to 2009 and 2009 to 2014 Aligarh Development Authority, U.P Housing Board and Cooperative Housing Societies. Some of the colonies in old Aligrh city i.e. Green park colony has been developed newly near S B B Inter college, Sasni gate, Awas Vikas Colony- Halwai khana, Manik Chowk, MamuBhaiya, Kanwarganj, Kapilvihar, Kishanpur, Rasalganj, Gambhirpara, Surendranagar, Mahindra Nagar, Trimurtinagar, Bank colony, Gandhinagar, Pathan Mohallas, Jama Maszid upper Coart and Phoolkhana colonies. Similarily some colonies has been developed as new Aligarh city as Pratibha colony, Firdausnagar, Church compound, Hamdard Nagar block- A, B, C and D, Jmalpur, Laldiggi compound, Taiyyab Colony, Anwar-ul-huda compound, Begambagh, Bargad house, New Jamalpur, Kabirnagar, Anwar villa, Niranjanpuri, Kisanpur, Quiraisinagar, Shatabdinagar, Swarn Jayanti nagar, Janakpuri, Jwalapuri, Naurangabad, Lekhrajnagar. Further Aligarh Development Authority is doing planning to develop some othe new colonies on Grand Truck (G.T.) Road highway. Besides of old Aligarh settlement, in periphery of city almost Agricultural land, lake/ponds and waterbodies and numbers of village has been converted/tranfonsformed into urban buillt -up land of Aligarh city in around 43 years from 1971-2014. Now-a-days due to not restriction of conversion from prime agricultural land to urban built-up areas, some private builders/ cooperative housing societies still active/ involved in plotting/ Construction of new colonies on various roads/ high ways connects to the Aligarh city.

7. RECOMMENDATIONS

Before going to acquire the land for various land uses/transformation for preparation of Master Plan map of city, the following should be considered

- Prime Agricultural land should be avoided for future urban growth/ expansion.
- To develop any colony in urban periphery, at first wastelands should be used if non-availability of wastelands, the ‘c’ quality of land (less fertile land) can be used for residential use as well as for commercial and other land uses.
- From environmental point of view, all large scale industries should be at a minimum distance of five kilometers from urban municipal limit and wastelands should be used for establishment of industry.
- Govt. institution/ schools/ college/ universities, which occupies large area should also not be constructed in fertile land.

- The four lane Express ways may be constructed to reach Aligarh from other major cities of Uttar Pradesh and from National capital Delhi to borders of other state like Haryana, so that population pressure on inner part of the major cities may be reduced. In state of U.P. there is only three express way like Noida to Greater Noida (24.53 km), Delhi to Noida direct Flyway (9.20 kms.) and Yamuna Express Way from near Agra- Greater Noida-Noida to Delhi (165 km). The total distance in state of U.P. is around 200 km and in our country length covered by the express ways is only 736.19 km.(9 August, 2012, Dainik Jagran Newspaper, Lucknow edition)

8. CONCLUSION

The study with the help of remote sensing data and GIS technique is vital tool for urban spatial growth and land transformation. The measurement of land use/ land cover change is very useful for future realistic planning at local and global level finally although the urban growth cannot be stopped but through proper planning and management it can be restricted and directed in a desirable and sustainable manner, in perspective or to protect prime agricultural land. It should be planned by the government that outgrowth of city should be as per the laws and standards decided by housing and urban planning /development authorities to protect the prime agricultural land, biological and hydrological phenomena.

9. *REFERENCES*

[1] Bhatta, B. (2009). Analysis of urban growth pattern using remote sensing and GIS: a case study of Kolkata, India. International Journal of Remote Sensing, 30, 4733-4746.

[2] Census of India, population data-1971, 2001, 2011.

[3] Gopalan A.K.S. (2009), High Resolution Imagery for developmental Planning with spatial references to development. GIS@development.net http:/www.GISdevelopmentmet.net/technology/rs/techrsr0014pf.htm.

[4] Kumar. V, (2009), Application of Remote Sensing & GIS in Landuse/ Landcover Mapping of Pratapgarh district. ISPRS Nagpur Symposium.

[5] Subudhi, AP et.al(1998)Modelling urban sprawl and future population prediction using remote sensing and GIS techniques J. Potonirwachak pp 125-129.

[6] Patkar,V.N.(2003)"Directions for GIS in urban planning". GIS@development,http/www.gisdevelopment.net/application/urban/overview/urban0042 p1/htm, map Asia conference, urban planning.

[7] Xu, H. (2008). A new index for delineating built-up land features in satellite imagery. International Journal of Remote Sensing, 29(14), 4269-4276.

[8] Batty, M. (1996). Urban change. Environment & Planning B. 23, 513-514. New York, Wiley.

[9] Kumar, V et al:(2016), Urban Spatial Growth and land transformation analysis using high resolution remote sensing data and gis techniques- a case study of Lucknow city, Uttar Pradesh, India pp-118-129.(Proceedings of Rapid Urbanization and Sustainable Development in Asia, The 13th International Urbanization Conference(ISBN:978-979-8786-58-7), Badan Penarbit Fakultas Geographi(BPFG), Universitas of Gadjah Mada, Yogyakarta, Indonesia.