

APPLICATION OF GIS TECHNIQUES IN EVALUATION OF URBAN SPRAWL

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Abstract- Sprawl is basically spreading of city. Urban Sprawl is the outward spreading of urban areas and suburbs around outskirts of the city. Urban land-use advancements of various kinds greatly affect the landscape. Such advancement cause change the function of urban landscape and it also leads to change in ecosystem services. In this paper, an attempt has been made to identify and analyse the rate of urban growth, characteristics of urban sprawl and to investigate the effect of Urban Sprawl on Land use / Land cover change of Lucknow City for year 1981-2016. Remote sensing and GIS is used to analyse the urban sprawl mapping and detect changes of sprawl of Lucknow city through different year. Satellite data are found to be very useful in mapping and quantifying the land use/land cover change in different time periods through Landsat images and GIS.

Keywords: Urban sprawl/development, vegetation change, Population density, Classification through GIS

I. INTRODUCTION

Urban Sprawl has become a complex phenomenon and is being faced by both developed and developing countries (Gurmeet Kaur, 44th ISOCARP congress 2008). There is also a big discussion on the definition of urban sprawling (Gordan and Rechardson, 1997; Fischel, 1999; Ewing, 1997; Brueckner, 2001). Urban Sprawl can also be derived as unplanned, uncontrolled and uncoordinated growth of urban areas which may be appear as different types of development such as low-density development, ribbon, leapfrog or isolated development, isolated development (Carruthers and Ulfarsson (2002:314). Urbanization can also be defined as physical change and change in function, components and uses of landscape (Dahal et. al). Urban area is basically an area which represent a complex association of population, varied economic activities and diversified life styles (A.P.Subudhi et. al). Economic structuring, growth and many other geographical and environmental changes are the dynamic drivers of landscape change (Iqbal et.al, 2012).

There is a need to measure urban growth, pattern of urban land use and its periodical changes to advance a technique for optimum land use and to detail a proper urban improvement design. Remote Sensing and Geographic Information System (GIS) techniques are turned out to be extremely useful than conventional techniques to break down the sprawl and its forecast. For mapping and checking the landscape changes utilizing traditional mapping methods with expanded cost and time, has prompted bigger enthusiasm for research and headways in current mapping and displaying procedures through GIS and Remote detecting. In the study, Landsat imageries were used to carry out to delineate the land use and pattern of city growth area of Lucknow.

In spite of the fact that urbanization is an overall marvel, it is likewise significant in India where unprecedented rate of populace and urban development happened over most recent 30 years. It is additionally characterized as a persistent development of developed and constructional zones of an all around characterized urban zone, viz., Lucknow. In terms of crowd, Lucknow is in eleventh position and in terms of urban agglomeration, Lucknow is in twelfth position. A few examinations have been made about perfect examples and scenes in Lucknow city and its encompassing locales. Five essential examples of metropolitan settlements: sprawl, cosmic system, minimal, star and ring structure have likewise been depicted (Lynch, 1961). The advancement is set apart with the development of estates, ventures, business territories and other non-accommodating area utilizes which are the significant reasons for urban sprawl. Developed zone can be clarified as the parameter for figuring urban sprawl (Torrens, 2000; Epstein et al., 2002 and Barnes et al., 2001). The analysis of Lucknow City of years 1981-2016 is finished with the assistance of ENVI and ARC-GIS programming. The present investigation is done to break down the populace development, low-density sprawl and characterization of satellite pictures and change identification has been seen by the unsupervised and maximum likelihood classification into five categories, mainly urban and green area of different years.

II. STUDY AREA

The City of Lucknow is situated at an elevation of 123m (above MSL) and lies between 26°30' to 27°10' North latitude and 80°30' to 81°13' East longitude. It covers an area of 310.104 sq km as per census 2011 excluding cantonment zone. The city is located in Great Gangetic Plain. The city is also surrounded by its villages and rural towns like Mohanlalganj, Kakori, Gosaiganj, Malihabad (the orchard town), Chinhath and Itaunja. Urban Sprawl is spread along both sides of Gomti river. Gomti river has separated it into two zones, i.e. Cis-Gomti and Trans-Gomti region as shown in Table 1. The terrain of Lucknow city is majorly flat with north-eastern part having a depression. In general, slope of the place is from North and North-west to South and South-East. The city's lowest and highest elevation is 110 above msl (mean sea level) and 123.5 m amsl in the east in flood plain of Gomti River. The Gomti River flows from North-West (Gaughat) to South-east (Piprahghat) also says that River flows in the heart of city. The seepage of Gomti waterway is predominantly through Haidar channel and Kukrailnala. It has 3.3 million population with the thickness of 7120.25 people for every sq. km. The number of inhabitants in Lucknow urban has been expanded from 1007604 of every 1981 to 3226000 out of 2011 (Census of India 2011). Barabanki region lies on its eastern side, Unnao area on its western side, Raebareli region on its southern side and Sitapur and Hardoi regions are lies on its northern side.

The whole city is divided into six zones and each zone is divided into wards and then mohallas. Thus, study area comprises of 6 zones and 110 wards. Lucknow is one of the densely populated cities among the Indian cities and its population increase rapidly. Lucknow had become free from Britain on 15th Aug, 1947 along with rest of India. It has been recorded the seventeenth quickest developing city in India and 74th in the world. The atmosphere of city is gentle, for the most part warm and mild. There is significantly less precipitation in winter than in summer and the normal yearly temperature in Lucknow is 25.7 °C. Precipitation here midpoints 1001 mm. The summers in Lucknow are exceptionally sweltering and winters extremely chilly. The temperature may ascend to around 46° Celsius in summers, however the normal temperature is around 38-39 degree Celsius.

There are three major national highways cross through Lucknow locale, First is NH-27 which joins Kanpur and Unnao, Second is NH-24B which joins Delhi, and third is NH-28 which joins Gorakhpur. Different local roads which interface Mohanlalganj, Bangarmau, Sultanpur, Faizabad, Kursi and so on. There is likewise a development of Lucknow Agra expressway, which is in finishing state. The northern and northern eastern zone railway lines goes through significant Railway station named Charbagh and Lucknow rail line intersection which associates the majority of the real urban communities like Kanpur, Delhi, Gorakhpur, Rae bareli, Allahabad and so forth. The primary period of Lucknow Metro is relatively finished. There is International air terminal named Chaudhary Charan Singh International Airport in Amausi which is at 15 km remove and has direct flight to Delhi, Mumbai, Hyderabad, Patna, Bangalore and Sharjah. The district amongst Amausi and Lucknow city has extremely influenced by sprawl.

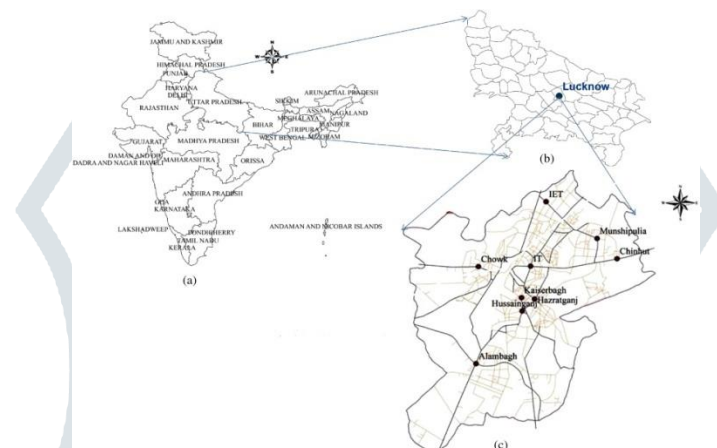


Fig 1. Location of Study Area

TABLE 1.

Settlements on both sides of river Gomti (Cis and Trans Gomti regions) in Lucknow

S.No.	Cis-Gomti regions	Trans-Gomti regions
1	Husainganj	Mahanagar
2	Aminabad	Vikas Nagar
3	Hazratganj	Nirala Nagar
4	Lal Bag	Aliganj
5	Golabganj	Jankipuram
6	Wazirganj	Gomti Nagar
7	Sarojini Nagar	Indira Nagar
8	Malviya Nagar	
9	Rajajipuram	
10	Aishbagh	
11	Rajendra Nagar	
12	Chowk	
13	Saadatganj	

III. DATABASE AND METHODOLOGY

DATA BASE

- Survey of India toposheets of Lucknow district 63F/1 and 63F/2 on scale 1:50,000.
- Census of India – Primary Census Abstract – 1971- 2016
- Satellite Data: LANDSAT 7 ETM+C1, LANDSAT 8 OLI/TIRS C1, LANDSAT MSS1-5(1972-1987) and ETM+(1999-2003) images

Source : (<http://earthexplorer.USGS.gov>)

The methodology of the study depends on usage of Remote Sensing information and satellite images for inferring physical qualities of urban phenomenon and spatio-temporal data on the urban land utilize. Landsat Thematic Mapper (TM) pictures of 1984,1990,2002 and 2010, and Landsat 8 OLI picture of 2016 were utilized for estimating urban spatial example and investigating pattern of urban development in Lucknow city. Land utilize/arrive cover maps were created by managed arrangement procedure and most extreme probability strategy. Different regular strategies are utilized to characterize arrive

utilize/arrive cover like help vector machine strategy (Chen et al. 2017a), counterfeit neural system (Erbek et al. 2004), however regulated characterization is presently widely used for the urban zone examination.. A transition matrix was created utilizing cross check tabulation in GIS to investigate changes in arrive utilize/arrive cover. The progress network gave data on real changes in the investigation zone. Methodology includes various steps:

- A. Create Segment Map
- B. Create Polygon Map
- C. Use Raster Maps and satellite images of different years
- D. Unsupervised Classification has been done
- E. Supervised and maximum likelihood Classification has been done
- F. Analyse land use/cover and analyse change in green area

G. RESULT AND DISCUSSION

A. Urban Growth

Lucknow is a metropolitan city of Uttar Pradesh which experienced substantial urban development increasing rapidly. Lucknow has significantly changed from small, less populated urban zone in mid 1990s into interconnected urban complex today and now it having differing financial, physical, and natural highlights. The dynamic development rate in 1921 more than 1901 was - 6.25 for every percent recorded by census year as negative development rate. This phenomenon occurred all through India and this period is known as great 'demographic divide' in the Indian history. During 1921 to 1951, the populace expanded from 0.240 million to 0.444 million. This 30 year duration has therefore enlisted a development of 107.05 percent. Hence, this period is known as the steady growth rate. The number of inhabitants in Lucknow city was 22.45 lakh in 2001 which increased upto 28.80 lakh in 2011. The progressive growth rate is forecasted upto 45 lakhs in 2021 and 65 lakhs upto 2031 which will be the major reason of urban sprawl and vegetation decrement.

We have also calculated growth rate by decadal method which is more efficient:

TABLE 2.
Decadal growth of Urban Population(1981-2021)

Year	Population	Decadal growth	Growth %
1981	1007604	193622	23.79
1991	1669204	661600	65.66
2001	2245509	573605	34.53
2011	3226000	980491	43.66
2021*	4500000	1274000	39.49
2031*	5884650	1384650	30.77

Source: Master Plan 2021 ; *Projected population(calculated),(census data and toposheets of Lucknow City)

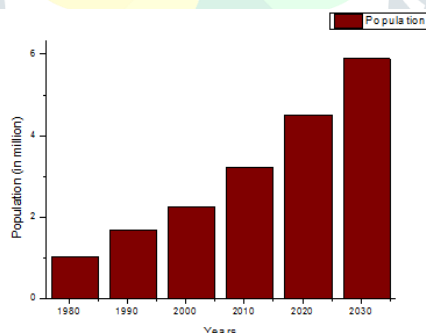


Fig 2. Population variation with time

TABLE 3.

Year	1981	1991	2001	2011	2021*
Area(sq.km)	146	159.26	212.25	303.62	414.35
% Change	14.3	9.08	33.27	43.04	36.47

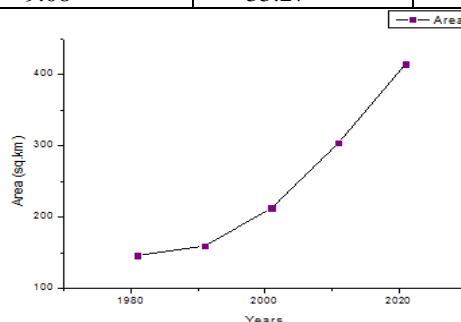


Fig 3. Graph shows area change with time

B. Pattern of Land use/Land Cover and change detection in vegetation:

Influx of the population has impacted the land use pattern of the study area posing numerous problems like change in physical as well as cultural environment, slum development, generation and accumulation of all sorts of wastes, colossal pressure on various amenities, arising hydrological scarcity etc. Thus high decadal growth rates are in conflict with traditions, making huge demands on land, transport and services. The city grew because of their land use pattern and its morphological development. Background study witnessed that it has major land use changes among various classes such as commercial area (548.65 per cent increase), residential area (386.67 per cent), recreational area (563.11 per cent increase), facilities/ utilities area (921.74 per cent increase) industrial area (612.23 per cent increase), administrative area (1134.84 per cent increase) open land, water bodies, forest and agricultural land decreased from 1973 to 2004 as -50.86, -33.76, -45.48 and -100 per cent respectively and other land use category 836.60 per cent increased. The study reveals that all the land use classes are increased but the ecological valuable areas such as open spaces, forest land, water bodies and agricultural land are decreased, which is the cause of degradation of environmental quality.

TABLE 4.
Changes in Land use Pattern in Lucknow City : (Land use in%)

Land use type	1987	2001	2001-1987
Residential	48.91	67.2	18.29
Commercial	2.43	4.1	1.67
Industrial	6.5	3.1	-3.4
Industrialpublic/ semi-public	15.02	8.2	-6.82
Transport	10.38	9.5	-0.88
Recreational	3.78	7.9	4.12
Vacant & Water body	12.98	-	-

Source: Master Plan 2021*

TABLE 5.
Existing and Proposed Land Use :

Land use type	Existing (2010-11)		Proposed land use 2021	
	Area (in hectares)	Percentage(%) of total area	Area (in hectares)	Percentage(%) of total area
Residential use	10278.68	42	18987	49
Commercial use	623.2	2.56	1180	3
Industrial use	940.56	3.83	1265	3.3
Office area	888.78	3.62	480	1.2
Communities and facilities	2137.25	8.70	3686	9.5
Park and open areas	997.8	4.11	6046	15.6
Traffic use	7842.73	32	5823	15
Rivers/lakes/water bodies	578.54	2.35	1283	3.4
Others	194.1	0.80	-	-

Source: Master Plan(draft) 2021

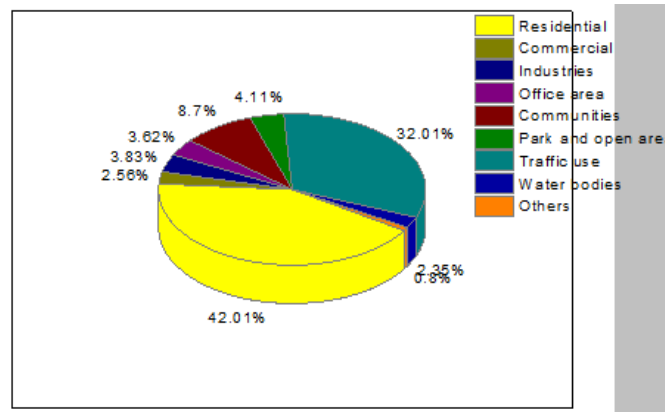
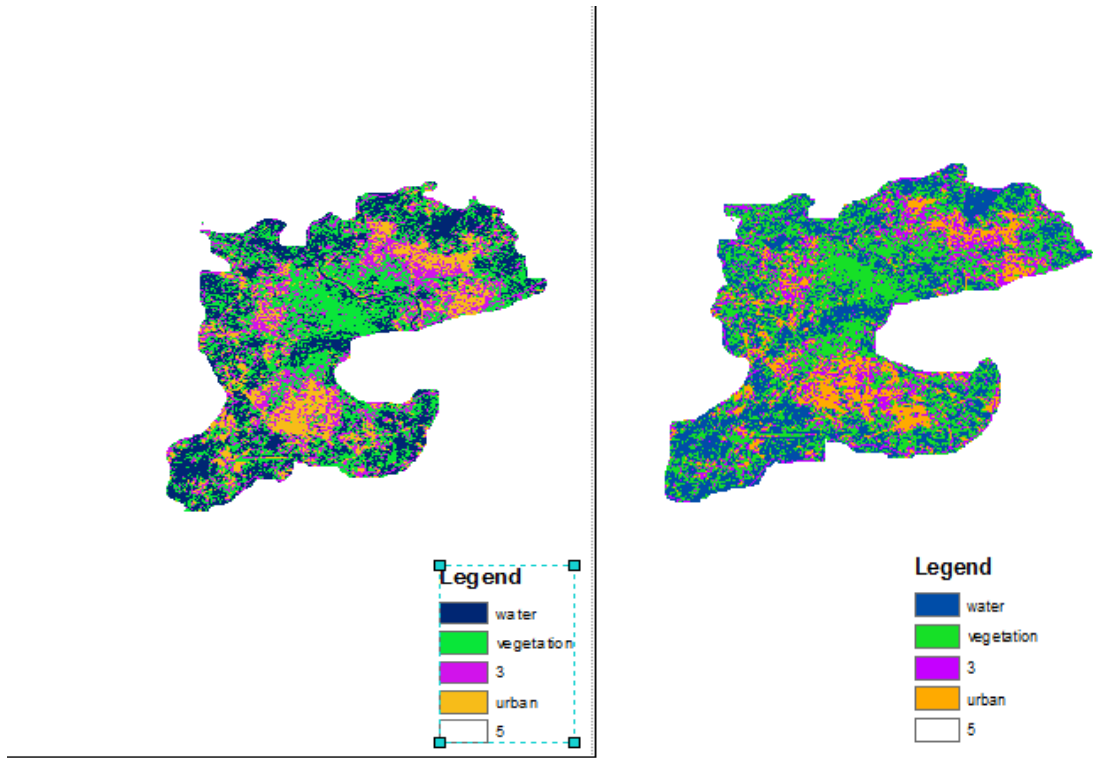


Fig 4. Existing Land use(2010-11)

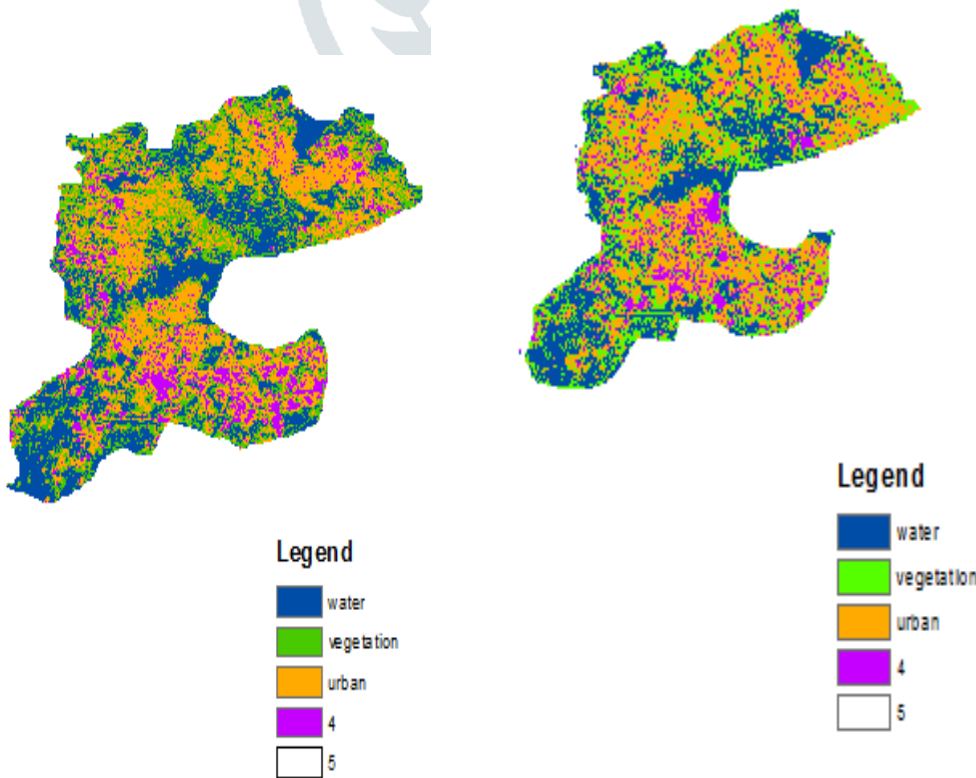
C. Change in urban landscape and its spatial pattern :

The relation between urban and non-urban area along with its hinterlands can possibly be establish with the help of satellite images and remote sensing data and technique. Data are used for land cover mapping with respect to urban areas. Vegetation decrement and urban land increment has been classified. Iso-cluster unsupervised classification and maximum likelihood classification has been used. Five classes of land use of Lucknow City for the period of 1984, 1990, 2002, 2010 and 2016 were identified: (1) Vegetation (2) Urban land (3) Water bodies (4) wetland and (5) other uses. The area experienced drastic change over last 25 years in land use/land cover. Built up area has been increased. Increase in agricultural area has been seen near built up area. It leads to urban expansion at the cost of vegetation area. Other classes of land i.e. vegetation land, open area, wetlands experienced a decrease in their respective areas.



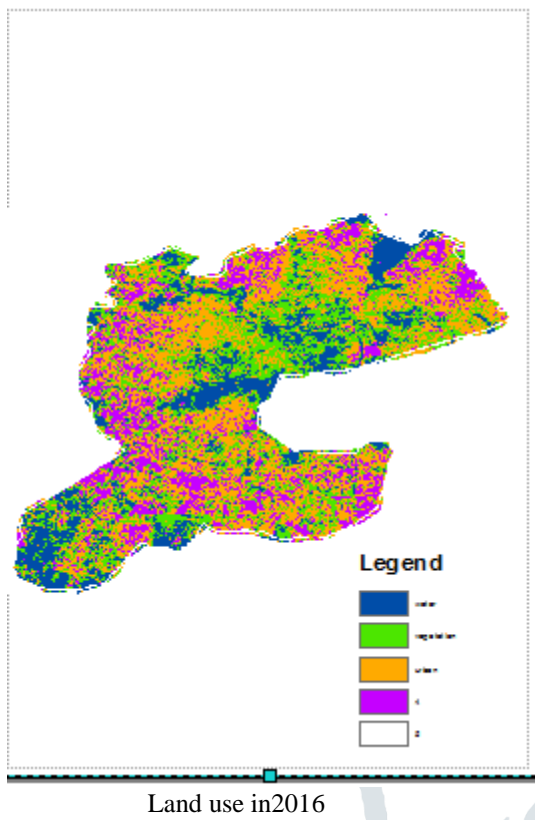
Land use in 1984

Land use in 1990



Land use in 2002

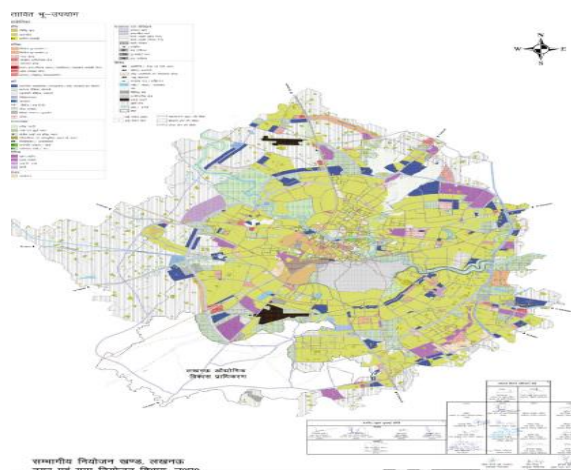
Land use in 2010



D. Roads and Railways Network of Lucknow City



Roads and railway networks in urban lucknow



Source: Master Plan 2031

H. CONCLUSION

Present study demonstrates that satellite data is very significant in demarcating the urban spread and land use categories. Further, GIS is a very powerful and efficient tool to detect the urban landscape and its spatial pattern. The study proposed satellite based methodology to explore the urban spatial pattern and trend of urban growth of Lucknow city by using urban sprawl matrix of years(1981-2016).

The study revealed that Lucknow city has been growing at a faster rate especially during 1991 and 2001. The city's structure has been expanded and become more complicated because of its continuous economic development. Major growth has observed towards north and north-eastern direction and along major transportation routes. New urban development occurred on agricultural, vegetation and forestry land caused a great reduction in green area. Decreasing green area leads to increase in heavy pollution in city. Sprawl has occurred significantly on both sides of river gomti. The land use/cover map has depicted reduction in green areas which has been extracted with the use of satellite imageries.

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