Change Detection and Assessment of Urban Growth in Patna Municipal Corporation using Geospatial Technology

• **Sonali Singh**   • **Anjali Srivastava**   • **Alina Ali**

Abstract: *Growth is the cause and consequence of development of a place. Urban Growth, according to UNICEF is defined as "The relative increase in the number of people who live in towns and cities." It is an important phenomenon which indicates development of any area or region. In context of Bihar, average level of urbanization as per 2011 census of India is 11.3 percent and that of Patna is 43.1 percent among all the districts. Patna has witnessed a rise of about 75 percent in population from 9.56 lacs in 1991 to 16.84 lacs in 2011. The present paper aims to identify the pattern of Urban Growth in the Patna Municipal Corporation area using geospatial technology and understand its socio-economic impact. The samples were collected from the six circles covering 75 wards. A total of 171 responses were recorded from the population. The sample collected corresponds to 0.01 percent of the total population. For identification of pattern of urban growth landuse/land cover map has been prepared using LANDSAT image for the year 2010 and 2020.The analysis outcome indicates that in the time period of 10 years the urban built-up area has increased from 74.11 sq. km in 2010 to 80.03 sq. km in 2020, thus, making 5.78 percent of change in a decade. A noticeable transformation of agricultural land or waste land into industries or buildings has also been registered. The present study quantifies the magnitude and direction of urban growth which can be used for sustainable planning and management of the city.*

Keywords : *Change Detection Technique, Land use/Land Cover Map, Patna Municipal Corporation(PMC), GIS, Urban sprawl.*

Sonali Singh

B.A. III year, Geography (Hons.), Session: 2018-2021, Patna Women's College, Patna University, Patna, Bihar, India

Anjali Srivastava

B.A. III year, Geography (Hons.), Session: 2018-2021, Patna Women's College, Patna University, Patna, Bihar, India

Alina Ali

B.A. III year, Geography (Hons.), Session: 2018-2021, Patna Women's College, Patna University, Patna, Bihar, India

Meenakshi Mishra

Assistant Professor, Department of Geography Patna Women's College, Bailey Road, Patna - 800001, Bihar, India

E mail - meenakshi.geog@patnawomenscollege.in

Introduction:

Growth is the cause and consequence of development of a place. 'Urban growth' in simple terms is defined as 'the expansion of city area with respect to the exceeding number and size of the settlement; and cause shift in the activity of people from primary sector to government, trade, manufacture or allied factors that is, tertiary sector'. It basically depends upon the desire

of human being for their betterment in living conditions and employment and as a result of this changes in land use / land cover can be seen all around the world.

The advancement in the field of science and technology has introduced various techniques for better understanding of urban growth, with analysis and monitoring and change detection technique being one of those, which is used to determine how the attributes of a particular area have changed over a period of time as it provides quantitative analysis of the spatial distribution of population and other environmental related activities. The varied and vital aspects of the sustainable urban management information that is, urban infrastructure and different social economic parameters are being used in conjugation with urban remote sensing to understand the size and dynamism of urban transformation (Goodchild et al., 1992; Marangoz & Alkis, 2012; Kanhaiya Lal et al., 2017).

Patna being the capital city of Bihar is a fast-growing city and has emerged as a trade centre in the last 10 years. Patna is experiencing exponential growth of urban population owing to the promise of more employment and good quality of life. Its growing population and rapid migration from different regions of Bihar has resulted in the rapid urbanization of Patna Municipal Corporation. It has become one of the environmentally vulnerable areas under the threat of degradation of environment and ecology. In order to study and analyse the change in urban area of Patna Municipal Corporation, use of geospatial technology is very helpful.

Literature Review :

Urban development is a major concern for developing nation like India as they strive to preserve their overall growth. Different geographers have witnessed various aspects of urban growth that leads to transformation of agricultural land and water bodies to industrial, residential and commercial areas. The ever-increasing population in the suburbs of the city has led to the rise in unplanned urban growth which is usually termed as urban sprawl. Land use and land cover change is a reflection of the impact of biotic drivers as well as abiotic drivers on the prevalent land use and land cover of the region (Roy and Roy, 2010).Change pattern

of land use /land cover is very convenient to get into the reality of anthropogenic pressure and dynamic of demography of a given area and for this purpose **change detection** technique is widely used to assess the driving forces of the changes. (Ashraf, 2014).Urbanization is always seen as a supportive force for both economic as well as social development. The people must seek out creative and sustainable ways to accelerate it in the interest of both common masses and our environment (Kumar and Rai, 2014).The availability of remote sensing satellite data at various spatial, temporal and spectral resolutions provides enormous opportunity to map the urban sprawl. When coupled with Geographic Information System (GIS) it is possible to evaluate, analyses and integrate large data (Ahmad and Goparaju, 2016). Patna is under the process of transformation from an old heritage city to modern smart city of the East. The natural vegetation of the capital city has been destroyed by settlement and agriculture. Thus, the study suggests that both the citizens and institutions should join hands with government to make Patna "smart and sustainable (Ghose, 2018)".

Objectives:

The current study has the following objectives:

1. To identify the pattern of Urban Growth in PMC area.

2. To delineate the decennial changes in PMC area.

3. To identify socio-economic impact of urban growth in PMC area.

Hypotheses:

The current study has been based on the following hypotheses:

1. Urban growth has taken place in the outskirts of the city.

2. With the growth of urbanization, urban greens have declined.

3. Urban growth has led to increase in slum areas.

Methodology and Database :

The research work is based on defined methodology, which is as follows:

Pre field survey: Pre field work is done to attain a satisfactory output of any study. It includes study of relevant literature, procurement of LANDSAT image for the year 2010 and 2020, collection of other secondary data and preparation of questionnaires to carry out survey.

Field survey: A total of 171 responses were recorded from the population from the six circles covering 75 wards through the prepared questionnaires.

Post-field survey: The responses collected through questionnaire was analyzed using Microsoft Excel and google sheets and inferences were made. Visual interpretation of satellite data was done on the basis of elements such as tone, texture, size, site, pattern, etc. for the preparation of LU/LC map. In QGIS software the satellite images were processed and band combination 5, 4, 3 were used for interpretation purpose and analysis was documented.

Table 1. Table showing specifications of the Satellite images

SPACECRAFT	LANDSAT-5	LANDSAT-8
SATELLITE IMAGES	PMC IN 2010	PMC IN 2020
DATE OF ACQUISITION	25-10-2010	20-10-2020
SENSOR	TM	OLI_TIRS
WRS_PATH	141	141
WRS_ROW	042	042
NUMBER OF BANDS	7	11
MAP PROJECTION	UTM	UTM
PROJECTION UNITS	METRES	METRES
DATUM	WGS84	WGS84

Study Area:

The Study Area of the research work is the Patna Municipal Corporation Area (PMC) area. Patna is the capital city of Bihar positioned at latitude of 25°30'11" N to 25°36'0" N and longitude of 85°7'0" E to 85°19'35" E.The administered area under PMC is 109.218 km². The population of this area is 1,683,200 (Census of India, 2011). Patna is the administrative and economic capital of Bihar. Lying in the Ganga Plain, this area is highly beneficial for the primary as well as tertiary activities. The Patna Municipal Corporation area has been divided into 75 wards under 6 circles, namely, New Capital, Patliputra, Kankarbagh, Bankipur, Azimabad and Patna City.
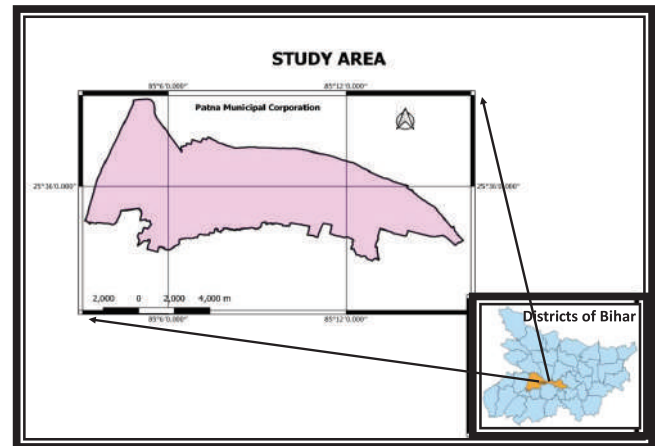
Map1. Map showing Study Area of PM
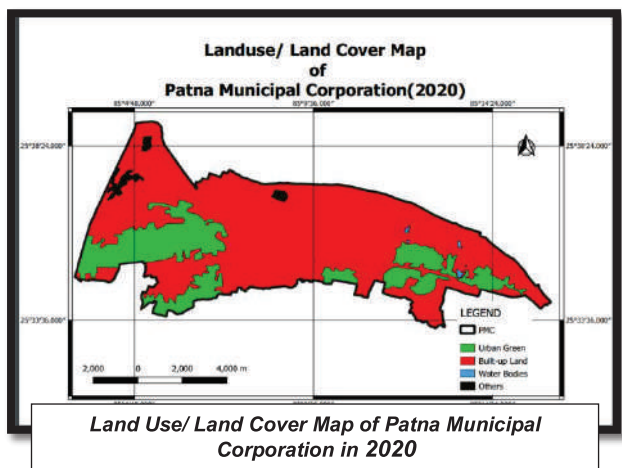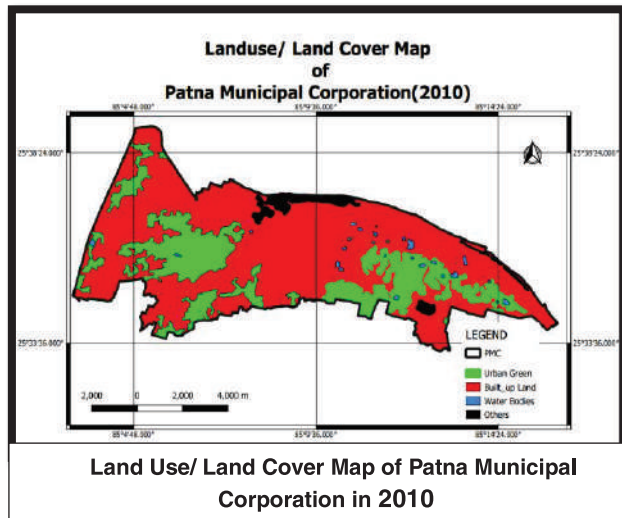*Based on PMC Administrative Command,2001

Result and Discussion:

Land use/ Land Cover change in PMC using Remote Sensing and GIS

The land use/ land cover map based on temporal image of LANDSAT exhibits noticeable rise in urban expansion in PMC. In 2010, PMC consisted of 72 wards and 4 circles and covered an area of 102.36 sq.km. 74.11 percent of PMC area was occupied by built-up land which mostly included residential areas. 24.25 percent of the study area was covered by urban greens which was mostly located in the south western part as well as the south eastern part of PMC area.Some small water bodies including tanks and ponds are detected in central and eastern part of the PMC area. 3.21 percent of the land consisted of other lands such as parks and barren lands.

The area of PMC now consists of 75 wards and 6 circles. Since the infrastructural development in Patna is at its peak, thus only 17.09 percent of the total study area is under urban greens. 5.09 percent of PMC area have been covered by the other areas like parks or other barren lands. Few water bodies including Mangal talab in Patna City circle and small water bodies in zoo and eco park have been detected in PMC area of 2020. Two to three small ponds or tanks have been found covering negligible portion of the land, that is, 0.23 percent. The built-up land occupies 80.03 percent of the total study

area in 2020 and is likely to increase in near future in order to accommodate large number of growing population of the city.

Land Use/ Land Cover Map of Patna Municipal Corporation in 2010

Land Use/ Land Cover Map of Patna Municipal Corporation in 2020

Patna has seen a distinct change in its land use and land cover from 2010 to 2020. This is mainly due to the expansion of the city aiming to enhance the economy and infrastructure of the city. The need for better standard of living and migration from rural to urban areas is another cause leading to urban expansion of the city.

Table 2. Change in Urban Built up 2010-2020

Land use/ Land cover feature	Area in Km2 (2010)	Area in Km2 (2020)	Change (2010-2020) in percentage
Urban Greens	24.25	17.09	-6.99%
Water Body	0.78	0.23	-0.53%
Built up land	74.11	80.03	+5.78%
Others	3.21	5.01	+1.76%
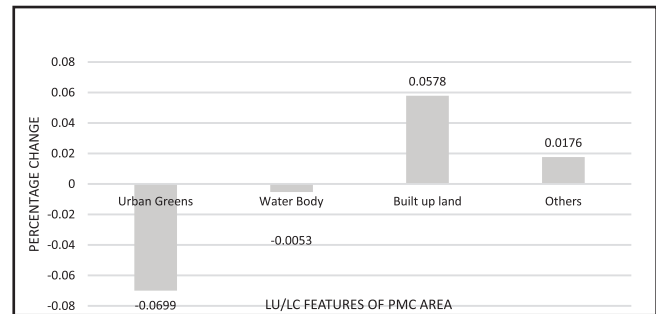
Fig. 1. Graph representing change in Urban LU/LC of PMC area from 2010-2020.

The map 3 indicates the changes in the built-up area of the Patna Municipal Corporation from 2010 to 2020. There has been a considerable expansion in the built-up area. The dark brown colour representing the built-up of 2020 clearly defines the increase. Major built-up transformation has been recorded in the eastern, northern and western parts of Patna. In 2010 there were 72 wards and 4 circles which increased to 75 and 6 in 2020. The analysis outcome indicates that in the time period of 10 years the urban built-up area has increased from 74.11 sq.km in 2010 to 80.03 sq.km in 2020, thus, making 5.78 percent of change in a decade.
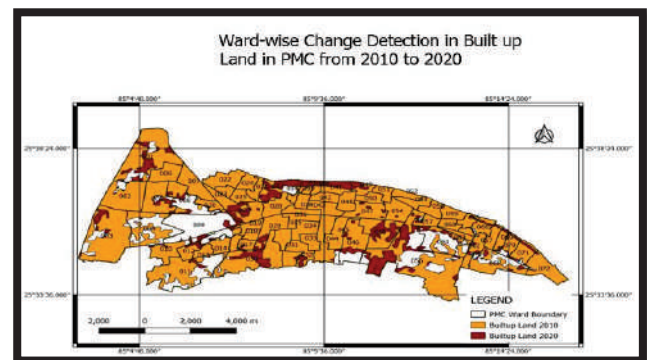
Map 3. Map showing ward wise change detection in Built up land in PMC from 2010 to 2020

Social and Economic impact of Urban Growth

The Patna Municipal Corporation (PMC) area shows a wide range of variation in its social and economic status. The sample collected corresponds to 0.01 percent of the total population and it was evenly spread across 75 wards of 6 circles under PMC area. In the present study, socio-economic changes in PMC are

mainly assessed through the indicators such as in-migration of population, hygiene, transport and network connectivity and upliftment of the slums. Economic changes in Patna can be gauged from the gradual increase in GDP, the improvement in the standard of living of the people.

Migration is said to be one of the major contributors of urban population growth. It's a common characteristic in case of underdeveloped place like Bihar. Lack of employment opportunities, lack of better educational facilities, poverty and the desire for the better standards of living acts as a push factor in several regions of Bihar. The following table indicates various factors that have been responsible for in-migration in Patna. As per the survey conducted in 2020, 25 percent of the sample population were migrated population. Out of this, 46.5 percent population migrated to Patna because of education and 46.5 percent migrated because of employment opportunities. Most of the migrated population accommodated in the regions around Kankarbagh Circle and Patliputra Circle. This leads to the formation of slums in these regions. Thus, migration forms an important factor for the population growth and slum formation. The major migration due to employment in Patliputra Circle indicates, more economic development of that area. Migration has a very significant impact on the population, infrastructure and society. But migration is also very helpful in order to improve the economy of the place.
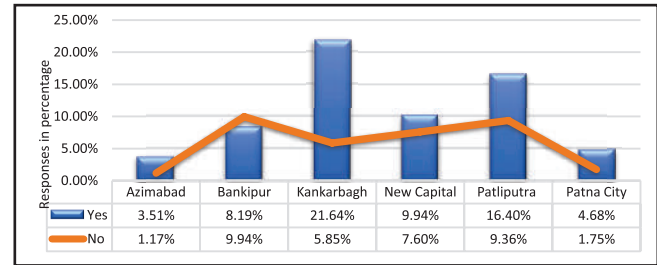
Table 3. Table showing factors of migration to PMC*

Circle	Factors of Migration to Patna			
	Education	Employment opportunities	Marriage	Medical
Azimabad	0.58%	0%	0%	0%
Bankipur	1.16%	0.58%	1.16%	0%
Kankarbagh	4.7%	3.5%	0%	0%
New Capital	2.34%	2.34%	0%	0.58%
Patliputra	2.9%	5.3%	0%	0%
Patna City	0%	0%	0%	0%

*Based on Sample Survey, 2020.

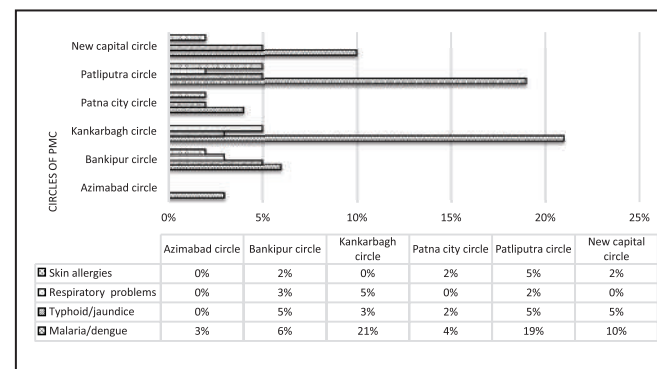Analysis of the study reveals that more than half of the sample population that is, 64.33 percent have slums in their locality, highest being in the Kankarbagh circle and the lowest in the Azimabad circle.

	Azimabad	Bankipur	Kankarbagh	New Capital	Patliputra	Patna City
Yes	3.51%	8.19%	21.64%	9.94%	16.40%	4.68%
No	1.17%	9.94%	5.85%	7.60%	9.36%	1.75%

*Based on Sample Survey, 2020.

Fig. 2. Graph showing responses of sample population regarding slum areas in their locality*

Poor sanitation often ends up causing various health issue. The following graph shows various health issues faced by the sample population of PMC area. The most common problem faced by the people are malaria/dengue highest being in Kankarbagh circle followed by Patliputra circle. This is mainly because of the water logging problem, prominent in these areas which forms the breeding grounds for mosquitoes. There has also been an increase in the respiratory diseases, mainly because of the increasing level of pollution. The situation has deteoriated as compared to the past decades when the atmosphere was cleaner and safer for the population.

	Azimabad circle	Bankipur circle	Kankarbagh circle	Patna city circle	Patliputra circle	New capital circle
Skin allergies	0%	2%	0%	2%	5%	2%
Respiratory problems	0%	3%	5%	0%	2%	0%
Typhoid/jaundice	0%	5%	3%	2%	5%	5%
Malaria/dengue	3%	6%	21%	4%	19%	10%

*Based on Sample Survey, 2020.

Fig. 3. Graph showing prominent health issues in PMC area*

The scheme of door-to-door garbage collection service initiated by Patna Municipal Corporation is available in most of the areas of PMC. This indicates that

the government is conscious about the increasing rate of diseases due to unhygienic conditions and are working to improve the situation. The disposal of wastes in differently colored dustbins is also an important step taken to improve the deteriorating situation of health facilities. The survey analyses that maximum population of the PMC avails the facilities of door-to-door garbage collection while the negligible percent of sample population do not avail this facility. The following table shows the responses of sample population regarding door-to-door garbage collection.

Table 4. Table representing responses of sample population regarding door-to-door garbage collection*

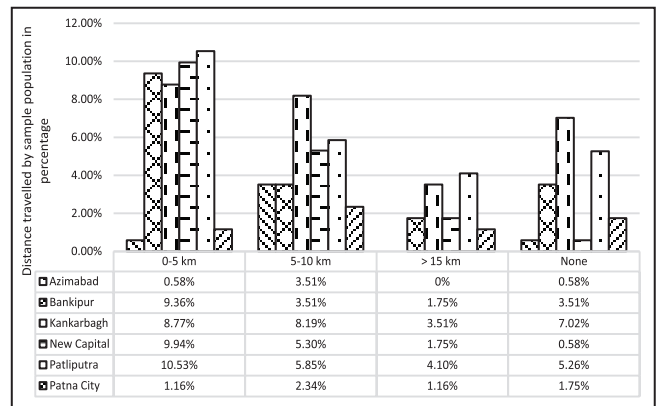| Circle	Yes	No	Sometimes
Azimabad circle	4.67%	0%	0%
Bankipur circle	15.79%	1.75%	0.58%
Kankarbagh circle	24.56%	1.75%	1.17%
Patna city circle	5.85%	0.58%	0%
Patliputra circle	19.30%	4.09%	2.34%
New capital circle	14.62	2.34%	0.58%

*Based on Sample Survey, 2020.

Patna has witnessed phenomenal growth in the energy sector in the last few years. The following table shows the duration of electricity in each circle of PMC. More than half of sample population that is, 53.21 percent experiences 24 hours of electricity supply in their locality. This clearly indicates that Patna has developed much more in terms of power generation. Per capita energy consumption has increased by 114 percent between 2012-13 and 2018-19. 43.85 percent of sample population have more than 20 hours of electricity supply in the locality. The data also signifies that among six circles of Patna Municipal Corporation, neither of them experience less than 10 hours of electricity supply and nor do they experience frequent power cuts.

Table 5. Table showing duration of electricity in each circle*

Circle	24 hours supply	> 20 hours	10-20 hours	< 10 hours
Azimabad	0.58%	4.10%	0%	0%
Bankipur	8.77%	8.20%	1.16%	0%
Patna City	1.75%	4.10%	0.58%	0%
Patliputra	17.54%	7.60%	0.58%	0%
New Capital	8.77%	8.20%	0.58%	0%
Kankarbagh	15.80%	11.70%	0%	0%

*Based on Sample Survey, 2020.

Patna known for its 'web of flyovers' has experienced an unprecedented growth in transportation sector in last few years. The physical framework in Patna has fortified considerably during the last decade. The following table represents the mode of transportation used by the sample population of PMC area.

	0-5 km	5-10 km	> 15 km	None
Azimabad	0.58%	3.51%	0%	0.58%
Bankipur	9.36%	3.51%	1.75%	3.51%
Kankarbagh	8.77%	8.19%	3.51%	7.02%
New Capital	9.94%	5.30%	1.75%	0.58%
Patliputra	10.53%	5.85%	4.10%	5.26%
Patna City	1.16%	2.34%	1.16%	1.75%

*Based on Sample Survey, 2020.

Fig. 4. Graph representing distance travelled by sample population from home to reach the work place*

In 2018-19, a total of 11.89 lakh vehicles were registered, compared to 5.53 lakh in 2013-2014 which also gives an idea that demand for private vehicle has increased leading to increase in number of private vehicle than public vehicle. The study clearly indicates that out of 171 sample population, almost 40.35 percent sample population travel only 0-5 km to reach their work place which signifies that maximum number of sample population have their work place in their area. This also signifies that development is taking place by leaps and

bounds and the outskirts of the city are experiencing this rapid phase of development. These areas are being merged with the main city thus enabling the people to travel less distance to reach their work place. 28.65 percent of population travel 5-10 km and only 12.28 percent of population travel more than 15 km to reach their work place. The reason for this can be stated as lack of job opportunity in their area and thus they have to travel to a much longer distance.

Conclusion:

The inversely proportional relation has been witnessed between the area under the urban greens and the urbanization trend of Patna Municipal Corporation. The processed result of the image interpretation demonstrates that there has been changes in the land use land cover pattern of Patna in the last 10 years. The increasing rate of urbanization has led to the encroachment in the urban greens and thus they have been converted into the built-up area in order to accommodate a large number of migrated populations. Suggestions for proper planning and management of urban expansion, following suggestions can be taken into consideration:1)Demarcation of areas around rural- urban transition zone where development is possible. 2)The use of geospatial technologies for land use mapping, regional planning, and development of measures for the utilization of the LU/LC of PMC area and its sub-urban areas. 3)The influx of migrants can be reduced if more employment opportunities like secondary sectors are created in the suburbs or peripheral areas of the PMC.4) Mandatory standards and regulations should be followed for change in land use pattern from agricultural land existing outside demarcated zone.

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