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Predicting Future Growth of Urban Sprawl in Terms of Population Growth and Built-up Area for Kolhapur City by using Geoinformatic Technologies

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Abstract: Nowadays urban sprawl is a major threat aspect for infrastructure development. An increased urban population and growth in an urban area in a disorderly manner has financial impact and concerns municipalities have to face. Urban dispersion processes in metropolitan areas have led to patterns of urban sprawl. In a town and city planning, the urban problems are in terms of housing, traffic congestion, parking problem, land utilization, water and electricity supply, garden development, waste disposal, slums, pollution. Kolhapur is a very ancient city. Kolhapur is one of the most important cities of Maharashtra. Last three to four decades, Kolhapur city has observed rapid growth. It is undoubtedly true that the population of the city increased very fast after independence. A quantitative and spatial analysis is done in order to see expansion dynamics in terms of built up areas as the key feature of sprawl through remote sensing and GIS.
Keywords: Urban Sprawl, Population, Built-up area, Remote sensing, ArcGIS.

I. INTRODUCTION

The Urban Sprawl is defined as "continuous expansion of big cities" marginal areas moreover [1]. It also means the increasing concentration of population within a town or city. Urban sprawl may also be defined as the rapid irregular growth of new development in independent ways.

The urban sprawl has a negative impact on the environment and socioeconomics. In cities, economic growth and industrial development are generally the first priority [6].

Urban sprawl or suburban sprawl mainly refers to the unrestricted growth in many urban areas of housing, commercial development, and roads over large expanses of land, with little concern for urban planning. Fast rate of increase in urban population is mainly due to large scale migration of people from rural and smaller towns to bigger cities in search of better employment opportunities and good lifestyle.

It is a growing problematic aspect of metropolitan and bigger city's growth and development in recent years in India. The study shows the extent and nature of sprawl going on in a region and causes of growth. This study would help developers and town planners to plan growth patterns and assist various infrastructure facilities.

In this way a challenge is made to evaluate the sprawl pattern, quantify sprawl and estimate the rate of change in built up area over period with the help of using GIS and Remote sensing.

Local infrastructure is the sum of point and network infrastructure and utilizes including public and semi-public facilities i.e. Roads, Bridges, public mass transport system, postal services and sewage [3]. In developing countries urban sprawl is worsened by the lack of land-use planning [4].

II. LITERATURE REVIEW

Several studies from the field of urban sprawl studied the phenomenon and process of urban sprawl and they also analyse the spatial patterns of sprawl. Researchers explained urban sprawl in many ways; and everyone has one result that, if urban sprawl is unplanned then it has a negative impact on the environment. Feng and Li (2012), studied the primary objective to recognize the spatial patterns of urban sprawl by taking one district as study area and four different years of Built-up area was studied to recognize the spatial patterns of sprawl.

Sperandelli et al., (2013), their result shows that urban sprawl is a continuous process and is encouraged by a permissible master plan and increase of green space is the result of growth upon the remaining forests in urban regions.

Yang et al., (2015), studied the use of land in a new city district with the aim of maximizing the quality of life of its workers and the productiveness of its living facilities, such as school, shops, leisure places and medical facilities. Researchers explained urban sprawl in many ways and the urban sprawl has a negative impact on the environment, which is unplanned.

So from above literature, it is important to study the urban sprawl for a developing city, quantify the urban sprawl, estimate the rate of change in built-up area over a period and this is done by using the spatial images, and GIS software. And it is also very important to predict the future growth of urban sprawl i.e. prediction of urban sprawl to provide them adequate supply of all basic infrastructure facilities or needs. So following objectives are defined from the literature review.

III. OBJECTIVE

The objectives of this paper is as follows:

A. To study the extent of urban sprawl in terms of population growth and built-up area for Kolhapur city during 1975-2019.
B. Prediction of sprawl growth in terms of population growth and built-up area up to 2030.

IV. STUDY AREA

Kolhapur is a very ancient city. Kolhapur is one of the most important cities of Maharashtra. Last three to four decades, Kolhapur city has observed rapid growth. The environment of the city is disturbed from the last one to two decades.

A. *Geographical Details*

Kolhapur City is located in the south-west part of Maharashtra. The Geographical Coordinates are 16.42 north latitude and 74.14 east longitude. On the western part of the city lies the range of Sahyadri Hills; the Warana river flows along the northern boundary. Kolhapur city abutted by Belgaum District on the southern side.

B. *Rainfall*

The city receives abundant rainfall from June to September due to its proximity to the Western Ghats. The heavy rains often lead to severe flooding in these months due to overflowing dams like Radhanagari. Kolhapur experiences winter from November to February.

C. *Temperature*

Kolhapur's climate is a blend of the coastal and inland climate of Maharashtra. Summer in Kolhapur is comparatively cool but more humid comparatively to its neighboring inland cities. Average temperature of the city is 27.9°C., the Max Temp is 38°C and the Min Temp is 12°C.

D. *Geographic Area*

The geographical area of Kolhapur city is 69.30 sq.km.

E. *Population*

The Population Data according to Kolhapur Municipal Corporation is as follows:

Table 1. Year wise population

YEARS	POPULATION
1911	42,018
1921	52,299
1931	66,728

1941	93,032
1951	1,36,835
1961	1,87,442
1971	2,59,050
1981	3,40,625
1991	4,06,370
2001	4,93,167
2011	5,49,236

If the population growth rate would be the same as in the period 2001-2011 (+1.06%) as per calculation, the population of Kolhapur city in 2019 is 6, 07,123. From the past 40 years the population growth has more than doubled.
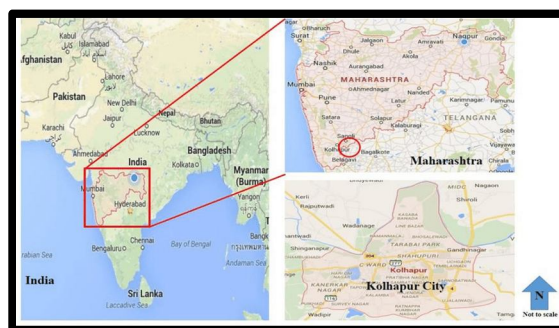
F. Location of Study Area

Fig. 1 Location of Kolhapur City

The above image 1 shows the location of Kolhapur city in India. This is a simple image downloaded from Google.

Following are the problems faced by Kolhapur city
There are many problems which the people of Kolhapur city are facing, some are listed below;
a) *High Density of Population:* High density of population is concentrated in the some wards of the city. Ward C is a densely populated area, whereas per 2001 census, the density was 18,146 persons per sq. km.
b) *Industrial units in Core City:* Several small industrial units exist in the core area of the city. Therefore, it creates pollution of water, noise and air.
c) *Heavy Traffic:* The city has some bottle-necks like Gokul Hotel to Vinus Corner, Bagal Chowk to B T College, Gavat Mandai, Commerce College to Bindu Chowk, etc. which obstruct the free flow of the traffic. Due to heavy traffic, noise and air pollution become a serious problem of the city.
d) *Slum Area:* We know the slum area is a highly populated urban residential area having closely packed housing units with incomplete infrastructure. Slum areas face severe problems like clean water, improper roads, improper sewage connections etc.
e) *Lack of Parking Facilities:* One of the major problems in the city, which results in road side parking and therefore traffic congestion occurs.
f) *Water Pollution:* Panchaganga water pollution is one of the major issues in Kolhapur city. But now pollution is under control due to the efforts taken by KMC.
g) *Limited City Area:* The area under corporation is limited and from the past two decades the area has not increased, but from the past two decades' population has increased in lakhs.

Above problems have severe impact on city's growth like less area and more people i.e. density of people increases in such case there is less area available for infrastructure facilities like no space for water storage tank, less parking facility, problems created due to improperly treated waste from industry, unhygienic conditions due to slum. When Municipal corporations provide facilities to overcome these problems then people construct new houses or offices near these facilities. For ex. Sprawl Development done along the major transportation routes, primarily roads called as Ribbon or Strip development and this is nothing but an unplanned growth or development and from all this urban sprawl occurs. And this urban sprawl which is unplanned growth is very dangerous for future city growth.

V.   GEOINFORMATICS

The Geoinformatics use some basic technology in which there is collection of Geological information by using satellite images and processing on the images is done for various applications. GIS and Remote sensing can help a lot in monitoring urban sprawl compared to conventional techniques. The technology used in Geoinformatics are as follows:

A.   Remote Sensing

Remote sensing refers to extracting information about an incident, thing or surface while satellites and spacecraft are used for collecting information about the earth's surface.

B.   Geographical Information System (GIS)

Geographical Information System (GIS) is a computer based information system used to spatially signify and analyze the geographic features present on the Earth's surface and the events (non-spatial attributes linked to the geography under study) taking place on it. The meaning to represent digitally is to transfer analog (smooth line) into a digital form.

VI.   METHODOLOGY

The related data for the database has been collected from primary and secondary sources. The information collected discussion & observations are as a primary source. Whereas, secondary data sources are published and unpublished material like satellite maps, Corporation map, census data, etc.

A.   Software Used

To achieve the above objectives various software's are used. After getting all information specific software is used to study Kolhapur area [Google earth], for image processing [GIS], for calculation & future prediction Statistical Package for the Social Science [SPSS]. Following Software uses are explained in detail:.

B.   Google Earth Pro

Google earth is one of the famous applications from which we can get detailed imagery of Google earth, along with the use of advanced tools we can measure 3D buildings, print high resolution images for the presentations or reports. Google earth pro is a geospatial software application that displays a virtual globe, which offers the ability to analyze and capture geographical data.

With the help of this software following work is done
1) Capture the image of Kolhapur City.
2) Study captured images like Water bodies, Major roads and nearby important areas, etc.
3) Study about the location of Kolhapur City.

C.   ArcMap/ArcGIS [Geographic Information System]

Geographical Information System (GIS) is a computer based information system used to spatially signify and analyze the geographic features present on the Earth's surface.

ArcGIS is a geographic information system [GIS] for working with maps and geographic information. Arc GIS is used for creating and using maps, compiling geographic information, sharing and discovering geographic information, analyzing mapped information and many more. The images downloaded from the website of United States Geological Survey [USGS] are then further processed in ArcGIS software. ArcGIS 10.5 version is used to achieve objective number one i.e. To study the extent of urban sprawl for Kolhapur City during 1975-2019.

D. Statistical Package for the Social Science [SPSS]

SPSS Statistics is a software package used for interactive or batch, statistical analysis. SPSS is a widely used program for Statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others.

Prediction for numeral outcomes: Linear Regression, in statistics, linear regression is a linear approach to modelling the relationship between a scalar response (dependent variable) and one or more explanatory (independent variables). The case of one explanatory variable is called simple linear regression and for more than one explanatory variable, the process is called multiple linear regression. Linear regression was the first type of regression analysis to be studied rigorously, and to be used extensively in practical applications.

E. Steps To Achieve Objectives Are As Follows

1) For Objective 1: To study the extent of urban growth in terms of population growth and built-up area for Kolhapur city during 1975-2019.

ArcGIS Software is used to achieve objective number one. ArcGIS version 10.5 is used for this.

Four satellite images of the year 1975, 1996, 2009, and 2019are downloaded from the United States of Geological Survey [USGS] website. Processing on these images are done in ArcGIS software. For this ArcGIS 10.5 version is used.

Table 2. Information about downloaded images.

YEAR	SATELLITE
1975	LANDSAT 1-3 MSS
1996	LANDSAT 4-5 MSS
2009	LANDSAT 4-5 MSS
2019	LANDSAT 8 OLI

Table 2 shows the complete file name of the downloaded images from USGS website with the name of the satellite from which the photo was captured.

The steps involved in ArcGIS software is as follows:

a) Open the downloaded image from the United State of Geological Survey [USGS] website.
b) Subset/ Extract the desired location.
c) Draw Polygon.
d) Create a signature file.
e) Performed maximum likelihood classification (supervised classification).
f) Area Calculation.
g) Map presentation.

2) For Objective 2: Prediction of Urban Sprawl growth in terms of population growth and built-up area for 2030.

SPSS software is used to achieve objective number two i.e. Prediction of urban sprawl growth for the year 2030. Urban Sprawl growth (BUA) is calculated by using SPSS software. The version used is SPSS 16.0. Here the dependent variable is Area and the independent variable is Population.

Steps involved in SPSS software is as follows:

a) Create two tables named Population & Area in the Variable View window of SPSS.
b) Put values under the respected tables in the Data View window of SPSS.
c) Perform Linear Regression.
d) Get Linear Regression Equation.
e) After solving the equation we get the prediction Value.

VII. RESULT

A. To study the extent of urban growth for Kolhapur city during 1975-2019: ArcGIS Result.

As we know ArcGIS Software is used to achieve the above objective so to achieve this we have already downloaded images from the USGS website and after performing all the steps we get the following results. Four clear images having years 1975, 1996, 2009 and 2019 are selected and perform steps in ArcGIS. We get the following results.

Result table contains Count [As the image contains a number of pixels therefore it counts the total number of pixels in respective feature], Area [area in hectares], Feature [Built-Up, Barren land and Vegetation] and Color [Blue, Red, Yellow and Green] etc.

1) For The Year 1975

Table 3. Feature wise area for the year 1975

SR. NO.	COUNT	AREA (Ha)	FEATURE	COLOUR
1	206	741.00	Water	Blue
2	2438	877.60	Built Up	Red
3	10771	3877.50	Barren land	Yellow
4	5835	2100.60	Vegetation	Green

Table 3 shows the results from the GIS software. It shows the total Count, Area (Ha), Feature and Color Code for the year 1975. The built-up area i.e., urban Sprawl in Kolhapur city in the year 1975 was 844.60 Ha.
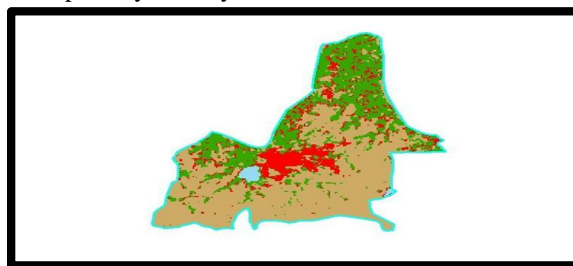

Fig. 2 Study area for the year 1975.

From above image 2 we can see the Built-up area of Kolhapur city in the year 1975. As the Built-up area is an indicator of urban sprawl. The Red color shows the Built-up area i.e., urban sprawl. And other colors like Blue shows Water, Yellow shows Barren land and Green shows the Vegetation area.

2) For The Year 1996

Table 4. Feature wise area for the year 1996.

SR NO.	YEAR	COUNT	AREA (Ha)	FEATURE	COLOUR
1	1975	1015	913.50	Water	Blue
2	1996	31732	2855.8	Built Up	Red
3	2009	24181	2176.2	Barren land	Yellow
4	2019	20077	1806.9	Vegetation	Green

Table 4 shows the results from the GIS software. It shows the total Count, Area (Ha), Feature and Color Code for the year 1975. The built-up area i.e., urban Sprawl in Kolhapur city in the year 1996 was 2855.80 Ha.
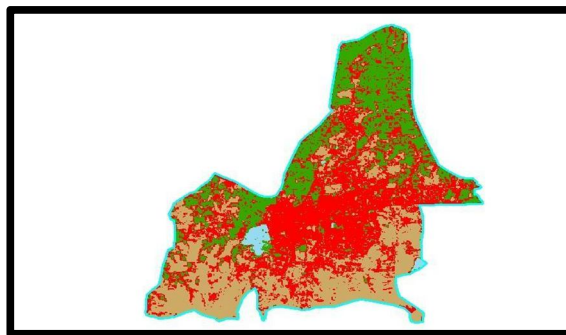
Fig. 3 Study area for the year 1996.

From image 3 we can see the Built-up area of Kolhapur city in the year 1996. As the Built-up area is an indicator of urban sprawl. The Red color shows the Built-up area i.e., urban sprawl. And other colors like Blue shows Water, Yellow shows Barren land and Green shows the Vegetation area.

3) For The Year 2009

Table 5. Feature wise areas for the year 2009.

SR NO.	YEAR	COUNT	AREA (Ha)	FEATURE	COLOUR
1	1975	1078	970.00	Water	Blue
2	1996	37218	3349.6	Built Up	Red
3	2009	13578	1222.0	Barren land	Yellow
4	2019	25131	2261.7	Vegetation	Green

Table 5 shows the results from the GIS software. It shows the total Count, Area (Ha), Feature and Color Code for the year 1975. The built-up area i.e., urban Sprawl in Kolhapur city in the year 2009 was 3349.60 Ha.
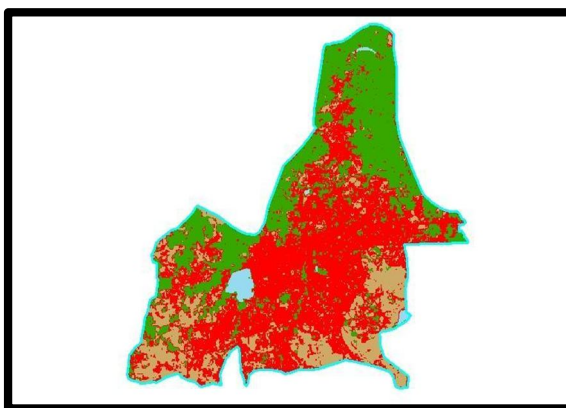

Fig. 4 Study area for the year 2009.

From image 4 we can see the Built-up area of Kolhapur city in the year 2009. As the Built-up area is an indicator of urban sprawl. The Red color shows the Built-up area i.e., urban sprawl. And other colors like Blue shows Water, Yellow shows Barren land and Green shows the Vegetation area.

4) For The Year 2019

Table 6. Feature wise areas for the year 2019.

SR NO.	YEAR	COUNT	AREA (Ha)	FEATURE	COLOUR
1	1975	943	848.00	Water	Blue
2	1996	41387	3724.8	Built Up	Red
3	2009	17641	1587.6	Barren land	Yellow
4	2019	17034	1533.0	Vegetation	Green

Table 6 shows the results from the GIS software. It shows the total Count, Area (Ha), Feature and Color Code for the year 2019. The built-up area i.e., urban Sprawl in Kolhapur city in the year 2019 was 3724.80 Ha.
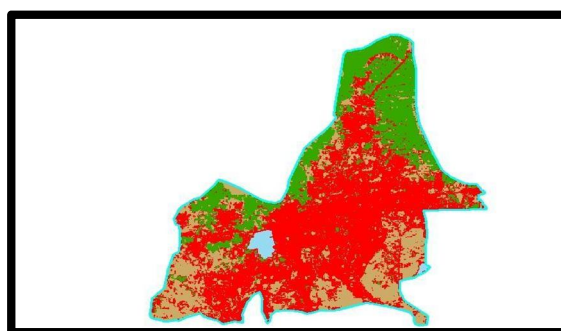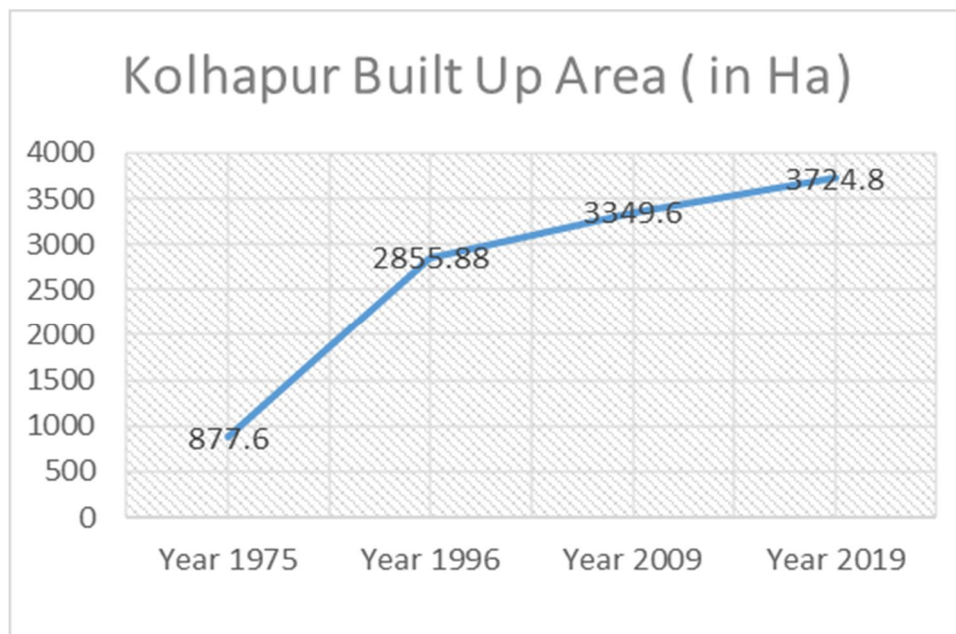

Fig. 5 Study area for the year 2019.

From image 5 we can see the Built-up area of Kolhapur city in the year 2019. As the Built-up area is an indicator of urban sprawl. The Red color shows the Built-up area i.e., urban sprawl. And other colors like Blue shows Water, Yellow shows Barren land and Green shows the Vegetation area. The classification of satellite images into built up areas (BUA) during 1975-2019 temporal span have produced abstracted and cut down visual images in the study area(Figure5.1) which defines the urban extents of specified times.

Table7. Result of change in Built-up Area.

SR. NO	NAME OF AREA	YEAR	AREA (Ha)
1	KOLHAPUR CITY	1975	877.60
		1996	2855.88
		2009	3349.60
		2019	3724.80

Table 7 shows the changes in the Built up Area for the year 1975, 1994, 2009 and 2019 respectively. From this table it is clear that the Built-up area increases as year increases. Built –up area is nothing but the Urban sprawl spread throughout the Kolhapur and it is measured in Ha.

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Graph 1. Increasing built up areas over the years.

From above graph 1, in 1975 built-up i.e., urban sprawl spread in around 877.60 Ha area and in year 2019 built-up area was 3724.80 Ha.

From this graph it is clear that urban sprawl is increasing as time passes and from this it is clear that in future population as well as built-up area will increase in Kolhapur city and in city very less agricultural and barren land is remaining right now so it's very important to increase the area under Corporation to provide all infrastructure facilities like water, roads, sewage and transport facility to these all people efficiently.

B. Prediction of Sprawl Growth up to 2030: SPSS Software Result.
SPSS Software gives results in the form of two tables i.e. ANOVA table and Coefficient table and lastly Regression Equation.
1) *The ANOVA Table:* The ANOVA table, which shows how well the regression equation fits the data (i.e., Predicts the dependent variable) and which is given below:

Table 8. ANOVA table from SPSS Software.

Model	Sum of Squares	df	Mean Square	F	Sig
Regression	4702861.570	1	4702861.570	81.961	0.012
Residual	114758.441	2	57379.220		
Total	4817620.011	3			

a) Predictors: (Constant), Population
b) Dependent Variable: Area

Table 8 indicates that the regression model predicts the dependent variable significantly well. We will know this by looking at the "Regression" row and going to the "Sig." column. This indicates the significance of the regression model that was run. Here, $p < 0.012$, which is less than 0.05, and indicates that, overall, the regression model statistically predicts the outcome variable (i.e., it is a good fit for the data).

2) The Coefficient Table: The coefficient table gives us the required information to predict Area from Population, as well as determine whether income contributes statistically significantly to the model (by looking at the "Sig." column).

Table 9. Coefficients table from SPSS Software.

Model	Unstandardized Coeff.		Standardized Coeff.	t	Sig
	B	Std. Error	Beta		
(Constant)	-625.730	386.591		-1.619	0.247
Population	0.007	0.001	0.988	9.053	0.012

Table 9 shows the Coefficients table obtained from the SPSS software. Here, the value of Sig. in the first row is 0.247 which is greater than 0.05 that means our hypothesis is accepted. And from this we have to generate a regression equation.

3) Regression Equation: Regression analysis is an arithmetical tool for the study of interaction between variables. It is used when we want to predict the value of a variable based on the value of another variable. The variable we want to predict is called the dependent variable (or sometimes, the outcome variable). The variable we are using to predict the other variable's value is called Independent variable (the predictable variable).

From ANOVA and Coefficients tables we get following equation,

Built-up area $= (0.007 \times 686718) - 625.73$

$= 4181.30$ Ha.

From this, In Year 2030 the Built up Area will be 4181.30 Ha.

Table 10. Predicted Sprawl Growth for Kolhapur City.

YEAR	POPULATION	AREA(Ha)
1975	2,91,778	877.60
1996	4,32,409	2855.88
2009	5,38,022	3349.60
2019	6,07,123	3724.80
2030	6,86,718	4181.30

Table 10 shows the future prediction growth for the Kolhapur city. The value in the last column and last row comes from the regression equation. In 2030 the built-up area will be 4181.30 Ha.

From results it is clear that in future most of the development will occur towards the North-East direction as more Agricultural land is available, so it will convert into Non-Agricultural land for development as Shirol MIDC and Panchganga river is also near and similarly, development will also occur towards the South-East & South-West as barren land is available which situated near the core of the city and also connecting nearby number of villages with roads. As per this table, the rate of growth of the Built-up area will be 1.58 % per year up to the year 2030. And the Population growth rate 1.09 % per year will be up to the year 2030.

VIII. CONCLUSION

As GIS and Remote sensing are used to study and analyze the urban sprawl for Kolhapur city. Satellite data are found useful in mapping and quantifying the extent of urban areas in different time periods. Results obtained from GIS software, in year 1975 Built-up area i.e., urban sprawl was 877.60 Ha, In this year 1996 built-up area was 2855.88 Ha, in year 209 built-up area was 3349.60 Ha, and now in year 2019 it is 3724.80 Ha. Between 1996 & year 2009 the population increased by 17.29 % and between year 2009 & year 2019 population increased by 11.20 %. So between 1996 & 2009 this was the period in which more population was increased. This increased population are those people who came from nearby districts or villages in search of education and then jobs.

In future the rate of growth of the Built-up area will be 1.58 % per year up to the year 2030. The Population growth rate 1.09 % per year will be up to the year 2030 and max of this growth will occur in North-East, South-East and South-West directions. This data will help KMC for providing local infrastructure facilities to the people in future. In future therefore KMC should concentrate on these [NE, SE & SW] directions to provide adequate local infrastructure facilities like Water, Roads, Municipal Transport and about Sewage Treatment.

Hence from these results it is clear that Urban sprawl is spreading at high speed. With the development and infrastructure initiatives mostly around the urban centers, the impacts of urban sprawl would be on the natural resources and ecology. And in the coming few years all barren land and agricultural land will turn into Built-up areas i.e., in urban sprawl. The present study demonstrates the usefulness of satellite data for the study of urban sprawl extent for Kolhapur city. The change detection and urban sprawl analysis shows that agricultural lands are rapidly transforming into lands for housing, both for commercial and industrial purposes. This study will help authority for future planning of Local infrastructure facilities.

REFERENCES

[1] L. Feng, "Spatial patterns analysis of sprawl: Case study in china , the journal of urban planning and development, pp. 263-269, 2016.

[2] P. Fenandez and Aracill, "Urban development model and municipal fiscal burden in Spain, the journal of urban planning and development", pp. 1-6, 2018.

[3] S. Klung, "urban sprawl and local infrastructure in japan and Germany", the journal of infrastructure development, pp. 232-241, 2012.

[4] D. lozzie, S. Dupas "Dynamics of urban sprawl, vacant land and green spaces on the metropolitan fringe", the journal of urban planning and development, pp. 274-279, 2013.

[5] L. Shi and S. Yang, "Effects of a compact city on urban resources and environment, the journal of urban planning and development, pp. 1-9, 2019.

[6] Z. Yang and X. Zhu, "optimization of land use in a new urban district, 2015.

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