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## Changing Urban Built-up Area of Sangli-Miraj and Kupwad Municipal Corporation, Maharashtra (India): Using Satellite Data and GIS

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### Abstract

Urbanization has been a universal and important socio-economic phenomenon taking place all around the world. According to United Nations; in 2011, 3.6 billion of the world's population (52%) was urban dwellers. In this paper an attempt is made to focus on changing built-up area of Sangli-Miraj and Kupwad Municipal Corporation. This work is based on both primary and secondary datasets. The SOI toposheet, remote sensing satellite images are used for quantification of built-up area. The methodology adopted for this study is comprehensive. The analysis is carried out by focusing particular aspect. The derived results are interesting and highlight the change in BUA (Built-up Area) of the city.

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**Introduction**

Urbanization has been a universal and important socio-economic phenomenon taking place all around the world. Rapid urbanization and urban growth especially in the developing world is continuing to be one of the issues of global changes in the 21<sup>st</sup> century. It is affecting the physical dimensions and socio-economic characteristics of the cities. The size and spatial configuration of an urban area directly and indirectly impacts on many aspects of city such as pollution, carbon emissions, slums, infrastructure demands, social problems and many more (Abebe, 2003). According to United Nations; in 2011, 3.6 billion of the world's population (52%) was urban dwellers. Universally, the level of urbanization is expected to rise to 67% by year 2050. In case of developing countries the proportion of urban areas will rise from 47% (in 2011) to 64 % by year 2050.

Rapid urban expansion necessitates proper planning to avoid negative environmental and socio-economic impacts. Remote sensing and GIS technology provides effective tools to understand the phenomenon as well as for planning and decision making process. Hence the changing built-up areas and its dynamics become interest of many researchers. In this paper an attempt is made to focus on changing built-up area (BUA) of Sangli-Miraj and Kupwad Municipal Corporation.

**Objectives**

The general objective of this research paper is to study the changing urban built-up area in Sangli-Miraj and Kupwad Municipal Corporation by using satellite data and GIS. The other related objectives are:

1. To construct spatio-temporal urban land use and land cover maps for Sangli-Miraj and Kupwad Municipal Corporation.
2. To quantify the ward wise built-up for 1971, 2006 and comprehend occurred changes within period of 35 years.

**Study Area**

Miraj tahsil contains one and only Municipal Corporation (Sangli-Miraj-Kupwad Municipal Corporation) in Sangli district. Sangli-Miraj and Kupwad Municipal Corporation is situated in the Krishna River basin, at the central part of the Miraj Tahsil. The urban governance is operating through Municipal Corporation. Sangli-Miraj -Kupwad Municipal Corporation has come in to existence on February 1999.

It extends from about 16° 46' 28" to 16° 53' 45" North latitude and 74° 31' 08" to 74° 40' 51" East longitude covering 111.74 sq km area. The climate of this region is dry. The average annual rainfall in the region is 692.4 mm. The mean daily maximum temperature is 37.5°C (99.5°F) and the mean daily minimum 22.7°C (72.9°F), recorded at the meteorological observatory located at Miraj (Sangli District Gazetteer, 2006). River Krishna is one of the three great rivers of Southern India, which passes through Sangli city.

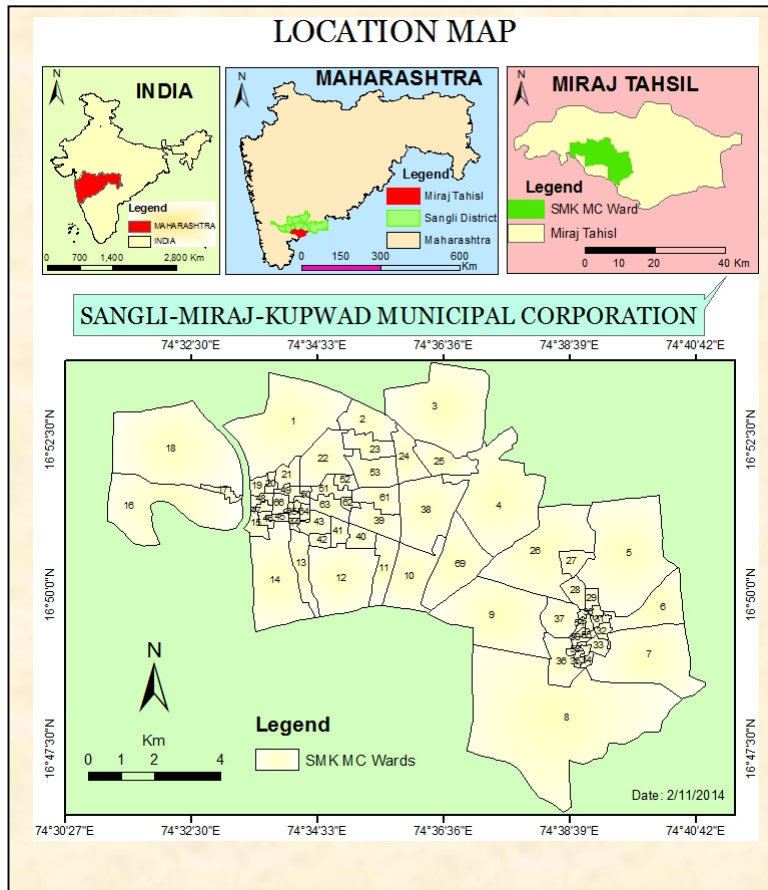


Fig.1 Location Map

Population of the area under the SMKMC has increased from 3,51,917 in 1991 to 5,02,697 in 2011; of which male and female are 255,270(51%) and 247,427(49%) respectively (SMK City Sanitation Plan, 2011). The urban area contains part of Sangli, Miraj, Kupwad, Wanlesswadi and Sangliwadi. SMK Municipal Corporation comprises four Prabhag (*Prabhag* is an urban unit, which is formed by clubbing many wards) of 69 wards. Among all, Prabhag-3 is the largest in size. Sangli city contains 38 wards, in Miraj there are total 24 wards and Kupwad is having seven wards (Fig.2).

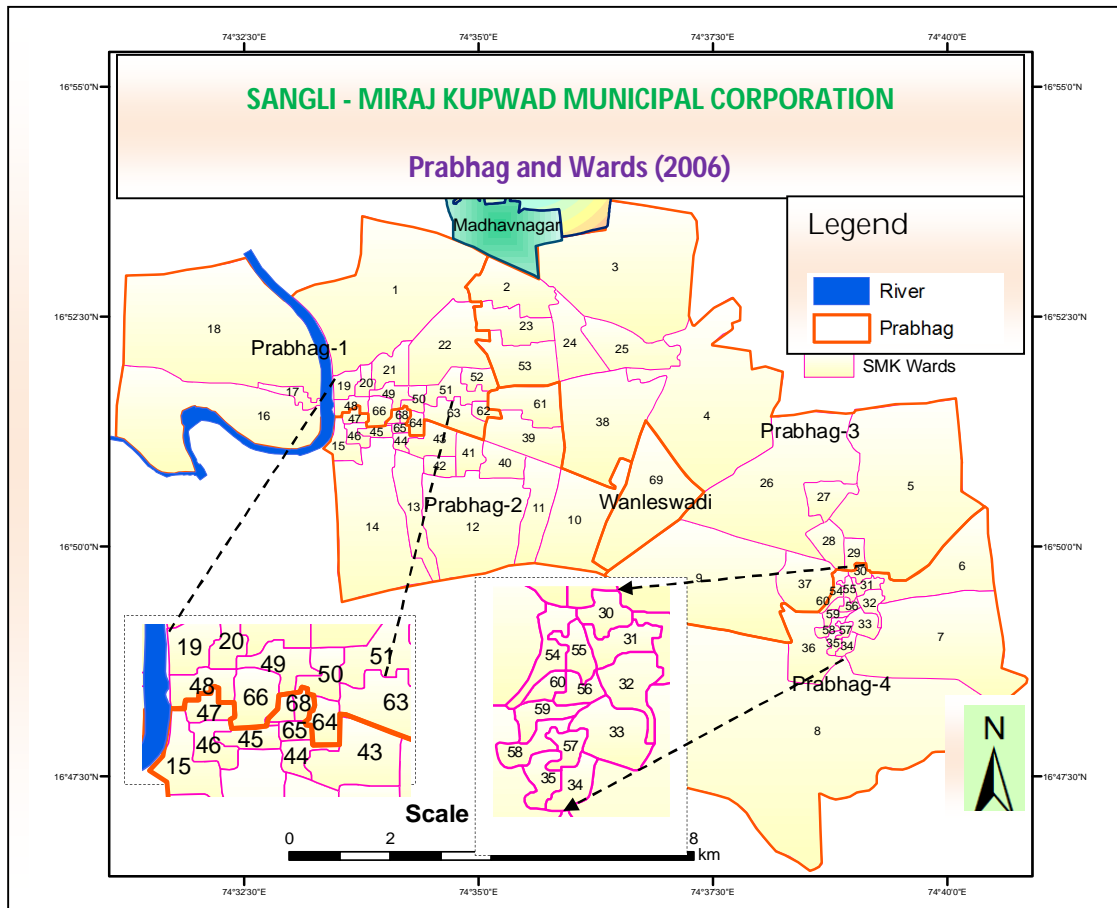


Fig.2 Wards and Prabhag

**Data**

This study of urban built-up change is carried out by using various datasets. The present study is based on both primary and secondary sources of data. The primary data is collected through field survey and secondary data is collected from various available sources. The change occurred in the built-up surface over 35 years time period is focused through this study. The satellite datasets of IRS, Land sat: MSS, TM and ETM+ are used to examine urban growth of Sangli-Miraj and Kupwad area, Maharashtra (India). The Survey of India toposheets of 1:50000 scale, are also utilized in this study for base mapping.

Table-1 Satellite Datasets Used in the Study

	Satellite	Sensor	Date	Path / Row	Source	Spectral Range	Spatial Resolution	Band
<b>Dataset - I</b>	Landsat	MSS	09-Jan-1976	157/048	GLCF	0.5 - 1.1 $\mu\text{m}$	68m X 83m	3
<b>Dataset - II</b>	Landsat	TM	25-Jan-1991	146/048	GLCF	0.45 - 12.5 $\mu\text{m}$	30 m (120 m-thermal)	7
<b>Dataset - III</b>	Landsat	ETM +	25-Nov-2000	146/048	GLCF	0.45 - 12.5 $\mu\text{m}$	30 m (60 m - thermal, 15-m pan)	8
<b>Dataset - IV</b>	Landsat	ETM +	22-Nov-2005	146/048	GLCF	0.45 - 12.5 $\mu\text{m}$	30 m (60 m - thermal, 15-m pan)	8
<b>Dataset - V</b>	IRS-1D	LISS-III	12-Mar-2003	978-985/ 986-993	NRSA	0.5 - 0.70 $\mu\text{m}$	23m	4

Source: Town planning report and SMK Municipal Corporation reports.

**Methodology**

This study is based on image processing and integrated analysis in a geographic information system environment. The base mapping is carried out using toposheet and cadastral maps. In this study a technique is used to extract urban built-upland features from Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) imagery. Image classification is carried out to understand exact change in BUA with quantification. The methodology applied for this study is represented through the flow chart.

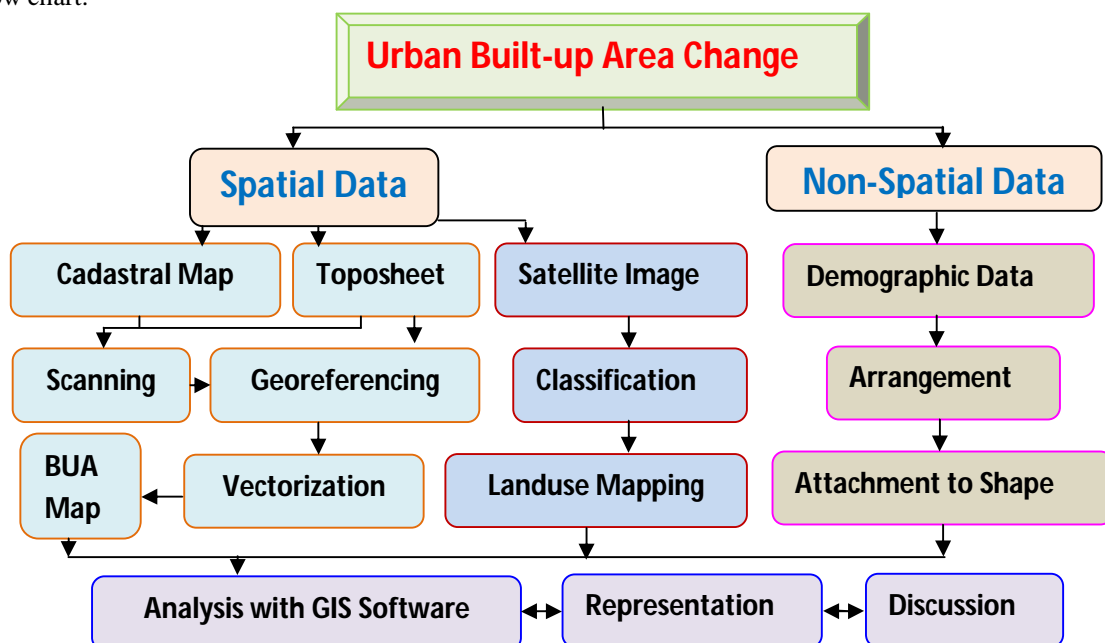


Fig-3 Flow Chart of Methodology

**Literature Review**

In India many geographers have been working on urban studies. Before independence also some scholars have focused on various aspects of city. The urban geographers from Calcutta have worked on urban growth and associated problems of Calcutta conurbation (Gosal 1972). K. Sita (1973) highlights the low level of urbanization in south Konkan, which needs adequate industrial incentives to raise its level of Urbanization. Deshmuk and Kulkarni (1978), Ramotra and Saymote (2010) studied the growth of Sangli-Miraj and Kupwad city. Abebe (2003) quantified urban growth pattern in developing countries using remote sensing and spatial metrics for Kampala (Uganda). The changes in urban built-up surface and population distribution patterns during 1986–1999 are studied in the form of case study (Zhi et.al., 2005). Hanqiu Xu (2007) extracted urban built-up land features from landsat imagery using a thematic oriented index combination technique photogrammetric engineering & remote sensing. Recently, an increasing concerns about sustainable development have fostered a new interest of the international literature on the physical dimension of cities and particularly, on the issues of urban growth pattern and urban form (J. Huang et al., 2009). Jyotishman et. al., (2012) worked on urban growth trend analysis using shannon entropy approach taking North-East India as a case study. Ö. Balkanay (2013) evaluated the build-up areas in the historic urban pattern by using geographic information technologies.

**Analysis and Results**

In this study image processing and GIS analysis is used to assess spatio-temporal change in built-up area of the Sangli-Miraj and Kupwad Municipal Corporation. The change in built-up is examined in association with change occurred in Landuse / Landcover and its association with demographic data.

**Landuse / Landcover Change**

The changes in built-up area are examined with the help of satellite image datasets. During the study it is noticed that within the period of 35 years urban land built-up surface has increased significantly. The image classification technique is applied to classify the LANDSAT and IRS data and derived results are presented in Fig.4.

The red colour patches represents built-up area which seems increasing continuously. The changes occurred in patches i.e. along Islampur road, towards Madhavnagar, in Kupwad particularly in the marginal areas of Sangli and Miraj, around Kupwad MIDC, etc. It seems that people have chosen the localities which are well accessible to all urban centers and also containing good infrastructural facilities. The expansion of built-up is happening in various patches in terms of sprawls.

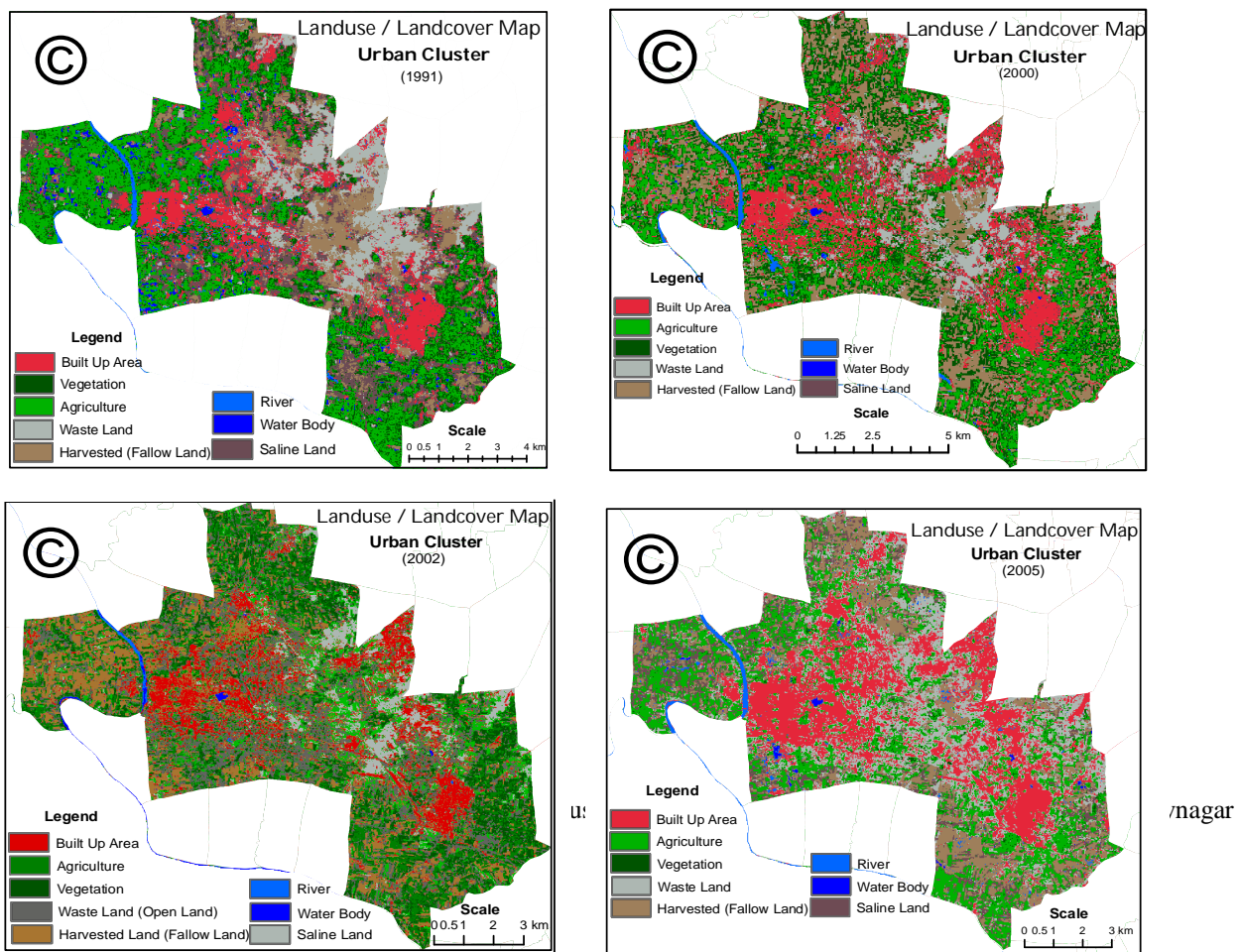


Fig.4 Changes in built-up area

(SMM) and Sangli-Miraj-Kupwad (SMK) given in Table5.4 which is quite interesting. In case of area; SMM occupied 4277.67 ha area which becomes 11174 ha for SMK urban cluster i.e. about 6900 ha additional land came under urban use. The agriculture land of SMM was 2749 ha (64.27% to total area) in 1971, which is increased by 2680 ha and becomes 5429 ha for SMK in 2006 but its percentage gets down to 48.59% to total area. The Residential area was 9.74% with SMM which is increased by 1394 ha and becomes 16.21% for SMK. Same time the proportion of vacant land in increased by 1563 ha; earlier it was 5.84% which becomes 16.23%. There are some categories which are having moderate change i.e. Transport and Communication (648.27 ha), Public and Semi-public areas (285 ha), Industrial sector (138.81 ha). Whereas there are some classes, which does not contains much change i.e. Water Bodies and Cemeteries & Public Utilities. In case of water body it was having 1.12% share which becomes 1.32% and the actual change is 99.82 ha. The Cemeteries & Public Utilities is increased by 52 ha i.e. earlier it was 0.15% which becomes 0.53%. The Trade and Commerce is increased by 22 ha but its share is decreased i.e. earlier it was 1.66% which becomes 0.84%. Same thing is happened with Open Space, Parks & Grounds category; though it is raised by only 9 ha area, its share is decreased from 0.51% to 0.28%. In this segment, the change which is measured in terms of area is not representing the clear-cut change because there is change in base area as well (Madhavnagar is comparatively smaller than Kupwad).

**Ward wise Changes in Built-up Area**

Wilson et. al (2003) cited at Abebe, ( 2003) identifies three major types of urban growth as : infill, expansion and outlying. Infill development is a new development within remaining open spaces in already existing built up areas whereas expansion or sometimes called urban extension or edge expansion is a non-infill development extending the urban footprint in an outward direction some time called urban fringe development.

The structure of city pattern is changed in few decades. During 1970s the urban area (City Pattern) was Sangli-Miraj-Madhavnagar (SMM) which is changed as Sangli-Miraj-Kupwad (SMK). Madhavnagar is situated in the urban fringe area and adjacent industrial sector help in its development.

**Table 5.4 Landuse Statistics and Trend of Change**

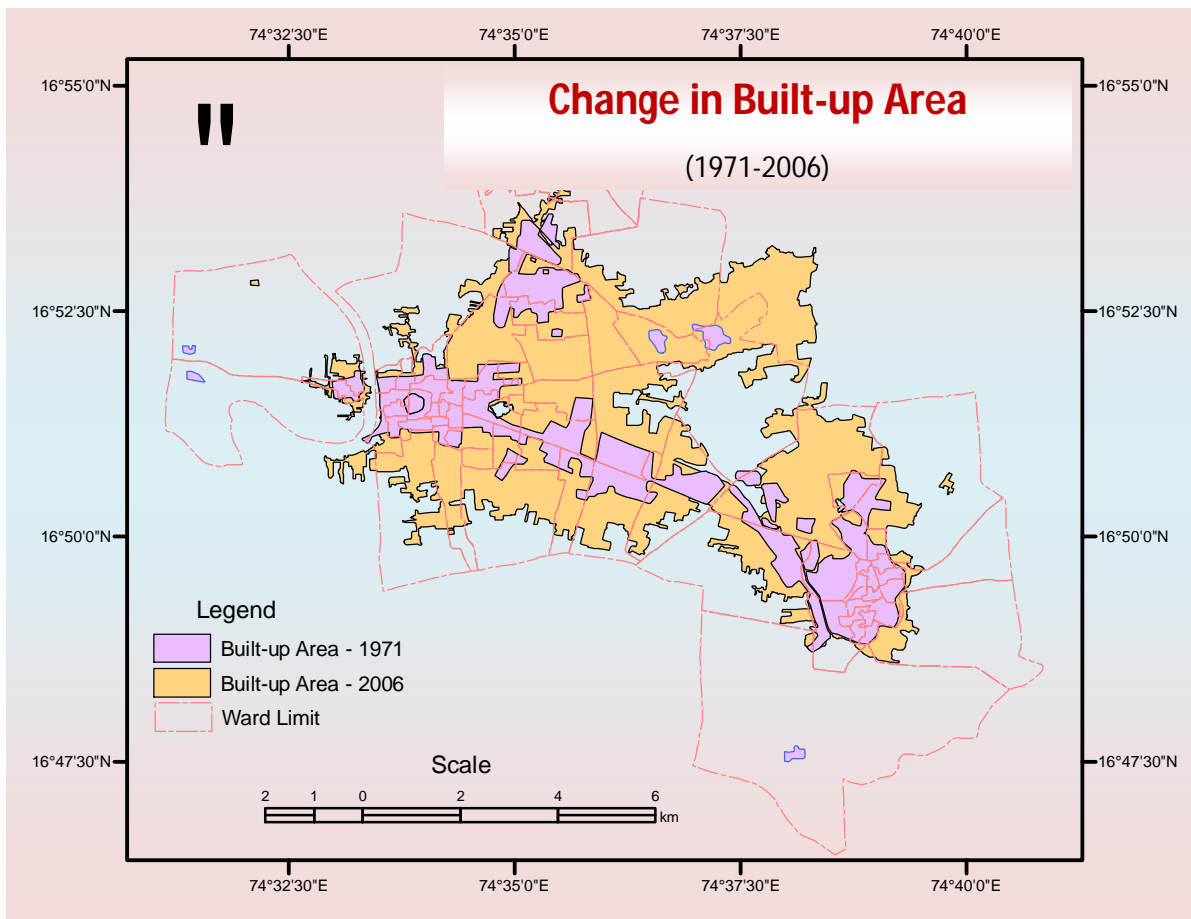
Sr. No.	Land use Categories	Sangli-Miraj-Madhavnagar (1971)		Sangli-Miraj-Kupwad (2006)		Trend of Change (+ / -)	
		Area in Hectare	% to Total Area	Area in ha	% to Total Area	Change in area ha	Change in %
1	Residential	416.6	9.74	1810.98	16.21	1394.38	334.70
2	Trade & Commerce	70.94	1.66	93.57	0.84	22.63	31.90
3	Industrial Area	142.04	3.32	280.85	2.51	138.81	97.73
4	Public & Semi Public	178.97	4.18	464.76	4.16	285.79	159.69
5	Transport & Communication	393.62	9.2	1041.89	9.32	648.27	164.69
6	Open Space, Parks & Grounds	22	0.51	31.74	0.28	9.74	44.27
7	Cemetery, Public Utilities	6.45	0.15	59.27	0.53	52.82	818.91
8	Agriculture	2749.33	64.27	5429.78	48.59	2680.45	97.49
9	Water Bodies	48.05	1.12	147.87	1.32	99.82	207.74
10	Vacant Land (Developing)	249.67	5.84	1813.29	16.23	1563.62	626.27
	<b>Total Area</b>	<b>4277.67</b>	<b>100</b>	<b>11174</b>	<b>100</b>	<b>6896.33</b>	

**Source:** Town planning report and SMK Municipal Corporation reports.

Due to close proximity many warehouses, small scale industries are gathered in Madhavnagar. Therefore, during 1970s development plan Madhavnagar was considered as third city center of Sangli-Miraj urban agglomeration. Later on due to various reasons the scenario is changed and Madhavnagar is not developed as per the made predictions. The development of Madhavnagar was lagged behind and Kupwad is emerged very fast and present city pattern Sangli-Miraj-Kupwad is developed. Considering the expansion and growth of these three sub centers Maharashtra Government declared this area as Municipal Corporation.

The purple colour patches in Fig.5 are the built-up of 1971. The brown patches are representing the built-up area of 2006 which is ultimately the location of change. There are total 14 wards which have expanded more than 100ha, particularly Miraj (3 wards), Sangli (4 wards) and Kupwad (7wards). The maximum built-up is taken place in Kupwad i.e. all seven wards have recorded more than 100 ha expansion.





**Table-2 Ward-wise changes in Urban BUA (2006)**

Class (Change in ha)	Ward Numbers	Total Wards
No Change	45,47,49,54,55,56,57,58,59,60, 64,65,66,67,68	15
0.01 to 10	16,17,19,20,21,29,30,31,32,33,34,35,36,44,46,48,50	17
11 to 50	2,6,8,15,18,27,28,37,40,41,42,43,51,52,62,63	16
51 to 100	1,7,11,13,23,39,61	7
101 to 150	9,10,14,24,25,53,69	7
Above 151	3,4,5,12,22,26,38	7
	<b>Total</b>	<b>69</b>

Source: Calculated on the basis of vector analysis

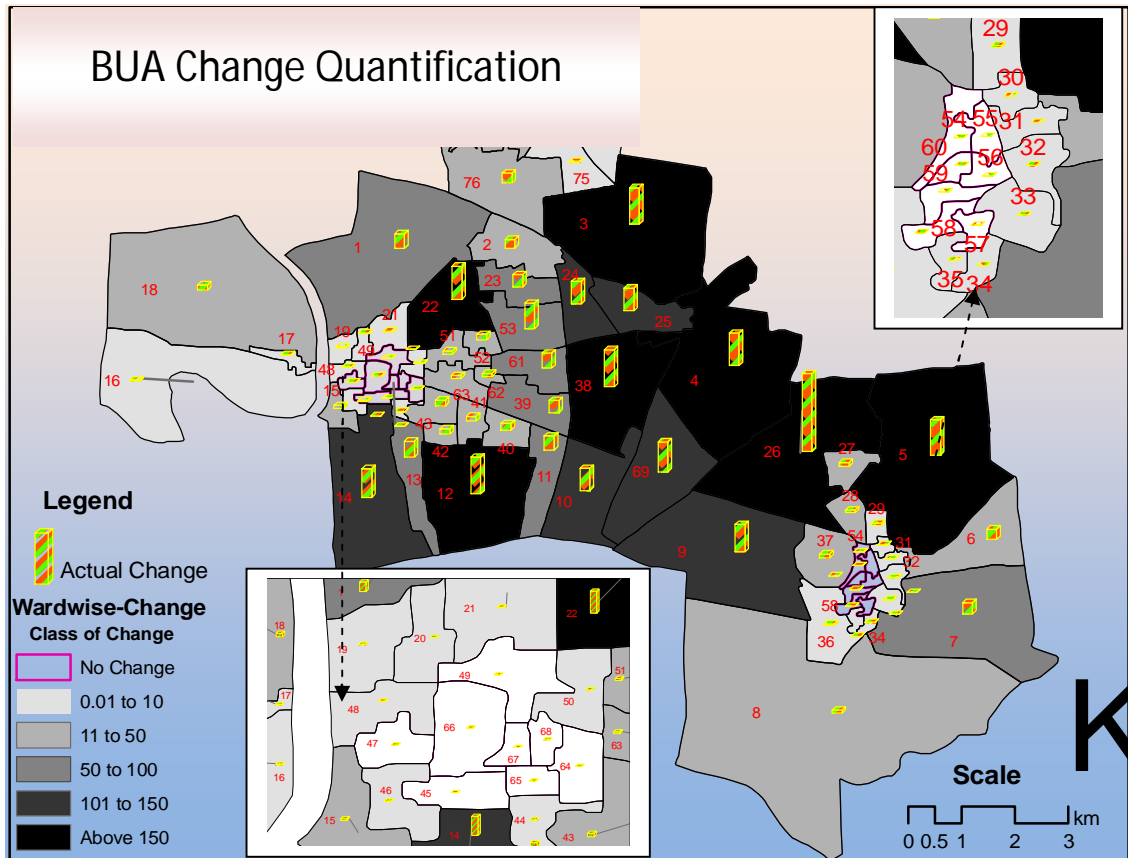


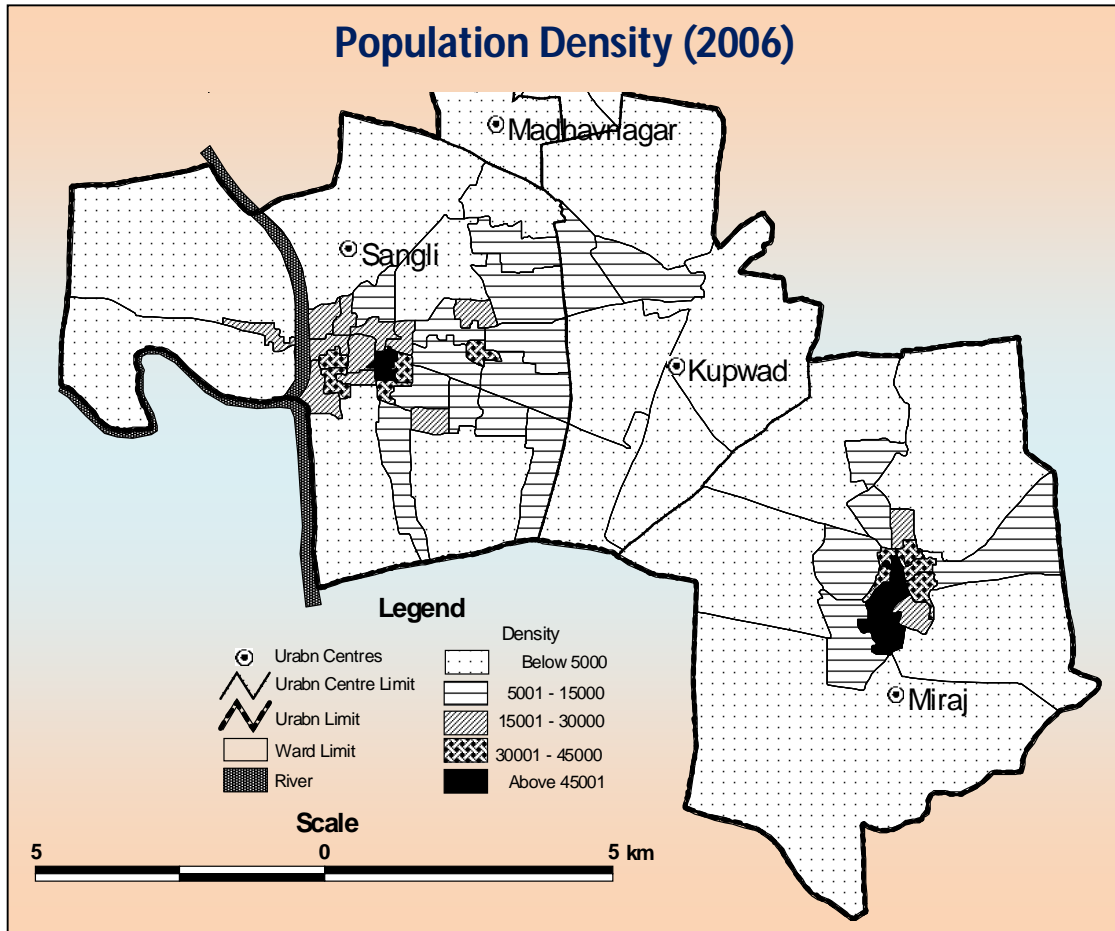
Fig.6 Ward wise change in Built-up area (1971-2006)

The actual changes in built-up area especially ward wise change is studied here. The built-up of 1971 and 2006 is overlaid on each other to understand the area of change. The core wards of Sangli and Miraj (ward no 54 to 60, 45, 47, 49 and 64 to 68) are already covered its entire area hence there are no changes in it.

**Built-up Area and Population**

The changes in built-up surface were analyzed against census data of 1971 and 2006, it was found that population per unit area of built-up surface may serve as a good indicator of urbanization. This metric offers a different measure from the traditional calculation of population density and provides a measure of urban living environment by reflecting the dynamics of both population and urban land use growth.

Sangli-Miraj-Kupwad has an average literacy rate of 77%, higher than the national average of 59.5%. In case of male literacy it is 81%, and female literacy is 69% Census of India, (2011). The population density of urban centres is mapped using 2001 census data (Fig.7). Only some wards in the core of Sangli and Miraj city are having high density.



**Fig.7 Population Density**

In Sangli there are three wards coming under very high range i.e. above 45001 where as in Miraj there are eight wards in same category. Ward number 65, 67 and 68 of Sangli are of very high density areas whereas in Miraj ward no. 34, 35, 55, 56, 57, 58, 59 and 60 are of same class. Among these wards except ward number 58 in Miraj which is having two functions i.e. residential and commercial rest all wards are having only single function i.e. residential. The functional classification and population density of wards are correlates each other. All outer marginal wards of urban centres are of very low density areas i.e. below 5000 population.

**Conclusion**

Urbanization is one of the most important human activities, which creates enormous impact on the environment at local, regional, and global scale. The changing built-up area is one of the indicators of urbanization. Rapid urban growth especially in the developing world is continuing to be one of the issues of global changes in the 21<sup>st</sup> century. It is affecting the physical dimensions and socio-economic characteristics of the cities.

The Land use classification shows that the changes occurred in patches i.e. along Islampur road, towards Madhavnagar, in the marginal areas of Sangli and Miraj, around Kupwad MIDC, etc. Its major reason is people have chosen the localities which are well accessible to all urban centres and also containing good infrastructural facilities. The Residential area was 9.74% with SMM which is increased by 1394 ha and becomes 16.21% for SMK. Also the proportion of vacant land in increased by 1563 ha; earlier it was 5.84% which becomes 16.23%. The satellite image represents day by day increasing built-up areas in the city.

In case of actual quantification of wards it shows that in core city areas due to limited space there is no increase in the BUA, but in peripheral wards the change is noticed more than 150 ha. The ward no 3, 4 5,12,22,26 and 38 have noticed more than 151 ha change in BUA same time in ward no 9,10,14,24,25,53 and 69 the change in noticed upto 100 to 150 ha. It means in 20% of the wards have noticed more than 100 ha change in BUA.

There is positive relation between population rise and increasing in BUA. The wards in the core of Sangli and Miraj city are having high density and it decreases to outward side. All outer marginal wards of urban centers are of very low density areas i.e. below 5000 population. Sangli there are three wards coming under very high range i.e. above 45001 where as in Miraj there are eight wards in same category. The proportion of developing land is increasing day by day and peoples are shifting in peripheral areas of Sangli and Miraj and Kupwad.

The entire study indicating that changing urban built-up and growth in terms of construction has brought changes in land use pattern of SMKMC. However, such changes were not evenly distributed. While most rise in built-up surface were found in the outer margin of the city. The population per unit and built-up area is increased most significantly in the peripheral areas of the city.

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