

From Green to Grey: Population Pressure and Land Use Dynamics in South Dumdum Municipality, West Bengal

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Abstract

Urban growth driven by population increase has led to substantial land use and land cover (LULC) transformation across Indian municipalities. This paper investigates the relationship between population growth and LULC changes in South Dumdum Municipality, West Bengal, using demographic data from the Census of India (1991–2011) and classified satellite imagery. The study reveals significant expansion of built-up areas at the expense of vegetation and water bodies. A regression analysis establishes a strong correlation between population density and built-up coverage, particularly in the 1991 and 2001 periods. The findings advocate for immediate ecological planning and sustainable urban development.

Keywords: Population Growth, Land Use Change, Urbanization, Remote Sensing, GIS, South Dumdum Municipality

1. Introduction

In recent decades, urbanization in India has accelerated, especially in metropolitan suburbs. One such area is South Dumdum Municipality in North 24 Parganas district, which has experienced intense demographic and spatial transformation. With expanding urban infrastructure and amenities, migration and natural population growth have led to high population density. The consequential LULC changes raise environmental concerns, such as loss of vegetation, declining water bodies, and groundwater depletion. Understanding these shifts is crucial for planning sustainable urban growth.

2. Study Area

South Dumdum Municipality lies between 22.34°N to 22.37°N latitude and 88.22°E to 88.25°E longitude, covering approximately 17.96 km². It includes zones such as Lake Town, Bangur, and Dumdum Park and shares borders with North Dumdum Municipality, Salt Lake, and Kolkata Municipal Corporation. The area features a tropical monsoon climate with an average annual rainfall of 120 mm. As per the 2011 Census, the population stood at 403,334. The region is well-connected via railways, metro, and arterial roads.

3. Objectives

- To assess population growth from 1991 to 2011.
- To examine demographic and socio-economic characteristics during this period.
- To classify and quantify LULC changes from satellite images using GIS tools.

- To evaluate the relationship between population density and built-up area expansion.

4. Data and Methodology

The study utilized secondary data, including:

- Census data (1991, 2001, 2011)
- Satellite images (GLCF, USGS/EROS) for the years 1991, 2001, 2011
- QGIS and MapInfo software for supervised classification and regression analysis

Population and LULC maps were generated using satellite images, while demographic changes were analyzed using cartographic tools (graphs, charts, choropleths). Regression and residual analyses were conducted to measure the association between population density and built-up areas.

5. Results and Discussion

5.1 Demographic Trends (1991–2011)

Between 1991 and 2011, South Dumdum Municipality witnessed steady demographic growth, with the population increasing from 378,322 to 403,334. The population density surged dramatically—from 200,790/km² to over 1,000,000/km², reflecting intense urban pressure. The sex ratio showed notable improvement, rising from 945.96 to 994.49, surpassing both state and district averages. General caste remained the majority, while the Scheduled Tribe population declined significantly. As per the 2011 Census, Hindus constituted 95.71%, followed by Muslims (2.49%), indicating a largely homogenous religious profile. Literacy levels improved, with male literacy reaching 176,828 and significant gains among females, though a gender gap persisted. Work participation showed a marginal rise, but so did the non-working population, suggesting growing dependency and highlighting the need for better employment avenues.

5.2 Land Use Land Cover (LULC) Changes (1991–2011)

Between 1991 and 2011, South Dumdum Municipality underwent a dramatic land transformation, driven by population pressure and urban expansion. Satellite image analysis revealed a clear shift from natural land cover—such as vegetation and water bodies—to predominantly built-up areas, reflecting rapid and largely unregulated urban sprawl. The municipality's proximity to Kolkata and its growing civic infrastructure made it a hotspot for residential and commercial growth.

Built-up area more than doubled over the two decades: from 5.35 sq. km (29.78%) in 1991 to 13.59 sq. km (75.64%) in 2011. This growth is attributed to multi-storied housing, commercial complexes, and roads, signifying a transition from horizontal spread to vertical urbanism.

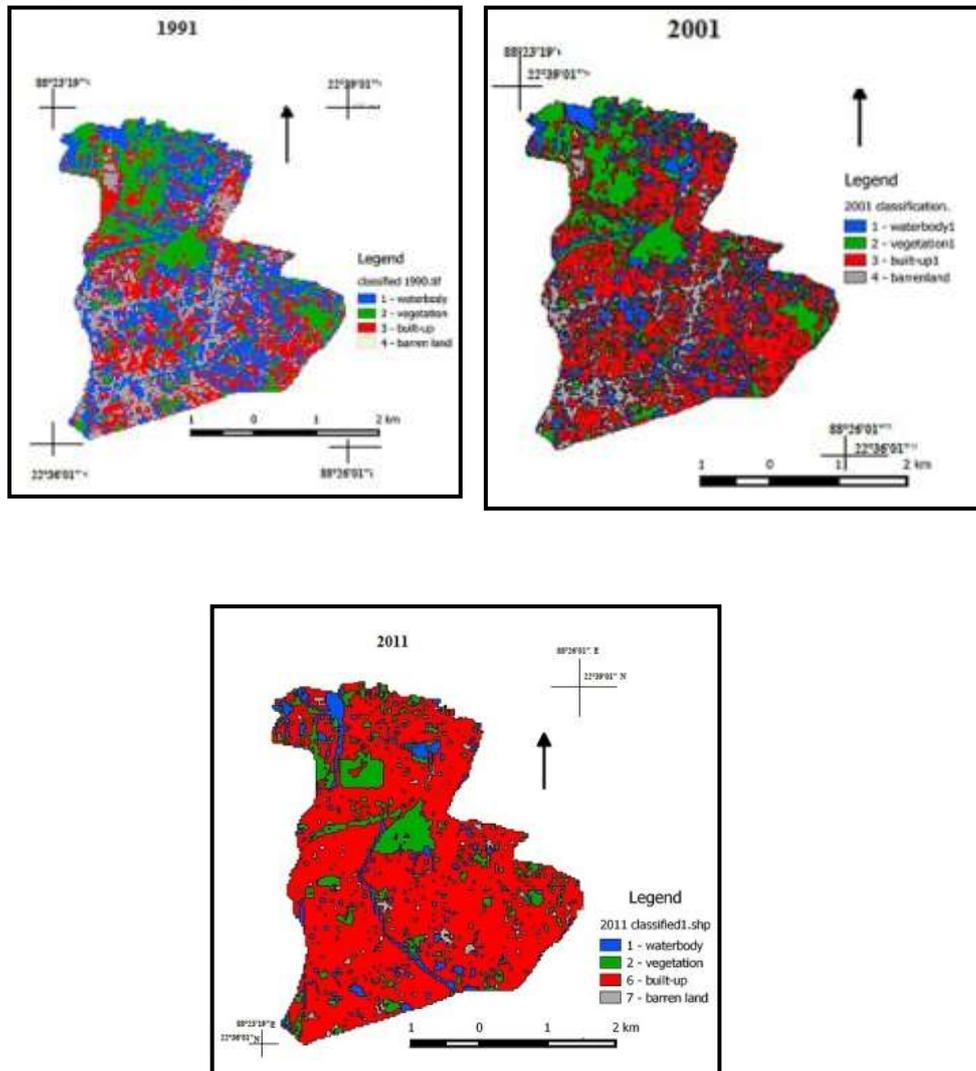
In contrast, water bodies shrank alarmingly—from 6.03 sq. km (33.58%) in 1991 to just 1.42 sq. km (7.89%) in 2011—largely due to encroachments and real estate development. Similarly, vegetation cover dropped from 3.90 sq. km (21.70%) to 2.48 sq. km (13.80%), reflecting the conversion of green spaces into concrete zones. This has serious implications for air quality, temperature regulation, and ecological stability.

Even barren/open lands declined—from 2.68 sq. km (14.94%) in 1991 to 0.48 sq. km (2.68%) in 2011—indicating complete saturation of vacant spaces.

Overall, the municipality has shifted from an ecologically balanced landscape to one dominated by human activity. With over 50% loss of natural cover, this trend, if unchecked, could lead to severe urban challenges: groundwater depletion, urban heat, flooding, and declining livability. The findings call for

urgent integration of environmental safeguards into urban planning to ensure South Dumdum’s sustainable future.

Figure 1 : Comparative Study on Land Use Land Cover (1991-2011).



5.3 Regression Analysis and Residual Analysis (1991–2011)

To assess the influence of population density on land transformation, bivariate linear regression was conducted for 1991, 2001, and 2011 across South Dumdum’s 35 municipal wards. In 1991, the relationship was strongly positive ($r = +0.93060$, $R^2 = 0.866$), indicating that 86.6% of the variation in built-up area could be explained by population density. The regression equation

($y = 2E-05x + 0.0268$) confirmed that denser wards saw greater horizontal expansion.

By 2001, the trend continued with a slightly lower correlation ($r = +0.90851$, $R^2 = 0.8254$), maintaining population density as a key predictor of built-up area. However, in 2011, the relationship turned negative ($r = -0.76040$, $R^2 = 0.5782$, equation: $y = -1E-05x + 0.7737$), reflecting a shift toward vertical growth due to land scarcity. This suggested that population alone no longer drove horizontal expansion—factors like real estate demand, policy, and zoning began influencing land use more significantly.

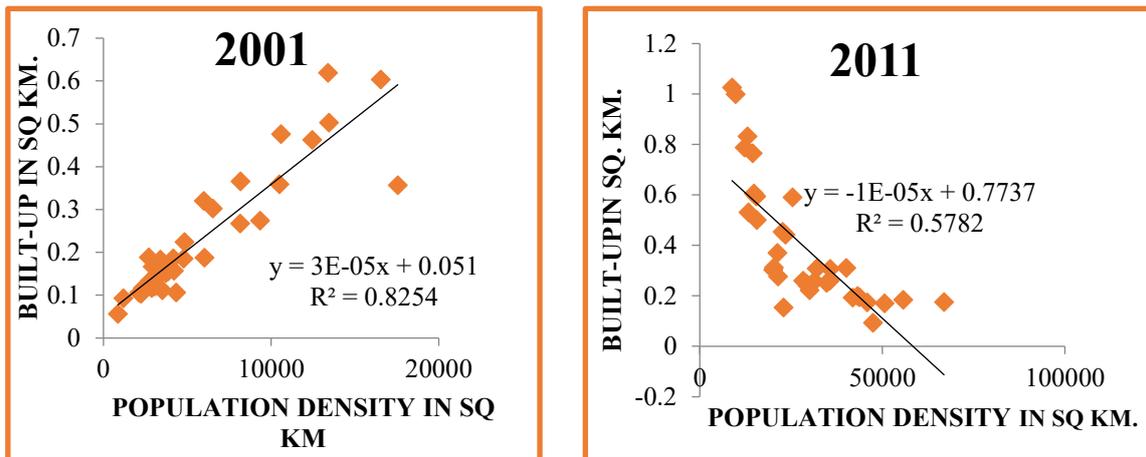
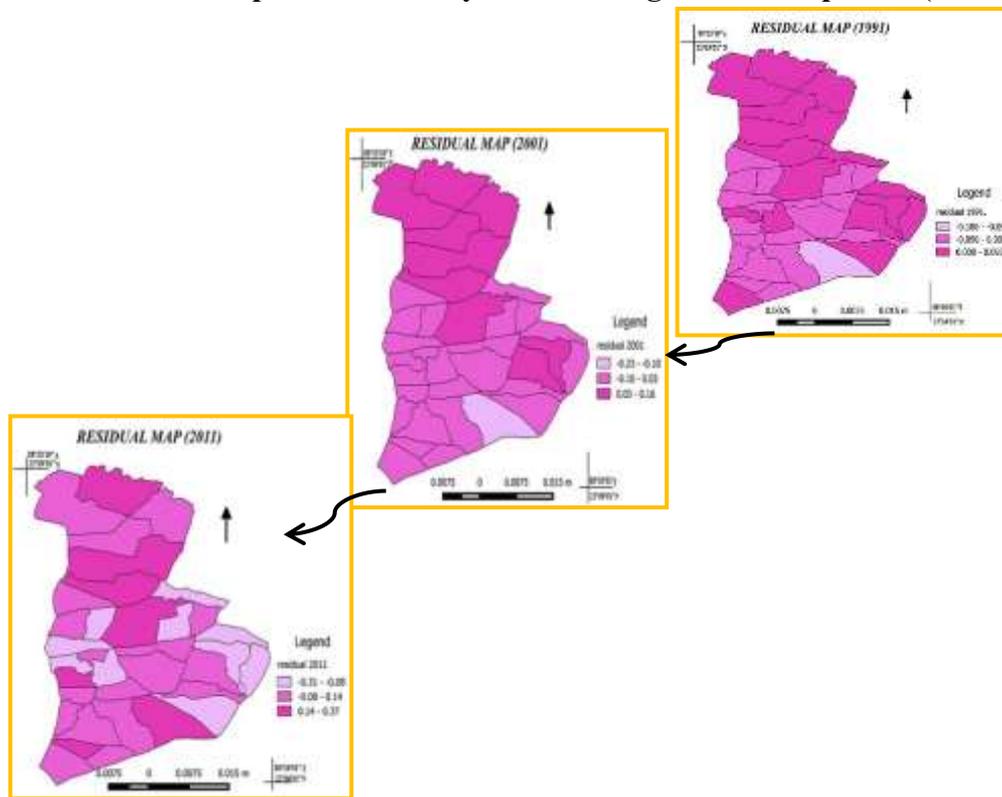


Figure 2: Relation between Population Density and Coverage of Built-Up Area (2001 & 2011)

Figure 3: Relation between Population Density and Coverage of Built-Up Area (from 1991 to 2011)



Residual analysis revealed spatial disparities. In 1991 and 2001, Ward 6 had the highest positive residuals (+0.0854 and +0.1559), suggesting excess built-up development beyond population expectations, likely due to infrastructure or favourable location. Ward 29 consistently showed negative residuals (−0.1315 and −0.2346), indicating underdevelopment despite population pressure. By 2011, residuals widened (+0.3684 in Ward 6, −0.3156 in Ward 16) and only 14 wards had positive residuals, signalling a shift where non-demographic factors played a larger role in shaping urban patterns.

In summary, population density was a dominant driver of urban growth in the 1990s, but its influence weakened over time as South Dumdum entered a phase of vertical expansion and complex urban restructuring, calling for multi-faceted planning approaches beyond just demographic considerations.

Table1: Land Use Land Cover (LULC) Changes: 1991–2011

LULC Category	1991 Area (sq. km)	1991%	2001 Area (sq. km)	2001%	2011 Area (sq. km)	2011%
Built-up Area	5.35	29.78	8.2	45.67	13.59	75.64
Vegetation	3.9	21.7	3.83	21.31	2.48	13.8
Water Bodies	6.03	33.58	3.22	17.93	1.42	7.89
Others/Barren Land	2.68	14.94	2.71	15.09	0.48	2.68

6. Major Findings

- The population and built-up area in South Dumdum Municipality increased rapidly between 1991 and 2011, reflecting the growing urban pressure and migration trends in the Kolkata metropolitan fringe.
- There was a sharp decline in natural land cover, with water bodies reducing by over 75% and vegetation cover shrinking significantly, highlighting the environmental cost of urban expansion.
- Post-2011, vertical urban growth through multi-storied buildings became prominent, indicating a shift from horizontal land consumption to high-density construction due to space scarcity.
- A strong positive correlation was found between population density and built-up area in 1991 and 2001, confirming that demographic pressure was a key driver of land transformation in the early phases of urbanization.
- Unregulated urban growth poses serious ecological threats, including groundwater depletion, loss of biodiversity, urban heat island effects, and reduced resilience to climate-related hazards.

7. Recommendations

To address the growing environmental and infrastructural challenges in South Dumdum Municipality, several strategic recommendations are proposed:

- Strict land allocation and building regulations must be implemented to control unplanned development and ensure that construction activities align with the municipality’s long-term urban planning goals.
- Vegetation and water bodies should be preserved through legal protection and conservation efforts, as they play a critical role in maintaining ecological balance, supporting biodiversity, and mitigating the urban heat island effect.
- Vertical growth should be encouraged, but it must follow eco-friendly practices, such as incorporating green roofs, energy-efficient designs, and rainwater harvesting systems to reduce environmental footprints and improve sustainability.
- Urban planning in the municipality must adopt an integrated approach, embedding principles of sustainability and ecological resilience to safeguard the area’s environmental health while accommodating future growth.

9. Conclusion

South Dumdum Municipality reflects a typical case of rapid urbanization in suburban India, where population pressure drives drastic LULC transformations. While development is inevitable, unregulated

expansion poses long-term environmental challenges. This study underscores the need for integrated planning and spatial management to balance urban growth with ecological preservation.

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