ANALYZING URBAN GROWTH DYNAMICS OVER SIXTEEN MAJOR INDIAN CITIES USING IRS AND SENTINEL SATELLITE OBSERVATIONS

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ABSTRACT

Urbanization in Indian megacities is pacing at an unparalleled and irreversible rate (31.1%). The current study focused on analyzing the growth dynamics of sixteen major Indian cities having population above one million. Rise in population corresponds to the increasing demand for land resulting in abrupt growth of the city known as sprawling. Land Use Land Cover (LULC) thematic datasets were acquired from ISRO (IRS data) and ESRI (Sentinel data) for 2005, 2010, 2015 and 2021 for the study. The variability of the five LULC classes viz., urban built-up, vegetation, water body, agriculture and barren land indicated that urban expansion mostly took place at the expense of barren lands. The urban landscape of Indian cities mostly depicts dispersive outward growth since the beginning of the 21st century with significant amount of compaction near the Central Business District (CBD) in the recent years. The results derived through Shannon's Entropy (SE) approach, various Spatial Metrics and urban density gradient analysis have also indicated the same. SE values nearing ln(n) indicates dispersion away from the CBD (maximum observed in Bhubaneshwar-Cuttack urban agglomeration i.e., ~1.702 in 2021). Spatial metrics like Patch Density, Contagion Index, Diversity Index, etc., and urban density gradient analysis have further confirmed the compaction of cities near the CBD (~95% within 5 km), and gradual decrease thereafter. Additionally, the morphology associated with the cities, influences the direction of city growth just like the course of river Hooghly dictates Kolkata's urban expansion. Population density compared with urban expansion indicates that both are proportional to each other (e.g., Pune exhibited ~83% increase in urban area corresponding to ~47% increase in population density). Thus, the derived results offer vital information regarding the existing patterns of urbanization and hence could be of use to city planners for better management of resources while building a sustainable city.

Keywords: Land Use Land Cover, Central Business District, Shannon's Entropy, Spatial Metrics, Urban density gradient

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- Urbanization is referred to the tendency of people to shift from rural to urban areas in search of better income, the standard of living, etc. In Indian megacities, it is pacing at an unparalleled and irreversible rate.
- The current study focused on analyzing the growth dynamics of sixteen major Indian cities. It includes eight Type-I cities (population of more than five millions), i.e., Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, and Pune, and eight Type-II cities (population of one to five million) viz., Chandigarh-Mohali, Ludhiana, Jaipur, Indore, Bhubaneshwar-Cuttack, Nagpur, Vishakhapatnam and Coimbatore. The mentioned cities and urban complexes have been considered for the study because of their population size, diverse climatic regimes, topography, and their incorporation into the smart city program.

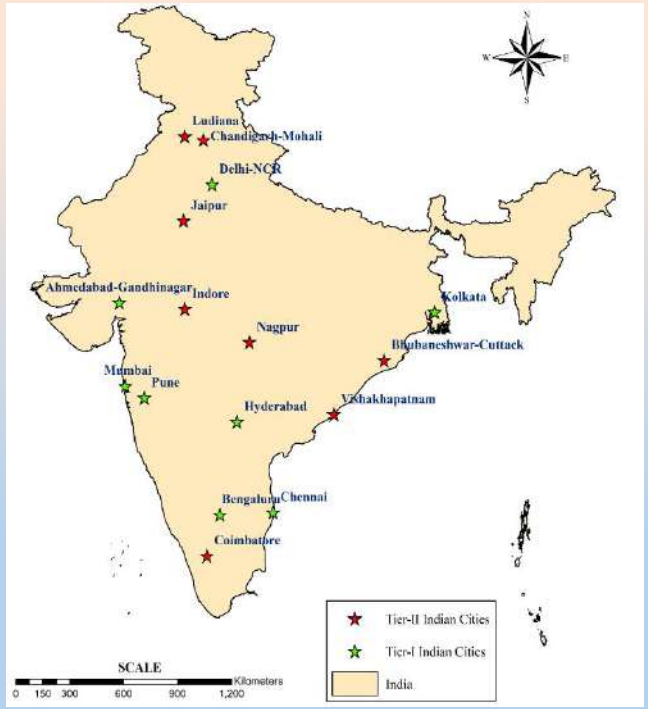


Figure 1: *Study Area Map*

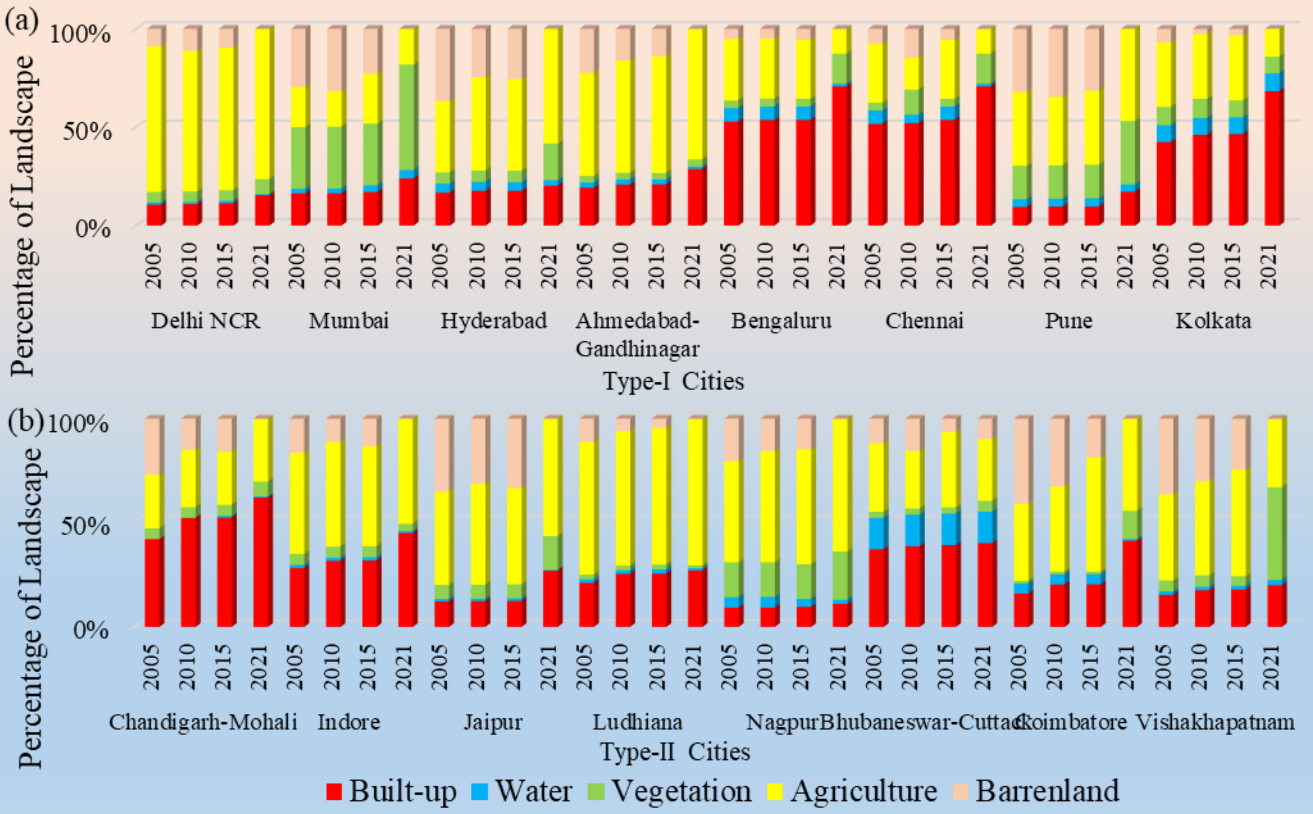


Figure 2: *Spatial variation in Percentage of Landscape (PLAND) for various land use classes from 2005 to 2021 in case of all type-I (a) and type-II (b) cities of India.*

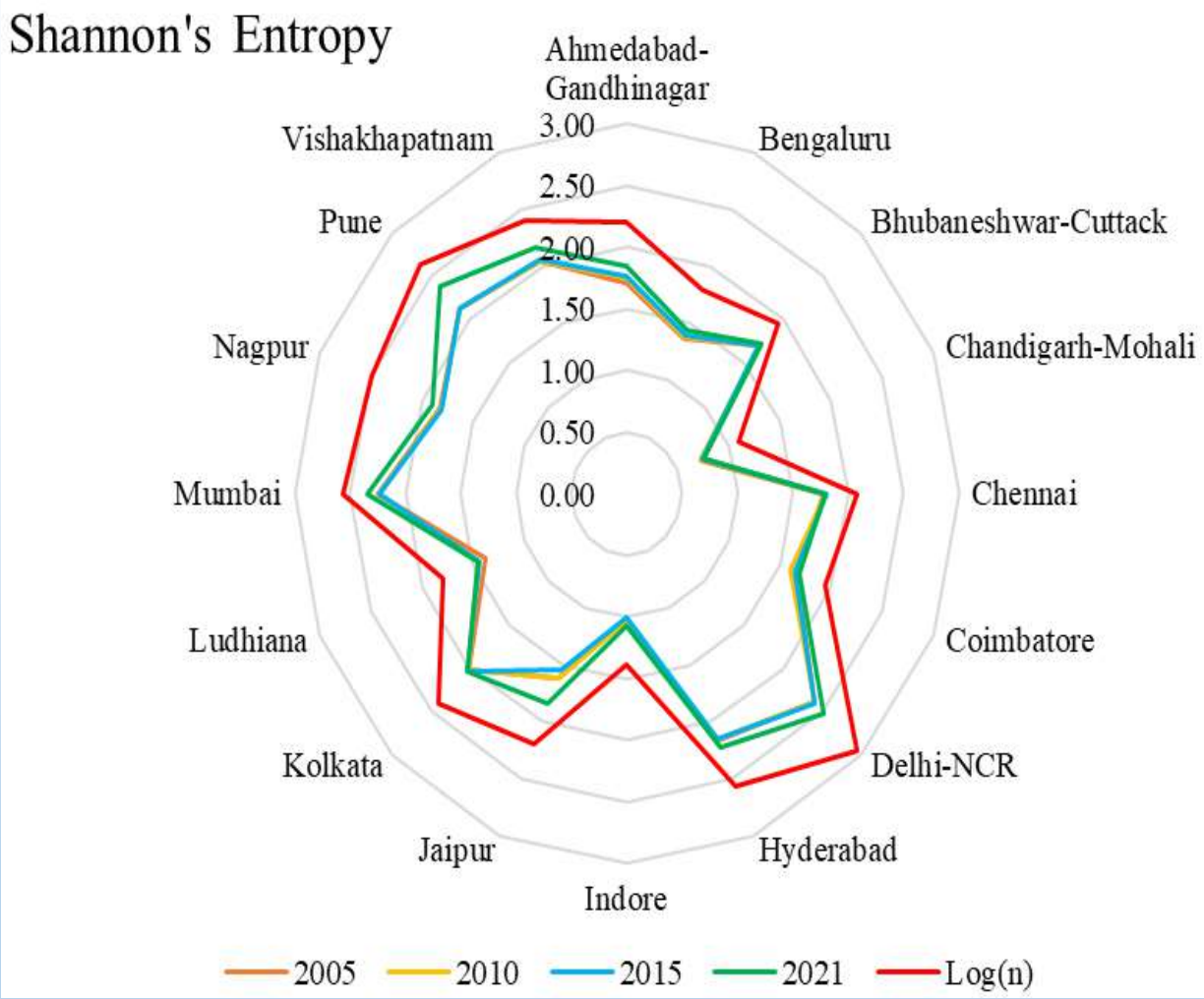
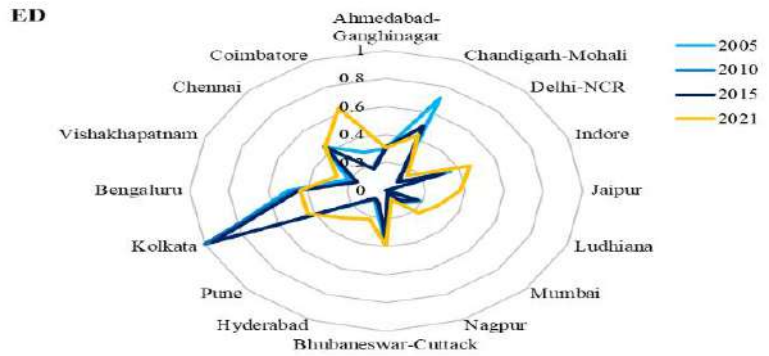


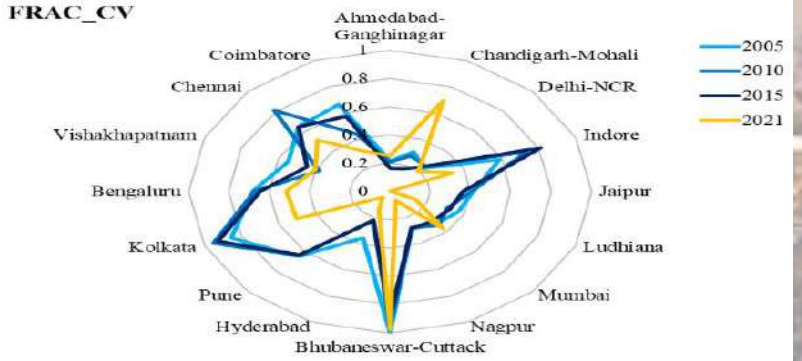
Figure 3: *Illustrating Absolute Shannon's Entropy of sixteen cities of India*

Spatial Metrics

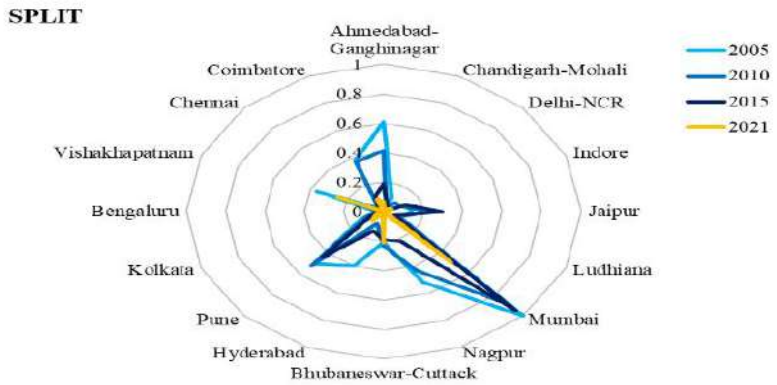
(a) Area & Edge Metrics



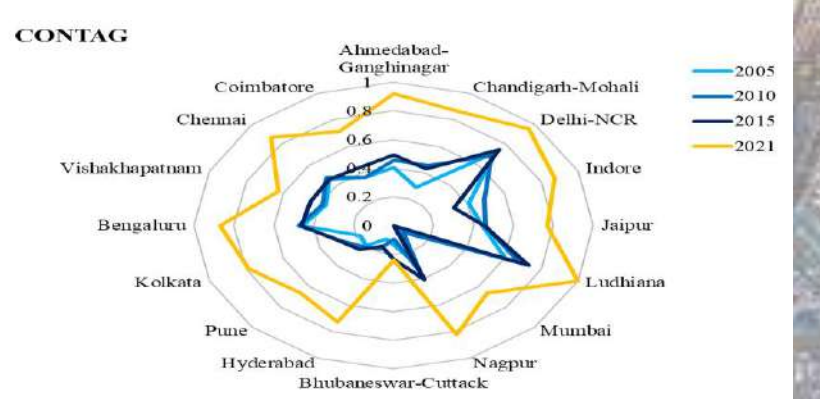
(b) Shape Metrics



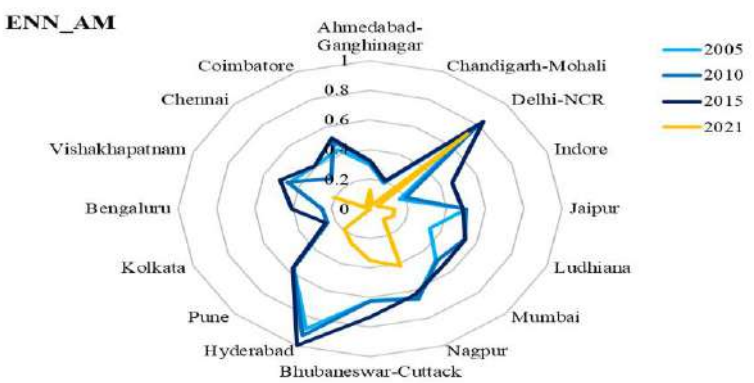
(c) Subdivision Metrics



(d) Dispersion & Interspersion Metrics



(e) Isolation Metrics



(f) Diversity Metrics

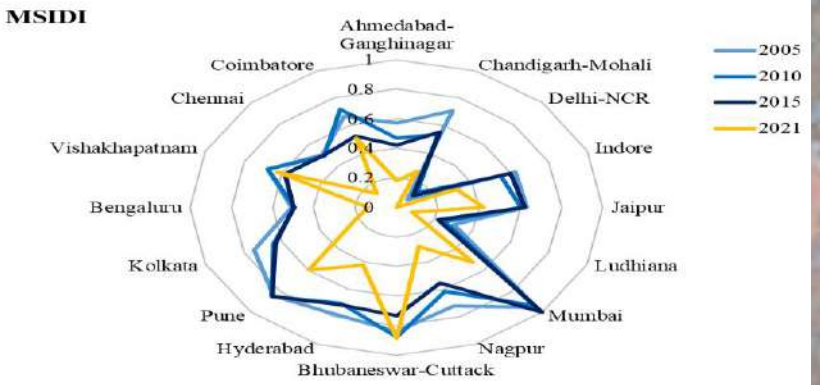


Figure 4: *Landscape metrics for all the selected cities showing four types of metrics, viz., (a)area & edge (edge density), (b)shape (coefficient of variation for fractal dimension), (c)subdivision (splitting), (d)dispersion & interspersion (i.e., contagion and normalized landscape shape index), (e)isolation (area-weighted mean nearest neighbour), and (f)diversity (modified Simpson's diversity index)*

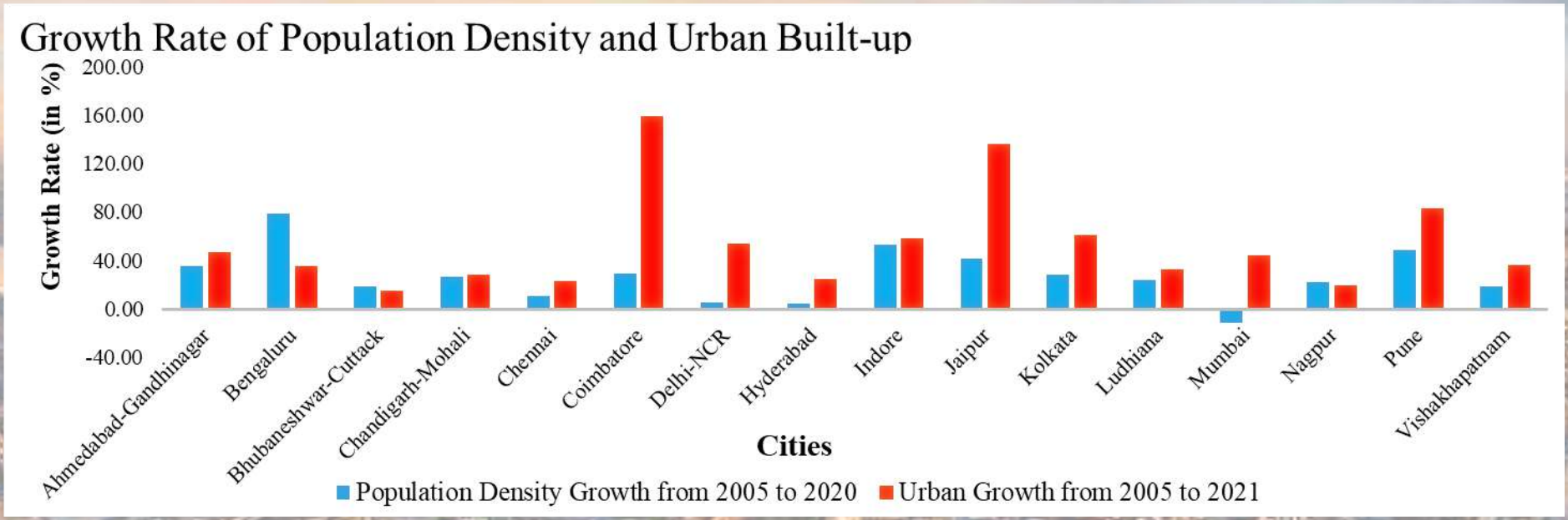


Figure 7: *Growth rate of urban built-up and population density*

Conclusions

- ❖The urban growth characteristics of each city, different forms of expansion have been observed in various areas of a single city, like in the case of Pune, where both edge development and ribbon development were noticed. Based on the values acquired, it can be concluded that the urban growth rate in Type-II cities like Coimbatore and Jaipur was excessively high during the concerned period from 2005 to 2021, i.e., even higher than that of Type-I cities.
- ❖The urban built-up grew altering barren lands and vegetation cover.
- ❖The Shannon's Entropy values indicate that most cities exhibit compaction near the city center, which gradually decreases with distance. With increasing distance from the CBD, dispersion of the built-up area mostly dominated the urban landscape. Also, the urban landscape progressed towards compaction (significant infill growth) with time.
- ❖Certain landscape metrics such as subdivision, dispersion, interspersion, isolation, etc., computed through FRAGSTATS, further confirmed that the city landscape progressed towards a more compact urban scenario with less diversity in land use over the years.
- ❖The comparison of the growth rate of population density with the growth rate of urban built-up indicates that the latter is higher.


Thank You