



# Monitoring urbanization and its implications in a mega city from space: Spatiotemporal patterns and its indicators



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## ABSTRACT

Rapid and invasive urbanization has been associated with depletion of natural resources (vegetation and water resources), which in turn deteriorates the landscape structure and conditions in the local environment. Rapid increase in population due to the migration from rural areas is one of the critical issues of the urban growth. Urbanisation in India is drastically changing the land cover and often resulting in the sprawl. The sprawl regions often lack basic amenities such as treated water supply, sanitation, etc. This necessitates regular monitoring and understanding of the rate of urban development in order to ensure the sustenance of natural resources. Urban sprawl is the extent of urbanization which leads to the development of urban forms with the destruction of ecology and natural landforms. The rate of change of land use and extent of urban sprawl can be efficiently visualized and modelled with the help of geoinformatics. The knowledge of urban area, especially the growth magnitude, shape geometry, and spatial pattern is essential to understand the growth and characteristics of urbanization process. Urban pattern, shape and growth can be quantified using spatial metrics. This communication quantifies the urbanisation and associated growth pattern in Delhi. Spatial data of four decades were analysed to understand land over and land use dynamics. Further the region was divided into 4 zones and into circles of 1 km incrementing radius to understand and quantify the local spatial changes. Results of the landscape metrics indicate that the urban center was highly aggregated and the outskirts and the buffer regions were in the verge of aggregating urban patches. Shannon's Entropy index clearly depicted the outgrowth of sprawl areas in different zones of Delhi.

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## 1. Introduction

Megacities in India are urbanising at an unprecedented and irreversible rate, as the global proportion of urban population has increased from 28.3% in 1950 to 50% in 2010 (World Bank, 2011). Urbanization is one of the demographic issues in the 21st century in India (Ramachandra et al., 2012a,b). Understanding the process of urbanisation would help the city planners to understand and plan and eradicate the problems associated with increased urban area and population, and ultimately build a sustainable city. Urbanisation is one of the few major topics that has been studied focussing on socio-economic, and environmental perspectives in urban areas

(Cohen, 2006), to economic perspectives in peri-urban areas (Ravallion et al., 2007), to the loss of vegetation (Ramachandra et al., 2012a,b) and with respect to urban emissions (Banerjee and Srivastava, 2011; Ramachandra and Shwetmala, 2009; Fung et al., 2005). Qualitative attempts have also been made to summarize the development of urbanization studies (Morse, 1965). The urban process refers to the conversion of the rural and natural forms into urban areas due to population immigration into existing urban area. Rural-urban migration is one of the major events that usually accompany economic expansion and hence leads to major agglomerations. Increased density of population has direct impact on the social and economic condition of the cities (Knox, 2009). This phenomenon is particularly significant in developing countries, where the rural-urban areas become one of the very important places of urban growth. These peri-urban areas where the urban sprawl occurs are devoid of basic amenities and are normally left out on most of the civic governing body facilities (Ramachandra et al., 2012b). Urban sprawl considered to be one of the major

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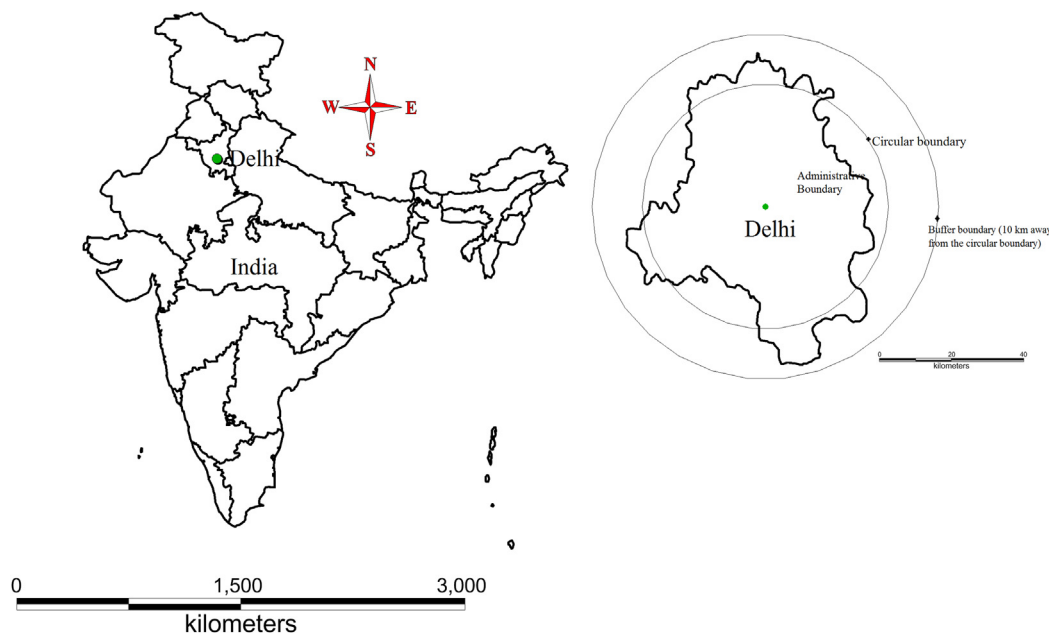


Fig. 1. Map depicts the Delhi administrative boundary.

reasons for rural push and spreading of city towards outskirts. The sprawl takes place at the urban fringes resulted in radial development of the urban areas or development along the highways results in the elongated development of urban forms (Sudhira et al., 2003). The urban sprawl quantifies the urban process and urban pattern. Urban Sprawl further affects the urban core areas by phenomena such as massive congestion, insufficient public transportation and infrastructure, lack of proper sanitation and many other basic amenities. With it come extreme socioeconomic disparities, vulnerability to natural and manmade risks (Fuchs et al., 1994; Mitchell, 1999; Kraas, 2007; Kraas and Nitschke, 2008; Ramachandra et al., 2012a). This necessitates the study of spatial urban growth patterns. Urban pattern refers to the spatial properties and configuration of the area at a particular time (Galster et al., 2001). Urban patterns also deals with physical structure and the spatial characteristics of the urban processes that vary over time (Aguilera et al., 2011). Urbanization process in Delhi has the major impact on the India's urban development. The rapid increase of urbanization resulted in the increased population density. Geoinformatics such as Geographic Information systems (GIS) with the temporal remote sensing data help to quantify changes in landscape structure that result from various disturbances (Turner and Carpenter, 1998). Many landscape-level metrics have been developed to examine and provide meaningful ways of measuring landscape characteristics (e.g., O'Neill et al., 1988; McGarigal and Marks, 1995; Gustafson, 1998; Hargis et al., 1998; Jaeger, 2000; Ramachandra et al., 2012a,b).

Spatial metrics measure the units derived from the spatial data that aid in quantifying the landscape features (Herold et al., 2002; Ramachandra et al., 2012a). The matrix based spatial analyses provide quantitative characterizations of the spatial and time composition of landscapes, which would be useful to analyse and understand the changes in landscape structure and patterns (Henebry and Goodin, 2002). The combination of remote sensing and spatial metrics helps to derive spatial information about urban growth, its structure and dynamics that helps in understanding of urban growth processes (Deng et al., 2009; Ramachandra et al., 2012b).

In this backdrop, the objectives of this communication i) understanding the urban dynamics through land cover and land use analysis, ii) understand the local level changes that takes place in the region using directional density gradients, iii) understand and quantify the growth and patterns through spatial metrics. This communication is divided into 4 parts. Part 1 gives details of the study area with its associated attributes. Part 2 discusses the methods adopted in the current research, third part deals with the results and discussion of the results. Final part draws the conclusion based on the analysis of the study area.

### 1.1. Study area

Delhi is one of the largest metropolis by area and second largest metropolis by population. It is the eighth largest metropolis in the world by population with more than 16.75 million inhabitants in the territory and with nearly 22.2 million residents in the national capital urban region. Delhi is located at 28.61° North latitude and 77.23° east longitude. It borders the Indian states of Uttar Pradesh to the east and Haryana on the north, Rajasthan on the west and south. Delhi is situated on the banks of the River Yamuna. The River Yamuna serves as the bed of agricultural land (Veronique Dupont,

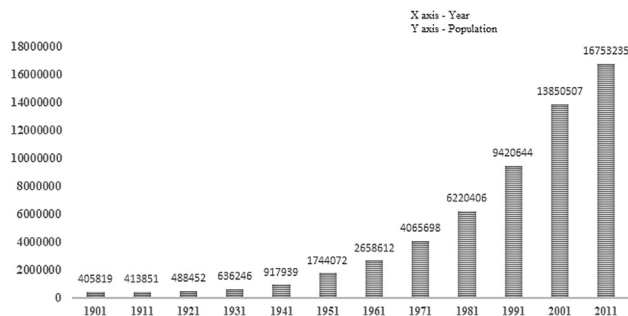


Fig. 2. Growth of population (in number crores) of Delhi from 1901 to 2011.

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