Geovisualization of urban densities using GIS: Case Study in Colombo Metropolitan Area, Sri Lanka

By

Padma Weerakoon
Senior Lecturer
Department of Estate Management and Valuation
University of Sri Jayewardenepura, Sri Lanka
kgpk@sjp.ac.lk

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Abstract

Urbanity is characterized by the agglomeration of human beings into specific geographic locations with urban features. Spatial interpretation of these urban agglomarations is essential for spatial planning in the country. Geovisualization provides a clear picture of the relationship of real world with manmade data. It also helps to overcome barriers of interpreting data and it creates a relationship of geographic information with other socio economic information. Studying urban densities are essential for the understanding of urban spatial structure. In urban land use analysis, planners have been facing the challenge of how to represent "real world" density patterns as accurate as possible. Moreover, Non-residential land use has a significant impact on urban population distribution and an analysis of land use and population density can improve the understanding of urban spatial structure.

Aggregate census data in Sri Lanka suffers from various analytical problems as they are available in report form. Studying urban population and spatial structure using aggregate census data suffers from problems of rapidly changing urban centers in Sri Lanka. Therefore our planners face some difficulties in analyzing land use compared with population data. This paper attempts to bridge those aggregate census data with disaggregate land-use data for analyzing urban population distribution in Colombo Metropolitan Region using GIS. It will provide meaningful spatial information for future decision making and planning.

1. Introduction

Geospatial analysis is able to create new information. Earlier, the reporting of census information was typically limited to standard administrative units. The strength of geospatial analysis allows data to be retrieved for custom geographic areas. The new era of electronic data, the internet, and GIS, geospatial tools have removed the limitations of printed reports and standard administrative boundaries. The result is a fundamental change in uses of census data for more meaningful interpretation using GIS. Geodemography, the linkage of geographic and demographic information, is a powerful tool, useful for many applications.

In order to define population with socioeconomic profiling it is necessary to integrate as well as utilize various types of data and their spatial geography to analyze the population. Geographic Information System (GIS) capabilities give the ability to query and review the spatial component of population data and their unique characteristics offering a new vision. Hence this paper attempts to visualize urban densities using geographic information system in the Colombo District, Sri Lanka.

2. Objectives of the Study

Main objective of the study is to analyze spatial distribution of urban population distribution in Colombo Metropolitan Region. To accomplish this main objective some specific objectives has been developed as follows

- To visualize urban densities by applying techniques of surface models in GIS.
- To integrate population data with disaggregate land use data using GIS.

3. Study Area

Colombo metropolitan region or Western province is a major population concentration node in Sri Lanka. 2011 census indicates total population of the Colombo Metropolitan Region as 5.8 million and it consists of 28.8% of the total population. The region covers an area which is nearly 6% of the total land area of Sri Lanka. This huge concentration of population is a result of increased human migration to the Western Province due to relatively better, economic and social infrastructure, concentration of administrative and financial institutions and the location of port and airport. The CMR accounts for 80 percent of all industrial establishments, 53 percent of Industrial employment and 31 percent of total employment in the country. Further, CMR contributes 44 percent of GDP of Sri Lanka. The comparative advantages of CMR in Sri Lanka continue to dominate economic development. Therefore, CMR is a large population concentrated pocket. It comprises 80% of total urban sector population in Sri Lanka.

4. Research Setting and Data Issues

Sri Lanka is geographically divided by 25 districts within 9 provinces. Each district is divided into DS (Divisional Secretariat) divisions and each DS division is sub divided into GN (Grama Niladari) divisions. Each GN division consists of several villages. The lower geographic area of census data is the GN division level and this level is mostly suitable for population analysis. Therefore, population analysis and establishment of GIS was done at the level of GN divisions. Considering the land use data, it was based on 1:50000 topographic maps prepared by the survey department, Sri Lanka and the main data issue is this few detailed land use map. A study area covers approximately 3745 sq. km and 2497 sub districts.

5. Methodology of the study

In spatial analysis of aggregate census data various analytical problems are gone through. The Modifiable Areal Unit Problem (MAUP) is one of the important phenomenon associated with the use of data aggregated to geographical areas. It was first identified by Gehlke and Biehl (1934)

and they apply where data are aggregated to areal units which could take many forms such as postcode sectors, local government units etc. Later Openshaw (1984) Openshaw S and Charlton M. 1987 provide a comprehensive review on the work of Gehlke and Biehl (1934) and it refers to the variation in analytic results due to alternative grouping of the areal units at the same spatial scale

Further, Lou J.(2005) stated the following problems regarding the population analysis.

1. In 1991 Fotheringham and Wong stated that due to the arbitrary boundary delineating of aerial unit, the outcome differs with modifying the boundaries
2. Population distribution is usually displayed homogenously in a census unit, which mis-represents the population variations.
3. Census unit boundaries do not match with diverse forms of other urban spaces and units, such as health districts, school districts, land use patterns etc. That makes data integration and sequential comparison difficult to build up by changing census.
4. In 2006 Jan explain that "Density functions based on census aerial units are less capable of capturing directional and local variations due to problems of aggregation.

Furthermore, In 1998 Ingram mentioned that Non-residential land use has a significant impact on urban population distribution and an analysis of land use and population density is a good indicator to perceptive of urban spatial structure. In 1998, Martin used population surface to develop a method of automatically identifying featured neighborhoods in Southampton of the U.K.

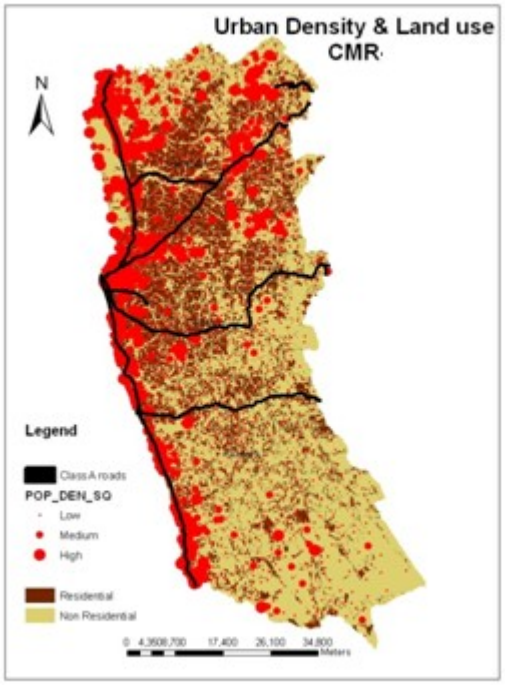
Here, the main issue is creating population surface models as a technique to apply population data into grid cells. As a clarification for that, in 1989, Bracken and Martin applied Inverse Distance weighted (IDW) method, a point interpolation technique, to develop population assigned to district centroids, and then interpolated surface for census enumeration districts in the U.K. According to that study, firstly, population counts are assigned on GND centorids.

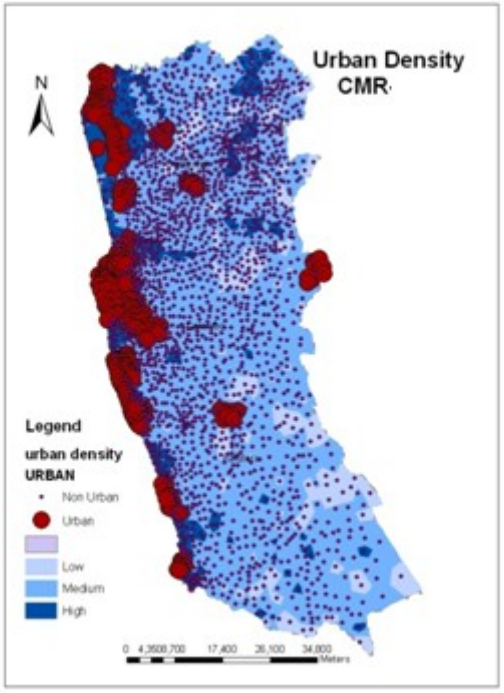
To generate population surface, study uses GN division level population. To spatial overlay operation, study assign population to centroid in GND and interpolate this data to 500X500 meter raster cell size. It further analyzes the population density variations and spatial associations of land use and population distribution. Calculation of population density based on built-up area in each GN division assigning the following formula and it was done outside the ArcGIS environment.

$$\text{Population Density} = \sum_{ji}^{n} \frac{[\textit{GND population j}]}{[\textit{Total area j - non residential area j}]}$$

6. Spatial variations on non-residential land use and population distribution in CMR

The population surface is used to analyze spatial associations between land use and population density. 20 land use factors are reclassified to two factors and it suggests that non-residential land uses had significant positive spatial autocorrelations with population density. Following figure shows spatial association and it significantly noted that most high densities are scattered along the major roads.





7. Conclusion

This paper investigates spatial structure of urban population distribution in CMR using disaggregate census data with GIS. Study used a simple rationalisation methodology to aggregate census data with spatial data to visualize population distribution. Furthermore, it attempts to develop an analytical framework to investigate urban population distribution and spatial structure through a flexible scheme of generating population surface. According to the analysis, it should be specifically mentioned that there are some relationships with land use, road network and population density in CMR.

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Biography

Padma Weerakoon is a senior lecturer in the Department of Estate Management and Valuation , University of Sri Jayewardenepura, Sri Lanka. She is member of Institute of Town Planners, Sri Lanka. She involved more research in GIS applications. Her research interest is GIS applications for urban planning.