A Fractal Approach to Dasymetric Population Estimation

Byong-Wooon Jun
Department of Geography
Kyungpook National University
Daegu, South Korea
E-mail: bwjun@knu.ac.kr

Abstract: This study explored a fractal approach to find the optimal grid cell size for the dasymetric estimation of population in Fulton County, Georgia in the US. Population surface maps were generated from 30m to 420m at intervals of 30m using an automated intelligent dasymetric mapping technique and simulated land use and cover data. Lumped fractal dimension values were calculated for the population surface maps generated from resolutions of 30m to 420m using the triangular prism surface area method. The accuracies of dasymetric population surfaces were evaluated using RMSE and adjusted RMSE. The results show that a grid cell size of 210m or smaller is required to estimate population more accurately in terms of thematic accuracy, but a grid cell size of 30m is required to meet an acceptable spatial accuracy of dasymetric population estimation in the study area. The fractal analysis also indicates that a grid cell size of 180m is the optimal resolution for dasymetric population estimation in the study area.

Keywords: Population, Dasymetric Estimation, Scale, Resolution, Fractal

Dasymetric mapping has been widely used for providing improved population estimates for investigating crime, public health, risk, service accessibility, and environmental justice issues in an urban area. Despite the wide-spread use of dasymetric mapping in population estimation, only few studies have been concentrated on investigating possible methodologies and data sources for implementing dasymetric population estimation (Mennis, 2003; Bozheva *et al*., 2005). The impact of grid cell size or spatial resolution on dasymetric estimation of population has not been thoroughly studied in the international research community for urban analysis and modeling (Longley, 2002; Mennis, 2003). Until recently, multi-resolution land use and cover data ranging from 1m to 2km have been used for dasymetric mapping of population at different spatial scales. The dasymetric population estimation is not free from the modifiable areal unit problem (MAUP). It is still not clear that to what degree the scale may over or underestimate populations and what the optimal spatial resolution is for representing populations with dasymetric mapping. In this context, this study explores a fractal approach to find the optimal grid cell size for the dasymetric estimation of population in Fulton County, Georgia in the US.

The primary data sets for this research include population data from 2000 US Census and land use and cover data derived from 2000 Landsat 5 TM imagery. The demographic data are collected at the census tract and block group levels. The land use and cover data are initially extracted using a hybrid digital image classification and reclassified into 3 classes such as residential, commercial/industrial, and others. The spatial resolution of land use and cover data is 30m. To simulate different spatial resolutions, the land use and cover data in 30m are resampled into from 60m to 420m at intervals of 30m, respectively. Population surface maps were generated from 30m to 420m at intervals of 30m using an automated intelligent dasymetric mapping technique and simulated land use and cover data. The accuracy assessment of 14 dasymetric population surfaces generated is implemented using RMSE and adjusted RMSE statistics for cross validation. Lumped fractal dimension values were calculated for the population surface maps generated from resolutions of 30m to 420m using the triangular prism surface area method. The fractal dimensions are quantified using the software package ICAMS (Quattrochi *et al*., 1997).

The results from accuracy assessment show that a grid cell size of 210m or smaller is required to estimate population more accurately in terms of thematic accuracy, but a grid cell size of 30m is required to meet an acceptable spatial accuracy of dasymetric population estimation in the study area. The fractal analysis also indicates that a grid cell size of 180m is the optimal resolution for dasymetric population estimation in the study area. This research discusses the importance of determining the optimal grid cell size for dasymetric population estimation to depict accurately total population and specific sub-population distribution for urban areas. This exploration will bring new research possibilities to urban analysis and modeling research.

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