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Disaggregating Job Seekers Allowance Statistics for Belfast using IKONOS Satellite Imagery

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Abstract: This paper presents a dasymetric map produced for Belfast, the capital city of Northern Ireland. The map was generated by integrating IKONOS satellite imagery from May 2003 with Output Areas from the 2001 Census. Urban areas are dynamic entities formed by the social processes and interactions of the urban population. The intricate patterns that exist within urban areas are largely hidden by the aggregation of statistics to larger areal units. Dasymetric mapping has been used widely to interpolate statistics from a set of source zones to a set of target zones. The provision of high-resolution satellite imagery enables the detection of smaller target zones that were previously hidden due to the coarse resolution of satellite imagery. The following dasymetric map identifies the ability of IKONOS data to distinguish between built land and non-built land within administrative units. The result is that population statistics can be interpolated more accurately to areas that are most likely to have a resident population.

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1. Introduction

Urban areas require a wide range of information about various human processes to predict form from process. A range of demographic datasets are available to give urban planners greater insight into the characteristics of the urban population. Demographic datasets have a two-fold responsibility: firstly, to address the characteristics of the population and secondly, to address the spatial dimension of that population. Due to the rapidity of change within urban areas techniques must be developed that monitor change on a regular and routine basis (Donnay, 1999).

Socio-economic data are often provided for aggregated units to preserve confidentiality, facilitate enumeration and reduce data volume. Each administrative unit is largely divorced from the underlying geography of the region and each enumeration zone varies in size and configuration. The aggregation of data and the variation in unit size has led to the ecological fallacy (Wrigley et al., 1996) and the modifiable areal unit problem (Openshaw, 1984). Areal units are composed of various land cover types, some of which do not have people residing on them. Ancillary data is needed to redistribute population statistics to residential land to improve statistical representation.

The origins of dasymetric mapping are credited to Semenov Tian-Shansky who used this technique to map population in Russia in 1922 (Mennis and Hultgren, 2006; Petrov, 2008). Dasymetric mapping integrates GIS techniques with additional geographic information to create new, relatively homogenous target units within an original areal unit from which to improve the analysis and visualization of census statistics (Robinson et al., 1995). Dasymetric mapping utilises ancillary spatial information regarding the distribution of a population. New density measures are calculated based on the assumption that the areal unit's population is restricted to specific areas that are identified by ancillary information. The dasymetric map consequently presents "quantitative areal data using boundaries that divide the mapped area into zones of relative homogeneity with the purpose of best portraying the underlying statistical surface" (Eicher and Brewer, 2001, p125). IKONOS satellite imagery is used in this paper to establish a new set of target zones within Output Areas from the 2001 Census. The increasing spatial resolution of satellite imagery offers the potential to accurately identify and record built land within urban areas that contain a resident population.

2. Methods

An IKONOS image was captured for Belfast in May 2003. The image was georectified and cloud was masked from the image. Cloud cover in the image restricted the study area to the south and east of the city. IKONOS imagery was supplied at one metre spatial resolution in panchromatic mode and at four metre spatial resolution in multispectral mode. The images were fused using the Principal Components function available in Erdas Imagine 9.1 software to create an image with a spatial resolution of one metre. A supervised classification was performed on the image to identify the areas of built land in the image. The residential land class was classified by selecting 40 training areas throughout the image. These training areas were merged to form one residential class while other land classes such as forest and grassland were merged into the non-built land class.

Output Areas (OAs) from the 2001 Census were obtained from Northern Ireland Statistics and Research Agency (NISRA). Job Seekers Allowance (JSA) statistics were downloaded from Northern Ireland Neighbourhood Information Service (NINIS) website for 2003. JSA is an income subsidy that is payable to people under pensionable age who are actively seeking work of at least 40 hours per week. Job seekers receiving an income subsidy are dispersed evenly throughout the total population. JSA data were joined to the OA data and intersected with the IKONOS classification to produce the dasymetric map. The population in the study area was excluded from non-built areas in the map. The map shows the percentage of the population claiming JSA payments for Belfast in 2003.

3. Results

The map identifies high densities of JSA claimants in the small OAs in the North West and North East of the city. These areas are characterised by high-density terraced housing with only small amounts of non-built land in each OA. These inner-city areas are characterised by higher unemployment rates and lower income families (Northern Ireland Statistics and Research Agency, 2008). JSA densities are lower in the East and South of Belfast where there is more non-built land in the form of large gardens and city parks. IKONOS imagery is well placed to differentiate between built and

non-built land within urban areas. This ability is especially relevant in the context of the 2001 census geography of OAs as these areas are generally smaller (mean area = 282 hectares for Northern Ireland) than the previous Enumeration Districts (mean area = 378 hectares for Northern Ireland). There is likely to be a high proportion of built land within urban OAs and coarse satellite imagery is unlikely to identify small areas of non-built land. Some small areas of residential land appear in areas of non-built land. These areas may represent individual dwellings that are sufficiently large to be identified by the IKONOS sensor. Classification error may result from spectral confusion between other hard surfaces such as quarries or sand pits and residential land.

4. Conclusions

Dasymetric maps assume that people and houses occupy built land. This is a rather rigid assumption which leads to some error being introduced to the dasymetric model. Sensors such as Landsat-TM offer a coarse spatial resolution of 30 metres which is often too low to identify individual dwellings within census zones.

IKONOS imagery offers a major improvement over Landsat-TM imagery due to a spatial resolution of four metres in the multispectral mode. IKONOS can differentiate between urban land classes more accurately as the pixel size begins to approach the level of an individual dwelling. While this can introduce a range of new problems such as radiometric variance and land cover arrangement (Mesev, 2003b) the imagery provides a useful tool for the redistribution of census counts for small urban zones

Classification errors need to be considered as roads, car parks and industrial land have similar spectral profiles to residential land. Fisher and Langford (1996) investigated the extent to which classification error of residential areas degraded the dasymetric model. The study showed that a classification error of up to 40% was necessary before population estimates based on the dasymetric method deteriorated to the level of any other areal interpolation technique. Additional work by Strahler (1981) found that classification error at the pixel level can be relatively large without affecting the accuracy of estimates of regional amounts.

New point based GIS datasets may provide a useful tool in guiding the classification process. Harris (2003) used Code-Point data as a first filter to distinguish between residential and non-residential land uses. The use of Address-Point and Pointer datasets from Ordnance Survey offer a useful source of ancillary information as they represent actual residential mail delivery points. McKenzie (2003) used COMPAS (Computerized Point Address Service) from the Ordnance Survey of Northern Ireland to redistribute census counts to residential properties. This method of dasymetric mapping was possible due to the provision of an area attribute within the dataset. The use of COMPAS data led to densities generally between three and ten times greater than the census model and densities generally between one and five times greater than the IKONOS model. The use of mail delivery point datasets may also be used to guide training site selection in a supervised classification (McKenzie, 2003), for post-classification editing, for monitoring changes in urban morphology (Mesev, 2003a) and for detecting function from form (Mesev and McKenzie, 2008). The dasymetric map provides a means by which public resources can be targeted to more deprived areas.

Software

IKONOS imagery was handled using Erdas Imagine 9.1 software while GIS analysis and map production was performed using ESRI ArcGIS 9.2.

Acknowledgements

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