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Overview of Urbanization in Geodemographic Approach; Colombo Urban Area, Sri Lanka

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Abstract:

The spatial revelation of urban population provides an amazing picture of the dense of population sharing within built up areas. It is important to analyse people according to the places where they live in. Geodemography provides an analytical overview to analyse this situation. Particular geodemographic tools make data access easier and more end-users can easily access the information they need. Studying spatial distribution of urban population is essential for the understanding of urban spatial structure and the formation of government policies. However, this is a challenging task because of the difficulty to integrate, aggregate census data with disaggregate land-use data. To perform this task the Modifiable Arial Unit Problem needs to be avoided and it is a challenging task. On the other hand, data limitations in developing countries is another issue in adaptation of geodemgraphy to explore the population. This research aims to minimize these two gaps.

Studying urban population and spatial structure using aggregate census data suffers from the 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 that aggregate census data with disaggregate land-use data for analyzing the urban population distribution during the last decade in Colombo Metropolitan Region using GIS. Results show that way of minimization of the above gap. It will provide meaningful spatial information for future decision making and planning.

Key words: geodemography, GIS, spatial interpolation, population density surface

1. Introduction

Population distribution pattern is one of the vital factors needed to take decisions related to urban planning, which helps to develop physical plans and the formation of urban development policies. Accurately analysed urban population distribution pattern show how to spread out people within the urban spatial structure and it provides a proper platform for decision making in urban planning (Luo 2005). Census data are the most significant sources showing demographic information in the country but they are mostly based on aggregate census units defined by the state. For example, in Sri Lanka, it is based on administrative units such as districts, district secretariat divisions (DSD) and grama niladari divisions (GND). The large metropolis and primate cities all over the world are the consequences of accelerated urbanization process during the last two decades. Visualization of multifarious concentration of population compatible with the ground station (Luo 2005; Bracken 1993) is one of the challenges for urban planners. Census units are arbitrary boundaries and visualization of population data in this platform is not shown real ground picture. The new era of electronic data, the internet, and GIS, geospatial tools have removed the limitations of printed reports and standard administrative boundaries. As a result of that geodemography come out as a subject to minimise limitations of visualization aggregate census data. Geodemography is a study of people based on their lives linked in a multidisciplinary manner. It connects with the discipline of demography (the study of human population dynamics) with geography (the study of the locational and spatial variation of both physical and human phenomena on Earth), and also sociology. Also, geodemography has a better relationship between demographic data and spatial location. For instance, demography outlines the population in specific categories of age, race, ethnicity, education, occupation etc. So geodemography highlights those categories related within 1km of the city centre etc. It is same as housing characteristics. In this, demography can also refer to housing characteristics, such as number of rooms in a residence, home ownership, housing value, and availability of infrastructure etc. Geodemography facilitates to compare this data within different zones of the city. Goodchild (2010) stated Geographic information as a science (GIScience) and it provides an outline to generalize about people and places connected with time. This concept draws deep analytical methods and techniques in human geography and it becomes one of the major roots (Longely, 2012). It is more evident that through Geodemography, there developed a novel field of GIS. Geodemography is defined as the classification of people by where they live (Harris et al. 2005). This is conceptually challenging to spatial representation as well as to organize, manage and analyse geospatial information with location attribute and time. It is also a combination of GIScience and geocomputation (Abrahart and Openshaw 2000).

1.1. Problems with census data

The restriction of aggregate census data with boundary definitions suffers various analytical problems. First, Modifiable Areal Unit problem (MAUP) is one of the main analytical problems associated with the use of data aggregated to geographical areas. First it was identified by Gehlke and Biehl (1934) and they applied where the data are aggregated to areal units which could take many forms such as postcode sectors, local government units etc. Later Openshaw (1984) and Openshaw and Charlton 1987 provided a comprehensive review on the work of Gehlke and Biehl (1934) and they refer to the variation in analytic results due to alternative grouping of the areal units at the same spatial scale. Secondly, analysis of population density with land use provides a better image of the real world situation. But it is a challenge, due to difficulties in integrating aggregate census data with disaggregate land use data. The population distribution is usually displayed homogeneously on a census unit, which misrepresents the population variations. On the other hand Census unit boundaries mismatched 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. 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".

Thirdly, influences of nonresidential land uses in defining urban densities force great impact to misinterpret real densities. In 1998 Ingram mentioned that nonresidential land use has a significant impact on the urban population distribution and an analysis of land use and population density is a good indicator for observation of urban spatial structure. Still this is a challenging task; because of the complexity to incorporate aggregate census data with disaggregate land-use data.

1.3 GIS and visualization of census data

In this decade, most GIS researchers attempt to develop different methodologies to minimize above issues and represent the population distribution using techniques of surface models which is identified as the most possible method. In 1998, Martin used population surface to identify featured neighbourhoods in Southampton in the U.K. Also in 2005 Luo used population density surfaces for analysing the urban spatial structure and further study mentioned that the surface model based population distribution pattern in the continuous field with grid cells provide a more detailed and an accurate representation of population distribution (Luo 2005).

In order to define population with socioeconomic profiling it is necessary to integrate various types of data and their spatial geography to analyse the population.

Incorporating geodemography with Geographic Information System (GIS) capabilities gives the ability to query and review the spatial component of population data and their unique characteristics focus on a new vision. Hence this paper attempts to apply demographic data with geographic information system for analysing the population distribution variations during the last decade of the Colombo Metropolitan Region.

2. Objectives of the Study

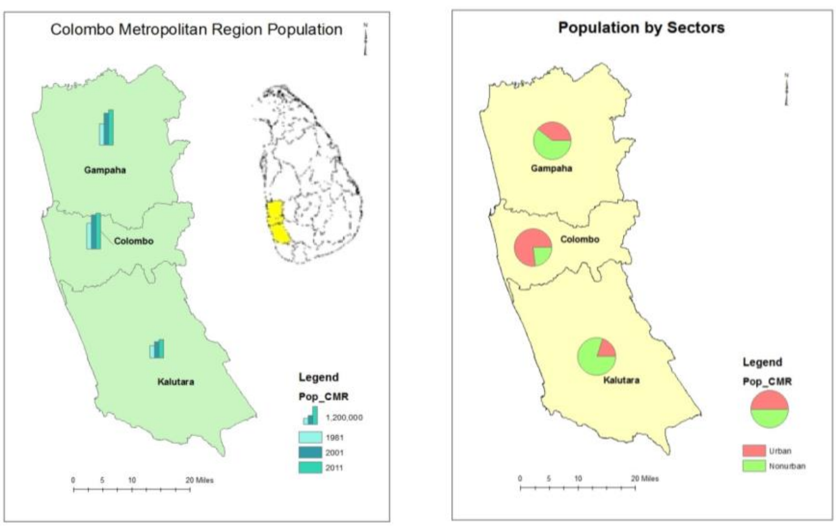
The main objective of the study is to analyse spatial distribution of urban population in Colombo Metropolitan Region during the last decade. To accomplish this main objective some specific objectives have been developed as follows:

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

3. Study Area

The Colombo Metropolitan Region (CMR) or Western Province of Sri Lanka is selected as the study area which covers three districts namely Colombo, Gampaha and Kalutara. According to 2011 census the total population of the region is 5.8 million and it accounts for 28.8% of the total population of Sri Lanka and this is one of the densest regions of the country. The extent of the region covers 3,694.20 km^2; which accounts for nearly 6% of the total land area of Sri Lanka. This enormous concentration of population is a result of increased human migration into 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 and Table 1 indicates a population distribution pattern within the three districts during last two decades. It comprises nearly 86% of the total urban sector population in Sri Lanka. Figure No 1 indicates the location of CMR and its population composition by sectors.

Figure No 1 CMR Population



4. Data

Sri Lanka is geographically divided into 25 districts and it comprises 9 provinces. Each district is divided into DS divisions (Divisional Secretariat divisions) and each DS division is subdivided into GN divisions (Grama Niladari divisions). Each GN division consists of several villages. The lower boundary 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 are done at the level of GN divisions**.** The land use data are based on 1:50000 topographic maps prepared by the survey department. Unavailability of the detailed land use map is the main data issue in Sri Lanka and it also limits this research. A study area covers approximately 3745sq.km.and it consists of 2497 sub districts. In Sri Lanka, there is a lack of experience in the studies of spatial distribution of population using GIS. This study has taken as a preliminary effort to enhance the representation and analysis of population distribution in CMR. With the facility of GIS, land use and census data, the study develops a method to generate population surface model for comparison of 2001 and 2011 census population. Further, the use of spatial data analysis investigates spatial associations between land use and population distribution.

5. Methodology

When developing a population surface, the main issue is applying population data into grid cells. As a clarification for that, in 1989, Bracken and Martin applied Inverse Distance Weighted (IDW) method, as a point interpolation technique, to develop population assigned to district centroids, and then interpolate surfaces for census enumeration districts in the U.K. That study pointed out aggregation of population counts assigned on GND centorids.

In 2005, Loi developed an alternative method for developing population surfaces and that study attempts to focus on exploratory spatial data analysis method. According to that it highly focuses on spatial associations between non residential land use and population distribution. The methodology of this study is based on the above concepts with some different modifications. Calculation of population density with avoiding Modifiable Areal Unit problem is a major obstacle of this study.

In this case study concerns only residential land uses to calculate population density of sub districts (GN Divisions). Following formula is used for that.

$$\sum_{ji}^{i} \frac{GND\ population}{Total\ areaj\ -\ non\ residential\ areaj}$$

Secondly a vector grid of 100X100 cell size and its centorids was created. After that calculated population density was assigned only grids represent on residential lands. Non residential grids are assigned only 0 values. This approach facilitates to minimize the modifiable areal unit problem and improve the accuracy of census population disaggregation. Spatial interpolation in ArcGIS 10 was used for generating population surface. Based on the generated population surface further analysis of the pattern of population distribution (2001 and 2011), housing distribution and spatial associations of land use and population distribution in the CMR was done. The following Table 1 shows

Summary Statistics of Population in GNDs
Table 1: Summary Statistics

	GND	Maximum	Minimum	Mean	Stranded
Total	2497	27309	143	2147	2175
Population	2497	54149	4	3036	4930
Built-up Area	2497	6.92	0	0.57	0.54
Non Built-up	2497	31.85	0	1.2	1.67

Based on above 2497 GND's in the CMR population surface was developed and Figure 1 indicates the population density distribution pattern among CMR.

Figure 2 Population Density surface 2001 and 2011

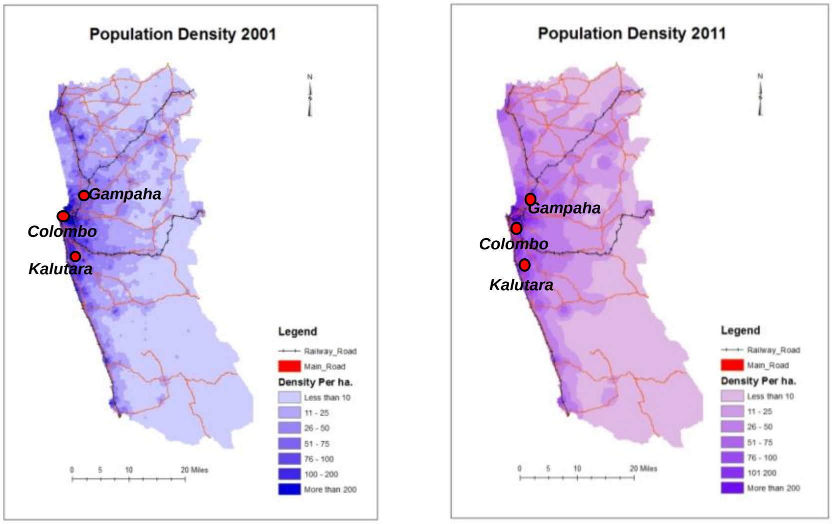
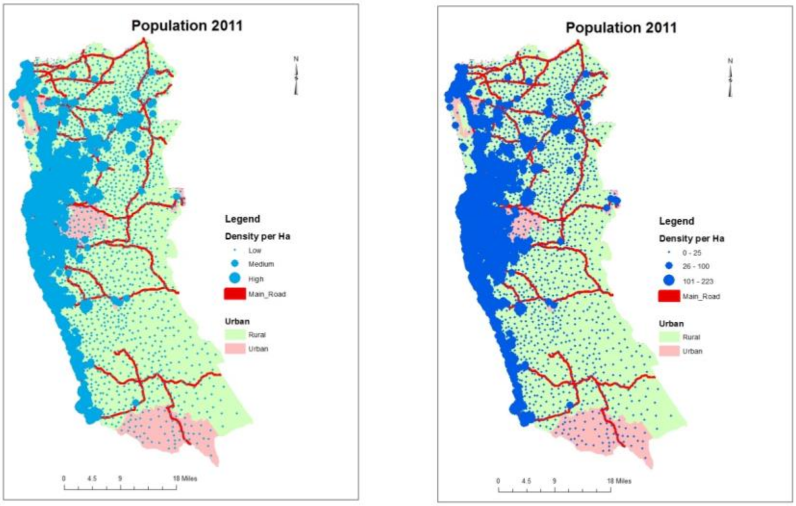


Figure 2 shows that high densities of population are concentrated around their capital cities of CMR, named Colombo Gampaha and Kalutara. Another important point is those high population densities are concentrated near main roads and small town centers. When comparing population distribution in the whole CMR, the majority of the area comprises low population densities like persons less than 10 in ha. Density of more than 200 per ha comprises an area in close proximity to the City of Colombo. Within 20 km meters from the city of Colombo population concentration is high and other areas show a moderate picture. But along main roads connected with other main strategic locations in the country high population densities are seen compared to other areas. It shows an expectation of accessibility to main cities.

Comparison of population density with urban population is another important planning task and this study next focuses on that. This task focuses on the comparison of population density like low, medium and high population density gradient with urban areas and Figure 3 shows that.

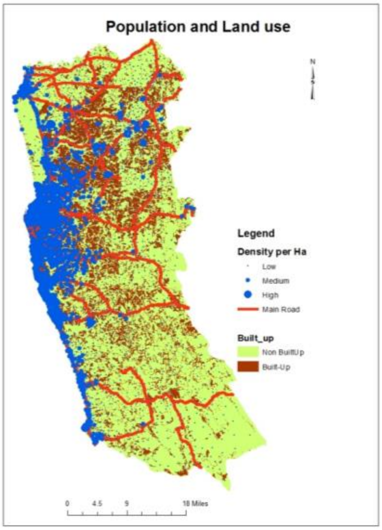
Figure 3 Population distribution in Urban and Rural Areas



Present Sri Lankan urban definition (population in Municipal councils and urban councils) is used for categorizing urban and rural areas. Population density is again recategorized as high, low and medium. Here, low population density means that the population density is less than 25 persons per ha.; medium population density means 26-100 persons per ha. and High population density means that population is more than 100 persons per ha. It is compared with urban and rural local authority areas and it clearly shows the urban definition problem. Therefore the boundaries of urban area should be updated, otherwise we cannot predicate the real picture of our urban areas.

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

Built-up area is in a close relationship with urban population. This suggests that non-built up land uses, from the global view, had significant positive spatial autocorrelations with population density. Therefore next analysis focuses on comparing population density variation of the residential and nonresidential land use. It expects to explore the relationship of spatial associations between land use and population density in exploratory spatial data analysis. There are 20 land uses reclassified into 2 land use factors as built-up and non built-up areas. Figure 4 indicates the above situation and it mainly stresses that most built up land uses are located close to the main road network. It is also significantly noted that higher densities are scattered along the major roads and town centers.



7. Conclusion

The new research agenda in geodemography with GIS faces some problems in MAUP about spatial association with census data. This study takes an attempt to develop some methodologies to avoid that problem. It explores the population distribution among spatial structure in CMR using 2001 and 2011 census data connected with geodemograpgy. The analysis of the data with GIS enables the identification of a population density pattern in CMR. For that purpose, the study has used a simple rationalisation methodology to aggregate census data with spatial data for identification of population distribution. Furthermore, it attempts to develop an analytical framework to investigate the urban population distribution and spatial structure through a flexible scheme of generating population surface. This method seems to avoid MAUP to some extent. Also analysis specifically mentioned that there are some relationships with land use, road network and population density in CMR. This method is specifically developed for some data limitations common in the developing countries. However it can be developed in a more advanced way with availability of data. But this study shows its use with certain data limitations in a developing country's perspective.

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