

# Analysis of the Spatial Distribution Pattern of Urban Population using a GIS-based Approach

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## Abstract

Spatial distribution of population is key indicator of population analysis, which is essential for urban planners and policymakers for planning and controlling urban densities and infrastructure. However, analysts are facing difficulties in obtaining input data for maps, as the required census data are available in report formats. Furthermore, the census data are at administrative boundary levels and show homogeneous distribution of population within the boundaries. Therefore, researchers and policy-makers have been facing the challenge of identifying methodology to show spatial distribution of population. This study attempted to develop GIS based methodology to illustrate spatial distribution of population. The identified methodology was applied to a selected case study area and results illustrate spatial form of urban population over a decade's period.

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**Keywords:** Population Density, Population Surface, Density Analysis, Spatial Distribution

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## Introduction

More than one half of the world population lives in urban areas and urban area can be defined as a location that characterized by high population density and many built environment features in comparison to the area surrounding it (Department of Census and Statistics Sri Lanka, 2013). The global urban population has grown rapidly from 751 million in 1950 to 4.2 billion in 2018 and the urbanization rate increased from 34% in 1960 to 55% in 2018. At the same time, the world average population density increases from 23 people per sq. km. in 1960 to 55 people per sqkm in 2018 (Department of Census and Statistics Sri Lanka, 2013). However, these rates are different from country to country and region to region. Some cities in low fertility countries of Asia and Europe have experienced urban population decline in recent years (Luo and Wei, 2006). Spatial distribution of population refers to the distribution of population in a certain geographical space at a given time, or to the spatial form of population. Population size and population density are the main

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indicators of population distribution and those are used to measure regional differences in population distribution (Department of Census and Statistics Sri Lanka, 2013). Analyze characteristics of population distribution and their patterns are very essential to urban planners and policymakers to plan and control the population densities and infrastructures in urban areas. But they are facing difficulties because census data are in report form and it has some analytical issues. Mainly, it is limited to the administrative boundary and it shows homogeneous distribution of population within the administrative boundary. Therefore, researchers and policymakers have been facing a challenge of how identifies real-world population distribution. But the recent development of Geographic Information System (GIS) has enabled researchers to represent population data with high accuracy using surface model technique (Department of Economic and Social Affairs - UN, 2018a). The surface model which creates continuous spatial distributions from point sampled data accurately represents real-world population distribution than areal unit based representation.

In 2016 Zeande & Jadhav used a surface model to assess spatial-temporal variations and pattern of population density in, western Maharashtra. Other worldwide researchers have used various quantitative methods, theories and models to analyze population distribution patterns. Such as the Clark model, the index model, density gradient, gravity model and the demographic transition model. Most recently conducted researches have identified spatial distribution and changes of urban population distribution (Department of Census and Statistics Sri Lanka, 2013; Weerakoon, 2013, 2016; Vyas and Shukla, 2017; Department of Economic and Social Affairs - UN, 2018a).

There are lack of spatial distribution of population studies in the Sri Lankan context. In 2013, Weerakoon conducted research to analyse spatial distribution in population in the Colombo district and this research create different population-zone-categorization based on the population distribution pattern and growth rates. It shows clear population decline in the core city. Further, in 2017 this study extend up to zone analysis using surface modelling in ArcGIS. That research used surface model to represent population distribution pattern in the Colombo Metropolitan Region with desegregating land use data. Apart from that there are lack of studies analysed population using surface modelling techniques. Therefore, this research aims to fulfill this gap and address to develop method for analyse spatial distribution of population using census data and administrative boundaries.

### **Objectives of the Study**

Main objective of this study is develop methodology to analysis of spatial distribution of urban population and housing data using surface modelling techniques in GIS.

### **Data and Method**

This study is based on secondary data and 2001 and 2012 census data used for that. GND boundary based shape files developed by Survey Department of Sri Lanka used to locate this data in spatial manner. GND based centroid created point data for spatial interpolation. Accordingly Population density maps and housing density maps of 2001 and 2012 (Department of Economic and Social Affairs - UN, 2018a, 2018b) were created using

population surface modeling technique through the IDW tool of Arc GIS 10.1. Then those maps are reclassified and converted to vector format to calculate the areas of each density category. This method is quite different from other researches methods whereas it uses only built up area for calculation and it is new methodological approach introduced through this research.

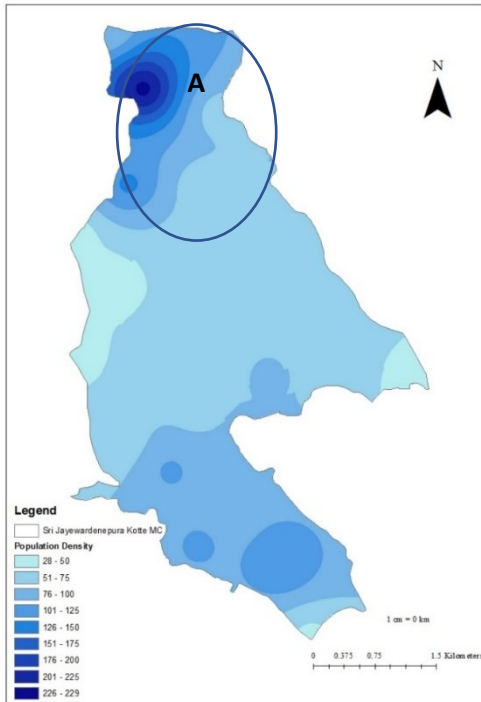
### **Study Area**

Administratively, Colombo District is divided into twelve local authorities, which consist of five Municipal councils, four Urban councils and three local councils. Each local authority is divided into small administrative units such as Grama Niladari Divisions. Out of five municipal councils four municipal councils shows negative population growth rate in 2012. Sri Jayawardanapura Kotte municipal council is one of the MC's shows negative population growth rate and it considered as case study area. Sri Jayewardenepura Kotte Municipal Council area is bounded on the north by Kolonnawa Urban council, North-East by Kotikawatta- Mulleriyawa Pradeshiya sabhctare area, East by Kaduwela MC, southeast by Maharagama UC, West by Colombo MC and South West by Dehiwala Mount Lavinia MC. It covers 1647.175 hectares of land area. Total population is 116,366 in 2001 and it decreased to 107,925 in 2012. GND based 2001 and 2012 population data and housing data used for the analysis.

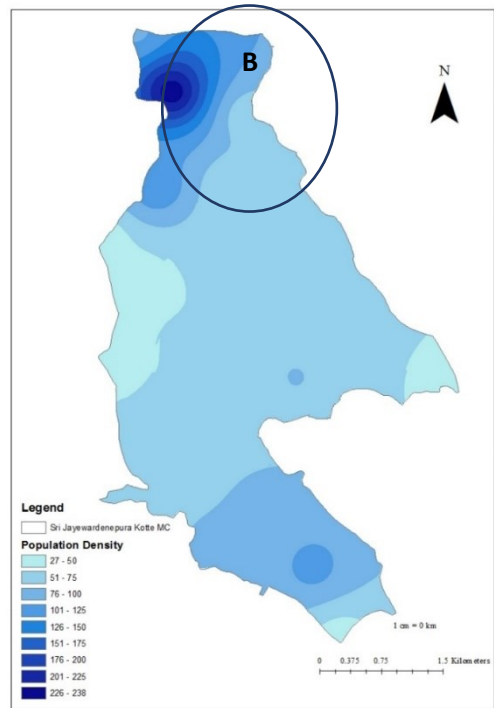
### **Data Analysis**

Figure 1 shows the population distribution pattern of Sri Jayewardenepura Kotte MC in 2001. Minimum population density is 28 persons per hectare and maximum population density is 229 persons per ha. Average population density is 78 persons per ha. As the map shows the population is centralized to north part of municipal council and density is decreasing when distance is increased from town center. East and west parts have lowest density. It is varying between 28-50 persons per ha. In Sothern, part population density is comparatively higher than the middle part of the municipal council. Figure 2 illustrates the spatial distribution of the population in Kotte MC in 2012. As map shows minimum density is 27 persons per hectare and maximum population is 238 persons per ha. Average population density is 72 persons per ha. In 2012, highest population density is recorded in upper part of municipal council.

**Figure 1: Spatial distribution of Population in 2001**



**Figure 2: Spatial distribution of population in 2012**



Source: Census data 2001 and 2012

Middle part population density is shown as 51-75 persons per ha. West and East corners recorded lowest density areas. It is between 27-50 persons per ha. Southern area population density is comparatively high than middle part of municipal council. In north area shows gradually decreasing pattern of population when increased distance from town center.

When compared 2001 and 2012 population distribution, minimum population density is decreased to 27 persons per hectare from 28 persons per ha. Maximum density increased from 229 persons per hectare to 238 persons per ha. It is a very small decrement. The average density is decreased to 72 persons per hectare from 78 persons per ha. Table 1 compares the population distribution pattern of 2001 and 2012.

**Table 1: Changing percentages of different density categories**

Population Density(Persons per ha)	Land Area (Ha) 2001	Land Area (Ha) 2012	Change from 2001 - 2012	Changing Percentage
27-50	119	167	48	28.7%
51-75	863	995	132	13.26%
76-100	406	296	-110	-37.16%
101-125	170	95	-75	-79%
126-150	37	37	0	0
151-175	21	21	0	0
176-200	15	15	0	0
301-225	14	18	4	22.22%

According to that density ranges of 27-50, 51-75 and 301-225 show area increment from 2001 to 2012. Those percentages are 28.7%, 13.26%, and 22.22% respectively. Those increment show in lower density rangers of 27 to 75 and highest density range of 301-225. Areas in the density range of 76-100 and 101-125 show minus growth. Those are -37.16% and -79% respectively. From 126 to 200 density range are not show any area changes. Those areas stay constantly without any change in population distribution. Following Figure 3 and Figure 4 represent these variations

**Figure 3: Minus growth areas in 2001**

**Figure 4: Minus growth areas in 2012**

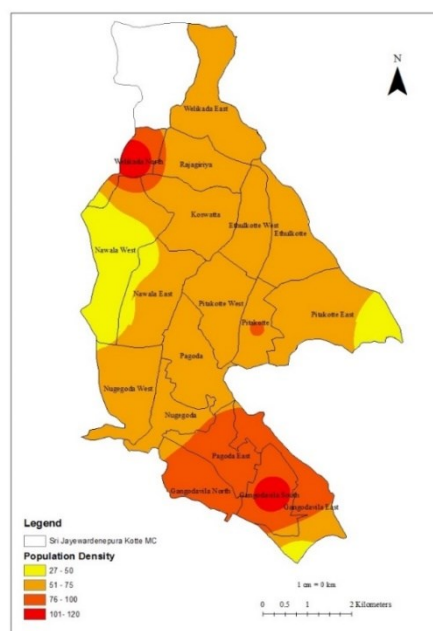
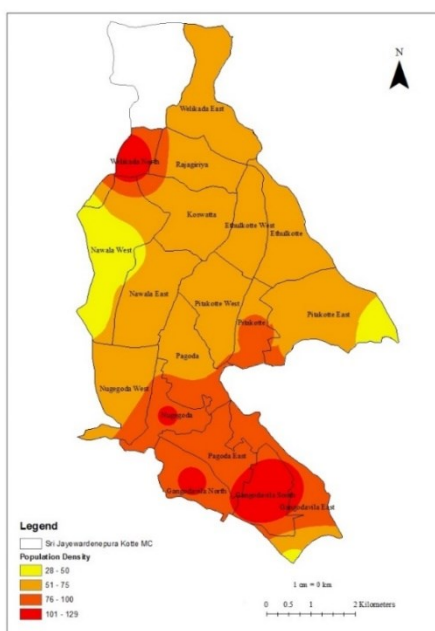


Figure 3. represents minus growth areas in 2001. According to that map Nawala West, East corner of Pitakotte East and South corner of Gangodawila East show minimum population in between 28-50 persons per ha. Within these same GND show various densities. Other areas of these three GNDs have population density in between 51-75 persons per ha. Welikada North, Nugegoda, Center of Gangodawila North and south have the highest population density. Pitakotte east and surrounding area have population density in between 76-100 persons per hectare and rest of the areas in GNDs' of the municipal council have population density in between 51-75 persons per hectare category.

Figure 4. illustrates the minus growth areas in 2012. As the map shows Wekanda North GN division population density is very high. Pitakotte GN division population density is decreased to 51-75 density category from 76-100 density category. Aholu Nugegoda GND population also decreased to 51-75 category from 76-129 persons per hectare range. Rest of the GNDs' vary between 51-75 density category from 2001 to 2012

### Conclusions

GIS surface analysis effectively use for show spatial distribution of the population densities among the area. In methodologically it is good method for illustrate population density variations. Based on the population surface analysis study finally concluded people are centralized to North part of Sri Jayewardenepura Kotte Municipal Council. Because that area is much closed to high-density area which located in Colombo municipal council. Southern part also shows little high density than surrounding area. The reason is town center of Dehiwala MC is located near to this area. When comes to middle part of municipal council, it has very low population and housing density. The main reason for that is, Kotte area has high demand for office use. Most of the government and private offices located in this area. From 2001 to 2012 population distribution pattern is not shown big difference. But the area located in southern part shows population decrement due to high development activities.

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