International Cartographic Association
Association Cartographique Internationale

Evaluating data classification methods for choropleth maps to visualise geographic accessibility in South Africa: A usability study

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Keywords: usability, data classification, choropleth map, population demand, geographic accessibility, South Africa

Abstract:

Geographic accessibility is all about supply and demand. Knowing where the population demand is enables government and policy makers to identify optimal locations for the positioning of facilities or service centres (which are close and accessible to citizens) to improve service delivery. Communicating or presenting results derived from a geographic accessibility analysis in a clear and effective way is just as important as the results. The effectiveness of the visualisation of the results depends on factors such as the purpose of the analysis, the intended target audience and the complexity of results. The inclusion of graphics such as maps or charts, (as powerful as they are), has the potential to mislead or confuse the audience if not done properly and according to good practice.

This study will expand on earlier work by the Department of Public Service and Administration (DPSA) which developed a practical step-by-step guideline for improving geographic access to government service points (DPSA 2021). Although the guideline was comprehensive regarding developing access standards, collecting and using quality geospatial data, conducting the accessibility study and developing an implementation strategy, little attention was given to the visualization of results.

Current geographic information system (GIS) applications have a plethora of spatial analysis and visualization tools which allow users to conduct sophisticated geographic accessibility studies. One of the most frequently used map types to visualize quantitative data in a GIS is choropleth maps (Tyner 2014). A choropleth map is a simple and easy to use technique to classify and visualize data for statistical areas (Tyner 2014), such as enumerator areas or wards. Choropleth maps are also frequently used to analyse and display the spatial distribution of population demand in order to measure and visualize geographic accessibility to service centres such as health care facilities. One of the challenges associated with choropleth maps is choosing a suitable data classification method (Slocum, McMaster et al. 2014) to display results in a clear and effective way. The wrong data classification method could highlight wrong or inappropriate locations for the optimal positioning of service centres, which in turn will lead to poor service delivery and dissatisfied or frustrated citizens.

The aim of this research is to develop a set of good practices for professionals who need to conduct geographic accessibility studies and present population demand to a specific target audience such as government officials or policy makers. In order to understand which data classification method(s) is/are suitable to effectively visualise population demand with choropleth maps, specifically within a South African context, a usability study will be conducted. The research objective is divided into three parts. Firstly, a series of choropleth maps will be created for selected local and metropolitan municipalities in South Africa, based on seven commonly used data classification methods (equal interval, quantiles, standard deviation, natural breaks, geometric interval, logarithmic scale and pretty breaks), and for three geographical units, including both equal and variable sized polygons, namely census small areas, census sub places and hexagons. Small area layer (SAL) polygons are the smallest building blocks with demographic data for both households and individuals. Sub places are aggregated polygons derived from SALs. Both data sets are created and maintained by Statistics South Africa (https://www.statssa.gov.za/). Population data will be proportionally distributed to the hexagons.

Secondly, classification methods that are not fit for purpose, i.e., where population demand is not clearly visible on the map, will be eliminated and excluded from the usability study. Figure 1 shows an example of two choropleth maps depicting population demand per SAL polygon for the Buffalo City Metropolitan Municipality. Equal interval classification was used for the map on the left and geometric interval classification for the map on the right. The equal

Abstracts of the International Cartographic Association, 6, 241, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
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interval classification method does not reflect the actual geographic distribution of the population and would lead to underestimating the population demand. This map was therefore excluded from the usability study.

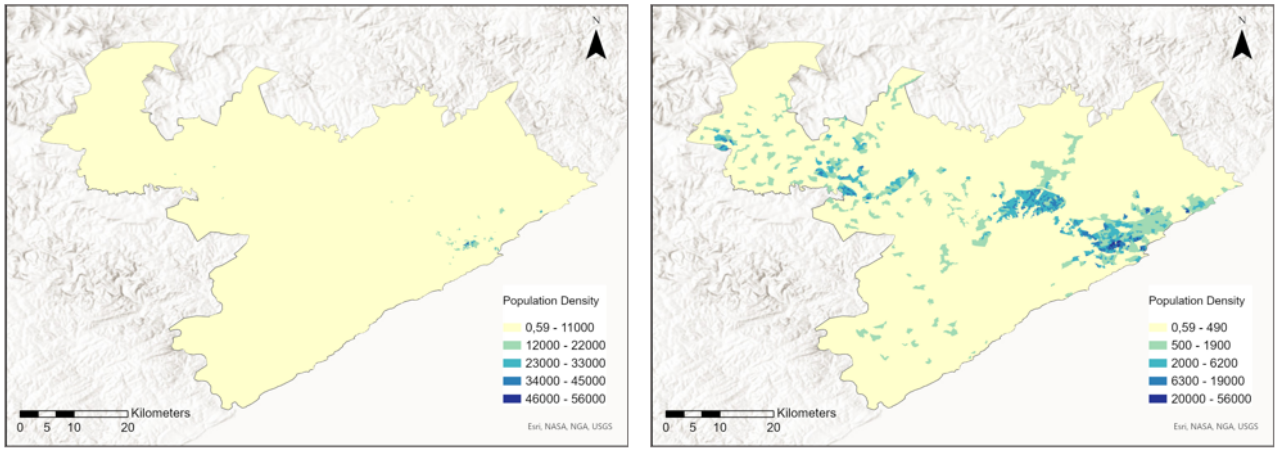

Figure 1. Choropleth maps depicting population demand for Buffalo City Metropolitan Municipality

Lastly, the effectiveness of the remaining data classification methods will be evaluated with an online usability questionnaire, similar to what others have done for epidemiological rate maps in the USA (Brewer and Pickle 2002), population density maps in the Special Region of Yogyakarta (Afifah 2019) and visual perception of spatial patterns in choropleth maps, United States (Schiewe 2019). However, our study is unique in the sense that it will focus on geographic accessibility to service centres in South Africa, where settlement typologies are highly diverse and dynamic. The political past of the country influenced the current unique and distinctive geographic distribution of urban, farm and traditional spaces. Also, the effectiveness of data classification methods for choropleth maps has never been evaluated for a South African target audience.

Participants (students with and without prior experience in geography and GIS) will be required to answer a series of questions, grouped into three categories. The first category captures general demographic information of participants such as age, gender, academic background, technical efficiency levels, etc. The second category is designed to test map literacy and spatial orientation skills with questions related to distance, direction and general identification of map objects. These questions establish a map literacy baseline for each participant. In the last category, questions are specifically related to geographic accessibility. Choropleth maps showing population demand based on the different data classification methods and geographical units will be presented to the participants. They will be required to identify optimal locations for new service centres in areas without any centres (greenfields approach) and in underserved areas in relation to the current footprint of centres (brownfields approach).

The presentation will show the suitability of each data classification method and geographical unit to effectively visualize population demand in South Africa with choropleth maps. Results emanating from the online usability questionnaire will inform the set of good practices for professionals for population demand in geographic accessibility studies. However, the results will also be useful for professionals who prepare choropleth maps in other applications, e.g., at the Electoral Commission of South Africa (voter registration and election results) and Statistics South Africa (census results).

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