# Spatial Measurement of Residential Segregation in Metropolitan Cape Town

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## Abstract

Residential segregation has been studied for more than half a century, due to the negative impact this phenomenon has on the cohesive development of urban societies and integrated infrastructure. Consequently, the measurement of segregation in the city has received increasing attention, with a focus on spatial segregation indices, which allow the study of spatial distribution of population groups. This paper focuses on the spatial distribution of racial segregation in Cape Town through the application of global and local spatial segregation indices.

**Keywords:** Racial segregation, Spatial Segregation Indices.

# 1. Introduction

Residential segregation has been studied and measurements applied in the urban environment for more than half a century, due to the negative impact segregation has on the cohesive development of urban societies and integrated infrastructure. The application of segregation indices allows for the analysis of segregation patterns and the formulation of a better understanding of segregation process in space. This paper studies the spatial distribution of racial segregation in Cape Town through the application of global and local segregation indices and the analysis of the results.

# 2. Indices of Residential Segregation

Residential segregation was conceptualised by Massey and Denton (1988) as five distinct dimensions: evenness, exposure, clustering, centralisation and concentration. Reardon and O'Sullivan (2004) proposed an alternative to these dimensions, as they argued that spatial residential segregation consists of two primary conceptual dimensions: spatial exposure or spatial isolation and spatial evenness or spatial clustering. Spatial exposure refers to how individuals of one group encounter individuals from another group or individuals of their own group (spatial isolation). Spatial evenness or clustering proposes the degree to which different groups are distributed in a residential area. Reardon and O'Sullivan (2004) pointed out that the evenness and clustering dimensions are collated into a single dimension and that the exposure dimension remains unchanged, but now conceptualised as spatially explicit.

Feitosa et al. (2007) built on the dimensions of spatial segregation by Reardon and O'Sullivan (2004) and developed spatial indices (generalized spatial dissimilarity index, the spatial exposure index, the spatial isolation index and the spatial neighbourhood sorting index ) for each of them. As foundation the notions of "*locality*" (locations in which individuals live) and "*local population intensity*" ("a geographically-weighted population average that takes into account the distance between groups", 2007:9) were applied. Hence, the local population intensity is calculated with a kernel density estimater and a bandwidth and distance decay specified by the user.

Feitosa et al. (2007) presented the following equation for the local population intensity of a locality:

$$\check{L}_j = \sum_{j=1}^{J} k(N_j)$$

Equation 1

With $N_j$ the total population in the areal unit *j*; *J* the total number of areal units in the study area and *k* the kernel estimator that estimates each areal unit's influence on the locality *j*.

Feitosa et al. (2007:15) proposed local indices that will indicate to what degree each locality makes a contribution to the global measure of segregation of the city and consequently, the Local Dissimilarity Index, Local Spatial Exposure Index and Local Spatial Isolation Index were developed.. Hence, local indices are provided in a way suitable for mapping and visualising extents of segregation. The output of the local spatial dissimilarity index ranges from 0 to 1, with 0 indicating a minimum degree of evenness and 1 a maximum degree of evenness. The formula for the index is presented by (Feitosa et al. (2007) as follows:

$$\check{d}_j(m) = \sum_{m=1}^{M} \frac{N_j}{2NI} \left| \check{\tau}_{jm} - \tau_m \right|$$

Equation 2

Where

$$I = \sum_{m=1}^{M} \tau_m \left(1 - \tau_m\right)$$

Equation 3

And

$$\check{\tau}_{jm} = \frac{\check{L}_{jm}}{\check{L}_j}$$

Equation 4

In the first two equations above, $N$ represents the total population of the city, $N_j$ the total population of aerial unit *j*, $\tau_m$ the proportion of a certain group m in the city, $\check{\tau}_{jm}$ the local proportion of population group $m$ in the locality $j$, $J$ the total number of areal units in a study area and $M$ is the total number of population groups considered. In the third equation $\check{L}_{jm}$ represents the local population intesity of population group $m$ in locality $j$.

The local spatial exposure index of population group m to n is as follows and ranges again between 0 for minimum exposure and 1 for maximum exposure:

$$\check{p}^{*}_{j(m,n)} = \frac{N_{jm}}{N_m}\left(\frac{\check{L}_{jn}}{\check{L}_j}\right)$$

Equation 5

With $N_{jm}$ the total of population group m in areal unit $j$, $N_m$ the population of group $m$ in the study area, $\check{L}_{jn}$ the local population intensity of group $n$ in locality $j$ and $\check{L}_j$ the local population intensity of the locality $j$.

In consideration of the local spatial exposure index, the local isolation index will effectively be as follows and ranges from 0 (minimum isolation) to 1 (maximum isolation):

$$\check{q}^{*}_{j(m)} = \frac{N_{jm}}{N_m}\left(\frac{j(\check{L}_{jm})}{\check{L}_j}\right)$$

Equation 6

where $j(\check{L}_{jm})$ is the local population intensity of group $m$ at the locality $j$

With reference to the new segregation indices proposed by (Feitosa et al. (2007), the above three indices were calculated for the case study area of Cape Town and the results analysed and discussed.

# 3. Spatial Segregation in Cape Town

For the application of segregation measurements to the study area, the most recent census data (2011) for Cape Town is used (Statistics South Africa, 2012). This study focuses on population group (racial) segregation in Cape Town and focusses on the Black African, Coloured, White and Indian/Asian population groups. The areal units selected are represented by the Small Area Layer (SAL) census tracts for Cape Town (Figure 1). The SAL census tracts are the smallest census tracts available for study and reflect a mean population size of 685 people per census tract for the 2011 census. These census tracts were then cropped to the extent of the urban development edge of Cape Town and the gaps in the layer indicate areas where no population was recorded, such as vacant land and conservation areas.

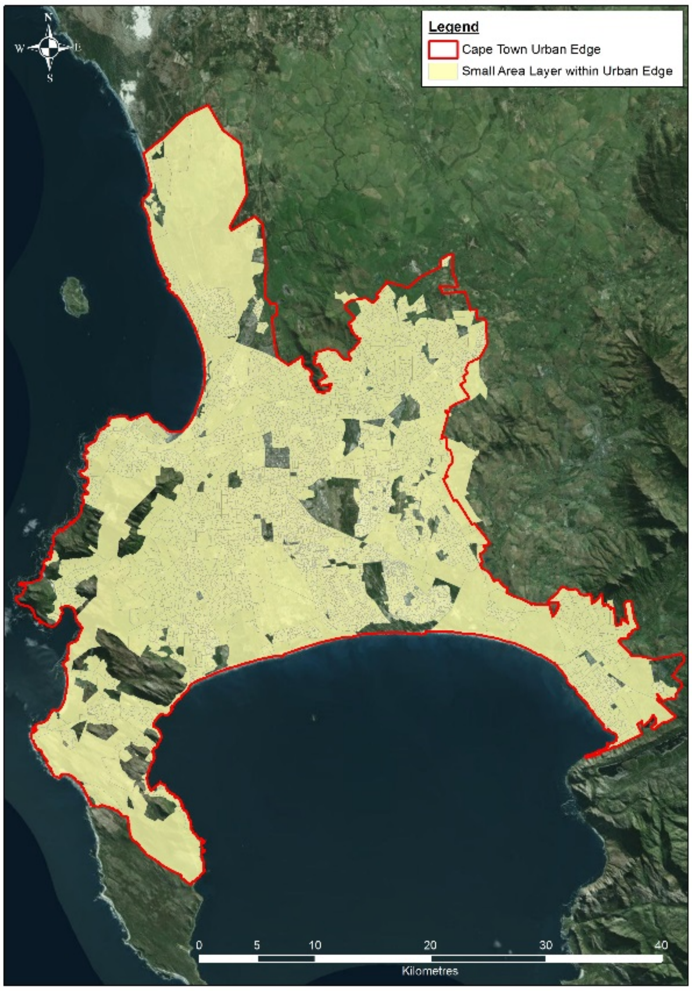


Figure 1: Census Tracts Cropped to Urban Edge

The local segregation indices were then applied to the study area and are discussed in the following sections. Segregation measurement outputs are only presented at the bandwidth of 1000 metres, due to the fact that very clear distribution patterns were obtained at this bandwidth. However, eight further bandwidths between 400 metres and 5600 metres were calculated to identify distributional changes between these bandwidth outputs.

## 3.1. Local Dissimilarity Index

The local dissimilarity index was computed to study the results of population group distribution in the study area. It is evident from Figure 2 that the dissimilarity index highlights the occurrence of clusters of population groups that reflect high levels of dissimilarity, but also areas with a much lower degree of dissimilarity. The highest levels of dissimilarity are found in the predominantly White neighbourhoods in the north, the predominantly Coloured neighbourhoods in the centre and south-east of the study area and Black African neighbourhoods to the south. Dissimilarity is lowest to the west, south-west and east of the study area. This can be assigned to the fact that these particular areas of Cape Town reflect high levels of diversity in population groups, with all races represented more equally in these neighbourhoods.

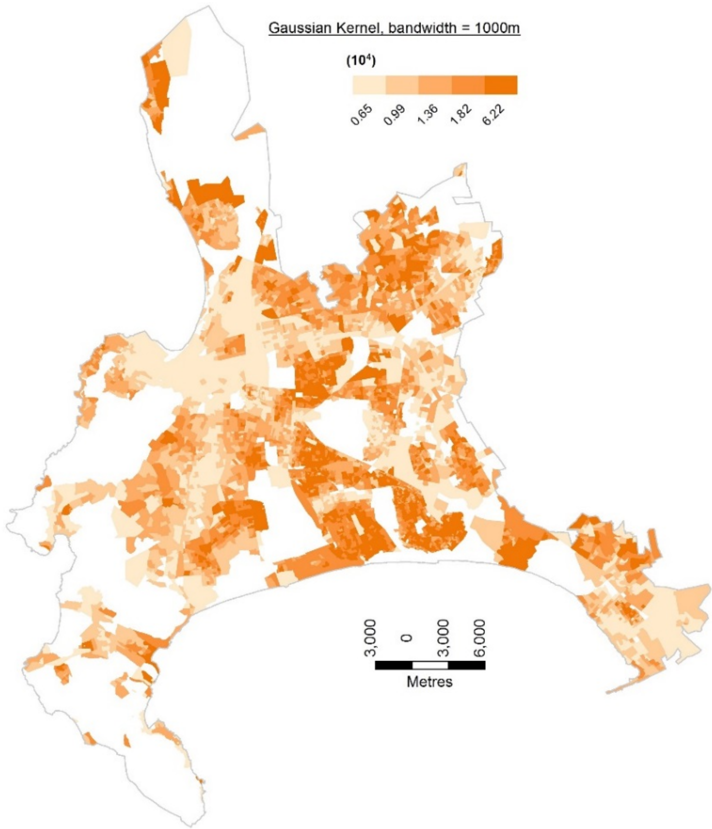


Figure 2: Local Dissimilarity Index for Cape Town - Gaussian bandwidth 1000m

## 3.2. Local Spatial Isolation Index

The local spatial isolation index was calculated for each population group and Figure 3 shows the four map outputs. For the Black African population group (top left) maximum isolation occurs to the south of the study area, where the Black African population also makes up the highest percentage of inhabitants. For the Coloured population group (top right) maximum isolation is found across a large area towards the centre and south of the study area. The local isolation map for the Indian/Asian population group (bottom left) shows a concentrated area to the west of the study area. The White population group (bottom right) shows maximum isolation to occur predominantly at the urban fringe to the north, west and south-east of the study area. When these four maps are considered collectively, it is evident that patterns of isolation between different population groups hardly overlap. This occurrence emphasizes the fact that areas with a high level of isolation of a particular group also reflect a high level of absence of individuals from all other population groups.

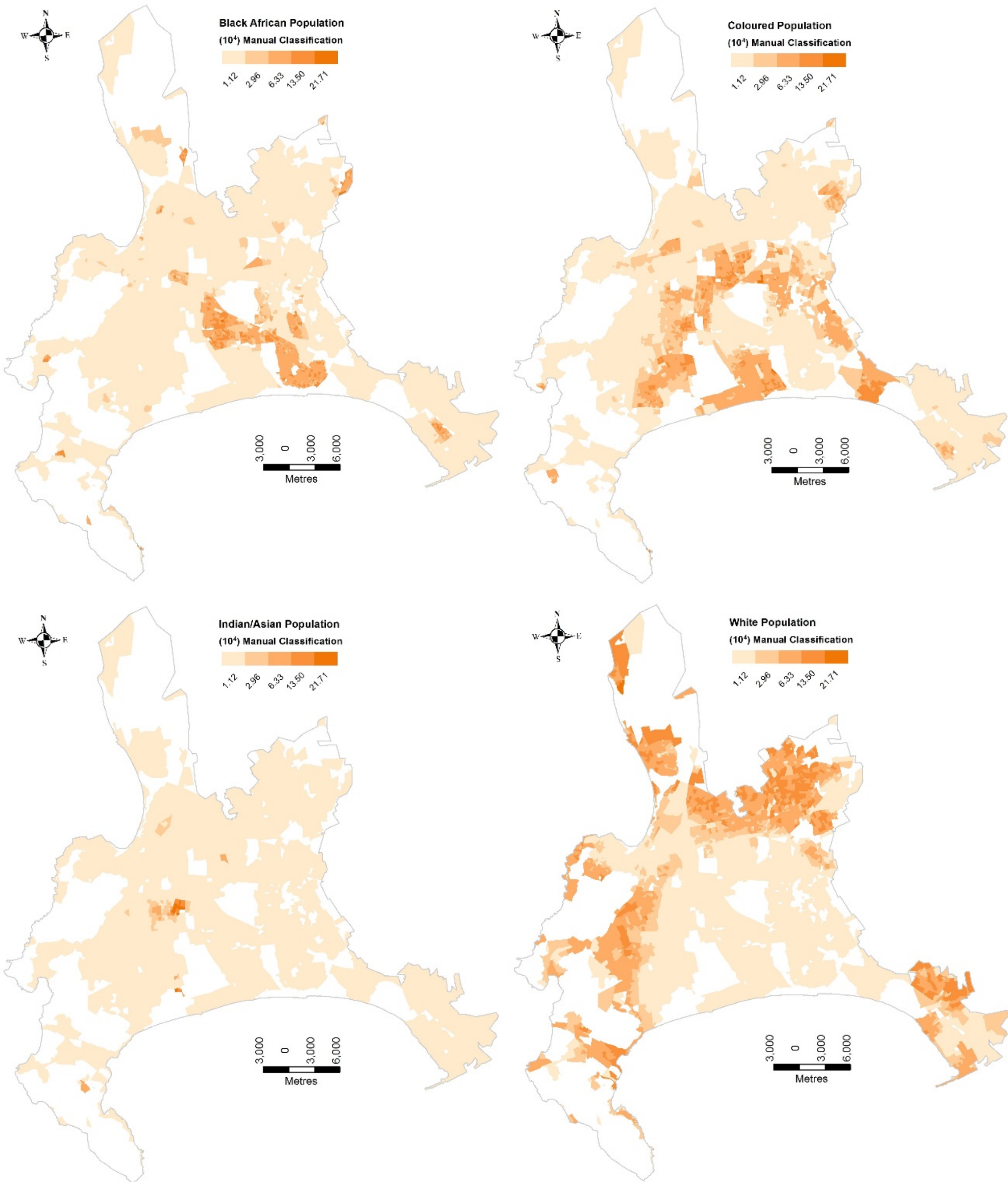


Figure 3: Local Spatial Isolation Index - Gaussian bandwidth 1000m

## 3.3. Local Spatial Exposure Index

The local spatial exposure index was computed for the population groups in the study area and Figure 4 shows the output of measurements for the two largest population groups (Coloured and White). Considering the map (left) showing exposure of Coloured individuals to the White population group, the level of exposure is highest to the north and west of the study area. This occurs due to the composition of population groups in these areas reflecting relatively equal numbers of Coloured and White inhabitants. In contrast, exposure is lowest to the central and southern parts of the study area, due to the fact that these areas are occupied predominantly by Coloured and Black African inhabitants respectively. Exposure of the White to Coloured population group (right) shows similar patterns in general to the map of Coloured to White population exposure. This is to be expected, due to the proportion of individuals from the White and Coloured groups being similar. However, a larger number of areas reflect high exposure levels, especially in predominantly White neighbourhoods to the south-west (Marina Da Gama) and south-east (Greenways) of the study area. Marina Da Gama is situated along waterways in the suburb of Muizenberg and 81% of inhabitants are White, compared to a 12% Coloured population group. Greenways is a neighbourhood of the suburb of Strand and has a population of 84% White and 8% Coloured. The lowest levels of White to Coloured population exposure is again found to the centre and south of the study area.

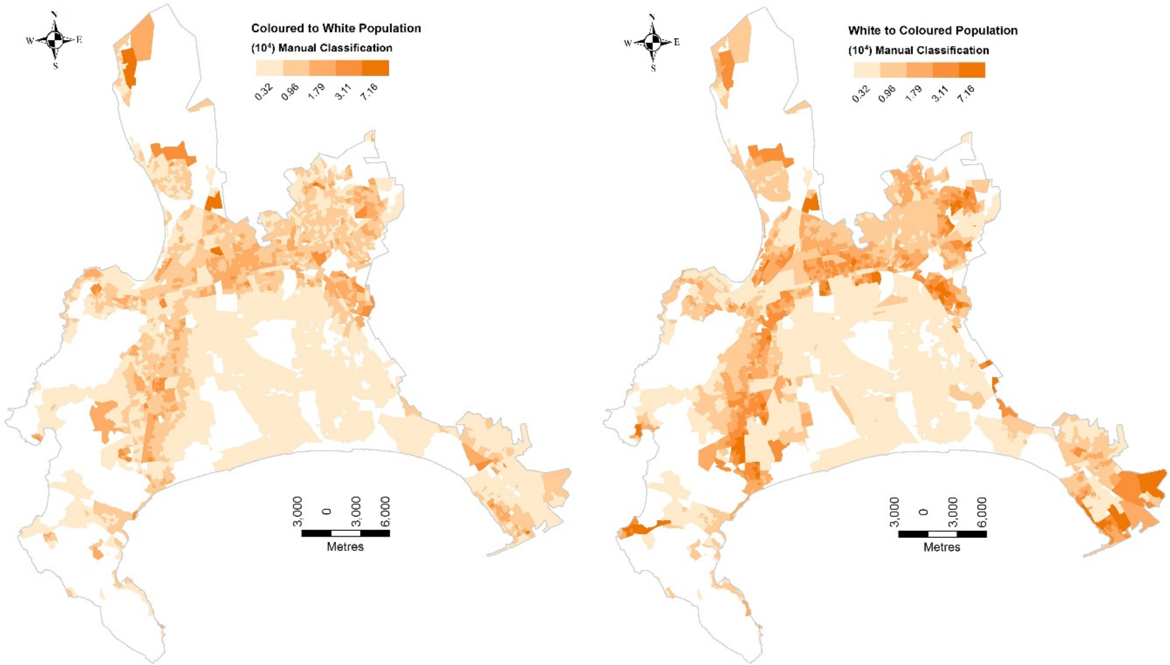


Figure 4: Local Spatial Exposure Index - Gaussian bandwidth 1000m

## 4. Conclusion

The application of the local spatial segregation indices by Feitosa et al. (2007) to the study area of Cape Town not only provides for the measurement of population group segregation at a local neighbourhood scale, but is also sensitive to space and considers the interaction of population groups across census tract boundaries. The measurement of local dissimilarity enabled the identification of clusters of population groups reflecting high levels of dissimilarity, which would not be evident through non-spatial measurement techniques. The local spatial isolation index for the study area highlighted distinct patterns of isolation for each population group and emphasized that the neighbourhoods with most isolated population groups reflects an absence of any other population group. The measurement of exposure of the Coloured to White and White to Coloured population groups at a local scale not only revealed areas where most exposure occurs between these two groups, but also areas of very low or no exposure which indicated where either one or both groups area absent. Through the application of local indices of segregation, it was possible to measure the intensity of segregation at various localities in Cape Town.

## 5. Acknowledgements

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