

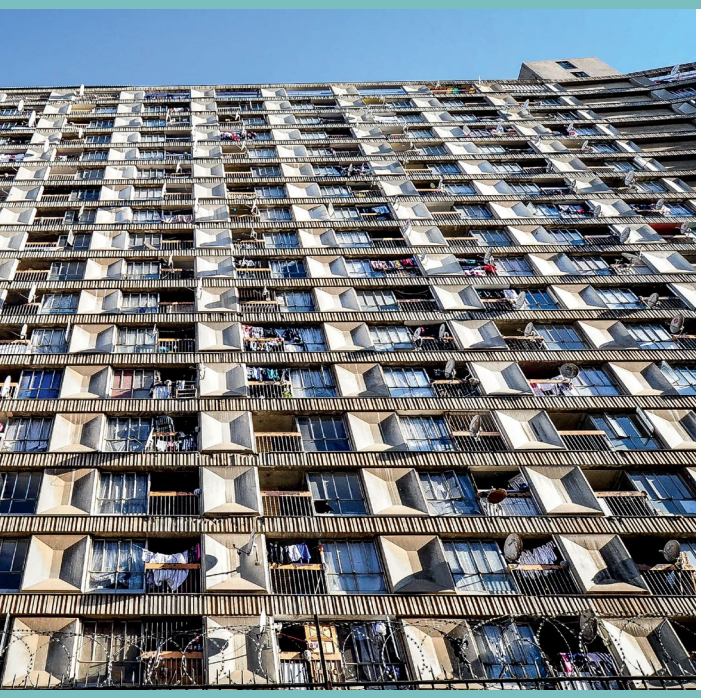
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GCRO OCCASIONAL PAPER
NO. 21

An analysis of microscale segregation and socio-economic sorting in Gauteng

APRIL 2024
Author: Christian Hamann

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With a background in urban planning and human geography, Christian does research on a variety of urban geography topics, including segregation and spatial transformation in the Gauteng City-Region as well as processes that enable social mobility. His applied geography research aims to inform urban policy development.

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Photograph by Mark Lewis



Abstract

Abstract

Apartheid was the way in which the white minority government in South Africa controlled access to urban opportunities. It was done by classifying people into race groups, and segregating residential areas according to these racial groups. As a result of the racially differentiated access to urban opportunities, a strong association between race and income developed over time in which white areas were wealthy and black African areas were working class. Once statutory segregation regulations were removed in 1991, an important question in urban studies was to what extent, and at what scale, racial desegregation would reshape the post-apartheid urban landscape. This question remains relevant today.

Research has shown that substantial racial-residential desegregation has taken place in some neighbourhoods while other neighbourhoods remain homogeneous. It is also clear that the affordability of accommodation influences segregation patterns. More affordable housing, in townships, informal settlements and public housing developments, tends to have low racial diversity. Middle- and upper-class housing tends to be associated with substantial racial desegregation.

This Occasional Paper analyses racial segregation and socio-economic sorting in Gauteng. It confirms many of the same findings of previous research on post-apartheid segregation and desegregation. In this study, a specific microscale analysis is added to the existing knowledge of segregation and socio-economic sorting patterns in Gauteng. A microscale representation of segregation is an important lens through which to view progress toward spatial transformation; it reveals how factors, such as residential expansion, the property market and the character of neighbourhoods, influence racial segregation and socio-economic sorting.

This research includes three points of inquiry with regard to racial-residential segregation and socio-economic sorting in Gauteng.

The first considers the relationship between racial diversity and residential expansion. Between 1990 and 2020, the residential footprint of Gauteng increased by roughly 905 km^2. The study investigated whether residential growth contributes to desegregation or perpetuates segregation. The analysis shows that areas of residential expansion tend to reproduce the racial composition of the areas from which they expanded. However, public housing programmes and inclusionary housing policies hold significant potential for desegregation at multiple scales.

The second inquiry of this study analyses the extent to which racial mixing contributes to class mixing and income equality in desegregated neighbourhoods. In South African cities, middle-class neighbourhoods have been celebrated for becoming racially integrated. However, behind this undoubtedly important transformation, this study finds a largely unrecognised feature: in racially mixed wards, the mean household income of the white residents is significantly higher than the mean household income of black African residents. Income inequality in neighbourhoods therefore remains high despite considerable racial desegregation.

Segregation in post-apartheid Gauteng is closely related to inequality

The third inquiry is concerned with patterns of microscale socio-economic sorting in desegregated neighbourhoods, and specifically how this is associated with the housing characteristics that shape neighbourhoods. The analysis is able to illustrate how the affordability of housing and the social character of neighbourhoods influences socio-economic sorting.

Together, the three inquiries highlight continued segregation, but also nuances in the nature of desegregation in the Gauteng province at macro- and microscales. Macroscale analysis in Gauteng shows that racial-residential segregation continues to happen in and around townships and is associated with low-cost housing developments. Desegregation is evident in the central suburban areas and is associated with mostly middle- to high-income housing. Although significant racial-residential desegregation has taken place in former whites-only neighbourhoods, the association between space and class in Gauteng has not changed significantly and spatial transformation is slow. The local-level, data-driven analysis reveals that desegregation is uneven in some neighbourhoods and the socio-economic sorting happens based on the characteristics (including quality, quantity and affordability) of the available housing stock.

The research argues that a multiscalar view of segregation and socio-economic sorting is essential to understand urban form and function. Microscale analysis reveals both barriers and opportunities for future spatial transformation. Residential expansion, whether by the public or private sectors, should be strategically driven with diversified housing at different affordability levels, while neighbourhood-level developments should foster socio-economic inclusion. In this way, desegregation and socio-economic integration are facilitated at different geographic scales and more equitable access to opportunities in the city is enabled.

Headline findings

- A key concern for this segregation research is the uneven distribution of opportunities in urban space.
- Segregation in post-apartheid Gauteng is closely related to inequality, which is continually reproduced by many urban growth patterns, despite desegregation taking place in many former whites-only neighbourhoods in the province.
- Areas of urban expansion tend to reproduce the racial diversity of the areas from which they expanded. Of the Gauteng population who live in residential areas that developed after 1990, 80% live in areas that have less than 10% of the maximum possible racial diversity. The overwhelming majority of new residential areas have very low racial diversity.
- New housing developments (public and private) have the potential to reshape patterns of segregation and create the potential for integration on the urban frontier, but only if they are strategically located and designed to include housing opportunities for a variety of income groups.
- In many suburban parts of the Gauteng province, increases in racial diversity are directly related to increases in townhouse, cluster complex and semi-detached housing developments. These housing developments are inhabited by middle- to upper-income households.
- In racially mixed wards, the mean household income of white residents is significantly higher than the mean household income of black African residents, signalling racial integration without greater equality in socio-economic status between white and black African residents.
- Affordable housing is associated with racial desegregation whereas the upper end of the housing market is slow to desegregate.



Photograph by Christian Hamann



Introduction

Introduction

Cities offer many opportunities and challenges. Opportunities include economies of scale, employment, availability of high-level basic services, social support networks and the fact that residents can access all the urban amenities offered by the city as a whole. Challenges include segregation, inequality, overcrowding, pollution and various socially produced issues such as social discontent, crime, violence and unrest.

Segregation – which is the spatial separation of population groups in a city – is a significant challenge to equality of opportunity. Residential location influences how residents are able to access and utilise the opportunities in a city because these opportunities are spatially embedded in specific locations. Residential location directly affects access to social networks, transport, education, amenities, employment opportunities and many other factors that contribute to higher quality of life. Therefore, segregation can be associated with negative spatial, economic and social outcomes such as racial inequality, unequal access to opportunity and low prospects for social mobility for residents who are confined to low opportunity spaces (Chetty et al., 2022; Charles, 2003).

Racial-residential segregation was a specific goal of the South African government until 1991 and residents were compelled to live in neighbourhoods designated for them based on their racial or population group classification. The result of apartheid[1] was substantial levels of racial and spatial inequality that continue to characterise the post-apartheid urban structure. To this end, urban policy in South Africa considers spatial transformation and desegregation to be essential. The National Development Plan (NDP) outlines spatial justice as a key principle for spatial development with the ultimate goal of reversing spatial fragmentation and ensuring that no social group is confined to limited space or places of limited opportunity as they were in the past. The NDP acknowledges that segregation is related to uneven access to public resources, increased transport costs and decreased opportunity for upward social mobility. The NDP also suggests that spatial transformation that addresses segregation can help to reduce poverty and inequality (National Planning Commission, 2011). Other policies and plans have followed suit in naming integration and spatial transformation as important goals. Examples include the Integrated Urban Development Framework of 2016 and the National Spatial Development Framework of 2019. Despite the reality of the problem and the redress efforts, the question of whether we are seeing integration over time, or continued segregation, remains current.

Urban development since the end of apartheid, both public and private, has had contradictory effects. Some developments have reproduced race and class segregation while others have disrupted it. These effects are visible in different ways at different scales. Macroscale changes include population composition changes in provinces, municipalities and municipal regions. When analyses focus on the macroscale, they often highlight an increase in the diversity of populations along with broad patterns of race and class separation (such as north-south or core-periphery divisions in a city). Analyses at the microscale are concerned with changes in neighbourhoods or smaller administrative or statistical-geographic units such as electoral wards,[2] suburbs, enumerator areas and hexagons. In these spaces, microscale analyses often reveal populations to be homogenous in one or more dimensions, with exclusionary processes blocking transitions to greater diversity.

The main aim of this Occasional Paper is to explore how the nature and location of urban expansion,

1 Apartheid is borrowed from the Afrikaans language (linked to the predominantly Afrikaans government during the period), which can be translated as 'separateness', referring to a system of segregation on the grounds of race in South Africa.

2 An electoral ward is a geopolitical subdivision of municipalities, delimited by the Municipal Demarcation Board and used for electoral purposes.

housing supply and demand, processes of socio-economic sorting and the influence of other neighbourhood-specific characteristics shape the reproduction or disruption of race and class segregation. This is done through a microscale analysis of racial-residential segregation and socio-economic sorting in Gauteng. A microscale analysis is preferred because the patterns of racial-residential segregation and socio-economic sorting that shape macroscale segregation tend to become clearer.

In this study, three research questions provide new insight into the reproduction and disruption of microscale segregation patterns in Gauteng. The first research question asked in this publication is: Does residential expansion disrupt or perpetuate patterns of racial segregation? In the context of robust apartheid legacies, it is residential expansion that provides a blank canvas with the potential to re-shape past patterns of racial-residential segregation and positively influence processes of socio-economic sorting. This question is analysed by tracking residential expansion since 1990 and relating it to racial diversity at a microscale in Gauteng.

Following this, the research turns to areas that have been celebrated for racial integration in the democratic era. The second research question is: To what extent does racial mixing contribute to lower racial income inequality within that neighbourhood? If a racially integrated neighbourhood were to exhibit income or wealth inequality with a racial characteristic, this could present challenges for equitable access to opportunity by residents of the neighbourhood. This question is analysed by selecting wards where both black African and white respondents in the Gauteng City-Region Observatory (GCRO) Quality of Life (QoL) survey reside and then analysing the household income differences between the two groups and their spatial distribution within a ward. The analysis shows how continued inequality shapes the character of seemingly integrated neighbourhoods.

The effects of segregation and inequality, as described by the analysis of the first two research questions, are seen in microscale patterns of socio-economic sorting. The literature suggests that further factors, such as the property market and community characteristics, also influence socio-economic sorting. Investigating these additional factors in a selection of case studies helps to relate segregation to socio-economic sorting. The third research question investigates these patterns in more detail by asking: What are the patterns of microscale socio-economic sorting, and associated housing characteristics, that shape neighbourhoods? Three examples are used to answer this research question. The analysis illustrates how property market dynamics and neighbourhood characteristics contribute to the mutually reinforcing relationship between segregation and inequality.

This Occasional Paper contains seven further sections. Section 2 outlines the research approach, the study area, the importance of analysing segregation at different geographic scales, and describes the data and methods that are used in the segregation analysis. Section 3 provides a brief overview of segregation research, including the measurement, causes and consequences of segregation to lay the foundation for the analysis that follows. Section 4 is focused on the past and present characteristics of racial-residential segregation in South Africa and Gauteng. Sections 3 and 4 highlight the large amount of macroscale segregation analysis that has been done, despite the fact that theoretical and practical principles of segregation research and data availability lends itself to multiscalar analysis of segregation. Sections 5, 6 and 7 present the main empirical analysis that answers the three research questions. These sections are focused on Gauteng for a regional perspective on segregation and include an analysis of microscale racial-residential segregation and socio-economic sorting. Section 8 draws out the implications of the various analyses and some future work that might be useful.

Continued inequality shapes the character of seemingly integrated neighbourhoods



Photograph by Clive Hassall



Research approach

Research approach

A wide variety of segregation indices and analysis methods are available for researchers to choose from, depending on their research objectives. The following section introduces the study area and provides a brief overview of why scale is important in segregation analysis, focusing on how the interpretation changes at different scales. Next, the data sources and geographic units that are primarily used in the analysis of microscale segregation patterns in this publication are discussed. Lastly, an overview of the available segregation indices and an explanation of the choice of indices used for the analysis are provided.

Study area

In this study, the focus is on the Gauteng province of South Africa. Gauteng is located in the northern part of South Africa and forms part of a larger region – the Gauteng City-Region (GCR) – of significant population concentration, natural resources and economic activity. The GCR, which includes the metropolitan municipalities of the City of Johannesburg, the City of Tshwane and the City of Ekurhuleni, is the economic heartland of South Africa and home to more than 26% of the national population on less than 5% of the country's land (Statistics South Africa, 2022). The region is characterised by rich cultural diversity and severe socio-economic inequality (Mushongera et al., 2015) and is also plagued by spatial inequality (Ballard, Hamann and Mosiane, 2021; Everatt, 2014), which results in contrasting spaces in close proximity to each other. In such a dynamic city-region, microscale investigations into segregation are important to shape our understanding of how the city-region is woven together, helping to identify where there are barriers that limit access to opportunity and that could be re-shaped in future.



Photograph by Christian Hamann

Why does scale matter in our analysis of segregation?

The size and distribution of populations are constantly changing. This means that assessments of segregation should be revisited and refined to craft a complete understanding of segregation's role in urban inequality. Boustan (2011, p. 321) specifically argues that the development of 'accurate measures of segregation is a necessary first step in assessing the causes of residential separation between groups and the social and economic consequences of these divisions'. Understanding how segregation patterns change at different scales helps explain how interventions can improve residential integration and equality. It has also been argued that policies aimed at social mixing are ineffective if they do not consider segregation patterns at a microscale in areas that are presumed to be racially mixed (Maloutas and Karadimitriou, 2022). Analysing segregation only at a macroscale would not reveal the effect that belonging and exclusion at a local level have on the distribution of opportunity in the city (Ballard et al., 2021).

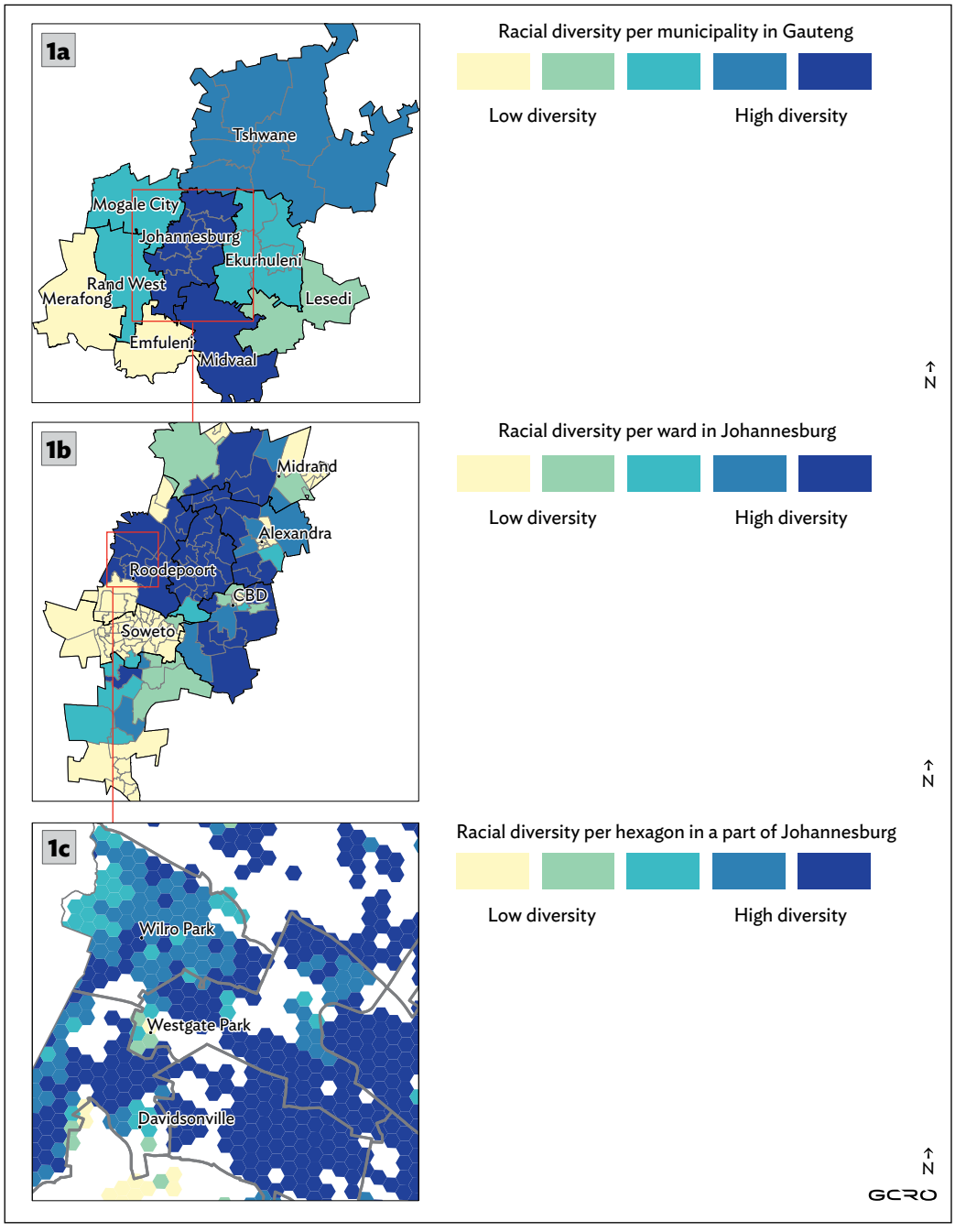
A multiscalar analysis of segregation is also necessary to overcome some of the limitations of segregation indices. Harrison and Todes (2013, p. 28) highlight that 'although aggregate indices do have a place in measuring progress towards desegregation, they tend to obscure the extent to which change is occurring, and further the broader context in which it occurs'. Segregation indices tend to be low – i.e. they show heterogeneity – when calculated at large scales (Parry and van Eeden, 2015) and such analyses miss the nuances of microscale residential settlement. Therefore, a local-level perspective of diversity could reveal the dynamic ways in which the composition of neighbourhoods influences the diversity of a larger geography, regardless of whether diversity at larger geographies increased, decreased or stayed the same (Katumba, 2019).

Figure 1 illustrates the influence of scale on our understanding of desegregation. Calculating the racial diversity of municipalities in Gauteng suggests that the City of Johannesburg is one of the most diverse municipalities in South Africa (Figure 1a). However, when racial diversity is calculated at the ward-level for Johannesburg, a clear north-south divide is revealed, with high racial diversity in wards in the northern parts of the city and low racial diversity in the south (Figure 1b). High racial diversity does not exist in all parts of Johannesburg as suggested by the municipal scale. When diversity is calculated at the even lower scale of 400-metre corner-to-corner hexagons, as shown in Figure 1c, it is further evident that the most diverse parts of Johannesburg are also shaped by pockets of low and moderate racial diversity. This multiscalar view of racial diversity emphasises that parts of Johannesburg still require interventions that drive greater racial diversity despite the municipality being one of the most diverse municipalities in the province. A further illustration of this argument, drawing on segregation index calculations at different scales, is provided in Appendix A.

Existing research has provided useful insights into the importance of multiscalar analysis of racial-residential segregation. Parry and van Eeden (2015) explored the implications of analysing segregation at different scales in the City of Cape Town and the City of Johannesburg. Their research highlights that the extent of segregation varies greatly between the two cities at macro- and microscales. Segregation in the City of Cape Town is influenced by microscale segregation processes while segregation in the City of Johannesburg is shaped by a macroscale division between population groups (Parry and van Eeden, 2015). This is influenced by, among other factors, the population composition of the cities. Cape Town is home to larger proportions of white and coloured residents than Johannesburg, resulting in lower segregation at macroscales, whereas the City of Johannesburg is home to a very large and relatively concentrated black African population and much smaller white and coloured populations, resulting in relatively higher segregation levels at macroscales. The findings by Parry and van Eeden (2015) for the City of Johannesburg are very similar to the results that Katumba et al. (2023) calculate for the Gauteng province – that segregation is influenced by macroscale patterns. However, this does not negate the importance of understanding how microscale segregation patterns contribute to the macroscale patterns (Figure 1).

Figure 1: Racial diversity viewed from macro- to microscales

DATA SOURCES: Census data – Community profiles (Statistics South Africa, 2011a); GCRO (2016, 2019, 2021); GeoTerraImage (2021b)



Data sources and geographic units

Data sources play an important role in any segregation analysis. A single data source which covers multiple scales that is available over time, that can be updated for recent years and that is available for all the areas of interest is not easily available. This Occasional Paper makes use of a variety of data sources to present segregation figures for various geographic scales and times in South Africa and Gauteng. In most segregation studies, census data is the most popular choice (Parry and van Eeden, 2015), and here too, census data from Statistics South Africa for the years 1996, 2001 and 2011 provides a useful base for an overview analysis.[3] The time points between the census years are filled with population estimates from Quantec EasyData.[4] This makes it possible to track changes over more points in time and over a longer period. For recent local-level population estimates, data is sourced from GeoTerraImage (GTI),[5] a private-sector company that creates spatial data. The GTI data is aggregated to hexagon shapes in the Gauteng province and therefore enables the microscale analysis of segregation patterns (described in more detail below). Quality of Life (QoL) survey data from the Gauteng City-Region Observatory (GCRO)[6] also adds value to the understanding of social mixing in Gauteng. The QoL survey data provides local estimates of population group distribution in the absence of recent census data and is used to understand race and class differences. Point locations of respondents in the surveys and their population group classification have been mapped in this research, but no personal identifiable information about respondents has been provided.

The datasets also have limitations that should be noted. Even though census datasets are considered as official statistics, the value of the data is somewhat reduced due to its age. Population estimates are updated to recent years in some of the private-sector datasets used, but often the modelling techniques are not fully disclosed, and the estimates cannot be considered as definitive. It is very likely that some populations have shifted in ways that modelling cannot predict. While the dot-distribution of respondents by population group category is an ideal method for multiscalar segregation analysis, survey data only provides a broadly representative picture of the population distribution. Survey data in an unweighted format does not provide sufficient coverage for a complete picture of residential neighbourhoods. The QoL survey is also designed to be representative at the ward level and cannot be further divided into smaller geographies such as sub-places, enumeration areas or hexagons.

The microscale analysis is achieved with data for hexagons in Gauteng – the smallest possible unit of analysis available at this time. The hexagon layer is a generic grid that is not based on any other administrative demarcations. There are 177 040 hexagons in Gauteng that are 0.1 km^2 in size. This provides a much more granular spatial perspective than the alternatives of analysing the 529 wards in Gauteng with an average size of 34.3 km^2 (ranging from 0.36 km^2 to 1 193 km^2) or of analysing 2 579 sub-places with an average size of 7 km^2 (ranging from 0.003 km^2 to 3 126 km^2).

Segregation indices

The first segregation index, the Dissimilarity Index (commonly denoted as 'D'), was developed by Duncan and Duncan (1955). The Dissimilarity Index compares two population groups in an area against the distribution of the same two groups in the entire study area. The resulting segregation index value is interpreted as no segregation if it is zero, or complete segregation when it is 100 (Boustan, 2011). D is a global index, providing a single value for an entire study area, such as a town or city (Parry and van Eeden, 2015). D can then also be interpreted as the proportion of one group who would have to change their residential

3 Statistics South Africa released the 2022 census results on 10 October 2023, but the results did not include population group counts below the municipal level and could therefore not be used in this publication.

4 www.easydata.co.za

5 www.geoterraimage.com

6 https://www.gcro.ac.za/research/project/detail/overview-quality-life-survey/

location to achieve an equitable distribution of the two groups (Duncan and Duncan, 1955). For example, in a two-group analysis of white residents and black African residents, a value of 30 would mean that 30% of white residents or black African residents would have to relocate to an area closer to the other group to achieve evenness.

Over time, numerous enhancements have been made to D and various other indices have been developed, including some that are spatially weighted. Reviews of available segregation indices (including the Dissimilarity, Multi-Group Dissimilarity, Multi-Group Spatial Dissimilarity, Isolation, Interaction, Entropy, Gini, Location Quotient and Local Moran's I Index) are available in White (1986), Wong (1998), Horn (2005), Brown and Chung (2006) and Katumba et al. (2023). Important advances include indices for multiple groups, understanding the spatial patterns of segregation indices, understanding segregation through other variables (such as language, income and gender) and applying segregation analyses to institutions or public facilities instead of just residential spaces. Each index has benefits and drawbacks that need to be considered by the researcher to ensure that the chosen index responds appropriately to the research questions and any data limitations. The choice of index depends on the availability of appropriate data, the application of the result and the skill of the researcher to calculate and interpret the result.

Calculations of segregation in this publication draw on two indices: the Multi-Group Dissimilarity Index (as derived from the Two-Group Dissimilarity Index) and the Entropy Index of Diversity (Table 1).

The two indices were chosen because they are relatively easy to calculate and interpret and because they can be applied at multiple geographic scales. The Multi-Group Dissimilarity Index is only used to provide an overview of segregation trends over time and to illustrate how a segregation index value is interpreted differently at different geographic scales. The main benefit of the Multi-Group Dissimilarity Index is that all four of the major population groups in South African data can be included in the same calculation. The Entropy Index is used to calculate racial diversity in Gauteng wards and hexagons and to highlight the spatial patterns of racial diversity in the province. The Entropy Index also includes all four major population groups into the calculation of the index. The main benefit of the Entropy Index is that it can be distinctly calculated for separate, small administrative units which can then be mapped.

Table 1: Calculating key segregation indices used in this publication

SOURCES: Duncan and Duncan (1955); White (1986); Wong (1998); Horn (2005); Parry and van Eeden (2015)

Formula	Description
Multi-Group Dissimilarity Index $D(m) = \frac{1}{2}\frac{\sum_i \sum_j \lvert N_{ij} - E_{ij} \rvert}{\sum_j NP_j(1 - P_j)}$ where $E_{ij} = \frac{N_i N_j}{N}$	'N_{ij}' is the population count of population group 'j' in administrative unit 'i'; 'E_{ij}' is the expected population size of population group 'j' in administrative unit 'i', under the assumption of a proportional population distribution; 'N_i' is the total population count in administrative unit 'i'; 'N_j' is the total population count in group 'j'; 'N' is the total population count in the entire study area; and 'P_j' is the proportion of the population in group 'j'.
Entropy Index $E = \sum_{r=1}^{n} pr \ \ln\left(\frac{1}{pr}\right)$	'*n*' is the number of groups in an administrative unit; *pr* is the proportion of the administrative unit's total population belonging to group *r*. If all groups are equally represented within a particular administrative unit, E will reach its maximum, which will be equal to the natural logarithm of the number of groups considered – ln(n), or in the case of four population groups, ln(4) = 1.386. Therefore, the diversity in an administrative unit can also be represented as a percentage of the maximum possible diversity.

The resulting maps have a smooth surface and are easy to interpret compared to a highly detailed dot-density mapping of population groups (e.g. Katumba et al., 2023; Khanyile and Ballard, 2022; Statistics South Africa, 2016; GCRO, 2013). Other available segregation indices, including those that are spatially weighted, were not calculated due to their complexity and because the result, a somewhat arbitrary score between 0 and 100, does not add value to the research objectives.

The Multi-Group Dissimilarity Index and the Entropy Index are not without limitations that should be noted. A key limitation is that these indices are not spatially weighted, and it is argued that they suffer to some extent from the 'chequerboard problem' and the 'modifiable areal unit problem'. The chequerboard problem suggests that the level of measured segregation remains unchanged even when the spatial arrangement of groups changes (Katumba et al., 2023). On a chequerboard, the number of light and dark squares are always the same even if you change their layout. Thus, 'diversity' of squares on the board is always the same, unless you remove squares or change the character of squares. In the example of an analysis with data for hexagons, the calculated racial diversity of a hexagon will remain the same even when groups reorganise themselves within the hexagon. This is an important limitation to note in relation to analysis at different geographic scales, but the chequerboard effect is limited when very small analysis units, such as hexagons, are used.

The modifiable areal unit problem refers to statistical bias when point data (such as respondents or voters) is aggregated to spatial containers for analysis. The position of a boundary determines whether a group of residents is included or excluded from the segregation analysis and can significantly impact the results (Katumba et al., 2019). A multiscalar analysis, down to the smallest possible administrative unit, helps to determine how significant the effect of the modifiable areal unit problem is and helps to make clear how the dynamics of continuity or discontinuity at each scale influence overall segregation levels in a city.



Photograph by Richard Ballard



Photograph by Christina Culwick Fatti



An overview of segregation research

An overview of segregation research

Segregation research has its roots in the sociological theory and research methodology developed at the University of Chicago in the early 1900s – commonly referred to as the Chicago School of Urban Sociology. The city of Chicago became the site of the sociology research as students studied how the city was made up of mosaics of different people and functions. One major contribution was the specific research methods that included the use of personal documents, intensive fieldwork, documentary sources, social mapping and ecological analysis (Bulmer, 1984). Researchers also included geographic sorting in their view of the city. Evidence showed how racial minorities and immigrants are marginalised into residential ghettos and these marginalised spaces endure various social ills. Due to various dimensions of racial inequality as well as a combination of state-led forced segregation and market-based segregation in many cities around the world, segregation became a prominent theme in urban studies. The rest of this section will focus on the definition, interpretation, measurement, causes and consequences of segregation and desegregation. The review will cover both international and South African examples, with a focus on the latter.

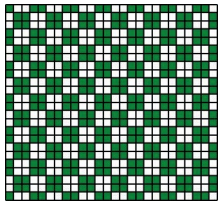
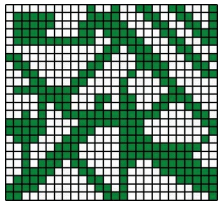
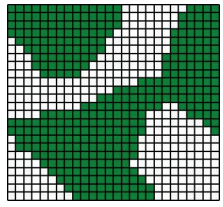
Definition and interpretation of segregation

During the 20th century, interest in the phenomenon of racial separation in urban spaces became stronger in response to the nature of urban development. In 1955, Duncan and Duncan (1955) showcased the Dissimilarity Index as a measure of racial-residential segregation in the United States of America. In doing so, they led the way for the development of the most significant segregation theories, measurements and debates. Massey and Denton (1988, p. 282) defined residential segregation as 'the degree to which two or more groups live separately from one another, in different parts of the urban environment'. Residential segregation can also be defined more broadly as a process of spatial separation among groups that is often associated with conditions of isolation, exclusion and deprivation (Hamann and Horn, 2015; Boustan, 2011; Horn, 2005; Wong, 1998). Although segregation research often focuses on racial groupings, segregation could also relate to separation between ethnic groups, language groups, socio-economic status or other social and demographic indicators.

Segregation analysis can be done by mapping the distribution of groups or by calculating one of the many available segregation indices. Maps provide a useful view of population distribution at one period whereas a segregation index can help to track change over time. However, an acceptable level of segregation is not easy to define because perfectly representative population distributions are a hypothetical ideal. In other words, it cannot be said that a segregation of 40 (out of 100) is ideal and that 70 (out of 100) requires a remedy. Rather, a general interpretation, as provided in Table 2, can be considered as a guide.

The hypothetical spatial representations of different levels of segregation are closely linked to the size of the areas where one group dominates and their relationship to other areas. In Table 2, a situation of *low segregation* is characterised by an even distribution of groups across an entire area. Areas dominated by one group (green squares on the diagram) are small and close to areas dominated by other groups (white squares on the diagram). Any unit of analysis will include a reasonable proportion of all groups. In a situation of *moderate segregation*, patterns emerge

Table 2: Interpretations of calculated segregation values
SOURCES: Boustan (2011); Christopher (2001)

	Low segregation	Moderate segregation	High segregation
Segregation index value	**Less than 30 (out of 100)**	**Between 30 and 60 (out of 100)**	**More than 60 (out of 100)**
Interpretation	**Groups are distributed in a manner which does not indicate significant segregation.**	**A degree of segregation exists but could be interpreted as voluntary congregation.**	**Structural segregation exists between groups.**
Hypothetical spatial representation of two groups			

that show how one group dominates continuous parts of the city (larger sections of green squares surrounded by other green squares), but at a scale that still provides equal access to opportunities in the parts of the city. *High segregation* is characterised by large concentrations of one group with clear separation from other groups and very little overlap between groups.

The interpretation of the hypothetical spatial representations of segregation is also influenced by our normative perspective on segregation. Horn (2005) argues that our normative perspective on segregation – neutral, negative or irrelevant – determines how we analyse and interpret urban spaces. A neutral perspective considers segregation as a result of voluntary social association or congregation, regarding it as a natural occurrence when small groups congregate in specific parts of the city, for example having high concentrations of Asian residents around a part of the city informally designated as 'China town'. Segregation can be considered negative when it is associated with institutional forms of exclusion or when socio-economic processes 'upscale' the extent of segregation and result in disharmony, polarisation and exclusion. Segregation is also considered negative when it is associated with high levels of inequality – both socio-economic inequality and inequality in terms of spatial opportunity. Segregation can be viewed as irrelevant in terms of a social ill, particularly racial-residential segregation. Social injustice, inequality, exclusion, discrimination and deprivation could be considered as more important root causes of social ills. If segregation is regarded as a symptom of social injustice, it follows that it is not possible to achieve desegregation without addressing social injustice more broadly; nor is it possible to fully achieve social justice merely through desegregation. This study operates with the assumption that racial segregation causes injustice and results in structural inequality. As such, desegregation is considered essential.

Desegregation should mean a better mix of all groups where there was previously limited access to an area and the opportunities of that area so that public investment is beneficial to all groups. In other words, residential desegregation would be based on the freedom of any individual to live wherever they choose. A comprehensive view of desegregation would also include a greater integration of land uses, equal access to services and employment opportunities as part of an overall reduction in socio-economic inequality (Pieterse, 2007). The achievement of desegregation would indicate that underlying structural causes of segregation have been removed and that desegregation reduces the knock-on effects of separation that help perpetuate inequality.

Negative consequences of segregation

It is important to appreciate why racial-residential segregation is considered negative and why desegregation is considered essential if the negative consequences of segregation are to be addressed. Broadly, the limitations of physical space (such as density limitations, distance and movement costs) and the power relationships that manifest in space mean that segregation has significant implications for diversity, inclusion and equality.

One of the most significant consequences of segregation comes from the relationship between segregation and inequality. Racial-residential segregation has long been strongly linked to racial inequality. Hamann and Horn (2015, p. 55) noted that 'racial-residential segregation, due to its connection with socio-economic conditions, remains a significant socio-spatial process hindering both progressive and equal urban development'. The spatial nature of segregation inherently restricts mobility and access to opportunities (such as jobs, education and social services) for those residents that are excluded from the areas where opportunities are located (Charles, 2003) and incurs unnecessary economic costs when residents try to access opportunities that are located far away (Budlender and Royston, 2016; Boustan, 2011). Exclusion from opportunities is evident in various examples. The potential impact of racial-residential segregation is significant separation between the places where people live and centres of employment – i.e. spatial mismatch (Budlender and Royston, 2016), where the marginalised or minority groups in society are excluded and burdened by increased costs of urban living. Another important example has been debated in relation to school admissions because residential segregation and admissions policies have led to frustrations over education segregation and being excluded from certain education opportunities based on one's residential location (Parker, Hamann and de Kadt, 2021). These dynamics then easily give rise to class segregation, which aggravates spatial inequality and complicates efforts to reduce urban poverty. Segregation could therefore be detrimental to future social mobility (Chetty et al., 2014). The result is that an individual's residential location becomes a powerful indicator (and stronghold) of their social position because socio-economic resources are unevenly distributed. Ultimately,



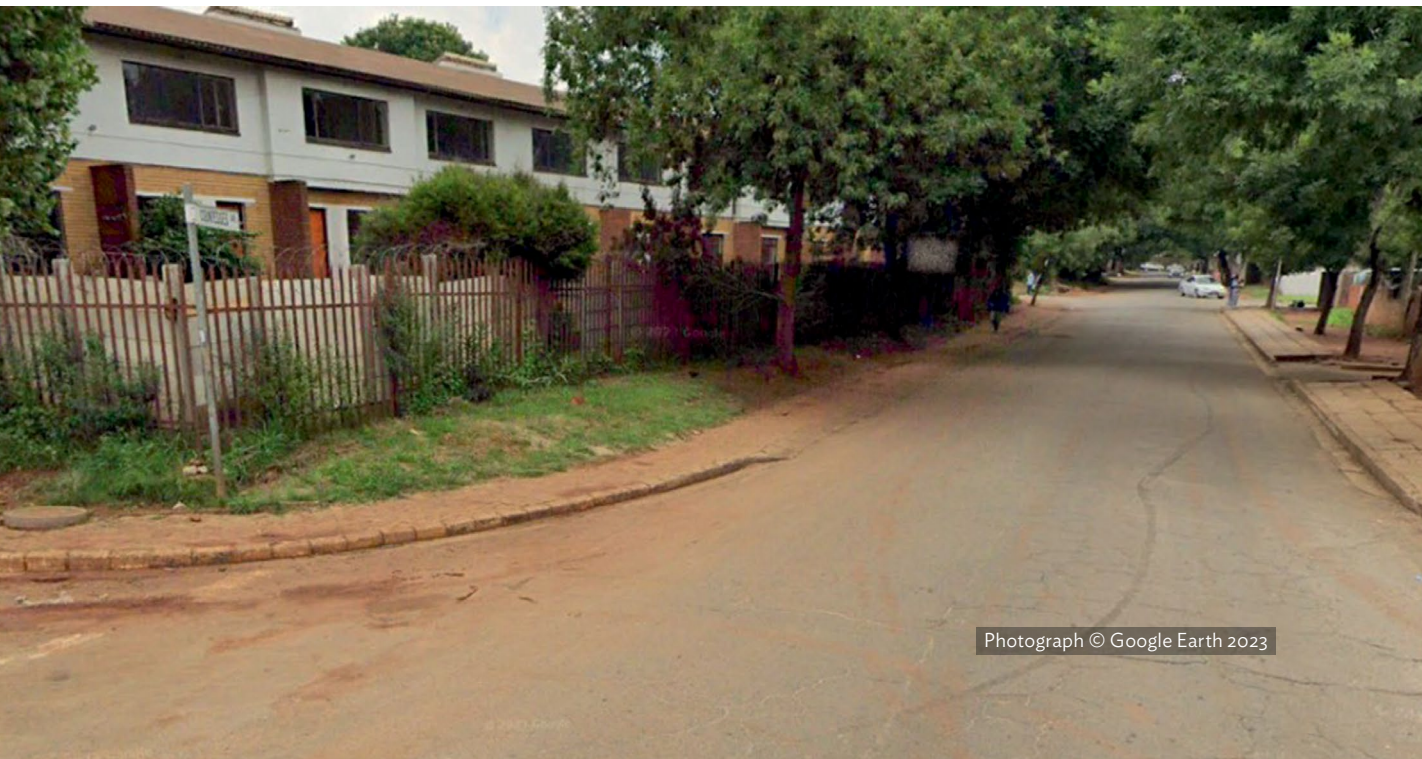
Photograph © Google Earth 2023

any form of segregation (voluntary or forced) has serious implications for the social mobility of those excluded from desirable areas.

The consequences of segregation are closely tied to theories of neighbourhood effect. Neighbourhood effect literature argues that neighbourhood characteristics constrain or enable residents on an individual level through the features of local environments, which then have consequences for behaviour and future development trajectories (Entwisle, 2007). Research in this domain has highlighted the geographic clustering of multiple forms of disadvantage (and advantage) which tend to be reproduced through the neighbourhood effect (Sampson, Morenoff and Gannon-Rowley, 2002). Negative neighbourhood conditions are cemented into low-income and segregated neighbourhoods that create mutually reinforcing spirals of decline (Charles, 2003). When it comes to racial-residential segregation, the neighbourhood effect theory argues that if the neighbourhoods inhabited exclusively by one group are embedded in more disadvantaged environments than neighbourhoods inhabited exclusively by wealthy groups, the consequences of racial-residential segregation on inequality and well-being are significant and systemic (Sampson, Morenoff and Gannon-Rowley, 2002).

Segregation also has various negative social effects. Segregation research argues that 'segregation has harmful effects on disadvantaged individuals through various channels: reducing exposure to successful peers and role models, decreasing funding for local public goods such as schools, or hampering access to nearby jobs' (Chetty et al., 2014, p. 1608). Physical distance between groups translates into social distance between groups, limited exposure to a diversity of people as well as misconceptions and a lack of empathy between groups (Badenhorst, van Helden and Schoonraad, 2005). Residential segregation also limits opportunities for informal relations with neighbours, leads to the segregation of public and private facilities or amenities, permits prejudice and ultimately undermines social and economic well-being (Charles, 2003; Massey and Denton, 1993). These residential environments become more isolated from society in geographic, social and economic terms.

In summary, an intricate and reinforcing relationship exists between segregation and inequality. Even though we can accept that segregation is an effect of inequality, the frameworks reviewed above also show that segregation perpetuates inequality in various ways.



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Photograph by Richard Ballard



Segregation and desegregation in South Africa and Gauteng

Segregation and desegregation in South Africa and Gauteng

There are many factors that contribute to segregation and desegregation, ranging from planned segregation, planned integrated housing and market dynamics, to more subtle factors such as self-segregation. The spatial patterns of segregation reflect historical and current political and economic forces. And while some political and economic forces can gradually shift certain spatial patterns (National Planning Commission, 2011), there are spatial patterns that remain largely unchanged. Since factors that contribute to segregation or desegregation are also context-specific, this section is focused on causes that are relevant to South Africa and Gauteng. Before 1991, racial-residential segregation was a state-led project in South Africa (political force). After segregation laws were repealed in 1991, segregation and desegregation were influenced by housing trends (including public housing development), income inequality and unequal spatial development (economic forces).

Historical segregation in South Africa

State-led segregation in South Africa started to take shape in the late 1800s when white minorities became concerned about the growing number of black African residents squatting on white-owned farmland. In response, Law 11 of 1887, also known as the Squatters Act (and later replaced by Law 21 of 1895), limited the number of black African families that could live on white-owned farmland to five families. White farmers ensured that the families who were living on their farms were also working for them (Horn, 1998). Although this was not strictly about separating people, it nonetheless controlled how different groups could occupy space. Ideas to control how different groups occupy and use urban space continued to develop to the point of statutory segregation between population groups.

Further steps towards statutory segregation in South Africa were made in 1913 when the Natives Land Act (No. 27 of 1913) was introduced and restricted the ownership of land by native residents. This was the first Act to separate population groups and restrict mobility on a regional scale. As many black African people migrated to cities for work, conservative racist ideologies wanted to maintain cities as 'white' spaces. Thus, black Africans could only come to cities to work on a temporary basis, and they were assigned to segregated neighbourhoods within the city. This allowed white minorities to benefit from African labour while maintaining cities as 'white' spaces (Ballard and Mapukata, 2022). The influence of migration, population shifts and stronger ideals to control population movement led to the passing of the Natives (Urban Areas) Act (No. 21 of 1923), which restricted the land ownership opportunities of black residents on a city scale. Several subsequent revisions and additions to these laws intensified and changed the character of racial-residential segregation in South African cities.

After 1948, legislation that restricted residential opportunities for all population groups increased significantly and led to the era known as apartheid. Apartheid (meaning separateness) refers to a period in South Africa's history when urban development was governed by policies of racial segregation. The segregation ideas, processes, power struggles and the newfound national approach to racial separation of the National Party[7] culminated in the

7 The National Party was a political party in South Africa founded in 1914. The party was an Afrikaner ethnic nationalist party that promoted Afrikaner interests in South Africa. The party was disbanded in 1997, shortly after democracy.

Population Registration Act (No. 30 of 1950) and the Group Areas Act (No. 41 of 1950). These legislative cornerstones of segregation classified and separated the population into distinct population groups. This legislation first categorised South African residents into five population groups for the census, namely, black African, coloured, Indian/Asian, white or other[8] (Statistics South Africa, 2011b; Christopher, 2005). Black Africans were defined as descendants from people indigenous to Africa; Indians/Asians were descendants from people originating in South Asia and descendants from people originating on the Indian subcontinent; whites were descendants from people of European origin and who possessed recognisably light skins; and coloureds were effectively everyone else not included in the three previous categories or people with mixed ancestry (Christopher, 2001). The use of the 'other' category has not been consistent in census results or in recent population estimates. This category intends to capture anyone who does not easy fit the four main categories, and is generally very small (less than 1% of the population). This publication does not include an analysis of the 'other' population category.

This classification system was used to physically separate people during apartheid. The Group Areas Act aimed for absolute residential segregation by assigning the different population groups to limited proclaimed land in urban areas. In addition, the Prevention of Illegal Squatting Act (No. 52 of 1951), limited peri-urban squatting options for black African residents seeking access to employment in adjacent towns; and the Native Laws Amendment Act (No. 54 of 1952) effectively 'laid the basis for all state intervention to control the distribution of labour between town and country, and between towns from that time onwards' (Southall, 2022, p. 3). The establishment of 'homelands' outside of urban centres and widespread industrial decentralisation meant that the largest, and often poorest, proportion of the South African population was moved furthest away from city centres, jobs and other facilities (Saff, 1994; Butler, Rotberg and Adams, 1978). Separation and widespread spatial re-ordering based on population group was significant, although absolute separation was never fully achieved, notably because white residential areas were always home to a black African labour force.

The effects of these separation attempts remain difficult to reverse today. Statutory regulations were removed in the early 1990s in the build-up to the first democratic elections, but racial-residential segregation and structural inequality induced by the spatial restrictions remain a defining feature of South African towns and cities (Ballard et al., 2021; Christopher, 2005).

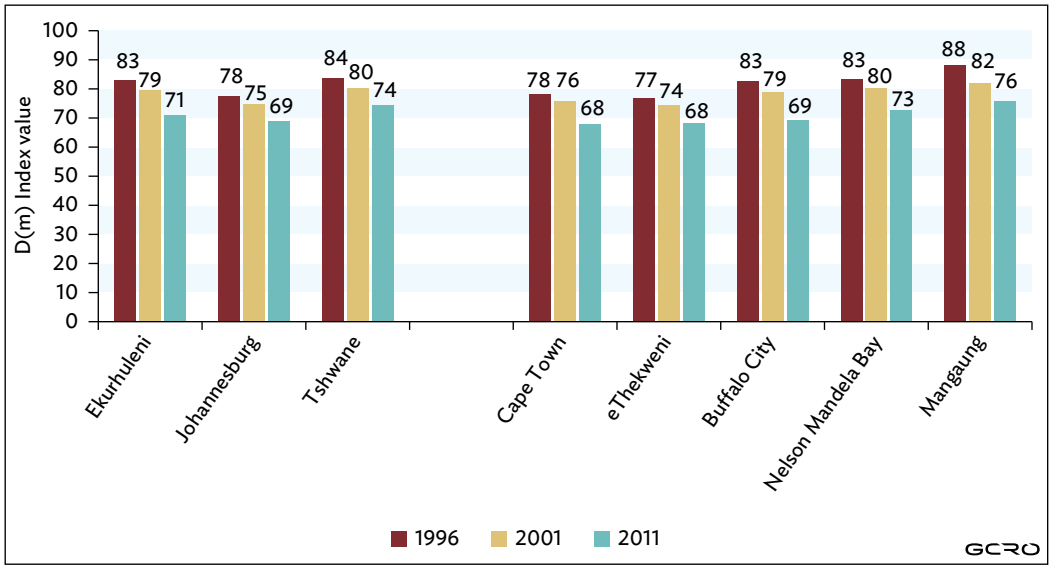
Entering an era of slow spatial transformation in South Africa

Although laws that confined population groups to specific areas were repealed in 1991, spatial transformation and desegregation was slow (National Planning Commission, 2011). Desegregation has mostly been influenced by the upward socio-economic mobility of black African, Indian and coloured residents, some of whom opted to move to former whites-only residential areas – particularly middle-income and inner-city areas (Harrison and Todes, 2013). There are various other factors that keep population groups separated or influence the slow pace of desegregation in South Africa. Neighbourhoods tend to function as spatial containers of historic characteristics that are shaped by individual actors whose ideals, choices and purchasing power produce (and often reproduce) the character of neighbourhoods over time and ultimately the cities that we observe (Ballard et al., 2021).

Urban segregation values reached their peak around 1991 and significant reductions in segregation values were evident in the data from the 1996 census. In some of the major economic hubs in the country (Cape Town, Durban, the City of Johannesburg, Gqeberha, and the City of Tshwane), more significant reductions in white segregation were evident in the build-up to democracy (Christopher, 2001). Figure 2 shows the overall decline in segregation levels in metropolitan municipalities between 1996 and 2011,

8 In 2022, the South African population was composed as follows: black African – 81.4%; coloured – 8.2%; Indian/Asian – 2.7%; white – 7.3%; and other – 0.4% (Statistics South Africa, 2023).

Figure 2: Multi-group dissimilarity per metropolitan municipalities in South Africa between 1996 and 2011
DATA SOURCES: Census data – Community profiles (Statistics South Africa, 2011a, 2001, 1996)



using census data from these years. The calculations not only show a decline in segregation levels but also show that the pace of desegregation was faster in the 2001–2011 period than the 1996–2001 period in all the metropolitan municipalities. The transformation of urban space looked different in different parts of cities and there were prominent distinctions between inner-city areas, suburbs and townships. The success of policy interventions has also varied throughout South Africa and parts of cities.

Several research efforts have focused on the transformation of inner-city areas. The much faster tempo of racial desegregation in most inner-city areas led to resegregation. Inner-city neighbourhoods (such as Hillbrow in the City of Johannesburg and Sunnyside in the City of Tshwane) have transitioned from homogenous white neighbourhoods to being racially mixed for a brief period and then transitioning further to dominantly black African neighbourhoods (Statistics South Africa, 2016; Hamann and Horn, 2015). This process initially gave black African residents ideal access to employment opportunities, but the benefits were limited due to decay in the inner city and the decentralisation of businesses to suburbs (Ballard, Hamann and Mkhize, 2021; Beavon, 2004). The individual actions of white residents to move out of inner-city areas because they were experiencing an influx of black African residents (often labelled as white flight[9]) had a significant impact on segregation patterns (Boustan, 2011).

Desegregation in post-apartheid South Africa has also been significantly shaped by the steady diffusion of black African middle-class residents into former whites-only suburbs (Crankshaw, 2022; Lemanski, 2006; Horn and Ngcobo, 2003). The pace of desegregation of former whites-only suburbs is closely linked to their class-based nature, where access depends on economic status rather than racial classification (Ballard, Hamann and Mkhize, 2021). The nature of the property market segregates residents according to their financial capabilities or socio-economic status in a particular society (Donaldson and Kotze, 2006; Christopher, 2001; Morris and Hindson, 1997; Massey and Denton, 1993).

9 White flight is a term used to describe the decisions by white households to leave neighbourhoods that are becoming more racially mixed when the black African population reaches a certain threshold or tipping point (Boustan, 2011).

The effect seen on the ground is that the housing market is broadly segmented into high-end suburbs and gated estates in middle-income suburbs, and low-income suburbs that include informal and backyard dwellings. Given that financial capabilities are largely influenced by labour market opportunities, unequal earning in the labour market is also considered as a significant contributing factor to segregation (Crankshaw, 2022). Market differentiation and earnings create opportunities for some residents to move to suburbs while others have to remain in more affordable areas of the city (Boustan, 2011). Suburbs are the spaces where the property market is favourable towards integration and where the upward social mobility of black African, Indian and coloured residents enables their entry into these former whites-only residential spaces. New suburban housing in or alongside former whites-only areas, such as middle-income cluster housing developments, are associated with more substantial desegregation (Chipkin, 2012).

Apart from the influence of the property market, the spatial character of suburbs and the limitations of space limit desegregation to some extent. The spatial variation of an area's age, history and morphology of a city creates a unique set of subtle spatial characteristics which influences segregation (Herbert and Thomas, 1982). The age of an area, for example, would often determine the availability of new housing or opportunities to desegregate, while morphology could limit the expansion of an area or the desirability of an area. These factors are often seen in suburbs.

Although suburban desegregation represents the one-directional nature of desegregation in South Africa, it has started to reshape social and spatial hierarchies (Crankshaw, 2022, 2008; Ballard and Hamann, 2021; Seekings and Nattrass, 2005). Desegregation is slowly changing the shape and character of suburbs and they have become important sites that are driving non-racialism (Southall, 2022). As Ballard, Hamann and Mkhize (2021, p. 49) note, 'racial desegregation of [former whites-only] suburbs [...] has become an unremarkable part of social life. While the process has not been entirely frictionless, integration has taken place to varying degrees through common class interests and networks that straddle different races'.

The substantial desegregation of suburbs stands in opposition to the continued segregation in townships, informal settlements and low-cost housing developments. These settlements are historically dominated by black African residents, and they remain largely unchanged in their population composition (Ballard, Hamann and Mkhize, 2021). The growth and densification experienced in townships, informal settlements and low-cost housing developments are also some of the most significant in Gauteng. The historic geography of townships, informal settlements and low-cost housing developments, combined with high levels of unemployment and concentrated poverty in these areas mean that there is a significant race and class isolation between disadvantaged township residents and the rest of the city (Crankshaw, 2022; Southall, 2022). These spaces are also shaped by factors such as the continued nature of rural-urban migration in South Africa. Migrants to cities are overwhelmingly black African and have low household income. The majority of affordable homes for migrants tend to be in peripheral locations or townships, informal settlements and low-cost housing developments. The result is clusters of racially homogenous settlements far away from residential areas that are experiencing racial desegregation and class integration. These spaces are unlikely to see significant change due to the demographic dominance of the black African population in terms of the group's size (Harrison and Todes, 2013), migration trends and the general lack of socio-economic opportunity and amenities.

Despite the low levels of racial diversity in townships, township expansion, the development of low-cost housing and the development of new informal settlements on land that was historically earmarked for other population groups do influence desegregation on a regional scale. These developments might exhibit a racial homogeneity, but to the extent that they occur on the fringes of white suburbs, the previously unconsolidated zones between white and black African residential areas are being transformed into consolidated black African residential zones (Hamann and Horn, 2015). On larger scales, this reduces racial-residential segregation.

Due to the varying success of post-apartheid policies, the road towards spatial transformation

and integration has remained riddled with obstacles. Interventions such as inclusionary housing initiatives, government-funded integrated human settlements and high-density transit-orientated developments have contributed only marginally to desegregation in the short time that they have been implemented (Ballard and Hamann, 2021; Ballard, Hamann and Mkhize, 2021; Lemanski, 2006). Housing development policies, for example, aimed to restructure and integrate cities by providing low-income housing in well-located areas (Todes, 2003). However, they have not supplied enough housing to meet the constantly increasing demand and the majority of units are not centrally located. The public housing programmes that have made some impact in cities such as Johannesburg have only changed the scale of segregation in some instances (Ballard and Hamann, 2021). In 2018, the City of Johannesburg became the first city in South Africa to formally introduce an Inclusionary Housing Policy (City of Johannesburg, 2019). According to the policy, private developers are required to dedicate at least 30% of new housing units to low-income and middle-income households (households earning R7 000 per month or less). However, the restructuring effects of the policy remain limited because it cannot be applied retrospectively to existing housing developments. Additionally, inequality also remained high despite various programmes that aimed to tackle poverty and inequality (Leibbrandt et al., 2010).

Desegregation trends in Gauteng

Local-level representations of segregation that include the entire Gauteng province are not very common, but the insights are useful. One analysis, by Katumba (2019), represented changes to racial diversity over time. This analysis concluded that province-wide patterns of racial diversity, at a ward level, have not changed significantly between 1996 and 2018. In another analysis, Katumba et al. (2023) make a very useful shift away from city-level analysis when they explore how segregation indices change at different geographic scales for the entire Gauteng province. The Katumba et al. (2023) calculations of segregation at different geographic scales represent important methodological progress and help to accurately quantify levels of racial-residential segregation. Their calculations show that microscale segregation patterns are significantly influenced by the macroscale segregation patterns in Gauteng.

Various city-wide research efforts also offer important insights. Crankshaw (2022) added segregation in Johannesburg as an additional nuance to his analysis of Johannesburg's economic geography. Crankshaw's work looks at the racial composition of former whites-only neighbourhoods and emphasises that substantial desegregation took place between 1996 and 2011 – despite city-wide segregation indices suggesting the opposite. Hamann and Horn (2015) explored racial desegregation on a sub-place level in the City of Tshwane with 2011 census data. They concluded that the racial-residential distribution patterns of the city changed significantly since 1991, but that high levels of segregation remain and are strongly connected to and influenced by socio-economic conditions. Building on the insights from the existing literature, there remains scope for multiple areas of further investigation. Further analysis can be done to understand the impact of urban growth on patterns of segregation, to understand uneven diversification, and to understand the socio-economic circumstances in racially diverse areas. All of these investigations should consider analysis at different geographic scales.

Some recent studies have also described the nature and pace of race and class mixing in the City of Johannesburg and the City of Tshwane. These studies have shown how socio-economic segregation endures even where there is racial desegregation. Hamann and Horn (2022) show the enduring spatial legacies of socio-economic status and segregation in the City of Tshwane and argue that socio-economic inequality and segregation are influenced by the mutually reinforcing relationship between income, unemployment and tertiary education qualifications. Even though a higher degree of socio-economic segregation than racial segregation exists in the City of Tshwane, the analysis shows that the historic contestations of race and space cannot be discounted as contributors to present socio-economic inequality. In the City of Johannesburg, Ballard and Hamann (2021) argue that racial desegregation does not necessarily disrupt

socio-economic segregation. Residents that are employed in the top tier of occupations remain highly segregated from those employed in the bottom tier. These socio-economic segregation and stratification patterns inhibit racial desegregation and make it impossible to separate social and spatial inequalities from each other or from racial segregation.

The research efforts in the City of Johannesburg and the City of Tshwane also highlight the fact that townships are not universally poor but include pockets of relative affluence. Thus, even though townships do not exhibit a great deal of racial diversity, they are mixed in terms of socio-economic status.

The intricate differences in socio-economic status within and between areas are explained, to some extent, by the fact that Gauteng's transition to a tertiary service economy was more beneficial to some than to others and because unemployment remains high and spatially concentrated (Crankshaw, 2022, 2008; Ballard and Hamann, 2021).

The history of racial-residential segregation in South Africa has shown how physical separation between groups is associated with significant socio-economic inequality. To the extent that race remains linked to divisions in the class structure of the population, a spatial division between racial groups is not desirable. Racial mixing remains something that occurs in previously white-dominated neighbourhoods as well as some former coloured and Indian neighbourhoods (Statistics South Africa, 2016; Lemanski, 2006). Despite significant desegregation in former whites-only neighbourhoods, the majority of the black African population remains segregated from whites and from opportunity-rich spaces, and the effects of apartheid history are still noticeable in the lived experiences of residents in South Africa and Gauteng. It is important that the boundaries between high and low racial diversity are softened and that urban growth becomes a driver for creating more inclusive and racially diverse settlement patterns. Thus, racial-residential segregation is not just an issue of the past but also an issue of the present and future.

Current distribution of population groups in Gauteng

The current overall pattern of racial diversity in Gauteng can be described as one with a racially diverse suburban core, surrounded by pockets of low racial diversity in townships and moderate diversity in the sparsely populated hinterland. This pattern is broadly visible when looking at the spatial pattern of population group data from the GCRO QoL surveys (Figure 3 and Figure 4). Figure 3 uses the residential location of respondents in the last three GCRO QoL surveys (2015/16, 2017/18 and 2020/21) to represent the population group distribution of respondents. Figure 4 uses the same data to calculate the racial diversity of each ward in Gauteng to provide an aggregated sense of the population group distribution shown in Figure 3.

The racially diverse suburban core (areas such as Hatfield, Centurion and Montana Tuine in the City of Tshwane, Bryanston, Randburg and Roodepoort in the City of Johannesburg and central parts of Ekurhuleni) includes a mix of all population groups (higher racial diversity). These suburbs were historically dominated by white residents along with a small proportion of black workers that lived on white properties. Suburban expansion and gradual desegregation mean that there are currently very few middle-class suburbs where just one population group dominates. New residential areas, especially those with new cluster housing options, are some of the most racially integrated parts of Gauteng (Chipkin, 2012).

Racial-residential segregation is not just an issue of the past but also an issue of the present and future

Figure 3: Population group categories of respondents from three GCRO Quality of Life surveys
DATA SOURCES: GCRO (2021, 2019, 2016)

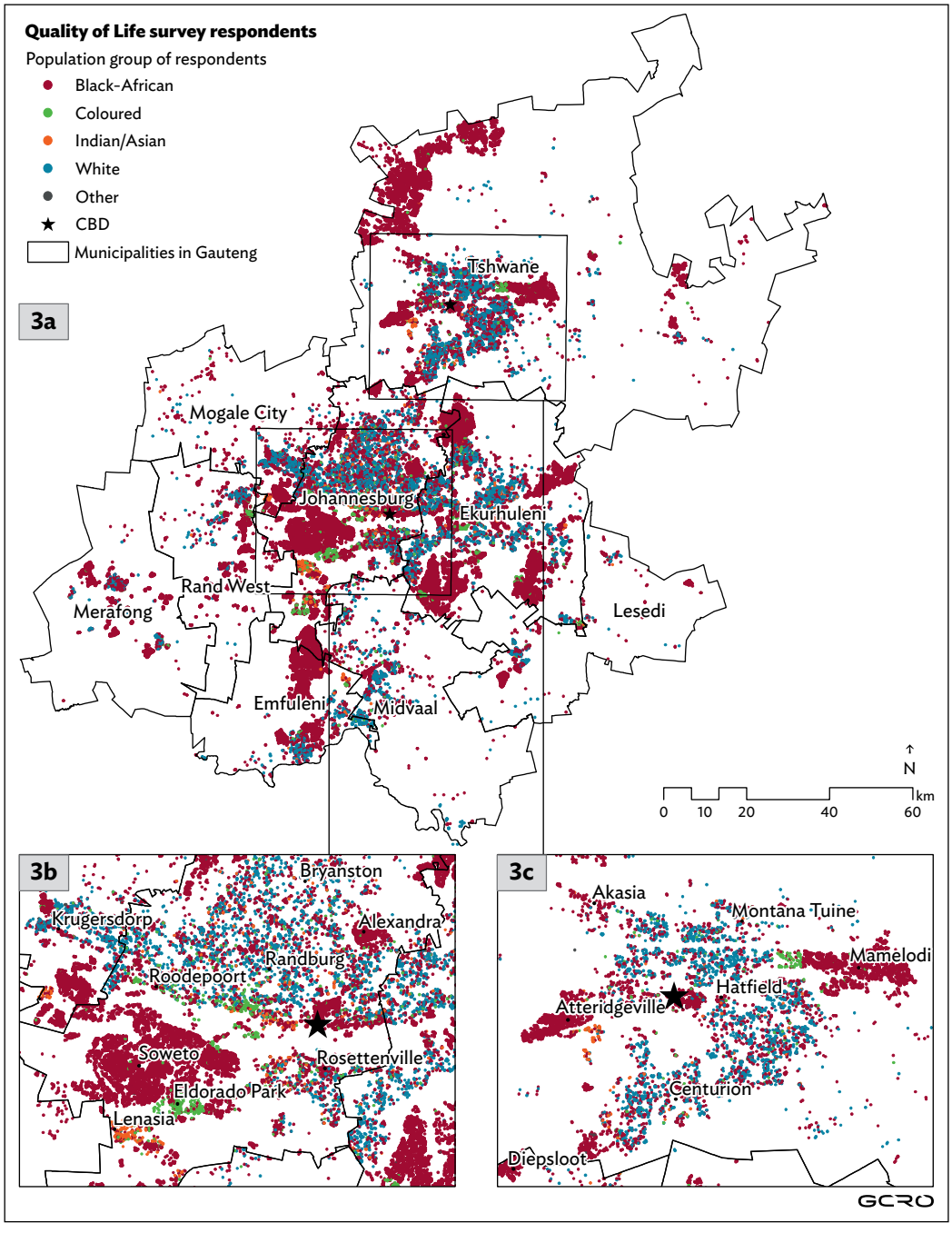
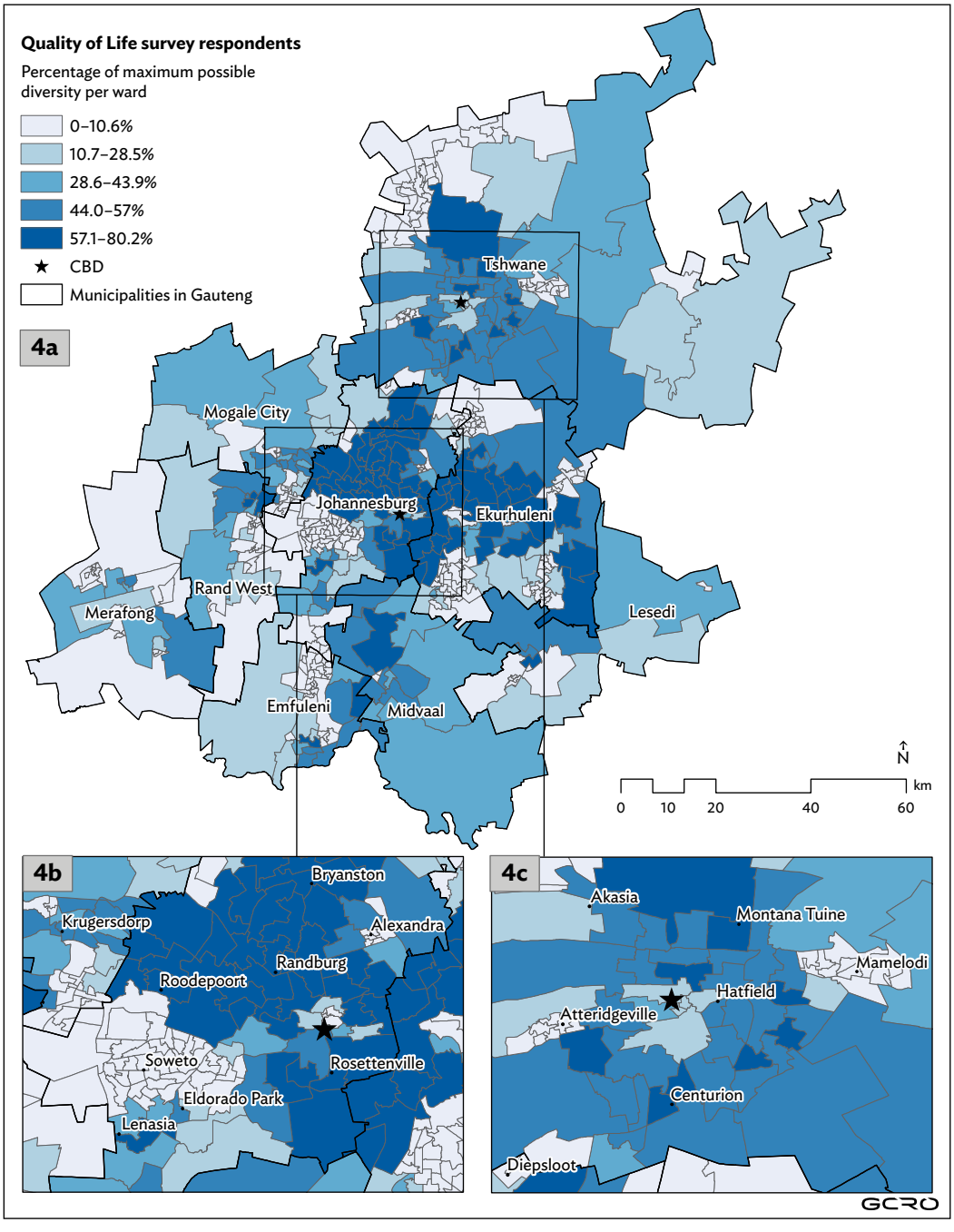


Figure 4: Racial diversity per ward in Gauteng

DATA SOURCES: GCRO (2021, 2019, 2016)



Suburbs play an important part in the pattern of desegregation in Gauteng because they present many opportunities for desegregation, but also various challenges. The challenges posed by suburbs are threefold. First, suburbs are home to a small proportion of the population in the province and therefore have a relatively small impact on overall diversity. Many suburbs would also require substantial redevelopment to create the housing opportunities that could accommodate greater racial diversity. Second, the middle- and upper-class status of suburbs precludes the majority of residents from living in these spaces (Chipkin, 2012). Thus, the extent to which race and class remain tied to each other will determine the opportunities for further integration. Third, the nature of suburban development means that the non-residential opportunities associated with them are concentrated in a small part of the province that can only be accessed by others through significant investment in transport.

In Gauteng, the racially diverse suburban core is surrounded by low racial diversity in townships. Townships such as Atteridgeville and Mamelodi in the City of Tshwane, Alexandra, Soweto, Eldorado Park and Lenasia in the City of Johannesburg, and townships in the south and north of Ekurhuleni are dominated by one population group (i.e. there is low racial diversity). Most of these townships have experienced significant expansion and densification (Ballard, Hamann and Mosiane, 2021), but their racial diversity has not changed significantly in the way that suburbs have changed.



Photograph by Phumzile Mapadimeng

The near-zero level of racial desegregation in townships is influenced by a variety of factors that have not been thoroughly investigated. Some of the reasons for limited desegregation in townships include that very few residents from minority groups (such as white residents) move into black African townships due to limited space, limited opportunities for cultural integration, as well as demands for employment, services and amenities that are not met. On the other hand, black African residents dominate township space due to the size of the population group, cultural ties to townships and a sense of belonging in townships as well as socio-economic limitations to moving elsewhere. Although it is not investigated in detail here, it should be noted that there are also other dimensions of diversity that make townships very heterogeneous, such as language and income diversity (Hamann and Ballard, 2017).

The overview of the distribution of population groups provided in Figure 3 and Figure 4 highlights two important dynamics. First, racial diversity is present in a relatively small part of the province and single-race communities remain in the locations that they were confined to in the past. Second, Figure 3 and Figure 4 illustrate the fact that these broad patterns are not visible from segregation index values that are calculated for municipalities or the province. Previously unclear boundaries also become visible in a representation like Figure 3. It shows the areas where racial-residential segregation remains a challenge in the shape of Gauteng.



Photograph by Richard Ballard



Photograph by Clive Hassall



Racial diversity and urban expansion in Gauteng

Racial diversity and urban expansion in Gauteng

The distribution of population groups in Gauteng broadly represents a high degree of continuation of past segregation patterns, but not without change over time, especially in areas of residential expansion. Previous illustrations by the GCRO have suggested an association between urban expansion and increased racial diversity. In the particular example of Midrand (Figure 5), racial diversity increased substantially where new urban development occurred (Parker et al., 2017). The increase in urban land cover around Greenstone Hill, Waterfall and the wards north of Midrand (black shaded areas in Figure 5b) are associated with high ward-level racial diversity (darker shades of red in Figure 5b). However, urban expansion is not always related to increased racial diversity, and the perspective provided in Figure 5 can be refined.

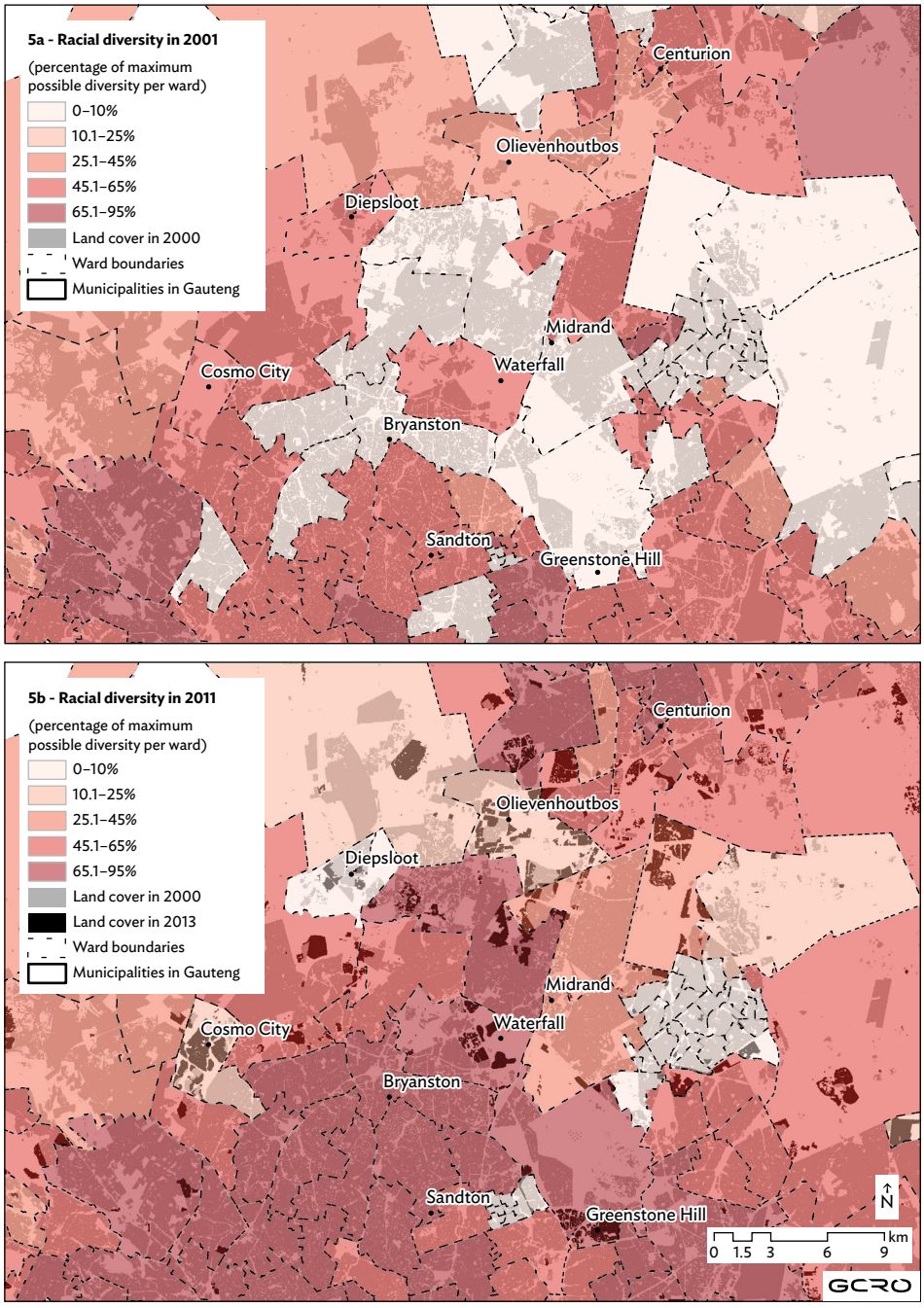
The rest of this section is focused on the first research question set out in the introduction of this study, namely whether residential expansion disrupts or perpetuates patterns of racial segregation.



Photograph by Clive Hassall

Figure 5: Racial diversity and urban expansion in Midrand, Gauteng, between 2001 and 2011

DATA SOURCE: Parker et al. (2017)



Overview of residential expansion in Gauteng since 1990

In this analysis, land-use data that is aggregated to hexagons is used to make a distinction between residential areas that existed in 1990 and residential areas that were added between 1990 and 2020 (GeoTerraImage, 2021a). For the purposes of this analysis, residential areas are defined as hexagons in which more than 30% of the total land use in the hexagon is classified as residential. Hexagons that contain less than 30% residential land use exclude only 10% of the estimated population. Excluded hexagons have an average population size of less than 80 residents whereas the included hexagons have an average population size of more than 160. The excluded hexagons prevent any patterns in the data that have low statistical confidence due to small population numbers. Re-modelled (from enumerator area to hexagon) population estimates for 2020 are used to calculate racial diversity for each hexagon (GeoTerraImage, 2021b).

The calculations show that roughly 905 km^2 of predominantly residential hexagons were added to the Gauteng residential footprint between 1990 and 2020 (Ballard, Hamann and Mosiane, 2021). In Gauteng as a whole, this residential expansion is not related to higher racial diversity. As shown in Table 3, the racial diversity of new residential developments is lower than residential developments on the 1990 urban footprint. This is mainly because areas of urban expansion that have low racial diversity are considerably larger, both in terms of total land area and estimated population, than those expansion areas with high racial diversity (Table 4 and Figure 6). In other words, on average, urban expansion is associated with low racial diversity.

However, while areas of urban expansion tend to be associated with low racial diversity *on average*, there is considerable variation across the province. As illustrated in Figure 6, which shows only the spatial pattern of racial diversity for residential areas that were added to the Gauteng urban footprint between 1990 and 2020, there is a distinct spatial separation between new residential areas with low and high racial diversity. Racial diversity is low in areas that were added next to townships such as Soshanguve, Mamelodi, Atteridgeville, Tembisa/Ivory Park, Soweto, Katlehong, Tsakane and Sebokeng. Meanwhile, the expansion of higher-income suburbs around the south-east of the City of Tshwane, northern parts of the City of Johannesburg and central parts of the City of Ekurhuleni is associated with higher levels of racial diversity.

When these patterns are compared to our established understanding of overall low and high racial diversity in Gauteng (Figure 4), it suggests that low racial diversity reproduces low racial diversity, and high racial diversity reproduces high racial diversity. These patterns also help to explain

Table 3: Racial diversity and residential expansion in Gauteng
DATA SOURCE: GeoTerraImage (2021a, b)

	Average diversity score	Highest diversity score
Residential hexagons in 1990	0.559 (40.4% of maximum possible diversity)[10]	1.383 (99.8% of maximum possible diversity)
Residential hexagons added between 1990 and 2020	0.279 (20.1% of maximum possible diversity)	1.325 (95.6% of maximum possible diversity)
All residential hexagons in 2020 (Gauteng)	0.452 (32.6% of maximum possible diversity)	1.383 (99.8% of maximum possible diversity)

10 Racial diversity (as calculated according to the Entropy Index explained on page 11) will reach a maximum that is equal to the natural logarithm of the number of groups considered. In a four group analysis, ln(4) = 1.386. Therefore, the diversity in an administrative unit can also be represented as a percentage of the maximum possible diversity.

Table 4: Racial diversity and associated land area and population for residential expansion in Gauteng
DATA SOURCE: GeoTerraImage (2021a, b)

Racial diversity as a percentage of maximum possible diversity	Total number of residential hexagons added to Gauteng	The total residential land area added to Gauteng	Percentage of total residential land area added to Gauteng	The total estimated population	Percentage of total estimated population
0%–10%	5 378	558.5 km^2	62%	5 246 613	80%
10.1%–30%	800	83.1 km^2	9%	558 858	8%
30.1%–50%	731	75.9 km^2	8%	250 829	4%
50.1%–70%	1 219	126.6 km^2	14%	325 947	5%
70.1%–95.6%	589	61.2 km^2	7%	192 578	3%
Total	**8 717**	**905.3 km^2**	**100%**	**6 574 825**	**100%**

the lower average diversity of residential expansion. The expansion of low diversity areas (townships and informal settlements) is spatially more significant and larger in terms of population than the expansion of other residential areas (upper and middle class) and contributes to lower overall diversity of urban expansion (Table 4).

Spatial-statistical analysis of the data can further nuance our understanding of the relationship between racial diversity and urban expansion. The Hot Spot Analysis tool in ArcGIS, a programme for spatial analysis, calculates where high and low values of racial diversity are spatially clustered (Figure 7). The analysis draws on the values of neighbouring features[11] to indicate where high values are surrounded by other high values and where low values are surrounded by other low values. The statistical confidence of each cluster is also calculated to show where more intense clustering of high values is located (or hot spots in shades of red) and where more intense clustering of low values is located (or cold spots in shades of blue). In other words, areas shaded dark red (or dark blue) indicate a cluster of high (or low) racial diversity and a high level of confidence in the cluster (99% confidence). Lighter shades of red (or blue) are also clusters of high (or low) racial diversity, but the confidence level of the clusters is slightly lower (95% or 90% confidence). Areas that do not form part of statistically significant hot or cold spots are also identified (in light grey) and help to focus the attention on the most statistically significant patterns. When the areas of residential growth (Figure 6) are added to the Hot Spot Analysis (Figure 7), it provides a visual illustration of how racial diversity is reproduced or disrupted through residential expansion.

Despite the overall dominance of residential expansion related to low racial diversity, there are important instances of high racial diversity in residential areas that developed since 1990. The next sub-section explores instances that are driven by either public or private initiatives. The key point highlighted by these examples is that new state-led housing developments have the potential to increase racial diversity in different ways and could be considered as one element that builds towards spatial transformation and an equal-opportunity city-region.

11 Neighbouring features are those polygon features that share a boundary or overlap and will influence computations for the target polygon feature. This is done by selecting the 'Contiguity edges only' parameter for the Conceptualisation of Spatial Relationships in the ArcGIS software.

Figure 6: Racial diversity of residential areas added to the Gauteng urban footprint between 1990 and 2020
DATA SOURCES: GeoTerraImage (2021a, b)

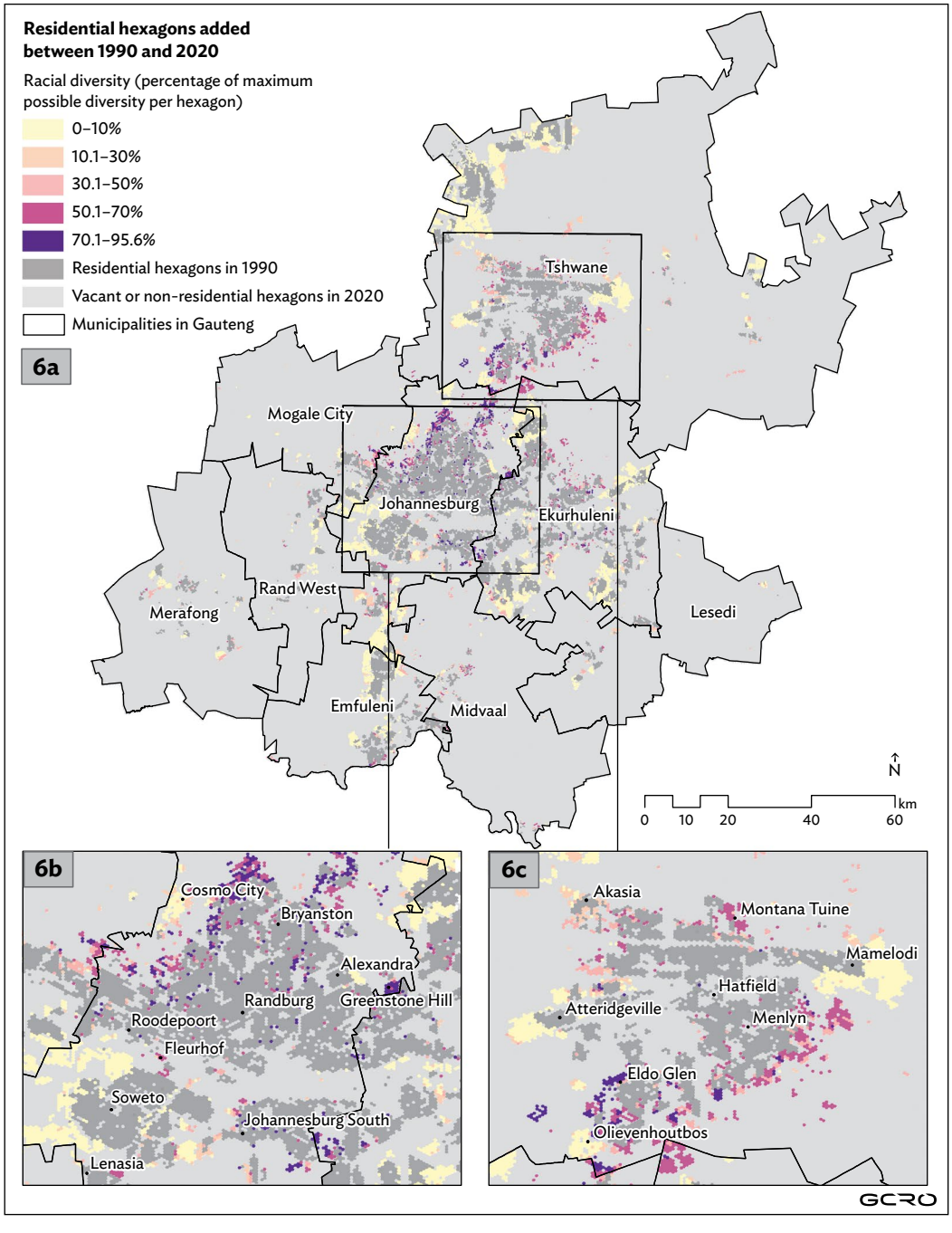
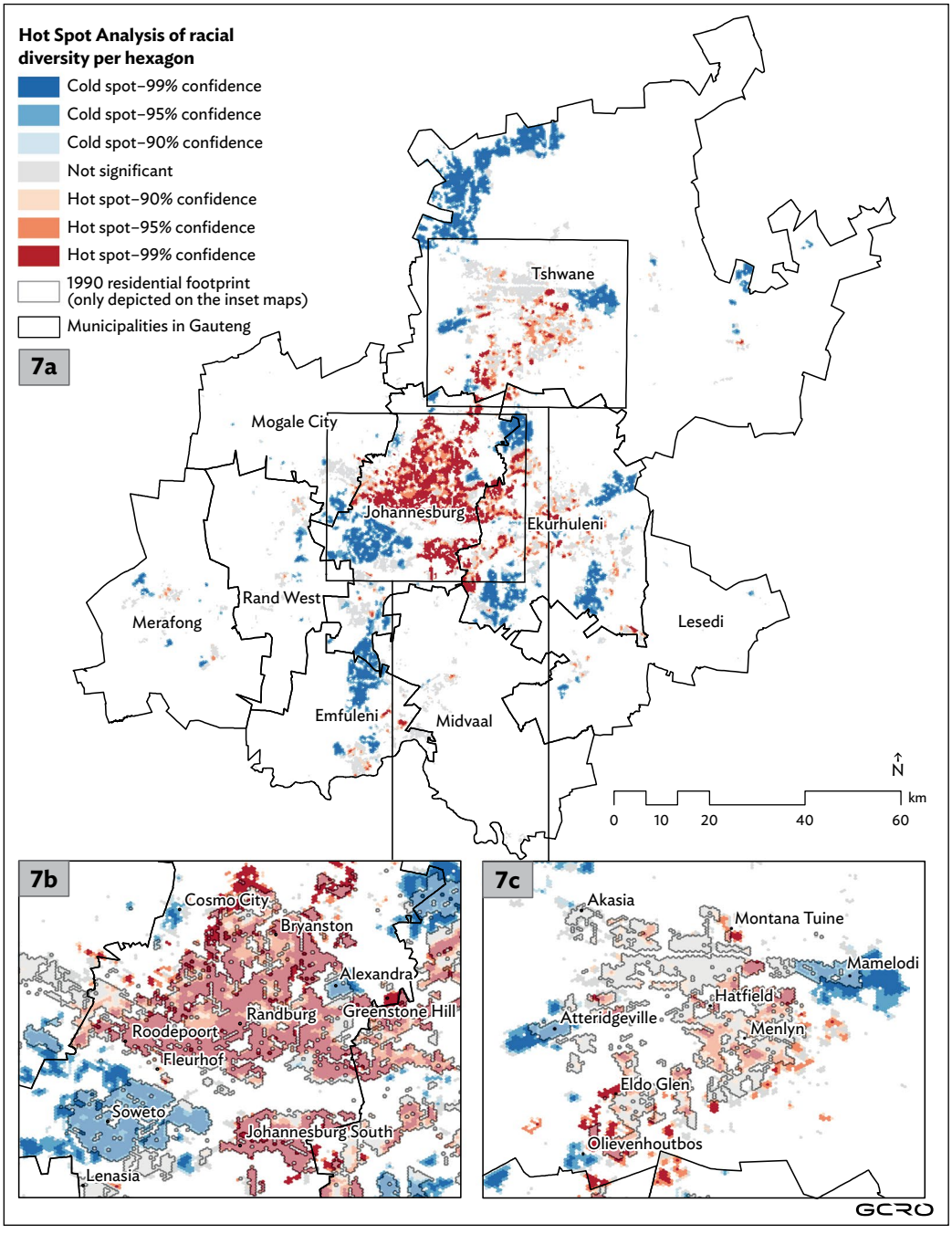


Figure 7: Hot Spot Analysis of racial diversity per hexagon in Gauteng and residential growth

DATA SOURCES: GeoTerraImage (2021a, b)



Public housing expansion and racial diversity

Public housing developments are important interventions toward the goal of creating a more equal city-region and have the potential to include a variety of population and income groups. This section looks from a local-scale perspective for the effect that public housing developments have on racial diversity. One such example is Fleurhof, which is a public housing development located in the mining belt of the City of Johannesburg just north of Soweto and south of Roodepoort, and about 13 km west of the City of Johannesburg central business district (Figure 6b, Figure 7b and Figure 8).

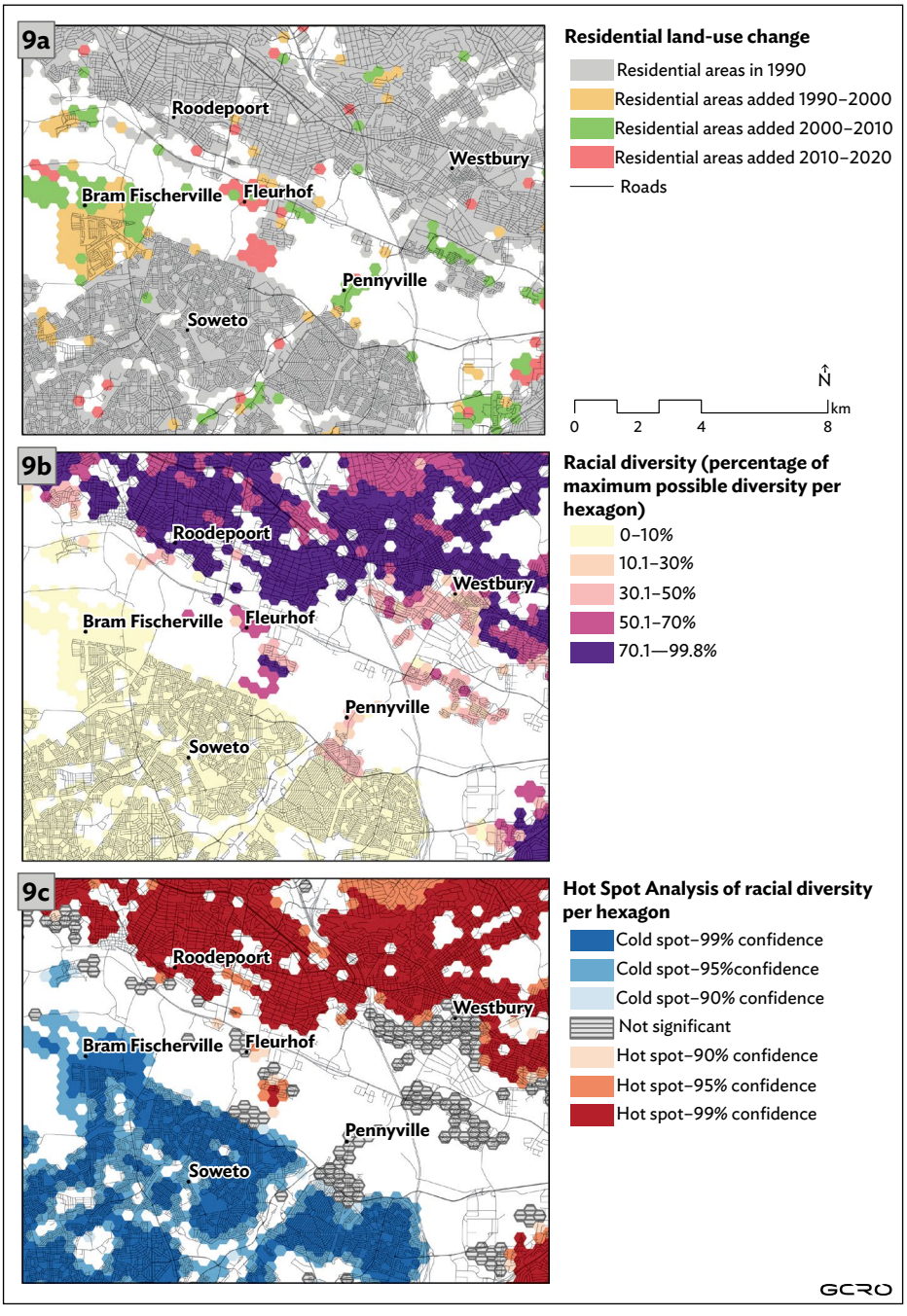
Fleurhof is a public housing development with relatively high racial diversity within the development itself. Before the construction of the government housing project, Fleurhof was a small neighbourhood of free-standing houses wedged between mine dumps and a light industrial area (the centre of Figure 9a). Up to the 2011 census, Fleurhof residents were mostly coloured (74%) and the area would therefore have exhibited relatively low racial diversity. The area was targeted for public housing development with the aim to 'integrate the geography of a city still divided by a legacy of apartheid spatial policies' (Rubin and Harris, 2018, p. 259). Since 2013, Fleurhof was redeveloped with higher density housing that includes fully bonded, semi-subsidised and fully subsidised housing. The development created an opportunity for higher racial diversity in this newly built residential neighbourhood. The development straddles the space between low racial diversity in Soweto and higher racial diversity in Roodepoort (Figure 9).

Figure 8: Fleurhof, City of Johannesburg, with the edge of Soweto in the foreground and Florida on the horizon
PHOTOGRAPH BY CLIVE HASSALL



Figure 9: Fleurhof, City of Johannesburg

DATA SOURCES: GeoTerraImage (2021a, b)



The analysis shows that, at a local scale, this new development is associated with higher racial diversity while overall racial diversity has also increased between areas with otherwise distinct levels of racial diversity. The red shaded parts in the centre of Figure 9a depict the areas that were added between 2010 and 2020. These hexagons are associated with the dark pink colours in Figure 9b as well as a hot spot of high racial diversity (red shading) in Figure 9c. Today, population estimates indicate that Fleurhof (including the government housing and the original neighbourhood) has an average racial diversity score of 0.796 (or 57% of the maximum possible diversity) and includes reasonable proportions of black African (51%), coloured (21%) and white (27%) residents.

From a microscale perspective, there is also uneven diversification within Fleurhof. This is evident from the different shades of pink in the centre of Figure 9b. Despite the presence of statistical diversity, individual experiences do not always amount to social integration (Ndaba, 2019). Residents of Fleurhof are aware of the diversity of population groups that reside in the area, but they are also aware of the distinctions between areas with lower and higher diversity within Fleurhof shaped by, among other factors, the history of the neighbourhood, tenure status and development quality (Ndaba, 2019). For example, one of the Fleurhof residents observed that areas with bonded housing are more racially integrated because the quality of the housing stock there is better, and also mentioned that coloured residents dominate the older parts of Fleurhof (interviewed in Ndaba, 2019). The resident also stated that inequality and racial classism were normalised within this new development. This suggests further social boundaries that are not visible from a quantitative perspective and could be investigated through qualitative analysis.

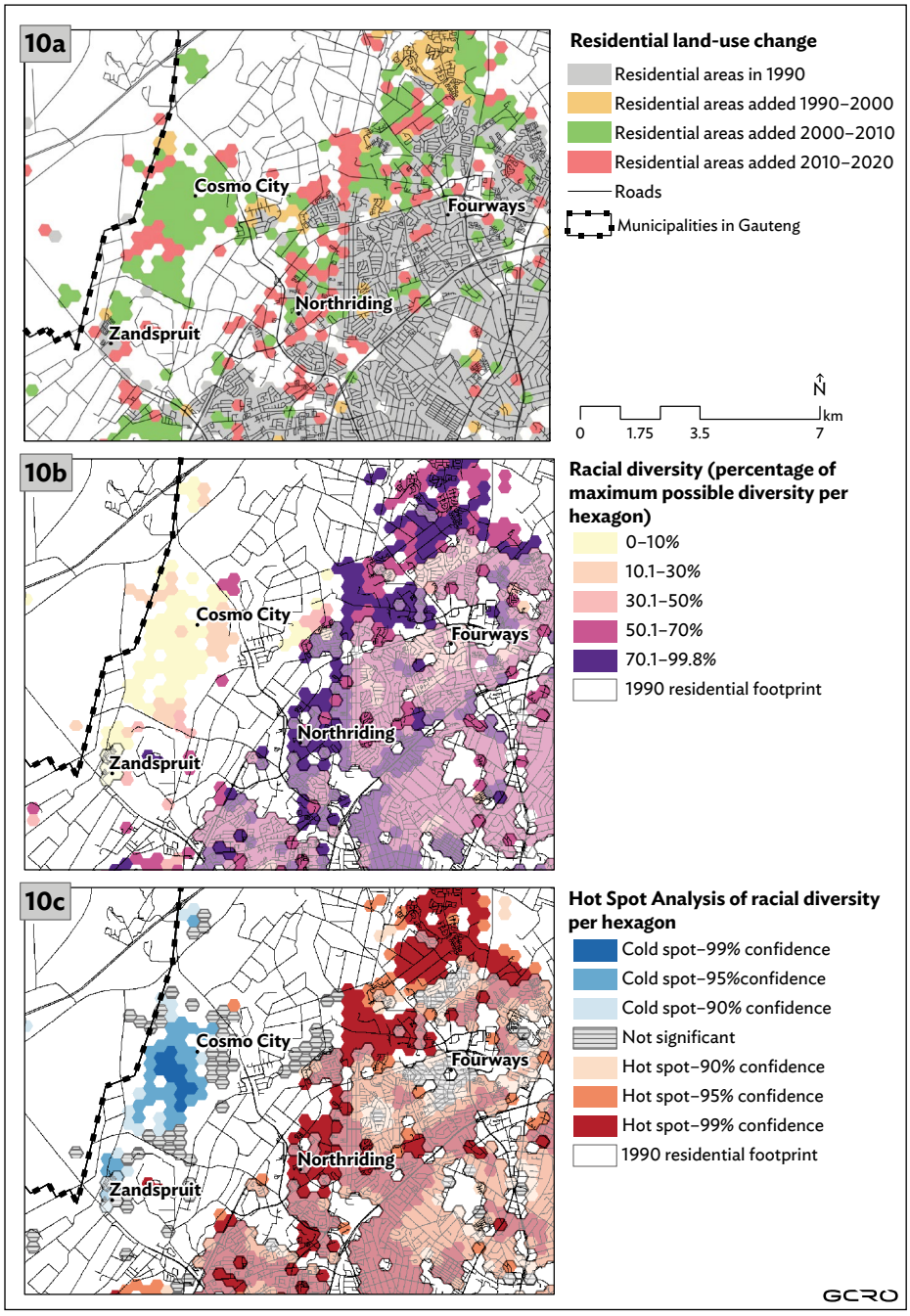
Another prominent public housing development in the City of Johannesburg is Cosmo City. Cosmo City is located 23 km north-west of the City of Johannesburg central business district and represents low racial diversity (Figure 10). Cosmo City is primarily occupied by black African residents and racial diversity is only 5.6% of maximum possible racial diversity. However, Cosmo City is located near the expanding middle-class suburbs around Northriding and Fourways (note the yellow, green and red hexagons in Northriding and north of Fourways in Figure 10a). These suburbs have higher racial diversity because of middle-class integration (dark pink shading in Figure 10b and the hot spots in Figure 10c). These developments bring lower- and middle-class residents to within a few kilometres of each other and might get even closer as the developments continue to expand towards one another in future.

Cosmo City provides one example of how certain developments disrupt, as opposed to reinforce, patterns of segregation. Despite the low microscale racial diversity in Cosmo City itself, the location of this development near the expanding middle-class neighbourhoods means that macroscale racial diversity and access to opportunities are increased in a way that other public housing developments located close to townships are not (Roitman, Webster and Landman, 2010). In some ways, this public housing development is reshaping the patterns of segregation through urban expansion and creates the potential for integration on the urban frontier.

Despite the presence of statistical diversity, individual experiences do not always amount to social integration

Figure 10: Cosmo City, City of Johannesburg

DATA SOURCES: GeoTerraImage (2021a, b)



Private housing development and racial diversity

Formal and informal private housing developments are also related to increases in racial diversity, but these developments are segmented into a broader affordability range and often create class segregation despite their racial desegregation contribution. Some of the private housing developments expand the urban footprint and can be analysed here. As noted above, new cluster housing developments tend to be racially integrated within a limited middle-class income range (Chipkin, 2012). On the other hand, informal and low-cost private housing development have low racial diversity.

An example of private housing development at both ends of the cost spectrum is Alexandra and Greenstone Hill. These two areas stand out in Figure 7b as a bright red cluster (Greenstone Hill) close to an island of low racial diversity denoted by blue shading (Alexandra). Private housing development on the low end of the affordability spectrum, in this instance informal dwellings on the Far East Bank of Alexandra, expand the urban footprint with very low racial diversity (Figure 11). Opposite this, middle- to high-cost private-sector housing development (in the form of cluster housing development) that expands the urban footprint, and showing high racial diversity, is evident in Greenstone Hill (Figure 11). The developments on the Far East Bank of Alexandra mostly took place between 1990 and 2000 (yellow hexagons in Figure 11a) while Greenstone Hill developed between 2000 and 2010 (green hexagons in Figure 11a).

An important insight from Figure 11 relates to the microscale nuance that this mapping adds to our current and future understanding of racial diversity changes. The Far East Bank developments and the Greenstone Hill development have changed the scale of separation between two very different kinds of housing development – bringing them to within a few kilometres of each other. At macroscales this increases racial diversity in the city and creates an opportunity for a certain level of integration (Roitman, Webster and Landman, 2010). However, the wealthy gated Greenstone Hill communities are not located in a relatively poor area. The reproduction of low racial diversity and low household income of the Far East Bank of Alexandra continue to stand in opposition to the reproduction of high racial diversity and high household income in Greenstone Hill. Being separated by a national highway also means that there is very little scope for social integration. Without linkages between the areas that allow opportunity sharing, the segregation in this instance will be directly linked to inequality and will be considered problematic in the future. The scale of segregation has reduced but segregation remains evident.

Another example of private housing development is Die Hoewes in the south of the City of Tshwane, an area previously dominated by smallholdings (Figure 12). Here, racial diversification has been happening through a transformation in the housing market in the area: smallholding properties that were primarily occupied by white residents have been redeveloped into cluster accommodation and marketed to a racially mixed middle class. By 2001, about half of the smallholdings were already subdivided and redeveloped to include medium-density cluster housing. This process accelerated in the early 2000s to the extent that nearly all smallholdings have now been redeveloped to include medium-density cluster housing (the red hexagons in Figure 12a). This has been accompanied by the development of transport infrastructure and increases in employment, retail and various social opportunities. The redevelopment is associated with significant changes to the population composition of the area.

Racial diversity in the area increased from 38% of the maximum possible diversity to 73% between 1996 and 2011 and is directly related to an increase in townhouse, cluster complex and semi-detached housing development and a rise in middle- to upper-income households (Table 5). The presence of poor households also increased slightly in the area, suggesting some class mixing that is made possible by affordable rental units or subletting in cluster complexes. Figure 12 also shows that areas that were already developed in 1990 (and presumably dominated by white residents) exhibit high racial diversity.

Figure 11: Urban expansion and racial diversity in Greenstone Hill and the Far East Bank

DATA SOURCES: GeoTerraImage (2021a, b)

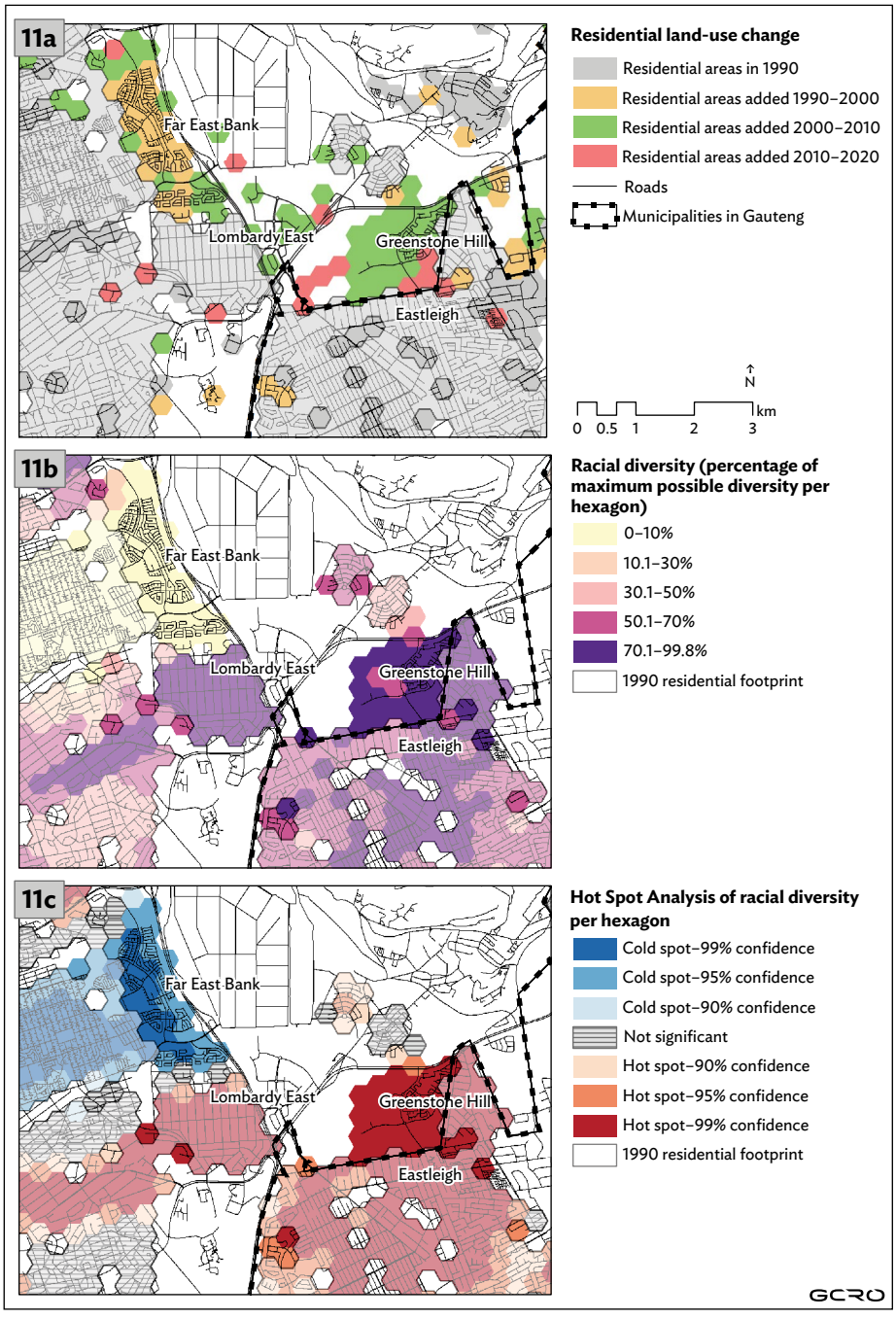


Figure 12: Die Hoewes, Centurion

DATA SOURCES: GeoTerraImage (2021a, b)

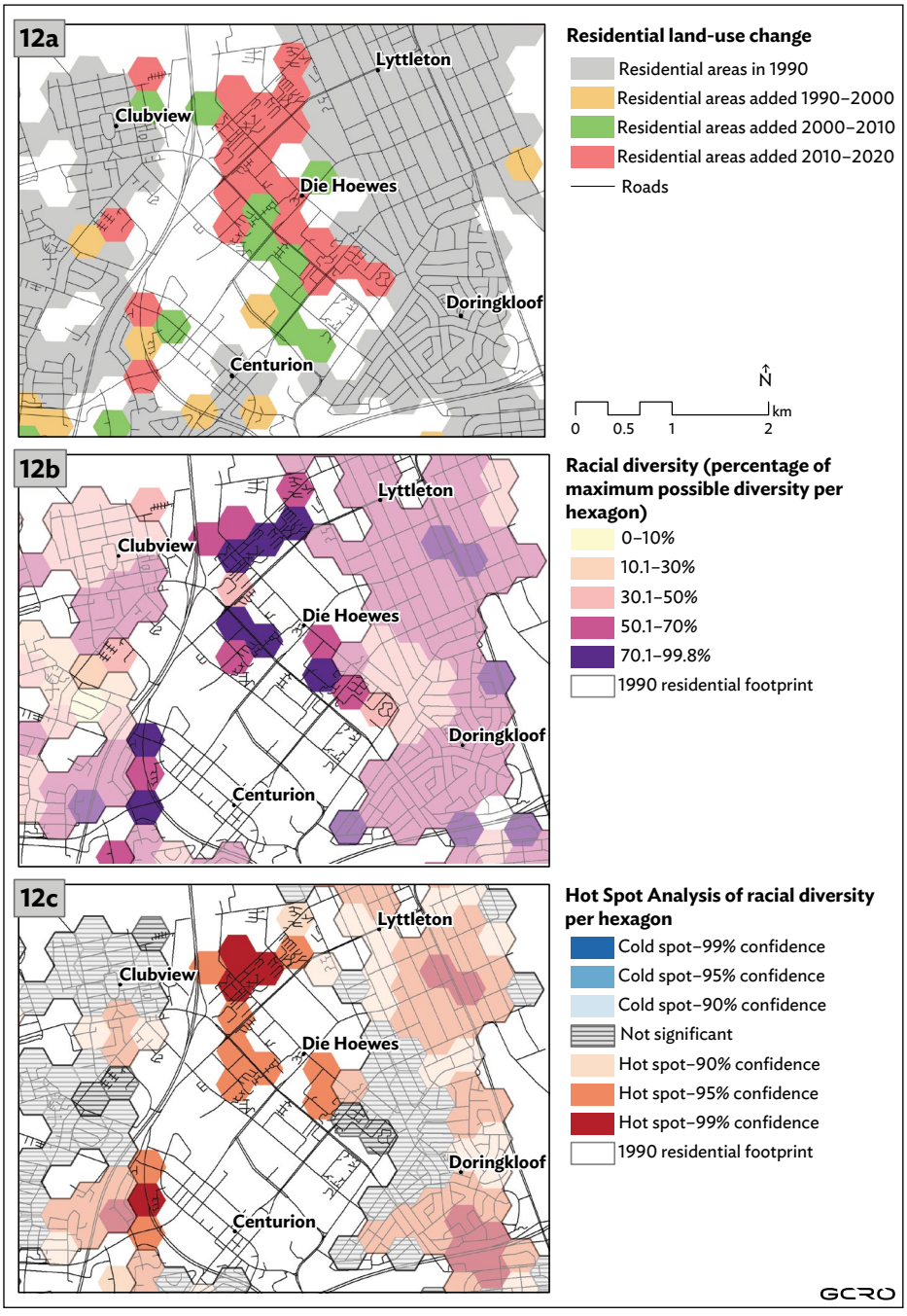


Table 5: A summary of demographic and socio-economic change in Die Hoewes, Centurion
DATA SOURCE: Census data – Community profiles (Statistics South Africa, 2011a, 2001, 1996)

	1996*	2001	2011
Racial diversity	0.520	0.598	1.014
Percentage of maximum possible racial diversity	38%	43%	73%
Dwelling type: House on a separate stand or yard	20%	14%	15%
Dwelling type: Flat or apartment in a block of flats	5%	11%	19%
Dwelling type: Townhouse/cluster/semi-detached	53%	66%	63%
Household income: Less than R19 200	n/a	8%	12%
Household income: R19 201–R153 600	n/a	49%	23%
Household income: More than R153 601	n/a	43%	65%

* The income categories that were used to capture the household income data during the 1996 census is not directly comparable to the categories used in the 2001 and 2011 census, therefore they are excluded from this table.

Summary

In trying to understand whether residential expansion contributes to desegregation or to continued segregation, this section quantified residential expansion and analysed its association with racial diversity. The residential footprint of Gauteng increased by roughly 905 km^2 between 1990 and 2020. The residential expansion is associated with a high degree of continuation of past patterns of racial-residential segregation, but not without change over time. The expansion of low-diversity areas (townships and informal settlements) is spatially more significant and larger in terms of population than the expansion of other residential areas (upper and middle class), resulting in lower overall diversity of urban expansion areas.

The section also explored how public and private residential developments shape racial diversity in relation to urban expansion. Some public and private housing developments have brought residents from opposite ends of the income spectrum to within a few kilometres of each other, thus changing the macroscale patterns of racial-residential segregation even though some microscale patterns of racial-residential segregation remain (Cosmo City, Northcliff, Fourways, Far East Bank and Greenstone Hill). Other public and private housing developments are associated with higher racial diversity than in the past and have changed the patterns of racial-residential segregation on a macro- and microscale (Fleurhof and Die Hoewes), albeit within a limited range of household incomes.



Photograph by Richard Ballard



Racial income differences in Gauteng

Racial income differences in Gauteng

High racial diversity in residential expansion areas and the continual decline in racial segregation in higher-income neighbourhoods does not eradicate all forms of segregation or reduce racial inequality. Linked to historic racial divisions – but fuelled by the workings of property and labour markets as well as concentrated poverty – new forms of segregation can be created along differences in wealth, income and employment (Crankshaw, 2022; Mabin, 2005). In many instances, racial heterogeneity increases in affluent areas while class homogeneity is maintained (Ballard, Hamann and Mkhize, 2021). In the presence of racial inequality, this leads to segregation and unequal access to opportunities. The co-presence of population groups in some areas requires further investigation to understand if new forms of localised class-based segregation may occur within an area (Hamann and Ballard, 2017). For example, in the City of Johannesburg, the informal settlements of Zandspruit and Kya Sands, the state-planned settlement of Cosmo City and the wealthy Jackal Creek Golf Estate are located very close to each other. However, because these residential developments are not functionally integrated neighbourhoods, segregation remains intact and racial inequality is high.

Breaking down the scale of the analysis by investigating the dynamics in a sub-selection of wards can provide further useful insight about other areas that experience socio-economic separation. The analysis in this section is concerned with the differences in mean household income and socio-economic status in wards where black African and white respondents are represented in relatively equal proportions, addressing the second research question of this Occasional Paper. Demographic data from the GCRO QoL 4, QoL 5 and QoL 6 surveys (GCRO, 2021, 2019, 2016)[12] are used to select wards in Gauteng with at least 25 black African and 25 white respondents, and where these respondents reported their household income.[13] Coloured and Indian/Asian respondents are not included in this analysis because their samples sizes across wards are too small to yield a useful selection of wards where they are equally represented. The associated household income responses are then used to calculate the difference between black African and white mean household income in each selected ward. Household income midpoints for QoL 4 (done in 2014/15) and QoL 6 (done in 2020/21) were adjusted for inflation to 2017 prices before calculating the mean household income to correspond with the completion of QoL 5 (done in 2017/18). By focusing on this selection of wards, the scale of the analysis is reduced from a provincial perspective where trends are harder to observe to a local perspective where nuances can be explored. The analysis helps to explain how processes of racial diversification and socio-economic sorting within former whites-only areas may still be associated with broader socio-economic segregation and inequality patterns.

12 The method of combining responses from different QoL surveys is unconventional, given that things can change over time. However, this method relies on an average indication of demographic composition and household income in the wards.

13 Over the course of the QoL surveys, an average of 80 respondents were interviewed in each ward in Gauteng. The selection of 25 black African and white respondents gives both a reasonable sample size to analyse per ward and a reasonable distribution of valid wards in Gauteng.

Income differences in diverse wards

Figure 13 plots the difference in mean household income in wards where at least 25 black African and 25 white respondents reside. A total of 57 wards were used in the analysis. The difference in mean household income between black African and white households was used to rank-order the wards from smallest difference to largest difference. The wards with the smallest difference are those in which black African mean household income is higher than white mean household income. There are only seven of these wards and the difference between black African and white mean household income is very small. In three of the wards in this analysis, the difference in mean household income is considered insignificant. In these wards, the ratio between black African and white mean household income is between 1 and 0.96, or between R53 and R2 412 in mean household income. The rest of the wards in this analysis (47 wards) are wards where white mean household income is higher than black African mean household income. On both ends of the spectrum of income differences, there are intriguing dynamics at play that shape racial diversification and socio-economic sorting at a very local level.

In the wards where black African mean household income is higher than those of white households, the wards have relatively low socio-economic status. Figure 14 shows that the average socio-economic status (indicated here by access to private healthcare, medical aid, tertiary education qualifications, hunger risk and use of social grants) of these wards remains lower compared to wards where white mean household incomes are higher. For example, in wards where the black African mean household income is higher than white household income (dark red bars), 51% of respondents used private healthcare facilities and 44% of respondents

Figure 13: Mean household income differences in wards with at least 25 black African and 25 white respondents
DATA SOURCES: GCRO (2021, 2019, 2016)

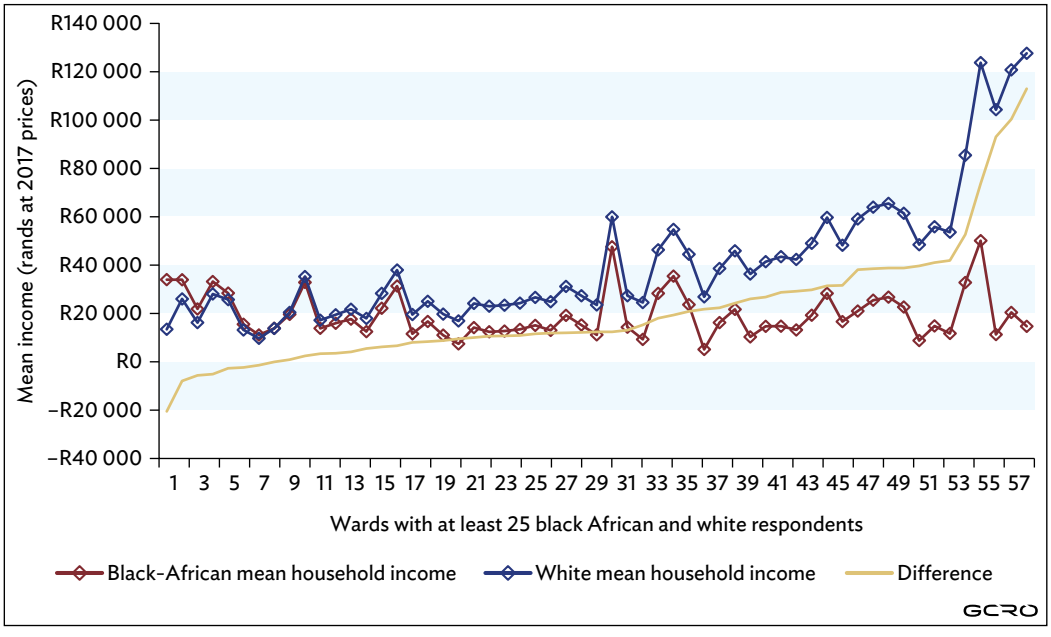
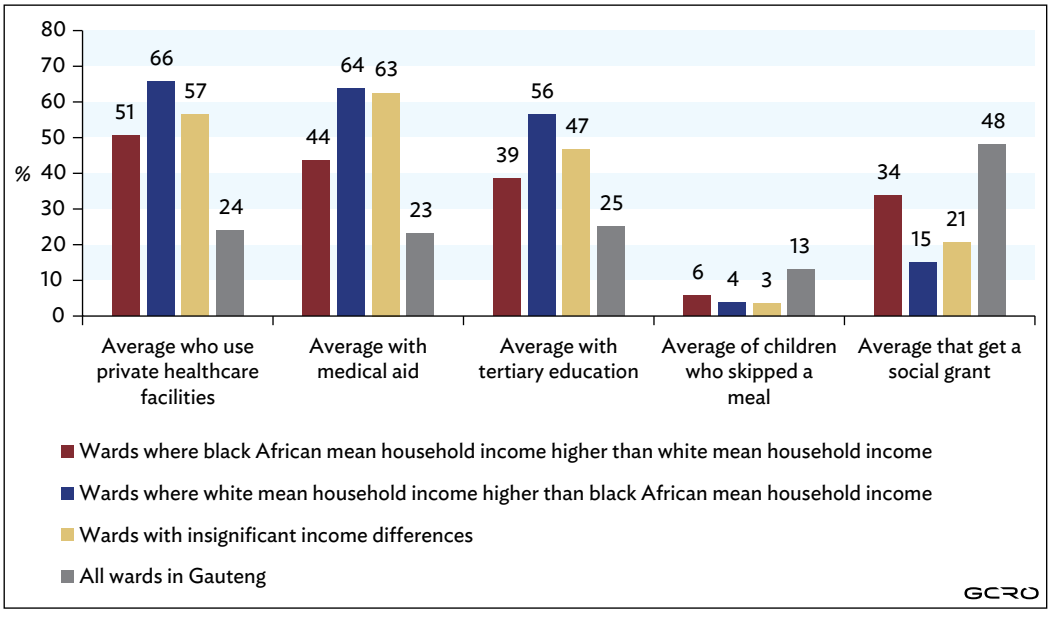


Figure 14: Socio-economic differences between wards with different black African-white income ratios
DATA SOURCES: GCRO (2021)



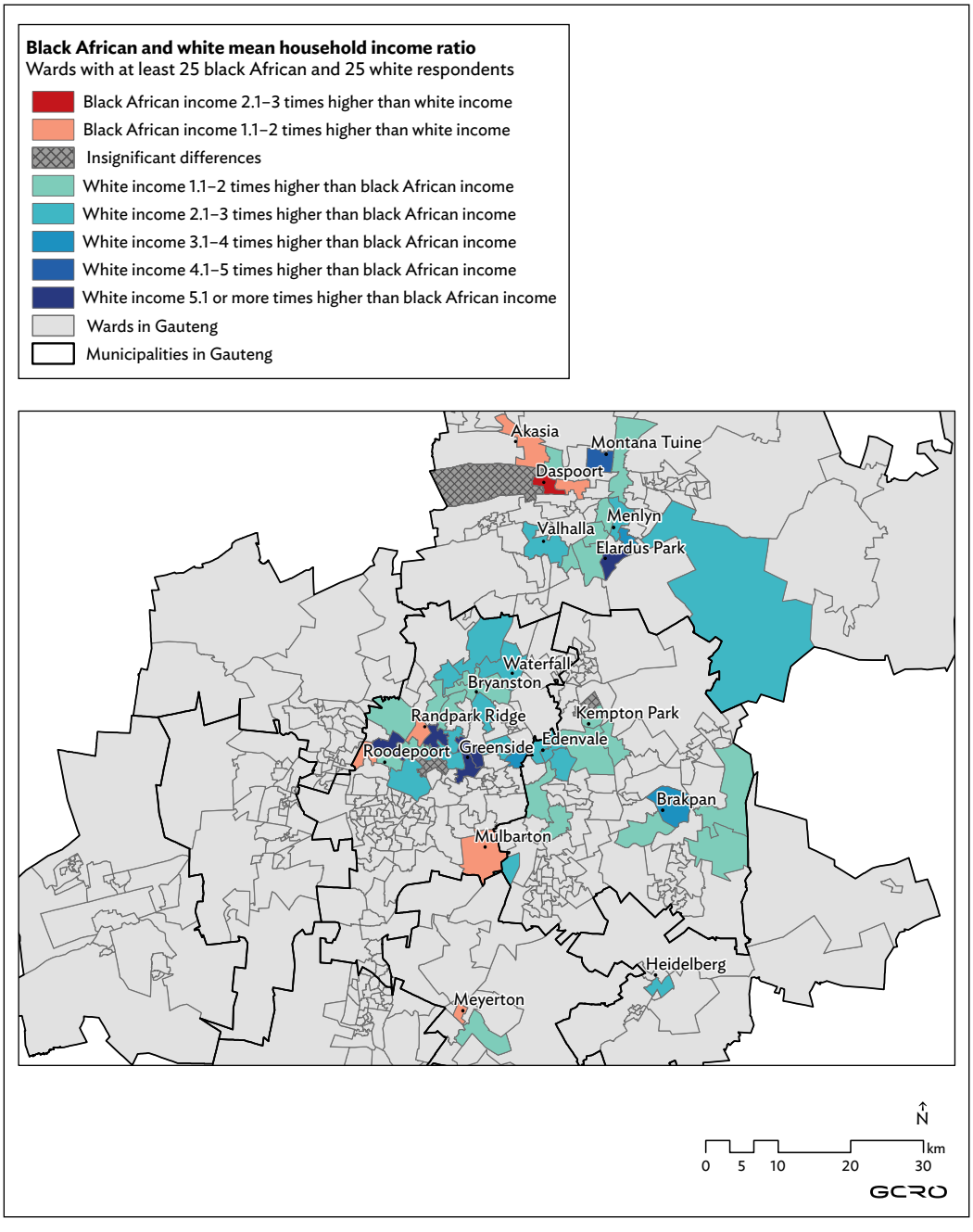
had access to medical aid. However, in wards where white mean household income is higher than black African household income (the dark blue bars), 66% of respondents used private healthcare facilities and 64% of respondents had access to medical aid. This suggests that mean household income data are related to overall socio-economic status and that access to high-value opportunities (such as private healthcare facilities or tertiary education) is unavailable to most low-income households. This also represents another way in which socio-economic status remains tied to space, even when the demographic composition of an area changes. Lower income areas remain lower income despite desegregation driven by upward mobile black African residents, and higher income areas remain higher income and continue to exclude on the basis of socio-economic status.

Wards where the difference between black African and white mean household income is the highest (white household income five or more times higher than black African household income) could be shaped by the presence of low-wage black African employees as opposed to black African homeowners or tenants, or by the presence of a very poor black African settlement. This would represent a situation similar to the race and class mixing that occurred in whites-only suburbs during apartheid, when domestic workers lived on the properties of their employers. These wards have maintained their socio-economic status (Figure 14) – to the benefit of those who can afford to live in the wards, but to the detriment of those that remain financially excluded from these wards.

Spatial view of income differences in diverse wards

Further nuance about the characteristics of the wards in this analysis can be gained by mapping their location (Figure 15). Most of the wards in this analysis are located in central suburban areas, in line with the distribution of racially diverse wards in Gauteng.

Figure 15: Mean household income ratios in wards with at least 25 black African and white respondents
DATA SOURCES: GCRO (2021, 2019, 2016)



The areas where white household income is substantially higher than black African household income (darker shades of blue) are the areas that were historically wealthy neighbourhoods inhabited by white residents in the northern parts of the City of Johannesburg (Bryanston, Greenside, Roodepoort) and eastern parts of the City of Tshwane (Elardus Park, Menlyn). Most of the areas where black African household income is higher than white household income are areas that were historically low-income neighbourhoods inhabited by white residents (Daspoort, Mulbarton and Meyerton). Many of the wards in this analysis are also associated with areas that experienced residential expansion between 1990 and 2020, including Akasia, Montana Tuine, Menlyn, Waterfall and Brakpan.

This analysis demonstrates that even though neighbourhood population group composition has changed significantly (racial-residential desegregation), the income distribution by population group in those same desegregated spaces has not changed significantly. The analysis also shows that in the same way as it is not possible to assume racial homogeneity in affluent areas (because this is just a small selection of suitably mixed wards), it is not possible to assume socio-economic equality in racially mixed areas. At a relatively local level, income and socio-economic status remains attached to historic distributions between population groups, despite desegregation. Proactive interventions, such as mixed housing developments, are required to improve access to high-value opportunities and reduce inequality.

The ward geography is useful for the overview of race and income mixing in Gauteng, but a micro-scale analysis would further help to explain the patterns of racial diversification and socio-economic sorting. A question that remains is whether there is still separation between race and income groups below the ward geography. Knowing that incomes are substantially different for black African and white residents, the extent of microscale separation can be assessed by mapping the distribution of either population group per hexagon in the wards where the two population groups are represented. Figure 16 shows that the proportion of white residents across the selected wards is not even. In each of the wards that surround Fourways, Orchards, Davidsonville and Windsor East and West, there are parts of the wards with small proportions of white residents and parts with large proportions of white residents. These distributions show physical separation between population groups and suggest that mean household income is also concentrated in some parts of the selected wards. A reasonable degree of class segregation exists in these wards despite racial mixing. In contrast, around Edenvale and Waterfall there are no clear clusters that are dominated by white residents. This suggests that there is a reasonable degree of race and class mixing at the ward level and at a microscale.

Summary

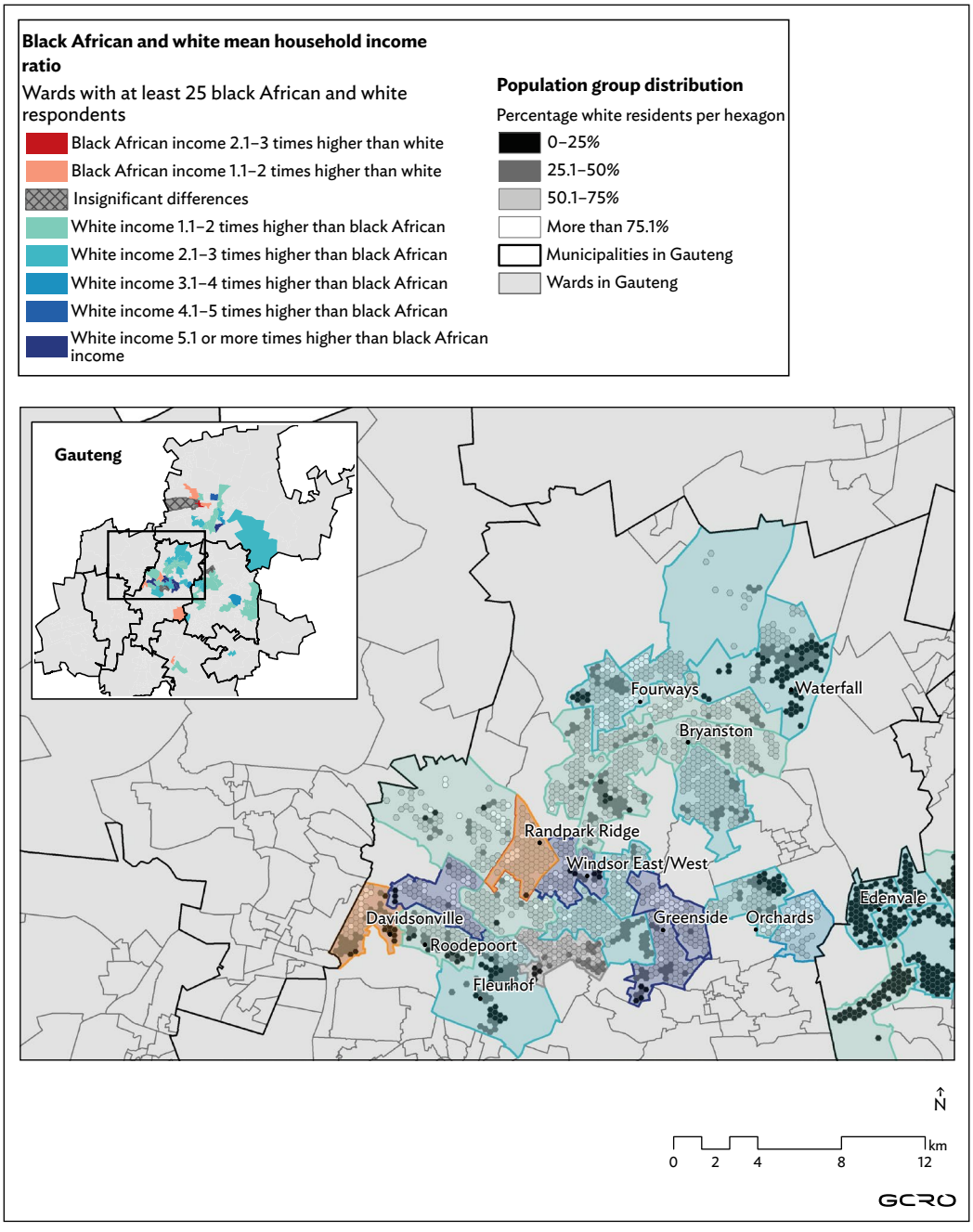
At different geographic scales, racial desegregation does not necessarily disrupt socio-economic segregation because racial and spatial inequality inhibits complete integration and equal access to the opportunities in the city.

This section focused on socio-economic mixing by analysing the income distribution of respondents in wards that are desegregated and mapping population group concentrations at a microscale. In the majority of desegregated wards that were analysed, the income distribution is significantly skewed in favour of white households. In some wards, white households have up to eight times higher mean household income than black African households in the same ward. In wards where black African mean household income is higher than those of white households, the ward has a relatively low socio-economic status.

Thus, the analysis shows that most desegregated wards maintain their socio-economic status and the racialised patterns of inequality associated with their past. However, the result of sorting based on mean household income is not the same in all wards. Microscale analysis shows that some wards are shaped by a degree of class segregation despite racial mixing, whereas other wards are characterised by race and class mixing at the ward level and at a microscale.

Figure 16: White population concentrations in wards with significant differences in mean household income between black African and white households

DATA SOURCES: GCRO (2021, 2019, 2016); GeoTerraImage (2021a, b).





Photograph by Clive Hassal



Uneven diversification at microscales

Uneven diversification at microscales

The racial diversity representations in this publication provide a valuable indication of the broad changes to the apartheid geography. However, the patterns of desegregation are not even. Desegregation takes places in a few areas of the province and creates macroscale patterns of high and low racial diversity. An example of this would be the north-south separation of high and low racial diversity in the City of Johannesburg (Figure 17). As the macroscale racial geography of apartheid erodes through desegregation in suburbs that were previously designated for white residents, uneven diversification at microscales and the associated barriers to diversification can be hidden from view.

This section focuses on the patterns of microscale socio-economic sorting in desegregated areas of Gauteng, the third research question of this Occasional Paper. The section explores three examples of uneven diversification at a microscale (areas A, B and C in Figure 17). The three examples were chosen because they represent interesting patterns of different groups in the same area and they are examples that build on the discussions that have been outlined so far in the publication. These examples are not intended to be exhaustive, but they provide a useful and nuanced indication of the dynamics of racial diversification and socio-economic sorting in Gauteng at a very local level.

Windsor East and Windsor West compared to Randpark, Windsor Glen, Fontainebleau and Kelland (area A in Figure 17)

In the City of Johannesburg, a collection of suburbs – Windsor East, Windsor West, Windsor Glen, Fontainebleau, Randpark and Kelland – provide an important example of uneven diversification (Figure 18). These suburbs are located in the northern parts of the City of Johannesburg, which exhibit very high racial diversity. In other words, it is generally a desegregated space when analysed with ward-level data, but microscale divisions should also be considered. At a microscale, the suburbs experience moderate segregation. The dot distribution of respodents in past GCRO QoL surveys shows that black African residents dominate Windsor East and West whereas white residents dominate the other suburbs.

Figure 19a shows that this collection of suburbs, with the exception of Kelland, were already developed in 1990. It is therefore an area that would previously have been dominated by white residents, but the area has experienced substantial desegregation. The differences in racial diversity per hexagon today (Figure 19b) and the Hot Spot Analysis of racial diversity (Figure 19c) are not very big, but they are nonetheless important. The gated area of Randpark, which is also associated with the Randpark Golf Club, has slightly lower racial diversity than Windsor East and West. These suburbs are shaped by trends towards smaller properties, the housing demand of the growing black African middle class and processes of gating (Ballard, Hamann and Mkhize, 2021). However, in this case, there is a distinct separation between race and class groups at microscales that is related to neighbourhood charactersitcs.

Figure 20 draws on census data from 1996, 2001 and 2011 to show how the population composition of the suburbs changed over time. Windsor East and Windsor West experienced significant desegregation. Black African proportions increased from less than 20% to more than 70% over the period whereas white proportions declined from around 80% to less than 15%. However, in the adjacent suburbs of Windsor Glen,

Figure 17: Racial diversity in Gauteng and uneven diversification case studies

DATA SOURCES: GCRO (2021, 2019, 2016)

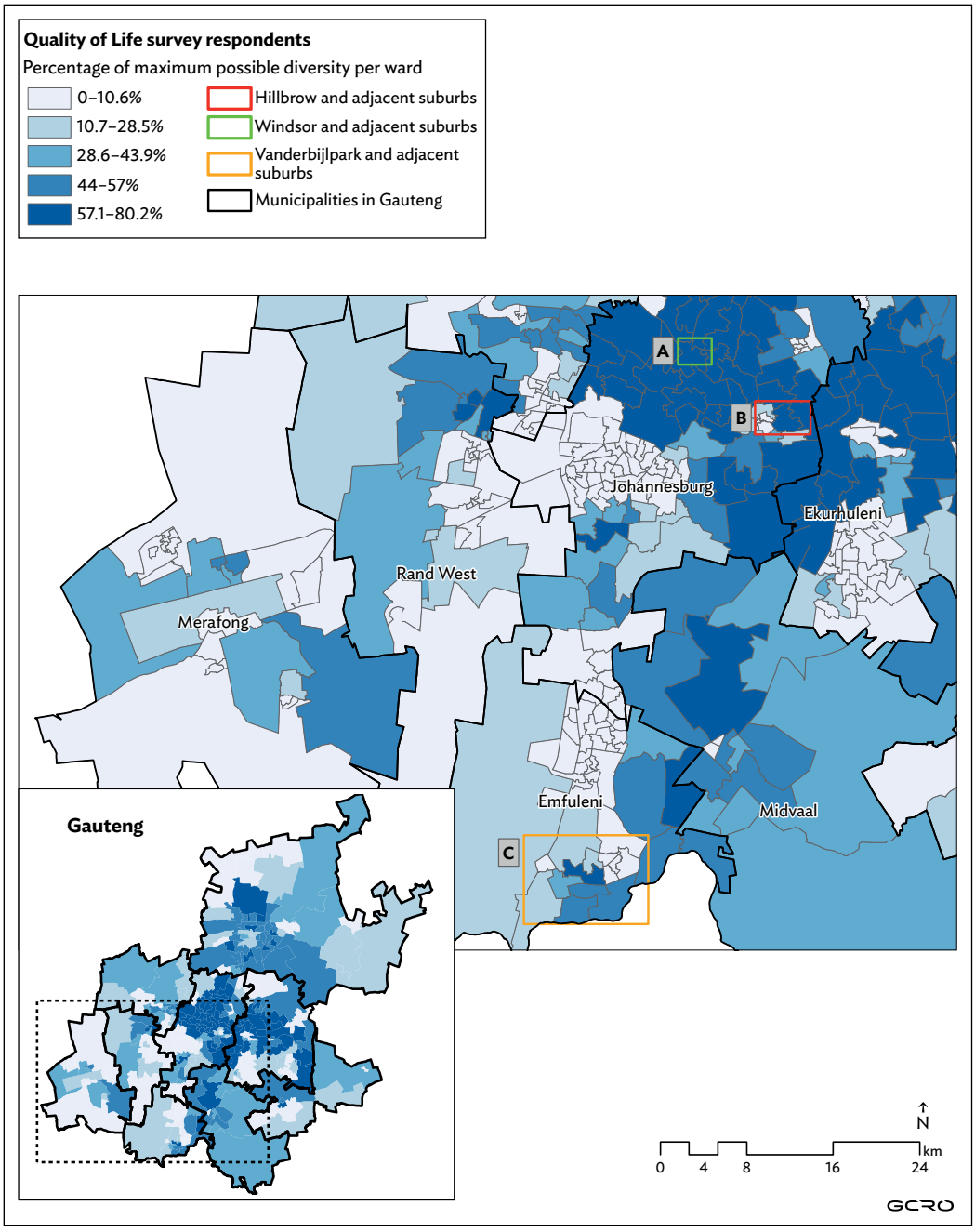


Figure 18: Windsor and adjacent suburbs, City of Johannesburg

DATA SOURCES: GCRO (2021, 2019, 2016)

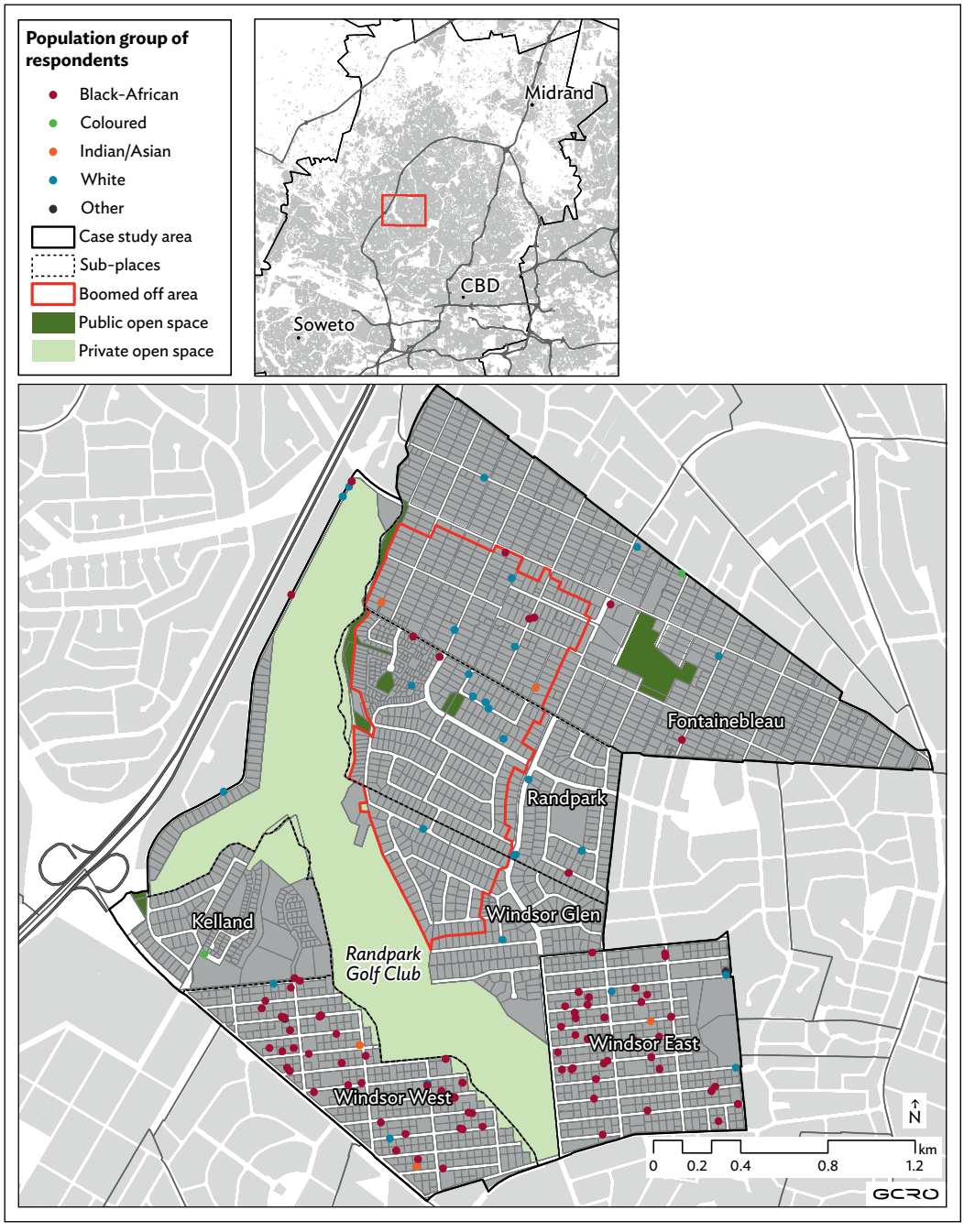


Figure 19: Uneven diversification in Windsor and adjacent suburbs

DATA SOURCES: GeoTerraImage (2021a, b)

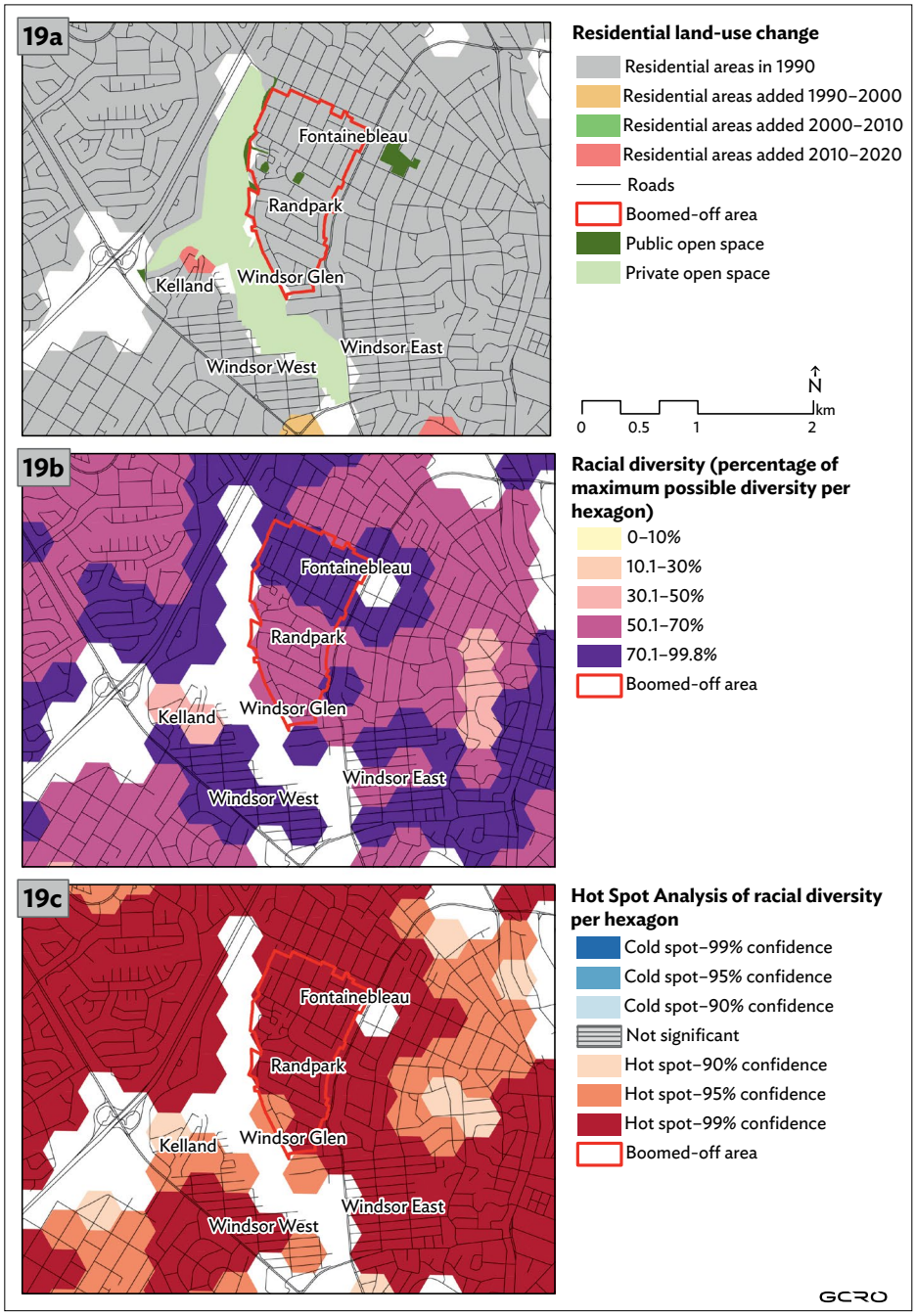
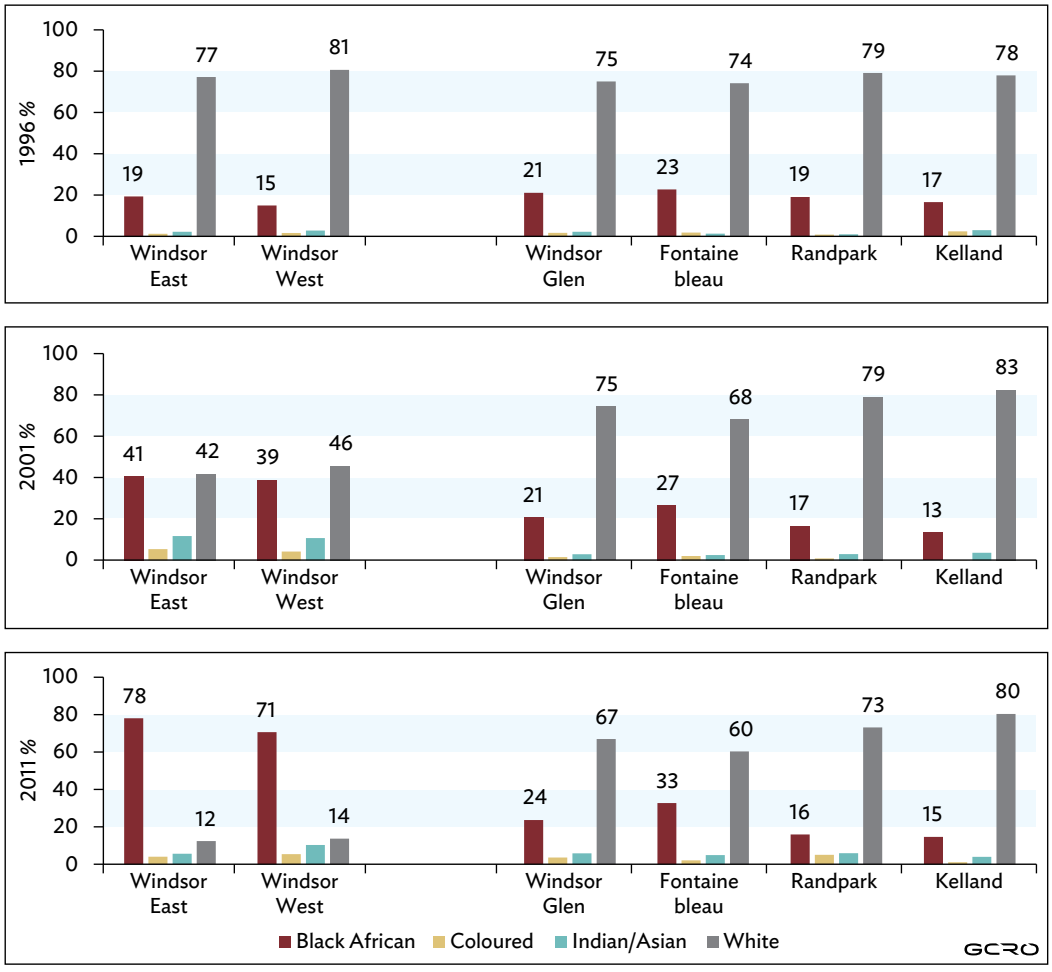


Figure 20: Changes in population group composition of Windsor and adjacent suburbs

DATA SOURCES: Census data – Community profiles (Statistics South Africa, 2011a, 2001, 1996)



Fontainebleau, Randpark and Kelland, the population composition remained largely the same between 1996 and 2011. In 2011, the proportion of white residents declined slightly and the proportion of black African residents increased slightly, but the suburbs remain predominantly white. The proportions of coloured and Indian/Asian residents remained small in all the suburbs but increased more significantly in Windsor East and Windsor West than in the adjacent suburbs.

There are important property market differences in these suburbs that contribute to the levels of segregation and desegregation. Windsor East and Windsor West include many sectional title properties with an average size of 1 270 m^2. The majority (or 40%) of property transactions in 2021 were in the 'affordable market' of between R300 000 to R600 000 (CAHF, 2021). This represents a lower-middle-class residential space (in terms of affordability) that is central and accessible to black African residents looking for

affordable and central housing. The surrounding suburbs (Windsor Glen, Fontainebleau, Randpark and Kelland) include properties in a gated community with an average size of 1 762 m^2. The majority (or 54%) of property transactions in 2021 were in the upper end of the housing market between R1 500 000 to R3 000 000 (CAHF, 2021). These suburbs are much less affordable and they serve as the gateway to the Randpark Golf Club. The contrast is significant and highlights the local-level barriers to entry into upper-class neighbourhoods and the result of socio-econoimc sorting despite the high level of diversity in the larger area. Put differently, although a ward-level analysis would suggest high racial diversity, the microscale analysis shows distinct patterns of class and race segregation. This analysis indicates that housing type and associated affordability is an important factor, either enabling desegregation or causing continued segregation at microscales.

Hillbrow and suburbs east of Hillbrow (area B in Figure 17)

Inner-city spaces, such as the central business districts of the City of Johannesburg and the City of Tshwane, were some of the first to experience significant desegregation (being former whites-only spaces) and tend to be dominated by black African residents. Hillbrow, near the Johannesburg central business district, is one of the spaces that experienced significant desegregation. However, at a microscale, the areas around Hillbrow exhibit different patterns of desegregation due to the influences of socio-economic sorting (Figure 21). Figure 21 also shows that racial diversity increases gradually east of Hillbrow, but it is also clear that uneven diversification happened at a sub-ward level. Some of the patterns are shaped by dynamics that are not clear at a ward level but which require a microscale perspective to illustrate. For example, in Figure 21b, it is clear that racial diversity increases from low to high within wards. Further, while a ward level analysis might distinguish wards in and around Hillbrow as high or low, the Hot Spot Analysis (Figure 21c) indicates that some of the hexagons create insignificant clusters in the transition from low to high racial diversity.

Hillbrow and the areas east of Hillbrow can be divided between areas with low racial diversity, areas with moderate racial diversity and areas with high racial diversity. Racial diversity increases from low in Hillbrow to high in the areas further east of Hillbrow. Areas with low racial diversity include Berea, Doornfontein, Hillbrow and New Doornfontein. Areas with moderate racial diversity include Bellevue, Bellevue East, Bertrams, Highlands, Judith's Paarl, Lorentzville, Randview, Troyeville and Yeoville. Areas with high racial diversity include Bezuidenhout Valley, Cyrildene, Dewetshof, Kensington, Linksfield Ridge and South Kensington.

Census data from 1996, 2001 and 2011 shows how the population composition of the suburbs changed over time (Figure 22). Changes to all the areas around Hillbrow are shown on the left of Figure 22, and changes to areas that currently have high, moderate or low racial diversity are provided on the right of Figure 22. Overall, the proportion of black African residents in the area increased from 68% to 88% between 1996 and 2011 whereas the proportion of white residents decreased from 22% to 6% over the same period. This represents such rapid and significant transformation that it led to the re-segregation of the area. Figure 22 also shows that the same trend does not apply to adjacent areas. Black African residents dominate in areas with high, moderate and low racial diversity, but the proportional changes in moderate and low racial diversity areas were much larger than in areas with high racial diversity. This suggests that some areas presented more opportunities to incoming black African residents than others.

The make-up and functioning of Hillbrow is influenced by many factors because it is a port-of-entry neighbourhood (Winkler, 2013) and there could be many reasons for uneven diversification. Uneven diversification is related to the effects of individual building management, the tenure status of buildings, variable maintenance levels and commitments, financial and managerial failure, the diversity of cultural customs being practised, the rate of residential turnover (whether residents are staying in the neighbourhood and establishing a community or not), the settlement patterns of cross border migrants,

Figure 21: Hillbrow and the areas east of Hillbrow, City of Johannesburg

DATA SOURCES: GeoTerraImage (2021a, b)

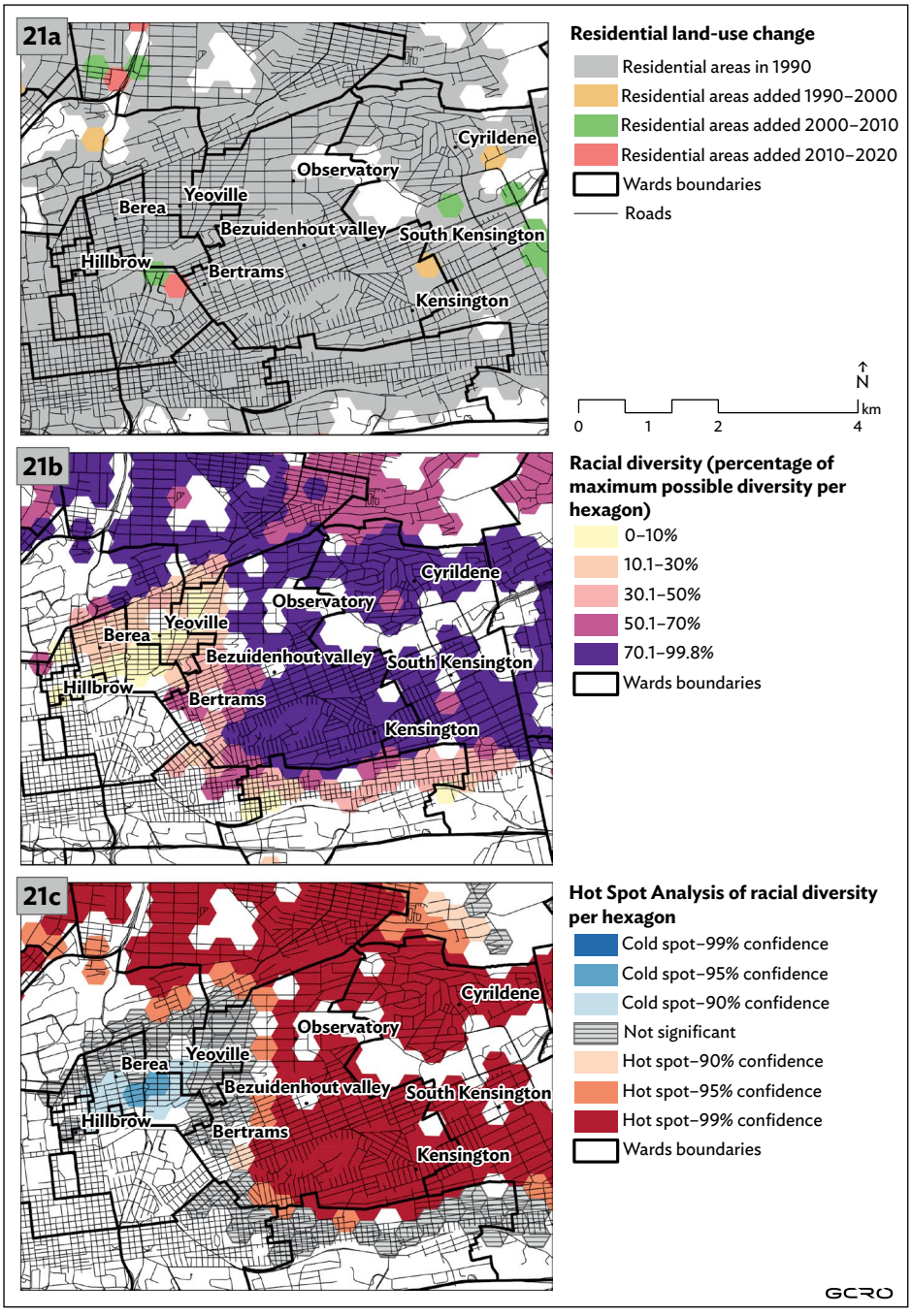
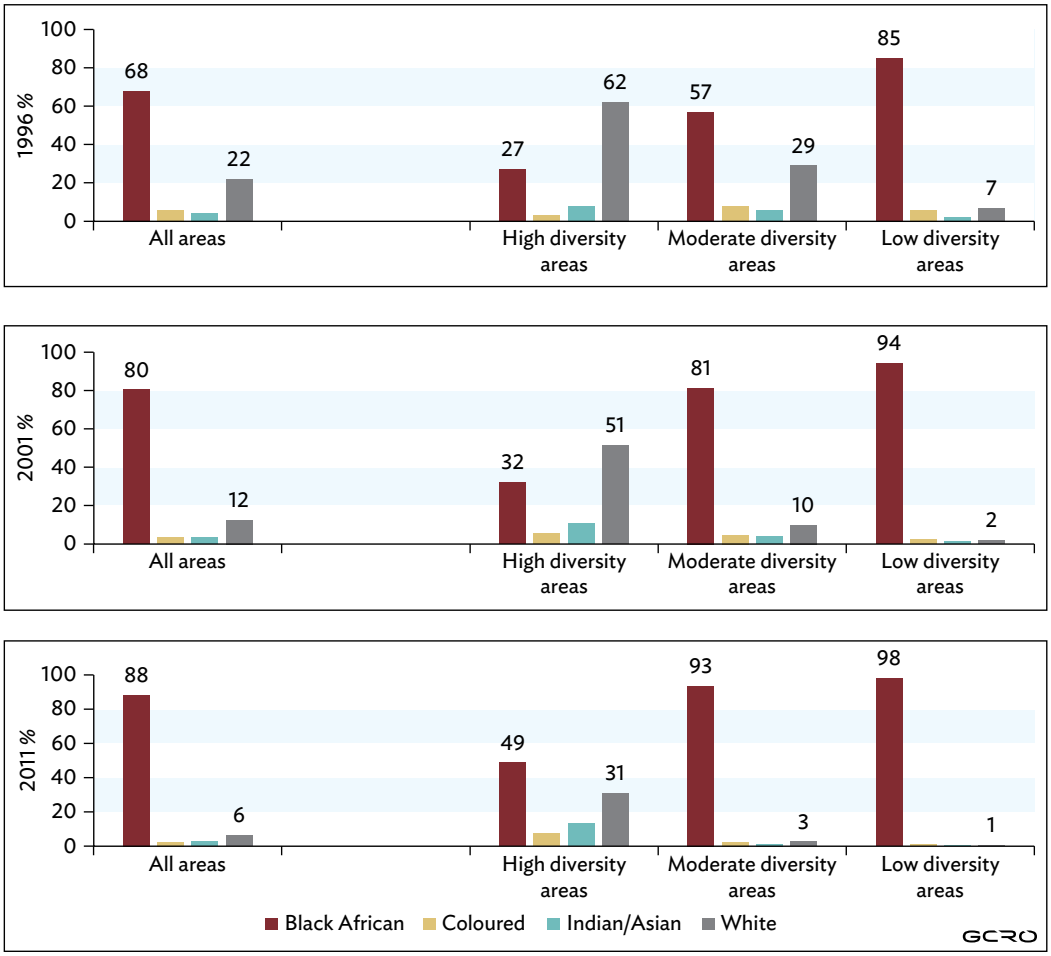


Figure 22: Changes in population group composition of Hillbrow and the areas east of Hillbrow, City of Johannesburg

DATA SOURCES: Census data – Community profiles (Statistics South Africa, 2011a, 2001, 1996)



and perceptions or identities that attach to spaces (Winkler, 2013).

A variety of data sources can shed some light on the reasons for uneven diversification in Hillbrow. Data from the Centre for Affordable Housing Finance (CAHF) helps to explain the influence of the property market on uneven diversification. In the areas with realtively high racial diversity (such as Bezuidenhout Valley and Kensington), the majority (or 45%) of property transactions in 2021 were in the 'conventional market' of between R900 000 to R1.5 million (CAHF, 2021). In the areas with relatively low racial diversity (Hillbrow and Berea), the majority (or 41%) of property transactions in 2021 were in the 'entry market' of under R300 000 and another 31% of the property transactions were in the 'affordable market' of R300 000 to R600 000 (CAHF, 2021).

An analysis of ward-level data from GCRO QoL 6 further suggests that areas with low racial diversity (Hillbrow and Berea) are also associated with higher

proportions of households who rent their dwellings, higher proportions of foreign migrants, lower household income and respondent education levels, a larger diversity of home languages and a majority sense that crime is worsening over time (Table 6). The areas with higher racial diversity (Observatory, Kensington, Bezuidenhout Valley, South Kensington, Cyrildene) are associated with households who are more likely to own their dwellings, smaller proportions of foreign migrants, higher household incomes and respondent education levels, a smaller diversity of home languages and a smaller proportion of respondents who felt that crime worsened over time. In all the wards, the respondents are most likely to have lived in the neighbourhood for more than five years, suggesting that the communities are established and strong.

Vanderbijlpark and surrounding suburbs (area C in Figure 17)

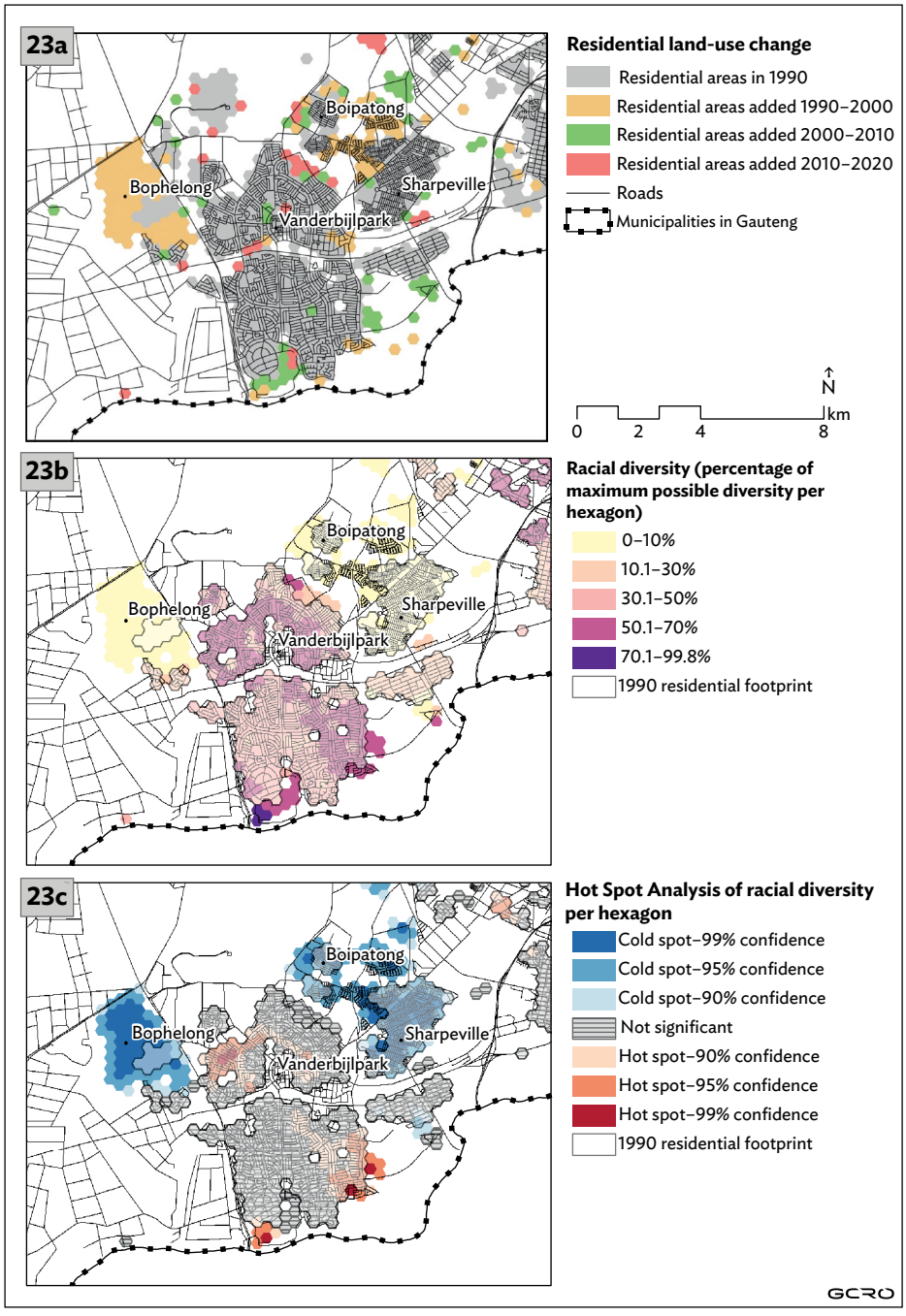
Vanderbijlpark (in southern Emfuleni Local Municipality) exhibits a continuation and disruption of racial diversity related to urban growth (Figure 23). The racial diversity score for the Vanderbijlpark Main Place, including the townships of Bophelong and Sharpeville, is 46.5% of the maximum possible diversity. At the larger scale, this is moderate racial diversity, which suggests a reasonable mix of population groups; however, it obscures clusters of high and low racial diversity in the area and the role that different types of residential expansion and socio-economic sorting play in establishing these patterns. The central parts of Vanderbijlpark are

Table 6: Socio-economic characteristics of the wards in Hillbrow and east of Hillbrow
SOURCE: GCRO (2021)

Area label in Figure 21	Hillbrow	Hillbrow	Berea	Yeoville	Observatory, Kensington, Bezuidenhout Valley	South Kensington, Cyrildene
Ward number	No. 62	No. 63	No. 64	No. 67	No. 66	No. 118
Relative racial diversity	Low	Low	Low	Moderate	High	High
Household owns their dwelling	8%	10%	16%	38%	58%	69%
Household is renting their dwelling	87%	77%	84%	33%	42%	28%
Respondent was born in another country	42%	32%	62%	21%	24%	12%
Respondent has a tertiary education qualification	29%	3%	14%	45%	48%	44%
Household income is R1–R3 200	26%	38%	51%	26%	38%	25%
Household income is more than R25 601	0%	0%	0%	17%	31%	15%
Household languages spoken by at least 10% of households	4	2	3	4	2	1
Respondent has been staying in the neighbourhood for more than five years	80%	73%	80%	90%	81%	82%
Respondent feels that crime has worsened in the last year	69%	54%	57%	40%	49%	29%

Figure 23: Vanderbijlpark, Emfuleni

DATA SOURCES: GeoTerraImage (2021a, b)



somewhat dominated by white residents, but not enough to create significant clusters of low racial diversity (hence the number of 'insignificant' hot spots). The clusters of high racial diversity on the south-eastern edges of Vanderbijlpark represent new suburban housing where black African and white residents make up similar proportions of the population in each hexagon. These are important sites of integration. The housing expansion towards the east (Sharpeville) and the west (Bophelong) of Vanderbijlpark represents low racial diversity because these areas are dominated by black African residents. The dominance of low diversity residential expansion contributes to the relatively low diversity of the larger area. This is similar to patterns of expansion around townships elsewhere in Gauteng.

Despite residential expansion and desegregation taking place in the same town, neighbourhoods with high or low racial diversity are separated from each other and influenced by socio-economic sorting. Socio-economic sorting is evident when comparing the housing characteristics of high and low diversity areas. Areas with low racial diversity include the expansion of low-cost, and often informal, housing development whereas areas of high racial diversity include the development of high-value formal housing. This dynamic is evident in the Vanderbijlpark example. The areas of Sharpeville and Bophelong, around Vanderbijlpark, are township areas that include mostly low-cost housing while the areas with higher racial diversity include higher-value housing (Figure 24). As noted in Hamann, Ballard and Naidoo (2020), there tends to be a separation between housing that serves different markets. There is no spatial overlap between gated communities on one hand and informal dwellings and government housing projects on the other, and gated communities tend to support high racial diversity while informal dwellings and government housing projects lead to low racial diversity.

Summary

In order to understand the effects of socio-economic sorting on desegregated spaces at a microscale, this section focused on three areas that have changed significantly in terms of its racial composition on a macroscale but remain segregated at microscales. The microscale analysis reveals that diversification is uneven and how barriers to diversification can be hidden from view at macroscales.

In Windsor East, Windsor West, Windsor Glen, Fontainebleau, Randpark and Kelland, the property market plays a significant role in socio-economic sorting. The effect is that the affordable market experiences significant desegregation and the upper end of the housing market does not.

In Hillbrow, an area that was one of the first to experience significant desegregation, various property-related factors and cultural customs shape diversification and socio-economic sorting at microscales. The Hillbrow example also illustrates how levels of racial diversity can change from low to high at microscales.

In Vanderbijlpark, even though the town is relatively diverse overall, areas of high and low racial diversity remain separated and are characterised by high- and low-value housing.

The microscale analysis reveals that diversification is uneven and how barriers to diversification can be hidden from view at macroscales

Figure 24: Examples of housing in Sharpeville (top), Bophelong (middle) and the southeast suburbs of Vanderbijlpark (bottom)

Photographs © Google Earth 2023





Photograph by Clive Hassal



Conclusion

Conclusion

Segregation research in South Africa has clearly demonstrated the extent of racial desegregation that has taken place in cities, but it is also clear that the legacy of apartheid remains significant. The challenge that remains is that segregation in post-apartheid Gauteng is closely related to inequality and is continually reproduced by the patterns of urban growth and development trajectories, and socio-economic sorting. The quantitative analysis in this Occasional Paper combined multiple data sources (census data, population estimates and survey data) to contribute a microscale view of racial segregation and socio-economic sorting in Gauteng.

The analysis focused on three questions with respect to racial segregation and socio-economic sorting in Gauteng. First, does urban expansion contribute to desegregation or does it perpetuate segregation? The analysis showed that areas of urban expansion tend to reproduce the racial diversity of the areas from which they expanded. However, public housing programmes and inclusionary housing policies hold significant potential for integration. Second, to what extent does racial mixing contribute to lower racial income inequality? The analysis showed that in racially mixed wards, the mean household income of the white residents is significantly higher than the mean household income of black African residents, signalling the relevance of class segregation. Third, what are the patterns of microscale socio-economic sorting that shape desegregated neighbourhoods? The local-level, data-driven analysis reveals that desegregation is uneven in some neighbourhoods and the socio-economic sorting happens based on the character (including quality, quantity and affordability) of the available housing stock.

Scale has been an overarching theme in this Occasional Paper. Racial segregation and socio-economic sorting happen at a variety of geographic scales, and all are important for understanding the challenges and opportunities in the city. When racial segregation is analysed at macroscales, such as municipalities or regions, it may disguise patterns of segregation that might otherwise be made visible when analysed at a microscale, such as the neighbourhood or hexagon.

The role of inequality and class segregation has been another overarching theme of this Occasional Paper. The spatial separation of income groups is a defining feature of racial segregation, which is accentuated by the nature of the housing market and the way it separates residents based on the affordability of areas. The limits of further desegregation are determined by the socio-economic equality achieved in society and the ability of people from all population groups to afford housing in different areas of the Gauteng province.

The insight from these two themes is that opportunities for racial and socio-economic integration can be created on a very local level if a diversity of housing options are provided in neighbourhoods. Such interventions could reduce the overrepresentation of one group in an area and allow equal access to opportunities. For example, new housing policies must aim to address both racial and socio-economic segregation in the planning and implementation of projects. Well-located public housing is not easy to implement, but various opportunities can be created for integration and access to opportunity through strategic planning. Public housing initiatives must continue to provide affordable housing in close proximity to areas of high opportunity and should consider developments that are in close proximity to other urban expansion paths and aligned with future urban development plans. Even if residential development continues at different ends of the affordability spectrum – government housing for low-income households and gated communities for high-income households – local government can direct these developments toward each other, and,

as argued by Roitman, Webster and Landman (2010, p. 5), 'there may be at least more economic integration between the two groups as gated communities can be sources of employment for low-skilled outside neighbours'. There is no doubt that public housing programmes can transform the city's spatial structure. Ultimately, policies should ensure that one's residential location is not the biggest (and most impossible) burden that one has to overcome to access opportunity.

Policy responses should also be able to use this analysis to develop a fresh understanding of the type of desegregation that we want to see in South African cities. It would be fruitless to restructure cities to have a 'quota' of residents in all spaces. The macroscale processes that produce urban space do not accommodate such an ideal. Rather, the microscale analysis of this publication highlights the areas where and how boundaries between high and low racial diversity, as well as high and low household income, could potentially be softened. At a microscale, interventions can help to share opportunities between communities even though a certain level of segregation remains. It is also at a microscale that one can efficiently analyse the opportunities and constraints that come with integration.

Segregation research will remain relevant in South Africa, but the future directions might look a lot different than previous studies. Researchers are encouraged to continue to adopt a multiscalar and multidimensional approach to segregation research.



Photograph by Christian Hamann

Appendix A: The importance of scale in segregation analysis

In addition to the discussion on page 11, a brief overview of racial-residential segregation calculations at different scales further illustrates the importance of scale.

As shown in Table 7, using data for population groups at the provincial level in South Africa, Multi-Group Dissimilarity Index values, commonly denoted as 'D(m)', are calculated between 43 (out of 100) in 1994 and 42 in 2020. This indicates a very low level of racial segregation and very little change over time. Given that provinces in South Africa are very large and that desegregation is more likely to take place within provinces than between provinces, it is essential to analyse segregation at a smaller scale.

At local scales of analysis (municipalities and regions within metropolitan municipalities), the results are quite different. Using population group data at the municipal and metropolitan region scale, the D(m) values range between 53 (out of 100) in 1994 and 50 (out of 100) in 2020 for municipalities and between 30 and 26 (out of 100) for regions within metropolitan municipalities (Table 7).

All these results would suggest that South Africa is not a segregated country. Three main reasons render these results insignificant. First, only a five point change or more in the index value is considered as a statistically significant trend (Christopher, 2005). Second, as with the sub-metro averages, index values below 30 effectively represent integrated populations or random distributions of population groups without any segregationist processes (Christopher, 2005). Third, population groups are represented relatively evenly at these large scales and reduce the value of the calculations. In other words, no province, municipality or sub-metropolitan region includes only one population group, but the presence of all population groups leads to the relatively low segregation values that are calculated.

It might seem interesting and counter intuitive that segregation values for municipalities (between 50 and 53) are higher than the segregation levels at other scales (provincial values are between 42 and 43) in Table 7, but further analysis of the data provides an explanation. In 2011, 153 of the 234 local municipalities in South Africa were composed of more than 75% black African residents. Between 1996 and 2020, the proportion of black African residents increased in 204 of these municipalities (Quantec, 2022). This means that many municipalities are dominated by the black African population group – hence the higher segregation levels when using municipal data than provincial or regional data.

Macroscale calculations of segregation levels are useful to track broad changes over time, but the value of these calculations is limited. Microscale data and mapping are important additions for a complete understanding of segregation in cities.

Table 7: Multi-Group Dissimilarity Index values at large scales over time

SOURCE: Quantec (2022)

	D(m) index values from population group data		
Year of population estimate	Provinces (9)	Municipalities (234)	Regions within metropolitan municipalities (43)*
1994	43.24	53.44	29.98
1996 (census year)	42.33	52.64	29.63
2001 (census year)	41.57	51.70	28.96
2005	41.45	51.07	28.36
2009	41.63	50.50	27.54
2011 (census year)	41.80	50.31	27.24
2013	41.97	50.15	26.93
2017	42.33	50.00	26.45
2020	42.70	50.08	26.31

* D(m) index values are calculated for each metropolitan municipality, using the population data for regions in each municipality. The index scores for each metropolitan municipality are combined in an average and represented in the table.

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