The geography of opportunity: Exploratory spatial data analysis in the City of Tshwane

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For the fulfilment of Master of Science in Geographic Information Systems and Remote Sensing

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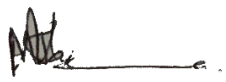
Declaration

I Mapogo Molamo declare that the work I have done on this report is unaided and was only supervised. The report is being submitted to the School of Geography, Archaeology, and Environmental Studies to fulfil my studies in Master of Science in the field of geographic information systems and remote sensing. The report has never been submitted for any degree or examination.



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Abstract

More than 25 years into democracy, South Africans are still being affected by the laws of apartheid. Inequality as established by the apartheid regime still affects black communities especially—socially, spatially, and economically (Berg, 2002). Owing to segregation, up to this day there are places where residences have no access to basic services in any form of (Rodina and Harris, 2016; Williams and Collins, 2001). Though the current government is trying to provide these services in communities, there is still uneven development and opportunities in all South African cities, the City of Tshwane included (Goduka and Hildebrand, 2006).

This study explored the geography of opportunity in the City of Tshwane to understand the spatial spread of opportunity. The study was carried out at the main place level and was based on data from Statistics South Africa (StatsSA), grocery stores (Pick ‘n Pay and Spar), and the CoT website for all primary care facilities in the metropolitan area. Using exploratory spatial data analysis techniques, the data collected were used to calculate the overall opportunity index for the city and to identify where there are clusters of opportunity or where they are evenly distributed.

The study findings illustrate that the spread of opportunity in the City of Tshwane is uneven. The greatest opportunities were found mostly in developed main places and most peri-urban areas were found to have less opportunity. The study also looked at the impact of population, and it can be safely concluded that the size of the population has a directly proportional relationship with the opportunity score. Main places with low population density have a low opportunity while main places with high populations have a high score. The overall index score for the City of Tshwane is 14.16

Keywords

Geography of opportunity

Opportunity index

Spatial mismatch

.

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Acronyms

CoT	City of Tshwane
ESDA	exploratory spatial data analysis
GIS	Geographic Information Systems
LISA	local indicators of spatial association
StatsSA	Statistics South Africa
USA	United States of America
WHO	World Health Organization

Chapter 1: Introduction and background

1.1. Introduction

The study explores the spatial distribution of the geography of opportunity in the City of Tshwane (CoT). There is still an uneven spread of opportunities in many countries including South Africa(Burns *et al.*, 2017; Williams and Collins, 2001) and there is still inequality in South Africa, the CoT included (Chatindiara, 2019; Goduka and Hildebrand, 2006). These include inequalities in income, access to health, education, clean water, jobs, and transportation to mention a few (Naudé, and Coetzee, 2004). These aforementioned, are a result of the discrimination and segregation of people according to colour pre-democracy (Venter,. *et al.*, 2020; Williams and Collins, 2001).

There is also inequality in the distribution of opportunity in the metropolitan areas of the United States of American (Mayberry *et al.*, 2000; Semyonov *et al.*, 1984; Wu *et al.*, 2020). Good opportunities are located in white-dominated urban areas, whereas black people mostly live in poor-opportunity peri-urban areas (Semyonov *et al.*, 1984). There is a noticeable distinction between the livelihood outcomes of the people in these geographic locations (Wu *et al.*, 2020). Studies in the USA show that most wealthy communities are populated by white people, while most black people tend to reside in poor communities. The developed communities have better job opportunities, schools with good education systems, adequate access to primary health care services, and access to grocery stores with fresh produce and healthy food. In contrast, poor communities are linked to high crime rates, poor education, poor access to services like water and electricity, high unemployment, and poverty rates (Powell *et al.*, 2007).

The study explores the geography of opportunity in the CoT using exploratory spatial analysis tools and the main data sources for our analysis are Statistics South Africa (StatsSA), the CoT, and some retail stores. Geography is defined as the study of the physical attributes of the earth and the surrounding atmosphere, the study of human activity as it affects and is affected by the physical attributes of the earth, the population spread, properties, political activities, and economic activities (Holloway *et al.*, 2003). Broadly, opportunity can be

divided into several segments, namely cultural, social, and economic opportunity (Altshuler *et al.*, 1999).

The geography of opportunity refers to the places individuals live and how this affects their opportunities and life outcomes (Ihlanfeldt, 1999). It was developed by Galster and Killen to define the spatial extents of opportunity at the metropolitan level (Wilson and Greenlee, 2016). According to Wilson and Greenlee, opportunity is not a substitute for jobs; but it comprises dimensions like jobs and local economy, education, community health, and civic life that allows exploring of social and spatial outcomes (Opportunity Nation, 2016).

The study is an exploratory spatial data analysis (ESDA) which can be defined as a research method used by data scientists to analyse and examine data and summarise their main features while using data visualisation methods like graphs, charts, and maps. It is also used to discover patterns in the data (Haining *et al.*, 1998). Locations are be explored and examined for the extended opportunity present and conclusions are drawn about the data from the resulting patterns. The study uses three ESDA techniques by creating the opportunity index, mapping the opportunity index, and mapping the hotspots and cold spots using Moran's I. Choropleth maps are used to analyse the spatial spread of opportunity in the CoT and to identify the areas which need serviceprovision. Services like provision of enough health facilities in communities and provision of RDP houses to allow people to own residential properties; this will avoid needing to spend money on rentals.

The opportunityndex is made up of three dimensions; each has indicators that together build the dimension score. The local economy dimension consists of (but is not limited to) indicators such as unemployment rate, affordable housing, poverty rate, level of income, access to the internet, and access to banking facilities. The education dimension includes indicators like preschool enrolment, school dropout rate, high school graduates, and post-secondary attainment. The community health and civic life dimension includes access to primary health services, access to healthy food, and people's involvement in social activities. This also covers aspects such as violent crimes and low birth weight (Opportunity Nation, 2016; Wilson and Greenlee, 2016). Using these indicators will enable the performance of ESDA in the CoT.

In the CoT, poor communities tend to be located on the outskirts of the city, referred to as townships, whereas wealthier communities are located in the central parts (Horn, 2021). Most

townships are overpopulated (Beukes and Colff, 1997) with less development and less opportunity. Many township residents do not have formal jobs or jobs that contribute to the township economy as most of the jobs are small-scale informal jobs (Hamann, C. and Horn, 2021). This study is a pioneering exploration of the geography of opportunity in the CoT. The results will inform the metropolitan authorities on where to direct resources to alleviate the inequalities within the area.

1.2. Problem statement

The City of Tshwane is one of the metropolitan cities in South Africa (Breetzke, 2008) and is also known for its economic and educational opportunities (Beer, 2012). As it is located in the 'province of gold' translated to 'Gauteng' in the Setswana language, it tends to have a high attraction for immigrants as well as migrants from other provinces (Oosthuizen *et al.*, 2004; Oosthuizen and Naidoo, 2004). Study of people's province of birth reveals that, of the 8.4 million Gauteng residents who are South African citizens, only 5.2 million were born in Gauteng and this means that more than one-third of South African-born Gauteng residents were born in the other provinces. Limpopo accounts for 10.1% of all South African-born residents, KwaZulu-Natal for (6.5%), and the Eastern Cape for 5.4% (Oosthuizen and Naidoo, 2004).

The rise in unemployment rates (Banerjee *et al.*, 2008) and increased poverty rates (Weatherspoon and Reardon, 2003) in Gauteng indicate the lack of opportunity. Studies in the USA show that areas with fewer opportunities have been more affected by the recession (Fairlie, 2013), and this finding underscores economic inequality. It is therefore important to know the distribution of opportunity within the city and to understand if people in different areas have sufficient opportunity to advance themselves.

1.3. Aim of the study

The research aimed at analysing the spatial distribution of opportunity in the City of Tshwane and to understand if people in different main places have enough opportunities to advance themselves.

1.4. Study objectives

The study had the following three objectives:

1. Calculate a multidimensional human opportunity index per the main place in the CoT.

2. Map the geography of opportunity to understand the concentration of opportunity across the city.
3. Identify clusters of high and low opportunity and calculate local indicators of spatial association (LISA) using Moran's I and map the hot and cold spots in the CoT. This map will help understand if an opportunity in CoT is clustered or dispersed.

1.5. Knowledge gap

This study will fill a gap by exploring the geography of opportunity in the metropolitan areas first identified by Greenlee and Wilson (2016) n their study done in the USA. The study will be done in the CoT municipality metropolitan area as no study has yet been done in South Africa concerning the geography of opportunity (although these were done in other places around the world) (Howell-Moroney, 2005; Ihlanfeldt, 1999; Reece *et al.*, 2019; Wilson and Greenlee, 2016). Based on past inequality, the study will explore the spatial spread of opportunity in the CoT and will identify where there is a need for development. The observations gathered in the study will be crucial to the municipality for future developments in the city and will be a reference for future researchers.

1.6. Report overview

The report has six chapters, namely the introduction, literature review, research methodology, presentation of results, discussion of the results, and the conclusion chapter. Chapter 1 has explained the background, the problem statement, the aims and objectives, and the knowledge contribution of the study. The second chapter reviews the literature that substantiates the research and reflects on the concept of spatial mismatch, the geography of opportunity and the opportunity index, as well as exploratory spatial analysis.

Chapter 3 outlines where the study was carried out, the data sources, data preprocessing and processing, the analysis methods used in the study, and their suitability for the study. The results presented in Chapter 4 are from the analysis methods described in Chapter 3. The literature from Chapter 2 and the results in Chapter 4 are used to build the results discussion in Chapter 5. Finally, the conclusion chapter, Chapter 6, includes the summary of the research and recommendations for future work.

Chapter 2: Literature review

2.1. Introduction

South Africa experienced apartheid and its laws until it gained democracy in 1994 (Maserumule, 2012). However, many years later, the effects and impact of the apartheid laws are still apparent in the country (Mariotti and Fourie, 2014). Apartheid spatial planning and racial segregation are still affecting communities in South Africa at large, the CoT included. Apartheid spatial planning resulted in the current spatial mismatch within metropolitan cities (Alenda-Demoutiez and Mügge, 2020). The issue of spatial mismatch and the geography of opportunity is not exclusively a South African problem—it is a global issue. Studies show that this, exists in other cities as well (Christopher, 2001; Semyonov *et al.*, 1984; Semyonov and Herring, 2007). The study draws on literature on three concepts: the geography of opportunity, spatial mismatch, and exploratory spatial analysis.

2.2. Geography of opportunity

The geography of opportunity can be defined as the series of conditions that open the doors for people to improve their economic mobility and advance their life chances (Fisher and Weber, 2004; Ihlanfeldt, 1999; Opportunity Nation, 2016). This study follows the 2016 guideline by Opportunity Nation which expresses that an individual's chance of upward social mobility is affected by essential factors. First, it is affected by factors such as race, ethnic group, and the individual's access to some form of education. Second, the individual's attributes like intelligence and third the presence of decent jobs and low levels of crime in their neighbourhoods affect this mobility.

A study by Galster and Mikelsons, (1995) explains the opportunity of geography in metropolitan areas. It describes the structure of socio-economic opportunities facing various societal groups living in metropolitan areas (Galster and Mikelsons, 1995). The study also provides a set of research questions, some of which Wilson and Greenlee (2016) explored. To calculate a multidimensional opportunity index and further extended the use of ESDA, their study highlighted some of the frameworks for investigating and measuring opportunity from a multidimensional perspective. Both Brain and Prieto (2018) and Wilson and Greenlee, (2016) expressed that the opportunity index is formed by a composite of three key dimensions with indicators (Brain and Prieto, 2018). The three dimensions are the jobs and local economy

dimension, the education dimension, and the community health and civic life dimension (Wilson and Greenlee, 2016).

The jobs and local economy dimension gives insight on whether the metropolitan municipality is in a good economic state and whether it has jobs for the communities or not (Hanratty, 2017). The dimension consists of the following indicators: unemployment rate, median income, and poverty rate in the metropolitan area (Wilson and Greenlee, 2016). The education dimension gives insight into the levels of education attained in the metropolitan area. The indicators used for measuring the education dimension are preschool enrolment, high school dropout rate, and post-secondary attainment. Last is the community health and civic life dimension, which gives insight into the access to grocery stores and fresh produce, access to primary health care services, and the involvement of the youth in the community. The indicators for the dimension are health institutions and retail stores, as well as youth economic participation and academic inclusion (Galster and Mikelsons, 1995; Ihlanfeldt, 1998; Wilson and Greenlee, 2016).

No study has been done yet on the opportunity of geography in South Africa and this study will be the first to directly address the geography of opportunity in the country though the study is done on a metropolitan level. But there are studies in South Africa that have assessed access to quality education among different races (Hill, 2016; Yamauchi, 2005). A study by Venter and others identified that in South Africa we still have locations with no opportunities and that causes people to have to travel far to search for opportunities (Venter, C. *et al.*, 2007).

2.3. Spatial mismatch

The spatial mismatch is the discrepancy between where low-income household dwellers live and where proper job opportunities are located (Howell-Moroney, 2005; Vanoutrive, 2019; Wang *et al.*, 2011). In America this discrepancy developed from the oppressive laws that affected mostly black communities. Spatial mismatch resulted from residential segregation by race and economic restructuring that excluded black people from opportunities. It also resulted from the suburbanisation of employment (Wang *et al.*, 2011; Vanoutrive, 2019; Howell-Moroney, 2005). The spatial mismatch theory was suggested by John Kain (Kain, 1968). After World War I, most rich Americans began to decentralise from the metropolises by moving into the suburbs. In the second half of the 20th century, retail stores also moved to

the suburbs and in 1968 Kain formulated a spatial mismatch hypothesis which stated that black employees were in segregated neighbourhoods that were far from (and not connected to) main centres of development (Kain, 2004).

Vanoutrive(2019) argues that although gateways such as seaports and airports provide job opportunities, they also contribute to spatial mismatch as they are located far from where people reside, because most people employed in the gateways require transport to get to work. Lyons and Ewing (2021) carry the same sentiment that employees require transport to get to their workplaces, the lack of which might hinder an individual from getting a job in a certain location. Lyons and Ewing (2021) further argue that the unavailability of transport might lead to unemployment which leads to poverty in the communities that suffer low job security. A study in England by Patacchini and Zenou, (2005) argues that there is racial inequality when it comes to access to transport and this affects the ability to search for employment (Patacchini and Zenou, 2005). The spatial mismatch in South Africa is a result of variances in 'friction of distance' as experienced by diverse groups given their ability to access transport systems and this is also the result of racial segregation (Naudé, , 2008a)

Racial segregation can be defined as the organised separation of people into different racial groups (Andrews *et al.*, 2017; Hu, 2019; Semyonov and Herring, 2007). This process includes the spatial separation of the races, the use of public facilities, services provision, and the use of institutions like schools and hospitals (Fernandes, 2017). To date, in America, white communities are still privileged compared to the black communities (Pulido, 2000). This is the result of low economic mobility, which means that people fromAfrican black communities (also termed black communities hereafter) are not able to secure either good education or good jobs (Andrews *et al.*, 2017; Stoll, 2006). In London, a study by (Fieldhouse, 1999) indicated that there is a complicated relationship between unemployment, ethnicity, and spatial location as unemployment amongst the Britain ethnic minorities is almost twice that of the Britain white population (Fieldhouse, 1999). A study by Hu (2019) shows evidence that low access to education affects the employability of an individual. In China and America, owing to lack of education, black people tend to end up being employed in low-salary jobs whereas their white counterparts with better education have access to jobs paying high salary (Hu, 2019; Semyonov and Herring, 2007). According to Naudé, (2008a), the issue of job suburbanisation also contributes to spatial mismatch.

The suburbanisation of employment can be defined as the relocation of jobs to suburban areas (Heider and Siedentop, 2020; Hu, 2019; Miller, 2018). This has seen many American black people left with no employment as they might not be able to access the jobs in suburbs (Miller, 2018). There are many disadvantages of the suburbanisation of employment. In South Africa, the large income gaps between suburbs and inner-city areas lead to polarisation and resentment, which results in social exclusion and segregation as most people in the low-income bracket cannot afford to live in the low-density suburbs (Mabin, 2005; Tammaru, 2001). Mabin (2005) and Tammaru (2001) further argue that suburbanisation of employment directly affects house prices which in turn affects the price of land, thus making it difficult for individuals in the low-income bracket to be able to afford houses. Land with high prices is associated with high opportunity and land with low prices is associated with low opportunity (Brain and Prieto, 2018). In 2014, Anciaes and his team reported that in Cape Verde, deprived areas are at a disadvantage in the access to formal employment opportunities when compared with more affluent areas. The reason for this is lack of access to public transportation (Anciaes *et al.*, 2014).

The other factor that contributes to the spatial mismatch is geographical economic restructuring. This is the locational study of economic restructuring that seeks to explain physical differences in economic development. It also sets out to recognise the geographical difficulties of economic restructuring that happen without an alternative to worldwide 'rules' of economics that are presumed to work in all places at all times (Zhou and Ma, 2000). The main cause of restructuring appears to be a series of industry-specific demand shocks that amplify what was already a declining trend in demand in several important industries, although technological change also plays a role in a few key sectors (Ma, 2005). This study further draws on literature on the spatial mismatch concept in South Africa and the CoT.

Spatial mismatch in South Africa

(Naudé 2008b)did a study on the suburbanisation of employment and population in South African cities and the significance of the rate of desegregation. His study found that the increase in concentration of the population for South Africa's cities are quite low, representing a relatively flat population distribution across the cities; this he saw as an inheritance of South Africa's apartheid spatial planning. When linking the suburbanisation of population to the statistics for work density gradients, South Africa's cities were found to be

bigger than the population density gradients. Therefore, employment is less uniformly distributed over the population (Naudé, 2008b). A study by Schultz and Mwabu, (1998) also found that there is still unequal distribution of jobs and income. The influence of employment growth on suburbanisation was found to be statistically insignificant, which suggests that population settlement does not automatically follow job opportunities in South African cities. (Gobillon and Selod, 2021; Naudé2010).

There has officially been desegregation in South Africa since 1996, though the change on the ground small. Christopher (2001) agrees that the rate of desegregation in South Africa has been relatively slow and further argues that the lack of economic empowerment of the African black population is the main impediment to the development of desegregation.

Studies by Christopher (2001); Naudé(2010) showed that the biggest decline in desegregation was as a result of the formation of white communities where African black people were spatially excluded. African black people are now gradually moving into those white communities to access economic activities (Christopher, 2001; Naudé2010). The relatively slow process of desegregation implies the insufficiency of residential mobility in African black communities Hunter, (2010); Naudé (2010); Andrews *et al.*, (2017). This could contribute to the possibility of a spatial mismatch in the market for city work.

Naudé (2010) concluded that the populations in South African metropolitan cities are suburbanising quicker than employment opportunities and that residential desegregation by race is comparatively slow. Therefore a spatial mismatch is contributing to high black unemployment (Christopher (2001); Hunter(2010); Naudé (2010)

Spatial mismatch in City of Tshwane

The study by Hamann (2015) also advocates that in main places where residents are racially grouped, desegregation takes time and is rather sluggish. The slow pace of the desegregation process is the result of the economic state of African black communities, as they are not able to buy housing in more affluent areas of the CoT. Regardless of this, communities of different races are free to interact and relocate from one place to another.

Racial divisions in the CoT are dominant in the north-western and the south-eastern parts of the City. The north-western part is characterised by highly populated, poor, and underdeveloped black communities, whereas the south-eastern part of the city is mainly

dominated by the white communities with well-developed services—yet they are the minority of the population (Hamann, and Horn, 2015; Horn and Ngcobo, 2003). The socio-economic elements that effortlessly distinguish the underprivileged and wealthy main places comprise employment opportunities and higher education attainments. Therefore it is inequality that poses a great threat to equal growth (Hamann2015).

2.4. Exploratory spatial data analysis

The study is an ESDA, which is a research method used to analyse and examine data and summarise their main features. It uses data visualisation methods like graphs, charts, and maps. It is also used to discover patterns in the data (Anselin *et al.*, 2007; Haining *et al.*, 1998). The ESDA research technique is flexible and is not bound to a specific formal structure (Anselin *et al.*, 2007). It uses tools to visualise, display, and determine patterns of groupings and spatial administrations. These tools are mainly applicable to small regions and they take into consideration the existence of both spatial heterogeneity and spatial autocorrelation (Geniaux and Martinetti, 2018). Spatial autocorrelation is adopted from Tobler's first law which describes the relations of the things that are close to each other rather than those that are at a distance (Anselin *et al.*, 2007), and spatial heterogeneity indicates the uneven distribution of different features at a location. This is the opposite of spatial autocorrelation (Anselin *et al.*, 2007; Geniaux and Martinetti, 2018).

Using ESDA, both spatial heterogeneity and spatial autocorrelation can be analysed and combined to describe spatial distributions, assess spatial patterns, predict the spatial administrations, and identify possible observations such as outliers (Anselin *et al.*, 2007; Rusche, 2010).

Several studies, both international and local, have been done using the ESDA tools (Anselin *et al.*, 2007; Breetzke Gregory, 2008; Reader, 2001; Rusche, 2010). The ESDA tool was used in a study to identify clusters and outliers based on data for a child risk scale computed for counties in the Virginia in the USA, and spatial clusters of high child risks were obtained in the southern region of that state (Anselin *et al.*, 2007). In Germany, ESDA tools were used to determine the quality of life in different regions (Rusche, 2010), while a further ESDA study in the USA was used to identify clusters in low birth weight incidents (Reader, 2001). In the CoT, a study was conducted on, amongst other offences, violent, economic, and sexual offence crimes. The study showed that the location of offenders within Tshwane appears to

be associated with the spatial incidence of two broad factors—unemployment and high residential mobility. Importantly, this shows how the spatial origin of offenders is driven predominantly along racially defined regions within the city (Breetzke (2008).

2.5. Conclusion

This chapter drew literature from three themes that will give further guidance to the report: the geography of opportunity, the spatial mismatch, and exploratory spatial analysis techniques. The chapter highlighted the gaps in the previous studies done. It also indicated papers that share the same views on the geography f opportunity, spatial mismatch and exploratoty spatial analysis The techniques used in this research study were also explained with the aid of literature.

Chapter 3: Research methodology

3.1. Introduction

This chapter (Chapter 3) indicates the study area of the research, how the data were collected, the preprocessing stage of the data, the software used, the analysis of the data, and how the results are be presented in Chapter 4.

3.2. Study area

The CoT (as shown in Figure 2) is one of the capital cities of the country. Also known as Pretoria (Wepener and Degger, 2019), it is located in the northern part of Gauteng province which is the smallest province in the country (Oguttu and Ncayiyana, 2020). The city was founded in the year 1855 (Van der Vyver, 2015) and was in 2000 renamed Tshwane(Raper, 2008).

Figure 2 shows the layout of the CoT The city has seven regions, 105 wards, and 210 councillors and is regarded as the largest municipality in the country because of its physical size (Matlala and Motsepe, 2015). CoT lies between latitudes 25°6′34.60″ S and 26°4′41.12″ S, and longitudes 27°53′24.26″ E and 29°5′54.31″ E. The city covers an area of 629 618 ha, has 2 921 490 people, and includes 911 536 households based on the census data of 2011 (Magidi, 2018).

South Africa has three capital cities, with Tshwane serving as the administrative capital. It also hosts most of the foreign embassies to the country (Mabin, 2015). The city has various health facilities like hospitals, clinics and private medical facilities but most of the facilities tend to be located in the developed areas (Gerritsen *et al.*, 2011). It also has formal and informal retail trading facilities, from big supermarkets and fresh produce markets to street vendors (see Figure 1).

Figure 1: Street vendors in the CoT (Ndhlovu, 2014)

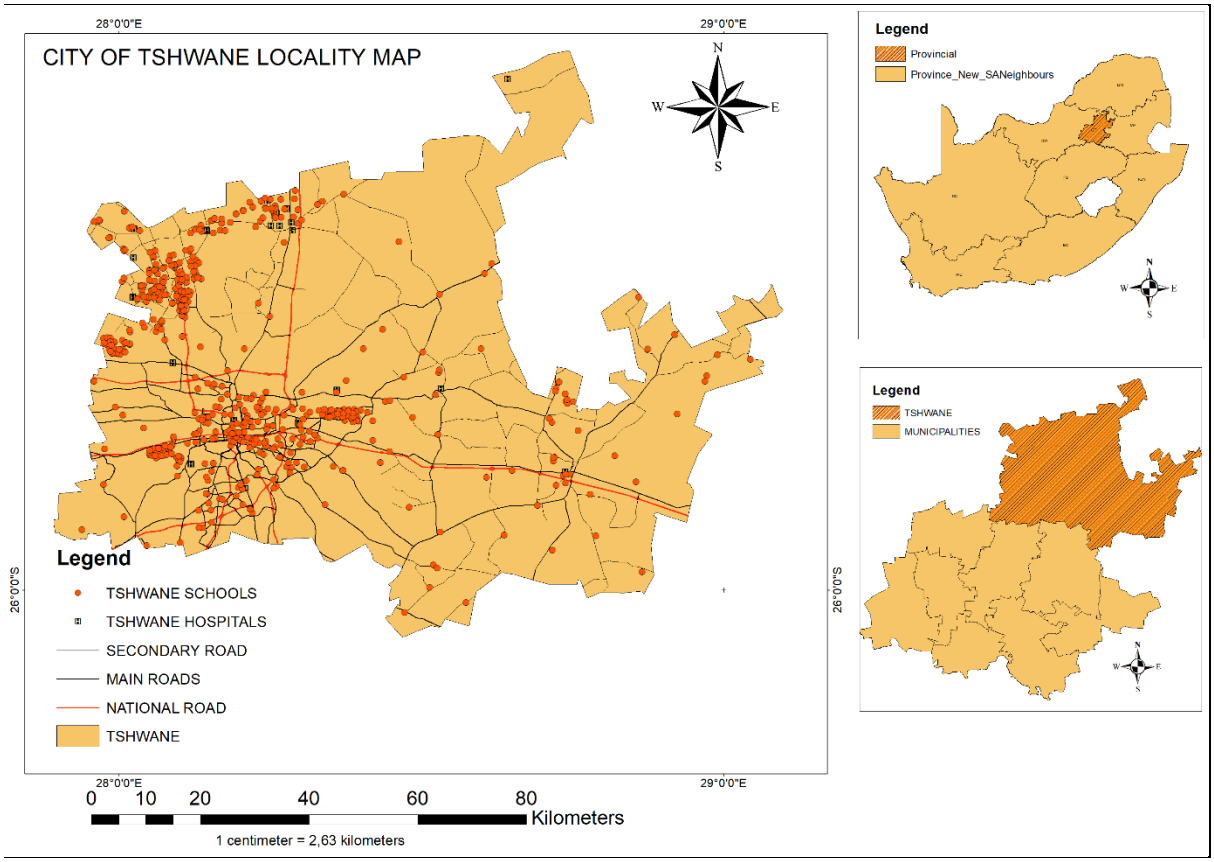

Figure 2: City of Tshwane (CoT) (Author, 2021)

The city hosts several higher education institutions; universities, Technikons, and technical vocational education and training colleges. The CoT also has several leading research and teaching universities. Including the Tshwane University of Technology, the biggest long-distance education university in the continent, the University of South Africa (UNISA), as well as The University of Pretoria. There is a scarcity of jobs in the CoT, yet the city has many employees in public service offices, functional private, agricultural, and tourism sectors to mention a few. The economic sector that contributes the most to the CoT economy is the

community service at 30% and the least contributing at 0.6% is agriculture as shown in Figure 3 below.

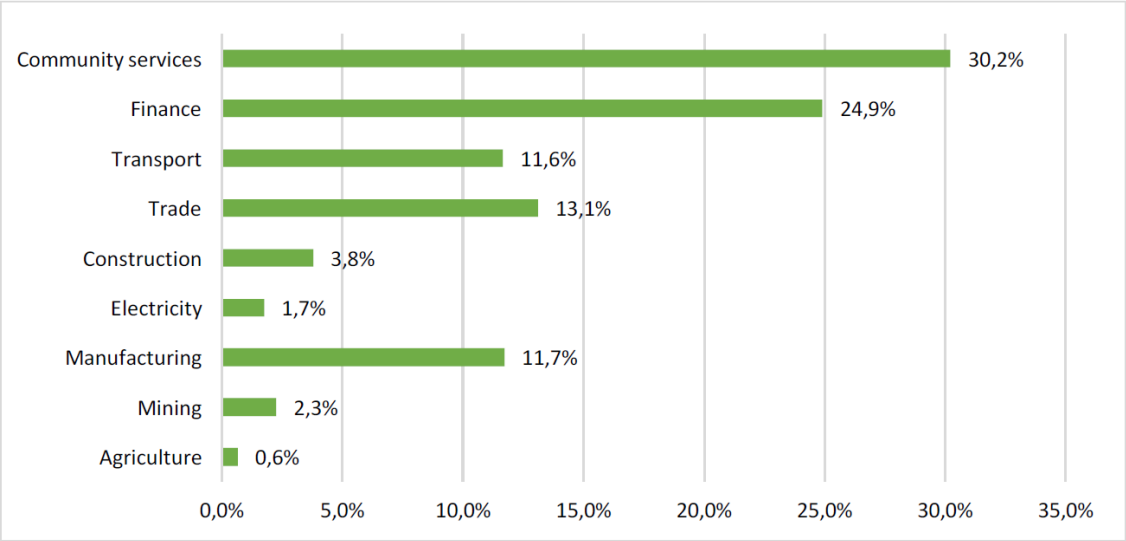

Figure 3: City of Tshwane (CoT) economic sectors (City of Tshwane, 2017)

3.3. Data acquisition

3.3.1. Data sources

The collection of data was guided by the study done by Wilson and Greenlee (Wilson and Greenlee, 2016), whereby opportunity is calculated using dimensions that contain certain indicators. The three dimensions were jobs and local economy; education and community health; and civic life. For each dimension, there were three indicators for the data collected.

The main places were used as the unit of study. Because the study was done based on a metropolitan area, these places were best for analysing the spatial spread of the opportunity. Further, as time was a constraint the study could not be done on a sub-place level as there would then have been too many units to analyse. There are 4 524 sub-places in CoT while the main places total 76. All the data collected were thus at the main place level for every main place in CoT. , All data collected in other units or levels had to be aggregated to the main place for all the data sets to be one level for the study. The main place is on level five on the geographical area hierarchy structure for StatsSA (Frith, 2011a) (Sukhai et al., 2009). The structure of the first path consists of seven levels, which are as follows: Level 1 – South Africa, Level 2 – Province, Level 3 – District Council or Metropolitan Area, Level 4 – Local Municipality (or District Management Area), Level 5 – Main Place, Level 6 – Sub-place, and Level 7 – Enumeration Area (Frith, 2011a). Though the aim was to get all indicators data on the main place level, some of the data were only available on ward level or only per

metropolitan area. Some of the indicators used by Wilson and Greenlee were not accessible in South Africa.

Table 1 below shows the dimensions, indicators, and their data sources. The indicators used were in line with the Wilson and Greenlee study to create a comparative study. But owing to the unavailability of some of the data sets in South Africa and the time constrain to the study, only some of the available data could be used. Wilson and Greenlee used grocery store and vendor data in their study, but this study only uses some grocery stores and no vendor data as South African vendors are not recorded in the data.

The data on the number of banking institutions was inaccessible, while household expenditure was only available per metropolitan area and not per the main place. Poverty data were not available per the main place but only per ward in the CoT and the data had to be aggregated to the main places.

Table 1: Data sets and sources(Author, 2021)

DIMENSION	INDICATOR	DATA SOURCE
Jobs and the local economy	Unemployment rate	Statistics South Africa 2011 census
	Median household income	General Household Survey Statistics South Africa 2011
	Poverty	Statistics South Africa 2011 census
Education	Preschool enrolment%	Statistics South Africa 2011 census
	High school dropout rate%	Statistics South Africa 2011 census
	Post-secondary educational attainment%	Statistics South Africa 2011 census
Health and civic life	Youth in economic and academic inclusion%	Statistics South Africa 2011 census
	Primary caregiving (per 100000 residents)	CoT website (CoT, 2020)
	Grocery stores and produce vendors (per 10000 residents)	Pick n Pay (Pick 'n Pay, 2015) and Spar (Spar, 2015)

Table 1 shows that there are three indicators associated with the first dimension, namely jobs and the local economy. The data for all indicators that as the unemployment rate, the median household income percentage, and the poverty rate indicators were acquired from StatsSA (StatsSA, 2011a). The unemployment rate is the percentage of people that are not employed in the community, and it helps with understanding the level of unemployment in the neighbourhood. The median income is the income level at the midpoint of all households

ranked by all incomes in the neighbourhood (tutor2u and Riley, 2021), and the poverty rate is the percentage of people whose income falls below the poverty line. The study used poverty data provided by StatsSA derived from the South African Multidimensional Poverty Index (SAMPI). SAMPI is not intended to replace the poverty headcount but rather it is complementary to the headcount and gaps. It is produced by StatsSA using the three national poverty lines being the food poverty line, the lower-bound poverty line and the upper-bound poverty line (Fransman and Yu, 2019) .

The jobs and local economy dimension demonstrates the economic and job standard of the neighbourhood (Wilson and Greenlee, 2016).

The second dimension is the education dimension, which has three indicators, namely preschool enrolment percentage, high school dropout rate, and post-secondary school attainment percentages. All the indicator data were supplied by StatsSA from their 2011 census. The preschool enrolment percentage dimension data indicate the number of children aged 3–4 years enrolled in a preschool, and it is calculated by taking the population aged between 3 and 4 years enrolled in preschools divided by the population size of these children per the main place.

The high school dropout rate (%) indicates the number of community members that are of school-going age but are not affiliated with any learning institution. It is calculated by taking the number of children aged 16–19 years not registered in any school and not graduates either, divided by the population in that age group in the neighbourhood (Isserman *et al.*, 2009).

Lastly, the post-secondary educational attainment indicates the percentage of residents who are at least 25 years old and have a qualification higher than secondary school. It is calculated by dividing the number of the 25-year-olds or older individuals who have post-secondary qualifications by the population size of individuals in that age group or older in the neighbourhood, then multiplied by 100 to be a percentage.

The health and civic life dimension have three indicators that look at the quality of life and opportunities for residents. The indicators are youth in economic and academic inclusion (%), primary caregiving facilities (per 100 000 residents), and grocery stores (per 10 000 residents).

The first indicator of the youth economic and academic inclusion (%) was acquired from StatsSA, and it represents the youth aged 16–19 years, who are not enrolled in any learning centre and are not working. This group is similar to NEET (Not in Employment, Education or Training) (Department of Labour, 2015). The South African Basic Conditions of Employment Act provides that ‘ . . .children below 16 years of age should not be allowed to work and that a child below 18 years may not perform work which is inappropriate for his or her age or which is hazardous or harmful to his health’(Collinson, 2010). For this reason, only data for youths aged between 16 and 19 were selected and used for the study.

The primary caregiving per 100 000 residents’ data source was the CoT website, which provides a list of clinics within the city. The data define access to primary medical facilities per 100 000 residents within the city. Grocery stores and produce vendors per 10 000 residents within the city are indicators of the availability of healthy food and show business patterns in the city.

3.4. Software and processing

3.4.1. Software used

The study used three software packages to preprocess, normalise and analyse the data. ArcMap 10.6 was used for data preprocessing and analysis, Geoda was used for analysis, and Microsoft Excel was used for cleaning and normalising the data.

3.4.2. Preprocessing and data aggregation

The poverty rate data from StatsSA were provided on a ward level, whereas the study was at the main place level, so the data were aggregated from ward level to main place level using ArcMap 10.6.

ArcMap was used to geocode the point data for primary caregiving facilities (clinics) and grocery stores. Both data sets were provided in a tabular format, with the locations of the facilities were in an address format. ArcMap software was used to geocode the addresses to point data shapefiles. The data for the health facilities and grocery stores were acquired in shapefile format in points. When doing analysis, new fields were created with facilities per the main place for calculations based on the population it serves. Health facilities were calculated per 100 000 residents and retail stores were calculated per 10 000 residents.

3.5. Data analysis

This section of the report outlines all the steps followed in analysing the data and that yielded the results for the next chapter. It starts with the descriptive statistics and elaborates on how the opportunity index was built, how the choropleth maps and their significance were determined, and the procedures the spatial weight matrix, the Local Moran's I, as well as the hot and cold spot analysis.

3.5.1. Descriptive statistics

Descriptive statistics involve the analysis, summarising, and presenting of results of a data set derived from a model or total population (Mishra et al., 2019). Descriptive statistics comprise three main classes. First, the frequency distribution depicts the frequency or count of the different outcomes in a data set or sample. Second, measures of central tendency give a descriptive summary using one value that reflects the centre of the data distribution. Lastly, measures of variability are summary statistics that reflects the extent of dispersion in a sample (Vetter, 2017) (Libman, 2010). Descriptive statistics provide a brief overview of the data and allow a simplified explanation of the data set (Marshall and Jonker, 2010).

In this study, descriptive statistics were done for the three dimensions and their indicators to enable analysis and presentation of the distribution, central tendency, and variability of the data.

3.5.2. Opportunity index

The opportunity index is an annual report and composite measure of key economic, educational, and civic indicators developed by Opportunity Nation (Opportunity Nation, 2016). The opportunity index was created using the data collected for each dimension. The creation of the opportunity index helped to achieve the first objective of this study. Creating the opportunity index involved three steps:

1. Rescaling indicators
2. Calculating dimension scores
3. Calculating opportunity scores and grades

1. Rescaling indicators

The different indicators that together build the opportunity index include values in rents and percentages. To be able to use them in the composite opportunity index, each of the values

must be converted to allow comparison on a similar scale. To create the opportunity index, all values collected for every indicator must be rescaled. Each main place record on every indicator is compared with the lowest score and the highest score for that indicator (Opportunity Nation, 2016). The formula below shows how the rescaling is done per indicator for every main place:

$$VALUE_{rescaled} = \left(\frac{VALUE_{observed} - VALUE_{minimum}}{VALUE_{maximum} - VALUE_{minimum}}\right) * 100$$

2. Calculating dimension scores

At the state level in the USA, the opportunity index is made up of 20 indicators across the four dimensions of economy, education, health, and community. In each dimension, the rescaled values for indicators are averaged to create dimension-level opportunity scores, ranging from zero to 100. (Opportunity Nation, 2016).

In this study, due to the unavailability of some data, the opportunity index was made up of nine indicators for all three dimensions. In each dimension, the rescaled values for each indicator were averaged to create a dimension-level opportunity score. All the rescaled values ranged from zero to 100.

3. Calculating opportunity scores

The goal of the overall opportunity score in the main place is achieved by adding the three-dimension scores for each main place and then average all these values range from 0 to 100. The overall opportunity score provides a unique value for each main place.

The World Health Organization (WHO) has mandated the nations to ensure that health facilities should be affordable and accessible to the citizens at the minimum distance of 5 km and their clinics should be a ratio of 1:100 000 citizens (Organization *et al.*, 2015), but owing to lack of services in most countries, this mandate is not followed.

3.5.3. Choropleth maps

A choropleth map is a thematic map in which a set of pre-defined zones is coloured in patterns that are based on a statistical variable representing a geographic characteristic for every zone. Examples of statistical variables include population, poverty levels, educational levels and crime levels. (Nguyen and Akerkar, 2020). The second objective of the study will be achieved in this section of the methodology. Maps were used to demonstrate the spatial distribution of the dimension scores for jobs and local economy, education, community

health, and civic life, opportunities index, and population per the main place within the metropolitan area.

3.5.4. Neighbourhood and Spatial weight matrix

The term ‘neighbourhood’ refers to a geographically localised community within a larger city, town, suburb, or rural area (Smith, 2010). When doing spatial analysis it should be observed that there might be factors affecting main places close to each other compared to main places far apart because the spatial analysis is based on the assumption that close phenomena are more similar than those that are farther apart (Dray *et al.*, 2012). Therefore, it is vital to explore the existence of spatial patterns before performing data analysis.

Spatial neighbours and weights determine the spatial relations between spatial units (Dubé and Legros, 2013). In this study the distance-based weight was used to determine the relationship between the main places based on a specific distance, also referred to as the Euclidean distance. This was measured using the distance between the centroids of main place polygons, also referred to as the great circle distance (Lin *et al.*, 2013) (Nastro and Tancredi, 2010). ArcMap 10.6 was used to calculate the weights and spatial neighbours for all the main places.

3.5.5. Local Moran’s I

Moran’s I quantifies the spatial autocorrelation and was developed by Patrick Alfred Pierce Moran. Spatial autocorrelation refers to the relationship among nearby locations in space (Kumari *et al.*, 2019). There are two types of spatial autocorrelations, namely the Global Moran’ I and the Local Moran’s I (Thompson *et al.*, 2018). In this study, the Local Moran’s I was used because the study is based on evaluation at the local area within CoJ.

The Local Moran’s I is a local indicator of spatial autocorrelation that measures the degree of relations at large scales, such as main places in metropolitan areas which may be overlooked by the Global Moran’s I (Wilson and Greenlee, 2016).

3.5.6. Hot and cold spot analysis

Using the Local Moran’s I, the hot and cold spots in the CoT were identified by measuring the spatial significance of main places to the extent to which clusters and outliers can be seen in the data. The analysis group features when similar high (hot) or low (cold) values are

found in a cluster (Mendizabal *et al.*, 2021). Spatial outliers can be defined as those main places whose opportunity index values are noticeably different from those of their spatial neighbours (Kou and Lu, 2017). This study used the fixed Euclidean distance band to calculate the hot and cold spots in the CoT.

The third objective of the study was fulfilled by the hot and cold spots analysis whereby clusters of high values, indicated by ‘high-high’, and low values, indicated by ‘low-low, were identified. The outliers are indicated by ‘high-low’ and ‘low-high’ (Wilson and Greenlee, 2016).

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Chapter 4: Results

4.1. Introduction

Using all the exploratory techniques indicated in Chapter 3 enabled the exploration of the opportunity dimensions and their indicators. As outlined in Chapter 3, the results first show the statistical description of the indicators and the opportunity index statistics. They then provide the spatial spread of each dimension, the opportunity index, and the population size per the main place. Lastly, the results of the hot and cold spots analysis for the opportunity index calculated using Local Moran's I are also indicated. Quantile classification is a method that allocates several values into groups that have an equal number of values, then the feature values are summed up, and divided into the predetermined number of classes or quantiles(Slocum *et al.*, 2000). Using this method, all the data sets are classified into four categories using quantiles.

4.2. Descriptive statistics of data

Descriptive statistics use numbers and graphics to give more information about the data. Tables 2 to 4 show all the dimensions and their indicators, while Table 5 shows the rental expenditure per metropolitan area in Gauteng.

4.2.1. Jobs and local economy dimension

Table 2 shows the descriptive statistics for the jobs and local economic indicators, namely the unemployment rate, median income, and poverty rate in the CoT. The city was found to have an unemployment rate that ranged between 0% and 62% across different locations, with the median income ranging from R9 003 to R421 160 per annum and the poverty rate between 0% and 17%.

Table 2: Jobs and local economy indicators (Author, 2021)

Jobs and local economy indicators			
Descriptive statistics	**Unemployment rate (%)**	**Poverty rate (%)**	**Median income (R)**
Minimum	0	0	9 003.00
Maximum	62.34	17.18	421 160.00
Mean	20.87	1.73	57 572.00
Median	14.67	0	28 346.00
Standard deviation	15.12	3.22	77 189.96

The statistics also show that the unemployment rate was positively skewed with no outlying main places, the median income was found to be slightly positively skewed with many outlying data and the poverty rate data were positively skewed with few outliers.

For the unemployment and the poverty rates, the standard deviation shows the data were less dispersed from the mean, while the median income data shows that the data were more dispersed.

4.2.2. Education dimension

Table 3 shows the descriptive statistics for the education dimension indicators, where the data sets included preschool enrolment, high school dropout rate, and post-secondary school attainment. The data show that there was a low dispersion from the mean with low standard deviation values. The preschool enrolment and dropout rate data were negatively skewed with few outliers while the post-secondary school attainment data were positively skewed with many outlying data points. Preschool enrolment, high school dropout, and post-secondary attainment data all ranged from 0%, with the upper values being33%, 49%, and 68% respectively.

Table 3: Education indicators (Author, 2021)

Education indicators			
Descriptive statistics	**Preschool enrolment**	**Post-secondary attainment**	**Dropout rate (%)**
Minimum	0	0	0
Maximum	33.00	68.00	48.72
Mean	6.26	18.81	13.02
Median	5.00	11.00	11.18
Standard deviation	6.05	15.16	9.79

4.2.3. Community health and civic life dimension

The third dimension is community health and civic life with the indicators being several health institutions and retail stores, as well as youth economic and academic inclusion. Table 4 below shows the standard deviation values of all indicators were low, meaning that there was little dispersion in the data, while all the indicators were completely different in their skewness. The third dimension (community health and civic life) shows there is a lack of

community services (such as health facilities and retail stores) mostly in the black communities.

The data for clinics were completely skewed to the left, while the retail data did not show any skewness, but many outliers and the youth inclusion indicator showed skewness to the right. All the indicator data showed there is a maximum of 87 of clinics per 100 000 people and a maximum of four grocery stores per 10 000 people.

Table 4: Community health and civic life indicators (Author, 2021)

Community health and civic life indicators			
Descriptive statistics	Retail stores per 10 000 population	Clinics per 100 000 population	**Youth inclusion**
Minimum	0	0	0
Maximum	4.41	19.00	49.00
Mean	0.13	1.32	12.98
Median	0	0	11.00
Standard deviation	0.55	2.67	9.78

Descriptive statistics analysis was also done for the opportunity index and the population of the CoT. The data showed a small deviation from the mean with the asymmetrical spread in the data with only one outlier. The population data showed that the data were dispersed from the mean, with a negative skewness to the data with many outliers.

4.2.4. Statistics of rental expenditure

Wilson and Greenlee (2016) included rental expenditure and banking institutions as part of the jobs and local economy indicator. Data on tenure status are collected by StatsSA and are made available by Small Area Layer. Although this study followed the variables used by Wilson and Greenlee, the percentage of income spent on rent was only available at the metropolitan level. Table 5 shows five metropolitan areas in the country. It indicates the total number and percentages of households that are renting, as well as the percentage of rental expenditure as part of the total household expenditure.

The City of Cape Town has the highest rental expenditure (16.6%) followed by the Nelson Mandela Bay metropolitan municipality. Even though the City of Johannesburg has the third-highest percentage expenditure on rentals, it has the highest percentage of households that are renting. The CoT has the fourth-highest number of households renting (10.1%) while Ekurhuleni has the lowest percentage of the five metropolitan areas evaluated. Table 2

column 4 (% of rental expenditure as a part of total expenditure) shows that the rental expenditures for all the metropolitan municipalities are less than 30%, indicating rental affordability is relatively favourable for households (Wilson and Greenlee, 2016) .

Table 5: Rental expenditure (StatsSA, 2011b)

Metro name	Number of households renting	% of households renting	% of rental expenditure part of total expenditure
City of Cape Town	371 153	33.0	16.6
City of Johannesburg	643 737	40.8	12.3
City of Tshwane	333 142	35.7	10.1
Ekurhuleni	384 915	3.5	9.5
Nelson Mandela	63 140	23.3	13.7
SA Metros	**1 796 087**	**33.3**	**12.4**

4.3. Spatial characteristics of data

Choropleth maps were created for each dimension to show the distributions of data in the CoT. A choropleth map for the opportunity index and the population distribution is also included. All maps were analysed using four levels ranging from very low to low, high, and very high.

A very high score is more desirable than the other three scores in all dimensions. A very high score in the jobs and local economy dimension indicates that few individuals are living in poverty in the main place, there is a low unemployment rate and the main place is in a good economic state. In the education dimension, a very high score indicates that there are many children registered in preschools, many residents with post-secondary school attainment, and a low school dropout rate.

A very high score in the community health and civic life dimension indicates that there are enough primary care facilities and retail stores, and most youths are included in the social and economic aspects of the community. Dimensions are analysed individually in the next section since they form the building blocks of the opportunity index.

4.3.1. Jobs and local economy dimension

The data were classified into four quantiles (see Table 6).

Table 6: Jobs and local economy quantile range (Author, 2021)

Category	Minimum value	Maximum value
Very low	0.24	9.42
Low	9.43	19.11
High	19.12	29.16
Very high	29.17	43.06

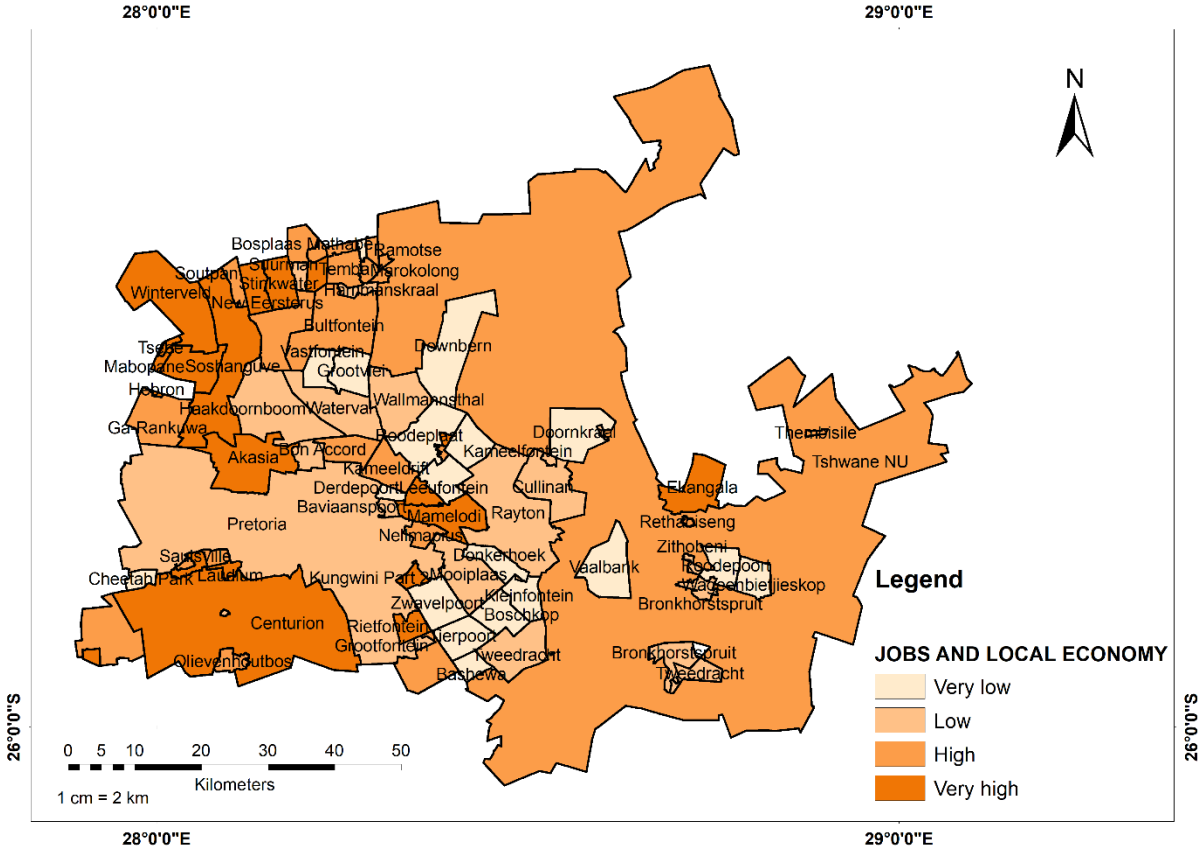

Figure 4: Jobs and local economy dimension map (Author, 2021)

The main places with the lowest jobs and local economy values were Babelegi, Kleinfontein, and Vaalbank, whereas Laudium, Winterveld, and Stinkwater scored the highest in this dimension. Babelegi's was demarcated during the apartheid era to stop the inflow of black workers into the white-dominated metropolitan areas (Tiro, 2015). The main place is situated approximately 40 kilometres north of Pretoria, on the extreme periphery of Tshwane (Rogerson, 1974).

Kleinfontein is a newly developed settlement in Tshwane, founded as a cultural village by Afrikaners in 1992 and has an inadequate economy (Hart, 2015). The township is situated approximately between Pretoria and Bronkhorstspruit and just south of the N4, west of the R515, and a few kilometres south of Rayton (Wyk and Stephanus, 2014). Vaalbank is located near Kleinfontein towards the south-eastern part of the CoT. Stinkwater and Winterveld are located in the far north-western part of the metropolitan municipality, in the periphery, characterised by many shacks and poor-quality services. Looking at Figure 4 above, it is clear that the very high score for the jobs and the local economy dimension tended to be randomly distributed and there was no clustering.

4.3.2. Education dimension

The data in this dimension were classified into four quantiles ranging from very low to low, high, and very high (see Table 7).

Table 7: Education quantile range (Author, 2021)

Category	Minimum value	Maximum value
Very low	3.89	14.50
Low	14.51	23.78
High	23.79	37.39
Very high	37.40	57.68

In the education dimension, the most dominating score was for low education. Figure 8 shows that the main places with the lowest score were Babelegi, Kleinfontein, and Bosplaas Mathabe. These three main places are located in the extreme periphery of the CoT and are associated with poverty and poor services, and they are mainly dominated by the black community (Frith, 2011b). The main places with the highest scores were Kameelfontein, Kungwini Part 2, and Zwavelpoort. These three main places are located in the eastern part of the metropolitan area. They are dominated by the white community (Frith, 2011b) and are affluent and well developed. In this dimension, there was a clustering of the very high scores in the south-eastern part and the metropolitan area; most of the main places in this area are well developed.

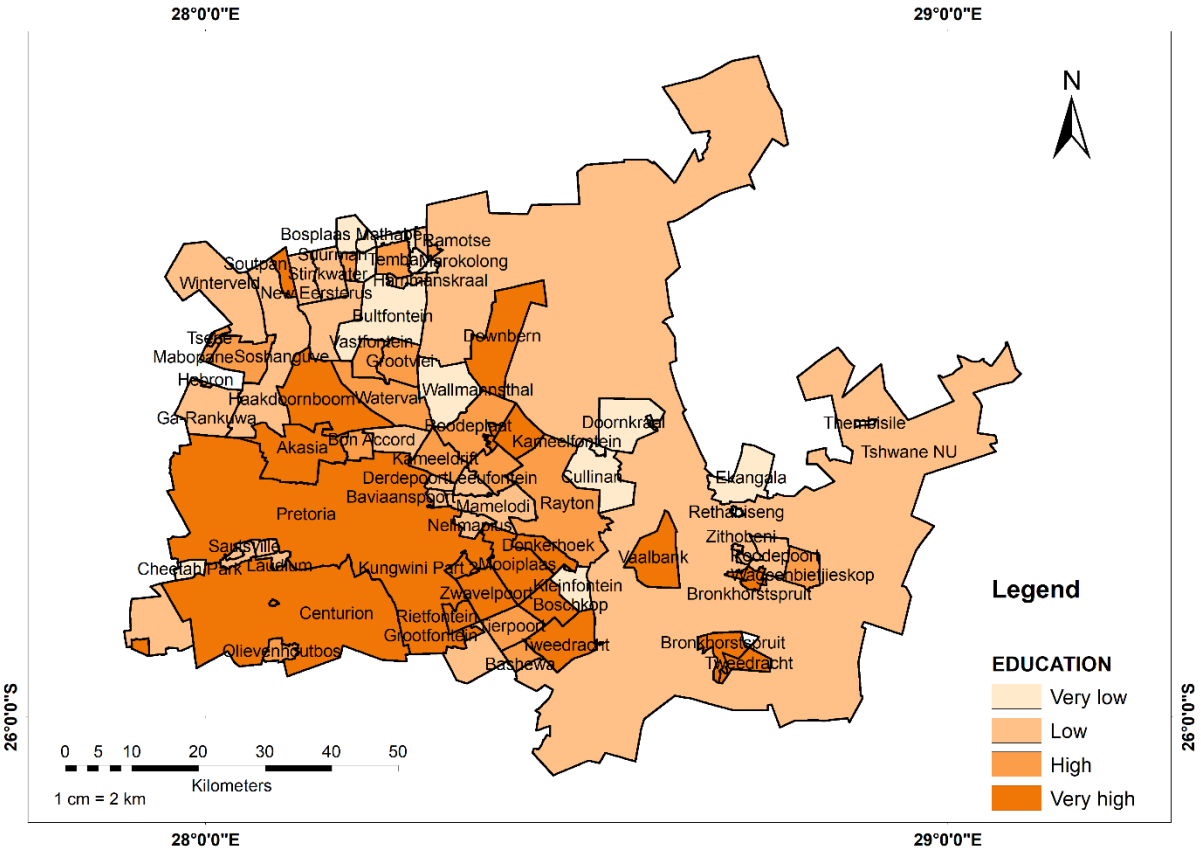

Figure 5 Education dimension map (Author, 2021)

Babelegi and Kleinfontein had the lowest score on education, and also had the lowest score on jobs and local economy dimensions. In the very high score, we have different main places for the education dimension as compared to the jobs and local economy dimension.

4.3.3. Community health and civic life dimension

The data in this dimension were classified into four quantiles ranging from very low to low, high, and very high (see Table 8).

Table 8: Community health and civic life quantile range (Author, 2021)

Category	Minimum value	Maximum value
Very low	0	0.42
Low	0.43	1.35
High	1.36	4.87
Very high	4.88	35.76

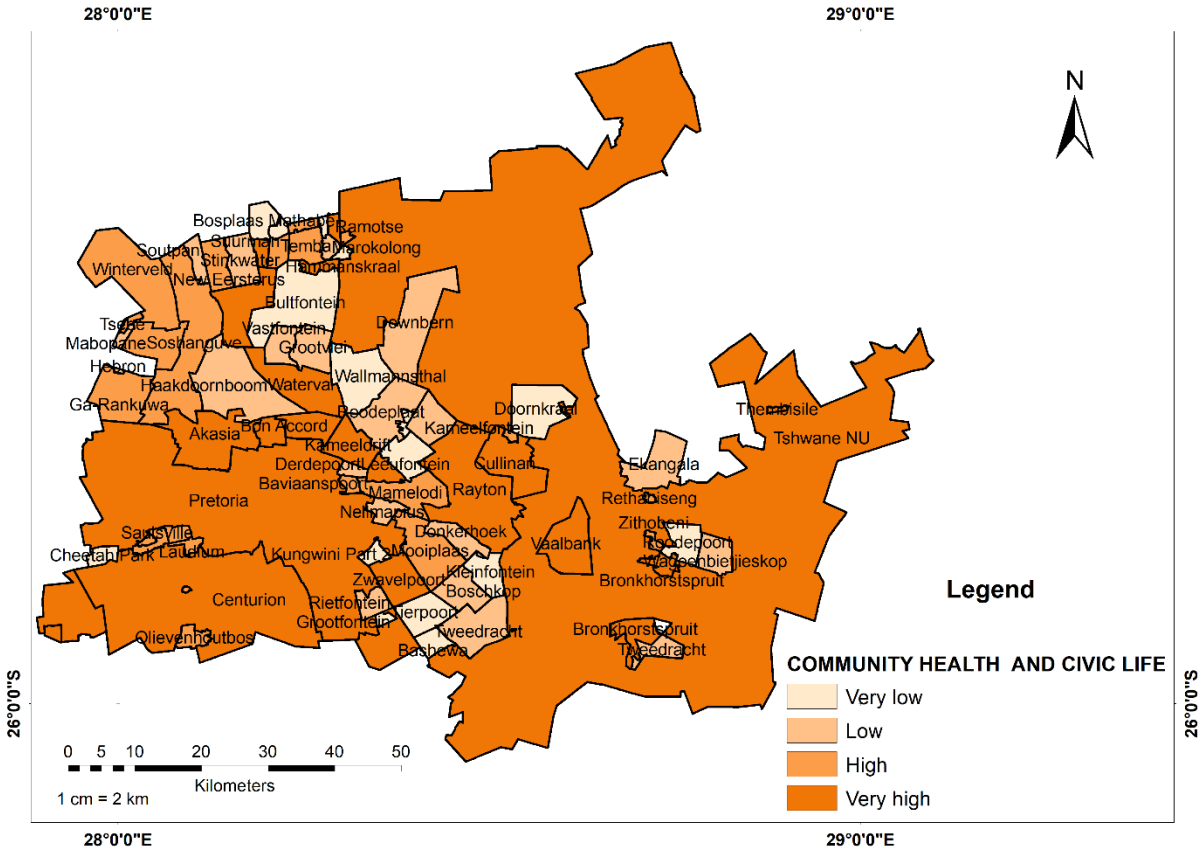

Figure 6: Community health and civic life map (Author, 2021)

In the community and civic life dimension, the very high category seems to have been more dominant in the CoT in comparison to other dimensions. There were few low scores in this dimension compared to the other two dimensions, with Bon Accord, Zwavelpoort, and Waterval scoring the highest and Babelegi, Kleinfontein, and Cheetah Park scoring the lowest. The three low-scoring main places have a very low population.

Figure 9 indicates a random spread in the very high score for the community and civic life dimension. Zwavelpoort scored in the very high category for this dimension and in the education dimension. Babelegi and Kleinfontein scored in the very low category, consistent with the other two dimensions.

4.3.4. Opportunity index map

The data in this dimension were classified into four quartiles ranging from very low to low, high, and very high (see Table 9).

Table 9: Opportunity index quantile range (Author, 2021)

Category	Minimum value	Maximum value
Very low	1.38	1.88
Low	1.89	15.57
High	15.58	18.42
Very high	18.43	30.72

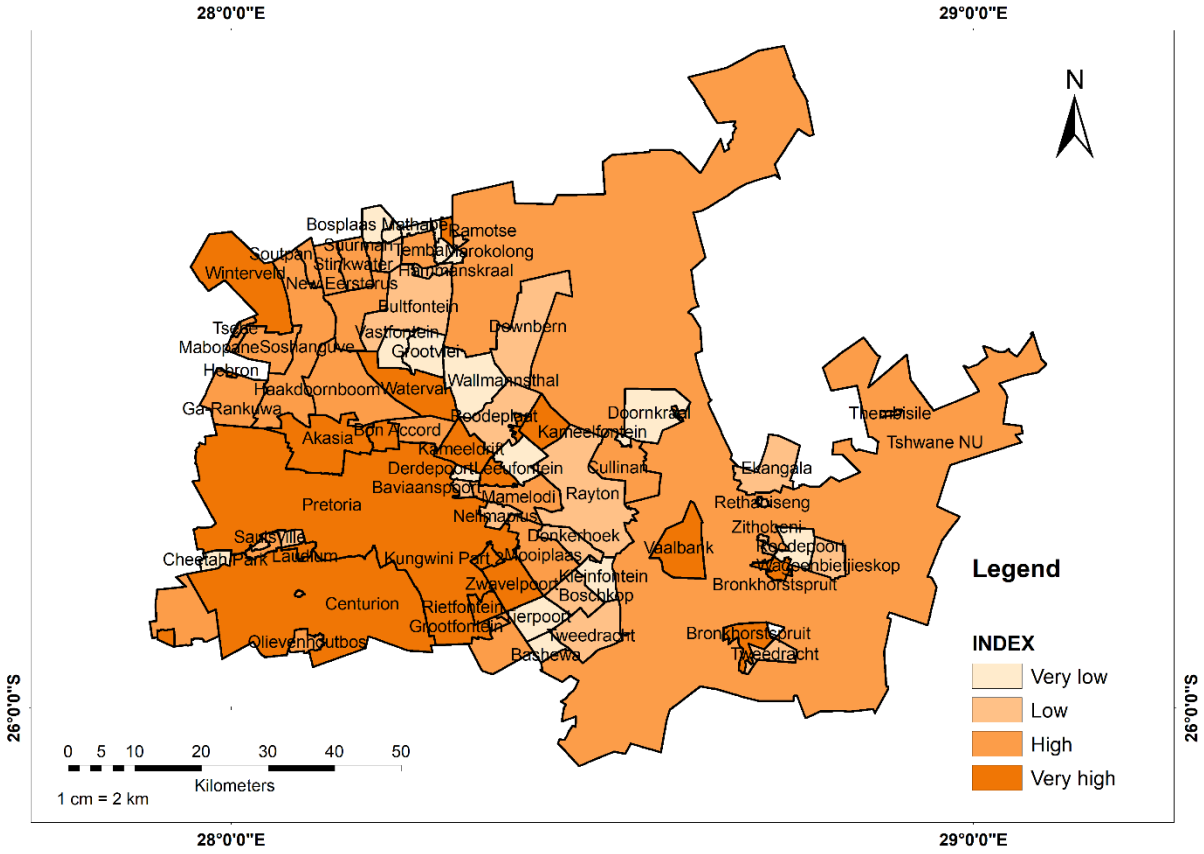

Figure 7: Opportunity index map (Author, 2021)

As the opportunity index is made up of the three dimensions, each has an impact on the outcome of the opportunity among the main places in the CoT. The main places that scored the highest in the CoT were Bon Accord, Zwavelpoort, and Waterval, while Babelegi, Kleinfontein, and Cheetah Park scored the lowest amongst all main places.

There is a clear indication that the main places that scored high in most dimensions also scored high on the opportunity index. For example, Babelegi and Kleinfontein scored the lowest in all three dimensions and also in the opportunity index. Bon Accord, Zwavelpoort,

and Waterval scored highest in community health and civic life dimensions and also had the highest score in the opportunity index.

The main places with very high scores differ from one dimension to the other; some main places that scored high in jobs and local economy are not the same main places that scored the highest in education or community health and civic life. However, the main places with most high scores in most dimensions had a high score in the opportunity index.

4.3.5. Population spread

The analysis had to touch on the population size per main place as that affects most of the dimensions—especially the community and the civic life dimension. Figure 11 shows the number of people in the city also ranging from very low to low, high, and very high; all categories are represented on the map.

The data in this dimension were classified into four quantiles using the range shown in Table 10.

Table 10: Population quantile range (Author, 2021)

Category	Minimum value	Maximum value
Very low	0	39 201
Low	39 202	120 827
High	120 828	403 162
Very high	403 163	741 651

The main places with the lowest population size were Babelegi, Kleinfontein, Cheetah Park, Bosplaas Mathabe, and Kleinfontein. Pretoria, Mamelodi, and Soshanguve scored very high for population size; these places cover a large area of the CoT.

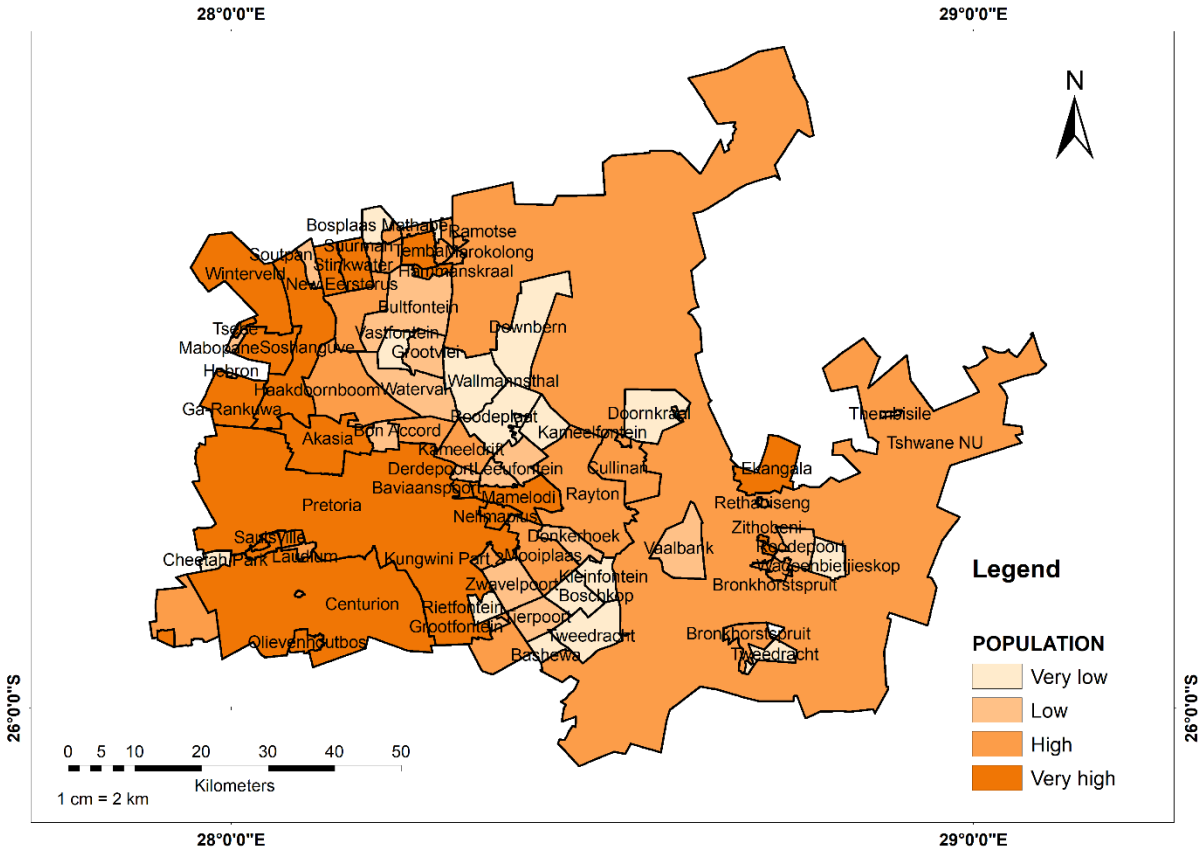

Figure 8: Population map (Author, 2021)

There was a strong relationship between the population size, the dimensions of the index, and the spread of opportunity in the CoT. The main places Babelegi and Kleinfontein scored the lowest in all the dimensions and the opportunity index. Both places also have the lowest population sizes. Both Cheetah Park and Bosplaas Mathabe scored very low in the community and civic life and education dimensions. As with places Babelegi and Kleinfontein, both Cheetah Park and Bosplaas Mathabe also have low population sizes and scored very low in the opportunity index.

Table 11 shows the summary of the most populated main places and their score in all dimensions and the opportunity index. Centurion scored in the very high category for all the dimensions including the opportunity index. All the main places that scored low in the education dimension scored high in the community health and civic life dimension, and scored very high in the jobs and local economy dimension. These main places also scored high in the opportunity index. Winterveld and Pretoria had a very high score for opportunity

index and population size. The results in Table 11 show that there is a strong relationship between population size and the opportunity index.

Table 11: Relationship between population and dimensions (Author, 2021)

Main place	Jobs and local economy	Education	Community health and civic life	Opportunity index	Population
Centurion	Very high	Very high	Very high	Very high	Very high
Mamelodi	Very high	Low	High	High	Very high
Pretoria	Low	Very high	Very high	Very high	Very high
Soshanguve	Very high	Low	High	High	Very high
Winterveld	Very high	Low	High	Very high	Very high

4.4. Spatial patterns

The spatial pattern map shows whether opportunities are clustered or dispersed and a hot and cold spots map analysis was used to illustrate this. The map was only done on the opportunity index derived from the three dimensions.

4.4.1. Hot and cold spots (Local Moran's I)

Using Local Moran's I, the results in Figure 12 show the main places where there are high opportunities clustered close to high opportunities, also called high-high clusters or hotspots, and areas where there are low opportunities close to low opportunities, which are called low-low clusters or cold spots. There are areas where high opportunities are surrounded by low opportunities and these are called high-low outliers, and areas where high opportunities are surrounded by low opportunities and are called low-high outliers.

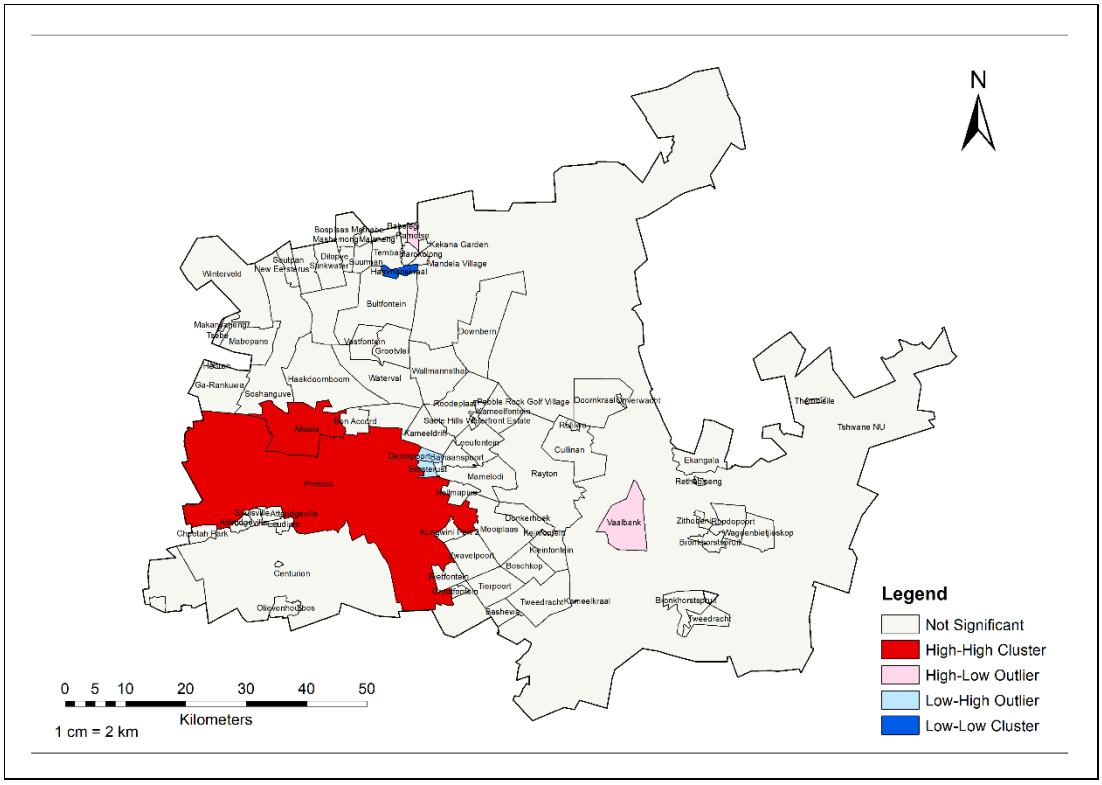

Figure 9: Hot and cold spots map (Author, 2021)

In CoT the main place Hammanskraal was a cold spot (in blue) , while Pretoria and Akasia (in red) were found to be hotspot areas (see Figure 9). Derdepoort and Eersterust were identified as low opportunity outliers near high opportunities, and Ramotse and Vaalbank weree identified as outlying areas with high opportunities next to low opportunity areas.

4.5. Conclusion

The information gathered from the descriptive statistics helped understand the spread of the raw data, as outliers and skewness of the data could be depicted. This indicated that not all data were symmetric as some places had large values while some had very small values.

The data enabled an understanding of how the opportunity index came about in terms of building dimensions. All dimensions scored differently in their respective main places, making the opportunity index follow suit. One dimension could score high in one place but score low on the other two scores which resulted in a low scoring opportunity index.

A strong relationship between the opportunity and population size per main place was depicted as some places had a high population with low opportunity whereas some had a high population with high opportunity. In some cases, there was a low population with high opportunity, while other places with low population had a low opportunity.

Chapter 5: Discussion of findings

5.1. Introduction

This chapter discusses the results presented in Chapter 4 in combination with the literature review provided in Chapter 2. First, the results from all the analyses are discussed. Second, the variations between the values attained in the descriptive statistics, the opportunity index, the choropleth maps for all the dimensions, and spatial pattern observed from the Local Moran's I analysis, hot and cold spots map are analysed. Third, the chapter discusses the results concerning the spatial mismatch as a result of racial segregation, job suburbanisation, and geographical economic restructuring.

5.2. Significance of findings

The significance of all the results is discussed so that we can elaborate on how the results impacted the study, because the results will give a viewpoint of the dimensions, opportunity index, and the spread of the opportunity and population.

5.2.1. Descriptive statistics

The results show that several indicators have a minimum score of zero, which is a good score for some indicators and a bad score for others. A zero score for the unemployment rate—meaning there are no people with jobs in the main place— is a bad score, whereas a zero score in dropout rate is a good score. In this case it indicates that there are no children leaving school before completing their matric.

The first dimension (jobs and local economy) highlighted that most main places with a high poverty rate score also scored high in unemployment. This indicates that there might be a possible relationship between the indicators; however, this needs further investigation. There is a direct link between poverty and unemployment in a community, as Cloete(2015) and others have said that a high unemployment rate in a community can result in a poverty-stricken community (Cloete, 2015; Lyons and Ewing, 2021). Most South African communities are still living in abject poverty, even though the government provides social grants and RDP houses (Aliber, 2003). The best way to alleviate poverty in communities will be the creation of job opportunities, as poverty and employment are inversely proportional.

One of the data challenges in this dimension was that many main places had a poverty rate of zero which might not be the reality on the ground. Several requests for the most recent, clean poverty data were to no avail. The only data obtained were from the year 2011. This could have skewed the results for Dimension 1.

Results for the second dimension (education) showed that there is a high dropout rate in secondary schools with fewer tertiary qualifications in the CoT. The school dropout rates were high in the same main places where there was a low number of post-secondary education attainments. The quality and level of education affect the income level of an individual (Hu, 2019). This ultimately affects the community as people with low income tend to live in specific areas (Bavarian *et al.*, 2013). The high score on dropouts combined with a low score on post-secondary attainment explain the high unemployment and poverty rates in some communities.

If a child drops out of school they will not get an opportunity to further their studies and attain a post-secondary qualification that can earn them a job payinga better salary; such a such a situation can lead to poverty. The main places with low scores in poverty rate are all located on the outskirts of the metro and are characterised by low population counts.

There are communities with no supermarkets that sell healthy food, or with no fresh produce vendors where communities can buy food. This impacts negatively on the health of the individuals and also the economy of the community. If there is a store in the community, it is likely to be too expensive for the community members, and that will help reduce the unemployment rate and alleviate poverty within the communities. The data acquired were only for Spar and Pick ‘n Pay stores; data for some grocery stores like Shoprite and Woolworths were not available. The challenge is that there might be incorrect results from the analysis because too few stores were included. Also, some main places have more grocery stores than the the number actually recorded for this study. However, the data are nevertheless relevant and useful for examining the geography of opportunity in the metropolitan area.

5.2.2. Opportunity index

The opportunity index score is the overall score of all dimensions. The main places that scored the highest are Zwavelpoort, Kungwini Part 2, and Centurion. These three main places are affluent and are predominantly occupied by white people, making up 68% of the

population in Kungwini main place, 59% in Centurion, and 42% in Zwavelpoort, respectively (Frith, 2011a). Centurion has a low school dropout rate, low unemployment level, a high score in the number of people with post-secondary attainment, and adequate health facilities and retail stores. This main place has many educational institutions, tertiary institutions, many office parks, and industries for formal employment and has a very high population count.

Zwavelpoort and Kungwini part 2 are located in the eastern part of the City and share a boundary. They are affluent areas with adequate basic services like primary health care, quality housing, and the best grocery stores. There is intensive human activity within the main place. This indicates that the very high score in these main places are owing to the availability of opportunities. Both main places have a very high population, although Kungwini part 2 is more populated than Zwavelpoort.

The main places that scored low in the opportunity index include Babelegi, Kleinfontein, Doornkraal, and Cheetah Park. However, Babelegi also scored the lowest in all dimensions because Babelegi itmainly consists of industrial plants and companies. The main place has has no schools, has no primary health care facilities, and the only shops are not large retail shops like Spar or Pick n Pay but small convenient shops. It also has the second-lowest population size in comparison to all other main places.

Doornkraal and Kleinfontein are situated in the eastern part of the CoT; these main places have farming activities and very low populations, respectively. There are low records in all the indicators of the three different dimensions; it is clear why these main places have very low opportunity. Cheetah Park is an open piece of land in the far western part of the CoT, with a very low population and relatively low human activity. This clarifies the low score in the opportunity index for this main place.

The city does not have any main places with a high population that scored very low in the opportunity index. All the main places with high populations scored high in the opportunity index.

The opportunity score was calculated from the dimensions but did not follow the trend followed by the dimensions. There are main places that scored high in the opportunity index but with low scores in some dimensions. This means that a high opportunity score in the main place does not automatically mean that all the dimensions in the main place have a high

score. The main place can have a good indication of opportunity, but with no adequate access to health facilities or good education. Therefore, communities cannot be regarded as opportunity hotspots by only looking at the opportunity index score. Rather, all the dimensions and indicators must be taken into consideration when making conclusions.

5.2.3. Choropleth maps

The choropleth maps of the opportunity index gave a visual understanding of how the opportunity score is distributed in the city. Most of the main places that scored in the very high category are located in the south-western part of the city. However, some main places which include the city centre Pretoria, Kameelfontein, Bronkhorstspruit, and Vaalbank scored in the very high category although they are not located in the south-western part of the city. This indicates that there is no pure clustering of opportunity in the CoT.

5.2.4. Spatial patterns

There is a spatial autocorrelation present in the geography of opportunity in the CoT. The hot and cold spot map showed the main places with high-high opportunity, low-low opportunity, and outliers.

The high opportunity cluster is in the south-western part of the city which includes Pretoria and Akasia. These two main places scored in the very high category in the opportunity index. The low opportunity cluster is in the far northern part of the city in Babelegi main place, which is the same main place that scored very low in all dimensions and the opportunity index. There are outliers in opportunity in the CoT, the main places Vaalbank and Ramotse are the high-low outliers meaning that they have a high opportunity but are located near main places with low opportunity. Vaalbank is outlying as it is surrounded by farmlands around its borders; the farmlands have no residential areas or lots of human activities, indicating that there is low opportunity. Ramotse is also an outlier as it is bordered by farmlands to the east and a semi-industrial area to the west. Both borders have a low opportunity.

Derdepoort and Eersterust main places indicate low opportunity outliers near high opportunities. These two main places are both bordered by Pretoria. This further indicates that there is no major clustering of opportunity in the city as there is a presence of outliers. The population spread does have a direct impact on the opportunity score of the main place,

as evidenced by the main places with low population sizes scoring very low in some dimensions and the overall opportunity index.

5.3. Relation between literature and findings

5.3.1. Geography of opportunity

The study has explored the geography of opportunity in the CoT and the study was the first done in the CoT or South Africa as a whole; but there have been other studies done on factors affecting opportunity. A study by Venter and others identified that in South Africa we still have locations with no opportunities, and this causes people to have to travel far to search for opportunities (Venter, C. *et al.*, 2007).

5.3.2. Spatial mismatch

Some studies hold that spatial mismatch is a result of the apartheid laws. The consequences of these laws are mainly ongoing inequalities in, social, economic, and as well as access to opportunities. The results of this study show that the spread of unemployment in the CoT is uneven owing to the clustering of job opportunities, and that it is possibly a result of the spatial mismatch. A study by Lyons and Ewing (2021) indicates that spatial mismatch might be caused by poor access to workplaces based on lack of public transport, or unaffordability of the available modes of transport.

The study also shows that there is an uneven spread of education levels resulting from the inequality in access to education. (Andrews *et al.*, 2017) and (Stoll, 2006) both agree that the South African black communities are exposed to low-quality education; with inadequate income, they are unable to access private schools for better education.

There is also an uneven spread of access to services and facilities such as primary health care and grocery stores. Fernandes, (2017) indicates that owing to inequality and segregation, African black communities in Brazil have insufficient access to health facilities. In general, it is difficult for the African black communities in South Africa to access private health facilities as these are beyond their reach financially. This study has indicated the presence of primary health facilities to peripheral communities, although the number of the health facilities is inadequate according to the WHO ratio.

5.3.3. Exploratory spatial analysis

The study was done on main place level and the ESDA method was deemed suitable to analyse the data as the tools are applicable to small regions with consideration to spatial heterogeneity and spatial (Geniaux and Martinetti, 2018). The study has found some opportunity clustering in the CoT. A study done by Anselin *et al.*, (2007) was also able to identify clusters and outliers in data for child risk for counties in the state of Virginia (USA).

5.4. Conclusion

The chapter discussed all the findings of the research—covering the descriptive statistics of all indicators, the results of all the mapped dimensions, and the Local Moran's I hot and cold spot map. The descriptive statistics of indicators and the dimensions gave a clear understanding of the results of the opportunity index. The opportunity level differs from one main place to another as they have different values per indicator. Some main places have higher opportunities whereas other main places have low opportunities. Some main places have a high population with low opportunities, and some have low opportunities with a low population. Most areas with low opportunities show characteristics of a spatial mismatch as a result of racial segregation, job suburbanisation, and geographical economic restructuring. It can safely be concluded that the city does not have an even geographical distribution of opportunities

Chapter 6: Conclusion

6.1. Summary of research

This research aimed to study the spatial distribution of opportunity in the CoT metropolitan municipality using exploratory spatial analysis. The study fulfilled its purpose as the main places in which there are high opportunities and where low opportunities are using the opportunity index could be identified.

The research had three objectives, the first one being to calculate a multidimensional human opportunity index, which was fulfilled by collecting data from various sources, preprocessing, rescaling, and normalising it to be on the same standard for calculating the opportunity index.

The second objective was mapping the geography of opportunity acquired, and this was achieved using ArcMap software to analyse the index dimension and map the dimensions and the opportunity spread. The last objective was to identify clusters of high and low opportunity using the LISA Moran's I and map the hot and cold spots in the CoT. The study was done to explore the geographical spread of opportunity in the city, results which would inform decision-makers on the main places to focus on when creating developmental projects for the city.

6.2. Limitations

The study followed the methodology used by Wilson and Greenlee, which did a comparison of two years of data in their geography of opportunity study (Wilson and Greenlee, 2016). Unfortunately, owing to time constraints on the study and the shift in the CoT demarcation, the study could only focus on one year. Therefore, a comparative analysis could not be performed. The other limitation was the unavailability of indicator data for the study. In the 2016 study by Wilson and Greenlee, Wilson and Greenlee's, 2016 , some dimensions had more than three indicators but in South Africa, some of the data sets were not available and hence the use of the relevant and available indicators data.

The last census was done in the year 2011 (approximately 10 years ago); therefore, there might have been many changes in current situation within the study area when compared

with the available data. Some of the data sets used in the study were collected in the year 2015 (grocery stores data), that is six years ago, which might also have a negative impact on the results of the analysis. Fortunately, the data are relevant and adequate for the study at the metropolitan level. Acquiring data for populations aged between 16 and 19 years who are not in school and not working was a challenge, as the StatsSA officials could not understand the exact type of data needed.

Below is the list of limitations for the study:

- Several indicators that were used by Wilson and Greenle (2016) in their study were unfortunately not available in South Africa.
- The data acquired from StatsSA might be outdated in some main places, as the last census was done in the year 2011 which is more than 10 years ago.
- Health care facilities data was not easily accessible and neither was the data for grocery stores and farm produce vendors.
- Grocery stores data sets used in the study were not collected in the same year as the rest of the data used in the study, which resulted in some inconsistency.

6.3. Recommendations

It is recommended that the scope of data collected by StatsSA is extended to allow access to more data sets for different research projects and that there should be a reduction in the number of years StatsSA takes before updating their census data. A census should be held at least every five years to improve the accuracy of the available data.

The South African government departments should start recording data for their respective disciplines and make it available to the public for ease of data access. In this case, the Department of Health should have a data portal for all the health care facilities with spatial references for all facilities in the country.

Future research in this field should consider the individual indicators, whether the values contribute meaningfully to the dimension scores or not. Even though each dimension index is supposed to even out outliers in the data, it could be those specific indicators like poverty and the number of clinics do not reflect opportunity adequately; both private and public hospitals should rather be added.

Owingue to the possibility of developments in the CoT, an exploratory study of the spread of opportunity should be done at least every five years to monitor the shift in the spread of opportunity. This will help in decisions on where to direct services within the city and improve equality. Similar studies can be done in other municipalities within other provinces in South Africa.

As there is no study on the geography of opportunity in the CoT, future studies can be done at the sub-place level for more insight on the spread of opportunity within main places.

The study was done in line with the Wilson and Greenlee (2016) study; but some of the aspects in their study were not repeated here. It is therefore recommended that future studies be done with more advanced techniques such as factor analysis.

6.4. Implications of the study

The study has addressed the issue of inequality in the CoT by helping the municipal decision-makers know where to direct resources. The study has also helped in understanding which parts of the City need economic services addressed, which parts of the city need educational issues addressed, and which parts of the city need civic life and health needs addressed. The CoT should direct resources to main places with low scores of opportunity such as Babelegi, Kleinfontein, and Cheetah Park and also put most focus on cold spot areas like Hammanskraal.

6.5. Concluding statement

It can be concluded that the geography of opportunity in the CoT is not equally spread. The study showed that there are main places with very high opportunity while there are also areas with very low opportunity. Also, there are clusters of low and high opportunity. Main places with high opportunity are the most developed areas in the metropolitan area and those areas with low opportunity are the peri-urban areas with low population counts.

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Appendix

List of main placesin Tshwane

NAME
Akasia
Atteridgeville
Babelegi
Bashewa
Baviaanspoort
Bon Accord
Boschkop
BosplaasMathabe
Bronkhorstspruit
Bultfontein
Centurion
Cheetah Park
Cullinan
Derdepoort
Dilopye
Donkerhoek
Doornkraal
Downbern
Eersterust
Ekangala
Ga-Rankuwa
Grootfontein
Grootvlei
Haakdoornboom
Hammanskraal
Hebron
Kameeldrift
Kameelfontein
Kameelkraal
Kleinfontein
Kekana Garden
Kleinfontein
Kungwini Part 2
Laudium

Leeufontein
Mabopane
Majaneng
Makanyaneng
Mamelodi
Mandela Village
Marokolong
Mashemong
Mooiplaas
Nellmapius
New Eersterus
Olievenhoutbos
Onverwacht
Pebble Rock Golf Village
Pretoria
Ramotse
Rayton
Refilwe
Rethabiseng
Rietfontein
Roodeplaat
Roodepoort
Sable Hills Waterfront Estate
Saulsville
Soshanguve
Soutpan
Stinkwater
Suurman
Temba
Thembisile
Tierpoort
Tsebe
Tshwane NU
Tweedracht
Vaalbank
Vastfontein
Wageenbietjieskop
Wallmannsthal
Waterval
Winterveld
Zithobeni

Zwavelpoort