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Mapping and examining the spatial dimensions of opportunity in Ekurhuleni metropolitan area: exploratory spatial analysis

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Mapping and examining the spatial dimensions of opportunity in Ekurhuleni metropolitan area: Exploratory spatial analysis



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A research report submitted to the School of Geography, Archaeology and Environmental Studies at the University of Witwatersrand, for the fulfilment of Masters of Science in Geographic Information System and Remote Sensing.

OCTOBER. 2020

DECLARATION

I Prudence Machebele declare that this report is my unaided work. The work was submitted to the School of Geography, Archaeology and Environmental studies for the fulfilment of the Master of Science in Geographic Information System and Remote Sensing. And has not been submitted anywhere for examination.



2.October.2020

Prudence Machebele

Date

DEDICATION

I dedicate this work to my lovely mom and my two siblings.

ACKNOWLEDGMENTS

First, and most importantly, I would like to thank my Lord and saviour Jesus Christ for the strength and grace to be a master of science candidate. Through His eternal love, I managed to face each day with a positive mind believing that I am capable of completing this research project. Some the days I felt like giving up, but He renewed my strength to press on. At the beginning of this research journey, I took for granted that I could work the whole night, until the point where I almost broke down. Especially at times when nothing seemed to be working out despite the hard work and effort, I was putting. I also appreciate my supervisor, Dr. Gina Weir-smith for the support and guidance that she gave me throughout this journey. Last but not least, I would like to say '*nakhensa swinene*' to my family and my loved ones particularly my lovely mom for supporting and believing in me.

ABSTRACT

The South African spatial pattern opportunity continues to be marked by segregation and fragmentation even after apartheid. The apartheid regime has created a country that is spatially, economically, and socially uneven. Some areas are well-developed while others are marginalised and under-privileged. Regardless of the country's interventions through development programmes and the provision of free services, the country's metropolitan areas remain fragmented. Ekurhuleni is one of the metropolitan areas that resemble this fragmentation.

This research study sought to examine the spatial distribution of opportunity in the Ekurhuleni Metropolitan area using exploratory spatial analysis. The data for the analysis were acquired from the Census of 2011 conducted by Statistics South Africa, Pick & Pay, Spar, and the Department of Health. A total of nine opportunity indicators were used to calculate three opportunity dimension scores. The dimension scores were then used to calculate the overall opportunity indices for thirty-three main places.

The findings demonstrated the spatial disparity in the distribution of opportunity across the Ekurhuleni Metropolitan area. Most of the main places that are known to be towns have good opportunities, while poor opportunities are predominantly in townships. Some of the townships were also classified as high opportunity areas, however, it does not look aesthetically pleasing. There are areas with a high number of people and good opportunity, while others had a high number of people and poor opportunity. This brought an understanding that the total number of people does not have a clear relationship with the opportunity score. The study concludes that there is an uneven distribution of opportunity in the metropolitan area and good opportunities are clustered in developed towns, while townships tend to have poor opportunities.

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ACRONYMS

CBD	Central Business District
CoE	City of Ekurhuleni
EMA	Ekurhuleni Metropolitan Area
ESDA	Exploratory Spatial Data Analysis
GIS	Geographic Information System
GCRO	Gauteng City Region Organisation
StatsSA	Statistics South Africa

Chapter 1: Introduction and Background

1.1 General Introduction

The disconnection between communities in the metropolitan area has been dealt with by the studies of the geography of opportunity (Powell *et al.,* 2007). The spatial dimension of opportunity also known as the 'geography of opportunity' refers to the spatial dimension of opportunity at a metropolitan level. It explains that the social and spatial outcomes of a neighbourhood are shaped by the interactions between the institutional system and people's choices (Wilson and Greenlee, 2016). Opportunity is not a synonym of jobs; however, it includes dimensions such as jobs and local economy, education, community health and civic life that enables monitoring of the neighbourhoods (Wilson and Greenlee, 2016). The local economy includes indicators such as unemployment rate, poverty rate, level of income, and access to the internet while education includes the level of educational attainment and dropout rates. Health and civic life include access to health services and people's involvement in social activities (Wilson and Greenlee, 2016).

The spatial distribution of opportunity in different countries like South Africa, United States regions has proven to be racialized and has created the notion of two cities in one. The two cities show a distinction between areas where whites and blacks stay (Reece *et al.,* 2009; Powell *et al.,* 2007; Howell-Moroney; 2005). Most of the affluent places were predominantly white, while black people tend to stay in vulnerable parts of these countries (Powell *et al.,* 2007). The privileged communities have advanced job opportunities, schools with well- developed education systems and grocery stores that sell healthy goods. Poor communities are characterised by factors that include high crime levels, marginalisation, poor resources, unemployment and the concentration of poverty.

According to Mahajan (2014), South Africa is currently known for uneven development and spatial gaps, which have also influenced the spatial distribution of opportunities in the entire country. Some of the country's regions are developed while others are lagging (Peberdy *et al.,* 2017). Development programmes have been adopted by both local and provincial governments to combat the spatial imbalances (Venter, 2016) however, the country remains spatially uneven.

The townships within the country accommodate most of the country's population, and these townships are at the peripheral locations where there are limited and poor initiatives (Peberdy *et al.,* 2017). People in these areas mainly depend on informal employment which negatively affects the growth of their local economies (Peberdy *et al.,* 2017). This research set out to examine the geography of opportunity in the main places of the Ekurhuleni Metropolitan area and reveal how it impacts people's livelihoods.

The study used opportunity indices to conduct the analysis. The indices were created based on census data, Department of Health and retail stores data. According to Opportunity Nation (2017), the Opportunity Index is an annual composite measure of economic, educational and civic factors at the state and county levels. The Opportunity index measures the access that people have to opportunity in their neighbourhoods across the metropolitan area. It is measured using three dimensions namely, Jobs and local economy, Education, Community health, and civic life as indicated by the study of Wilson and Greenlee (2016).

1.2 Background of the study

The geography of opportunity embraces a wide range of themes that include, but are not limited to spatial mismatch, uneven development, neighbourhood segregation and spatial inequalities. These themes explain a particular dimension of opportunity. Due to uneven urban structures, most of the themes consider the uneven distribution of opportunity in metropolitan areas of both international and local contexts.

This research report presents the findings of the spatial distribution of opportunities in the Ekurhuleni metropolitan area. The emphasis is on determining the clusters of both low and high opportunity and to understand the distribution of spatial opportunity of the metropolitan area. The author of this research study contends that there is an uneven distribution of opportunity in the metropolitan area. Well-advanced opportunities are located in white-dominated areas, while black people are predominant in poor opportunity areas. Therefore, as a result, there is a noticeable distinction between the livelihood outcomes of people in both geographic locations.

To improve the uneven distribution of opportunity, interventions such as place-based developments should be adopted to target the development of each neighbourhood.

1.3 Problem statement

The spatial arrangement of the opportunities is significantly interlinked to the economic structure and the livelihoods of people within the area. The arrangement also indicates the spatial patterns of how the opportunities are located in the neighbourhoods (Picard and Zenou, 2018). Ekurhuleni metropolitan area is characterized by spatial disparities and unevenly developed places (Todes *et al.,* 2010). These places display spatial gaps through the location of advanced amenities within the economic nodes while surrounded by overpopulated townships at the outskirts (Todes *et al.,* 2010).

Ekurhuleni Metro is one of the three metropolitan areas located in Gauteng. The province is one of the richest and densely populated in the province with about 3.2 million population and 896 117 households (Marutlulle, 2017). The Ekurhuleni Metropolitan area has a very diverse economy and accounts for almost a quarter of Gauteng's economy (Marutlulle, 2017). The metropolitan area is traditionally known as a manufacturing heartland and accommodates most of the country's factories of production (Cross *et al*,2005; Todes *et al.,* 2010; Marutlulle, 2017). The industrial sectors provide jobs for both skilled and semi-skilled workers (Cross *et al*,2005). The municipality is also home to the OR Tambo International Airport, which is a transport hub that services both international and local travellers (City of Ekurhuleni, 2019; Marutlulle, 2017). Other developments (such as retail development, public sector investment) are also emerging and growing the economy and attracting people into the metropolitan area (Rogerson, 2018; Todes *et al.,* 2010).

The metro has the fastest growing population in the country with most of the households spending their income in rental housing (Stats, 2011). The influx of people is causing a high constant demand for housing because most of the households do not have formal shelters Marutlulle, 2017). According to Marutlulle (2017), Cross *et al* (2005) and Mushongera (2018) high

influx of people into the metropolitan area has resulted in a concentration of informal settlements and induced poverty – making this metropolitan area suitable for the study.

Theoretical work has been done to analyse the geography of opportunity at the international, no official research has been done in South Africa, nor Ekurhuleni, about geography of opportunity. Some studies have been done dimensions other than all aspects that determine the geography of opportunity. For instance, there is much work done on issues such as poverty, informality, and unemployment (Peberdy *et al.,* 2017; Marutlulle, 2017; Cross *et al*,2005 and Mushongera, 2018).Some tackled the spatial mismatch and neighbourhood segregation (Naudé, 2008; Turok *et al.,* 2017). However, there has been a minimal focus by scholars on the spatial distribution of opportunity in South Africa. This research adds to the existing body of knowledge by focusing on the spatial dimension of opportunity in the metropolitan area. It focuses on the collective dimensions that explain the geography of opportunity in the metro.

1.4 Aim

The main purpose of the study was to assess the spatial distribution of opportunities by identifying clusters of high and low opportunity in the Ekurhuleni metropolitan area.

1.5 Objectives

The research focussed on the following objectives:

- To create an opportunity index using the three opportunity dimensions which are, jobs and local economy, education, community health, and civic life;
- To map the results from the opportunity index;
- To identify the spatial patterns of opportunity using exploratory spatial analysis tools.

1.6 Contribution to knowledge

The theory of the geography of opportunity has been of interest to international authors. have tackled various factors of the geography of opportunity using exploratory analyses. However, none of the studies were done to understand the spatial dimension of opportunity and more so in a local context like the Ekurhuleni metropolitan area. Therefore, this research report will be

the first to present knowledge about the clustering of opportunities within the metropolitan. This study will inform officials about the sense of where to target for development purposes. It will also give direction to future researchers to expand beyond understanding the spatial dimension of opportunities in metropolitan areas to a broader context.

1.7 Overview of the Report

The first chapter of the research report presents the background and outlines the scene of the study. The background leads to the introductory chapter that summarises the purpose of the study. The second chapter presents the literature that supports the research topic. This literature review touches on some of the conflicts, consensus, including the gaps that give a clear understanding of the study focus. Chapter three of the research report presents the contextual setting of the study area and why it is suitable for this research. The chapter outlines the methodological approaches of how the data has been acquired and analysed. The data acquisition approach includes requesting data from various institutions and departments, while data analyses include approaches such as creating the opportunity index and examining the spatial patterns of opportunity. Chapter four presents the results found after performing the analysis. This findings chapter, together with the literature review builds the arguments presented in chapter five. The arguments in chapter five also enable the achievement of the research's aim and objectives. The last chapter is the concluding remarks and recommendations. This chapter reflects on every chapter of the research to draw an informed conclusion.

CHAPTER 2: DRAWING FROM THE LITERATURE

2.1 Introduction

There has been empirical work done to explain the spatial dimension of opportunity in underdeveloped metropolitan regions (Lens, 2017; Powell *et al.,* 2007; Hellerstein *et al.,* 2008; Picard and Zenou, 2018; Howell-Moroney, 2005). Although the literature on this topic includes different theories, this report will only be based on the major themes which emerged repeatedly in the literature. The three major themes include the dynamics of the geography of opportunity, livelihoods perspective, and the exploratory spatial data analysis. The geography of opportunity literature will draw on mechanisms such as spatial mismatch and neighbourhood segregation. Exploratory spatial data analysis will focus on the rationale and methodological aspects. Most of the literature presents the international contexts of these themes and few are based on South African contexts. The specific literature that relates to the study include; Wilson and Greenlee (2016), Howell-Moroney (2005), Naudé (2008), and Powell *et al* (2007). This literature presents an understanding of the geography of opportunity in both international and South African contexts.

2.2 Dynamics of the geography of opportunity

The geography of opportunity is a phrase that refers to the "spatial dimensions of opportunity at the metropolitan level" (Wilson and Greenlee, 2016; 626). It explains that the structural aspects of the neighbourhood and people's preferences influence the social, economic, and spatial prospects (Brain and Prieto, 2018; Galster and Killen, 1995; Wilson and Greenlee, 2016). It has been referred to as communities of opportunity by Powell *et al* (2007), where it implies that the area where people are located within the metropolitan area determines their access to opportunity. In support of Powell's argument, Picard and Zenou (2018) argue that the metropolitan region that is developed should improve access to opportunity and livelihood of all the residents, while the underdeveloped one is characterised by unequal distribution of opportunity.

The notion of developed and underdeveloped areas in one metropolitan area is predominant in most countries. In these instances, advanced opportunity is clustered in the white-dominated areas while, poor living environments characterises the areas dominated by black people (Howell-Moroney, 2005; Powell *et al*, 2007; Hellerstein *et al*, 2008; Picard and Zenou, 2018). This is the case for most South African metropolitan areas not only Ekurhuleni where white people are predominant in well-developed areas while black people stay in marginalised townships (Todes *et al.,* 2010; Naudé, 2008).

2.2.1 The hypothesis of spatial mismatch theory

The uneven spatial distribution of opportunity has been discussed in a variety of literature with theories such as spatial mismatch and residential segregation (Naudé, 2008; Howell-Moroney, 2005; Gobillon *et al.,* 2007). The spatial mismatch refers to the physical separation between job opportunities and residential areas. It can be explained by three spatial restrictions namely: space, race, and job information (Howell-Moroney, 2005; Naudé, 2008). Space restriction theory explains that long commuting times restrict access to a job opportunity. Turok *et al.,* 2017 and Gobillon *et al* (2007) argue that outcomes for residents that are spatially disconnected from the job opportunities are associated with the poor labour market.

The housing market is another factor that causes space restriction (Hellerstein *et al.,* 2008; Picard and Zenou, 2018; Squires and Kubrin, 2005). The job opportunities in most metropolitan areas have been decentralised to suburban areas where most of the white people have also moved to, hence the increase in housing prices (Howell-Moroney, 2005). Housing markets are determined by land prices, and it has been observed that in areas with high land prices there are good opportunities, while low land price areas are characterised by poor opportunity (Brain and Prieto, 2018). They also argue that low-income housing is in underprivileged areas while expensive housing markets are in economically advanced areas. In the South African context (particularly in Gauteng), the apartheid legacies have resulted in poor housing and informal settlements

located at the peripheral edges where black people stay (Peberdy *et al.,* 2017). Although the post-apartheid government has adopted policies to redress these challenges; however, the housing services that are provided indicate marginality and peripherality (Peberdy *et al.,* 2017). For instance, the RDP (breaking new ground) housing developments are targeted at the peripheral areas away from the major economic developments.

The race restriction explains that jobs provided at proximity to some of the residential areas cater for white people rather than black people (Howell-Moroney, 2005; Gobillon *et al.,* 2007. In support of their arguments, Hellerstein *et al.,* (2008) contend that spatial mismatch is not always the space restriction (absence of jobs in areas where black people are located), but the lack of jobs in which black people could be hired (labour market). One could agree with the authors' arguments about space and race restriction particularly regarding South Africa because the job opportunities are available in proximity to black townships, however, black people do not have sufficient skills to participate in those job opportunities. Therefore, they are forced to commute long distances for jobs requiring low skills.

According to Naudé (2008), the friction of distance is another cause of racial mismatch and is experienced differently by both black and white groups. The friction of distance, according to Naudé (2008) refers to the challenges associated with the distance between job opportunities and residential areas. This implies that there are different experiences between blacks and whites concerning commuting costs or access to transport. These factors have noticeable implications on employment status and the level of income for black people (Naudé, 2008). One could agree with Naudé; for example, some black people spend considerably more time in public transport to access their workplaces. Moreover, they also spend most of their limited salaries on public transport. Therefore, one could also argue that spatial mismatch resembles the racial mismatch in the context of South Africa.

Job information restriction theory explains that black people have limited information about the informal way of job applications (Howell-Moroney, 2005; Gobillon *et al.,* 2007). According to Gobillon *et al.* (2007), the diversity of the network that a person has can also determine the job

information they will have. In a sense that a person that moves beyond their immediate circle, share strong networks, and non-redundant job information. This is also applicable in the South African context because Gobillon *et al.* (2007) indicate that unemployment is induced by inappropriate means of searching for a job opportunity. Moreover, most black people live in segregated locations where they tend to acquire information only from the people that they socialise with daily (Peberdy *et al.,* 2017).

The outcome of the spatial mismatch differs from geographical contexts. In the case of the US counties, the inner cities are characterised by unemployment and poor opportunity and are mostly occupied by black people (Glaeser *et al.,* 2004; Hellerstein *et al.,* 2008; Gobillon *et al.,* 2007). In the South African context, black people are mainly located in the peripheral townships away from the city centres. However, this trend is changing because inner cities are becoming more occupied by black people (Peberdy *et al.,* 2017). The spatial mismatch arguments relate to the case of the Ekurhuleni Metropolitan area, Todes *et al* (2010), outline that as a result of apartheid legacy, black people remain located in the peripheral townships that are characterized by high unemployment rates. Areas where they have to commute long hours to access opportunities within the metropolitan area (Naudé, 2008). Thus, it indicates that there is an uneven distribution of opportunity in the metropolitan area to a certain extent that will be substantiated by this study.

2.2.2 Neighbourhood segregation

The neighbourhood segregation includes the separation of individuals from livelihood opportunities based on race, class, and income (Lens, 2017; Venter *et al.,* 2007). It is also referred to as the segmentation that creates neighbourhood disparities and has an impact on people's welfare, such as level of education and poverty (Howell-Moroney, 2005). This happens because the metropolitan's economy is concentrated in specific geographic areas which results in a high level of unemployment in marginalised communities (Turok *et al.,* 2017). Marginalised neighbourhoods also have a poor economic structure and labour market which restricts access to employment opportunities (Powell *et al.,* 2007; Howell-Moroney, 2005). In support of the

argument, Márquez et al, (2019) indicate that the geographic location of the neighbourhood has an impact on its economic structure. In these communities, grocery stores sell poor quality goods at a higher price (Powell *et al.,* 2007). Residents in the segregated neighbourhoods stay without work for a longer period because of the lack of job opportunities in their communities and inadequate information about job opportunities. One could argue with the statement because most residents of similar employment status are likely to stay together, and they only interact with unemployed individuals within their segregated neighbourhoods (Picard and Zenou, 2018). However, if they were integrated, it would enable the sharing of information through different platforms. One could contend that segregation makes unemployment pervasive in some of the townships because the interaction is limited to the neighbourhood.

According to Lens (2017), neighbourhoods are not just segregated by race, class, and income, but they also have an impact on an individuals' livelihood outcome. Howell-Moroney (2005) and Powell *et al* (2007) also gave an instance where educational outcomes of students in segregated communities are poor (with more drop-outs) compared to those that are in integrated neighbourhoods. Hellerstein *et al* (2008) did their study in cities like Chicago in the United States, which outlined the distinctive difference between the educational level of the blacks and the whites. It was found in their study that the segregation the black communities is the main influence of the differences in education levels. Their argument is also applicable to the context of the South African neighbourhoods where Naudé (2008), Howell-Moroney (2005) and Venter et al (2007) indicate that the level of educational attainment of people in poor black neighbourhoods, is lower compared to those in well-advanced communities.

These poor communities are also associated with high dropout rates as compared to white communities. The condition of segregated neighbourhoods also has a major influence on the concentration of poverty, and the quality of institutions such as schools and hospitals (neighbourhood effects) (Turok *et al.,* 2017; Powell *et al.,* 2007). In these neighbourhoods, the institutions are under-resourced and inadequate to meet people's needs (Powell *et al.,* 2007;

Howell-Moroney, 2005). Neighbourhoods that are well-developed enhance the livelihoods of the residents while poor neighbourhoods do not (Turok *et al.,* 2017).

The mismatch of space and residential segregation are closely related (Hellerstein *et al.,* 2008). This is because spatial mismatch could be a result of residential segregation. One could agree with the argument because the more people are segregated spatially, the more they are separated from opportunities such as employment. In the case of the Ekurhuleni Metropolitan, Todes *et al* (2010) indicate how peripheral townships are characterised by high unemployment because they are disconnected from the economic centres.

2.3 Livelihoods perspective

The geography of opportunity has also been used to understand the difference between the livelihoods of residents in poor and well-advanced neighbourhoods (Howell-Moroney, 2005; Powell *et al.,* 2007). The concept of livelihood explains the way people live in their neighbourhoods which is determined by the assets that enable one's everyday living (Rakodi, 2002). Before modernisation, the literature about livelihood perspective was centered on rural development in which factors such as, wage employment, farm labour, and agriculture were used to understand the collective livelihoods of the entire community (Scoones, 2009). However, the rise of the modernisation era has shifted the focus to the understanding of livelihoods in the urban context (Scoones, 2009; Rakodi, 2002).

For this study, understanding urban livelihoods' perspective would be relevant, because it has direct relations with the spatial location of opportunity. Livelihood refers to all the assets essential for the means of survival (Rakodi, 2002), These are assets grouped into five categories based on their functions for an individual's living standard. The five categories include physical capital, social and political capital, human capital, natural capital, and financial capital. According to Rakodi (2002), political and social capital are social resources that promote social inclusion and a sense of belonging. These resources include community meetings, membership groups, and

other institutions. Social and political resources create a platform for residents to share information and raise issues that affect their livelihoods. Human capital refers to the labour resources that enable one to be competent for job opportunities. Labour resources include educational and non-educational skills. These livelihood assets allow all individuals to generate income based on the skills they have. For instance, one could generate income from their businesses while others could rely on a professional job to generate income. Natural capital is an all-natural resource that people can utilise to produce goods and services. Some businesses use primary goods such as trees to produces secondary goods like furniture. The financial capital refers to savings or pensions. These resources enable the exchange for goods and services. Lastly, physical resources include infrastructures including houses and transport. The basic infrastructures ensure safety and security (Rakodi, 2002).

Studies have been done to understand the impact of livelihood resources. Chen *et al* (2016) gave an instance of the financial capital (particularly addressing the informal employment). In their study, they argue that in most developing countries, people generate their income through informal employment such as street vendors and road-side shops, etc. As a result, people's livelihoods are affected because informal employment is exposed to various threats. For instance, some government laws and regulations limit the growth of informal employment by regulating where these informal sectors should locate. Hovsha and Meyer (2015) also give a similar scenario for the South African context. In their research, they argue that due to a lack of educational qualifications and skills, informal employment has a huge impact on the livelihoods of South Africans. Although there are municipal by-laws that regulate informal employment, in practice, it is not prioritised as compared to formal employment which makes informal employment less profitable to benefit business owners.

In another study Skinner (2000) explains the impact of physical assets on people's livelihoods. He gives instances of energy infrastructures. In the study, he argues that energy is a physical capital that is used for purposes like lighting and cooking. Both low (mainly blacks) and middle/high (mainly white) income groups have different sources of energy. Low-income groups depend on fuels such as paraffin and coal as the main source of energy which exposes their lives to fire hazards (Skinner, 2000). According to GCRO (2017/2018), several households in Ekurhuleni

metropolitan townships still depend on energy sources such as woods, candles, and paraffin. This indicates that poverty is a social issue within the metropolitan area.

Transportation is another physical asset. Sohail (2000) indicate that low-income people mainly use public transport for their mobility. Most of these public transports are inadequate and not reliable. However, due to high commuting costs, they are forced to settle for these types of transport. For instance, some of the low-income groups in South Africa use Metrorail trains and other public transport to commute for about 20 km, this forces them to spend most of their time away from their families. With regard to this argument, it is clear that public transport has a negative effect on the livelihood of people. The GCRO (2017/2018) also indicates that numerous households in the Ekurhuleni metropolitan area use public transport to commute to their workplaces. Most of these households travel long distances in their everyday lives (Naudé, 2008). Thus also indicating there is a relation between the location of opportunity and people's livelihoods.

2.4 Application of exploratory spatial data analysis

2.4.1 Rationale

The exploratory spatial data analysis (ESDA) is a research method that is considered as flexible and not limited to a specific formal structure (Davies, 2011). It uses tools to visualize, display, and to determine patterns of clusters and spatial regimes (Dall'erba, 2003; Celebioglu and Dall'erba, 2009). These tools are mainly applicable to small regions and take into consideration the existence of both spatial heterogeneity and spatial autocorrelation (Rusche, 2008). Spatial autocorrelation is taken from Tobler's first law which explains the relations of the things that are close to each other than those that are at a distance. For instance, the regions that are close to each other might have the clustering of activities with similar functions. The spatial heterogeneity is the opposite of the spatial autocorrelation which explains that effects in the same area could have a different extent of impact (Rusche, 2008). The ESDA can analyse the above-mentioned two spatial effects, and incorporate them into different contexts to achieve the following

objectives: describing spatial distributions, assessing the spatial patterns, predicting the spatial regimes, and identifying possible observations such as outliers (Rusche, 2008).

Most international studies have dealt with the use of exploratory spatial analysis for different purposes (Wang *et al.,* 2016; Anselin *et al.,* 2006; Duque *et al.,* 2013). For example, in countries like China, the exploratory spatial analysis has been used as a tool to describe spatial inequalities and redistribution of services (Duque *et al.,* 2013; Wang *et al.,* 2016). The analysis process involved analysing factors such as unemployment rate and regional economic growth (Duque *et al.,* 2013; Wang *et al.,* 2016). In the state of Virginia, the exploratory spatial analysis was used to analyse social indicators such as the spatial clusters of high child risk scale (Anselin *et al.,* 2006). However, in this research study, the exploratory spatial analysis will be used to identify clusters of high and low opportunities in the Ekurhuleni Metropolitan area.

2.4.2 Methodological approaches to ESDA

Descriptive statistics

Descriptive statistics is the principal component of the exploratory study that provides summaries of the raw data, and also shows relationships between the variables (Kaushik and Mathur, 2014; Sharma, 2019). This analytical method can be presented numerically or graphically (Kaushik and Mathur, 2014). The descriptive statistics can also be utilised to detect outliers and normality of the distribution.

Neighbours and spatial weights

Spatial neighbours and weights determine the spatial relations between the spatial units (Chen, 2012; Cheng *et al.,* 2014; Shen, 1994). Spatial analysis is based on the assumption that close phenomena are more similar than those that are farther apart (Foster and Evans, 2008). Therefore, it is crucial to define neighbours and spatial weights before checking the presence of spatial patterns. There are different types of spatial weights, but for this study, only Distance-based weight will be used. Distance-based weight is the spatial weight that could be measured using the distance between two spatial neighbours. It is also called Euclidean distance. It can also

be measured using the distance between the centroids of polygons which is also called Great circle distance (Waller and Gotway, 2004; Bivand *et al.,* 2008).

Choropleth mapping

The Choropleth map is one of the ESDA tools which are used to display the spatial attributes (Leonowicz, 2006). It enables one to compare the differences between the neighbourhoods and analysing spatial distributions (Celebioglu and Dall'erba, 2009).

Spatial autocorrelation

The spatial autocorrelation measures the degree to which observations at nearby spatial locations are similar or dissimilar (Chi and Zhu, 2008). It includes techniques such as global and local spatial autocorrelation. The global spatial autocorrelation (known as Moran's statistic) provides the linear relationship between the spatial units. The local l autocorrelation (local Moran) can be used to identify the spatial observations that might indicate homogeneity (Sridharan *et al.,* 2007; Wang *et al.,* 2016; Arun, 2013; Foster and Evans, 2008). Spatial autocorrelation analysis is a crucial step to consider before any analysis of the spatial phenomena. The ESDA can also be used to measure the spillover effects across the area that one is analysing. Therefore, for this research, only the local spatial autocorrelation (Local Moran) will be used because the study site is on a local scale.

2.5 Conclusion

This chapter presented the literature using three themes, namely the dynamics of the geography of opportunity, livelihood, and application of the exploratory spatial data analysis. The chapter has also presented gaps, agreements, and conflicts in the literature. The dynamics of the geography of opportunity theme was based on theories such as spatial mismatch and neighbourhood segregation. Spatial mismatch theory indicated how the distance between job opportunities and place of residence differs between poor and well-advanced neighbourhoods and how it affects people's livelihoods. The neighbourhood segregation outlined how segregated communities tend to have a poor opportunity outcome as compared to integrated communities.

The livelihood theme presented all the factors that determine people's livelihoods, and how they are affected by the spatial location of opportunity. Lastly, the exploratory data analysis theme outlined the rationale and the methodological approaches of carrying out an exploratory spatial analysis.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The methodology section outlines the procedure of how the data was acquired, pre-processed, and analysed. This research study is exploratory, which is considered as an approach of investigating, identifying and manipulating spatial data (Sridharan *et al.,* 2007; Lincaru *et al.,* 2016; Jung and Vijverberg, 2019), it is flexible and not limited to a specific formal procedure (Davies, 2011).

3.2 Background of the Study site

The study is based in the Ekurhuleni Metropolitan area, one of the three metropolitan municipalities in Gauteng. It was officially constituted to be a standalone metropolitan municipality in 2001 after being part of the Johannesburg metropolitan before (Naudé, 2008). The metropolitan covers an area of about 1901.47 km^2 (Todes *et al.,* 2010). It is comprised of nine towns. Spatially, the area is highly fragmented, consisting of developed suburbs and lagging

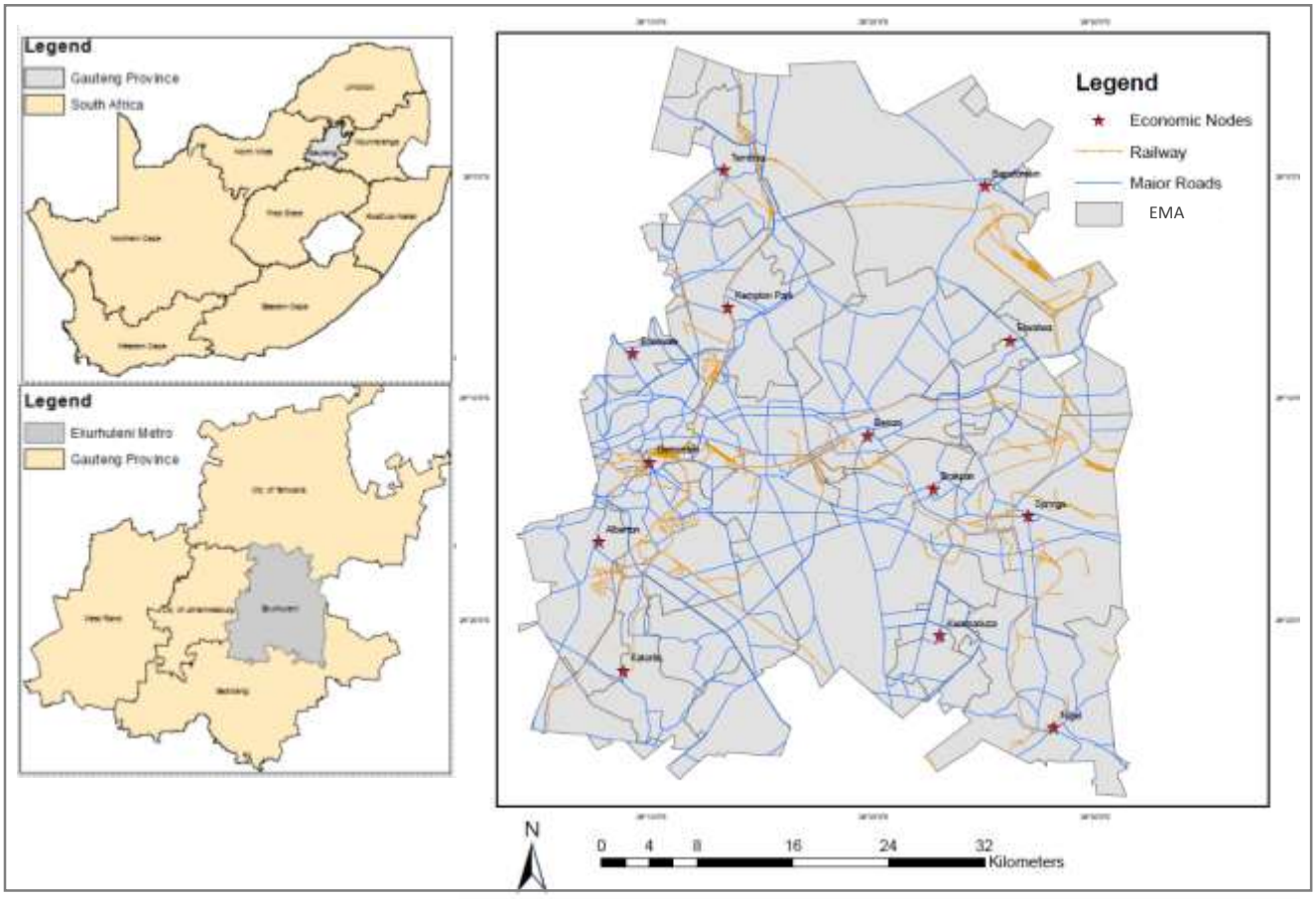


Figure 1:Map showing the location of Ekurhuleni Metropolitan area (Author, 2020)

townships (Todes *et al.,* 2010). To give a general overview of the metropolitan's social-economic dynamics, according to the StatsSA (2011), Ekurhuleni's total population is about 3.718 million of which black people are the dominant population group (see Appendix A). Seventy-one percent of the metropolitan's population is in the age group between 15 to 64 years. About 49.4 % of the population is employed while 19.9% is unemployed, and amongst those that are employed the average income is R29 400 per annum (StatsSA, 2011).

The Metropolitan's economy is dependent mainly on the manufacturing sector which is also the sector that produces employment for most residents. However, due to the decline of the mining sector and restructuring of industries, it has shaken the economy of the metropolitan area. This has been a great knock for Ekurhuleni and has resulted in challenges such as the loss of jobs (Todes *et al.,* 2010). However, developments (such as retail development, public sector investment, and aerotropolis) have been emerging to re-attract investments and bring income into the metropolitan area (Rogerson, 2018; Todes *et al.,* 2010). The economic fluctuations and spatial variations of development within the metropolitan area make the study site suitable for this research study.

3.3 Data Acquisition

The data used was collected based on the three analytical dimensions namely, Jobs and local economy, Education, Community health and civic life as indicated by the study of Wilson and Greenlee (2016). The study followed the model of Wilson and Greenlee (2016) where the three dimensions are used for measuring the opportunity index. Measuring these dimensions is important even in the context of South Africa because they are key determinants of a neighbourhood's outcome. For instance, measuring the economic standards of the neighbourhood could enable officials to make informed decisions with regards to strengthening the economy or developing the area.

The main places have been used as the unit of study. The main place is level five in the geographical area hierarchy structure of StatsSA. It is above the sub-place and two levels below the metropolitan area (Frith,2011). All the data were obtained at the main place level, therefore there was no need to aggregate it. The main places that form part of Ekurhuleni metropolitan

area are as follows; Alberton, Bapsfontein, Benoni, Boksburg, Brakpan, Breswol, Centurion, Chief A Luthuli Park, Clayville, Daveyton, Duduza, Dukathole, Edenvale, Ekurhuleni NU, Etwatwa, Geluksdal, Germiston, Harry Gwala, Kanana, Katlehong, Kempton Park, Kwa-Thema, Langaville, Lindelani Village, Nigel, Springs, Tembisa, Thinasonke, Thokoza, Tsakane, Tweefontein, Vosloorus, and Wattville.

Data for the local economy and education dimensions were acquired from the Census 2011 of Statistics South Africa. The community health and civic life data were acquired from the Department of Health (2011), Pick n Pay (2015) and Spar (2015). There was no available data close to the year the census data was collected, therefore we had to use data that was available. The indicators for Jobs and local economy dimension include the unemployment rate, household median income and poverty rate. The unemployment rate refers to the percentage of people that are not employed. This indicator helps to understand the level of unemployment. The median income is the income that is in the middle of the overall income distribution, while the poverty rate is the percentage of people with the income that is below the poverty line. This dimension shows the economic and job standard of the neighbourhood (Wilson and Greenlee, 2016). The education dimension includes indicators like pre-school enrolment, dropout rates, and post-secondary education attainment.

The pre-school enrolment is all the children between 3 to 4 years-old that are enrolled at school. The dropout rate refers to the number of residents between the ages of 16 and 19 who are neither enrolled in school nor high school graduates, divided by the number of individuals aged 16 to 19. The pre-school enrolment indicates the number of children that attending pre-school education while the dropout rate indicates the percentage of residents that have dropped out from school. Post-secondary education attainment is the percentage of people with post-secondary education qualifications (Wilson and Greenlee, 2016). The education indicators indicate the level of education of a particular area. Health institutions, grocery stores, and youth inclusion are indicators of the community health and civic life dimension. Health institutions are the number of clinics per 100,000 people, while grocery stores include all the grocery stores per

10,000 people. Youth economic and academic inclusion refers to the residents between the ages of 16 and 19 who are enrolled in the educational institution and also not working (Wilson and Greenlee, 2016). These are indicators that promote a sense of belonging and provide networking platforms amongst the members of the neighbourhood (Rakodi, 2002; King, 2011). Table 1, shows the summary of datasets used and their sources.

Table 1:datasets and their sources

Data	source	Type
Jobs and local economy		
Unemployment rate (%)	Census 2011 of the Statistics South Africa	Area attribute data
Median income(R)	Census 2011 of the Statistics South Africa	Area attribute data
Poverty rate (%)	Census 2011 of the Statistics South Africa	Area attribute data
Education		
Preschool enrolment (%)	Census 2011 of the Statistics South Africa	Area attribute data
High school dropout rate (%)	Census 2011 of the Statistics South Africa	Area attribute data
Post-secondary educational attainment (%)	Census 2011 of the Statistics South Africa	Area attribute data
Community health and civic life		
Youth economic and academic inclusion (%)	Census 2011 of the Statistics South Africa	Area attribute data
Health institutions per 100000 population	Department of Health,2011	Point attribute data
Grocery stores/Retails per 10000 population	Pick n Pay,2015 and Spar,2015	Point attribute data

3.4 Data analysis

Microsoft Excel was used to calculate the dimensions, and indices, while two software programmes, namely ArcMap 10.5.1 and R-studio 8.10, were interchangeably used to analyse the data.

3.4.1 Data pre-processing

3.4.1.1 StatsSA attribute data

The StatsSA data was provided in a spreadsheet format with different indicators. The data was cleaned by removing all variables/indicators not relevant to this project. The database was subsequently joined with the administrative boundary shapefile of Ekurhuleni's main places for analysis.

3.4.1.2 Point attribute data

Data for the health facilities and grocery stores were acquired in shapefiles format (particularly points). For analysis, new fields were created with facilities per main place to calculate it based on the population it serves. i.e. health facilities per 100,000 residents and retail stores per 10,000 residents. The metadata for all the point data is included in Appendix B.

3.4.2 Descriptive statistics on the raw data

The statistical description is a principal component of the exploratory study that provides summaries of the raw data, and also shows relationships between the variables (Kaushik and Mathur, 2014; Sharma, 2019). This analytical method can be presented numerically or graphically (Kaushik and Mathur, 2014). The numeric representations have been used to illustrate the distribution, the central tendency, and the variation in the data.

3.4.3 Creation of the Opportunity Index

The opportunity index was created using the data collected for each dimension. The creation of the opportunity index helps achieve the first objective of this study. The method of calculating the opportunity index includes normalizing the indicators using the observed values of the indicator. The indicators were normalised by comparing the observed raw data with the minimum and maximum values as indicated by the following formula (Wilson and Greenlee, 2016).

Equation 1:

$$Value_{Normalized} = \frac{Value_{observed} - Value_{minimum}}{Value_{maximum} - Value_{minimum}}$$

The normalized indicators were averaged (by adding the rescaled values and divide by the total number of indicators for each main place) to create the scores for each dimension. Then the scores of all the dimensions were averaged (adding all the dimension scores and divide by the total number of dimensions for each main place) to calculate the opportunity index.

3.4.4 Choropleth Mapping

The Choropleth map is one of the ESDA tools which are used to visualise the spatial attributes (Leonowicz, 2006). The maps were used to show the spatial distribution of opportunities and population within the metropolitan area, and also illustrate the relationship between the opportunity and neighbourhoods. The second objective of the study is achieved in this section of the methodology.

3.4.5 The Neighbours and spatial weights matrix

Spatial analysis is based on the assumption that close phenomena are more similar than those that are farther apart (Foster and Evans, 2008). Therefore, it is crucial to investigate the presence of spatial patterns before data analysis. Spatial neighbours and weights determine the spatial relations between the spatial units (Chen, 2012; Cheng *et al.,* 2014; Shen,1994). Distance-based weight is appropriate since it determines the relations between spatial units based on a specified distance. Distance-based weights could be measured using the distance two spatial units, it is also called Euclidean distance. It can also be measured using the distance between the centroids of polygons which is also called Great circle distance (Waller and Gotway, 2004; Bivand *et al*., 2008). R studio was used to define the spatial neighbours and weights in which main places were used as the units of analysis.

3.4.6 Spatial autocorrelation

There are two spatial autocorrelation methods (Global and local Moran). However, for this research study, only the local Moran was used to examine the spatial relations between the main places and the opportunities. Local Moran was chosen because the study site is more local.

Local Moran's I

The local Moran is a local indicator of spatial autocorrelation which quantifies the degree of relations between smaller scales which may be overlooked by the Global measure (Moran's I) (Wilson and Greenlee, 2016; Anselin, 1996). It also identifies clusters of a high and low distributed residuals whereby negative values indicate spatial outliers, and the positive values indicate clusters (Tiefelsdorf, and Boots,1997; Wilson and Greenlee, 2016; Anselin, 1996). The local Moran was used to measure the spatial autocorrelation between the main places.

3.4.7 Hot spot and cold spot analysis

The hot spot analysis is an extension of the local Moran analysis, it measures the spatial significance of the areas such that the area forms part of clusters and outliers. Clusters of high values indicated by High-High and low values indicated by Low-Low. The outliers are indicated by High-Low and Low-High (Wilson and Greenlee,2016). The analysis was adopted to examine areas with high (hot) and low (cold) clusters of opportunity. This part of the spatial analysis (including spatial autocorrelation) help solve the third objective of this study.

3.5. Limitations

The first limitation of this research approach is that it is mainly dependent on census data which was last updated in 2011. Since 2011, changes have occurred spatially, socially, and economically within the metropolitan area. This could have impacted the results in the case where the measured variables may have changed. Another limitation is that census data, and other data that have been used have different collection years. For instance, some datasets were collected in 2015 (which is four years) after the StatsSA data was collected. If all the data was collected at the same time it would be easier to compare it. However, the data is relevant and useful for examining the geography of opportunity in the metropolitan area. Lastly, the limitation of the

methodology lies in the fact that exploratory analysis does not have a formal procedure of how the analysis should be structured; therefore, it is difficult to determine how far the analysis should be performed.

CHAPTER 4: RESULTS

4.1 Introduction

The use of different exploratory angles is essential for a clear understanding of the spatial dimension of opportunity in the Ekurhuleni metropolitan. The result first presents the statistical description of the indicators data that were used to create the opportunity index. The second section outlines the results of the analytical steps indicated in the methodology section. These analytical steps include the creation of the opportunity index, choropleth mapping of the opportunity index, detecting the spatial autocorrelation, hotspots, and cold spots. This section unravels the findings that answer the objectives of the research.

4.2 Descriptive statistics

Numerical and graphical representations of the data have been used. Table 2, shows the descriptive statistics for the jobs, and local economy dimension which comprises the median household income, poverty rate, and unemployment rate indicators. It is clear from the table that, there is less deviation from the mean for the poverty rate indicated by the low value of the standard deviation, while the high value of the unemployment rate and median household income's standard deviations show a notable variance from the mean. The difference between the minimum, maximum, and median indicate that the data for the unemployment rate indicator is skewed to the left. While the poverty rate and median household income indicator are skewed to the right.

The table also indicates that some of the main places have the unemployment rate of 2% and it goes up to 46% for some of the main places as indicated by minimum and maximum values. The poverty rate goes between 0 and 12% while the median income ranges from 3 to 16 957 for some of the main places. Main places with a high unemployment rate also have high poverty rates with several residents earning the median income.

Table 4:Descriptive Statistics for Jobs and local economy indicators

Jobs and local economy			
Descriptive Stats	**Unemployment rate**	**Median income**	**Poverty rate**
Mean	26.6	3320	3.7
Median	31	1868	3.4
Standard Deviation	12.01	4055	3.8
Minimum	2.4	3	0
Maximum	45.9	16957	11.8

Table 3, shows that as compared to jobs and local economic indicators, all indicators of the community health and civic life show less deviation from the mean as indicated by the low value of the standard deviations. The difference between the minimum, median, and maximum values for Youth inclusion and health institutions per population indicators show that they are heavily skewed to the right while the grocery store per population is slightly skewed to the right. The most popular observation for retail outlets and health institutions per population is 0 indicating a lack of grocery stores and health institutions in most of the main places.

Table 7:Descriptive Statistics for Community health and Civic life indicators

Community health and Civic life			
Descriptive Stats	**Health institutions per pop**	**Grocery stores per pop**	**Youth economic and academic inclusion**
Mean	4.9	0.18	10.9
Median	4.9	0	10.8
Standard Deviation	4.3	0.28	6.8
Minimum	0	0	0
Maximum	18.3	0.88	28.0

The standard deviations of all the Education indicators are low (see Table 4) showing less deviation of the data from the mean. The minimum, median, and maximum values indicate the right skewness in the data. The higher education attainment indicator has 0 as a popular

observation indicating the dominance of residents that do not have tertiary educational qualifications.

Table 10:Descriptive Statistics for Education indicators

EDUCATION			
Descriptive Stats	**Preschool enrolment (%)**	**Post-secondary educational attainment (%)**	**High school dropout rate (%)**
Mean	9.6	3.0	17.6
Median	8.0	1.1	16.2
Standard Deviation	7.3	4.5	10.5
Minimum	0	0	0
Maximum	29.5	15.6	41.4

4.3 Opportunity Index

The opportunity index scores show variation amongst the main places, some have high while others have low scores (see opportunity index Table 5). The scores range from 2 to 49. The two main places that have the lowest scores of below 20 are Tweefontein and Kanana. Tweefontein has zero scores for education and civic life dimensions which resulted in the lowest overall opportunity score. Unlike Tweefontein, Kanana has comparable scores for all the dimensions which also boosted the overall opportunity. The main places that have the highest opportunity score of above 46 are Germiston and Nigel. Germiston scored above 50 in both the local economy and civic life dimensions while Nigel scored above 50 in Civic life dimension only, which resulted in the highest opportunity scores. Generally, most of the main places with high opportunity are developed towns while a few are townships. Table 5 shows the numerical representation of the opportunity indexes and dimension scores.

Table 13:Opportunity Index

MP_NAME	Jobs and Local Economy	Community health and Civic life	Education	Opportunity Index	Total Population
Tweefontein	5	0	0	2	63
Kanana	22	14	19	18	2049
Thinasonke	21	18	23	21	2730
Centurion	0	22	42	21	11373
Chief A Luthuli Park	26	16	24	22	17715
Bapsfontein	13	0	58	24	708
Geluksdal	22	35	15	24	14487
Duduza	30	32	21	28	73311
Breswol	33	10	42	28	492
Lindelani Village	28	26	34	29	11934
Kwa-Thema	43	27	21	30	103725
Tsakane	46	29	18	31	136002
Clayville	11	58	25	31	14526
Langaville	53	22	20	32	54690
Tokoza	45	30	21	32	105792
Vosloorus	42	30	24	32	163224
Wattville	57	18	21	32	25665
Edenvale	6	45	46	32	49302
Ekurhuleni NU	38	25	35	33	19104
Harry Gwala	30	29	39	33	1848
Brakpan	32	36	32	33	73059
Etwatwa	55	24	21	33	151863
Alberton	15	40	46	34	121545
Daveyton	54	22	26	34	127959
Kempton Park	23	28	61	37	171579
Springs	48	36	34	39	121584
Katlehong	66	26	27	40	407247
Tembisa	71	20	29	40	463095
Benoni	36	38	47	40	158787
Boksburg	49	40	49	46	260301
Dukathole	65	42	31	46	18405
Nigel	32	76	33	47	38301
Germiston	54	35	57	49	255840

The dimension scores also show variations amongst the main places. Some main places scored higher in all the dimensions which resulted in a high score for the opportunity index. Other main places scored higher and lower in other dimensions which led to lower scores for the overall opportunity. The descriptive statistics were also presented to relate the dimensions and the opportunity as shown in Table 6. It is apparent from the table that Jobs and the local economy dimension scored higher on average with a score of 35.5 followed by education with a score of

31.5 while community health and civic life scored the least score of 28.8. Jobs and local economy also scored higher than the opportunity index on average. The standard deviations of the dimensions also follow a similar trend as that of the average scores. Jobs and local economy have the highest standard deviation with the opportunity index having the lowest.

Table 16:Descriptive statistics of the opportunity index

Dimension	Indicator	Min	Max	Mean	SD
Jobs and local economy	Unemployment rate (%)	2.4	45.9	26.6	12.0
	Median income(R)	3	16957	3320	4055
	Poverty rate (%)	0	11.8	3.7	3.8
Education	Preschool enrollment (%)	0	29.5	9.6	7.3
	High school dropout rate (%)	0	41.4	17.6	10.5
	Post-secondary educational attainment (%)	0	15.6	3.0	4.5
Community health and civic life	Youth economic and academic inclusion (%)	0	28.0	10.9	6.8
	Health institutions per 100000 population	0	18.3	4.9	4.3
	Grocery stores/Retails per 10000 population	0	0.88	0.18	0.28
Dimension scores	Jobs and local economy	0	71	35.5	18.6
	Education	0	60.9	31.5	13.8
	Community health and civic life	0	76.0	28.8	14.7
Opportunity	Opportunity Index	2	49	32	9

According to Wilson and Greenlee (2016), banking institutions and households spending on rental housing were also part of the jobs and local economy indicators. However, due to the scarcity of the data these indicators were not included. The rental expenditure data was only acquired at the metropolitan level (see table 7). While it does not give detailed information about the rental expenditure per main places, it gives a general overview of the metropolitan's rental expenditure. Ekurhuleni is the municipality that has the lowest number of households renting

and spending their income on rental houses followed by Tshwane, while the city of Johannesburg has the highest number of households spending their income on rental housing.

Table 19:Rental expenditure statistics

Metro name	Number of households renting	%of households renting	% of rental expenditure on total expenditure
City of Johannesburg Metropolitan	643 737	40.8	12.3
City of Tshwane Metropolitan	333 142	35.7	10.1
Ekurhuleni Metropolitan	384 915	33.5	9.5

4.4 Mapping the distribution of opportunity

The choropleth mapping includes the maps of the opportunity index and the individual dimension. The choropleth map of the opportunity index is also overlaid with the total population to relate the distribution of opportunity to the total population. The number of population for each main place is indicated in table 5, while the population groups per main place are included in Appendix C.

4.4.1 Opportunity Index choropleth map

The opportunity index choropleth map shown in figure 5, was created using the opportunity index scores indicated in table 5. The map presents the distribution of opportunity in space. The spatial manifestation of the opportunity shows that there are variations in the opportunity distribution within Ekurhuleni. The opportunity distribution ranges from a very high to a very low. Germiston, Boksburg, Nigel, and Dukathole are the four main places that have the highest opportunity scores. Amongst these four main places, three are developed towns while one is a

township. It can also be observed from figure 2 that the distribution of high opportunity is predominantly in areas known as towns while low and very low distribution of opportunity is

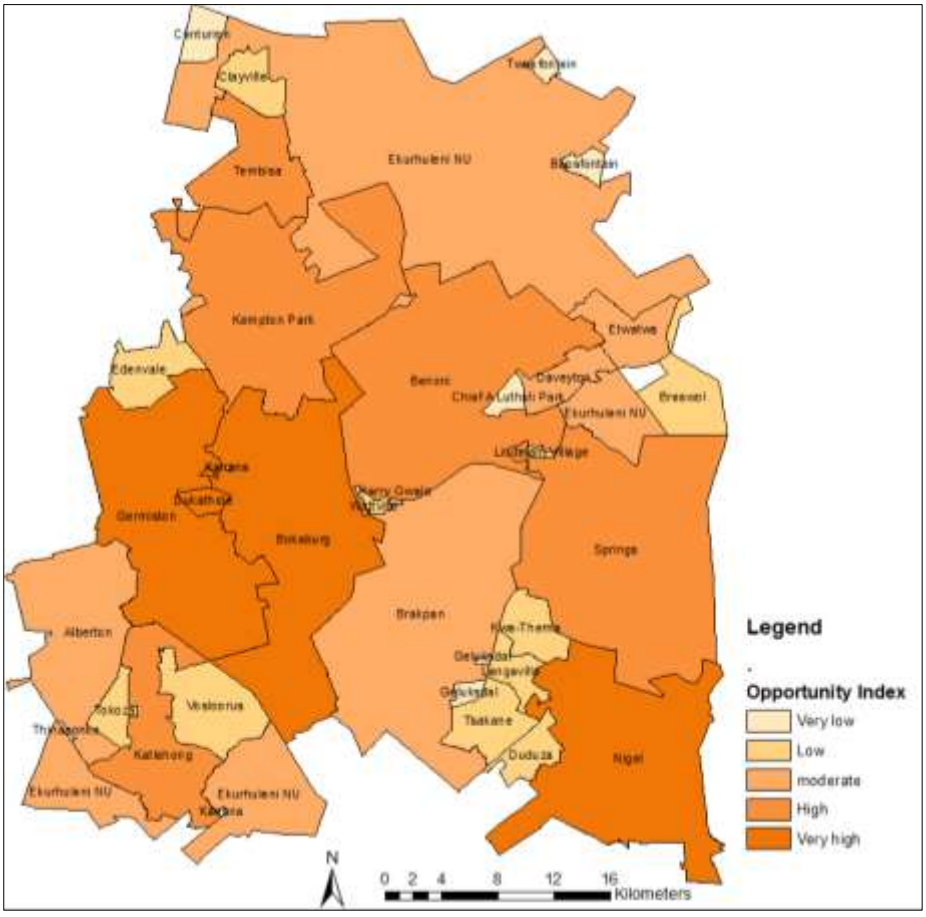


Figure 3: Opportunity index choropleth map (Author, 2020)

predominant in areas known as townships. As also indicated by table 5 that the main place with the highest opportunity index score is Germiston (developed town) and the lowest is Thinansoke.

The findings show that there is no clear link between the distribution of opportunity and the area's total population. For example, some main places (see figure 3) like Tembisa and Katlehong have a high distribution of opportunities with a high number of people staying in them. While main places like Nigel (developed town) do not have many people but have a very high opportunity distribution. There are also main places like Duduza, Vosloorus, Tsakane, and Kwa-Thema that have a low distribution of opportunity with a high number of people staying in them.

These main places are located at the peripheral locations, and the towns near them are well serviced. For instance, townships like Tsakane have a poor opportunity with a high population, however, it is located next to Nigel town which is well-developed and having advanced opportunities. Generally, the metropolitan's high opportunity is concentrated in main places considered to be well-serviced towns while low opportunity population is concentrated in townships. Figure 3, shows the opportunity index per total population of each main place. One dot on the map indicates 2,500 people.

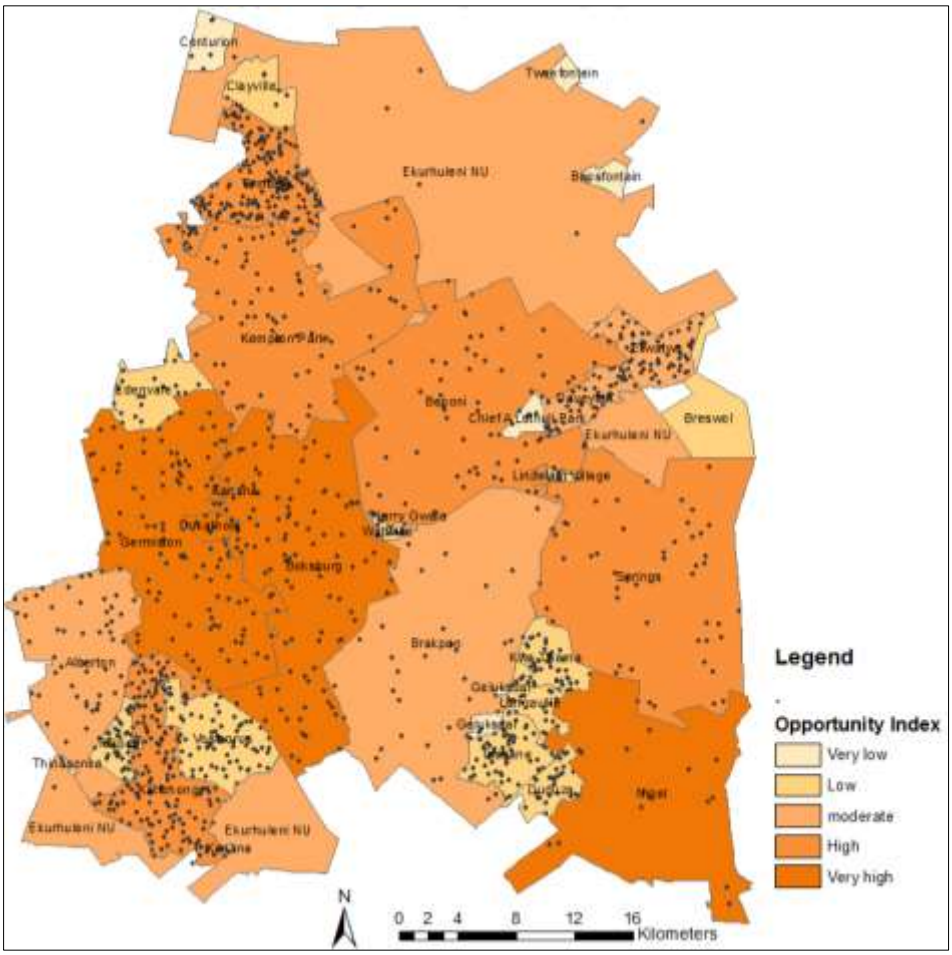


Figure 4: Opportunity index choropleth with total population distribution(Author,2020)

The physical appearance of space in some of the main places do resemble the level of opportunity they have while others do not. Main places (particularly towns) that have good opportunity distribution are also physically appealing, while some have different characters of areas that have a good opportunity. Images have been captured to illustrate the physical appearance of some of these main places. It is expected that the main places that have a high opportunity score should have aesthetically pleasing spaces, however, it is not the case for some main places. Boksburg is one of the developed towns characterised by high opportunity distribution. Figures 4 and 5 show the physical appearance of some parts of Boksburg. The town has unpolluted streets and well-planned buildings. Land use is also integrated (different land use close to each other) to enables access to different opportunities within proximity. There are also street lights to enhance safety and security in the area (see Figure 4).



Figure 5: Image showing some parts of Boksburg town(Van Zyl, 2013)

As shown in figure 5, the main place has recreational activities that act as the tourism centre that attracts the main place's income and for entertainment. Figure 5, shows the Wild water recreational area in the Boksburg main place. The area is the tourism site in which both local and international residents spend their summer days. It is clear from the figure that the area is well serviced and attract people of different races.



Figure 6: Image showing the recreational area in Boksburg(Wang, 2018)

Compared to Boksburg, Kempton Park main place has spaces that are visually appealing and indicate that the area is well-developed. Figure 6, shows the OR Tambo International Airport which is located in Kempton Park (City of Ekurhuleni, 2019). The airport is the transport hub for international and local travellers and is declared as the metropolitan area's aerotropolis (City of Ekurhuleni, 2019).



Figure 7: Image showing OR Tambo International airport(TimesLIVE, 2017)

The townships like Katlehong and Tembisa were classified as a high opportunities distribution area with a high number of people staying in them. However, unlike Boksburg and other developed towns, these townships do not visually look good or resemble an area with high opportunity. Figure 6, shows an image of Katlehong township. The township is still deprived; some parts of the area have informal dwellings that are built without a proper plan. There are no proper streets or street names that could be useful for navigating through the area. The trees in figure 10 show that the settlement has long been in existence, hence many people are staying in it. Despite the high number of people, the residents still use communal buckets toilets (see Figure 7).

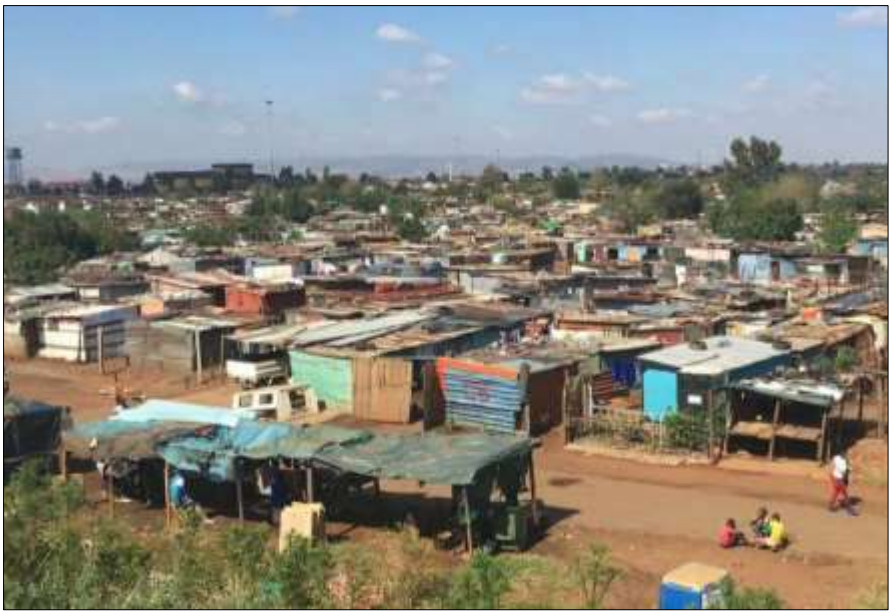


Figure 8: The physical appearance of some parts of Katlehong township (Janine, 2018)

Dukathole is another main place that was classified as a very high opportunity area. This main place is bounded by both Germiston and Boksburg (both developed towns). This main place consists of both informal and formal dwellings. Structurally, the area is not properly planned, and according to the statistical data, the main place has high unemployment and poverty rate. It is clear from figure 11 that the area is underprivileged. Figure 8, shows the location of the school and informal structures along Peterson road. It is apparent from the figure that unlike Katlegong

township, Dukathole is electrified, and has formal streets with street names, but they are not in good condition. Judging from the physical appearance of the area, one could see that the area does not indicate good opportunity as indicated by the opportunity index results.



Figure 9: Location of school and shacks along Peterson road in Dukathole (Street view, 2017)

Among the main places that were classified as low opportunity areas, is Thokoza township. The area does resemble areas of poor opportunity as indicated by Figure 9. It can be observed from the figure that Thokoza also has a cluster of shacks.



Figure 10: Cluster of shacks and informal trading in Thokoza township (Khumalo, 2014)

4.4.2 Jobs and local economy choropleth

The individual dimension gives a clear sense of what opportunity index comprises. Therefore, it is crucial to understand the distribution of each dimension in space. Figure 10, indicates the distribution of jobs and the local economy's dimension distribution. It is clear from the figure that the distribution of jobs and local economy differs from the overall economy. Very high distribution is noticed in three, main places namely Katlehong, Etwatwa, and Tembisa. Two of the three main places (Katlehong and Tembisa) also have higher opportunity distribution while Etwatwa has a low distribution. Unexpectedly, Kempton Park is characterised by the lowest distribution on jobs and local economy. This main place has a higher score of opportunity distribution and it is also known as one of the developed towns. Although it has a higher distribution of overall opportunity, the standard of its local economy is proven to be vulnerable (see figure10).

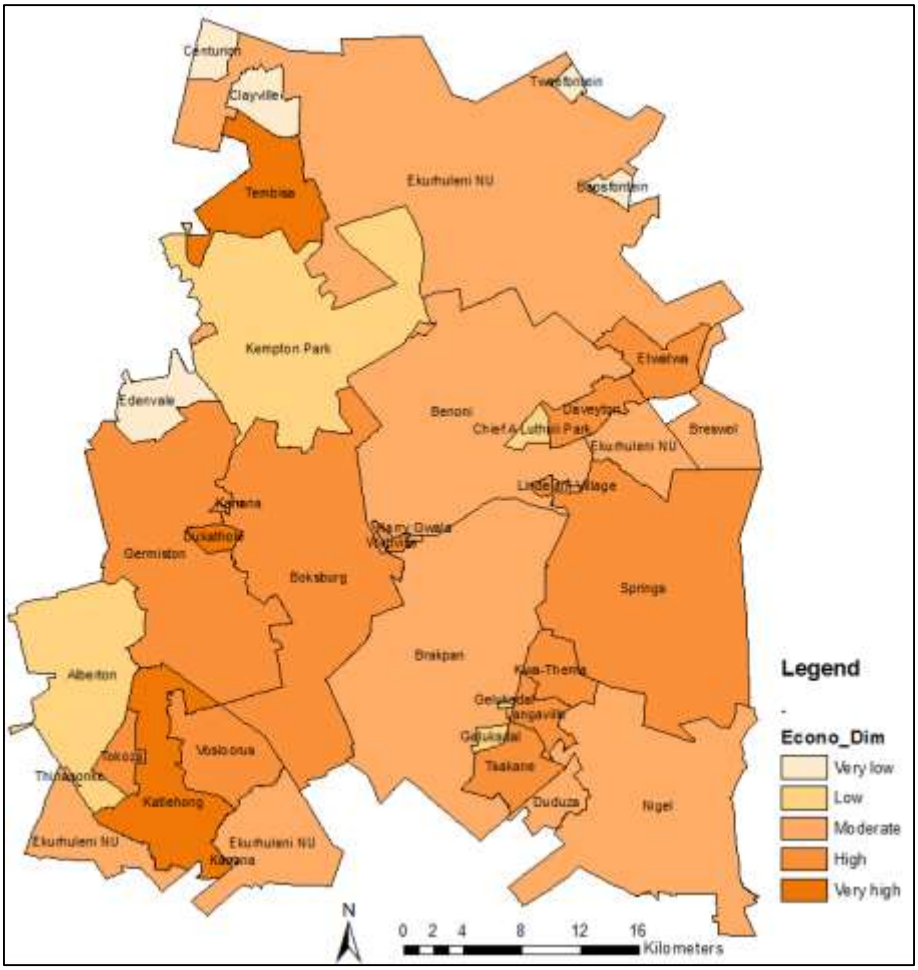


Figure 11: Choropleth map for jobs and local economy dimension(Author, 2020)

The other main places that have a low distribution of jobs and local economy are Edenvale Alberton and Clayville. Among the three, Clayville and Edenvale also have low opportunity distribution while Alberton has a high distribution. As compared to Kempton Park, Edenvale and Alberton are known to be the developed towns. Therefore, it was unexpected that they could have a low distribution of the local economy.

4.4.3 Education

The education dimension choropleth shows a different trend to that of jobs, the local economy, and that of the opportunity index (see figure 11). Four developed towns have a very high distribution of education dimension. Two (Germiston and Boksburg) of these towns also have the highest distribution of overall opportunity while the other two have higher distribution. All the main places that have the lowest distribution range of education are townships located in the peripheral areas.

Kempton Park has a very high distribution of education dimension which is different from that of jobs and local economy dimension. Images were used to illustrate the quality of schools in some main places. Figure 12 shows one of the schools in Boksburg, the school is well maintained, clean, and liveable for children. According to Powell *et al* (2007), children in well-advanced schools tend to perform better than those in poor schools.

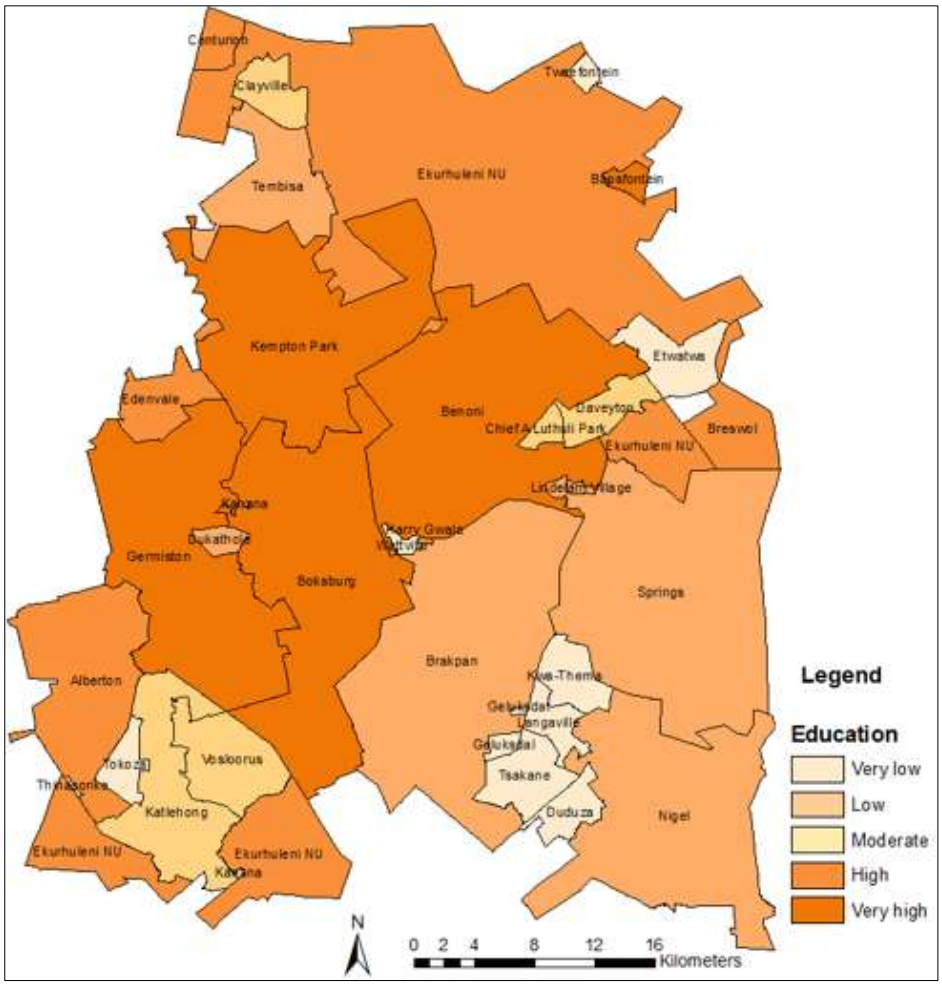


Figure 12: Choropleth map for Education(Author, 2020)



Figure 13: School in Boksburg (Grove, 2010)

4.4.4 Community health and civic life

The community health and civic life dimension scores indicated a completely different distribution compared to other dimensions, and this opportunity index as shown in figure 13. The towns that are characterised by a very high distribution of opportunity as indicated in figure 5, are all associated with a low distribution of community health and civic life opportunities. Most of the places that have a high distribution of community health and civic life opportunities are the areas that also have a very low overall opportunity. Brakpan is the main place with a high distribution of high community health and civic life but having the lowest opportunity score. This indicates that although the economy and the education standard of the area is poor, there is a strong interaction between the residents.

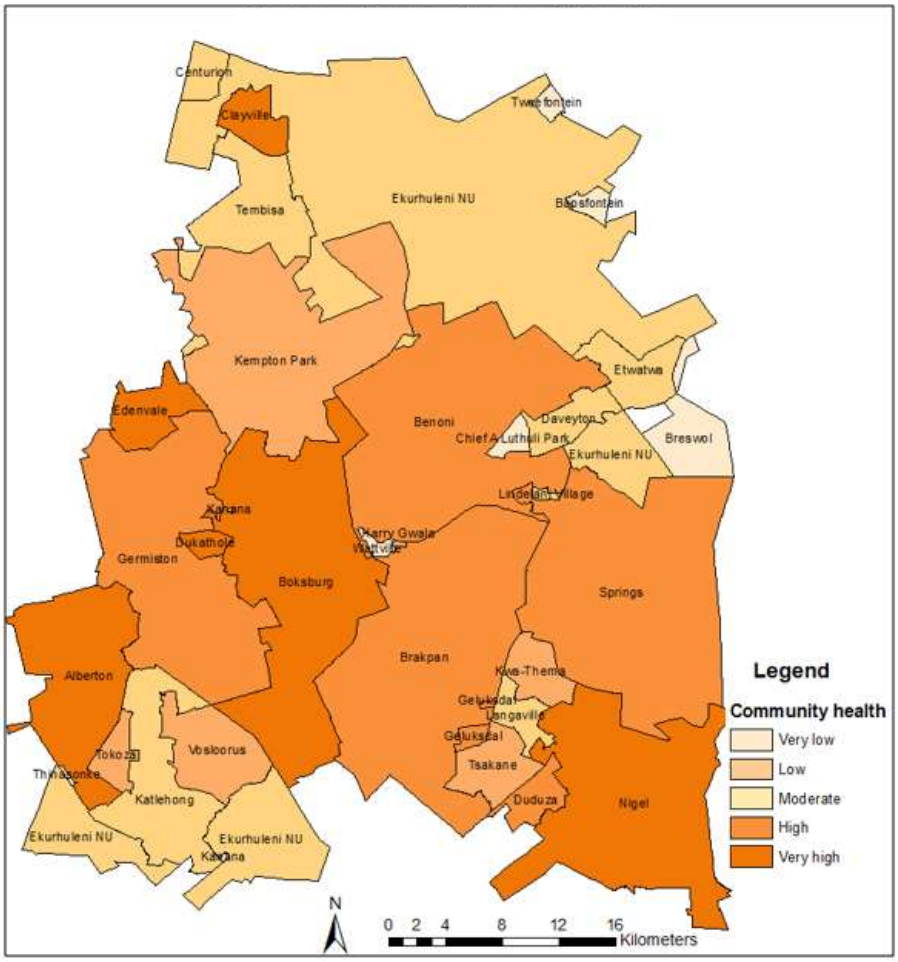


Figure 14: Choropleth map for community health and civic life dimension(Author, 2020)

Access to grocery stores is one of the community health and civic life indicators (Wilson and Greenlee, 2016). The availability of the grocery stores that are supporting a specific number of people improves the level of opportunity in the area. Boksburg town has a variety of stores that provide adequate and healthy goods. These stores also provide goods even for people in other main places (Evans,2014). Unlike in Boksburg, residents in townships like Duduza depend on spaza shops (see figure 14) for the supply of goods on their daily bases. These informal stores do not sell all the required goods since they are small businesses ran by fellow residents. Therefore, residents have to travel to other areas to buy goods. Moreover, the quality of these foods can also be questioned considering the state the spaza shops, and the time that the goods spend without being sold. Some goods are sold by street vendors (see figure 15). These goods are exposed to the sun and could easily be infected by bacteria. Therefore, residents might have access to grocery stores in the township, but the quality of food offered can be questionable.



Figure 15: Grocery stores in Duduza township(Baloyi, 2013)



Figure 16: Street vendors in Thokoza township(Andrews, 2009)

4.6 Examining the spatial pattern of opportunity

4.6.1 Local Moran

The local Moran results show the spatial autocorrelation and significant difference between the main places' opportunity. It can be observed from the map in figure 16, that there are spatial clusters (indicated by the positive values) and spatial outliers (indicated by negative values). The areas that have a clustering of opportunities are Boksburg, Germiston, Kempton Park, Benoni, Springs, Nigel, Brakpan, Alberton, Katlehong, Etwatwa and Tembisa (showed by positive values), while the rest are outliers (showed by negative values). However, it is not clear whether the clusters are (high) or cold (low), hence the need to perform the hot spot analysis.

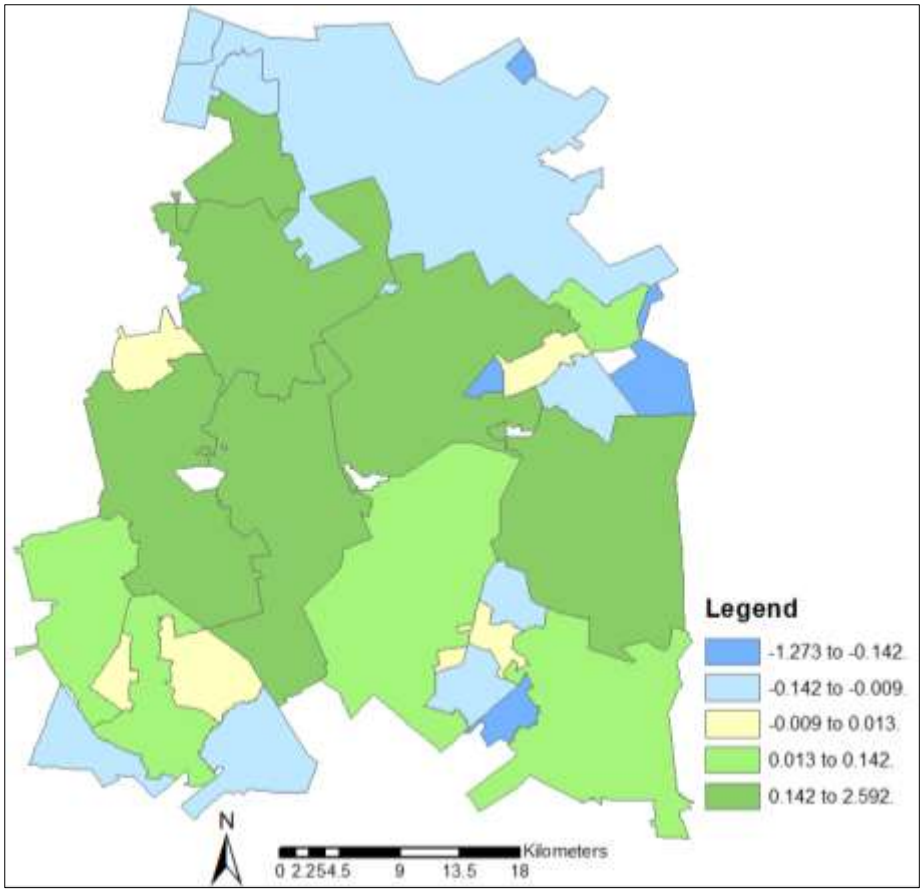


Figure 17: Local Moran statistic map(Author, 2020)

4.6.2 Hot spot and cold spot clusters

Since the local Moran statistics only indicated the clusters without indicating whether they are hot, and cold spots, figure 17, categorises the clusters as high and low. It can be seen from the figure that Boksburg, Germiston, and Kempton Park are the only main places that have a high cluster (hot spots) of opportunities while Tweefontein has low cluster (cold spots) of opportunities while the rest was classified as not significant.

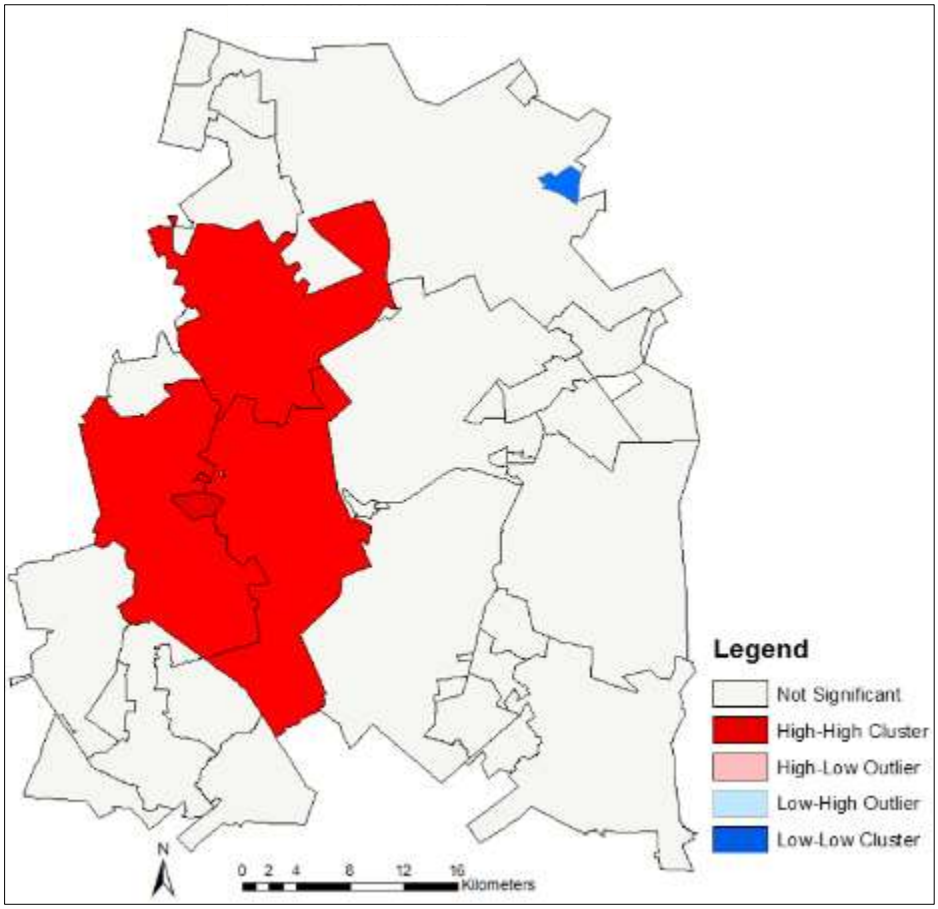


Figure 18: Hot and cold spot map(Author, 2020)

4.7 Conclusion

The raw data of the indicators has given an understanding of where the opportunity indices came from. They indicated why some main places scored higher in their dimensions which also boosted the overall score of the opportunity index. The mapped opportunity index showed that the distribution of opportunity differs between the privileged and underprivileged communities. It was also observed that there is no clear relationship between the distribution of population and the distribution of opportunity as there are townships that have high population distribution but different opportunity distribution. Some main places were classified as high opportunity areas but they are not physically pleasing.

The individual dimension has a different distribution trend in comparison to the coverall opportunity index. Some main places have a low distribution of the overall opportunity while having a high distribution of dimensions. This indicates that the area might have a low opportunity score, but performing well in some of the other dimensions.

CHAPTER 5: DISCUSSION OF FINDINGS

5.1 Introduction

The findings have generally proven the uneven distribution of opportunity between the privileged and vulnerable areas of the metropolitan area. This chapter elaborates more on these variations and interprets their implications. The first section of the chapter will reflect on the implications of the main results while the second segment will present the reflection of the findings relative to the arguments presented by the literature. The scholars' arguments will be drawn from the themes such as the hypothesis of spatial mismatch, neighbourhood segregation, and livelihoods as presented in the literature review. The overall reflections from this section will direct the concluding remarks of the research.

5.2 Reflection on the significance of the main findings

The main results give a clear perspective of the spatial dimension of the overall opportunity and individual dimensions. Therefore, the purpose of reflecting on these findings is to present their implications for this study.

5.2.1 Descriptive statistics

The statistical descriptions have indicated the dominance of 0 observation in some opportunity indicators. Zero observation is a bad indication for some, and good indication for other indicators. For instance, the dominance of 0 observation in the Higher education attainment indicator implies that most of the residents within the metropolitan area do not have an associate or higher degree. A few main places have notable high unemployment and poverty rate and these two indicators have a positive relation to each other. Implying that the main places that were found to have a high level of unemployment also have high rates of poverty. There is a direct link between poverty and unemployment i.e. high rates of unemployment can result in induced poverty intensity (Cloete, 2015). One of the causes of poverty is that the country's economic systems promote self-reinforcement of other areas while others remain poor (David *et al.,* 2018). The country provides free services such as social grants to combat these challenges, however,

poverty persists in the country (David *et al.,* 2018). The results showed that most of the main places have a high percentage of the unemployment rate and according to Cloete (2015), unemployment has racial and sexual implications in South Africa. Despite the skills and educational qualifications, black South Africans (mainly women) are unemployed while the whites tend to be employed.

The indicators have also shown the dominance of the high school dropout rate and the shortage of higher education attainment in most of the main places. This reveals that the standard of education is a social issue in some parts of the metropolitan area. According to Gregorio and Lee (2010), education has a strong relation to the distribution of income within the area. Therefore, the attainment of higher associate degrees can impact the distribution of income within the area. The level of education explains why the income is unequally distributed within the municipality. The poor standard of education also explains why some of the main places have high unemployment rate because the more residents drop out from high school, the more they will not attain tertiary qualifications, and not acquire necessary skills to be competent for employment (the author is aware that poor standard of education is not the only cause of unemployment but is very significant).

The result also indicated that most of the main places do not have many health institutions and grocery stores. This is an indication that most of the population compete for the existing facilities which increase infrastructural pressure to the institutions or induce distance travelled by residents to access these facilities. There is evidence that poor geographic accessibility of facilities results in the loss of lives, therefore, it is needed to locate health facilities at an optimal location to accommodate many people (Rahman and Smith, 2000). 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, this has not been a case in many countries. People are still forced to travel long distances to access health services (McLaren *et al.,* 2013; Kemboi and Waithak, 2013). Other than distance frictions, health facilities are exposed to the pressure of servicing the population beyond their capacity. Therefore, a shortage of health facilities in most of the Ekurhuleni's main places indicates the residents are exposed to the challenges mentioned above.

5.2.2 Opportunity

The presented opportunity index and the choropleth indicate the variation between the opportunity of the main places. Most of the main places that have very high scores are those that are known as the developed towns (Germiston and Boksburg) and one township (Dukathole) which is adjacent to the same developed towns. Surprisingly, the township that was classified as a very high opportunity area has a visual appearance that does not resemble an area with high opportunity. This means that the opportunity index does not consider appearance but focuses on a numeric analysis dependent on the dimensions applied. Therefore, it could have argued that the location of Dukathole with the developed towns might have influenced its opportunity score. Because there are no physical boundaries that separate main places, therefore some could be subjected to the spillover effects. This implies that the development of one area could result in a negative or positive spillover effect on the neighbouring areas. Thus, it is worth stating that Dukathole township is the product of the positive spillover effect from both Boksburg and Germiston.

There are main places that scored lower and are mainly townships, most of these main places have low opportunity scores and many people staying in them. Ravallion (2001) named situations such as this 'urbanisation of poverty'. Implying that the influx of people in a poor urban environment increases the level of poverty. This could be as a result of the high competition for the livelihood resources and infrastructural pressure. One could also argue that although these townships are poor, people choose to locate in them because of the affordable land and flexibility of building dwelling structures (particularly shacks). These are the poor townships mainly located at the peripheral locations or next to developed towns. One reason that induces their vulnerability is the self-reinforcement of the developed towns and the negative spillover effects. This implies that the developed towns continue to grow and as they grow the surrounding areas become poorer.

The distribution of the opportunity does not follow the same trend as that of the individual dimensions. Areas that have a high distribution of opportunity also have a low score in some of the dimensions. With this, one could argue that a high distribution of opportunity does not

necessarily mean that all the dimensions are well presented in that particular area. Thus, indicating that the area can still be classified as the cluster of opportunity, although their level of education or standard of the economy is low. This also shows a limitation of classifying communities as clusters of opportunity because it is not an informed conclusion to refer to a community as a cluster of high opportunity while, for instance, people are economically struggling.

5.2.3 Local Moran

The local Moran showed the spatial autocorrelation between the main places. It was also observed from the Moran statistics map that, there are clusters of opportunity in some of the areas. The hotspot map indicated the High-High cluster and the outliers. The High-High indicates the clustering of high opportunity (also known as a hotspot). The areas with high-high clusters of opportunity are developed towns such as Germiston, Boksburg, and Kempton Park. Although some townships have a high distribution of opportunity as indicated by the choropleth maps, they are not classified as high-high clusters. This supports the statement made previously that although the townships are classified as areas of high opportunity distribution, they might still be socially, spatially, and economically vulnerable.

5.3 Reflections on the findings in relation to the literature

The literature was centred on themes such as the hypothesis of the spatial mismatch, neighbourhood segregation, and livelihoods. Therefore, this section will reveal how the research results could help to fill in the gaps identified in the literature review.

5.3.1 The hypothesis of spatial mismatch theory

The spatial mismatch has been discussed as the physical separation between the job opportunities and the residential area (Howell-Moroney, 2005; Naudé, 2008; Gobillon *et al.,* 2007). They further alluded that this happens because most of the economic activities are concentrated in developed areas while most people reside in areas with poor opportunities away from these economic activities. In the case where the townships are located close to economic activities, the residents do not have the necessary skills to participate in the economic activities offered (Howell-Moroney, 2005; Naudé, 2008). Another cause of the spatial mismatch was found

to be the housing markets whereby the houses provided next to the economic centres caters only the affluent group (Naudé, 2008; Powell *et al.,* 2007).

Ekurhuleni metropolitan area has proven to have a high distribution of jobs, and the local economy in few towns and few townships. The availability of jobs and economic activities enable residents residing in or near these places to have access to these opportunities at proximity. However, this is pertinent to residents that have relevant skills needed for the jobs provided. As for those that do not qualify or staying in distant areas will have to commute to access these opportunities. Scholars like Naudé (2008) argued that in some contexts spatial mismatch is a resemblance of what they termed 'racial mismatch'. This phrase explains the lack of job opportunities where black people can be hired. Most of the townships in Ekurhuleni are dominated by black people, and clusters of low opportunity. Thus indicating that 'racial mismatch' could describe the spatial mismatch in Ekurhuleni metropolitan area.

5.3.2 Neighbourhood segregation

One of the apartheid's legacies in South Africa was to separate people based on race, class, and income. Black people have been pushed towards the peripheral townships away from economic activities (Mahajan, 2014; Peberdy *et al.,* 2017). According to Powell et al (2007) the influence of land use regulations, the spatial sprawl also causes the isolation of communities. These marginalised townships are characterised by livelihood opportunities (Peberdy *et al.,* 2017; Naudé, 2008; Powell *et al.,* 2007). Townships like Duduza and Thokoza have the characteristics of those that are marginalised: poor opportunity, poor local economy, education, and community health opportunities. These neighbourhoods struggle to provide the necessary resources to sustain their people. Social issues such as unemployment rate, dropout rate, poverty rate, etc. are also persistent in these areas, thus, affect people's outcomes. To make social issues worse, it was indicated that these neighbourhoods have a high number of people staying in them. According to Sinding (2009), there is a close relationship between poverty and overpopulation in the sense that a high population could induce poverty. A high concentration of population induces the competition for the limited resources, induces crime activities, and acts of violence

thus impacting the quality of their livelihoods. Although neighbourhood segregation plays a role in understanding the spatial distribution of opportunity in Ekurhuleni, there was no adequate data to explore this factor efficiently.

5.3.3 Livelihoods perspective

The level of opportunity determines the standard of living for people in both developed and undeveloped areas (Howell-Moroney, 2005; Powell *et al.,* 2007). The availability of livelihood assets (indicated in chapter two) improves the standard of living (Rakodi, 2002). Areas with High opportunity increase access to resources and improve livelihoods. The findings have indicated that there is a variation in the distribution/clustering of opportunity in Ekurhuleni. Areas like Boksburg, Germiston, Kempton Park, etc. have a high opportunity. These areas have adequate grocery stores, schools, health facilities, etc. However, places like Duduza, Thokoza, etc. have been found to have a poor opportunity, poor standard of education, and economy. In such neighbourhoods, residents have limited skills or inadequate education to acquire a decent job. The townships themselves do not have adequate resources needed for the improvement of livelihoods, and they are exposed to high levels of criminal activities and violence. Thus, it is worth stating that the areas with high opportunity also improves the quality of people's livelihoods while areas with low opportunity do not.

5.4 Conclusion

The chapter has reflected on the findings of the research. The opportunity indicators and dimensions gave an understanding of the output of the overall opportunity. The performance of dimensions depends on the indicators which also affect the score of the overall opportunity. Opportunity differs across the metropolitan areas. Some of the areas are characterised by the high opportunity while others are characterised by low opportunity. Some of the areas with high opportunity also have many people staying in them. However, there are also places with low opportunity with many people staying in them. The areas with low opportunity also show the characteristics of spatial mismatch and segregated neighbourhoods. Thus, it is worth mentioning that this metropolitan area has an uneven distribution of opportunity.

CHAPTER 6: Conclusion

6.1 Summary and research overview

The acquisition of indicator data is a prerequisite for calculating the opportunity index which can be utilised to determine the distribution of opportunity over space. The spatial dimension of opportunities in South Africa is modelled by the apartheid legacies. Up to date, areas that were marginalised during apartheid remain poor, while others are flourishing. This research aimed to study the spatial distribution of opportunity in the Ekurhuleni metropolitan area using the exploratory spatial analysis. The first and the second objective of this study was to create the opportunity index and display it using maps. Using the indicators' data, the opportunity indices of the 33 main places were calculated and displayed in tables, and the maps. For a clear understanding, the opportunity indices were also correlated with the total population for each main place.

Some indicator variables that were used are the unemployment rate, poverty rate, dropout rate, etc. The raw data of these indicators are significant in determining the overall opportunity index. Poverty and unemployment rate is notably high in most of the main places, and they indicate a positive relationship with each other. Areas with a high percentage of unemployment rate also had a high poverty rate. These two indicators have a negative relationship with the median income because areas with a high unemployment rate have fewer people that are earning the median income.

Both the opportunity index table and the maps indicated that there is a variation in the distribution of opportunities within the main places. Some main places scored better than others, and the leading main places with a very high distribution of opportunity are the areas that are known as the developed towns of the metropolitan area with areas that scored least being mainly the townships. To give a clear picture, main places like Germiston and Boksburg are the ones that have a high opportunity score and these main places are some of the developed towns. Unlike other main places, these two developed towns have a less number of people staying in them.

Other main places that have high opportunity scores are developed towns and few townships. The townships also have the highest number of people staying in them than all other main places

but their physical appearance is not aesthetically pleasing and does not resemble an area that has a high opportunity. The main place like Katlehong was classified as the area of high opportunity, however, this main place is under deprivation and the quality of life is poor. Thus, indicating that other factors can influence local outcomes. The main places that have the lowest opportunity score are the townships and these areas also have many people staying in them. Some of these main places are comprised of informal dwellings, poor infrastructure, and are located in peripheral areas.

The last objective of the research was to identify the spatial patterns of opportunity. Using the Local Moran statistics and the hotspot analysis, the spatial patterns of opportunity were examined. There is a significant difference between the opportunity of each main place. Similar to the choropleth maps, the local Moran statistics indicated that clustering of opportunity is in developed towns. The local Moran statistics indicated that all the developed towns are clusters of opportunity, however, only three of these developed towns are hotspot areas. The three objectives of this research study were achieved as the opportunity index was successfully calculated using the indicators data and mapped using the choropleth maps. Moreover, by employing local Moran statistic and hot spot analysis as tools, the spatial dimension of opportunities was identified.

6.2 Recommendations

The collection of census data at a national level might be costly and time-consuming, but it should be prioritised that data is updated at least every five years. The reason is the data is very useful for various projects that could also help in decision-making. Although, one was able to achieve the objectives of this study, for the study to be useful for future decisions updated census data would be needed.

The exploratory approach could be useful for framing future place-based policies that can be used for neighbourhoods and regional developments. There are limited studies done locally to address the spatial dimension of opportunity, as for Ekurhuleni, none has been done. Therefore,

future researchers should explore the change in the spatial dimension of opportunity over a five-year interval and its implications on policy-making.

6.3 Personal reflections

It was expected that opportunities would be unevenly distributed across the metropolitan area, but less was known of the extent. Thus, embarking on this study has been an eye-opening mechanism that has brought an understanding that high opportunity score does not necessarily mean that all areas are developed and aesthetically pleasing but some factors can influence local outcomes.

6.4 Conclusion

The research study has presented the findings of the spatial dimension of opportunity in the Ekurhuleni Metropolitan area using the opportunity index. The indices of each main place have revealed that some of the main places are well-serviced, while others are vulnerable. Additionally, most of those that have high opportunity distribution are the areas regarded as the developed towns, while poor opportunity is in the townships. Therefore, it can be concluded that there is an uneven distribution of opportunity in Ekurhuleni Metropolitan areas and developed towns have good opportunities, while townships remain deprived.

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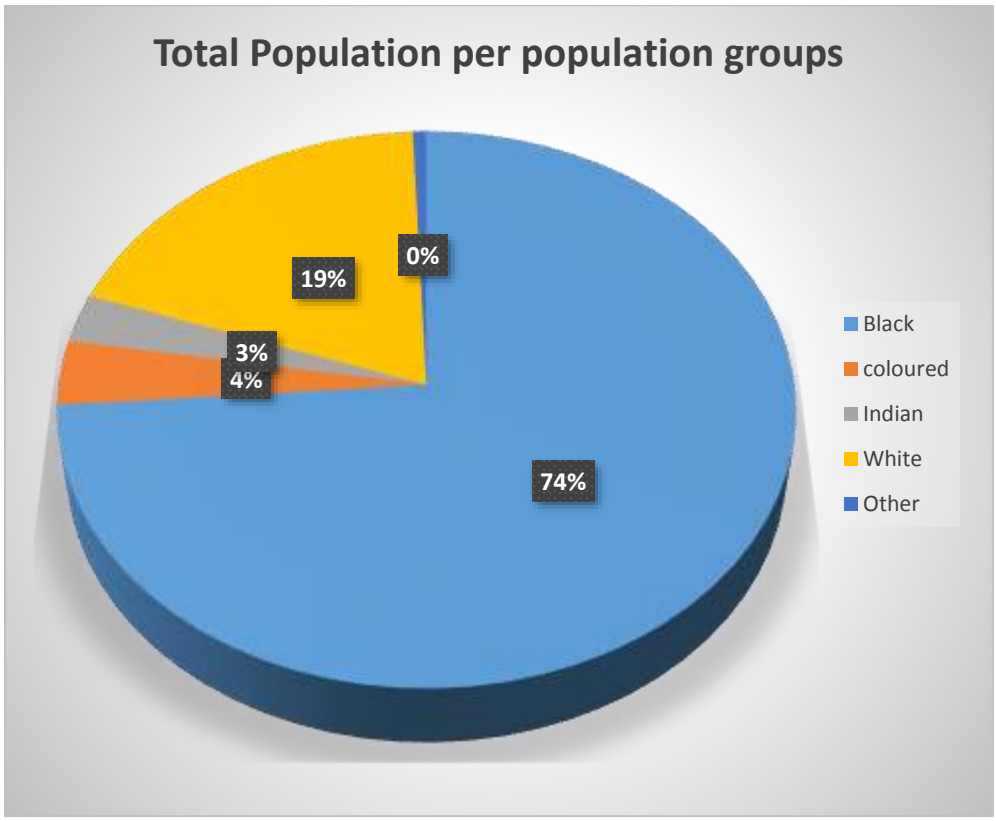
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Appendix A: Total population per population groups



Appendix B: Metadata for point attribute data

Administrative boundary	
Data Type:	Shapefile Feature Class
Geographic Coordinate System:	GCS_WGS_1984
Datum	D_WGS_1984
Prime Meridian:	Greenwich
Angular Unit:	Degree
Geometry Type:	Polygon
Resolution	1:250,000
Health institutions	
Data Type:	Shapefile Feature Class
Geographic Coordinate System:	GCS_WGS_1984
Datum	D_WGS_1984
Prime Meridian:	Greenwich
Angular Unit:	Degree
Geometry Type:	point
Resolution	1:250,000
Pick n Pay retail	
Data Type:	Shapefile Feature Class
Geographic Coordinate System:	GCS_WGS_1984
Datum	D_WGS_1984
Prime Meridian:	Greenwich
Geometry Type:	Point
Resolution	1:250,000
Spar retail	
Data Type:	Shapefile Feature Class
Geographic Coordinate System:	GCS_WGS_1984
Datum	D_WGS_1984
Prime Meridian:	Greenwich
Geometry Type:	Point
Resolution	1:1 500 000

Appendix C: Population groups per main places

