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The development of a liveability index for Tshwane to inform insurance practices

Keegan Fraser

1250795

A dissertation submitted to the Faculty of Science, in fulfilment of the requirements for the degree of Master of Science

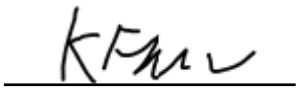
School of Geography, Archaeology and Environmental Studies

University of the Witwatersrand, Johannesburg

June 2023

DECLARATION

I, Keegan Fraser (1250795), hereby declare that this dissertation is my own, original work, except where otherwise acknowledged. It is being submitted for the degree MSc to the University of the Witwatersrand, Johannesburg. I have not submitted it previously, for the purpose of obtaining a degree, qualification or otherwise, at this, or any other, university.



Keegan Fraser

06/06/2023

Date

ABSTRACT

Understanding a city's liveability can be a valuable tool for individuals, businesses, and governments. Identification of locations with higher levels of liveability allows prospective homebuyers to make informed decisions on potential locations, simultaneously, businesses can identify locations with high potential for growth and be used as a tool to help demarcate locations for further or future investment. Finally, liveability can identify not only the more liveable locations but also the locations with poor liveability, granting governments insight into the regions that require upliftment. With an ever-increasing population and economic growth, there is a significant need to identify locations in South Africa with a high potential for growth. This research aimed to produce a liveability index for Tshwane, South Africa, to inform insurance practices. Proximity to points of interest, government institutions and open spaces were provided by RiskScape, while climatic data was provided by the South African Weather Service. After the construction of a liveability index and distribution of questionnaires, this research used a comparative analysis approach to determine the reliability of the index compared to public perception. Findings indicated that Tshwane's central and western regions have the greatest liveability when assessed against accessibility to facilities. However, crime is the most considerable influence on liveability and results in residents disregarding other liveability factors. Due to this factor, extending the index to other regions is not recommended prior to understanding what the population ranks as having the greatest effect on liveability.

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LIST OF ACRONYMS

BCI: Beach Climate Index

CBD: Central Business District

CHIRPS: Climate Hazards Group InfraRed Precipitation with Station

EIU: Economist Intelligent Unit

GCRO: Gauteng City-Region Observatory

GDP: Gross Domestic Product

GMPI: Gauteng Multidimensional poverty index

HCI: Human Capital Index

LMIC: low- and middle-income countries

MPI: Mazziotta-Pareto Index

NFIP: National Flood Insurance Program

PoI: Points of Interest

SACSC: South African Council of Shopping Centres

SAWS: South African Weather Service

TCI: Tourism Climate Index

CHAPTER 1: INTRODUCTION

1.1 Background

The level of satisfaction and perceived happiness of a population within the area in which they work and reside is intricately linked to the level of economic growth within that area (Oishi, 2010). The calculated level of satisfaction experienced by people living in an area is a result of comparing several different factors, such as distance to shops, crime rate and access to leisure activities, all of which have different weightings, in an attempt to determine which regions in a city are more suitable for living and which areas are less suited (Okulicz-Kozaryn, 2013). Areas with valued characteristics have an increased likelihood for the residents to have a higher sense of well-being (Lucas, 2014). Some of these characteristics that influence an individual's level of satisfaction include the climate of the region, access to amenities such as sports grounds or theatres, job availability, job satisfaction, the cost and quality of housing, and potentially the proximity to family (Lucas, 2014; Bernarto *et al*., 2020). Other factors that influence life satisfaction include health status, household financial status, freedom of choice and the level of migration into the region, as a higher growth rate is identified as a result of high levels of satisfaction (Lucas, 2014; Ngamaba and Soni, 2018).

Indicators are used to measure the liveability of the study area and are weighted according to their perceived level of importance to that specific area or study (Chi and Mak, 2021). Indicators vary immensely and can provide detailed statistics on a region (Conger, 2015; Chi and Mak, 2021). Some liveability indices, such as the Monocle Quality of Living Survey or the Economist Intelligent Unit (EIU) liveability index, use between 11 and 30 different indicators (EIU, 2011; Conger, 2015). Indicators can differ immensely, as some measure the quality of healthcare or education, while others measure the distance to specific places of interest, such as shopping centres or local sports grounds (Higgs *et al*., 2019). These indicators are then used to rank the location on a scale ranging from high to low. The specialisation of indicators used

in individual studies results in the liveability index being tailored for that study area (Conger, 2015). These tailored indices, therefore, cannot be directly transferable to other study areas without adjustments (Conger, 2015).

Locations that receive a higher score with a specific indicator when compared to others are, in turn, deemed to be more liveable than the surrounding areas (Namzi-Rad *et al*., 2012). These factors are often used to measure the liveability of an area. Conversely, these factors can be used to indicate shortfalls in an area, allowing for the municipality or government to focus on improving these areas (Okulicz-Kozaryn, 2013). Liveability indices have been used to identify locations with lower income levels; these low-scoring areas are identified by the city, after which hardship allowances are assigned (Manolakis and Kennedy, 2012; EIU, 2021). The liveability of a city or region is constantly changing due to people moving in search of other job opportunities, or technology allowing for the development of new and improved infrastructure (Chaffer, 2015). The fluctuations in population and changes in infrastructure all indicate the need for liveability indices to be updated regularly (Chaffer, 2015). The need to update liveability indices regularly has been addressed by companies such as the EIU, Monocle or Mercer (EIU, 2021; Monocle, 2021; Mercer, 2021) who have released annual liveability indices, all with the exception of a 2020 or 2021 liveability index, with some stating that "due to the effects of the COVID-19 pandemic", they were not able to release an updated liveability index (Mercer, 2021).

A liveability index is a concept of using several factors to determine how liveable an area or city is (VCEC, 2008). There are several working definitions of liveability; however, a comprehensive definition is: liveability indicates the well-being of a community by considering the safety, attractiveness, diversity, and affordability of housing that is in close proximity to public transport, the condition of walking, cycling and road infrastructure, education, public green open spaces, local shops, community services and cultural and leisure opportunities

(Namzi-Ra *et al*., 2012; Giap *et al*., 2014). Many of these aspects of liveability are used to determine what makes a location desirable and attracts people to reside there (VCEC, 2008; Higgs *et al*., 2019). Liveability indices, such as the Urban Liveability Index, have been created to identify spatial inequities in an attempt to better inform decision makers during the city planning policies process (Higgs *et al*., 2019). Other liveability indices have been produced to evaluate specific infrastructure, such as the availability and quality of schools and public transport, all of which can influence the quality of life of a city's population (Okulicz-Kozaryn, 2013; Higgs *et al*., 2019).

Urban liveability indices have been used to inform municipalities of how different cities compare to one another, by breaking down the factors influencing the quality of life into three categories (Conger, 2015). These categories are: firm-orientated, policy-orientated, and lifestyle-orientated (Conger, 2015). Firm-orientated indices on quality of life are used to inform businesses on cost-of-living data, while the policy-orientated indices analyse urban policies in an attempt to highlight what policies are suitable for the city or region and what needs to be re-evaluated (Conger, 2015). Lifestyle-orientated indices are developed for specific demographics, such as students or seniors, allowing for an analysis of the best areas for that specific demographic to live in (Conger, 2015). Making use of these three categories in conjunction with one another allows for an average quality of life profile to be created (Kashef, 2016). A quality of life profile can be applied to a specific city or environment, allowing for one to track the fluctuations throughout the city (Kashef, 2016). Liveability indices have been valuable tools for city planners to identify areas with low scores and invest in these areas to attract more people (Giap *et al*., 2014).

Liveability indices have become more prevalent over the last decade due to the United Nations' sustainable development goals promoting the use of urban planning (WHO, 2016; Higgs *et al*., 2019). However, the notion of liveability and measuring the liveability of an area can be traced

back to the 1960s and early 1970s (Phillips, 2017). Early measurements of liveability had been used whereby scientists identified an area to be redeveloped, in an attempt to provide a higher quality and more liveable environment (Phillips, 2017). Research has found that measurements of the quality of the environment made in 1972 are completed by using eight features, namely: the environment must be nuisance-free, provide proper housing, employment and education, be healthful, promote health and recreational opportunities, and contain modern amenities (Namazi-Rad *et al*., 2016). These eight features can also be identified in more modern lists of indicators used to measure liveability (Higgs *et al*., 2019). Modern features/indicators include walkability, social infrastructure, public transport access, access to public open spaces and affordable housing to name a few (Higgs *et al*., 2019).

Modern liveability studies have separated the different indicators into clusters, being: socio-political environment, economics, sociocultural environment, health, education, utilities, recreational facilities, market and housing and natural environment (Kashef, 2016; Higgs *et al*., 2019). An example of specific indicators within the utility cluster includes the number of supermarkets and the distance to these supermarkets within a specific radius (Namzi-Rad *et al*., 2012). Socio-cultural environment encompasses the ease at which people can access specific locations and the distance to infrastructures such as a bus stop, supermarket, school, or pharmacy (Higgs *et al*., 2019). The outcome of an urban liveability study is an index that places cities or regions into categories according to their total score when evaluated against the abovementioned clusters (Giap *et al*., 2014).

The categorised cities and regions within cities can then be evaluated to determine which is deemed more liveable (Giap *et al*., 2014). The ranking of cities in the liveability index can be utilised by insurance agencies. Indicators that measure the quality of road infrastructure can be used to identify locations with low scores, which can potentially indicate areas with a higher number of insurance claims resulting from car damage (Guerrero-Ibáñez *et al*., 2018). This

scenario has been identified when analysing roads in Zimbabwe, whereby insurance claims due to poor road infrastructure have led to thousands of car claims and are seen as a setback to the insurance industry (Eriksson *et al*., 2008; Zikhali, 2017). Another use of indices could be to assess the health of the region, as studies completed in northeast Germany have found a correlation between location and health insurance claims (Kauhl *et al*., 2016).

This information can be used by insurance agencies as they can assess the locations with higher health and damage insurance claims, and adjust the cost of insurance accordingly for these areas (Arumugam and Subramanian, 2019; Magsino, 2020). Furthermore, the information can be used by governments and other institutions when identifying new locations for clinics and other care facilities (Faruque *et al*., 2012). However, indicators such as total travel time to and from a clinic could also be used as a baseline for people looking to develop new clinic facilities (Ayyalasomayajula *et al*., 2011). Similarly, measuring the level of wealth of an area can inform insurance agencies of the likelihood of the residents of this area to purchase life insurance, therefore providing information on which locations might require more insurance pay-outs over time (Kumi-Kyereme and Amo-Adjei, 2013). However, when looking at a larger scale, regions with higher liveability index scores can be understood as being more resilient and, therefore, less likely to have a high number of insurance claims (Kabisch *et al*., 2017).

Liveability indices have been used to measure and compare many different aspects which impact people's lives. While some indices have been used as a city ranking tool, such as the Mercer Quality of Living City Ranking (Mercer, 2021), others have been used to inform specific audiences (Braza *et al*., 2004; Conger, 2015). Liveability indices can be used to inform the insurance Indus about the level of risk of specific areas, which can subsequently be used to adjust the cost of insurance (Miller *et al*., 2019). This has been identified in northern Australia, whereby regions that are more exposed to tropical cyclones and flooding have increased insurance premiums when compared to those at decreased risk in southern Australia

(McAneney *et al*., 2016). The increased cost of insurance in these high-risk areas has resulted in local governments to consider introducing a government-sponsored reinsurance program (McAneney *et al*., 2016), while others have led to improved land-use planning (Serra-Llobet *et al*., 2013), all in an attempt to mitigate disaster risk and reduce the cost of insurance.

The examples provided show the usefulness of liveability indices to the insurance industry; however, many of the indicators measured the physical aspects of the study area. Another aspect that can be introduced into liveability indices is the crime rate. Crime can result in significant costs to people and the insurance industry when pay-outs are needed (Kądziołka, 2016). Therefore, by personalising the liveability index to include crime-related indicators, insurance agencies can understand the level of risk in specific areas and adjust the cost of theft and crime insurance accordingly (Ratcliffe, 2010). It is therefore evident that liveability indices can be used by many different people or businesses and can be used to inform decisions on many measurable datasets (Conger, 2015; Real *et al*., 2020). However, there is a need to focus the study on a specific audience so as not to lose detail while including as many factors as possible (Conger, 2015).

1.2 Rationale

Liveability indices have been used across many different countries with varying levels of success and acceptance (Namzi-Rad *et al*., 2012; Conger, 2015). Liveability indices such as the Mercer Quality of Living City Ranking and the EIU Global Liveability Index have ranked between 130-231 cities, while the Urban Liveability Index developed by Higgs *et al*. (2019) is specialised to measure travel behaviours in Melbourne, Australia. Accurate urban liveability indices allow for institutions and some government sectors to begin working on enhancing the specific area, which is identifiable by low scores in the index (Valcárcel-Aguiar *et al*., 2019). Although there is little literature on how liveability indices have been used to inform the

insurance industry, dismantling the different indicators used highlights the potential areas for collaboration with the property and building insurance sector. Although the medical insurance industry would value the outcome of liveability indices, this is not explicitly considered in this study.

Insurance markets are accountable for large amounts of economic growth in the world's economies (Olayungbo and Akinlo, 2016). The global insurance industry fluctuates annually, as in 2013 the global insurance premiums cost approximately 4.64 trillion dollars; however, due to the COVID-19 pandemic, the global insurance premiums are expected to contract to 4.2 trillion dollars in 2021 (Olayungbo and Akinlo, 2016; Fan, 2020). The insurance industry has a significant impact on the economic growth of a country (Han *et al*., 2010; Kjosevski, 2012). Due to countries' economies being at risk from natural disasters such as floods, earthquakes and hurricanes, it is important for the insurance industry to be able to protect people and the economy against these risks (Khan and Uddin, 2013). In developing countries, the growth of the insurance industry can promote the development of the country's economy (Han *et al*., 2010). The National Flood Insurance Program (NFIP) in the United States of America annually underwrites 1.2 trillion dollars' worth of flood risk (Wagner, 2021). This indicates the importance of understanding what and how much risk is faced by people, to allow for an accurate calculation of how much risk to underwrite. Underwriting large amounts of money for insurance risk also places the insurance sector at risk of insolvency or loss of surplus (Kleindorfer and Kunreuther, 1999).

These challenges faced by the insurance industry can be addressed with the use of audience-specific liveability indices. Liveability indices that make use of indicators, such as distance from flood-risk areas, can provide insurance companies with the information necessary to adjust the cost of flood insurance in high-risk areas (Sanders *et al*., 2005). Similarly, identifying locations that are at increased risk of damaging hail or those with a high crime rate, can be used

to adjust policy costs (Ratcliffe, 2002). Although measuring the risk of floods can be completed with the use of flood risk mapping (Armenakis and Nirupama, 2014), and assessing the risk of hail damage is available through the use of GIS-based applications (Wang *et al*., 2016), a liveability index can encompass all of these risks into a single platform, providing more accessibility to the public and for insurance agencies.

A liveability index for locations within South Africa is critically important in order to inform people and businesses about the state of the area in which they live. Furthermore, a South African-specific liveability index can move away from mainly informing government policy and planning, as has been the shortfall of previous indices (Conger, 2015). The development of the economy, as well as the economic risk that is faced by people and insurance agencies after disasters such as tropical cyclones and floods, indicate the need for people and insurance agencies to be informed of the risk they face. The development of a liveability index that assesses the risk posed to people will allow the insurance industry to make use of this information and adapt their insurance policies. New liveability indices designed for regions within South Africa, can focus on informing the insurance sector of locations that require specific adaptions to insurance policy coverage, potentially influencing the cost of insurance in those areas (Zietz, 2003). A well-defined liveability index can be produced for specific audiences, further allowing for insurance companies to be informed when underwriting, resulting in adequate pay-outs to customers. A well-constructed liveability index could allow for people to have a better understanding of how much insurance would cost them, resulting in customers to ensure that they are not overpaying for risks not associated with that location.

1.3 Aims and Objectives

This project aims to construct a detailed and usable liveability index for Tshwane, South Africa, for use within the insurance industry, and to reflect on the potential applicability to other

regions in South Africa. The developed index will make use of a variety of indicators with inspiration drawn from Giap *et al*. (2014), Khalil (2012) and Higgs *et al*. (2019). Finally, residents' perceptions of quality of life will be gathered and used to assess the usability of the index. The objectives put forward to achieve these aims are as follows:

1. To develop a list of indicators through triangulation of what has been used in previous liveability indices, public perception, needs of the insurance industry and data availability.
2. To determine a suitable weighting system to measure the selected indicators through analysis of previous liveability indices, public perception and needs of the insurance industry.
3. To apply and test the final liveability index against public perception of Tshwane and to determine if the index can be applied to other municipalities across South Africa.

1.4 Structure

This study will be structured as follows; firstly, liveability indices will be introduced, and their history, usability and shortfalls will be discussed. The research paper will then continue by explaining why there is a need for a liveability index to be produced for areas within South Africa, as well as discussing the details of the study area. The paper will highlight the literature surrounding liveability indices before highlighting how the index has been developed. Finally, the paper will discuss how the new liveability index can be used and its implications for the insurance industry.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In order for this study to develop a viable liveability index for insurance agencies in Tshwane, South Africa, there needs to be an understanding of what liveability indices are, how they are used and their potential limitations. The following section considers the literature surrounding liveability indices, highlighting the history of liveability indices, their uses, how liveability is measured, their usefulness and shortfalls, and where liveability indices have been used. The characteristics of the insurance industry are also examined by analysing location determinates on insurance, how insurance is used and managed in suburban areas, and finally, linking insurance and liveability indices.

2.2 Liveability

2.2.1 History of Liveability Indices

Liveability has become a popular term over the past decade, driven by a renewed interest in increasing the habitability of a region (Howley *et al*., 2009; Michel *et al*., 2011). The definition of liveability varies depending on location, economic status, and gender, all of which influence what is deemed to be more or less desirable (Lawanson *et al*., 2013; Okulicz-Kozaryn, 2013; Reid *et al*., 2017). An overarching understanding is that liveability is the ease with which people can interact with the environment around them, influenced by safety, environmental sustainability, affordability, community services, the convenience of public transport, and cultural and leisure opportunities, which promote an environment that is desirable to work and reside in (Namzi-Rad *et al*., 2012; Giap *et al*., 2014; Higgs *et al*., 2019). As liveability encompasses a wide variety of aspects that influence the quality of everyday life, and as the demand for more liveable spaces increases, research is being conducted to explore the

variations in liveability and to assess the potential for urban and social development to increase liveability (Paul and Sen, 2020).

The study of how liveable a region is and the development of liveability indices have become increasingly popular over the last decade, in part, due to the United Nations' sustainable development goals promoting the use of urban planning (WHO, 2016; Higgs *et al*., 2019). Although this has resulted in an increase in the measurement of the liveability of an area, the notion of liveability and measuring the liveability of an area can be traced back to the 1960s and early 1970s, when scientists identified areas to be redeveloped in order to provide a higher quality and more liveable environment (Phillips, 2017). Research indicates that in 1972 eight features had been used to measure the quality of the environment, these being: the environment must be nuisance-free, provide proper housing, employment, education, be healthful, promote health and recreational opportunities, and contain modern amenities (Namazi-Rad *et al*., 2016). These eight features can also be identified in more modern lists of indicators used to measure liveability (Higgs *et al*., 2019). Rapley (2003) places further emphasises on the notion that liveability indices have historically focused on the well-being of the entire population, although they have evolved to measurements of an individual's subjective experience.

Liveability indices have developed from those used in the late 1960s and early 1970s, which made use of eight indicators, to the modern liveability indices that explore approximately 30 indicators (EIU, 2011). The expansion of indicators used in modern liveability indices includes measuring water and air quality and the approximate location of and distance to educational facilities, local convenience stores, recreational facilities, hospitals and other government departments (EIU, 2011; Shekhar and Kumari, 2018). Furthermore, the development and improvement of accurate satellite remote sensing techniques have allowed for more frequent measurements of vegetation cover, air quality and land-use patterns (Xue *et al*., 2008; Lee *et al*., 2009). This enhancement of satellite imagery and remote sensing technologies allows for

developers of liveability indices to make use of metrics such as total vegetation coverage and air quality, which had previously been measured by ground-based sensors in a discrete set of locations (Davis, 2007; Lee *et al*., 2009).

The use of indices to measure and assess factors within a specific location or study group is not limited to liveability indices. A multidimensional index has been used to analyse infant food security in New Zealand (Schlichting *et al*., 2019), and a soil degradation index has been developed with the use of remote sensing images to identify areas that require improved management (Nascimento *et al*., 2021). Further indices that have been produced include those assessing the impact of weather and climate on the tourism industry. The tourism industry provides significant economic benefits to the city or region, and identifying locations and time periods that are attractive to tourists will allow the region to tailor its amenities to attract more tourists (Vianna *et al*., 2012). The Tourism Climate Index (TCI) was developed to integrate the climatic variables that are relevant to tourism into a single index, and allows tourists to assess when it will be optimal to visit (Mieczkowski, 1985). However, similarly to liveability indices, the TCI is criticised for its subjectivity of weighting of climatic variables, the quality of data used and variations in location requirements (Moreno, 2010; Rutty and Scott, 2014).

The usefulness of indices has also been identified by the medical field as indices have been used extensively in research, an example of this being the use of different indices in cancer research (Guerard *et al*., 2017; Tong *et al*., 2017; Bartlett *et al*., 2019). Furthermore, modern indices have been developed to measure and monitor factors that influence a person's life, such as the Human Capital Index (HCI), which makes use of health and education indicators to measure the expected amount of human capital attained by an 18-year-old (Kraay, 2019). Finally, indices have been used to inform people on personal choices, an example of this being the Beach Climate Index (BCI), which assesses beach front climatic conditions to identify the optimal time to visit the beach (Morgan *et al*., 2000). Indices allow for the evaluation of specific

sectors and can be a useful analytical tool; however, these indices are sector-specific and, therefore, cannot be applied more broadly.

2.2.2 Uses of Liveability Indices

Liveability indices have been used for many different reasons. Initial liveability indices were produced to quantify the liveability of areas to determine where redevelopment and upliftment should occur to provide a higher quality of life (Phillips, 2017). Liveability indices have also been used as a tool for companies assigning hardship allowance, which makes use of living condition indicators and reflects a single rating to be used by the company (Namzi-Rad *et al*., 2012). The concept of liveability indices being used as a tool is expanded on by Coisson *et al*. (2016), whereby they use liveability indices to identify areas with low levels of comfort, therefore indicating which locations need redevelopment. Identification of climatic variables such as wind and temperature, which influence the liveability of a location, provides a goal for redevelopment designers to work towards. Coisson *et al*. (2016) make use of a bioclimate analysis to identify areas with poor climatic liveability, and propose a redevelopment design to mitigate these issues.

Similar to Coisson *et al*. (2016), Zhu *et al*. (2015) argue that redevelopment of land can have social and environmental benefits, potentially improving the quality of life in that area. Locations with low liveability scores can potentially indicate the presence of a brownfield zone, which is an area that has been abandoned or underutilised due to potential environmental contamination (Zaletova *et al*., 2021). Redevelopment of the identified brownfields zone could potentially reduce the pollution of surrounding areas, reduce health threats, and improve the liveability of citizens in the surrounding areas (Zhu *et al*., 2015).

Modern-day liveability indices have migrated away from the identification of areas for redevelopment and have realigned to be used to inform policy (Higgs *et al*., 2019). However,

Zhu *et al*. (2015) and Coisson *et al*. (2016) demonstrate that liveability indices can still be used to identify areas with low climatic or health liveability, thereby indicating areas in need of redevelopment and upliftment. Although liveability indices can be used as a tool for the identification of redevelopment zones (Coisson *et al*., 2016), Higgs *et al*. (2019) indicate that modern liveability indices have been produced to inform policy. With the use of location-based indicators that measure destination access, a liveability index can inform policymakers on areas that require more schools, hospitals, and other government institutions (Higgs *et al*., 2019).

Furthermore, liveability indices can be used to measure the liveability of an area for a specific target audience (Conger, 2015). Liveability indices produced for specific audiences include those for students and retirees (Conger, 2015). Student-specific liveability indices assess indicators that are deemed desirable for students and have been developed for schools in California, to inform the audience on which locations are best suited to walking and cycling modes of transport (Braza *et al*., 2004). Similar studies have been completed by Ewing *et al*. (2004), whereby they produced an index to measure the walkability to schools in Florida and what locations influence students' mode of transport.

Liveability indices have also been produced to inform retirees about what locations are best suited for their potential needs and desired lifestyles (Duncombe *et al*., 2003). Studies completed in the United States of America have produced a retiree liveability index that identifies areas with potentially high liveability for retirees by analysing factors such as climate, amenities, economic conditions, and distance to hospitals and clinics (Duncombe *et al*., 2003). Similarly to Duncombe *et al*. (2003) and Higgs *et al*. (2019), Poudyal *et al*. (2008) identifies locations that are potentially attractive to retirees, and states that the results can predict future amenity demands, therefore being a valuable tool to inform policy and regional agencies.

The variations in the production and uses of liveability indices over time (Namzi-Rad *et al*., 2012; Conger, 2015; Phillips, 2017; Higgs *et al*., 2019), display the flexibility of liveability indices and their reliance on what indicator is used (Figure 2.1). Liveability indices used to inform policy can be used as a basis for redevelopment, as the identification of areas in need of assistance can be useful to policy makers and government sectors (Giap *et al*., 2014). This variation in the production and use of liveability indices highlights the possibility for new indices to be produced to inform specific sectors of risk and mitigation strategies (Xie *et al*., 2019; Cichosz, 2020).

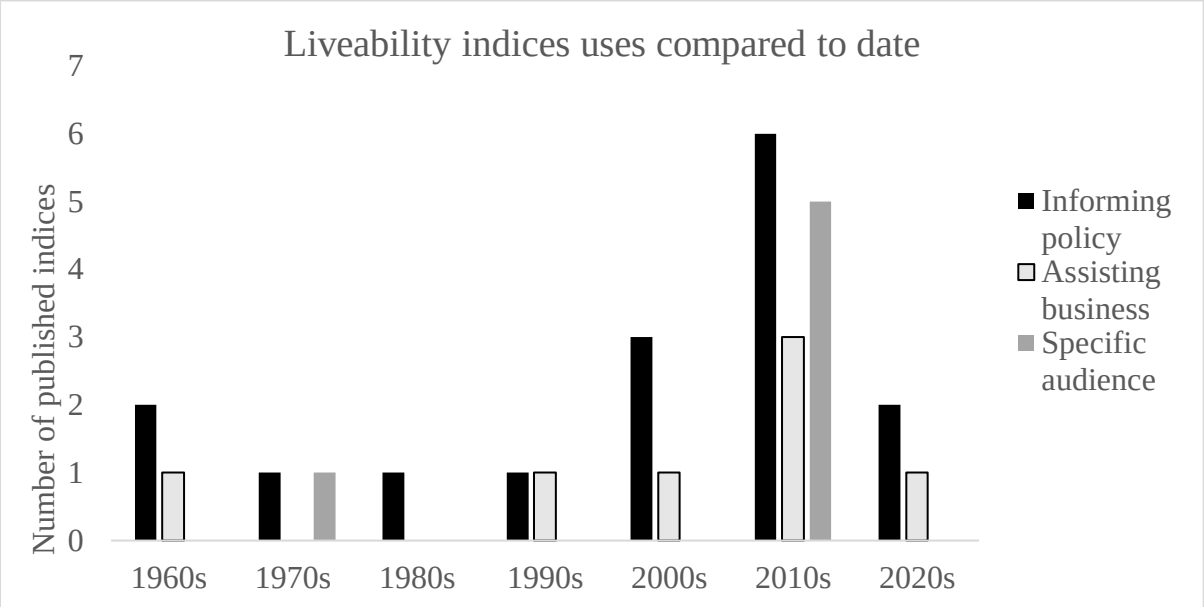


Figure 1.1: Graph showing the development of liveability indices per decade.

2.3 How is Liveability Measured?

2.3.1 Indices

Indices have been used across many different studies and allow for evaluating and comparing different regions or characteristics within a region (Mirazadi *et al*., 2017; Foški and Lamovšek, 2019). Indices can be a valuable tool in identifying areas at risk of disasters such as drought,

which cause an increased risk of forest fires, land degradation, desertification and negative emotional well-being (Vicente-Serrano, 2007; Sartore *et al*., 2008). Drought indices can be used to identify drought sensitive areas allowing for action to be taken to reduce the impact of potential droughts (Vicente-Serrano, 2007). Indices have been used to describe drought characterisation as it allows for differentiation between the complex mechanisms that cause drought (Chandramouli *et al*., 2017). This drought index makes use of daily precipitation data, which is reclassified to identify how extreme precipitation events will impact periods of drought (Chandramouli *et al*., 2017).

Indices have also been used to monitor land-use change, which is completed by analysing the shape, compactness, contrast, diversity, aggregation, areas and edges of the landscape (Foški and Lamovšek, 2019). The analysis of these seven characteristics allows for the calculation of the vegetation diversity of the area, which is measured using the 'patch richness index', the distribution of land use proportion is measured using the land-use proportion index, and finally, the Simpsons Diversity Index allows for the measurement of the relationship between the different land uses (Foški and Lamovšek, 2019). Further uses of indices include examining land use impact on forest ecosystem dynamics (Mirazadi *et al*., 2017). This index was developed by assessing the land use within the region by analysing the plant diversity and comparing it to estimates of the herbaceous plant's coefficient of conservatism in the study region (Mirazadi *et al*., 2017).

The development of indices requires measurements of different characteristics of a region in order to gather information for comparison and analysis (Schlichting *et al*., 2019; Nascimento *et al*., 2021). These characteristics are broad topics and include the size of the region, the climatic characteristics, land use and population statistics, to name a few (Schlichting *et al*., 2019; Nascimento *et al*., 2021). In order to measure these characteristics mentioned by Schlichting *et al*. (2019), indicators which focus on specific aspects within the category can be

used; for example, ethnicity, age, population density and food security can all be used to measure population statistics (Nascimento *et al*., 2021). Indicators can range drastically from soil organic matter to psychological stress and therefore explain why they need to be tailored to the specific study and study region (Schlichting *et al*., 2019; Nascimento *et al*., 2021).

2.3.2 What are Indicators?

Accurately measuring how liveable a specific region is, is dependent on several factors, including the purpose of the study, the location, the quality of data used as well as the indicators used within the study (Higgs *et al*., 2019). Indicators used in the development of a liveability index allow the producers to select what they want to be measured (Namzi-Rad *et al*., 2012; Higgs *et al*., 2019). This selection process, however, can introduce conflict between different indices when comparing the rankings of cities, as the indicators used can be more beneficial in some cities but unfairly reflect the conditions in another city (Khalil, 2012; Conger, 2015).

The use of indicators allows the researcher to measure, compare, and display a wide variety of aspects that influence the liveability of a region (Lawanson *et al*., 2013; Giap *et al*., 2014). The various indicators used within liveability indices display their flexibility and uses for many different applications, including evaluating policy, enhancing competition, and ranking the various conditions of different cities (VCEC, 2008; Tan *et al*., 2012; Giap *et al*., 2014). Liveability indices such as the EIU liveability index and the Monocle quality of life survey are produced for different audiences and uses (Shekhar and Kumari, 2018), which leads to different indicators being used in the study. Variations in the indicators used in liveability indices highlight the potential causes for indices to produce drastically different results (Khalil, 2012).

2.4 Indicators Used Within Liveability Indices

Modern indicators used in liveability indices differ depending on the purpose of the liveability index; however, commonly used indicators include walkability, which is used to measure the ease and convenience at which the general public can access local amenities such as shops, hospitals, and transport stations (Table 2.1). Social infrastructure is another commonly used indicator as it analyses the quality and number of health and recreational facilities in an area; these include the number of hospital beds per 1000 inhabitants, the number of cinema seats per 1000 residents, the quality of road networks as well as the quality of water provision (Khalil, 2012; Valcárcel-Aguiar *et al*., 2019; Table 2.1). Access to public transport and public open spaces is similar to indicators reporting on the walkability of a location, as they are used to measure the availability of, and distance to public transport stations and green open areas such as parks and sports fields (Khalil, 2012; Valcárcel-Aguiar *et al*., 2019; Table 2.1).

Table 2.1: Table comparing the indicators used within different liveability indices

	Liveability Indices							
Indicators used	Mercers (Khalil, 2012)	EIU (Khalil, 2012)	Nation Ranking (Khalil, 2012)	OECD (Khalil, 2012)	Namzi-Reza *et al*., 2012	Giap *et al*., 2014	Higgs *et al*., 2019	Valcarcel-Aguiar *et al*., 2019
Crime rate	•	•	•	•	•	•		•
Civil unrest	•	•	•			•		
Threats to domestic security	•					•		
Affordability of:								
1. Healthcare	•	•	•		•	•		•
2. Public housing				•	•	•	•	
3. Sanitation	•				•	•		•

4. Transportation	•				•	•	•	•
5. Basic supplies (bread/milk)		•						
Income disparity			•	•		•		•
Demographic burden						•		
Community cohesion						•		
Policy effectiveness		•				•	•	
Fair and efficient justice system	•					•		
Air pollution	•			•		•	•	•
Access to:								
1. Education	•	•	•	•	•	•	•	
2. Green spaces					•	•	•	•
3. Supermarkets/ essential shops					•			
Recycling rate						•		
Unemployment rate		•		•		•		•
Level of internet access					•	•		
Natural disaster death toll/ frequency	•					•		
Life expectancy		•		•		•		
Number of hospital beds per 1000						•		
Quality of:								
1. Housing	•	•			•			•
2. Education		•	•	•	•	•		
3. Ground transport network		•			•	•		
4. Roads		•				•		
5. Electricity supply	•	•				•		•
6. Healthcare		•	•	•				•
7. Water	•	•				•		

Control and perception of corruption		•				•		
Walkability							•	
Local work opportunities					•		•	
Climate	•	•						
Traffic congestion	•							•
Variety of restaurants	•	•			•			
Sports and leisure activities	•	•		•	•			•

Liveability indices have been produced for many different reasons, some of which are to identify redevelopment areas, inform policy, or inform specific audiences (Conger, 2015; Coisson *et al*., 2016; Higgs *et al*., 2019). As there are approximately 30 indicators that have been used with liveability indices (EIU, 2011), variations are likely to occur between what indicators are used across the produced liveability indices. Indicators such as threats to domestic security, community cohesion, demographic burden, number of hospital beds, and access to essential shops have been measured once across eight analysed liveability indices (Table 2.1). Although the indicator measuring the number of hospital beds is recorded as being used once, the affordability of healthcare and quality of healthcare has been measured six and four times, indicating that although the liveability indices are recording similar fields, there will be variations in the final index due to differences in what is measured (Table 2.1; Conger, 2015).

Indicators such as affordability of public housing and transport, policy effectiveness, level of air pollution, access to green spaces and local work opportunities have been tailored to measure economic and environmental factors that influence the daily liveability on a city scale of Melbourne and Sydney (Table 2.1; Higgs *et al*., 2019). However, some liveability indices have been produced to measure governmental structures, policies and the sustainability of a region

which is measured on a global scale by comparing cities such as Zurich, Singapore, Auckland, Vancouver, Abu Dhabi, and Manila (Table 2.1; Giap *et al*., 2014). These global liveability indices use crime rate, policy effectiveness and recycling rate to compare different cities (Table 2.1). Exploring these liveability indices in chronological order reveals that there are no noticeable thematic variations in liveability indicators used over time (Table 2.1).

The use of different indicators in liveability indices allows for the study to be tailored to a specific audience. The potential uses of liveability indices have been introduced by Conger (2015), who states that liveability indices can be used to inform students about what location will best suit their desired lifestyle. Liveability indices produced for specific audiences, such as students, rely on the use of carefully selected indicators to provide information on what is deemed more desirable for that target audience (Woolcock, 2009). These indicators could include distance to school, tree coverage, crime rate, school age and neighbourhood population (Braza *et al*., 2004; Ewing *et al*., 2004). Conversely, indicators used to inform retirees on the best locations to retire could include crime rate, cost of living, distance to social and cultural amenities, distance to healthcare facilities (Duncombe *et al*., 2001), sunshine hours, humidity, and average ethnicity (Duncombe *et al*., 2003). This variation in the potential indicators used for two different target audiences demonstrate the flexibility of liveability indices, although, it enforces the importance of using relevant indicators for the location and purpose of the study (Lawanson *et al*., 2013; Conger, 2015).

2.5 Weighting of Indicators

The weighting of indicators is a necessary process that takes place across many liveability indices (Namzi-Rad *et al*., 2012; Onnom *et al*., 2018; Higgs *et al*., 2019; EIU, 2021). The weighting of indicators differs between studies, as location-specific liveability indices result in some indicators being deemed more desirable when compared to others (Lawanson *et al*.,

2013). These weighting systems, therefore, allow for indicators to be compared to one another despite the fact that some are deemed more desirable than others (Higgs *et al*., 2019). Weighting systems used in previous studies rank six indicators; home, neighbourhood, work and education, services, entertainment, and transport on a scale of one to six, with six being the most desirable and one the least (Namzi-Rad *et al*., 2012). Quality of life surveys completed within Gauteng make use of a weighting system that considers gender, race, and ward of the surveyed location, to equalise the differences between respondents and surveyed locations (Parker, 2018).

The weighting of indicators is influenced by the grouping of indicators, as if the distance to a recreational sports ground was grouped with the distance to a hospital, the data would inaccurately reflect the importance of distance to a recreational facility; however, if these are separated, the weightings would be more accurate (Higgs *et al*., 2019). Lawanson *et al*. (2013, p. 575) argue that the weighting system used is "skewed towards western concepts of what is pleasant and acceptable urban living". The use of an indicator weighting system is limited by what is deemed to be desirable by the producers of the liveability index and in the selection of indicators, which is evidence of unconscious-bias or method-bias, therefore, potentially reducing the comparability of different liveability indices, as they are not all developed by the same producer with the same level of unconscious bias (Vijver, 1998; Marcelin *et al*., 2019).

The weighting of indicators plays a pivotal role in the compatibility of different liveability indices and is influenced by the proposed use of the liveability index. Namzi-Rad *et al*. (2012) proposes a new technique for determining the weighting of indicators and allows for sampled individuals in the study area to rank life aspects on a scale of one to six, with one being the least important and six being the most important. Weighting is then processed with the following equation (H: Home, N: Neighbourhood, S: Services, E: Entertainment, WE: Work and Education, and T: Transport):

$$W_1 = \frac{7-H}{21}\ ;\ W_2 = \frac{7-N}{21}\ ;\ W_3 = \frac{7-S}{21}\ ;\ W_4 = \frac{7-E}{21}\ ;\ W_5 = \frac{7-WE}{21}\ ;\ W_6 = \frac{7-T}{21}$$

(Namzi-Rad *et al*., 2012).

Whereby W_x provides the final weight of that specific indicator. The use of these equations allows for personalised weightings to be used for the liveability index, and although they can be incompatible with other liveability indices, it provides a more detailed perspective on what is deemed to be more desirable in that specific study area (Namzi-Rad *et al*., 2012). The urban liveability index has been produced by making use of the Mazziotta-Pareto Index (MPI) method, which allows for the study locations to be ranked fairly and to mitigate against outlier scores, as Higgs *et al*. (2019 p. 7) states; "scoring high on one or two within a suite of indicators should not wholly compensate for poor performance on the rest". The MPI method uses the following equation to calculate the normalised matrix R={**r**ij}:

$$\boldsymbol{r}_{ij} = \frac{(X_{ij} - Min_x)}{(Max_{xj} - Min_{xj})}60 + 70$$

(Pareto and Mazziotta, 2013, p.97)

"Where X_{ij} is the value of the indicator *j* for the unit *i* and Min_{xj} and Max_{xj} are the 'goalposts' (highest and lowest possible scores) for the indicator *j*" (Pareto and Mazziotta, 2013, p.97).

2.5.1 Usefulness and Shortfalls of Indicators and Liveability Indices

The various indicators used within liveability indices display their flexibility and uses for many different applications, including evaluating policy, enhancing competition, and ranking the various conditions of different cities (VCEC, 2008; Tan *et al*., 2012; Giap *et al*., 2014). Liveability indices such as the EIU Liveability Index and the Monocle Quality of Life Survey are produced for different audiences and uses (Shekhar and Kumari, 2018), which leads to different indicators to be used in the study. The EIU Liveability Index has made use of 30

different indicators that are scientifically selected to identify the potential challenges faced by an individual's lifestyle; however, the Monocle Quality of Life Survey makes use of non-scientific indicators such as urban design and quality of architecture (Shekhar and Kumari, 2018; Cichosz, 2020).

The different indicators used within the indices allow for the index to be tailored to, and understood by different sectors, as the EIU liveability index can be used to inform and adapt policies, while the Monocle quality of life survey can be used to identify areas deemed to be more visually appealing and those that will attract more tourists (Specht, 2009; Scerri *et al*., 2019). The variations in indicators used between these two studies resulted in the liveability indices having inconsistent results, as the Monocle magazine places Vancouver in 15th place, while the city placed 3rd in the Economics Intelligent Unit study (Conger, 2015). Although there are contrasting results, the use of different indicators and the target audience of the liveability indices will lead to different results, and it is essential to note that the indices are not designed to have similar results.

A wide variety of indicators can be used when developing a liveability index as it allows for more measurement points; however, this is also a shortfall as too many indicators can result in choice overload, which potentially leads to conflicting results (Park and Jang, 2013). This concept of choice overload for the potential indicators used within a liveability index can, however, be advantageous. Scheibehenne *et al*. (2010) argue that with many choices, there is an increasing likelihood of satisfying a wider audience. This can be implemented into liveability indices as if they make use of a wide variety of indicators, such as that used within the EIU and Monocle studies combined, it could result in a more comprehensive index to be used by many different audiences (Shekhar and Kumari, 2018; Cichosz, 2020).

This demonstrates the importance of using indicators that are tailored to the specific study, therefore allowing for the results of the liveability index to be relevant and useable (Lawanson

et al., 2013). Furthermore, as there is a wide variety of indicators to choose from when developing a liveability index, the quality of the indicators used influences the final output and useability of the index; therefore, the selection of indicators is also reliant on the quality of the data used (Conger, 2015).

2.6 Liveability Indices

Liveability indices are tailored to the target audience and are reliant on the indicators used as well as the weighting of indicators, quality, and availability of the data used when analysing indicators. Liveability indices have been praised as being valuable tools for city planners to identify areas with low scores that require more development (Giap *et al*., 2014), for the analyses and comparison of cities (Conger, 2015), and for the introduction of competition between regions, promoting economic growth within the region, and attracting people and businesses to that location (Vickers, 1995; Davies *et al*., 2004). However, liveability indices become problematic when used to compare drastically different regions, such as that in different countries to one another (Lawanson *et al*., 2013). This occurs when the indicators used within a liveability index are not tailored to all regions and are based on what is deemed to be more desirable in one region compared to another (Lawanson *et al*., 2013). Alderton *et al*. (2019, p. 2) argue that "there is limited guidance about what constitutes a liveable city or neighbourhood from a LMIC [low- and middle-income countries] perspective, with most of the evidence relating to high-income country contexts".

This concept of low- to middle-income communities having a different perspective of liveability is repeated by Lawanson *et al*. (2013), who argue that viewing the concept of liveability through the lens of a wealthy western society will unfairly reflect the actual liveability of low to middle-income communities. This concept can be understood by highlighting the indicators used in some studies (Table 2.1), whereby water quality, quality of

healthcare and road quality are used to determine the liveability of Malborne (EIU, 2011; Higgs *et al*., 2019), which, as of 2016 was ranked within the top 20 countries by Gross Domestic Product (GDP; Hawksworth *et al*., 2017). However, in low- to middle-income regions, the quality of healthcare and road infrastructure would be less desirable when compared to access to water and access to healthcare. These minor variations impact the liveability of a region, although definitions of liveability do not bring to light these nuances (Alderton *et al*., 2019). Paul and Sen (2020) take this into account when assessing liveability indices and claim that liveability encompasses human development and community wellbeing, which is based upon the physical and cultural dimensions of cities and regions.

Liveability indices have been used for different purposes and are widely used as tools to inform policy (Giap *et al*., 2014; Higgs *et al*., 2019). The use of indicators that are aligned with specific urban planning practices allows for a thorough evaluation of these practices, enabling future urban planners to make use of this when producing new policies, all in an attempt to encourage the development of healthier, more sustainable cities. Conger (2015, p. 1) disagrees, stating that liveability indices are merely lists that are produced for a specific audience, "but the temptation to use these lists to develop public policy must at all costs be avoided", due to the objective selection and weighting of indicators, and the oversimplified quantification of what makes one place more liveable compared to another when economic, social and political factors vary between cities. The Joint Research Centre-European Commission (2008) argue that liveability indices and indicators cannot always be used to inform policy as there is a high reliance on the quality of the data used to create the indicator; however, if high-quality data is used for a specific location, consistent evaluation and adaption of the policies can be made (OECD and European Union, 2008).

Woolcock (2009) provides a middle ground between the positions of Conger (2015) and Higgs *et al*. (2019), stating that liveability indices should be used in conjunction with peer-reviewed

academic research rather than overshadow it; allowing for high quality studies to be completed that can support the evaluation and adaption of city-specific policies. This concept of city-specific policies accentuates the importance of scale when developing a liveability index, as analysis of many different cities will potentially hinder the policy analysis (Woolcock, 2009). Management of the scale of a liveability index can help inform policy on the quality of life in a specific region, as has been completed in Minna, a city in Nigeria, whereby a city-scale study was completed to identify the satisfaction of residents living environments, the results of which have been used to recommend areas of improvement in the city (Iyanda and Mohit, 2016).

Liveability indices are often thought of as valuable tools to rank the cities in the world and provide an objective opinion on which cities are deemed to be more liveable (Conger, 2015). However, the identification of cities that are deemed highly liveable due to high levels of employment options, and access to quality education and health facilities are also factors that are attractive to migrants, immigrants, and refugees (Paul and Sen, 2020). The city of Vienna had ranked as the best city to live in from 2018 to 2020 (EIU, 2011); however, it has dropped to 12th place as of 2021 (EIU, 2021). Previously topping the EIU liveability index could have resulted in increased migration to Vienna, Goujon and Bauer (2015) argue that one of the challenges faced by the council of Vienna is to safeguard the religious freedoms of migrants; however, the shelters and homes provided has led to segregation, poor social cohesion, and changes in voting preferences, potentially threatening the social and political stability of the city. However, the EIU contradict Goujon and Bauer (2015) and states that the coronavirus pandemic is the cause for Vienna dropping out of the top ten most liveable cities ranking (EIU, 2021).

2.7 Insurance

2.7.1 Location Determinants on Insurance

Location plays a pivotal role in the type of insurance provided by insurance agencies. This can be understood by assessing flood insurance in coastal regions when compared to inland or arid locations (Bellomo *et al*., 1999). Flood insurance is in higher demand in coastal zones due to the higher risk of coastal flooding; furthermore, the type of flood insurance offered is less desirable to inland areas (Landry and Jahan-Parvar, 2011). Fan and Davlasheridze (2016) disagree with Landry and Jahan-Parvar (2011) and state that changes in climate will result in an increase in the intensity of heavy rainfall among most inland regions, potentially resulting in more flood-related hazards, such as landslides and burst dams. The insurance offered to people and businesses differs depending on if the region is considered to be urban or rural (Fang *et al*., 2012). Furthermore, it is likely that business insurance is in higher demand than personal insurance in Central Business Districts (CBD) or industrial areas when compared to suburban areas. Locations that are at higher risk of natural disasters will result in an increase in the uptake of insurance; however, this only occurs when there is a disaster of a similar type in a neighbouring region (Krawczyk *et al*., 2017). Business insurance in CBD's and industrial areas have evolved as the monitoring and awareness of illness and diseases increase; on this, businesses are more likely to make use of sick leave insurance as workers are losing approximately 5% of their contracted work time (Grahn and Stigsdotter, 2003; Henrekson and Persson, 2004).

Similar variations in the use of insurance based on location are brought forward by Michel-Kerjan *et al*. (2015), who states that the purchasing of terrorism insurance rises in urbanised areas as population density increases. However, Bartik (1985) argue that tax variables such as workers' insurance do not have a significant impact on business location. The location that people reside in often dictates their accessibility to essential services such as insurance (Barnett

and Mahul, 2007). This concept is discussed at length by Liu (2004) and Ahmed (2013), who states that there is still a shortage of insurance availability in rural China and rural India. Potential causes for the discrepancies in access and usage of insurance in a rural location are due to the use of traditional insurance instruments, the underdeveloped rural insurance market, high transaction costs, and low daily income (Barnett and Mahul, 2007). The lack of insurance in rural areas is discussed by Schnake-Mahl and Sommers (2017), as they argue that suburban areas are often overlooked, as the percentage of poverty-stricken people living in suburban areas increases, resulting in an increased number of people being unable to have access to and make use of insurance. These fluctuations in insurance prove the importance of location when analysing the insurance market.

2.7.2 Insurance in Suburban Areas

Literature on insurance in suburban areas often focuses on health and life insurance (Cai *et al*., 1998; Schnake-Mahl and Sommers, 2017; Dewanto *et al*., 2020). This pattern of results is expected as the life insurance industry is a widely valued financial product and the value of life insurance policies in 1998 exceeded US$2 trillion (Brown and Goolsbee, 2000). This economic perspective highlights the expansive amount of literature on health and life insurance; while other insurance markets, such as motor, fire and household insurance, are still present, they hold a smaller market share when compared to life and health insurance. Although life insurance has been identified as the largest insurance sector by Brown and Goolsbee (2000), Mills (2009) notes that the worldwide economic losses from weather-related natural disasters were approximately US$130 billion in 2008, with only US$44 billion being insured.

As climate change has been identified as a driver of increasingly heavy rainfall, the likelihood of flood-related insurance claims increases (Cheng *et al*., 2012). This rise in climate-related disasters driven by climate change and the resulting increase in insurance claims poses the most

significant risk to the insurance industry (Mills, 2009; Cheng *et al*., 2012). As the risk of weather-induced insurance claims rises, as does the literature on flooding and insurance, which has focused on coastal regions and the risk they face (Bellomo *et al*., 1999; Bin *et al*., 2008; Fan and Davlasheridze, 2016). Research indicates that over half of the United States of Americas (USA) population reside in coastal regions, often due to the desired access to unique coastal amenities (Bin *et al*., 2008). This rise in the population near coastal regions and the increased risk faced by the population has resulted in concern in the insurance sector, and has led to the introduction of flood insurance programs such as the NFIP in the USA (Michel-Kerjan, 2010; Fan and Davlasheridze, 2016).

The risk of flooding to the insurance sector has resulted in increased acceptance of science and macroeconomic modelling of the risk locations (Mills, 2009). This partnership and acceptance is further explained by Hu *et al*. (2017), whereby a flood risk index is developed to determine the level of risk faced by specific locations within suburban areas. Partnership with the academic community provides detailed information on the level of risk faced by society; Mills (2009) indicates that by understanding the level of risk faced by a community, it allows for insurance companies to adjust their policies and reduce the vulnerability to the risk. Guiller (2017) disagrees with Mills (2009) by stating that risk prevention can be more beneficial, as it can result in less economic loss for insurers; an example of this can be seen in France, whereby insurers can refuse pay-outs if there is no evidence of a risk prevention plan.

2.7.3 Insurance and Liveability Indices

As more people aspire to live in locations deemed more liveable, liveability indices can be used as a source of information on potential risks in these areas. Indicators that identify locations that are at higher risk of crime, accidents or flooding due to rainfall can all be used to inform businesses on risk mitigation and adaption strategies (Xie *et al*., 2019; Cichosz, 2020). These

risk identification indicators will allow for comparison between different locations, informing businesses on what risk they face, as well as informing people on what locations will place them at more risk (Cichosz, 2020). The use of a liveability index that includes indicators that measure road conditions can benefit the insurance industry in regions such as Zimbabwe, whereby thousands of insurance claims have been made due to poor road infrastructure and is seen as a setback to the insurance industry (Eriksson *et al*., 2008; Zikhali, 2017).

With the use of liveability indices, the insurance industry can identify areas with greater attraction for people of a specific age or cultural group, potentially allowing for companies to tailor the insurance advertising and premiums in that area. An example of this would be to use indicators that measure the level of wealth of an area, which can be used to inform insurance agencies of the likelihood of the residents of that area to be able to purchase life insurance, therefore providing information on which locations might require more insurance pay-outs over time (Kumi-Kyereme and Amo-Adjei, 2013). Kabisch *et al*. (2017) disagrees with Kumi-Kyereme and Amo-Adjei (2013), arguing that although measuring the wealth of an area to determine the potential need for life insurance has its uses, regions with higher liveability index scores can be understood as being more resilient and therefore less likely to have a high number of insurance claims.

There is a vast amount of literature on the insurance industry and its many different sectors, as highlighted in the above chapter. Changes in the type of insurance have been identified to be linked with location, as suburban insurance differs from that required within a CBD or industrial area (Michel-Kerjan, 2010; Ahmed, 2013). Health and medical insurance continue to hold the largest economic stake, although climate change is posing the most significant risk to the insurance sector (Brown and Goolsbee, 2000; Mills, 2009). The insurance industry has a significant focus on flood risk and how insurance can assist with reducing how vulnerable people are to this risk; however, arguments have emerged stating that mitigation of the risk is

more important than insuring for the damages after it occurs (Mills, 2009; Guillier, 2017). The partnership with the academic community has allowed for the insurance sector to make informed decisions on what areas face higher risk, and has highlighted the possibility for the insurance sector to make use of a city-specific liveability index (Eriksson *et al*., 2008; Kumi-Kyereme and Amo-Adjei, 2013).

2.8 Conclusion

Indices have been used in different sectors, such as in the medical field (Bartlett *et al*., 2019), the economic sector (Kraay, 2019), the tourism industry (Morgan *et al*., 2000), as well as in the insurance industry (Zikhali, 2017). Liveability indices have been produced to inform policy (Higgs *et al*., 2019), identify areas for redevelopment (Coisson *et al*., 2016), and to inform specific audiences (Conger, 2015). This demonstrates how indices and liveability indices have been used as a tool to inform people, businesses and governments on how to mitigate risk and to identify areas with high potential for growth (VCEC, 2008; Cichosz, 2020). However, little research has been conducted on the benefits of using liveability indices in the insurance industry. This research paper addresses the gap in the literature by analysing the needs of the insurance industry and how liveability indices can potentially be used to fulfil these needs. Producing a liveability index that is a combination of being audience-specific and policy-informing (Conger, 2015; Higgs *et al*., 2019), will allow for the insurance industry to adjust its policies according to the risks present in that location (Kumi-Kyereme and Amo-Adjei, 2013).

CHAPTER 3: STUDY SITE

3.1 Introduction

This study is focused on the liveability of Tshwane based on individuals' proximity to different locations. This chapter describes the geographic location of Tshwane, topographic characteristics, climatic conditions, population statistics, as well as other influences on the liveability in Tshwane, such as; different modes of transport, average commute time, crime statistics, and the number of public facilities and institutions. The chapter will continue with assessing the history of liveability indices in South Africa and Tshwane. The city of Tshwane was founded in 1855 by Marthinus Pretorius, and in 2000 it was merged with the Metsweding District and renamed Tshwane (Magidi and Ahmed, 2022). This study analyses the different suburban areas within Tshwane, a suburban area is defined by the building density, plot size, population density, and lack of agricultural practices (Weeks, 2010; Crawford *et al*., 2011).

3.2 Location and Geography

3.2.1 South Africa

South Africa is located on the southern tip of the African continent and is located between 22-35°S and 17-33°E, and covers an approximate land area of 1,219,602km^2 (Landman *et al*., 2017; Gov, 2022). South Africa has six bordering countries, including Lesotho, Mozambique, Swaziland, Zimbabwe, Namibia and Botswana (Grab and Knight, 2018). There are nine provinces in South Africa: Limpopo, Mpumalanga, Northwest, Gauteng, Northern Cape, Free State, KwaZulu-Natal, Eastern Cape and Western Cape (StatsSA, 2022). South Africa has an approximate population of 60.6 million people, with 17.01 million people below 15 years of age, and 38 million people aged between 15 and 60 years old (StatsSA, 2022). International migration in South Africa has declined since the implementation of COVID-19 travel restrictions, with an 88.8% decline in foreign travellers in 2021 (StatsSA, 2022). Although

there is a 128.9% increase in travellers entering South Africa in 2022 compared to 2021, this is still lower than the number of travellers entering South Africa prior to the COVID-19 restrictions (StatsSA, 2022). Inter-provincial migration in South Africa is still based on pre-COVID-19 statistics; however, this indicates that the Western Cape and Gauteng provinces receive the greatest number of migrants, while the Eastern Cape, Limpopo and Gauteng had the largest number of outflow migrants (StatsSA, 2022).

Transport in South Africa is primarily separated between public and private modes of transport, and as of 2013, over 90% of the population relied on public transport methods (Teffo *et al*., 2019). In 2020 over 54 million South Africans commuted to different locations across all nine provinces, with Gauteng consisting of the largest number of recorded commute trips (StatsSA, 2020). Commuting to education facilities was the primary purpose for travel across South Africa, and commuting to the workplace was the second most common; finally, trips to welfare offices and leisure trips are the least common reasons for travel (StatsSA, 2020). Approximately 17.4 million South Africans walk to their destination, and 10.7 million use public transport, while trains are the least used mode of transport (StatsSA, 2020).

The average commute time to education facilities is dependent on the mode of transport used; those that used trains took approximately 91 minutes to reach their education facility, bus transport averaged 59 minutes, taxi users took 51 minutes, car passengers needed 35 minutes, personal drivers travelled for 41 minutes and finally, those who walked, averaged 29 minutes (StatsSA, 2020). Commute time to the workplace is similar to that of travel to an education facility, with trains averaging 107 minutes, busses taking approximately 84 minutes, taxis travelling for 63 minutes, car passengers needing 49 minutes and private drivers travelling for 44 minutes (StatsSA, 2020). The impact that COVID-19 had on travel in South Africa is significant; it is observed that there was a decrease in mobility coupled with an increase in travel time (Barbieri *et al*., 2021; Dorward *et al*., 2021).

3.2.2 Gauteng

Gauteng is the smallest province in South Africa at 18,178km^2; however, it has the largest population, at over 15 million people (StatsSA, 2022). Limpopo boards the Gauteng province to the north, Mpumalanga to the east, the Free State to the south and the North West province to the west. There are 11 municipalities in Gauteng, including the City of Ekurhuleni, the City of Johannesburg Metropolitan Municipality, the City of Tshwane Metropolitan Municipality, the Emfuleni Local Municipality, the Lesedi Local Municipality, the Merafong Local Municipality, the Midvaal Local Municipality, the Mogale City Local Municipality, the Rand West City Local Municipality, the Seidibeng District Municipality and the West Rand District Municipality (GOV, 2022).

The Gauteng province is projected to gain approximately 1.4 million provincial migrants over the next four years and lose over 600,000 'out-migrants' (StatsSA, 2022). Gauteng has the largest number (28.2%, n=45 million) of transport trips in South Africa, as well as the largest workforce, with 15.5 million people (StatsSA, 2022). Approximately 30-40% of South Africans who own or have access to any type of vehicle reside in Gauteng (StatsSA, 2020). A taxi is the most common form of transport within municipalities, while private vehicles are more commonly used for transport between municipalities (Simpson *et al*., 2012).

3.2.3 Tshwane

The Tshwane Metropolitan Municipality is located at 25º19.5'-25º 56.3'S and from 27º53.25'-28º 27.3'E and has a land area of 6368km^2 (Adeyemi *et al*., 2015; StatsSA, 2022; Figure 3.1). Tshwane has approximately 2.9 million residents who are spread across 107 wards, with 24.3% (n=2.9 million) living in poverty (StatsSA, 2022). Approximately 89.3% (n=2.9 million) of the residents in Tshwane live in urban areas. The City of Tshwane's economy contributed 27% to

Gauteng's GDP and, as a well-established manufacturing centre, contributed 22.2% to South Africa's total exports (StatsSA, 2022). Tshwane has an average annual temperature of 18.7°C, with summer rainfall and annual precipitation of 715mm (Adeyemi *et al*., 2015).

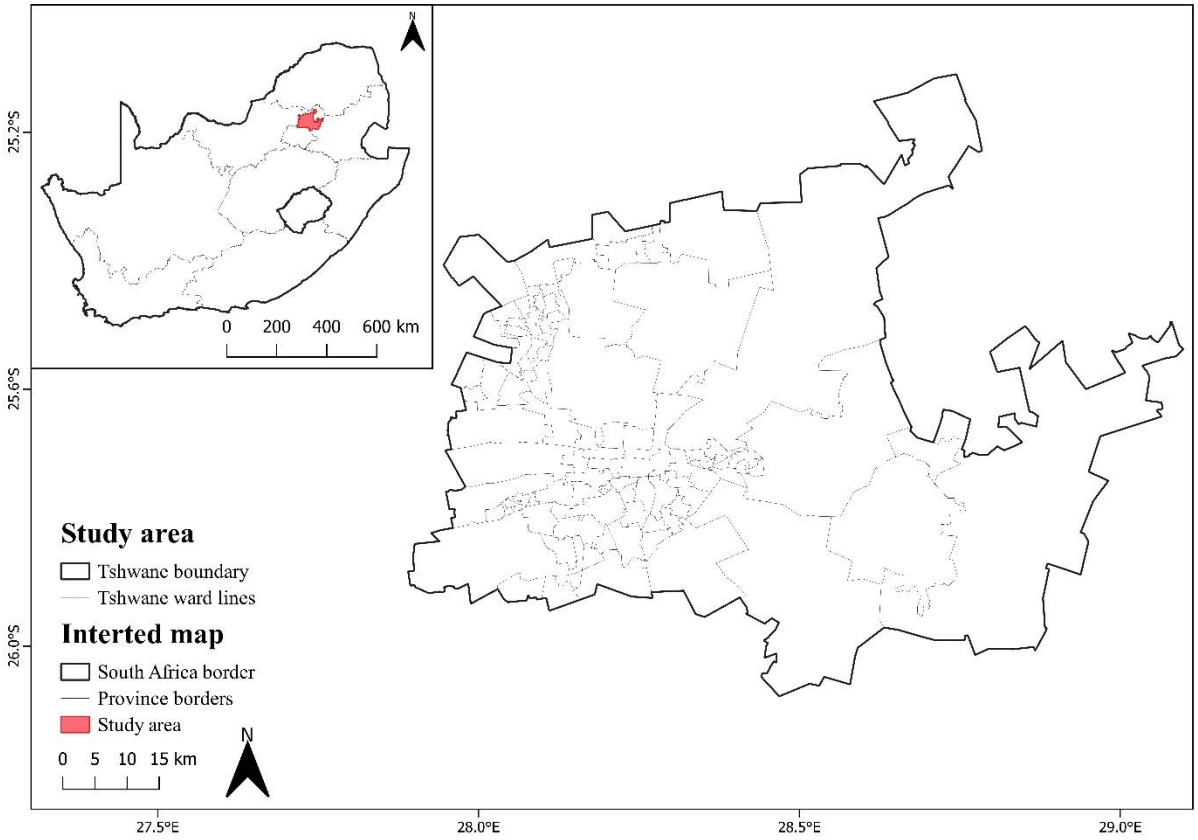


Figure 3.1: Study site of the Tshwane municipality, Gauteng, South Africa.

There are approximately 415 schools in Tshwane (Schools4SA, 2021). As of the latest census, Tshwane had approximately 1.1 million households and three people per household (Tshwane, 2020). The transport sector in Johannesburg and Tshwane is inundated with different modes of transport, including walking, bus, taxi, car and others. As of 2013, Johannesburg saw a total of 3,159,000 modes of transport used by the public, including trains, taxis, buses, and cars, with private car usage being the preferred mode of transport with 1,169,00 recorded uses (van Ryneveld, 2018). Similarly, private car usage was most popular in Tshwane, with a total of

767,000 recorded uses, while a taxi was used approximately 484,000 times (van Ryneveld, 2018).

The average travel time for commuting to work and for education in Johannesburg was 61 minutes in 2013, while Tshwane was three minutes longer at 64 minutes (van Ryneveld, 2018). Distance to and from local transport, which includes trains, busses and taxis, influences thousands of people's transport opportunities, as approximately 8% of the population in Johannesburg in 2011 claimed that it is too far (Joburg, 2013). Similar findings indicate that approximately 30% of people are dissatisfied with the distance they have to travel to find public transport in Johannesburg, and in Tshwane, 33.9% were unhappy with the distance in 2013 (van Ryneveld, 2018).

3.3 Liveability Indices in Tshwane and Characteristics of Indicators

Liveability indices have been developed across South Africa (Peres *et al*., 2017; Africa.com, 2020). With specific reports being developed for the City of Tshwane (Dallimore *et al*., 2021). These Tshwane specific liveability indices have been adapted to focus on measuring and improving the built environment, in order to better improve the liveability of the city. There are approximately 1050 schools in Tshwane that have been separated into seven categories; pre-primary, primary, secondary, tertiary, after-schools, day-cares and assisted learning facilities (DoE, 2022). The retail sector in Tshwane is growing rapidly, with new shopping locations being planned and implemented in an attempt to increase trade and retail by 20% (Tshwane 2004, 2006). Tshwane has approximately 247 retail facilities, which include malls, plazas, standalone shops and second-hand dealers. (Tshwane 2022).

Tshwane offers over 18 municipal nature reserves and resorts as well as several other smaller city parks for public use (Tshwane, 2022). Schoolchildren use parks and open spaces in

Tshwane for after-school extramural activities and sports, as well as for sports such as soccer on the weekends; some parks in Tshwane also have playground equipment for children (Makakavhule and Landman, 2020). The city of Tshwane also boasts 26 swimming pools for public use (Tshwane, 2022). Points of Interest (PoI) in Tshwane range from museums and art galleries to heritage sites. There are approximately 15 museums in Tshwane, 38 art galleries and 22 heritage sites (Tshwane, 2022).

Municipal institutions in Tshwane included in this research study are police and healthcare facilities. Approximately 24% of Tshwane has no medical insurance (DoH, 2011). There are five categories of healthcare facilities in Tshwane, one regional hospital, five district hospitals, eight community health centres, 68 clinics and three satellite units (DoH, 2011). An average travel time to a clinic in Tshwane is 30 minutes or less, which equates to approximately 5km, with taxis being the average mode of transport (Nteta *et al*., 2010). Comparatively, there are 33 police stations in Tshwane (Tshwane, 2022), potentially resulting in increased levels of community dissatisfaction, and over 220,000 contact crimes, including murders, rapes and assaults in Tshwane between 2002 and 2006 (Breetzke, 2010; Masogo *et al*., 2014).

The Tshwane road network is plagued with poor stormwater management, unpaved roads and a lack of sidewalks (Tshwane 2017). There is approximately 8600km of road network in Tshwane, of which only 2300km are covered by public transport methods (Pienaar *et al*., 2007). There are three classifications of roads in Tshwane, which encompass 25 road categories (Ross and Townshend, 2018).

CHAPTER 4: METHODOLOGY

4.1 Introduction

The overarching aim of this study is to produce a liveability index for suburbs in Tshwane, which can be used to inform insurance practices on the potential risk faced by people residing in these areas. In order to achieve this aim, a mixed methods approach was used throughout this study; this combined approach allowed for high-quality analysis of hundreds of locations throughout Tshwane. This section will build on the work of Onnom *et al*. (2018) and their liveability index for the Khon Kaen District in Thailand. Their liveability index made use of a Geographic Information System (GIS) to map their findings (Onnom *et al*., 2018).

The following section will outline the techniques used to determine the liveability of Tshwane. The acquisition of data will be discussed, after which, information on the classification of data will be described. An investigation into the questionnaire follows this. The section will finalise with a description of the approach used to produce the final composite liveability map.

4.2 Acquisition of Data

Liveability indices are produced for different reasons; however, they all require location-specific information in order to make informed decisions on the perceived level of the liveability of that region (Onnom *et al*., 2018; Higgs *et al*., 2019; Dallimore *et al*., 2021; EIU, 2021). The quality of the liveability index is often reliant on the data used throughout the study (Conger, 2015), highlighting the need for relevant and updated information. Given the need for updated, accurate and relevant data, this study gathered data from several different sources. Point location data was provided by RiskScape (a Big Data solutions service); this included the location of parks, education facilities, hospitals, police stations, retail facilities and points of interest. Climatological data was provided by the South African Weather Service (SAWS),

which included the location of weather stations in Tshwane, the average annual temperature, and the annual rainfall. The location of major roads and road classification in Tshwane was provided by the City of Tshwane. This information was then analysed and used in the production of liveability maps. Questionnaires were used to gather information on the residents' perspectives of Tshwane and allowed for comparison to the produced maps, greater detail on this process is discussed in further chapters.

4.3 Production of Maps

In order to display the perceived liveability of Tshwane, maps were produced to identify the locations with varying levels of liveability for each indicator (Table 4.1). The maps are produced individually based on the available data and the required buffer distances, all maps have the same WGS84 projection and scale. Literature analysis of each indicator was used to determine the global average for each buffer and compared against the South African standards. The subsequent produced buffer distances were based off averages used throughout other indices or where specified by South African institutions.

Table 4.1: Table demonstrating the indicators used in this study, their buffer distance or display range, and reasoning for range selection. Some rainfall data is gathered from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS).

Indicator		Database	Buffer distance			Reasoning
			Good	Average	Poor	
Schools	Pre-primary	RiskScape	<5	5-15	>15	The average proximity to all education facilities has been based on the South African government-specified school
	Primary	RiskScape	<5	5-15	>15	
	Secondary	RiskScape	<5	5-15	>15	

	Combined	RiskScape	<5	5-15	>15	catchment areas. Good and poor access to education facilities has been based on international literature on the distances travelled to school (van Dyck *et al*., 2010; D'Haese *et al*., 2011).
	Universities	RiskScape	<5	5-15	>15	
Hospitals		RiskScape	<6	6-20	>20	The ideal distance to a hospital was based on cardiac arrest survivability as well as other international liveability indices (Onnom *et al*., 2018).
Police stations		RiskScape	<3	3-5	>5	Proximity to police stations has been mapped using questionnaire responses as well as what has been identified in the literature, which finds that close proximity to police stations can potentially reduce crime (Fondevila *et al*., 2021).
Points of Interest	Other	RiskScape	<0.5	0.5-10	>10	Points of interest are understood as increasing liveability, the literature uncovers that an ideal range to points of interest is between 1-3km, which has been used as a guideline for the buffers used in this study (Davern *et al*., 2017; Jeuring and Haartsen, 2017; Higgs *et al*., 2019).
	Golf courses	RiskScape	<5	5-15	>15	Proximity to a golf course has been based on the need to transport sporting equipment which results in the inability to walk to these facilities, therefore, as transport to golf courses is predominantly completed with the use of

						a car, the buffer zones are similar to that of education facilities.
Major roads		RiskScape	>0.15	0.09-0.15	<0.09	Literature finds that being within 0.15km from a road increases the health and crime risk (Venn *et al.*, 2001; Reid *et al*., 2014), based on this, this study has ranked proximity to major roads as a negative influence on liveability.
Retail facilities	Convenience	RiskScape	<1	1-1.5	>1.5	The buffers used for proximity to retail facilities have been provided by the South African Council of Shopping Centres (SACSC) and describe the average distance to each category of shop in this study (Prinsloo, 2016). Ideal and too far to travel to retail facilities has been based on other liveability indices and literature (Coveney and O'Dwyer, 2009; Onnom *et al*., 2018).
	Neighbourhood	RiskScape	<1.5	1.5-2	>2	
	Community	RiskScape	<2.5	2.5-3	>3	
	Small regional	RiskScape	<3	3-5	>5	
	Regional	RiskScape	<5	5-8	>8	
	Super regional	RiskScape	<7	7-10	>10	
	Value centre	RiskScape	<5	5-8	>8	
	Shopping centres	RiskScape	<3	3-5	>5	
	Bix Box	RiskScape	<5	5-8	>8	
Precipitation		SAWS	Precipitation scale			Precipitation levels are displayed to highlight potential differences between datasets. Precipitation levels have not been ranked on their influence on liveability as they are dependent on a person's needs and perspectives.
Precipitation		RiskScape				
Precipitation		CHIRPS				
Avera	Maximum	SAWS	Temperature scale			

	Minimum	SAWS		Average temperature scales have been displayed to determine locations with higher and lower temperature ranges. Good and bad influence on liveability has not been mapped.
Risk	Fire risk	RiskScape	Low to high scale	Fire risk in Tshwane has been calculated in the density of thatch houses per suburb. Areas with increased thatch house density have increased fire risk.
	Flood risk	RiskScape	Low to high scale	Flood risk has been based on water ponding information. Locations with a higher likelihood of water ponding have been identified as at higher risk of flooding.
Slope aspect		RiskScape	Aspect	The slope aspect has been displayed however does not differentiate between good and bad slope aspects as this is based on personal preferences.

4.4 Questionnaires

Questionnaires were used to gather information on the individual perspectives of Tshwane residents and their perceptions of liveability in Tshwane. Electronic questionnaires allowed for a larger portion of Tshwane to partake, as well as simplified the data collection process through the use of Google Forms (McPeake *et al*., 2014). Google Forms was used due to it being inexpensive, easily accessible, provides aesthetically pleasing questionnaires and displays the final results in a practical and convenient way (Bondarchuk *et al*., 2020; Google, 2022). The questionnaire response data sheet was exported for analysis. Previous liveability indices have

made use of survey and questionnaire data to determine commute distances or location-specific perspectives and preferences (Higgs *et al*., 2019; Dallimore *et al*., 2021).

Electronic questionnaires were distributed via social media to Tshwane residents between March 2022 and July 2022. Questionnaires were also posted on social media sites, Facebook, LinkedIn, and Instagram. This technique was used to mitigate the potential for data-capturing errors. Electronic questionnaires shared via online social media platforms were perceived to have the greatest potential to reach a larger audience in Tshwane (Wesley *et al*., 2022). However, approximately three months into the distribution of the questionnaire, there was a significant decline in the response rate despite the questionnaire being reposted. Subsequently, the researcher travelled to Tshwane to administer the questionnaire in hard copy in public spaces. This process was undertaken to reach new potential audiences and resulted in successfully reaching the desired number of responses. There was a total of 30 online responses and 20 responses captured in person.

Questionnaires were produced using Google Forms software as this platform allowed for multiple-choice, Likert scale, open-ended and closed questions to be developed. The opening section of the questionnaire was used to determine the demographic of the responder, after which there were several sections pertaining to the indicators used in the study (Appendix C). The questionnaire continued with a Likert scale to gather liveability preferences from the respondents before concluding with open-ended questions used to determine the respondent's perspectives on liveability and insurance (Appendix C).

4.5 Questionnaire Analysis

4.5.1 Quantitative Analysis

After the desired number of questionnaire respondents had been reached and the questionnaires administered in person were digitised, the responses were analysed. Responses were exported from Google Forms to Excel as it allowed for more in-depth analysis and production of figures and tables. Responses for each question were analysed, and graphs were developed for the closed questions. Closed-ended and multiple-choice questions allowed responses to be categorised and classified, resulting in the production of graphs that display the preferences of the residents in Tshwane (Patel *et al*., 2020). Likert-scale questions used within this questionnaire uncover what respondents believe influences their liveability the most. Several Likert scales provided the grounds for ranking the indicators used in this study. Respondent's identification of ideal travel distances ware collated and displayed within graphs. Questionnaire responses were grouped and assigned percentages, allowing for further analysis of the perceived ideal travel distances to facilities in Tshwane.

4.5.2 Qualitative Thematic Analysis.

Thematic analysis coupled with quantitative analysis is an invaluable tool in determining patterns within data and elucidating the potential reasons for questionnaire responses. Open-ended questions provided insight into the thoughts of the Tshwane residents. This information was analysed, and themes were uncovered, subsequently allowing for a comparative analysis of the wards in Tshwane that are perceived to have high and low levels of liveability, as well as uncovering what influences the perceived liveability of these wards (Kiger and Varpio 2020).

4.6 Ethical Compliance

Ethical clearance for the distribution of research questionnaires was attained through the University of the Witwatersrand. Participants were informed on the details of the research study and the manner in which their responses would be used (Appendix C). Questionnaire respondents provided consent to participate in the study by selecting the appropriate box (Appendix C). The information was stored on a safe and secure computer and destroyed after one year. There was no incentive for the questionnaire, and respondents were able to end the questionnaire at any moment without reasoning.

4.7 Integration of Questionnaire Responses and Produced Maps

The final composite liveability map for Tshwane required the completion of all other individual maps as well as for the desired number of questionnaire responses to be reached. The individual map data was organised, and an analytical hierarchy process was implemented to allow for comparison between different factors and for a weighting system to be implemented (Onnom *et al*., 2018; Figure 4.1).

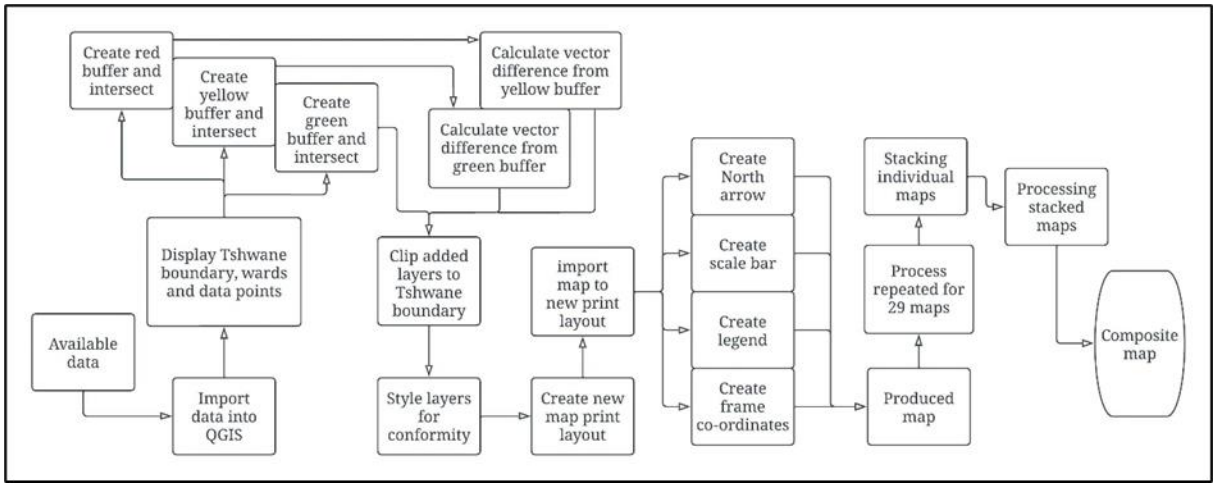


Figure 4.1: Flow diagram demonstrating the process used to develop individual maps and composite liveability maps.

4.8 Conclusion

The study aims to develop a liveability index for Tshwane, that can be used to inform insurance practices about the risk faced by people within the region. A mixed methods approach was used to develop this index, incorporating qualitative thematic analysis with quantitative analysis. The location of critical facilities in Tshwane and climatic information were provided by RiskScape, the SAWS and the City of Tshwane. The data was processed and used to produce several maps that display location-specific information. Simultaneously, questionnaires were distributed online through social media platforms and in person. Questionnaire responses were analysed to provide a greater understanding of liveability in Tshwane, subsequently allowing for a comprehensive liveability map to be produced. Due to the nature of liveability indices and the potential to include many different variables, there will always be additional indicators that are not included. This study did not include crime and service delivery due to scope limitations.

CHAPTER 5: RESULTS

5.1 Introduction

This research has analysed several aspects that influence liveability in Tshwane. Mapping these aspects allows for one to determine what locations have higher levels of liveability. Proximity to schools, parks, healthcare facilities, police stations, points of interest, major roads, and retail facilities have been mapped and analysed on their distribution and availability across Tshwane. Climatological aspects of Tshwane, including annual rainfall and average maximum and minimum temperatures, have also been mapped and analysed for their impact on liveability. The slope aspect, flood risk and fire risk are mapped and discussed. Finally, questionnaire results have been displayed and analysed against the produced maps. Mapping and analysing proximity-based information and questionnaire responses will allow this research paper to better inform insurance agencies about the potential risk they face in Tshwane.

5.2 Proximity to Schools

Education facilities have been divided into pre-primary, primary, secondary, combined, and universities. Proximity to schools has been deemed desirable in this research, given the average age of residents in Tshwane and the subsequent need for schooling. Proximity to an education facility has been measured in a radius surrounding the school point. A distance of 5km is identified as the ideal travel distance to all education facilities. At the same time, 5-15km are considered moderately acceptable, and over 15km is too far to travel to an educational facility. The RiskScape database records only two pre-primary schools in Tshwane (Figure 5.1).

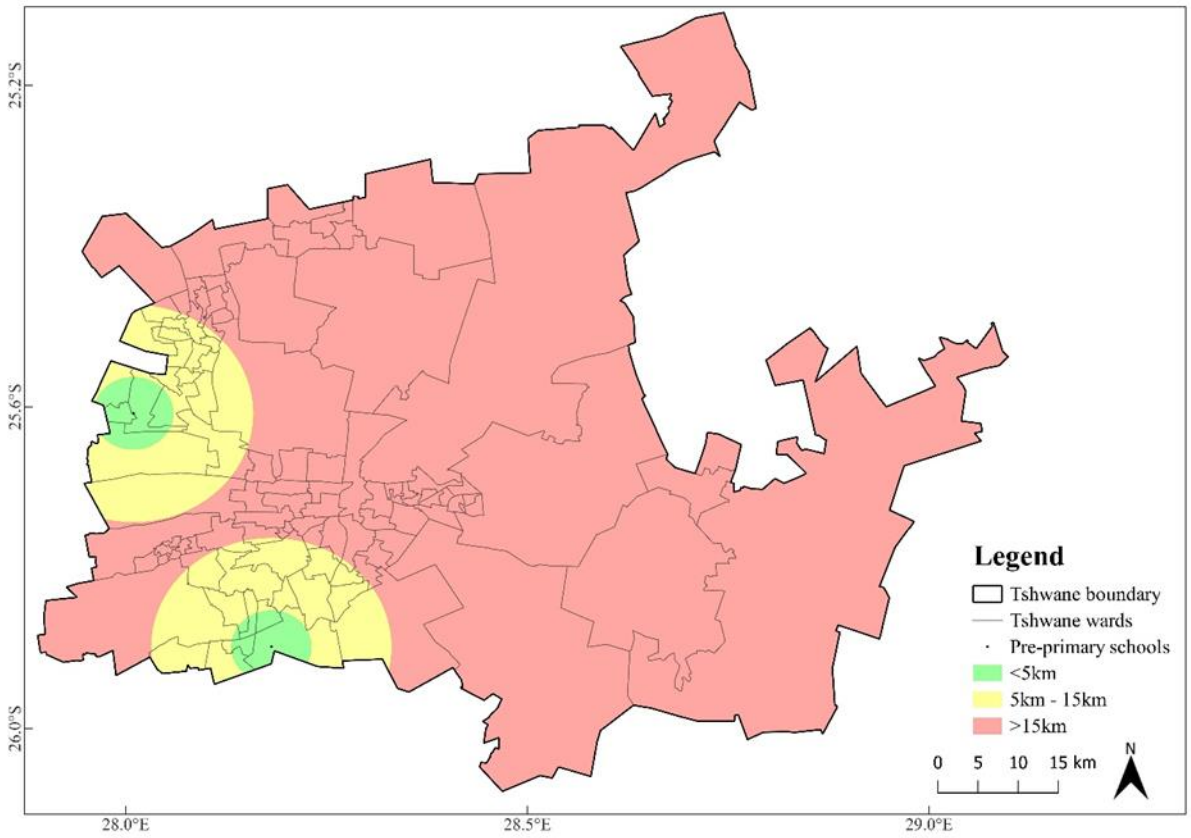


Figure 5.1: The location of pre-primary schools in Tshwane and surrounding distance buffers.

The RiskScape pre-primary school database is considered incomplete, with no complete dataset available. However, other lists of pre-primary schools are available after an online search (Table 5.1), although they do not contain the two pre-primary schools listed in the RiskScape database (AfricanAdvice, 2022). The RiskScape database is incomplete due to it still being under development. Although there are only two pre-primary schools in the RiskScape database, this was used to maintain consistency throughout the index.

Table 5.1: List of pre-primary schools in Tshwane (AfricanAdvice, 2022).

Pre-primary schools			
1	Playgroup & Pre-School Assn Of Pretoria	38	Glen Play Centre & Pre-primary School
2	Monument Park Nursery School And Creche	39	Whiz Kidz Academy Nursery School & Creche
3	Dwergieland Nursery School	40	Bonthuis Nursery School
4	Bennie Boeekwurm Kiddies Campus	41	Constantiapark Kleuterskool
5	Hennie Pen Kleuterskool	42	Sprokieland Kleuterskool
6	Millennium Montessori Kids Bk	43	Akasia Kleuterskool
7	Kleutervreugde Nursery School	44	T L C Kiddie Centre
8	Kleuterskool Katjiepiering	45	Trippe-trap Pre-primary School
9	Tomorrow's People Nursery School	46	Woelwater Kleuterskool
10	Soenetjie Kleuterskool	47	Babbelbekkie Kleuterskool
11	Happy Hours Nursery School	48	Verfkwassie Nursery School
12	Kleuterskool Zonkie Montessori	49	Kleuterskool Kwaggasrand
13	Silver Stars Pre-school	50	St John Fisher Pre-primary & Day Care
14	Doornrosie Kleuterskool	51	Hompie Kedompie Kleuterskool
15	Floralise Pre School	52	Enoch Nursery School
16	Woelieland Playgroup	53	Meyerspark Kleuterskool
17	Snoetjies En Sproetjies	54	Kleuterskool Blommeland
18	Canny Kids Nursery School	55	Kleuterskool Capital Park
19	Higlands Kids Nursery School	56	Tshwane Nursery School
20	Woolly Rabbit Nursery School	57	Woelbos Kleuterskool
21	Montessori Morning Star	58	Kiddies Academy Nursery School
22	Sunnyside Pre-primary School	59	St George's Pre-school
23	Hatfield Montessori Preschool	60	Tiggywinklers Nursery School
24	Morsjorsies Kleuterskool	61	Eastern Suburb Nursery School
25	Die Babelbekkies Kleuter Klassie	62	Vrolike Viooltjie
26	Knikkie Knakkie Nursery School and Day Centre	63	Noddyland Creche & Nursery School
27	Montessori Pre-school (shere)	64	Heeltyd Speeltyd
28	Kleuterskool Doring And Rosie	65	Kleuterkasteel
29	Heeltyd Speeltyd Kleuterakademie	66	Speelkasteel Kleuterskool
30	Little Village Christian Nursery School	67	Dawie Kabouter Kleuterskool
31	Drie Beertjies Kleuterskool	68	Woeligewerkers Kleuterskool
32	Maja Kleuterskool	69	Kleuterskool Kokkewiet Kokkedoor
33	Pierneef Kleuter Akademie	70	Kleuter Paraydys - Kleuter & Bewaar Eenheid
34	Kleuterskool Snipper - Snip	71	Tomorrow's People Kleuterskool
35	Kiddo Kleuterskool	72	Crayon Kids
36	Smiley Kids	73	Nursery School Tinky Winky
37	Wonderboom Suid Klueter	74	Onderstepoort Kleuterskool

Pre-primary schools, also known as grade R, accommodate children ages between four and six. The pre-primary schools are found in the west and southwest corners of Tshwane. Approximately 133km^2 of Tshwane is within 5km of a pre-primary school, 746km^2 is between 5-15km, and 5420km^2 is located over 15km from a pre-primary school (Figure 5.1). The pre-primary schools are located in Tshwane's western and southwestern regions (Figure 5.1). Although only two pre-primary schools are identified within the RiskScape database, primary schools and combined schools could potentially offer grade R and would, therefore, not appear on this map. Secondly, if a pre-primary school falls outside the Tshwane boundary, it would not be included in this map, indicating that there could still be pre-primary schools available to the Tshwane residents not shown on this map.

There are 396 primary schools found in Tshwane, as indicated by the RiskScape database, which is the greatest number of schools found in this research (Figure 5.2). Primary school students are typically between five to six years of age when they join a primary school in grade one and usually complete grade seven aged between 12 and 13. The primary schools in Tshwane are primarily located in the northwest and central to western regions. However, there are approximately 21 schools found in the eastern sector of Tshwane. There are 41 schools found in Mamelodi, which is centrally positioned in Tshwane, 15 are located in the southwest district of Atteridgeville, and 118 are found in the northwest in Soshanguve (51), Mabopane (21), Winterveld (15) and Hammanskraal (31). Approximately 3478km^2 of Tshwane is within 5km of a primary school, as indicated by the green buffer zone (Figure 5.2). While 2303km^2 is 5-15km away, only 516km^2 is situated more than 15km from a primary school.

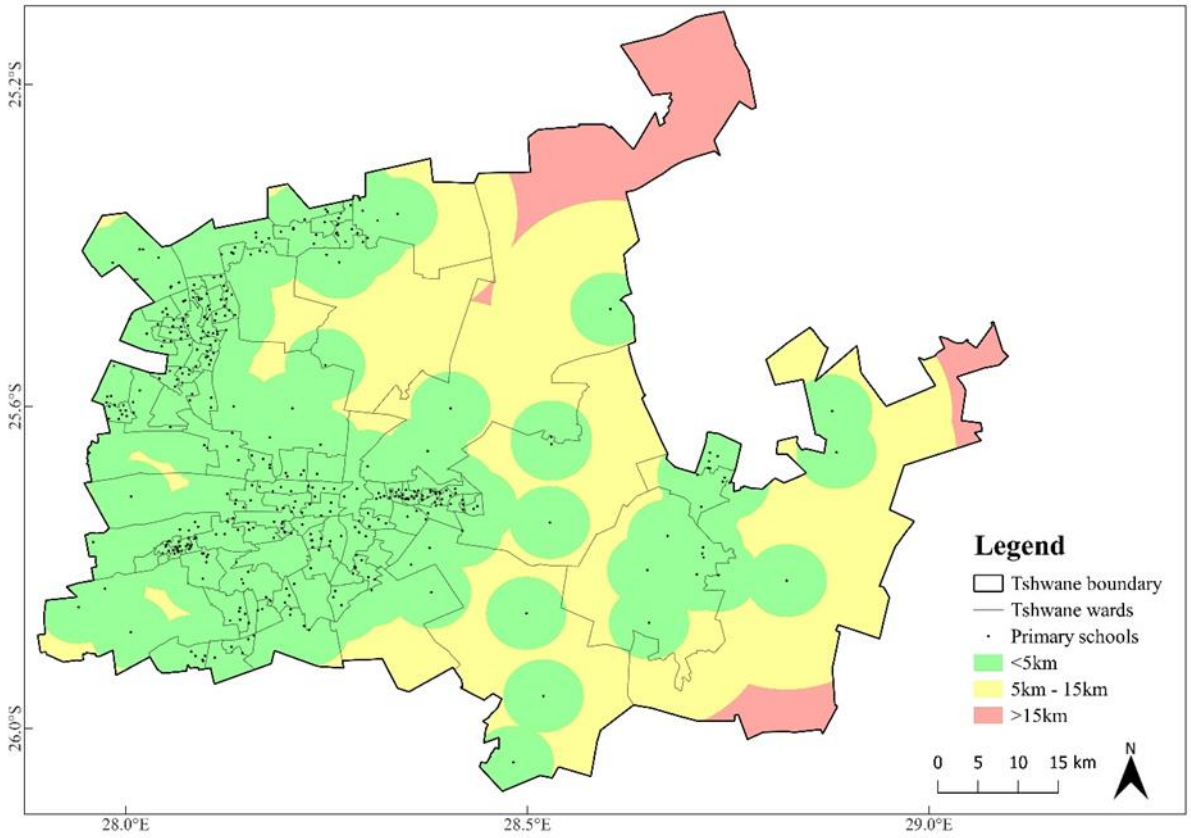


Figure 5.2: The location of primary schools in Tshwane and surrounding distance buffers.

Secondary schools, also known as high schools, start from grade eight, whereby the students are usually aged between 13 and 14 and ideally complete grade 12 aged 18 to 19. Secondary schools are the second most common school in Tshwane, according to the RiskScape database, with over 191 recorded campuses (Figure 5.3). The coverage of secondary schools is similar to that of primary schools, with few schools located in the east and a more significant number of campuses found in the central and northwest of the municipality (Figure 5.3). There are 11 secondary schools identified in the east of Tshwane, while central Mamelodi has 16 secondary schools. Patterns emerge in the northwest of Tshwane, whereby Soshanguve has 21 secondary schools, Mabopane contains nine, Winterveld also has nine, and Hammanskraal has 17 secondary schools. Although the secondary schools found in Tshwane are in similar suburbs

compared to primary schools, there are differences in the feeder areas for these secondary schools. Approximately 1605km^2 of Tshwane is located within 5km of a secondary school, and 2729km^2 is found between 5-15km away (Figure 5.3). Finally, 1129km^2 is positioned over 15km from a secondary school (Figure 5.3).

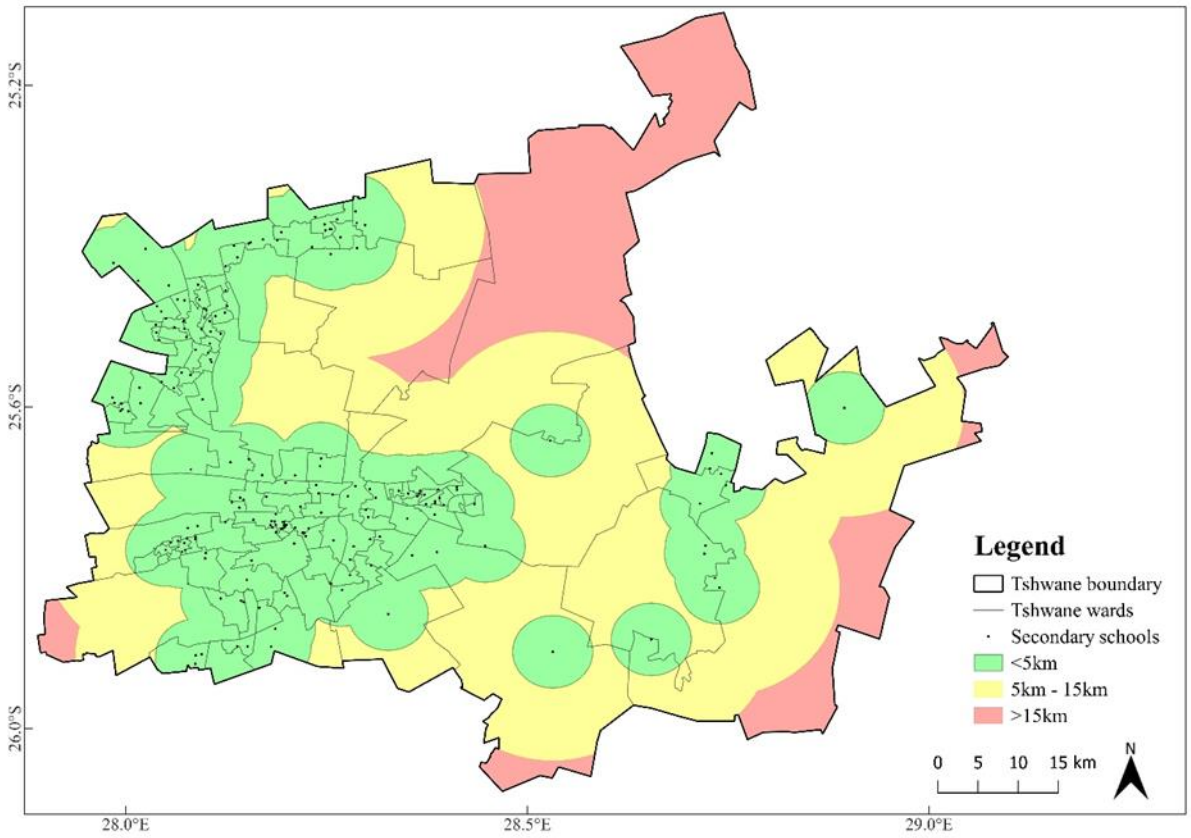


Figure 5.3: The location of secondary schools in Tshwane and surrounding distance buffers.

Combined schools in Tshwane are a combination of primary and secondary schools and are commonly found in central Tshwane (Figure 5.4). The RiskScape database identifies approximately 80 combined schools in Tshwane (Figure 5.4). Laudium contains the greatest number of combined schools and is situated in the southwest corner of Tshwane, while the greatest concentration of combined schools is found in central Tshwane between Berea Park, Arcadia, and Pretoria (Figure 5.4). Combined schools have approximately 1605km^2 of

Tshwane located within 5km and 2352km^2 between 5-15km, making these education facilities the third most accessible in Tshwane, even though there is 2341km^2 of Tshwane that is over 15km from a combined school (Figure 5.4).

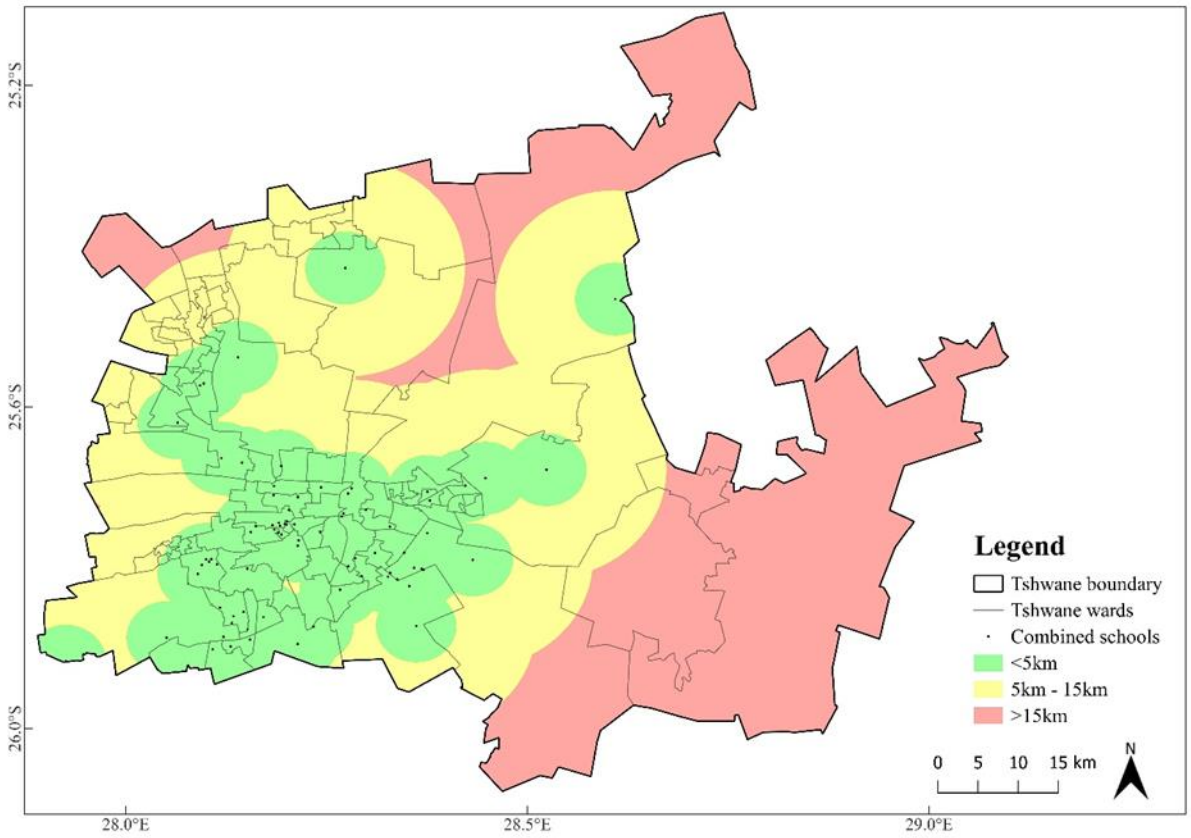


Figure 5.4: The location of combined schools in Tshwane and surrounding distance buffers.

Merging the pre-primary, primary, secondary and combined schools' maps identifies the locations in Tshwane with good, moderate and poor access to education facilities (Figure 5.5). There is approximately 3744km^2 of Tshwane that is within 5km of a school. This zone is mainly in the central to western and northwest of Tshwane. Tshwane has approximately 2084km^2 between 5-15km from all schools and only 470km^2 that is over 15km from all schools and is situated in the upper northeast, east, and southeast of the map (Figure 5.5).

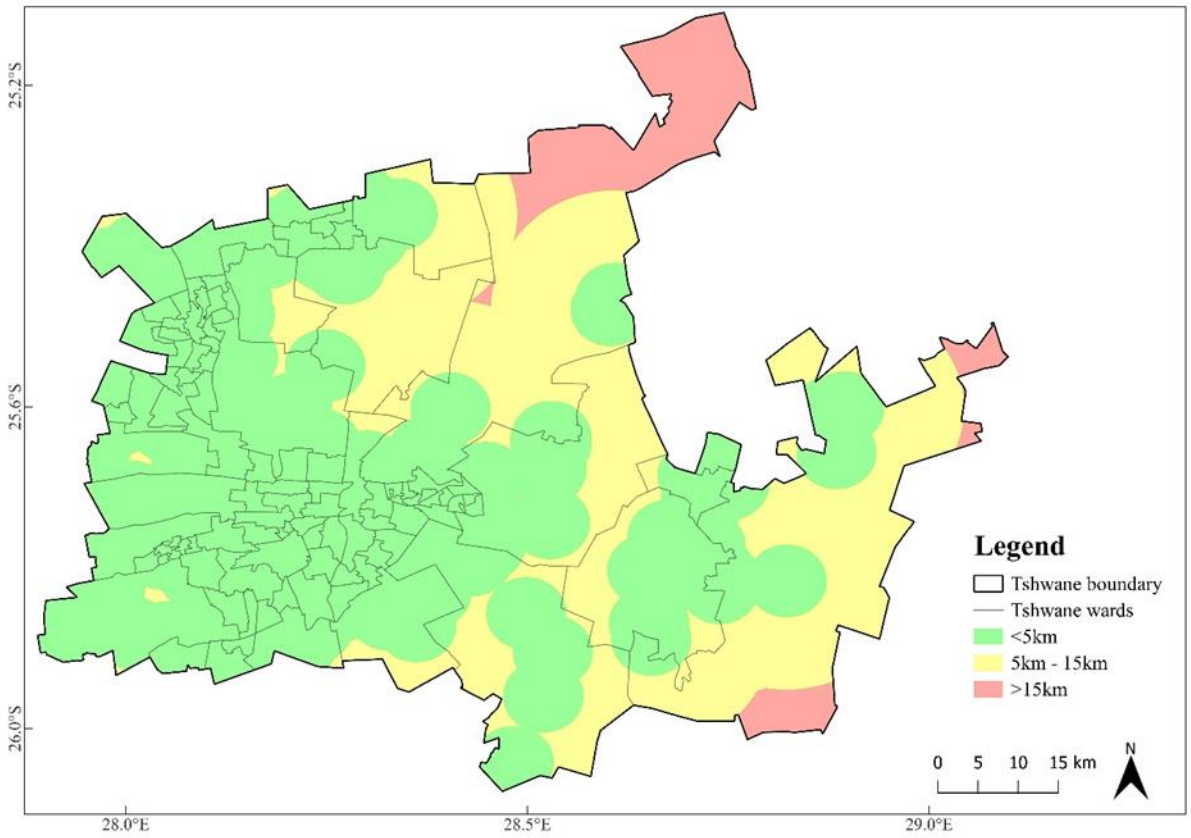


Figure 5.5: The location of all schools in Tshwane and surrounding distance buffers.

Three universities are identified by the RiskScape database, all of which are situated within a 9km^2 area around central Pretoria (Figure 5.6). The universities have a similar green catchment area of 5km that designates those with good access to a university, a 5-15km yellow buffer that identifies moderate access and over 15km in red to indicate poor access (Figure 5.6). Approximately 163km^2 of Tshwane is within 5km of a university, and 795km^2 is between 5-15km away. Universities have the largest area with poor access, as 5340km^2 of Tshwane is over 15km from a university (Figure 5.6).

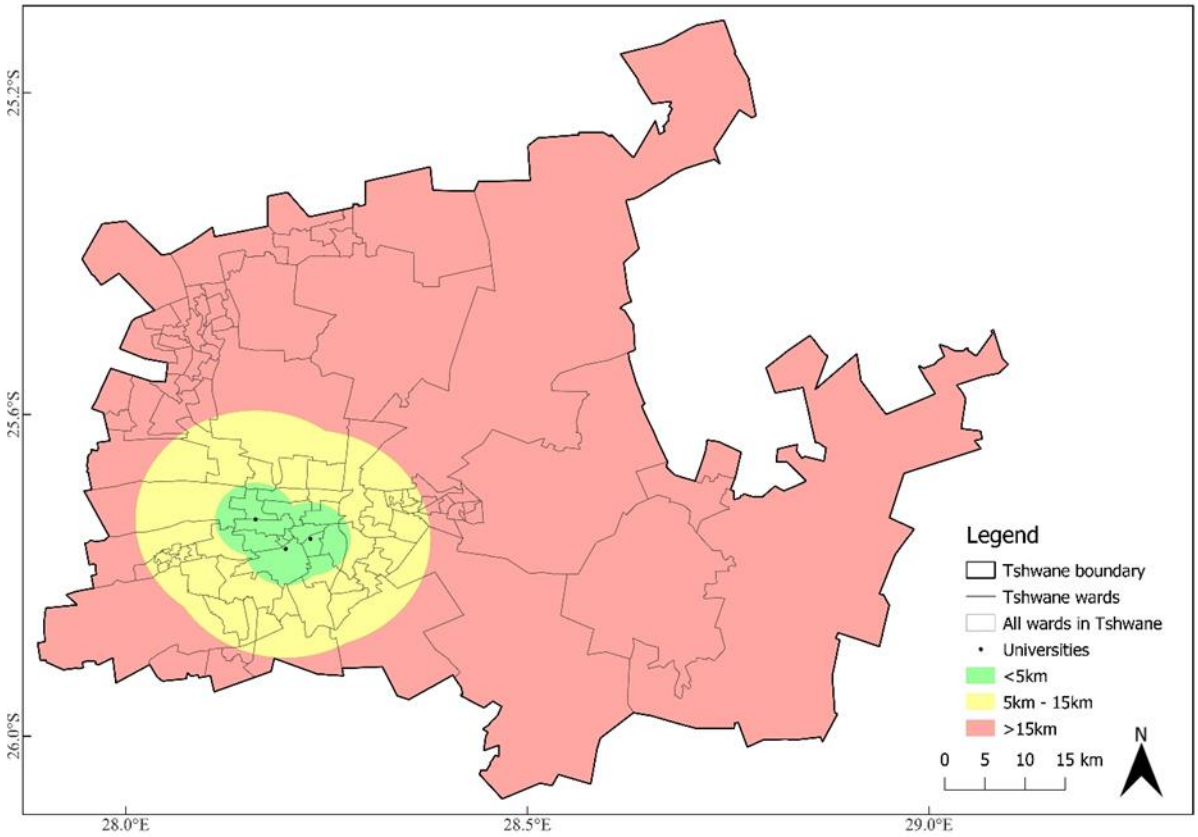


Figure 5.6: The location of universities in Tshwane and surrounding distance buffers

5.3 Proximity to Parks

Parks have been identified as positively influencing liveability in Tshwane due to their use by residents for relaxation and exercise. It is therefore essential for residents to be located close to a park or open space as it is more convenient and provides easy access. The RiskScape database identified that there are a total of 24 parks in Tshwane, which cover an area of approximately 120km^2; however, there are two parks found outside the north-eastern border of Tshwane (Figure 5.7). The parks were analysed for the area they covered to determine the catchment area based on each park's size. There are 17 parks under 5km^2, four between 5km^2 and 50km^2, and three above 50km^2. All of the parks have been allocated a light green 0.5km walking buffer. Approximately 108km^2 of Tshwane is within 0.5km of a park. Parks under 5km^2 in size have a light green catchment area of under 0.5km, a yellow area between 0.5-5km and a red zone

indicating that it is over 5km to access these specific parks. Parks with an area of between 5km^2 and 50km^2 also have a light green catchment area of 0.5km, while the yellow area spans from 0.5-10km around the park and a red zone indicating poor access to a park is over 10km. Finally, parks with an area larger than 50km^2 have a 0.5km light green walking buffer, a yellow catchment area between 0.5-15km, and a red zone greater than 15km (Figure 5.7).

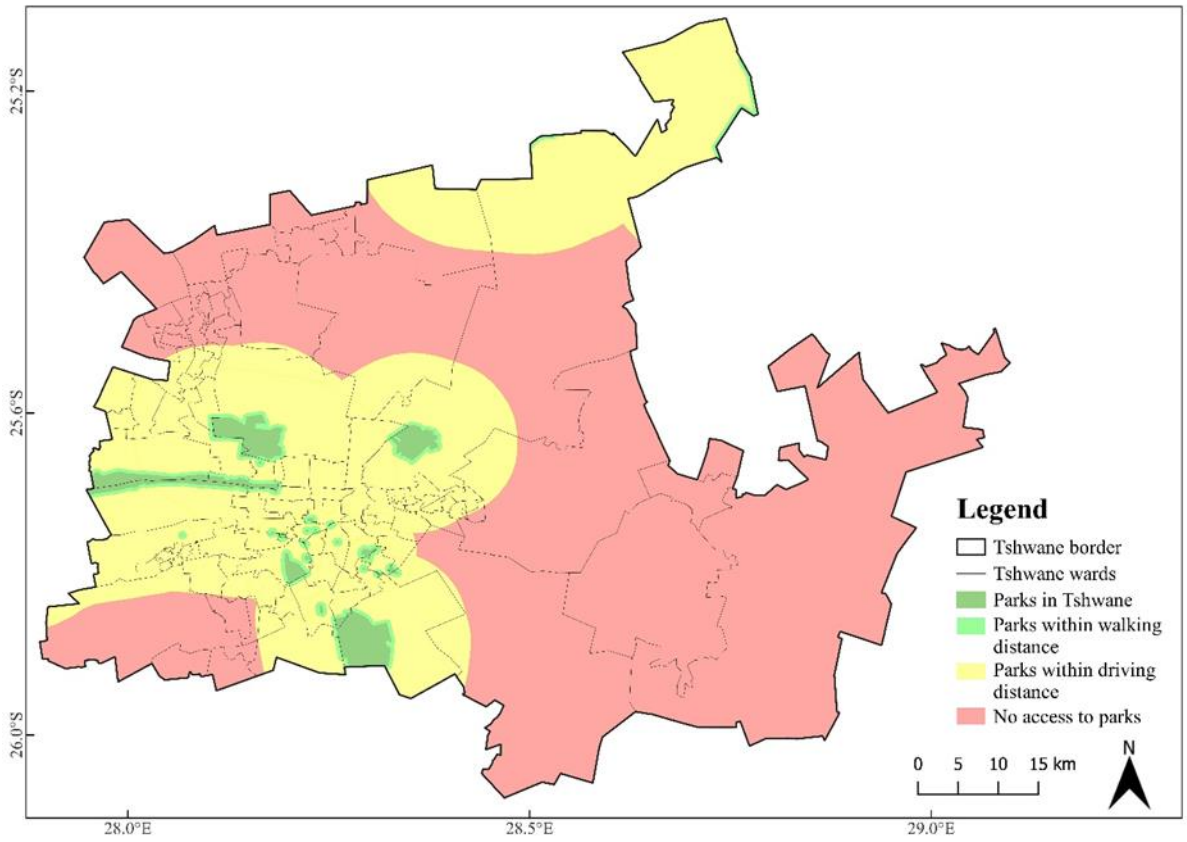


Figure 5.7: The location of parks in Tshwane and surrounding distance buffers.

Many parks are located in the central to southern regions of Tshwane. Approximately 16 small parks (under 5km^2) are found in a 116km^2 area in central Tshwane (Figure 5.7). In comparison, the medium sized parks are found in the southern, central and western sectors of Tshwane. Only one of the three largest parks is within the Tshwane border and stretches inward from the western border. The other two large parks are located outside of Tshwane towards the northeast

of the municipality; however, the 0.5km green zone and 0.5-15km yellow zone fall within the Tshwane boundary, therefore allowing Tshwane residents the same level of access. There is approximately 2215km^2 of Tshwane that is located within the yellow park catchment areas, highlighting that a large portion of the municipality has average access to a park. However, a larger area of Tshwane is located within the red catchment area that spans 3854km^2. The areas with poor access to parks are located in the southeast corner, eastern section, northwest corner, and above central Tshwane (Figure 5.7).

5.4 Proximity to Municipal Institutions

5.4.1 Hospitals

Several government and private healthcare facilities are located across Tshwane, as identified by the RiskScape database. Proximity to healthcare facilities is understood as increasing the liveability of that area due to the convenience when in emergencies. There are approximately nine government healthcare facilities in Tshwane and 40 private healthcare institutions (Figure 5.8). Private healthcare facilities are situated centrally and southwest in Tshwane and are located in and around Pretoria central (Figure 5.8). Four hospitals are identified in northwest Tshwane, with two hospitals found in Soshanguve, one in Mabopane and one in Ga-Rankuwa. No private hospitals are located in Tshwane's east, southeast and northern territories. Government healthcare facilities are less common in Tshwane but are more spread across the municipality (Figure 5.8). Three healthcare facilities are found in the northwest regions of Tshwane, one in the more northern Themba, one in the northwest Mabopane, and one in westerly Ga-Rankuwa. One government healthcare facility is found in the eastern region of Bronkhorstspruit. While there are four government healthcare facilities located in the central to western sections of Tshwane (Figure 5.8).

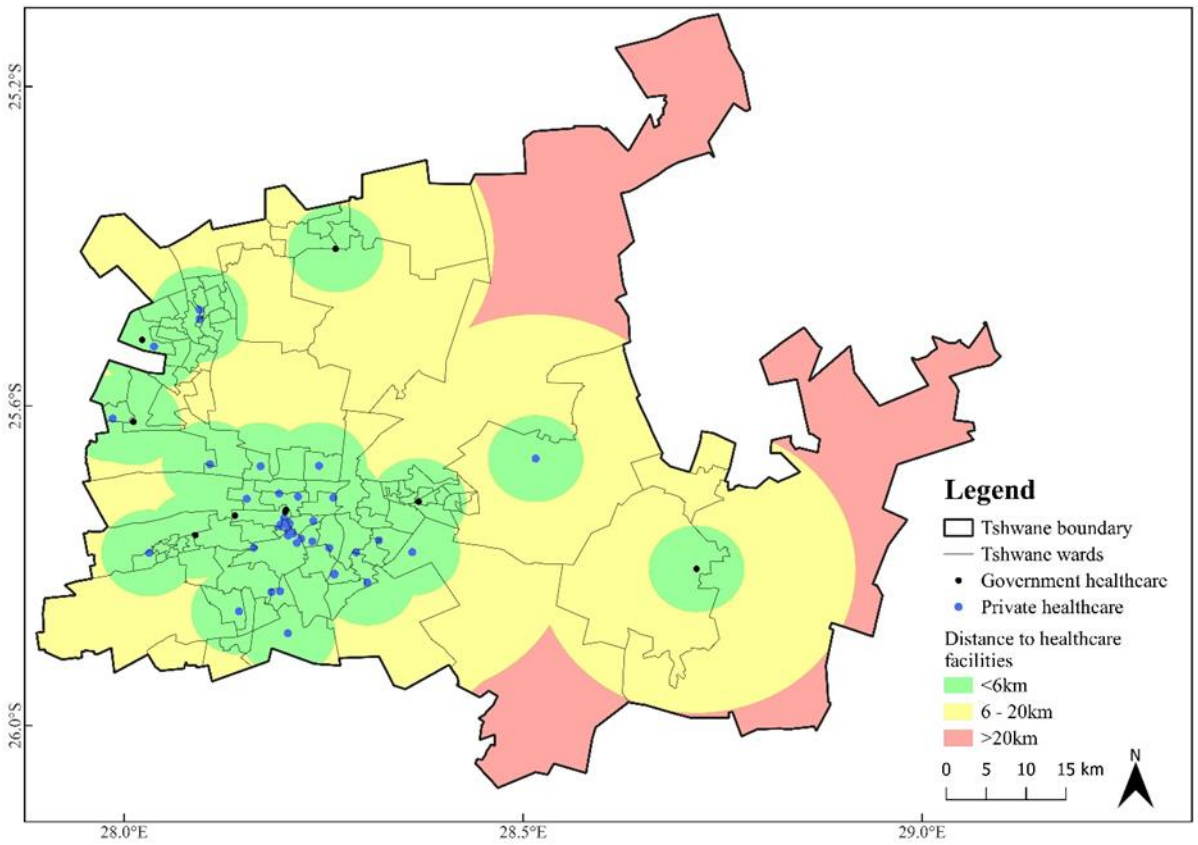


Figure 5.8: The location of public and private hospitals in Tshwane with surrounding distance buffers.

Private healthcare institutions are more common than government healthcare facilities. However, when assessing the number of beds available to patients, there is less variation, with private institutions offering a total of 4548 beds while government hospitals can accommodate approximately 4322 patients. Under 6km is identified by the green buffer zone and indicates areas with good access to healthcare facilities. Approximately 1666km^2 of Tshwane is within 6km of a healthcare facility (Figure 5.8). This research has identified that 3246km^2 of Tshwane is 6-20km from a healthcare facility, as indicated by the yellow buffer zone (Figure 5.8). Finally, the red zone indicates that 1386km^2 of Tshwane is over 20km from a healthcare facility (Figure 5.8). Tshwane residents living in the central to northern territories have moderate

access to healthcare institutions, as indicated by the yellow zones. In contrast, residents in the northeast, eastern and southern territories all have poor access to healthcare facilities.

5.4.2 Police Stations

The RiskScape database has identified 36 police stations in Tshwane, which are located in similar positions to healthcare facilities (Figure 5.9). There is a higher concentration of police stations in central Tshwane, in the southwest and northwest regions. Central Pretoria, as well as Pretoria west, Arcadia and the surrounding suburbs, have a greater concentration of police stations (Figure 5.9). Northwest of Tshwane contains seven police stations, found in Winterveld, Soshanguve, Mabopane and Ga-Rankuwa (Figure 5.9). There are two police stations located in the eastern regions of Tshwane, one in Ekangala and the second in neighbouring Bronkhorstspruit (Figure 5.9). The northeast of Tshwane has the most significant lack of police stations and is identifiable by the large red buffer zone (Figure 5.9). Central to western Tshwane has the greatest access to police stations. Approximately 793km^2 of Tshwane is within 3km of a police station, 840km^2 is situated 3-5km away, and 4664km^2 is over 5km from a police station (Figure 5.9). Close proximity to a police station is deemed to be desirable as it provides easy access when there is a need to open a case, when in need of support, to have documents certified or for fingerprints.

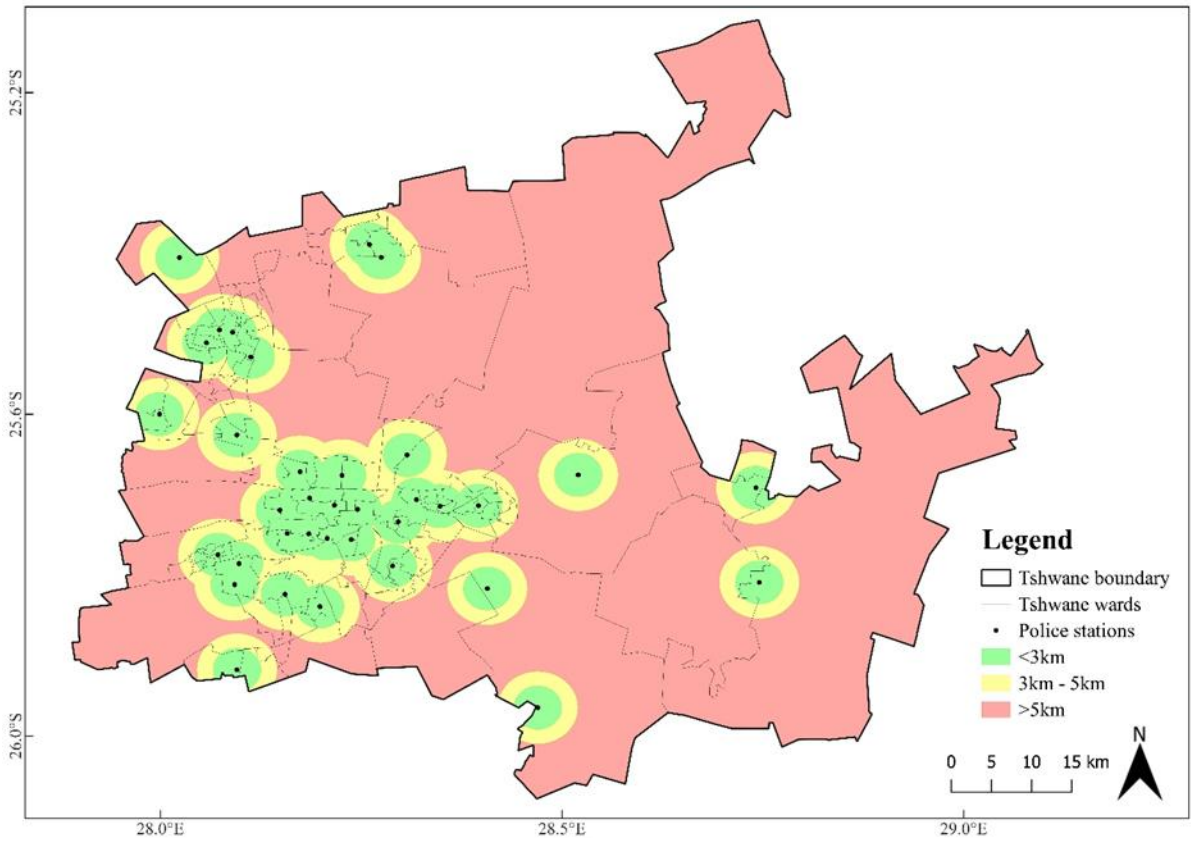


Figure 5.9: The location of police stations in Tshwane and surrounding buffers.

5.5 Proximity to Points of Interest.

Points of interest have grouped facilities, such as libraries, stadiums, monuments and golf courses together. Proximity to these facilities is understood to increase liveability as they are locations used for relaxation and communal activities; therefore, having good access to them is seen as favourable. The RiskScape database identifies approximately 657 points of interest in Tshwane (Figure 5.10). These points of interest have been analysed, and a 0.5km buffer has been added to all of the points, excluding golf courses which have a 5km green buffer (Figure 5.10). These green areas are found in central Tshwane and are densely packed in the central to southwest regions of the municipality. Approximately 32 points of interest are located in the north-western territories of Mabopane, Soshanguve, Kudube and Temba (Figure 5.10). There are four points of interest found in the eastern regions of Tshwane. The yellow buffer zone

indicates a distance of 10km for other points of interest and 15km for golf courses (Figure 5.10). There is an area of 1818km^2 that does not have access to any point of interest or golf courses (Figure 5.10). These red zones are primarily located in the northeast of Tshwane, with some sections in the lower southeast also being over 15km from a point of interest (Figure 5.10).

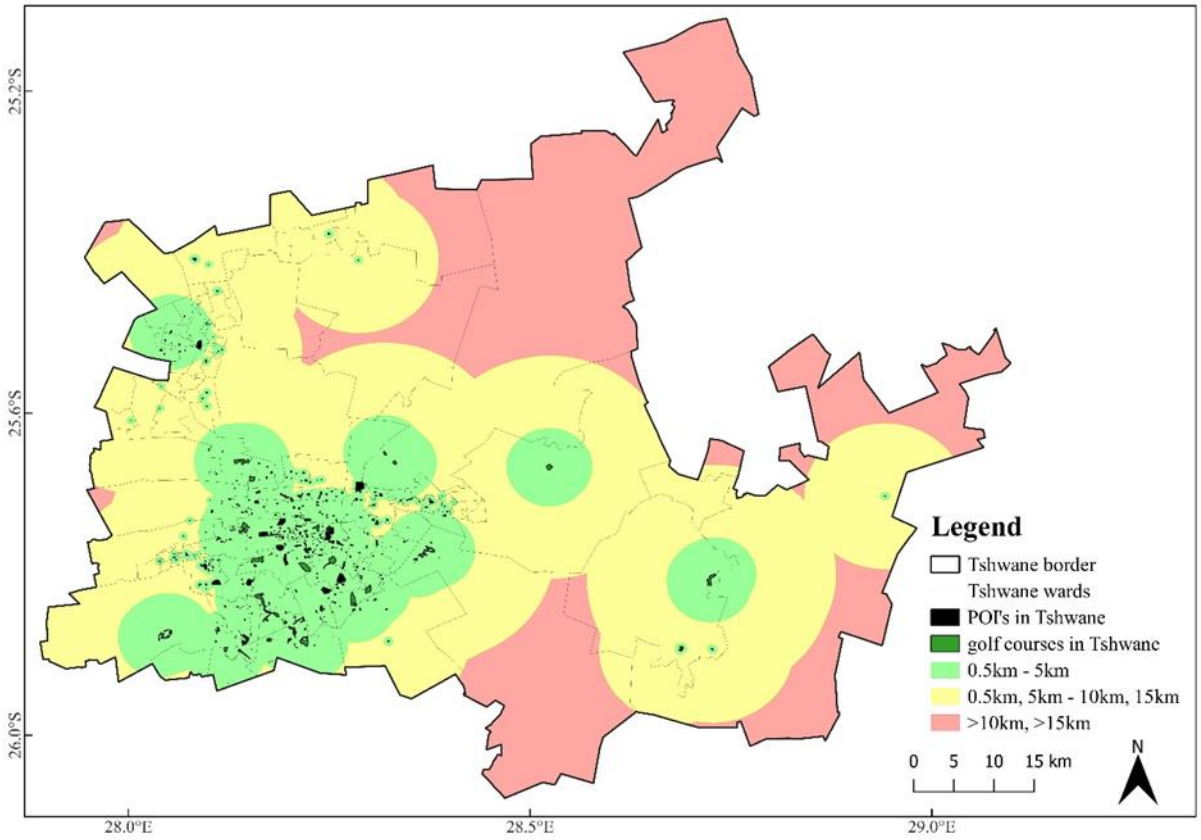


Figure 5.10: The points of interest in Tshwane, including golf courses and surrounding distance buffers.

5.6 Proximity to Roads

Roads have different influences on liveability, as they can add interconnections between places and increase the walkability of areas; they can also be a source of noise and air pollution. This

research paper identifies proximity to major roads as detrimental to liveability, given their potential for health risks. The City of Tshwane and RiskScape database has provided an expansive road network to be mapped (Figure 5.11). The major roads in Tshwane are surrounded by a 90m red buffer, indicating the not ideal distance from a road (Figure 5.11). A yellow buffer is the second addition to the map and indicates the zone within 150m of a road (Figure 5.11). A final green buffer has been added, highlighting the areas of Tshwane that are over 150m from a road (Figure 5.11). The major roads in Tshwane are concentrated in the central regions, near Pretoria central and south of Pretoria central (Figure 5.11). Motorways run from the eastern border to Pretoria central, where they separate and continue in a northern and southern direction. The north-eastern territories consisting of Soshanguve, Mabopane and Ga-Rankuwa all have high congestion of secondary and tertiary roads (Figure 5.11).

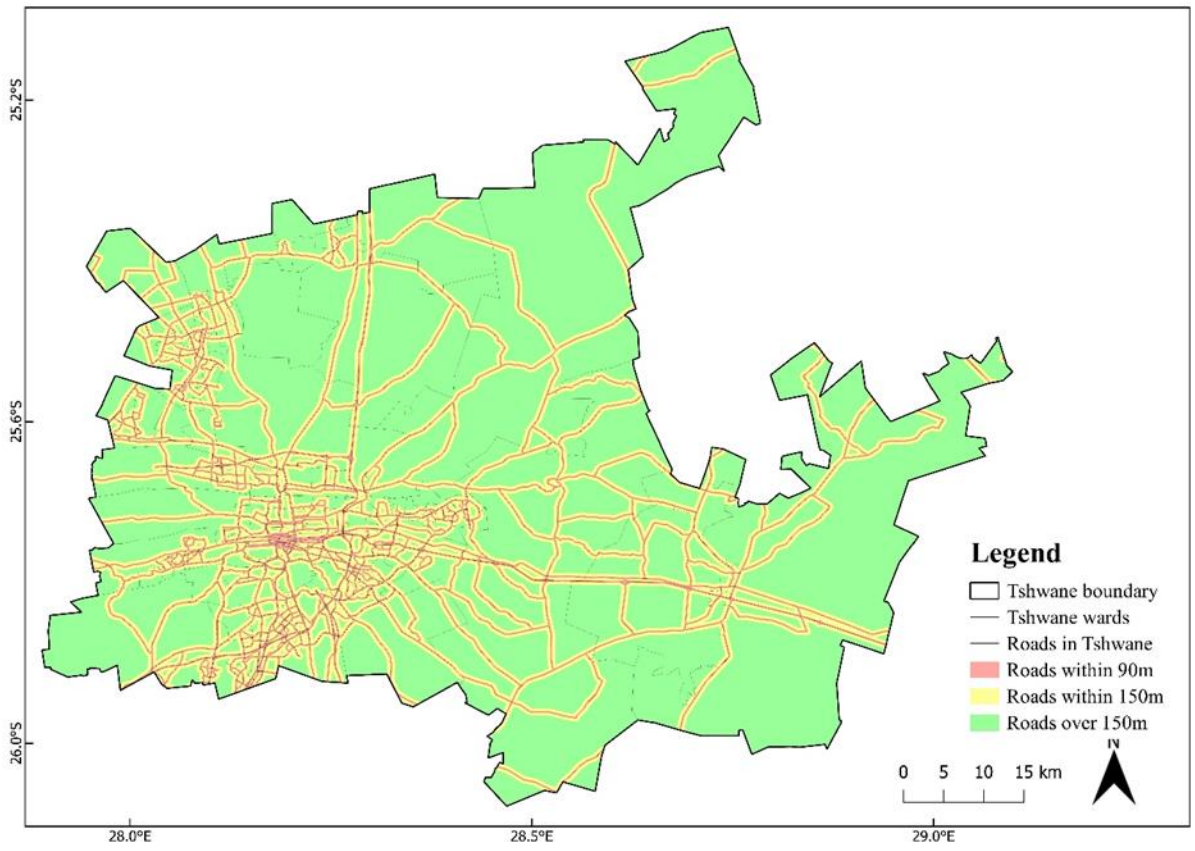


Figure 5.11: Major roads in Tshwane and surrounding distance buffers.

5.7 Proximity to Retail Facilities

Retail facilities have been identified and categorised from the RiskScape database and list the location of different size retail facilities. Close proximity to retail facilities allows for convenient access when purchasing everyday items and is therefore understood as increasing the liveability of the surrounding area in this research study. There are approximately 108 convenience shops in Tshwane (Figure 5.12). The smallest of the retail shops results in a green buffer displaying the regions that are under 1km from these facilities (Figure 5.12). Approximately 239km^2 of Tshwane is within 1km of a convenience store (Figure 5.12). A yellow buffer is added surrounding the green zone to demonstrate the area between 1-1.5km from a convenience store, and a final red zone identifies the areas over 1.5km away. Approximately 192km^2 of Tshwane is 1-1.5km from a convenience store, and 5866km^2 is over 1.5km away (Figure 5.12). The convenience stores in Tshwane are primarily located in the southwestern territories. The greatest concentration of convenience shops is located near Montana Park and Rosslyn. The northern, eastern and south-eastern territories of Tshwane are found to have no convenience stores (Figure 5.12). There is always potential for some retail facilities and informal shops to not be identified due to their portability, however, the data provided by RiskScape does include small informal shops as a classification category.

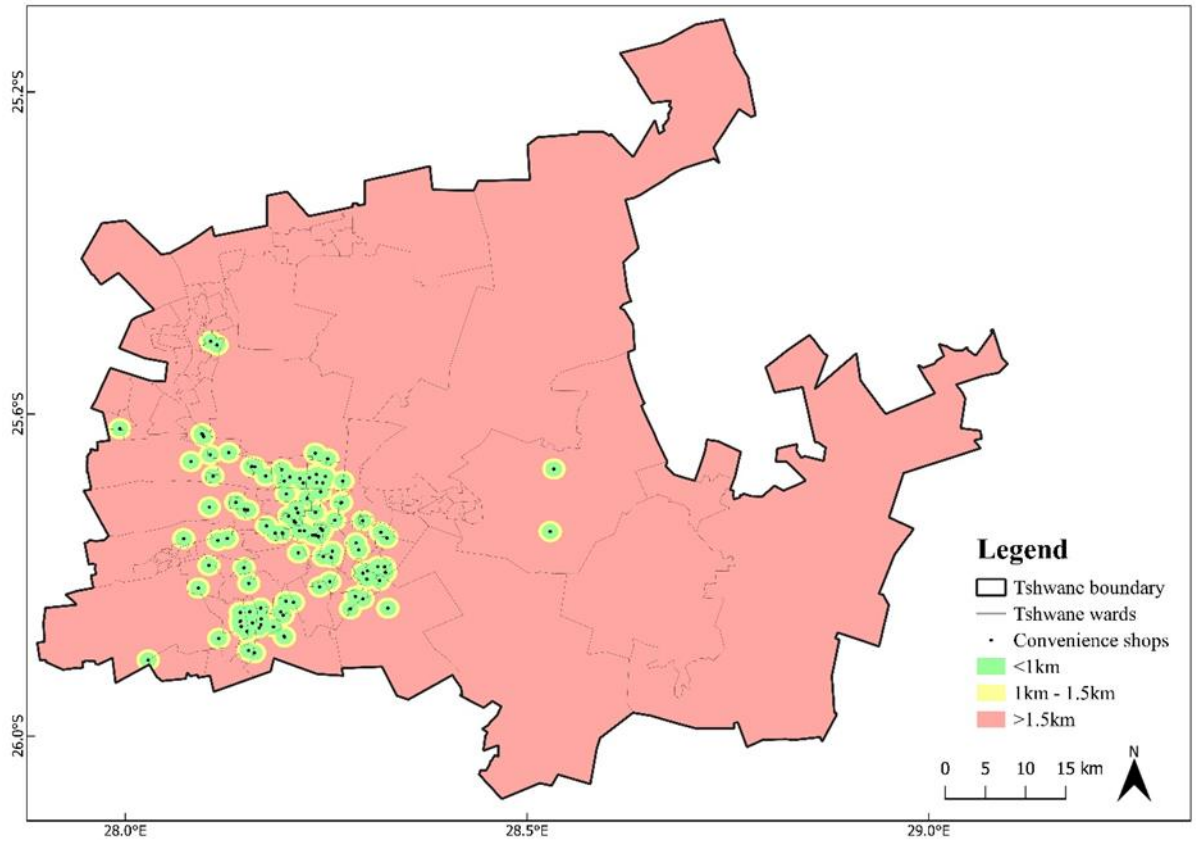


Figure 5.12: The location of convenience shops in Tshwane and surrounding buffers.

Neighbourhood shops are the next tier of retail classification. There are approximately 90 neighbourhood shops in Tshwane based on the RiskScape database, with a large portion of these being found in central Pretoria (Figure 5.13). Five shops are located near Lynwood and in Brooklyn, resulting in these areas having the greatest concentration of neighbourhood shops (Figure 5.13). There is approximately 379km^2 of Tshwane that is situated within 1.5km of a neighbourhood shop as indicated by the green zone, and 156km^2 is found between 1.5-2km from these facilities (Figure 5.13). Finally, the red buffer indicates the 5769km^2 of Tshwane that is situated over 2km from a neighbourhood retail facility (Figure 5.13). This red zone is found in the northeast, east and south-eastern regions of Tshwane, with five neighbourhood shops located in the central-eastern regions.

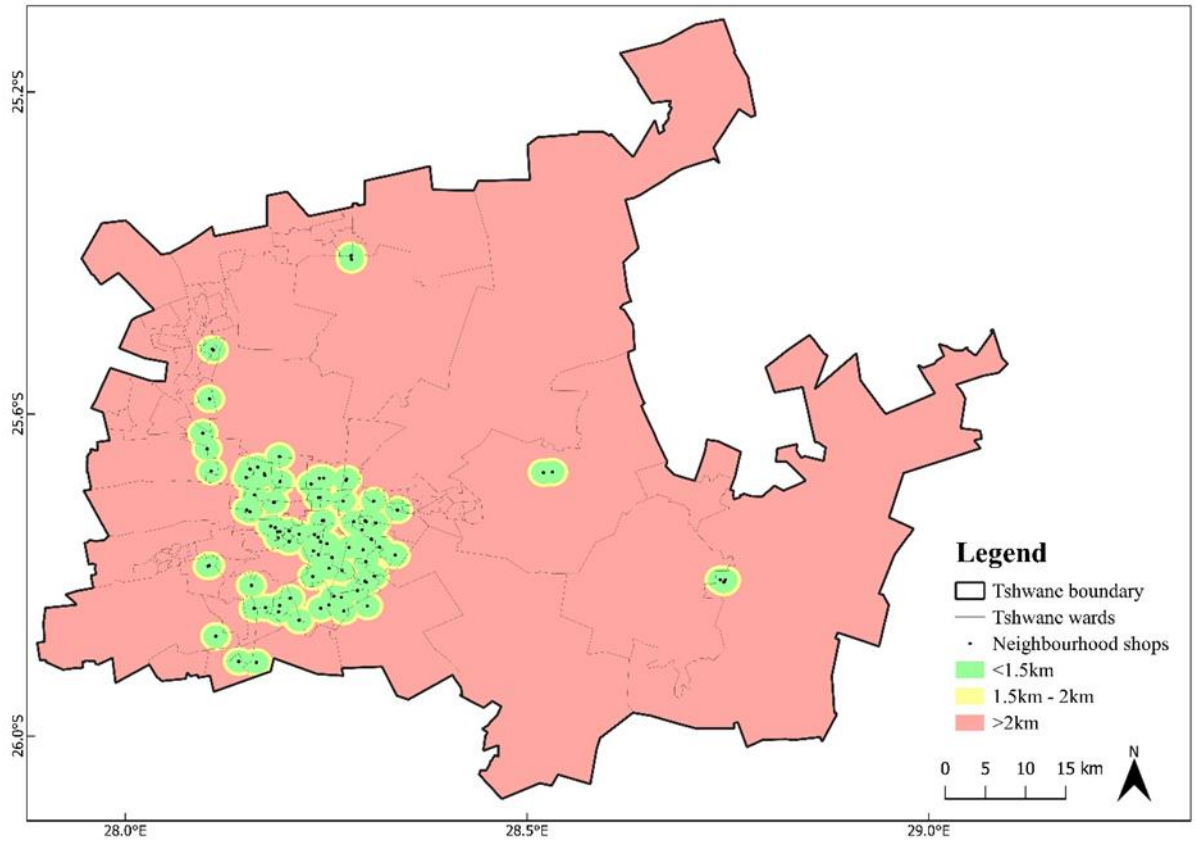


Figure 5.13: The location of neighbourhood shops in Tshwane and surrounding buffers.

The third largest retail classification in Tshwane is the community shops, of which the RiskScape database finds 68 of these facilities in Tshwane (Figure 5.14). Similarly to Figures 5.12 and 5.13, there is a concentration of community shops in the central to southwestern regions of Tshwane. However, seven community shops are found in the north-western territories of Tshwane. The northeast, east and south-eastern regions of Tshwane contain three community stores in total, indicating how these areas are located mainly in the red zone (Figure 5.14). The greatest concentration of community shops is found in Highveld and Menlyn, both of which have four. There is approximately 664km^2 of Tshwane that is within 2.5km of a community store, as indicated by the green buffer (Figure 5.14). Surrounding this is the yellow zone, which indicates the 158km^2 between 2.5-3km from a community shop (Figure 5.14). The

final red buffer covers an area of 5476km^2 and identifies regions over 3km from a community shop (Figure 5.14).

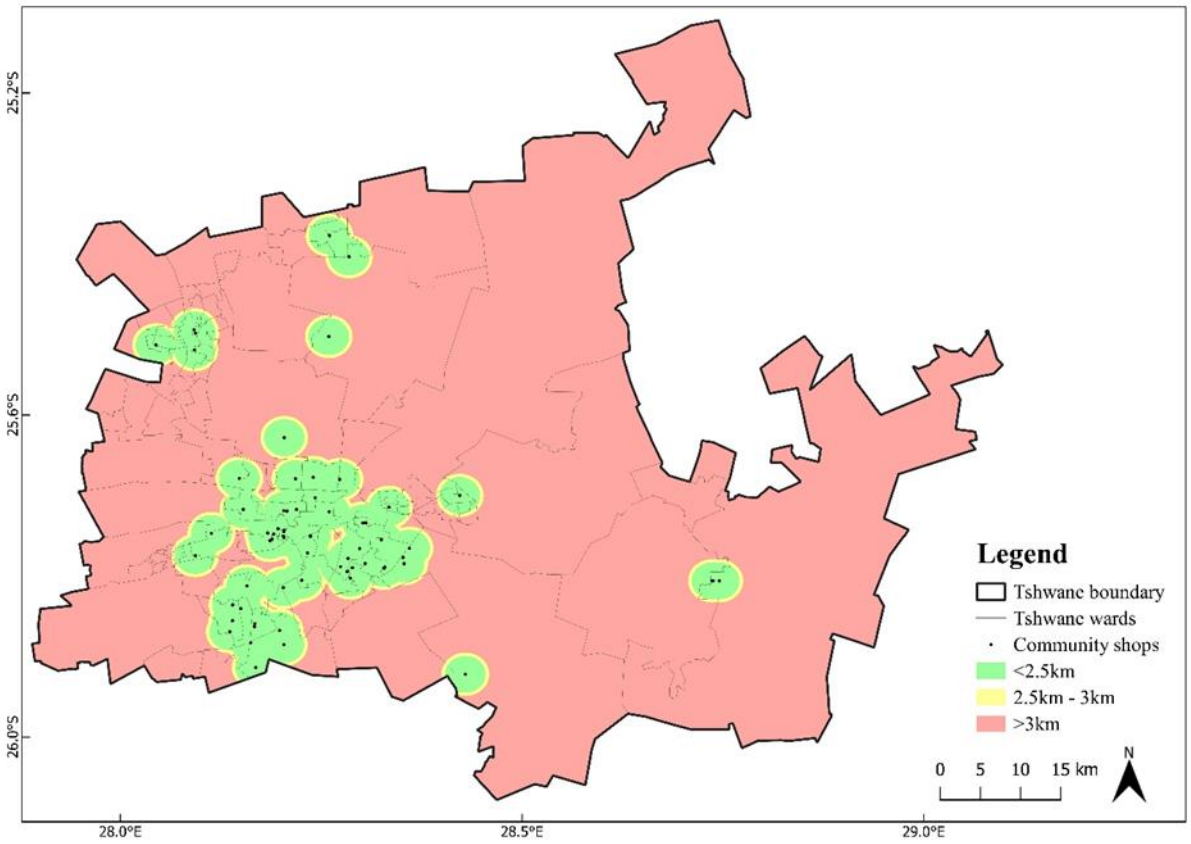


Figure 5.14: The location of community shops in Tshwane and surrounding buffers.

Approximately 20 small regional retail facilities are situated in Tshwane, as indicated by the RiskScape database. Small regional retail facilities are the smallest regional facilities and service those within 3km of the store, as indicated by the green zone (Figure 5.15). Approximately 425km^2 of Tshwane is within 3km of a small regional retail facility. The small regional facilities are located in Tshwane's central to southwestern regions (Figure 5.15). There are three small regional facilities located in the northwest, while one facility is found in the northeast (Figure 5.15). The yellow buffer indicates a 3-5km buffer around small regional facilities, with 440km^2 of Tshwane situated in this zone (Figure 5.15). Approximately 5433km^2

of Tshwane is located over 5km from a small regional retail facility, as indicated by the red zone (Figure 5.15). Pretoria north contains the greatest number of small regional stores, two, while there are 88 wards with no small regional retail facilities (Figure 5.15).

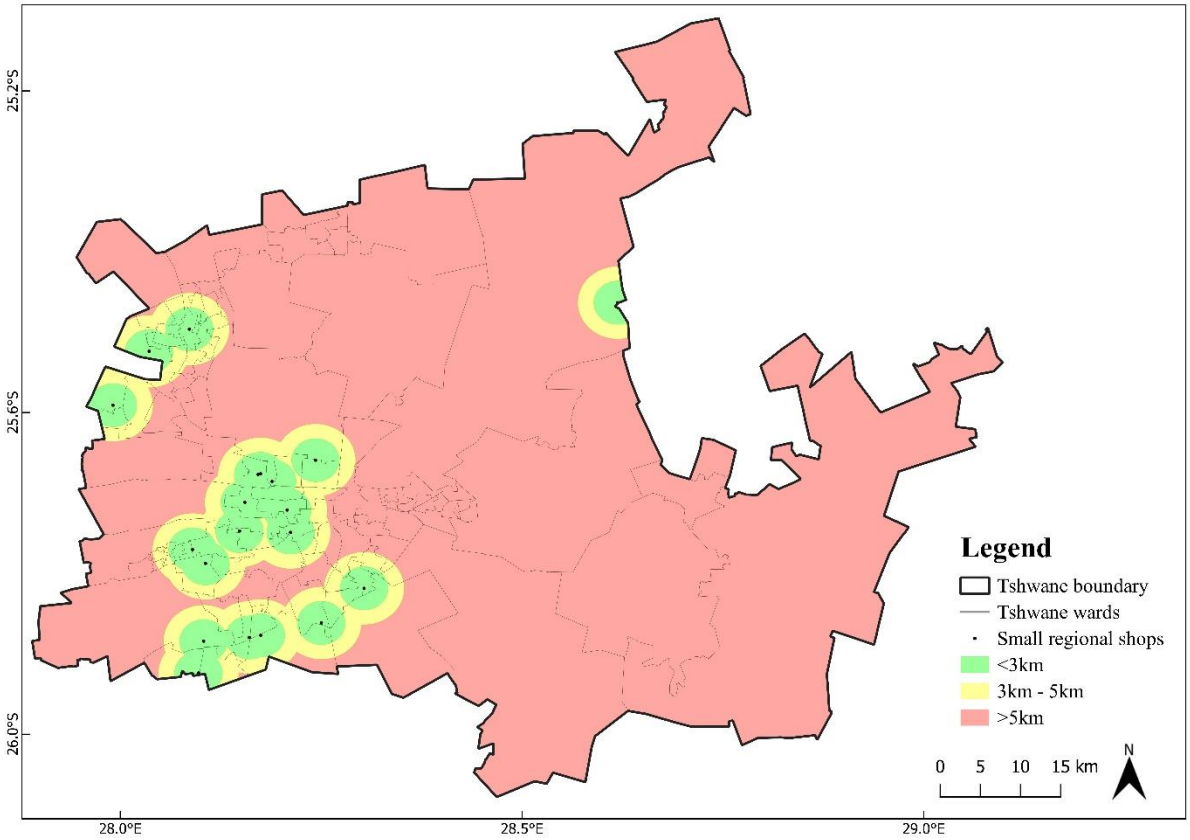


Figure 5.15: The location of small regional shops in Tshwane and surrounding buffers.

Regional retail facilities are the following category of shops in Tshwane and are found in 22 locations, according to the RiskScape database (Figure 5.16). These facilities are located in the central to south-western regions of Tshwane, while there is one regional retail facility in the northern regions. Montana Park is the only area with two regional facilities, while there are approximately 86 wards with no regional retail facilities (Figure 5.16). The 22 regional retail facilities are surrounded by a 5km green buffer, a 5-8km yellow buffer and an over 8km buffer indicated by the red zone (Figure 5.16). Approximately 1040km^2 of Tshwane is located within

5km of a regional retail facility, 694km^2 is between 5-8km, and 4564km^2 is over 8km away (Figure 5.16).

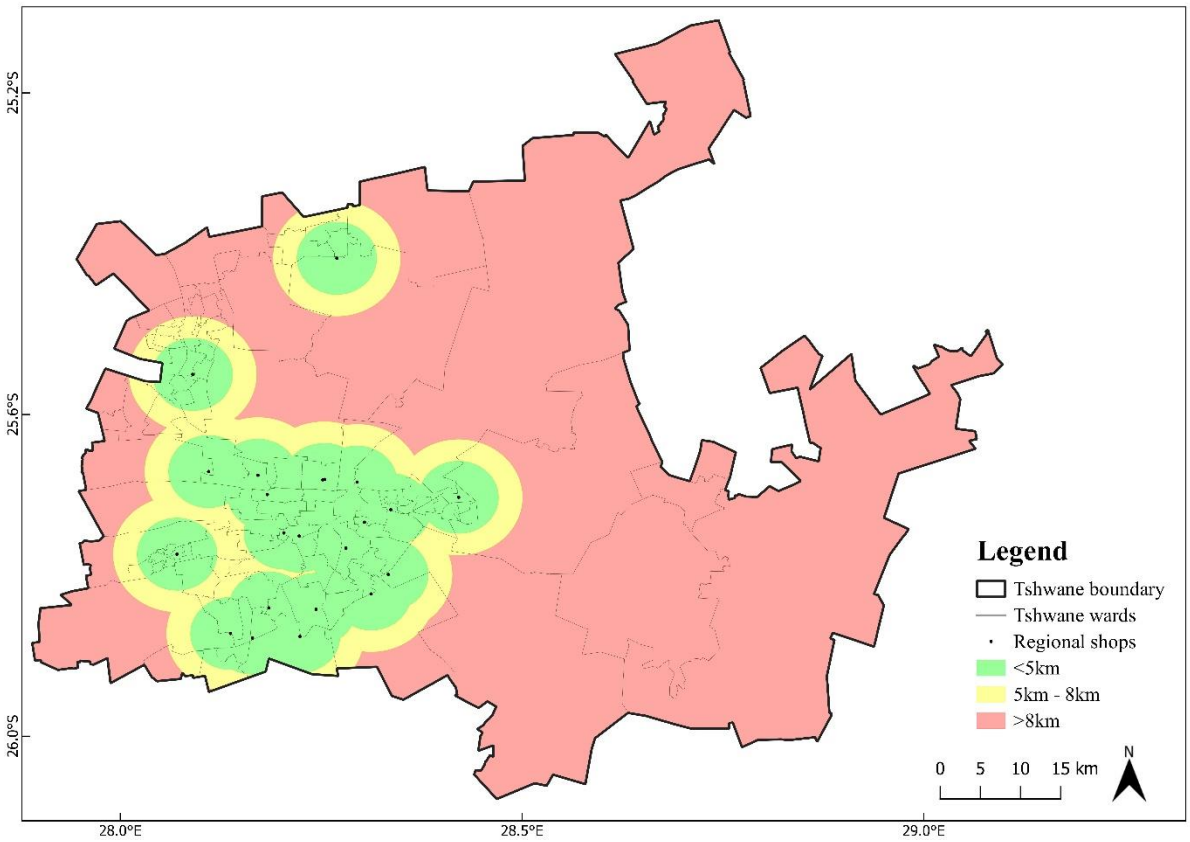


Figure 5.16: The location of regional retail facilities in Tshwane and surrounding buffers.

Four super regional facilities are found in Tshwane and are the largest regional facility in Tshwane, as identified with the RiskScape database (Figure 5.17). Three super regional retail facilities are situated in Menlyn, and the fourth is found in Brooklyn, all located centrally and south of Tshwane. The green buffer surrounding these super-regional facilities demonstrates the 227km^2 of Tshwane that is within 7km (Figure 5.17). While 192km^2 of Tshwane is situated between 7-10km from a super-regional facility, as indicated by the yellow buffer zone (Figure 5.17). Approximately 5878km^2 of Tshwane has poor access to a super-regional facility, as demonstrated by the over 10km red buffer (Figure 5.17). The northern and eastern regions of

Tshwane have poor access to super-regional retail facilities, as there are approximately 105 wards in Tshwane with no super-regional retail facilities (Figure 5.17).

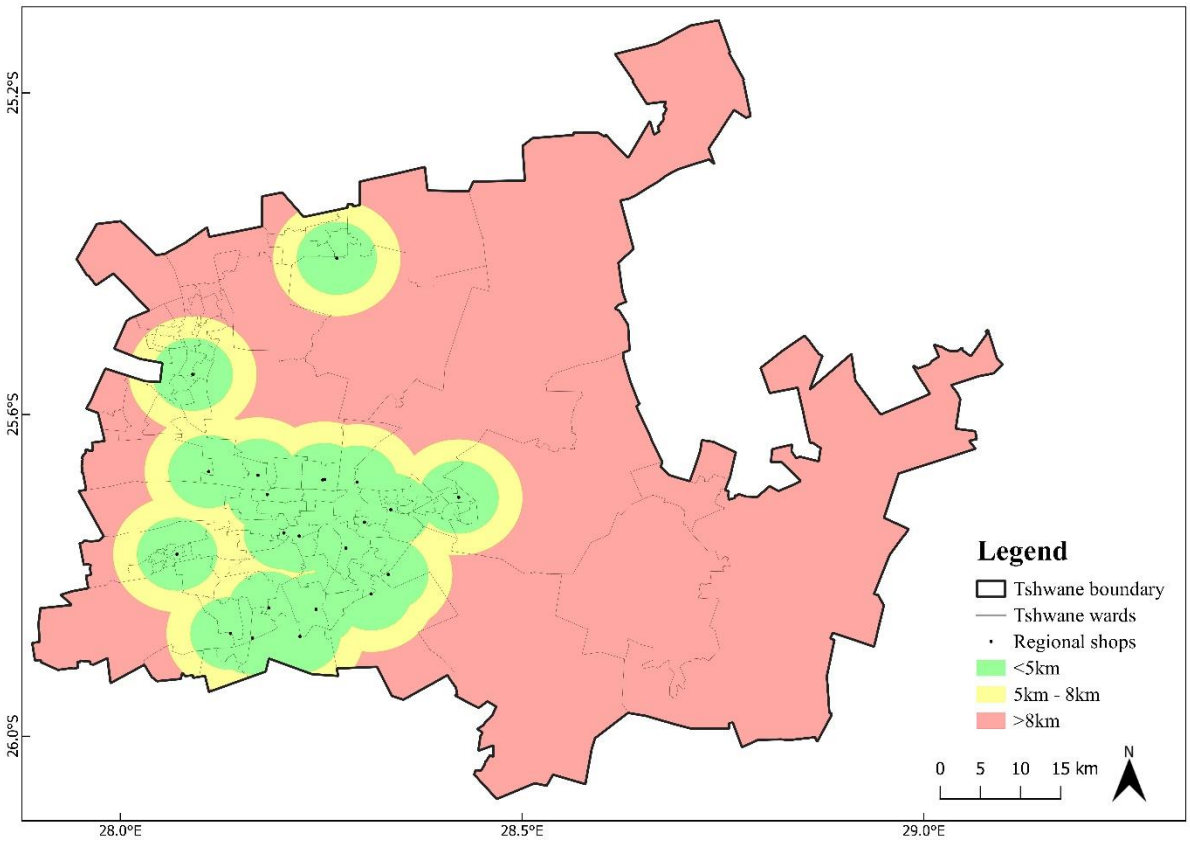


Figure 5.17: The location of super regional retail facilities in Tshwane and surrounding buffers.

The RiskScape database has identified seven value centres across Tshwane, with six centres being found in central to southwestern Pretoria and one found in the southwest of Tshwane (Figure 5.18). The value centres in Tshwane are spread across seven different wards, while 100 wards do not contain any value centres. Value centres have a green buffer indicating the zone that is less than 5km from this facility (Figure 5.18). Approximately 409km^2 is within 5km of a value centre. The yellow zone is identifiable between 5-8km from a value centre, which covers an area of 373km^2 (Figure 5.18). Approximately 5517km^2 of Tshwane is over 8km from

a value centre, as indicated by the red buffer zone (Figure 5.18). The north and east of Tshwane have poor access to value centres.

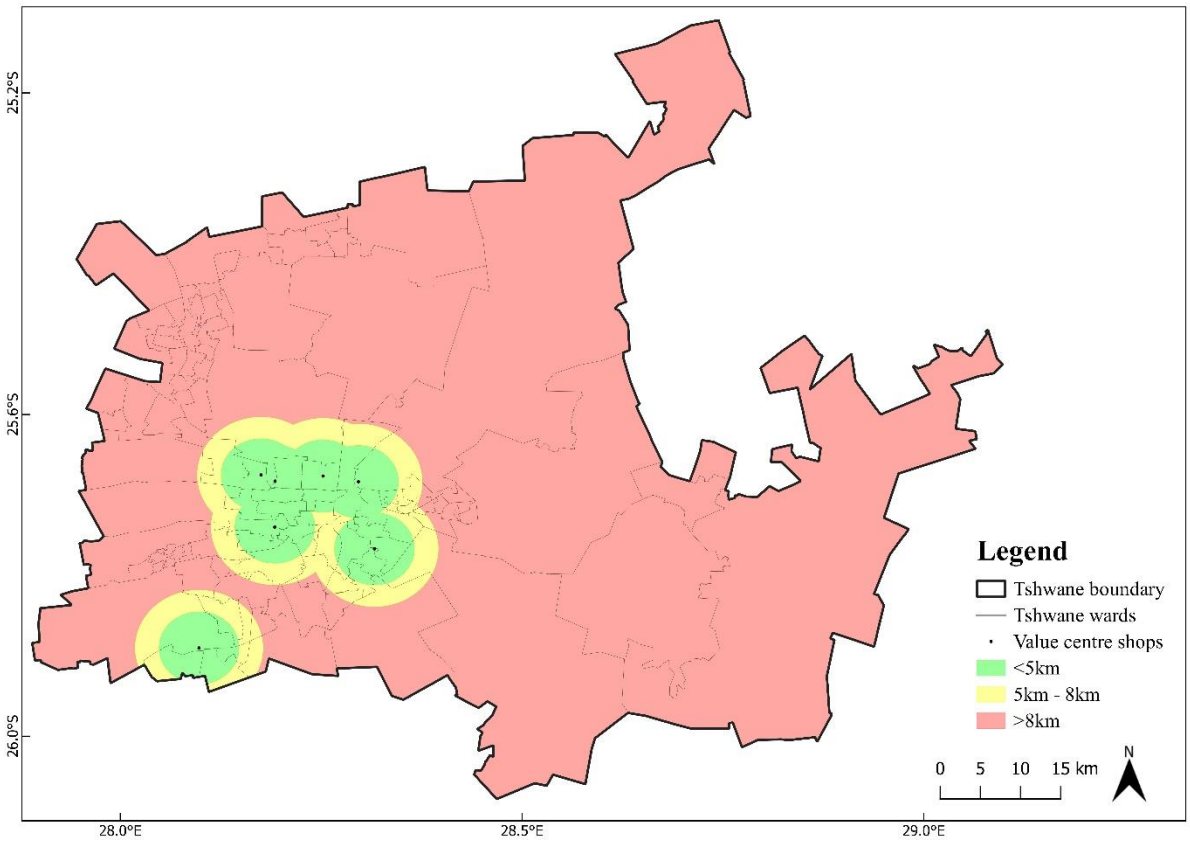


Figure 5.18: The location of value centre shops in Tshwane and surrounding buffers.

Shopping centres are largely populated in the central to southern regions of Tshwane, with seven of the 27 shopping centres located in Pretoria central, as found in the RiskScape database (Figure 5.19). There are a total of 95 wards with no shopping centres. Shopping centres are surrounded by a green buffer that indicates the area within 3km of a shopping centre, 267km^2 of Tshwane is within this 3km zone (Figure 5.19). Approximately 287km^2 of Tshwane is between 3-5km from a shopping centre which is demonstrated by the yellow zone (Figure 5.19). Finally, 5744km^2 of Tshwane is over 5km from a shopping centre and is identifiable from the red buffer zone (Figure 5.19). The east of Tshwane has poor access to shopping

centres; although the northern regions have one shopping centre, large portions still have poor access (Figure 5.19).

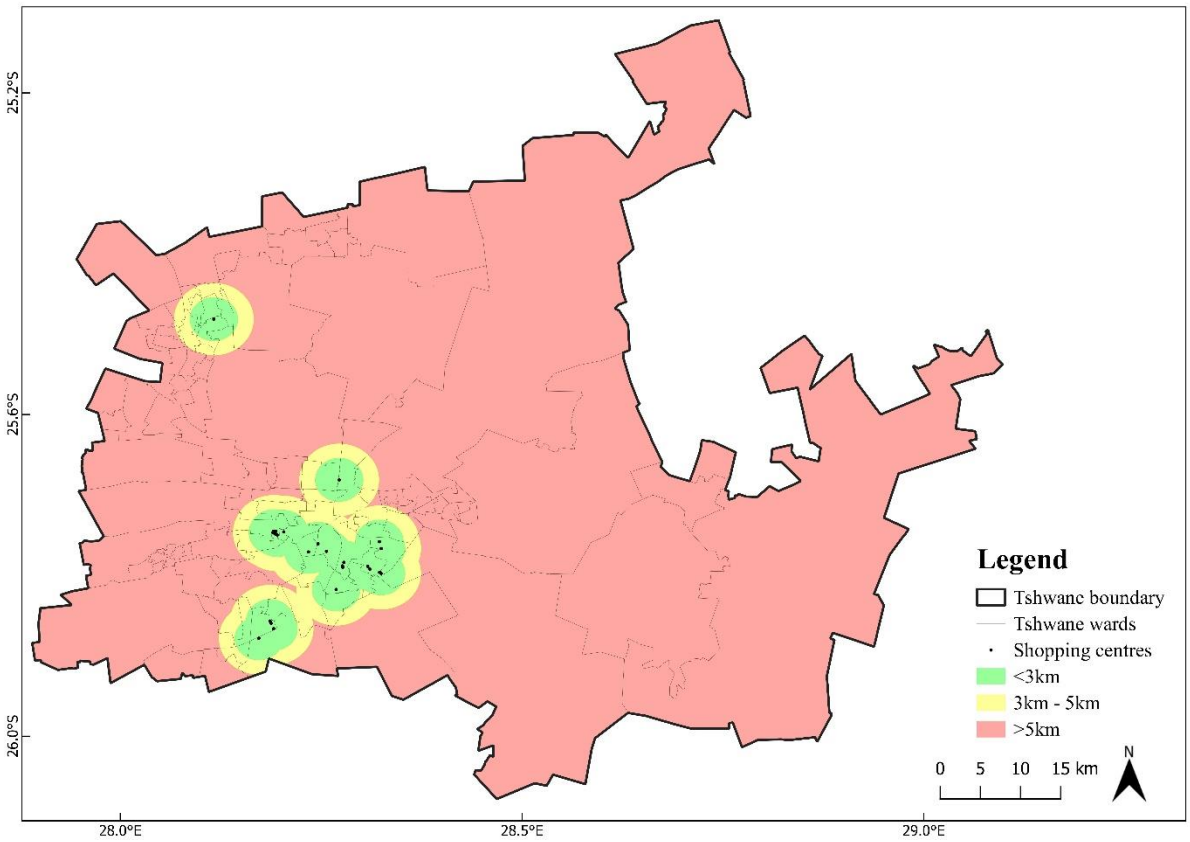


Figure 5.19: The location of shopping centres in Tshwane and surrounding buffers.

Bix Box retail facilities are found in ten locations across Tshwane, according to the RiskScape database, and four of these retail facilities are found near Hennopspark (Figure 5.20). Bix Box facilities are often used for buying goods in bulk, an example of these facilities is Makro. These retail facilities are located near central to western Pretoria, while the north and east of Tshwane have poor access to Bix Box retail facilities. A total of 419km^2 of Tshwane is within 5km of a Bix Box retail facility, as indicated by the green buffer zone (Figure 5.20). The yellow zone highlights the 395km^2 of Tshwane, which is 5-8km from these facilities, while the red buffer zone demonstrates the 5484km^2 of Tshwane over 8km away (Figure 5.20).

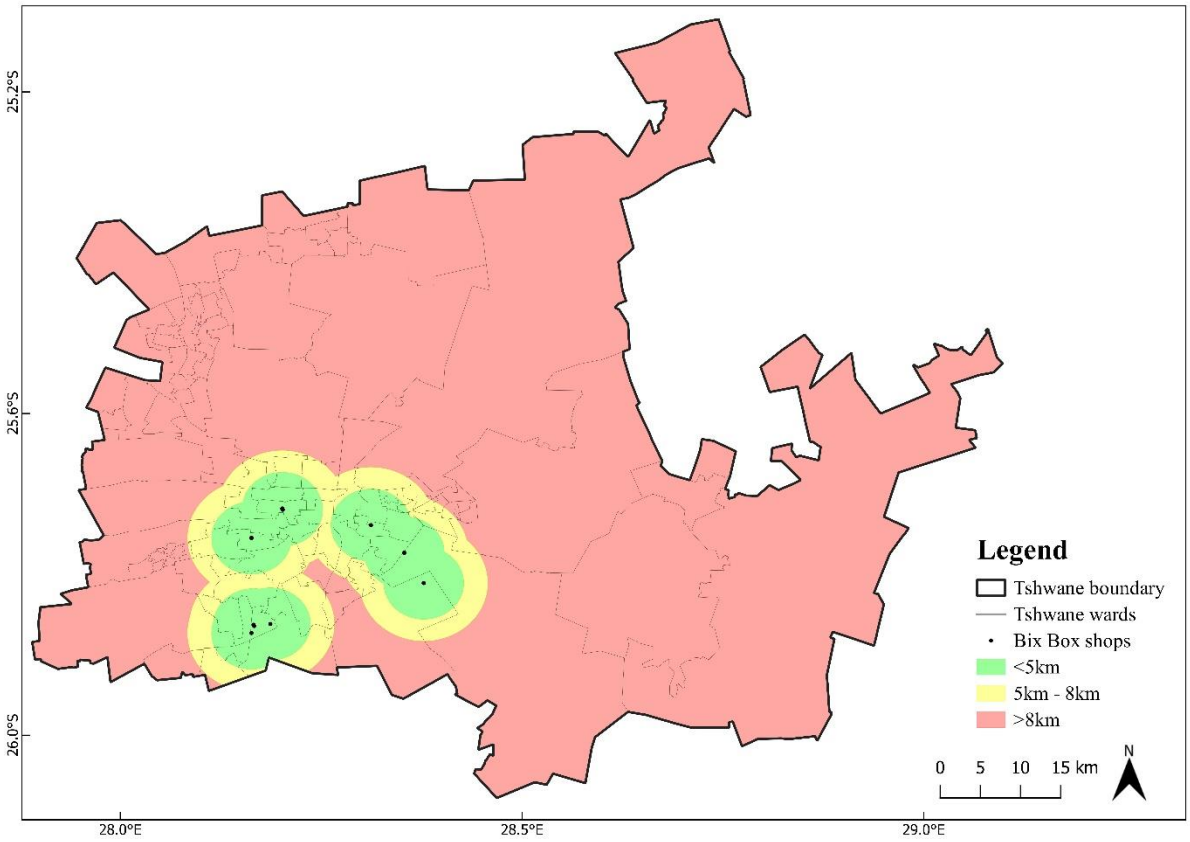


Figure 5.20: The location of Bix Box retail facilities in Tshwane and surrounding buffers.

The final retail facility map identifies all of Tshwane's combined green, yellow and red distance buffers (Figure 5.21). The central to western regions of Tshwane have good access to shops, with areas in the northwest, such as Mabopane, also having good access to shops. The northeast and eastern territories of Tshwane have two small zones with access to shops, with the remaining areas having no access (Figure 5.21). There is approximately 1402km^2 of Tshwane that is within an ideal distance to any retail facility, while 107km^2 has moderate access to retail facilities in Tshwane. Finally, approximately 4188km^2 of Tshwane has no access to any form of retail facility (Figure 5.21).

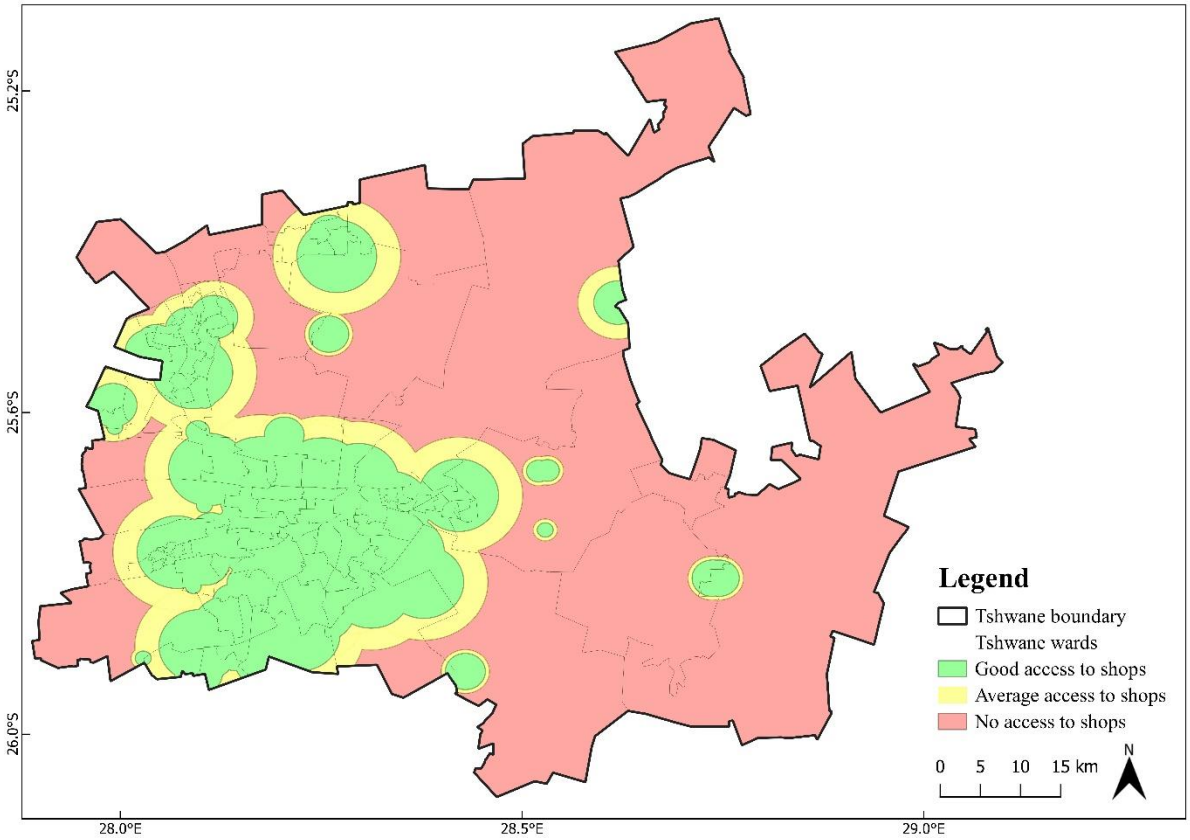


Figure 5.21: The proximity to all retail facilities in Tshwane.

5.8 Climatic Conditions in Tshwane

This research study uses annual precipitation data for Tshwane from 2019 until 2020. Greater levels of precipitation can lead to flooding and low precipitation to droughts, thus influencing the liveability of an area. Preferences for the average maximum and minimum temperatures in Tshwane are highly influenced by individuals' preferences and have subsequently not been ranked on their influence on liveability. Although liveability has not been ranked in this study, other studies, such as tourism climate indices, categorise the suitability of tourist locations based on levels of rainfall; however, these indices are highly variable in the methods used.

5.8.1 Precipitation

There are four weather stations in Tshwane that are used by the SAWS, three of these weather stations are found west of Pretoria central and in the central to western region of Tshwane (Figure 5.22). The third weather station is located on the southern border of Tshwane in Doringkloof (Figure 5.22). The annual rainfall is displayed in a 25km radius around each weather station from January 2019 until January 2020 (Figure 5.22). The northernmost weather station is located at Wonderboom. Unisa is the westernmost weather station, with Pretoria University holding the easternmost station, which is approximately 6km east of the Unisa station. Finally, the southernmost weather station is located in Irene and is approximately 16km from the Unisa station (Figure 5.22). The annual rainfall displayed indicates the rainfall from during a La Niña year, demonstrating that the long term mean is most likely lower than what is displayed (figure 5.22)

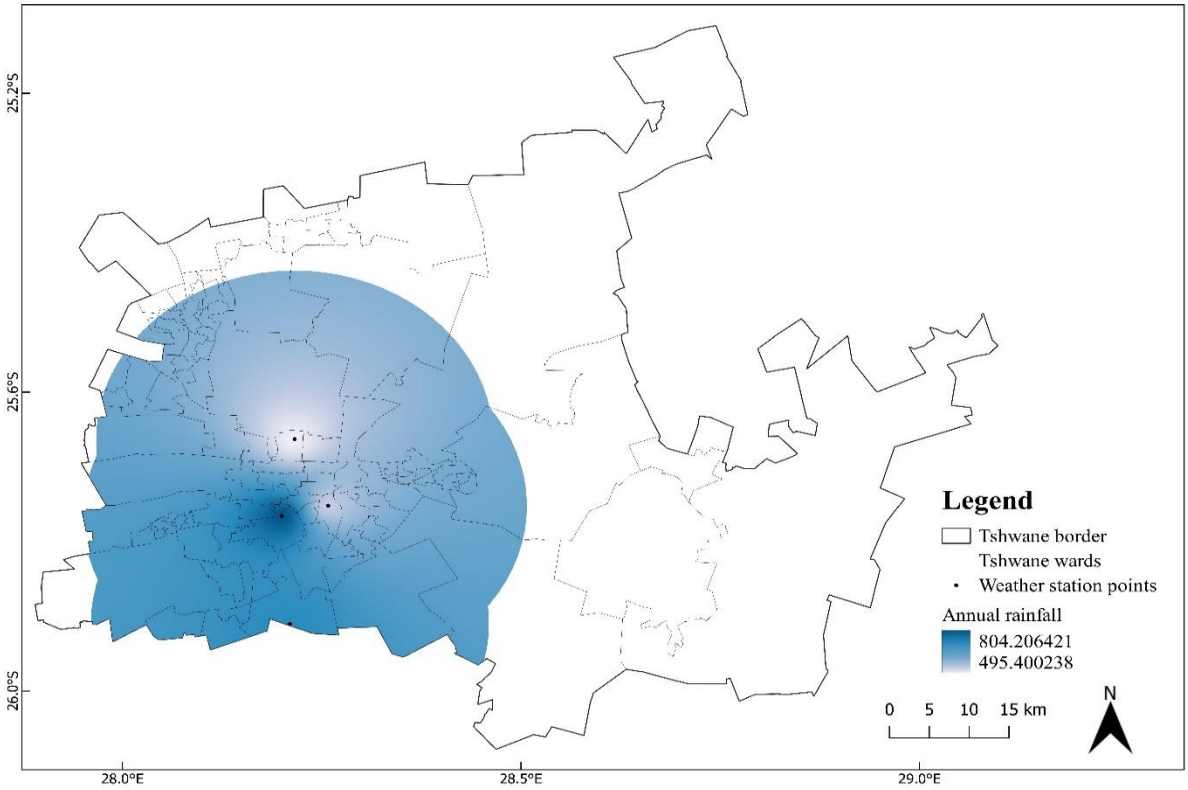


Figure 5.22: The annual rainfall from 2019 to 2020 recorded from the SAWS in a 25km spatial interpolation.

The second rainfall map is populated with information supplied by RiskScape (Figure 5.23). This map demonstrates the annual rainfall in Tshwane from January 2019 until January 2020 (Figure 5.23). Tshwane's northern and eastern regions receive the highest amount of annual rainfall compared to the northwest and western regions (Figure 5.23). Tshwane's northern and eastern regions receive between 685mm and 705mm of rainfall annually. The northwest of Tshwane receives an annual rainfall of between 553mm and 600mm (Figure 5.23). The central regions of Tshwane located around Pretoria central receive variations in annual rainfall, ranging between 600mm and 685mm (Figure 5.23).

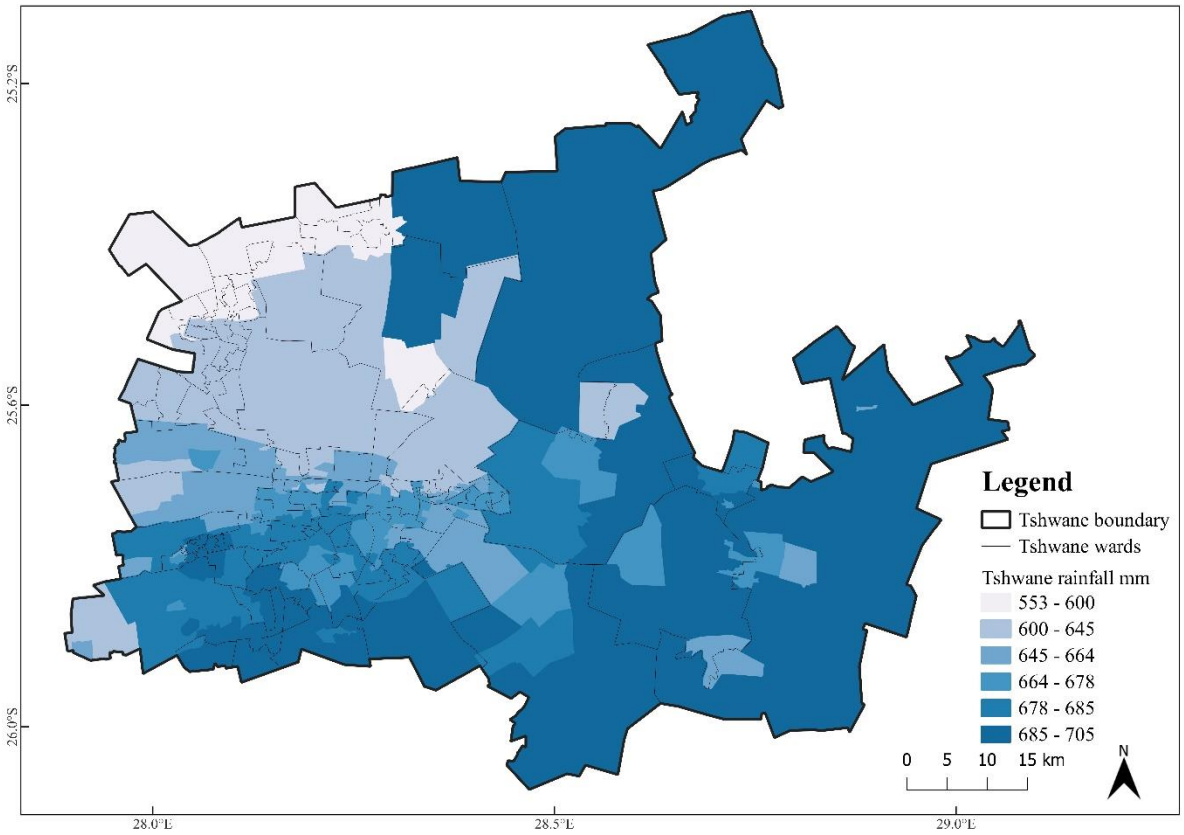


Figure 5.23: The annual rainfall in Tshwane based on RiskScape data.

The third and final rainfall map uses the CHIRPS gridded data (Figure 5.24). This map identifies the annual rainfall for Tshwane and ranges between 2019 and 2020 (Figure 5.24).

This map indicates that the northern territories of Tshwane receive less rainfall when compared to the southeast regions and shows some similarities to Figure 5.23, in the distribution of precipitation over the central to western regions of Tshwane (Figure 5.24).

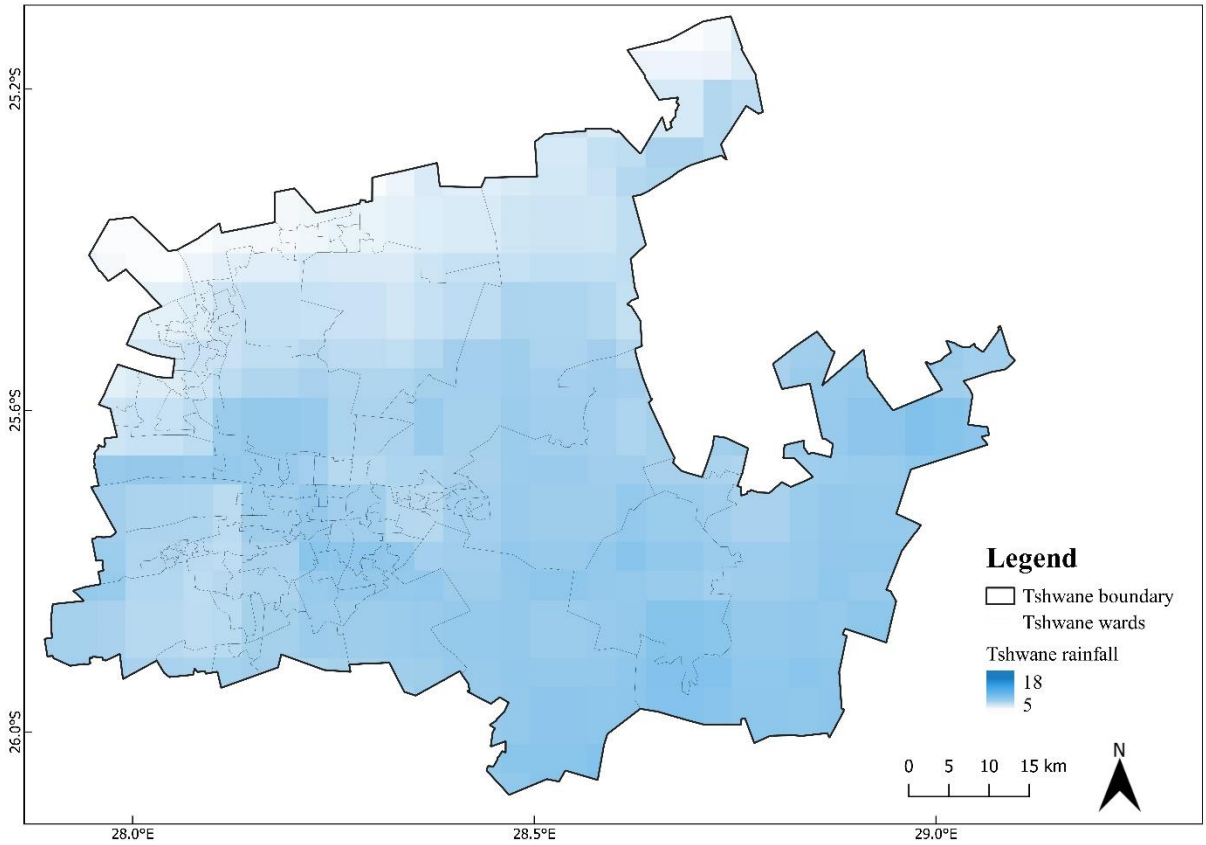


Figure 5.24: The rainfall in Tshwane from 2019 to 2020 from CHIRPS pentad data.

5.8.2 Temperature

Two temperature maps have been produced, both based on information gathered from the SAWS (Figures 5.25 and 5.26). The average maximum temperature for 2019 and 2020 in Tshwane was between 27°C, recorded at the UNISA weather station, and 25.5°C, recorded at the IRENE weather station (Figure 5.25). Wonderboom and Pretoria University weather stations both recorded an annual temperature of 26°C.

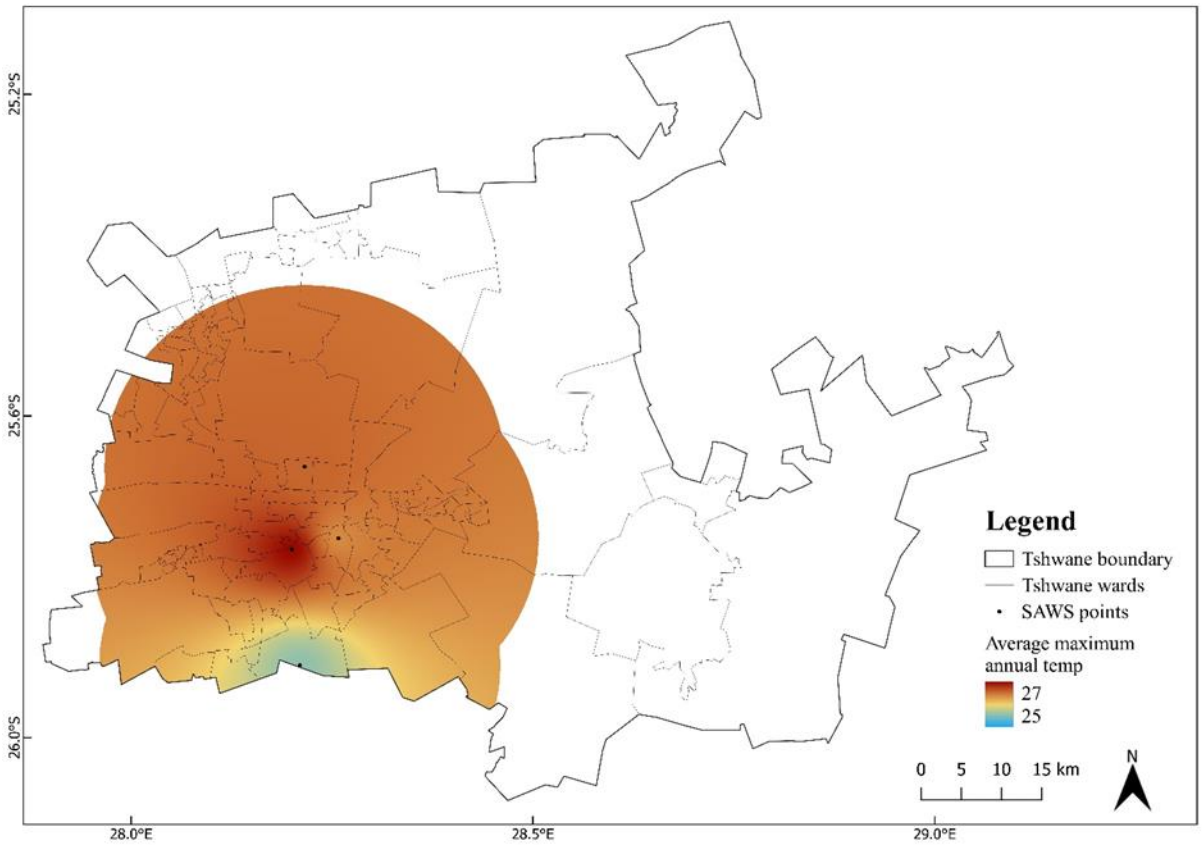


Figure 5.25: The average maximum temperature recorded in Tshwane from 2019 to 2020.

The second temperature map displays the average minimum temperatures from the same SAWS weather stations in Tshwane (Figure 5.26). The average minimum temperature in Tshwane is between 11°C and 12°C (Figure 5.26). Wonderboom, the northern most weather station, recorded the lowest average temperature of 11.5°C, while the western weather station, UNISA, recorded an average minimum of 12.2°C (Figure 5.26). IRENE and Pretoria University weather stations both recorded an average temperature of 12°C (Figure 5.26).

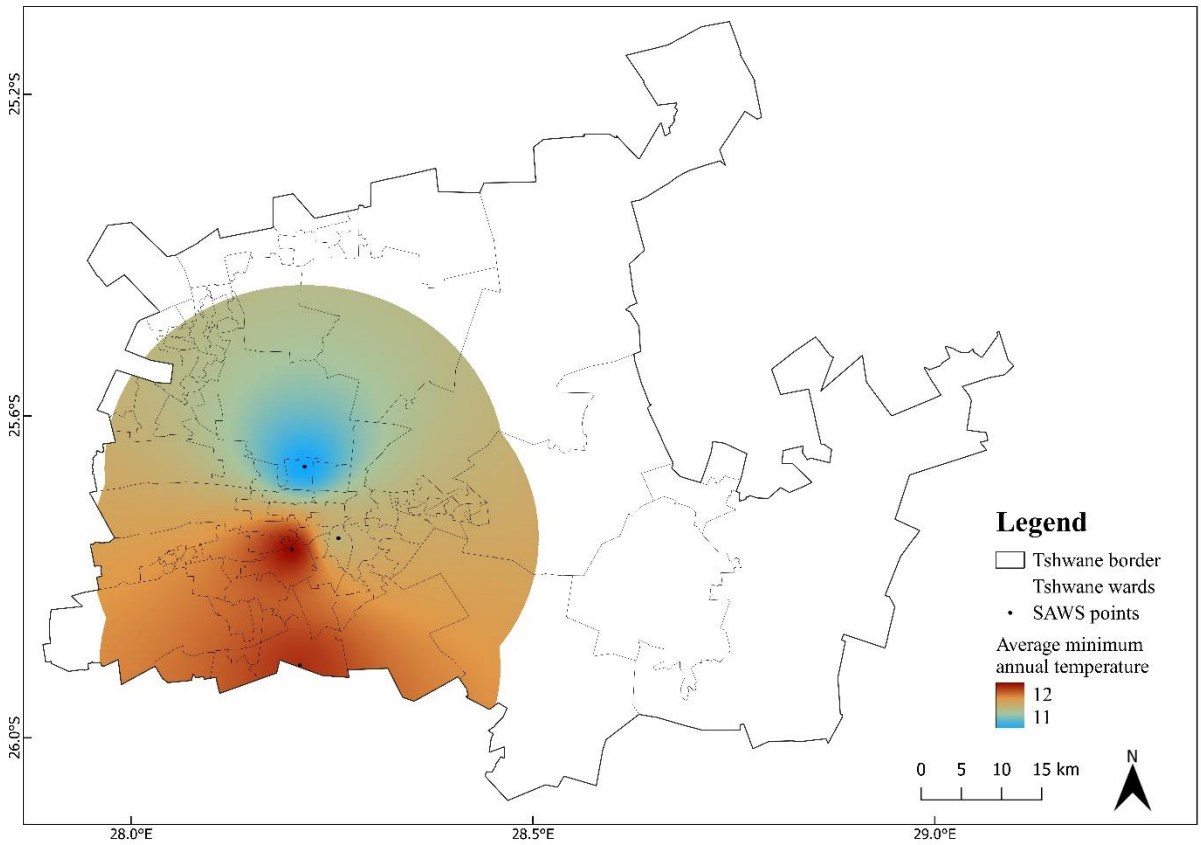


Figure 5.26: The average minimum temperature recorded in Tshwane from 2019 to 2020.

5.9 Risk in Tshwane

The high risk of floods and fires can significantly reduce the liveability of the regions in Tshwane. As floods and fires can destroy homes, endanger people's lives, and potentially increase insurance premiums in high-risk areas, this research study has identified high flood and fire risk as negatively influencing liveability.

5.9.1 Fire Risk

The risk of fires is ranked based on the number of thatched houses in an area, which has been found using the RiskScape database. Tshwane's northern and eastern regions have negligible fire risk (Figure 5.27). The central suburbs of Tshwane, surrounding Pretoria central, contain areas at higher risk of thatch fires, as well as some parts of Soshanguve and Mabopane (Figure

5.27). Approximately 3459km^2 of Tshwane has a negligible risk of thatch fires, while 90km^2 are at moderate risk and 35km^2 is at high risk of thatch fires (Figure 5.27).

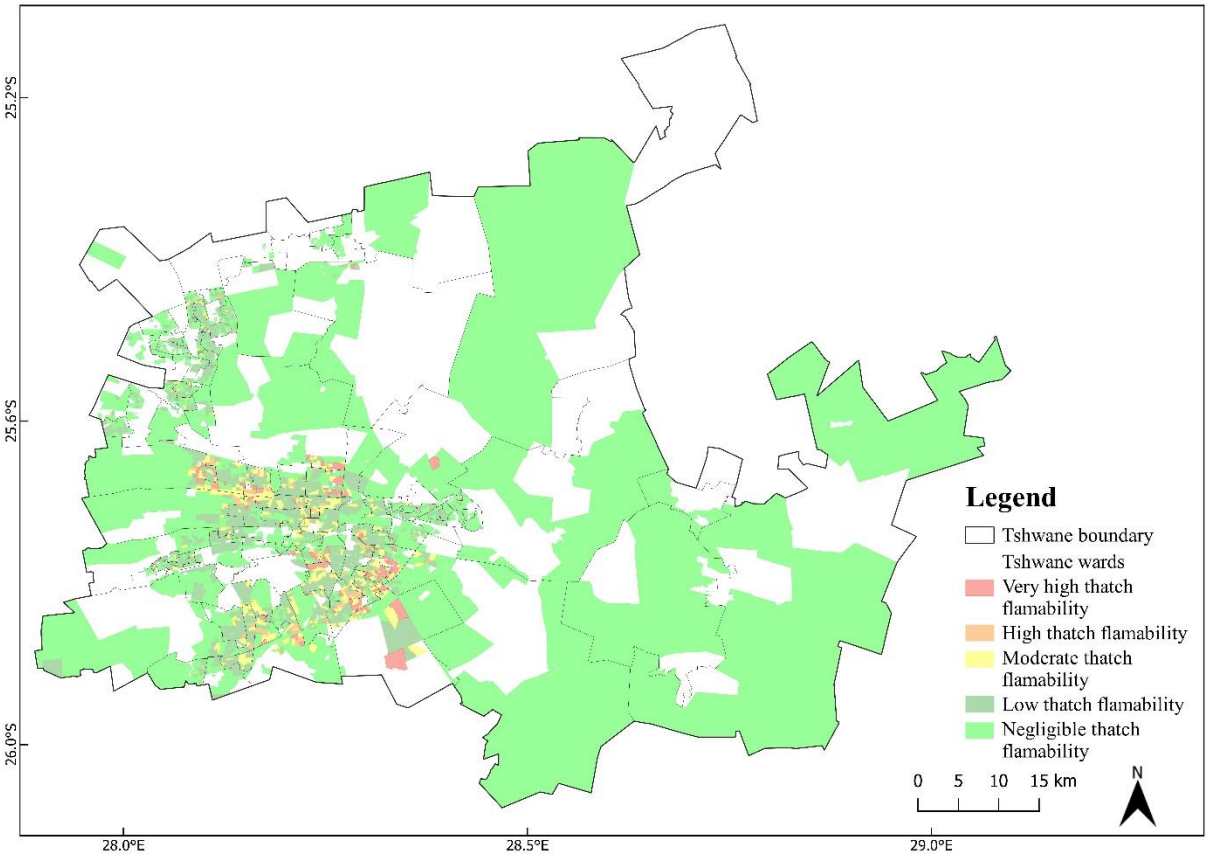


Figure 5.27: Fire risk map based on thatch flammability.

5.9.2 Flood Risk

The risk of flooding is the final risk map in this study and is displayed using flood ponding data gathered from the RiskScape database (Figure 5.28). Water ponding data displays the areas where water can collect on the basis of the topography. The information covers the central regions of Tshwane, which includes Pretoria central and its surrounds, as well as parts of Soshanguve, Hammanskraal and Centurion (Figure 5.28). There are approximately 35km^2 of Tshwane that is at a very high risk of flooding (Figure 5.28). It is found that around 175km^2 of

Tshwane has a moderate risk of flooding while 233km^2 of Tshwane has a low flood risk (Figure 5.28).

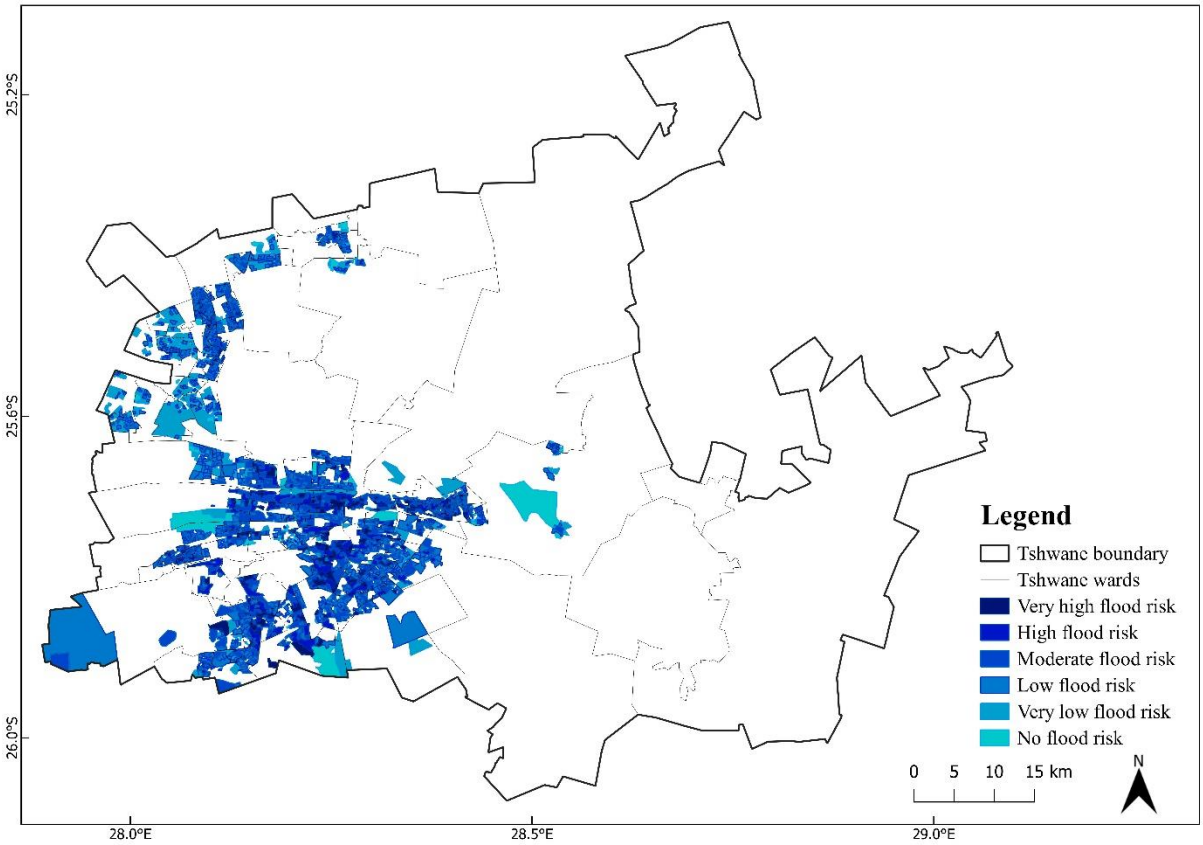


Figure 5.28: Flood risk map based on water ponding data.

5.10 Topography

The slope aspect of Pretoria has been mapped based on the information gathered from the RiskScape database (Figure 5.29). The northern regions of the populated map area indicate a mountain range that runs from west to east, as the northern side of the mountain is facing in a northerly direction as indicated by the dark green colour, and the south side of the mountain is identified by the red colour (Figure 5.29). The plateau of the mountain range is identified by the yellow colour, separating the north and south slopes (Figure 5.29). This study has analysed the slope aspect rather than degrees of slope, therefore leading to highly objective preferences

of slope suitability. The topography of Central Tshwane has been analysed as there was insufficient data for the surrounding areas.

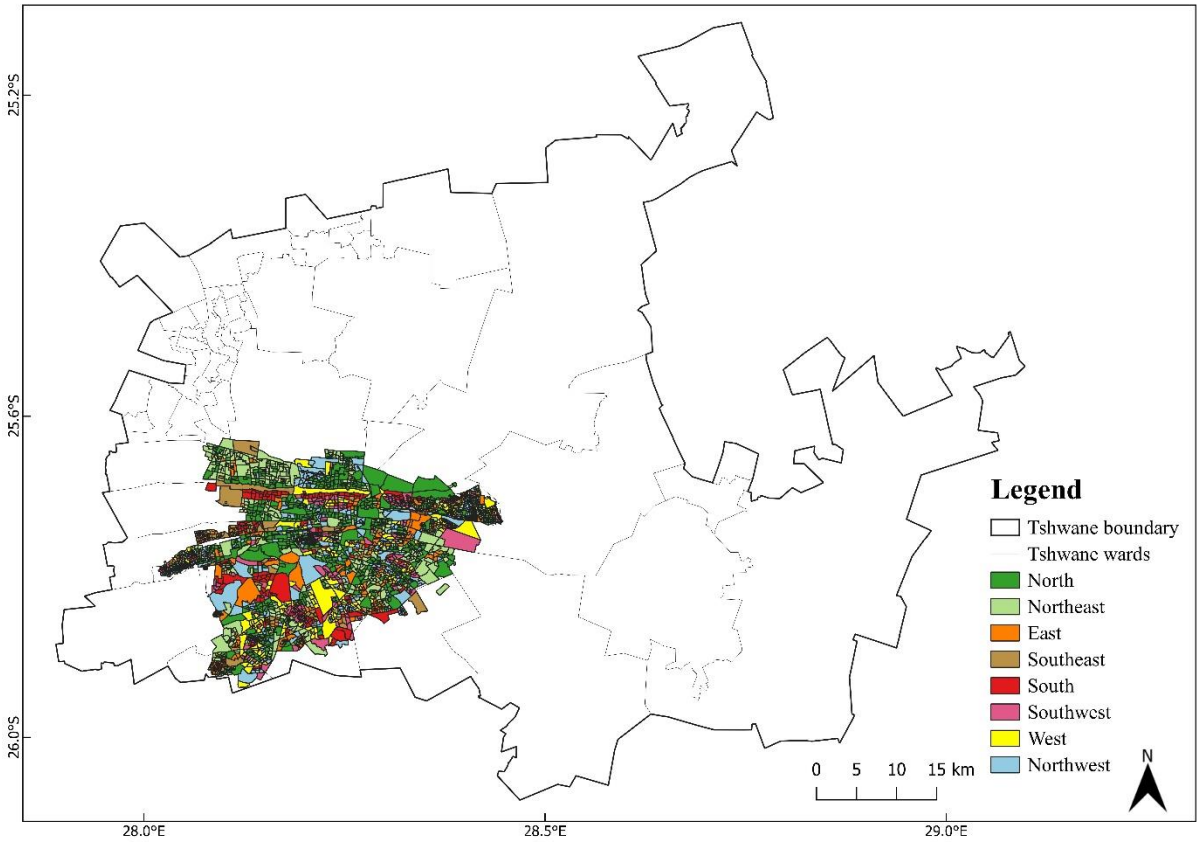


Figure 5.29: The slope aspect in Tshwane.

5.11 Questionnaire Results

Understanding and measuring the liveability of Tshwane was also undertaken with the use of questionnaires. Questionnaires were shared via social media and between friends and family to reach the target of 50 respondents. The questionnaire was closed after 52 responses as two respondents did not live in Tshwane and therefore did not qualify to continue with the questionnaire. The respondents are not completely geographically representative of all wards of Tshwane but do not only represent one clustered region (Figure 5.30).. There is a clear diversification of respondents, which is represented within the results of the questionnaire .

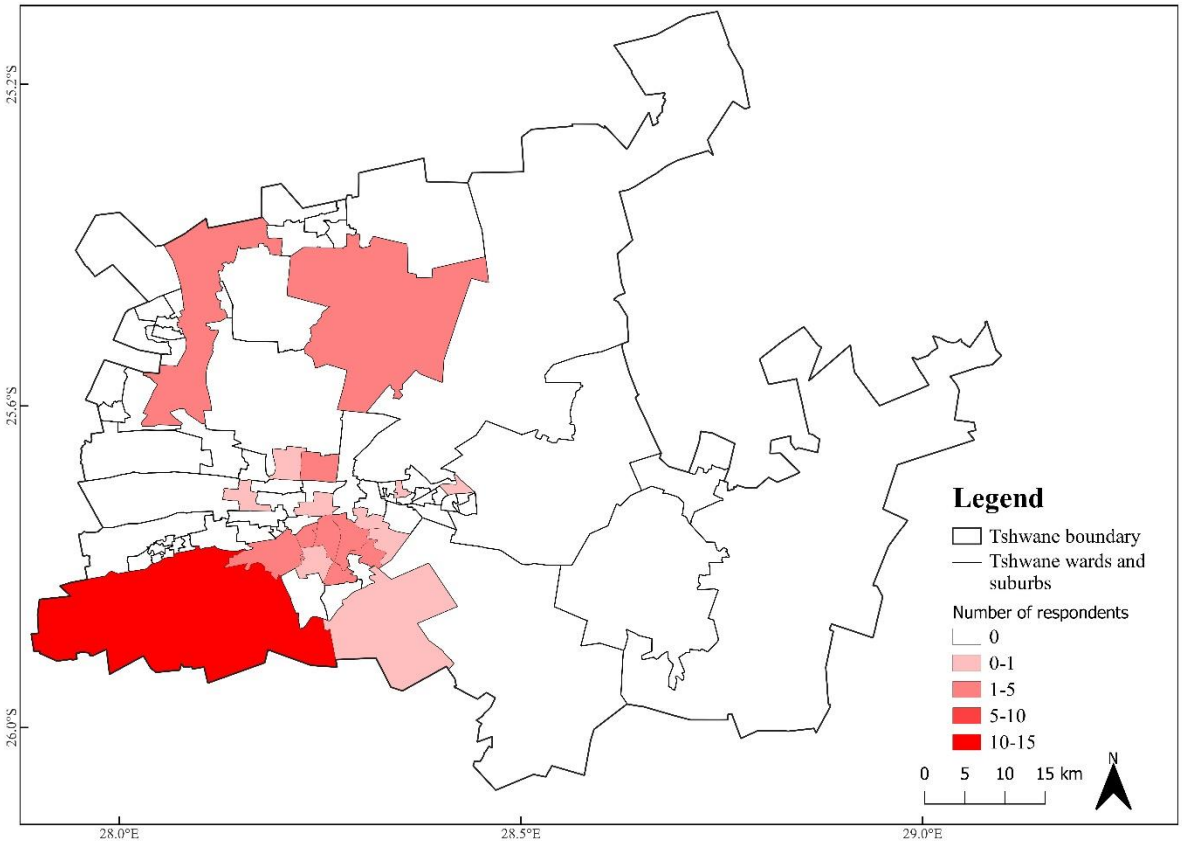


Figure 5.30. The location and number of questionnaire respondents.

A total of 44% (n=50) of the respondents have lived in Tshwane for over 15 years. The following most common response was from 20% (n=50) of the respondents, which indicates that they have lived in Tshwane for between 0-2 years. Three to five years was the least typical response, with 1.5% (n=50). The questionnaire reached people from 26 different suburbs, with the most respondents (9) being from Centurion. A total of 60% (n=50) of the respondents are not looking to move from where they stay, while 20% (n=20) of the respondents are looking to move out of their current suburb and into another suburb in Tshwane. A total of four respondents reside in Hatfield; however, all four are looking to move out of this suburb. Approximately 55.56% (n=9) of the residents that live in Centurion are looking to move out of this suburb within the next 16 months.

Vast differences appeared when respondents were asked what they understood about the term liveability. Respondents indicated that liveability measures the living conditions that affect them and how easy it is to live. One respondent stated:

"Liveability to me mean that the conditions of the area are relatively safe, clean/neat. That there is access to basic needs like housing, water and electricity."

Another respondent stated:

"It is a measure of how easy it is to live in s specific place by analysing everyday tasks."

Approximately 40% (n=50) of the respondents stated that suburbs to the east of Tshwane are thought to be the most liveable due to the lower crime rate, good service delivery and cleanliness. When asked which suburbs are considered the least liveable, 76% (n=50) of the respondents mentioned suburbs found in the northern and western regions of Tshwane. A total of 68% (n=50) of the respondents indicated that these are deemed to be the least liveable due to the higher crime rate, 30% (n=50) listed poor service delivery, 20% (n=50) mentioned high population density, and 16% (n=50) claimed that higher poverty is a cause for low liveability.

Out of the 50 respondents, seven (14%, n=50) believe their current suburb is not considered liveable. While 50% (n=50) of the respondents claim that the suburb they live in is considered to be liveable. The remaining 36% (n=50) of the respondents believe that their current suburb is not the most liveable; however, it also does not qualify as the least liveable. A total of four respondents reside in Hatfield, which is located in central Pretoria towards the south of Tshwane. These four respondents make up 40% (n=10) of the residents that have lived in Tshwane for less than two years. This is potentially due to the large number of university students that live in this area due to its close proximity to tertiary education facilities (Figure 5.6). Two respondents reside in Groenkloof, which is also located near central Pretoria towards the south of Tshwane and have lived in this suburb for less than two years, potentially due to its close proximity to tertiary education facilities (Figure 5.6).

Approximately eight respondents stated that they walk or cycle to purchase basic groceries, and all of these respondents would like to stay within 1km of a small shop. A total of 25% (n=8) of the respondents that walk or cycle to purchase basic groceries live in Hammanskraal, Groenkloof and Soshanguve, while 12.5% (n=8) live in Murrayfield and Moreleta Park. With the exception of Murrayfield, all of these suburbs are considered to be the least liveable, according to respondents. Travelling to purchase larger shopping items has similar patterns to that of smaller shops, with five respondents stating that they walk, use public transport or uber when travelling to purchase larger shopping items. All of these respondents stated that they would like to live within 1km of a larger shopping centre due to convenience and cheaper transport.

5.11.1 Travelling to Retail Facilities

Respondents were asked what they believe to be an ideal distance, moderate distance and too far to travel to purchase basic groceries and larger shopping items. A total of 34% (n=50) of the respondents stated that an ideal travel distance is 2km, and 28% (n=50) said that 1km was ideal (Figure 5.30). A distance of 5km were selected by 44% (n=50) of the respondents as a moderate travel distance to small shops (Figure 5.30). When asked what is too far to travel to purchase basic groceries, respondents (36%, n=50) stated that over 10km was too far, and the second most common response was that over 5km are too far to travel (Figure 5.30). A private car is the most popular mode of transport to these small shops, with 64% of the respondents stating that they use this mode of transportation. Approximately 22% (n=50) of the respondents walk to purchase basic groceries, and only one uses a carpool arrangement. While 18% (n=50) of the respondents use more than one mode of transport, and 8% (n=50) stated that they have their groceries delivered.

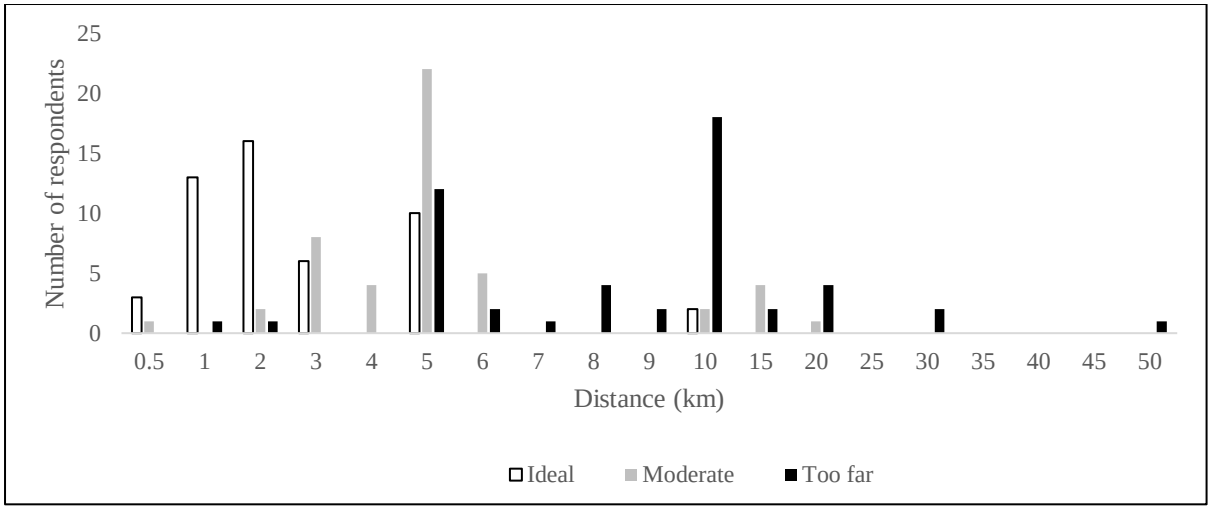


Figure 5.31: Graph showing the ideal, moderate, and too far travel distances to small shops.

Respondents were asked what they believe to be an ideal distance, moderate distance and too far to travel to purchase larger shopping items. Ideal travel distances ranged from 3-20km, with 24% (n=50) of the respondents stating that 3km are ideal, and 4% (n=50) claiming that 20km is ideal (Figure 5.31). A total of 20% (n=50) of the respondents indicated that 5km is a moderate distance, while 4% (n=50) stated that 30km is moderate (Figure 5.31). Finally, the questionnaire asked what is considered too far to travel to purchase larger shopping items. A total of 26% (n=50) of the respondents stated that 10km is too far, while the furthest distance of 50km was put forward by 4% (n=50) of the respondents (Figure 5.31).

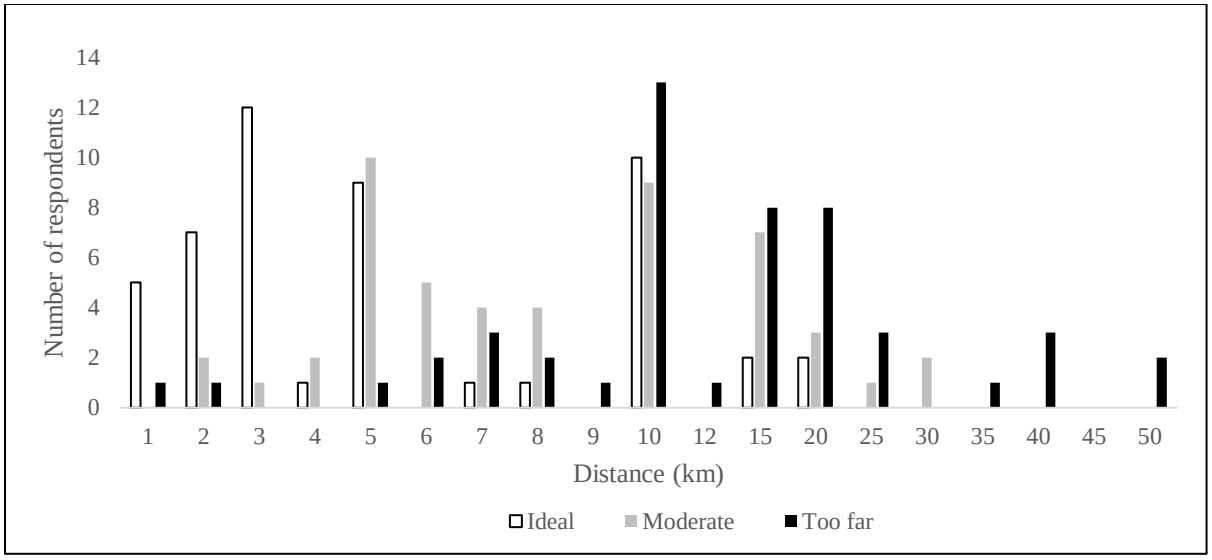


Figure 5.32: Graph indicating the ideal, moderate, and too-far travel distances to larger shops.

Respondents were subsequently questioned on how close they would like to live to a small shop that sells basic groceries. A total of 38% (n=50) of the respondents claimed that they would like to live 1-2km from these shops, while 24% (n=50) stated that they would like to live between 0.5-1km from the shops, 18% (n=50) and 16% (n=50) stated that they would live 2-5km and within 0.5km (Figure 5.32). At the same time, no respondents wanted to live further than 10km from a small shop.

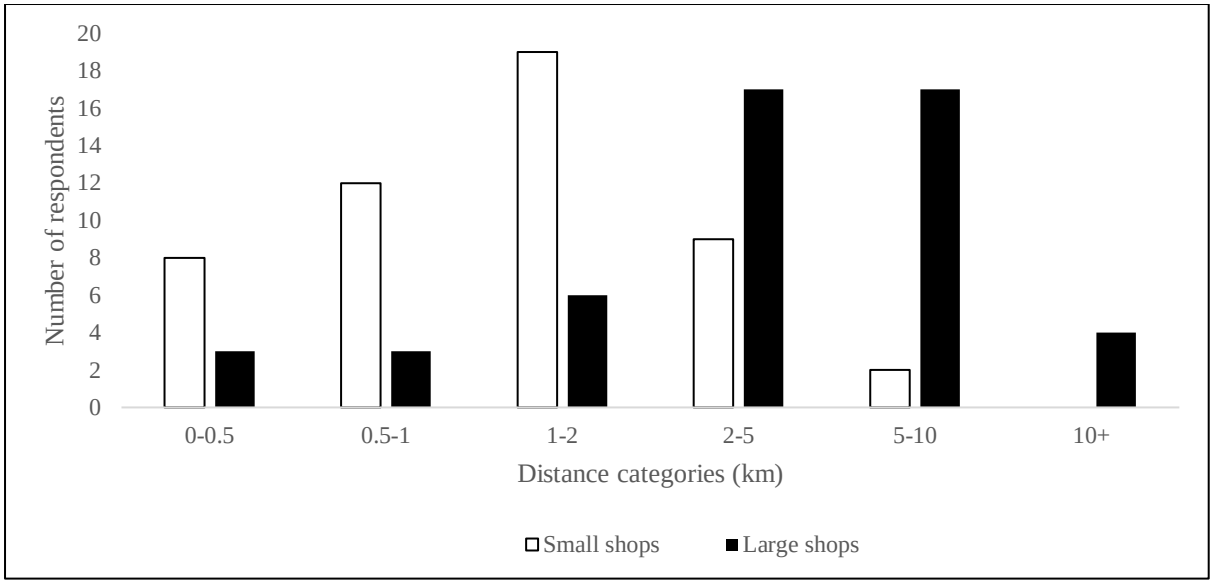


Figure 5.33: Graph showing the preferred distance to both small and large shops.

Respondents (58%, n=50) stated that they wanted to live within these distances because it is more convenient. An equal distribution of respondents, 34% (n=50), said they would like to live 2-5km or 5-10km from a larger shopping centre (Figure 5.32). Similarly to smaller shopping centres, convenience was listed by 46% (n=50) of the respondents as to why they wanted to stay within a specific distance range from a larger shopping centre. However, 30% (n=50) of the respondents highlighted concerns around the amount of traffic in and around these larger shopping centres, while 12% (n=50) and 10% (n=50) claimed that fuel price and noise pollution was a deciding factor when living close to a large shopping centre.

5.11.2 Travelling to Schools

A total of 64% (n=50) of the respondents did not have children at a primary school, 70% (n=50) did not have children at a high school, and 62% (n=50) did not attend or have children attending a tertiary education facility. The questionnaire continued to ask what is considered ideal, moderate, and too far to travel to a primary school, high school, and tertiary education facility. Under 5km was the most common distance selected when asked what an ideal distance to a

primary school is, with 30% (n=50) of respondents selecting this (Figure 5.33). A range of 3km or less were chosen by 18% (n=50) of the respondents, and under 1km had a 16% (n=50) uptake (Figure 5.33). A moderate travel distance to a primary school is thought to be less than 5km, as selected by 26% (n=50) of the respondents (Figure 5.33).

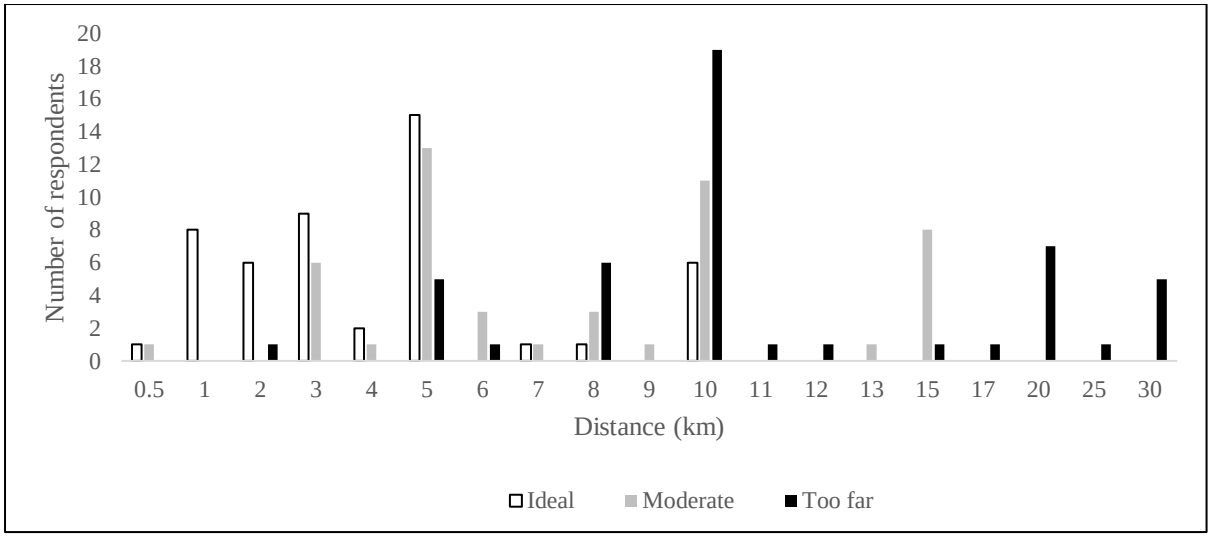


Figure 5.34: Graph indicating the perceived ideal, moderate and too-far travel distances to primary schools.

Although 22% (n=50) and 16% (n=50) of the respondents claimed that under 10km and under 15km are moderate distances (Figure 5.33). Variation was found when asked what is too far to travel to a primary school, with 12 different answers provided (Figure 5.33). Over 10km was mentioned by 36% (n=50) of the respondents, with the second most popular distance (14%, n=50) being 20km (Figure 5.33).

A total of 18 respondents have children attending a primary school, of which 27.78% (n=18) currently live 2-5km from the school (Figure 5.34). Another 27.78% (n=18) of the respondents live 1-2km from the primary school (Figure 5.34). One respondent (5.56%, n=18) lived over 10km from their child's primary school (Figure 5.34). Discrepancies between the number of

people with children attending primary school, and the number of respondents answering how their children are transported to school have been identified. Approximately 18 respondents claimed they have children at primary school, and 19 answered when asked what transport their child uses to get to school. A total of 73% (n=19) of the respondents stated that their child is taken to school in a private car. While 26.32% (n=19) of the respondent's children walk to primary school, and 21.05% (n=19) use public transport. Approximately 42.11% (n=19) of the respondents stated that their children use more than one mode of transportation to get to primary school, with cycling (15.79%, n=19), carpooling (10.53%, n=19) and Uber (5.23%, n=19) making up the remainder of the modes of transport.

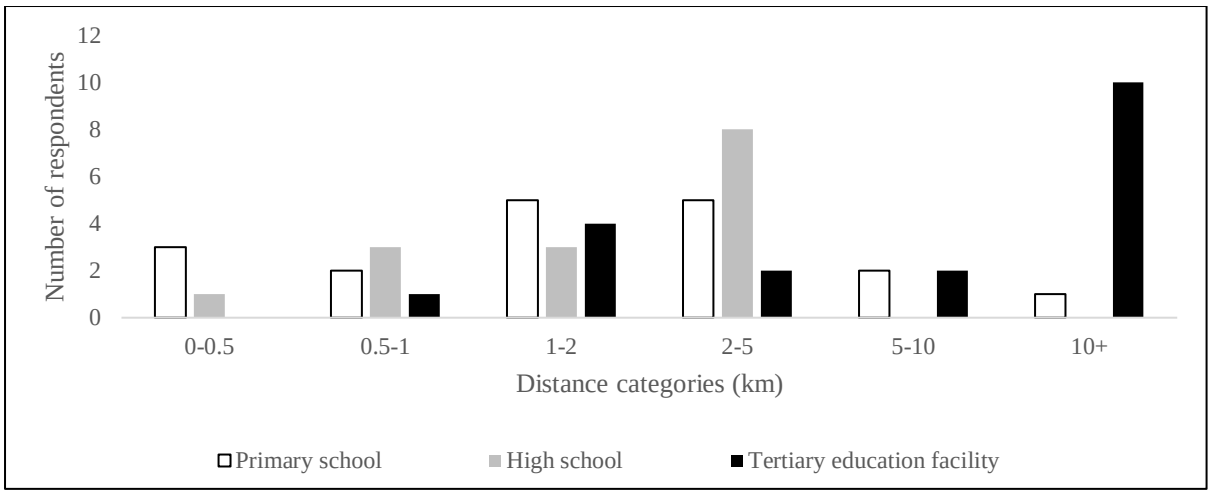


Figure 5.35: Current travel distance to a primary, high or tertiary education facility.

The questionnaire continued to ask what the ideal, moderate, and too far-to-travel distances were to a high school. A total of 44% (n=50) of the respondents stated that 5km is an ideal distance to travel, while the next most common selection was 3km at 22% (n=50, Figure 5.35). Moderate travel distance to high schools was more spread than in Figure 5.33, as distances ranged from 0.5-30km (Figure 5.35). Approximately 26% (n=50) of the respondents stated that five and 10km are both moderate travel distances (Figure 5.35). The next most common

moderate travel distance is also tied at 10% (n=50), between 6km and 15km (Figure 5.35). Respondents provided a wide variety of distances when asked what is too far to travel to a high school. Over 10km was selected by 32% (n=50) of the respondents, making this the most popular choice (Figure 5.35). Over 20km had been mentioned by 22% (n=50) of the respondents (Figure 5.35).

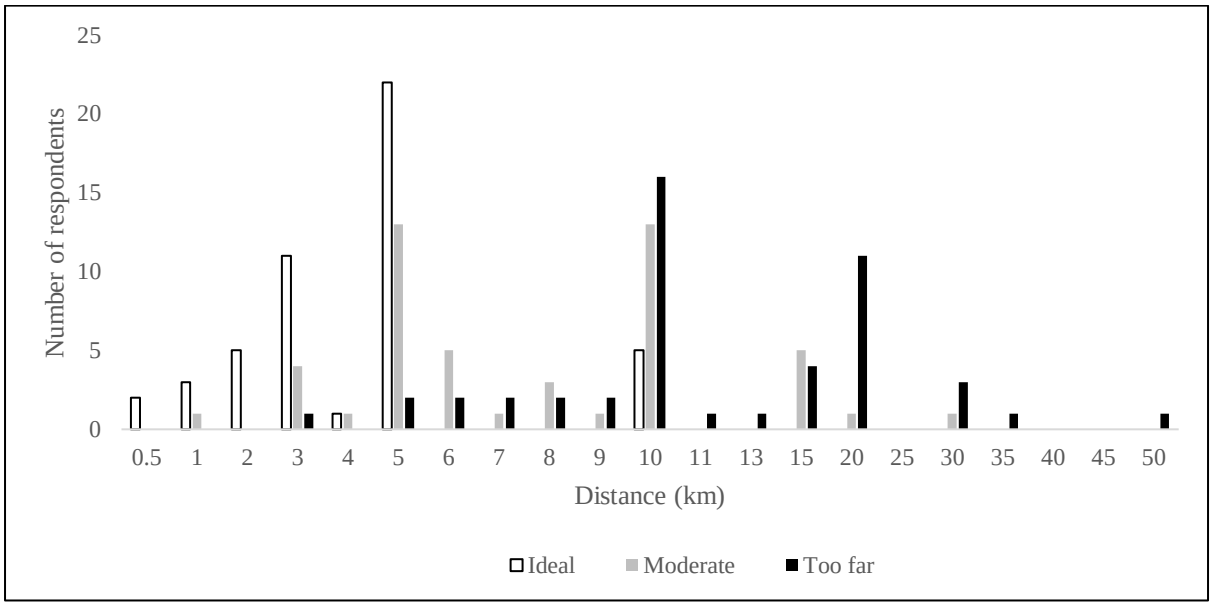


Figure 5.36: Graph depicting the perceived ideal, moderate and too-far travel distances to high schools.

Fewer respondents have children attending a high school compared to a primary school, with 15 (30%, n=50) respondents indicating how far they travel to high school. Over half of the respondents (53.33%, n=15) state that they live 2-5km from a high school (Figure 5.34). While 20% of the respondents lived between 0.5-1km and 1-2km (Figure 5.34). One respondent lives within 0.5km of a high school (Figure 5.34). Unlike the responses to the primary school questions, there are no discrepancies between the number of responses between how far people travel to high schools and the mode of transport used to travel to high schools.

A total of 60% (n=15) of the respondents stated that they only use a private car to travel to high schools, while 13.33% (n=15) only walk to a high school. While 26.67% (n=15) of the respondents use more than one mode of transport to get to high schools, with an equal distribution of 6.67% (n=15) using a private car or walking, public transport or a bicycle or walking, a private vehicle or carpool arrangement, and a carpool arrangement or a private car or cycling or walking.

The ideal distance, moderate distance, and too far to travel to a tertiary education facility were the final tier in the education and travel category of the questionnaire. Respondents were asked the same questions as in the other two sections. The ideal travel distance to a tertiary education facility is a mirror of that for primary and high schools (Figures 5.33 and 5.35), with 5km being selected by 30% (n=50) of the respondents, making this the most popular ideal travel distance to both primary, high and tertiary education facilities (Figure 5.36). Under 10km was the second most popular ideal travel distance to tertiary education facilities, with 28% (n=50) of the respondents selecting this (Figure 5.36).

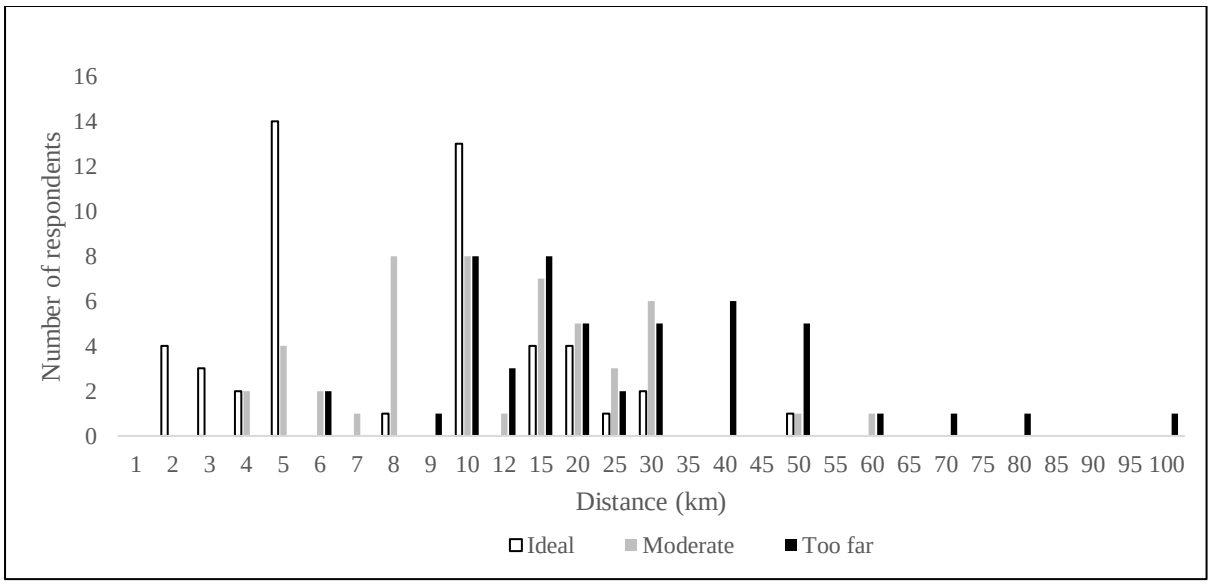


Figure 5.37: Graph showing the perceived ideal, moderate and too-far travel distances to tertiary education facilities.

Approximately 38% (n=50) of the respondents have children attending or are personally attending a tertiary education facility. A total of 19 (38%, n=50) of the respondents answered how far they live from a tertiary education facility, of which 52.63% (n=19) live farther than 10km from these facilities (Figure 5.34). It is found that 21.05% (n=19) of the respondents live 1-2km from a tertiary education facility (Figure 5.34). An equal portion of these respondents, 10.53% (n=19), live 2-5km, and 5-10km (Figure 5.34). Only one respondent lives within 0.5-1km of these institutions (Figure 5.34). Transport used to tertiary education facilities is primarily completed with a private car.

Approximately 52.63% (n=19) of the respondents only use a private car, while 21.05% (n=19) use a private vehicle along with another form of transport. The only other single-use transport method was public transport, selected by one respondent. Walking was the next most common form of transportation, with 26.32% of respondents stating that they walk to campus; however, walking was always accompanied by another form of transport, either cycling, a carpool arrangement, or a private car. While 21.05% (n=19) of the respondents used public transportation when travelling to a tertiary education facility. A carpool arrangement was selected by two respondents, while uber (or similar services) was only mentioned by one respondent.

5.11.3 Travel to Municipal Institutions.

Municipal institutions are separated into hospitals and police stations. The questionnaire continued to ask what the ideal travel distance is, moderate travel distance and too far to travel to hospitals and municipal institutions. The respondents were then asked how close they would like to live to the municipal institution, why, and how they travel to these places. The ideal travel distance to a hospital is thought to be 2km, with 32% (n=50) of the respondents selecting

this (Figure 5.37). A total of 22% (n=50) of the respondents indicated that 5km is an ideal travel distance. As chosen by 18 (36%, n=50) respondents, a moderate travel distance is 5km (Figure 5.37). The following most selected moderate travel distance is 15km, as chosen by 11 (22%, n=50) respondents (Figure 5.37). Too far to travel to a hospital is 8km, as supported by 24% (n=50) of the respondents; however, 22% (n=50) also stated that 10km is too far to travel to a hospital (Figure 5.37).

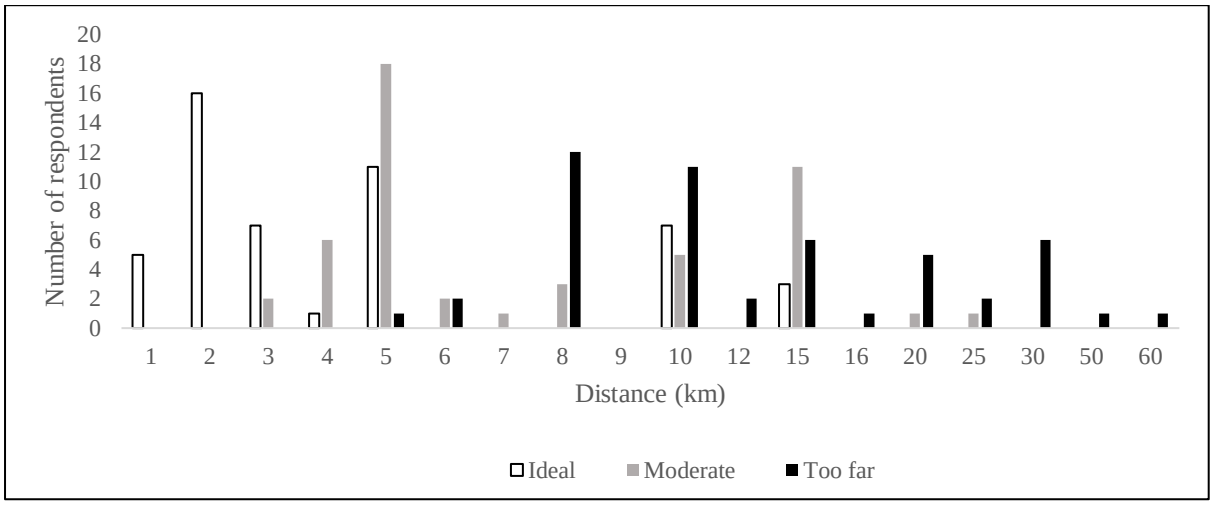


Figure 5.38: Graph indicating the perceived ideal, moderate and too-far travel distances to a hospital.

Travelling to a hospital is completed mainly with a private car, as 72% (n=50) of the respondents stated that they use this mode of transport. A private car and ambulance were the next most common selection, at 18% (n=50). Respondents were asked how close they would like to live to a hospital and why, with the most common response being 2-5km (Figure 5.38). Respondents (46%, n=50) stated that they wanted to live this close in case of an emergency, while the next most common answer was supported by 36% (n=50) of the respondents who stated that it is more convenient. Respondents who selected a range over 2km noted that this is

due to not wanting to be too close to hospitals to avoid traffic, noise and air pollution and because they do not need to be closer.

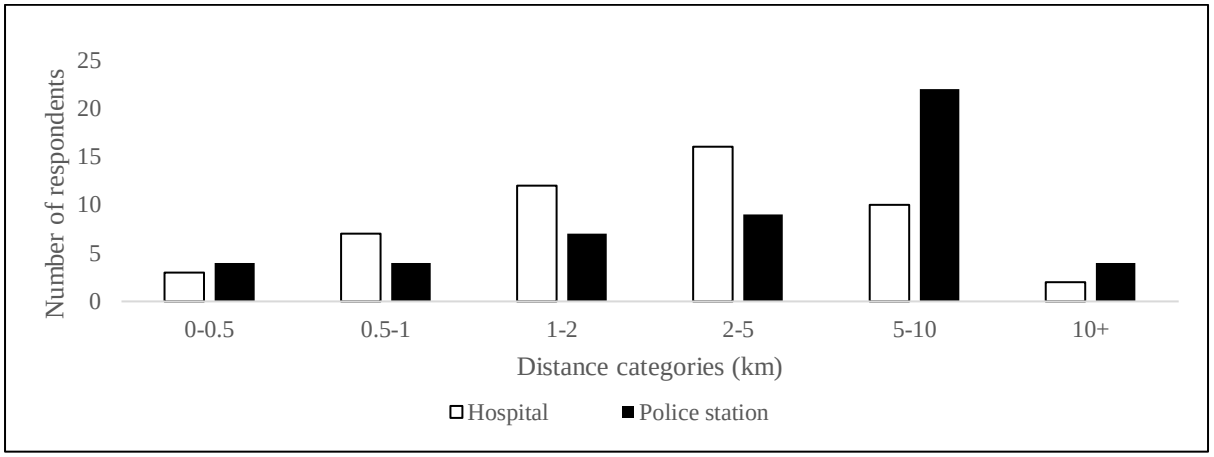


Figure 5.39: Graph showing the desired travel distances to hospitals and police stations.

The respondents were asked what they perceive to be ideal, moderate and too far to travel to a police station. It was found that 42% (n=50) of the respondents claimed that 5km is an ideal travel distance to police stations (Figure 5.39). A distance of 2km were also selected as an ideal distance by 18% (n=50) of the respondents (Figure 5.39). Moderate travel distance to police stations is thought to be 10km, with 28% (n=50) of respondents selecting this distance (Figure 5.39). However, 5km was the next most common selection with 20% (n=50) respondent selection (Figure 5.39). Too far to travel to a police station is thought to be 15-20km, with 24% (n=50) and 22% (n=50) selection. Although one respondent stated that 50km is too far to travel, and another indicated that 5km are too far (Figure 5.39).

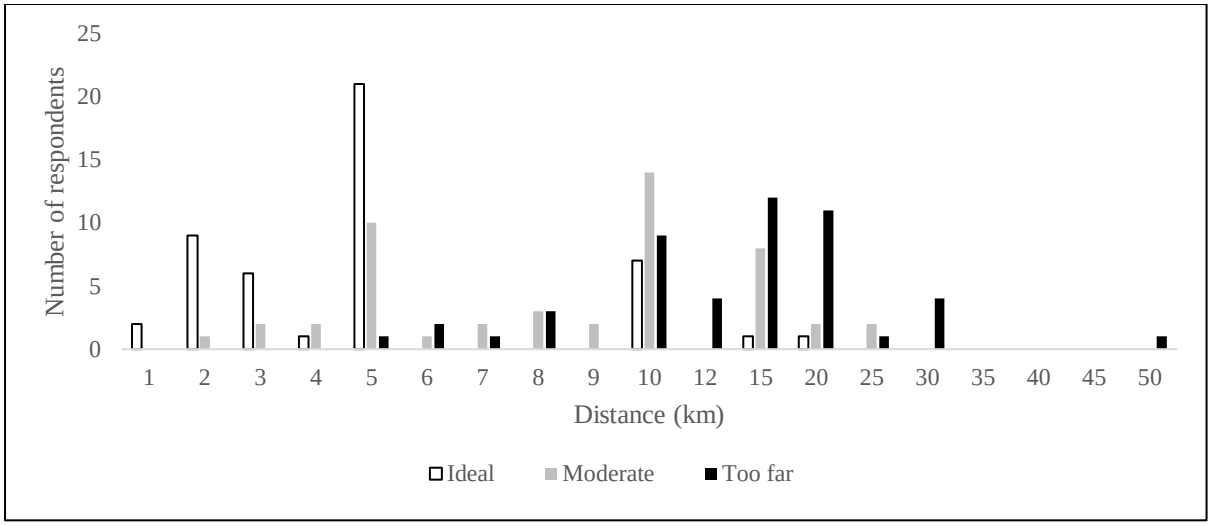


Figure 5.40: Graph showing the perceived ideal, moderate and too-far distances to police stations.

Respondents were asked how close they would like to live to a police station and why. The most common answer was 5-10km, as supported by 44% (n=50) of the respondents (Figure 5.38). Between 2-5km was the next most common selection, with nine respondents (18%, n=50) selecting this distance (Figure 5.38). Convenience was the most common reason for these selections, as supported by 22% (n=50) of the respondents. Close proximity in case of an emergency, the potential for crime deterrent and not needing a police station were selected by 20% (n=50) of the respondents. Three respondents did not provide a reason for their selection. When travelling to a police station, 86% (n=50) of the respondents travel by car, while only 8% (n=50) walk or use public transport.

5.11.4 Travelling to Parks

Respondents were asked what they believe to be an ideal travel distance, moderate travel distance and too far to travel to a public park or open space. A total of 34% (n=50) of the respondents stated that 1km is an ideal travel distance, while 16% (n=50) claim that 2km are ideal (Figure 5.40). Moderate travel distance to a park is shared between 2km and 10km, with

20% (n=50) of the respondents selecting these distances (Figure 5.40). A distance of 3km was the next most common moderate travel distance as selected by nine (18%, n=50) respondents (Figure 5.40). Finally, 5km is seen as too far to travel to a park or open space by 30% (n=50) of the respondents (Figure 5.40). While 14% (n=50) of the respondents selected 10km and 15km as too far to travel (Figure 5.40). The most significant variation between distances is found here, as 0.2km was selected by one respondent and over 50km by another.

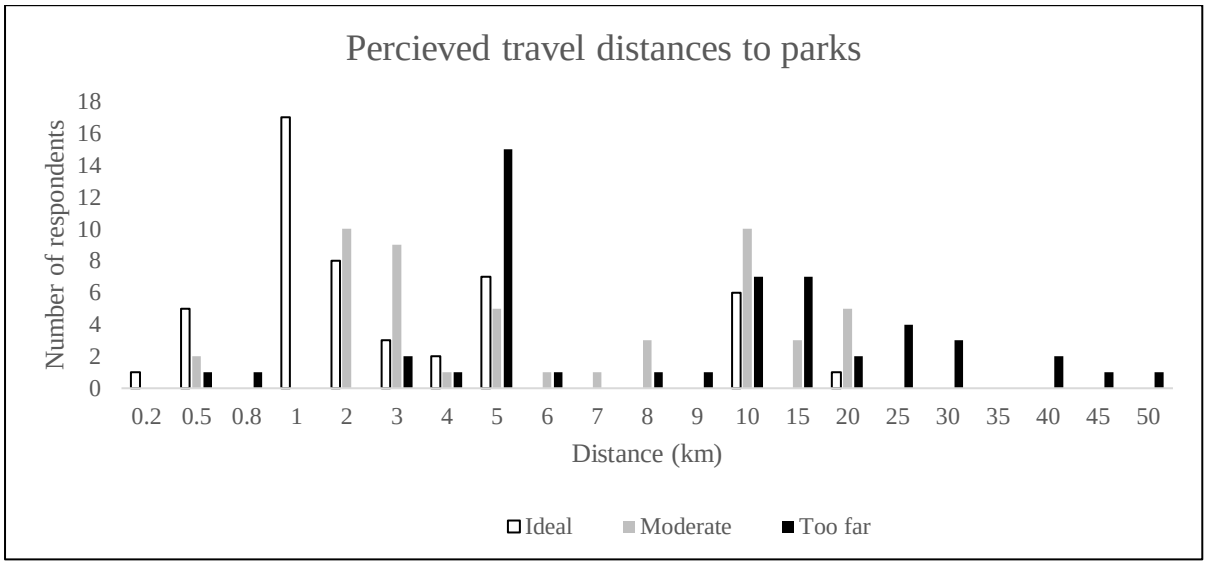


Figure 5.41: Graph indicating the perceived ideal, moderate and too-far distances to travel to parks.

When respondents were asked how far they would like to live from a park, 24% (n=50) stated that 0.5-1km is desirable, and another 24% (n=50) believed that 5-10km is desirable (Figure 5.41). Respondents (78%, n=50) claimed that convenience is why they selected these distances. Five respondents (10%, n=50) stated that they do not want to stay too close as they can be crime hotspots, while other responses included that they wanted to avoid the traffic and noise (6%, n=50), they don't use parks so do not care (4%, n=50) and that they are aesthetically pleasing (2%, n=50).

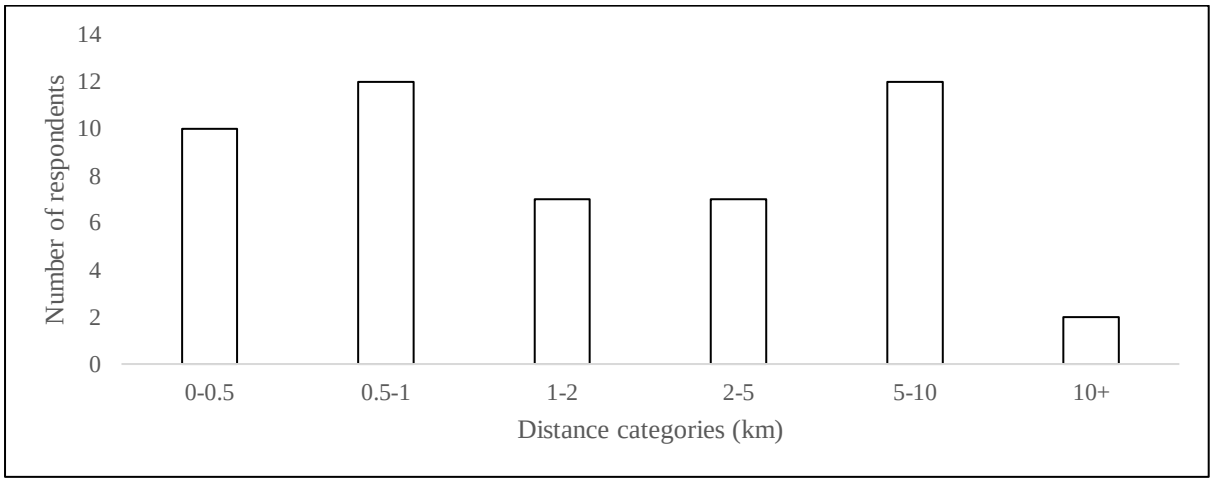


Figure 5.42: Graph showing the desired travel distance to parks.

5.11.5 Slope and Liveability

A total of 76% (n=46) of the respondent's state that slope does affect liveability. Respondents' reasoning for this varies drastically, with some stating that it can be more prone to flooding, lighting strikes and erosion, while others stated that people can still live and survive on slopes, so it does not impact liveability. Few respondents indicated that it is harder to travel and walk up slopes or stairs and, therefore, it affects your liveability. In contrast, some respondents claim that slope can increase property prices due to the improved aesthetics of the house or surrounding views. Four respondents did not provide a usable answer to this question.

5.11.6 Importance of Factors Influencing Liveability

Respondents were presented with a Likert scale and asked to rank how important specific factors are when assessing the liveability of an area. The scale required respondents to rank aspects on a scale of one to five, where one was not important, and five was extremely important. The respondents ranked 12 different aspects, including daily temperature, amount of daily rainfall, amount of daily sunshine hours, amount of slope, distance to a public park or

open space, distance to a police station, distance to a hospital, distance to a tertiary education facility, distance to a high school, distance to a primary school, distance to a larger shop, and distance to a small shop (Figure 5.42).

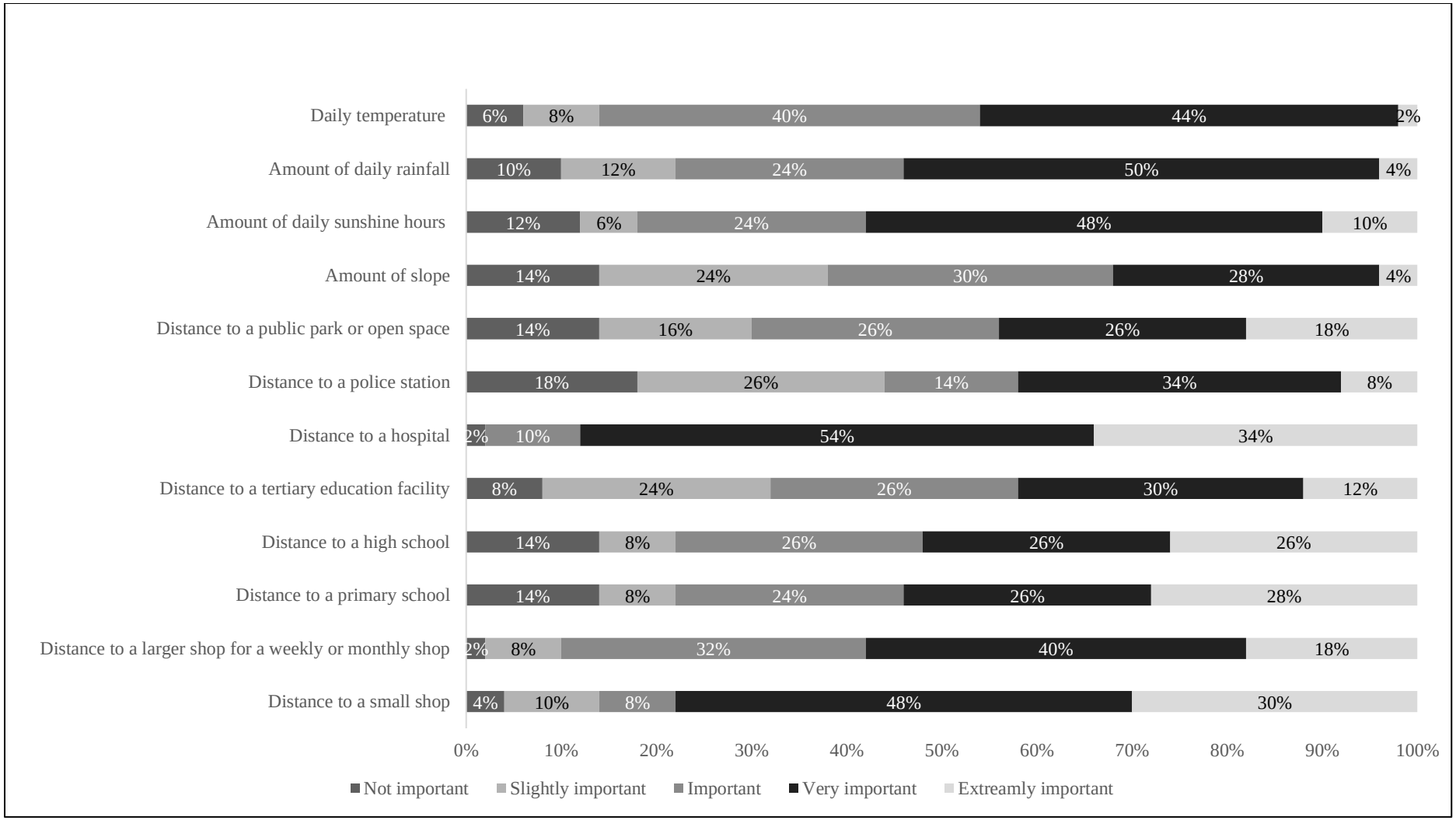


Figure 5.43: Graph showing the respondent's selection of the importance of factors.

The respondents indicate that some factors influence liveability more than others (Figure 5.42). In this case, distance to a hospital is seen as the most important factor when assessing liveability, as 34% (n=50) of the respondents stated this is extremely important, while only 2% (n=50) indicated that it is unimportant. Distance to a police station is deemed the least important factor when assessing liveability, as 18% (n=50) claim that it is not important (Figure 5.42). Distance to a small shop and distance to a primary school is seen to be the next most important aspects that influence people's liveability, as 68% (n=50) state that distance to a small shop is either very or extremely important, while 58% (n=50) state that distance to a primary school is very or extremely important (Figure 5.42).

5.12 Composite Liveability Map

A composite map indicates the areas deemed to be more liveable based on travelling (Figure 5.43). This map draws on information from Figures 5.5, 5.7-5.11, and 5.21, with scores being given to each zone. Each of the corresponding maps provided a green, yellow and red zone; each zone was assigned a score, with green being five, yellow three and red one. All 107 wards in Tshwane were ranked based on the percentage of how much each zone covered the ward, and subsequently allowed each ward to be given a score based on how close they are to a retail facility, school, point of interest, park, hospital, road and police station. Each score was then totalled per ward, providing the grounds for producing the composite map. A perfect score would be a total of 35 points.

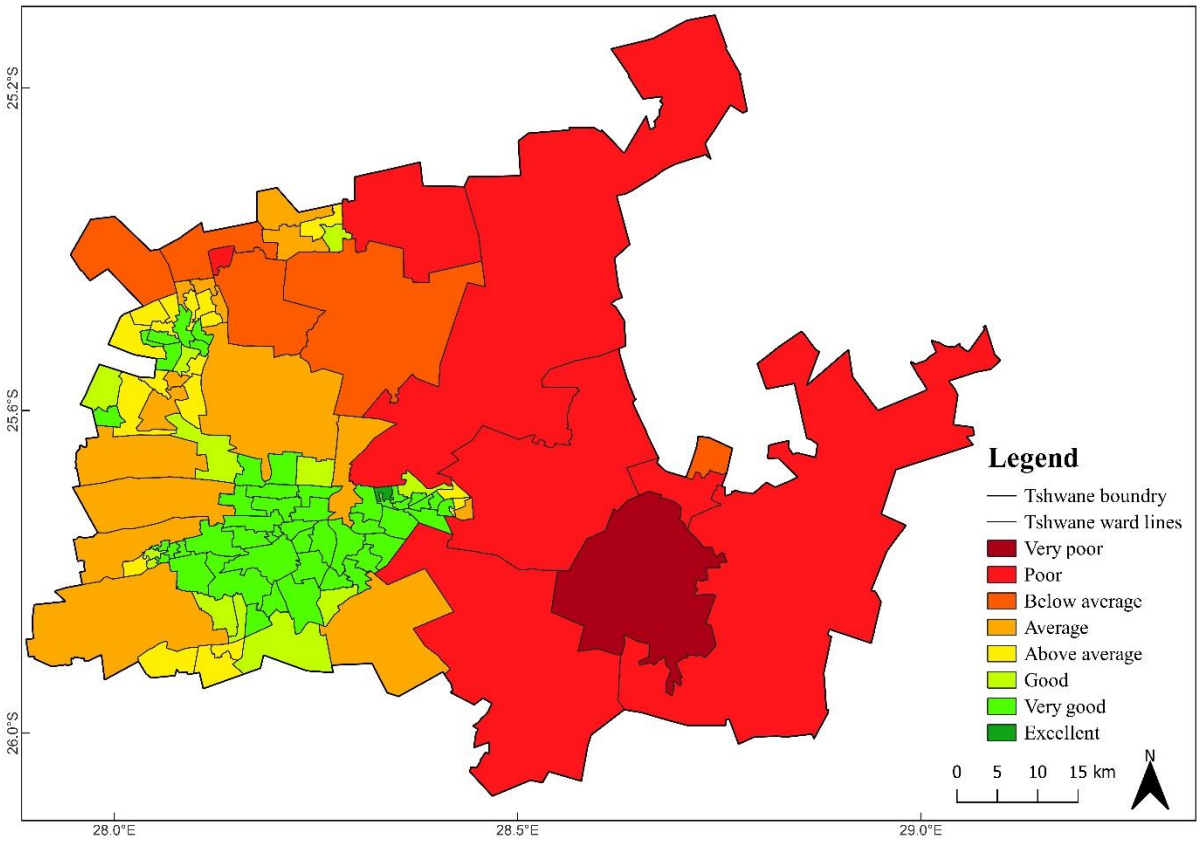


Figure 5.44: Map showing the location and level of liveability based on category scores.

The central to southern suburbs of Tshwane are identified as having the highest scores, as well as some suburbs located towards the west of Tshwane (Figure 5.43). The northeast, east and southeast suburbs have the lowest recorded scores and are therefore presumed to be the least liveable (Figure 5.43). Only one ward has scored in the excellent category, while 48 are classified as having very good liveability. The east of Tshwane contains wards with the lowest liveability scores.

The scores used to rank the liveability in Tshwane are unweighted and do not demonstrate a true reflection of liveability, as some factors are seen to be more influential on liveability compared to others (Figure 5.42). Based on public perception obtained from the questionnaire responses, weighting each indicator has allowed this study to determine what areas are more liveable, providing a more realistic image of liveability (Figure 5.44). Weighting each indicator

based on questionnaire results has allowed for the production of another map, identifying which areas are more liveable based on the respondent's importance of indicators (Figure 5.44).

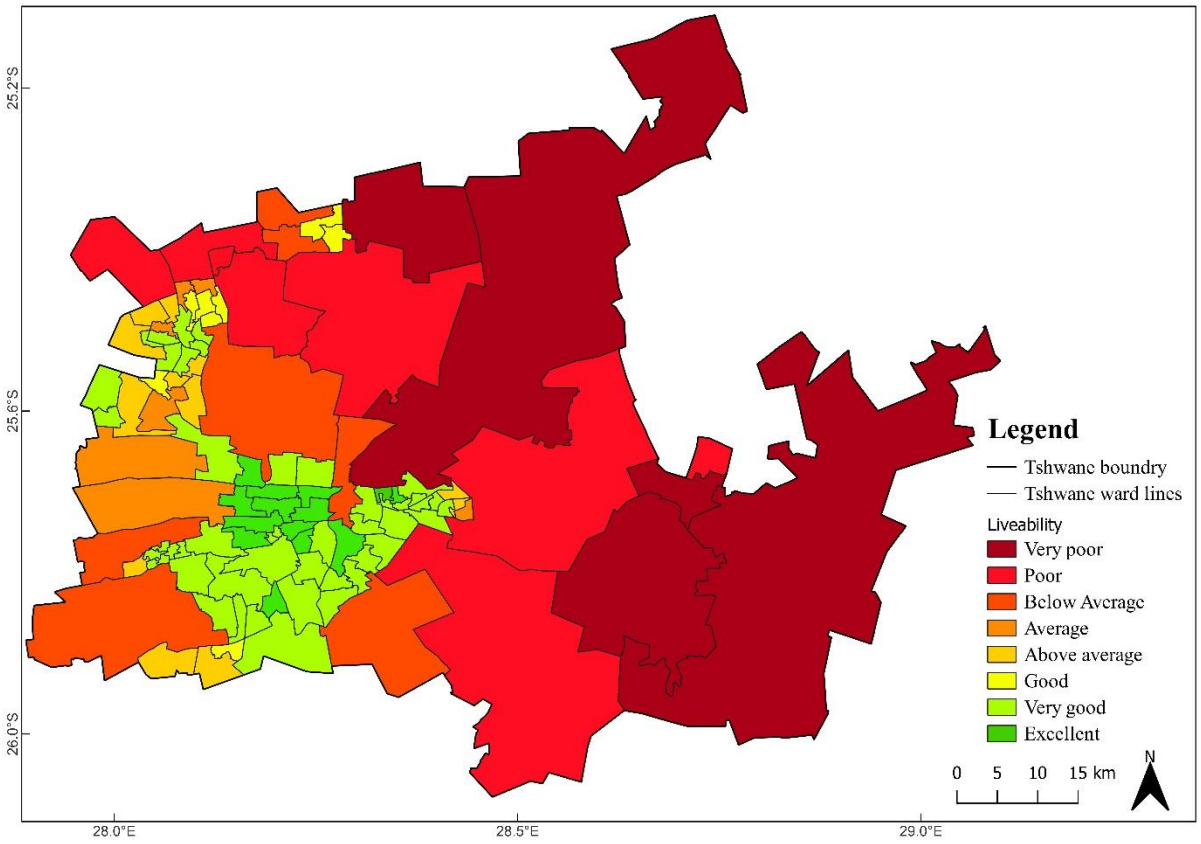


Figure 5.45: Map showing the location and liveability of wards in Tshwane based on weighted indicators

Weighting the indicators based on the respondents' selection of what influences liveability has highlighted several variations compared to the unweighted indicators displayed in Figure 5.43. Similarly to Figure 5.43, the east of Tshwane is populated with wards that have poor liveability (Figure 5.44). Approximately 14 wards, primarily located in central to southern Tshwane, have excellent liveability.

Areas in Tshwane that are found in the extremely liveable category have the highest scores in location to retail facilities, schools, points of interest and hospitals; however, they fall short of

the distance to parks and proximity to roads categories, giving all of these wards a score of between 31-33 out of 35. Proximity to points of interest or parks was the differentiating factor between those in the excellent and good categories, as some wards scored highly in proximity to points of interest but fell short in proximity to parks. A noticeable decline in scores relating to proximity to parks is identified in the wards considered to have above-average liveability, with this being a contributing factor to the lower liveability score. Wards categorised with average liveability have an overall average weighted score of 3.5; however, they only average a score of two when assessed against proximity to parks. Proximity to schools is still high with an average of five. A total of five wards fall within the very poor liveability category, out of which, only three wards scored a single five points for proximity to roads. Proximity to retail facilities, parks and points of interest is the leading cause of these wards' low liveability scores.

5.13 Conclusion

Liveability in Tshwane has been mapped and measured against the proximity to commonly used locations. Questionnaire respondents identified their perceived liveability of specific locations and what they believe influences liveability. Although close proximity to facilities is largely understood as being desirable, primarily due to convenience, respondents indicated that being too close brings challenges of noise pollution, crime and traffic congestion. The central to western suburbs are identified as having the greatest liveability based on proximity to facilities, as there is a higher density of schools, retail facilities and municipal institutions in these areas. Although proximity to facilities such as hospitals and retail facilities have a significant influence on liveability, it is found that residents of Tshwane favour high service delivery and reduced crime rates when comparing suburbs.

CHAPTER 6: DISCUSSION

6.1 Introduction

This study aims to develop and use a liveability index for Tshwane to inform insurance practices that can be applied to Johannesburg. Thus far, this research study has highlighted the global benefits of liveability indices and their potential shortfalls. The analysis of Tshwane-specific indicators has allowed for the compilation of index values based on what respondents believe to influence their liveability. The following chapter critically discusses the results presented in this research and reflects on the broader literature. This chapter begins with assessing the indicators used in this study compared to other liveability indices, after which the chapter discusses the findings of other indices compared to what has been found in this research study. The discussion continues with the usability of this study before ending with what limitations have been identified.

6.2 Comparison of Results to Other Studies

Analysis of the results found in this study allows for comparison between other indices produced globally. Cross-analysis of different indices allows for comparing Tshwane to other regions within South Africa and globally. This section discusses the results found in this study and compares what has been found to other available literature.

6.2.1 Education Facilities

This study presents several maps based on varied factors that influence liveability. Although many of these factors are important to different people, there are several different perspectives that one could have on whether these positively or negatively influence liveability. Proximity to education facilities demonstrates that areas within 5km of a school are deemed more

desirable as determined by government-specified catchment areas and other studies' access to education facilities (Figures 5.1 to 5.6, van Dyck *et al*., 2010; D'Haese *et al*., 2011). These maps do not show schools outside the Tshwane boundary, although they are still available to people living in Tshwane, and those living close to the border may be positioned closer to them than schools in Tshwane. Figure 5.5 indicates that the east of Tshwane has less access to schools; however, there may still be schools bordering Tshwane that are more accessible to residents not displayed on this map.

The ideal distance to schools in Tshwane, as perceived by the respondents of the survey questionnaire, is 5km (Figures 5.33, 5.35). This supports the information mapped from the RiskScape database (Figure 5.5), that those within 5km of a school, as identified by the green buffer zones, have ideal access. However, these distances can vary based on the mode of transport used to access schools, as those that use passive transport methods, such as cars and busses, tend to travel further to school (McDonald, 2008; Chillón *et al*., 2015). The ideal travel distance to schools in Tshwane is three times higher than that in Australia, with 1.6km being found as ideal in Australia compared to 5km in South Africa (Badland *et al*., 2015; Higgs *et al*., 2019).

Proximity to schools is mapped as a feature that improves liveability, as it is helpful for families who are looking for locations close to schools or have children at schools. However, close proximity to schools could potentially reduce the liveability of some people, such as those who do not have children at school, attend boarding schools, or do not need close access to schools. Close proximity to schools could negatively influence liveability as there is increased noise surrounding schools (Bulunuz, 2014; Okwudili *et al*., 2021). Similarly, some might see proximity to schools as a negative impact on liveability as there is an increase in traffic congestion surrounding schools during peak times, potentially leading to more air and noise pollution (Li *et al*., 2021; Cvitković *et al*., 2022).

Proximity to education facilities has been measured in other indices in an attempt to find how far people walk to these facilities and how changes in access can influence liveability (D'Haese *et al*., 2011; Namzi-Rad *et al*., 2012; Higgs *et al*., 2019; Ikeda *et al*., 2019; EIU, 2021). Other liveability studies that have measured proximity to education facilities have used various weighting methods (Namzi-Rad *et al*., 2012; Higgs *et al*., 2019). The Economist's Intelligence Unit global liveability ranking claims that education is the lowest priority for liveability as it is weighted at 10% (EIU, 2021). In comparison, Higgs *et al*. (2019) does not directly weight the indicators used in their study. Similarly to this study, Namzi-Rad *et al*. (2012) weights the access to education facilities based on questionnaire responses.

6.2.2 Proximity to Parks and Open Spaces

The value of proximity to parks and open spaces carries similar arguments as proximity to schools. In this study, proximity to parks is viewed as increasing liveability; however, they can also be viewed as a hindrance to liveability. A buffer of 0.5km is considered the ideal distance to parks in this study, consistent with other indices (Li *et al*., 2019; Guan *et al*., 2020). Questionnaire results indicate that 1km is perceived to be an ideal travel distance to parks and open spaces in Tshwane (Figure 5.40), confirming that the green 0.5km distance buffer found in Figure 5.7 is within an ideal range. Desired travel distance to parks in Tshwane is perceived to be between 0.5-1km (Figure 5.41). This is primarily due to the convenience of easily accessing the park and increased park visitation after the lifting of COVID-19 restrictions (Geng *et al*., 2021). The ideal distance to parks in Tshwane is similar to that of Australia and Tokyo, as ideal distances are found to be around 0.5km (Giles-Corti *et al*., 2005; Guan *et al*., 2020). However, other studies have found that park catchment sizes range from 0.4km to 2km (Higgs *et al*., 2019; Li *et al*., 2019).

Close proximity to parks and open spaces can lead to an increase in physical activity (Burrows *et al*., 2018). Parks can reduce the air temperatures of surrounding areas, providing reprieve during hot periods, which can average 29.6 °C in Tshwane (Nowak and Heisler, 2010; Adeyemi *et al*., 2015). Parks can also lead to improved air quality and therefore are valuable aspects of an area and will increase its liveability (Nowak and Heisler, 2010; Huzlik *et al*., 2020). This questionnaires results uncovered that close proximity to parks had been reported to negatively influence liveability due to its higher crime risk. Close proximity to parks could negatively impact the area's liveability due to the higher potential for crime, which is particularly pertinent in the South African context (Groff and McCord, 2012). However, crime also depends on the type of land use surrounding the park (Boessen and Hipp, 2018). Although some questionnaire respondents believe that parks attract crime, this is disproved by Kvit *et al*. (2022) and Venter *et al*. (2022), who find that the crime rate is reduced in green open spaces in both South Africa and the USA. Although these findings demonstrate that parks can reduce crime, it could potentially be due to the affluence and high security that houses in South Africa have, whereas standalone houses next to a park, could potentially be at higher risk when compared to houses a couple of streets away from the park.

Further perspectives are found when assessing whether proximity to parks can negatively influence liveability (Zannin *et al*., 2006; Noori *et al*., 2016). Parks can be understood as negatively affecting liveability as they can be a source of noise pollution (Zannin *et al*., 2006). However, recent research suggests that parks can reduce noise pollution due to the increased presence of trees and vegetation (Kumar *et al*., 2013; Noori *et al*., 2016). Close proximity to parks not only allows the surrounding residents to use the facilities but also promotes a healthy lifestyle and higher quality environment, therefore supporting this study's identification of close proximity to parks as increasing the liveability of an area. These findings identify that the east of Tshwane has the lowest levels of liveability based on proximity to parks, whereby the

north of Tshwane has moderate liveability and central to western Tshwane has the greatest levels of liveability when measured against proximity to parks.

6.2.3 Proximity to Hospitals

Proximity to hospitals is closely linked to the influence on liveability, as respondents indicated that they believe that liveability increases the closer you are to a hospital (Figure 5.42). Ideal access to a hospital in this study is considered anything under 6km, which is determined by cardiac arrest survivability (Lyon *et al*., 2004; Jennings *et al*., 2006; Figure 5.8). Close proximity to a healthcare facility has been linked to increasing liveability as emergency survivability increases as proximity decreases (Lyon *et al*., 2004). Respondents demonstrated that an ideal travel distance to a hospital is 2km, while 5km is considered moderate (Figure 5.37). However, respondents indicated that 2-5km is the desired travel distance to a hospital. This is a smaller range than has been mapped (Figure 5.8).

This study has a larger ideal range for healthcare facilities compared to other liveability indices, at 6km (Lyon *et al*., 2004; Jennings *et al*., 2006). It is identified that 1km is considered the ideal range for a healthcare facility in Australia (Higgs *et al*., 2019), while in Thailand, proximity of less than 5km is considered ideal (Onnom *et al*., 2018). Although close proximity to a hospital is thought to be highly desirable and drastically increases the liveability of the surrounding areas, differences between public and private hospitals are prevalent across South Africa (Dell *et al*., 2018). Therefore, although residents can have good access to a hospital, if this is a private hospital, they might be denied access depending on their medical aid or financial status, and subsequently have poor access to usable hospitals (Bhalla *et al*., 2019). Similarly, residents might have good access to a government healthcare facility but choose not to use it and therefore have to travel further to a private healthcare facility, potentially reducing their liveability based on personal preferences.

Although being near a hospital is seen as increasing liveability due to the ease of access in emergencies, the modes of transport available to people to access these facilities can also result in changing levels of accessibility. The response time of ambulances is drastically different according to location; in Nigeria, the average response time for public ambulance services is 17 minutes, while in Japan, it takes approximately four minutes (Huang *et al*., 2021; Venkatraman *et al*., 2021). In Cape Town, South Africa, it has been found that the average response time for private ambulance services is ten minutes, while public ambulance services take approximately 20 minutes (Stassen *et al*., 2021). This would demonstrate that although some people might be within reasonable driving distance of their preferred hospital, when in need of an ambulance, there are longer waiting times. However, government ambulance services in Tshwane have an average response time of 3.1 minutes, indicating the vast difference in response time per location and medical provider (Baloyi *et al*., 2017). There is an apparent reduction in the number of hospitals in the east of Tshwane (Figure 5.8), and therefore, a longer response time would potentially apply in this region. This is supported by findings in the Gauteng City-Region Observatory (GCRO) quality of life survey, whereby they identify the far east of Tshwane are most likely to struggle with access to healthcare and will use government healthcare facilities (Dallimore *et al*., 2021).

Questionnaire respondents have indicated that excessive noise and traffic are reasons as to why proximity to a hospital could negatively influence liveability. Ravindra *et al*. (2016) agree that loud noises from traffic and ambulance sirens are potential factors that could reduce the liveability of areas near hospitals. Furthermore, close proximity to hospitals can lead to more traffic congestion, potentially reducing the everyday liveability of the area (Song *et al*., 2019). Although distances to hospitals have been used to measure liveability in this study, community health clinics are often used in non-emergency situations, or can have emergency departments depending on their size and location (Nteta *et al*., 2010; JhbMetroRehab, 2022). Distance to

commonly used community clinics would therefore provide areas surrounding these clinics with more liveability than what is displayed in this study.

6.2.4 Proximity to Police Stations.

Crime and safety are pivotal influences on an area's liveability level. The level of crime and how safe an environment is, has been analysed across various liveability indices (Namzi-Rad *et al*., 2012, Giap *et al*., 2014, Valcárcel-Aguiar *et al*., 2019, EIU, 2021). However, only one of these indices has assessed the reliability of police (Giap *et al*., 2014). Several studies have been completed on crime in South Africa and Tshwane (Breetzke and Cohn, 2012; Schutte and Breetzke, 2018; Schutte *et al*., 2021). By contrast, this research study analyses police stations and how proximity to police stations can potentially influence liveability. Measuring the level of crime is an essential aspect of liveability, as over 40% of the residents of Tshwane believe that crime is getting worse (Dallimore *et al*., 2021).

Police stations have a vastly different impact on liveability than previously thought. Based on the literature (Fondevila *et al*., 2021), the buffers and classifications for distance to police stations were computed on the basis of crime levels and ease of access, with areas within 3km computed as the most liveable due to indications of decreased crime in these zones. However, respondents indicated that an ideal distance to a police station is 5km (Figure 5.39) due to a potential increase in noise, and if they need to travel to a police station, then it is still convenient. The desired travel distance is between 5-10km (Figure 5.38). This demonstrates that the buffer zones in Figure 5.9 somewhat align with what is perceived to be desirable in Tshwane.

Close proximity and availability of police stations are not seen as a priority, as respondents stated that they no longer need a police station and therefore do not need to live close to one;

and could be a cause for the underreporting of crime to the police (Breetzke, 2010). Similar research has found that the availability of police protection is perceived as a less critical safety attribute (Leby and Hashim, 2010). Iyanda and Mohit, (2016) find that in Nigeria, the protection offered by the police is not satisfactory; therefore, close proximity to a police station is unhelpful. Proximity to a police station could be seen to reduce liveability based on the same factors as hospitals, as noise pollution and traffic congestion increase closer to these establishments (Murthy *et al*., 2007). Information on how proximity to police stations influences crime in Tshwane is insufficient, resulting in trying to determine how crime influences liveability being unachievable. However, using crime statistics rather than what influences crime could provide the information needed to assess the liveability of Tshwane based on crime.

6.2.5 Proximity to Points of Interest

The impact that points of interest have on liveability has been assessed in several studies (Jeuring and Haartsen, 2017; Higgs *et al*., 2019, 2021). Points of interest in this study include libraries, theatres, museums, and stadiums, which are mapped as having an ideal range of 0.5km, and golf courses with an ideal range of 5km (Figure 5.10). Staying close to a point of interest is thought to increase the liveability of that area due to decreased transport time and ease of access (Jeuring and Haartsen, 2017). Studies based on population survey information have found that an ideal range to points of interest in Australia is between 1-3km (Davern *et al*., 2017; Higgs *et al*., 2019). Although there are benefits to living near a point of interest, there are also potential drawbacks. Noise pollution is found to negatively influence liveability across all of the previously mentioned indicators and in proximity to points of interest. Noise levels exceeding acceptable standards have been recorded in and around stadiums, drastically reducing the liveability of the bordering areas (Kalipci and Arslan, 2007; Atere, 2021).

Traffic congestion is a major contributing factor to reducing an area's liveability, as the residents cannot easily access their houses or surrounding destinations (Talukdar, 2013; Sun *et al*., 2017). Furthermore, points of interest, such as sporting stadiums and concert venues, can lead to increased crime surrounding the area, making the suburbs less liveable (Ristea *et al*., 2018). Although close proximity to points of interest has various negative influences on liveability, these are often localised to stadiums and large arenas (Ristea *et al*., 2018; Atere, 2021). As proximity to points of interest decreases, there is an increase in walkability and a reduced need for passive transport methods, therefore increasing one's health and lifestyle overall (Higgs *et al*., 2019). Proximity to points of interest were not included in the questionnaire due to them being interpreted in many different ways.

6.2.6 Proximity to Roads

Roads have been separated into two classes in South Africa: mobility roads and access/activity streets (CoTO, 2012). These two classes are broken down further, with principal arterial roads, major arterial roads and minor arterial roads being found in the mobility roads class, and collector streets, local streets and walkways found in the access/activity class (CoTO, 2012). Mobility roads are used to link large centres of development, while access streets are used to distribute traffic between properties and mobility roads (CoTO, 2012). A higher density of access points and interconnectedness of different road classes results in impaired mobility and a hazardous environment (CoTO, 2012). Although freeways (mobility roads) are not designed for pedestrian usage, in South Africa, it is common for pedestrians to cross and walk along these roads (Sinclair and Zuidgeest, 2016). Proximity to main roads can be pivotal to a person's liveability; being over 0.15km from a road is ideal based on health and crime risks faced by living close to a road (Figure 5.11, Venn *et al*., 2001; Reid *et al*., 2014). This study identifies

that close proximity to a main road reduces liveability due to increased noise pollution and health risk due to pollutants (Venn *et al*., 2001; Cvitković *et al*., 2022).

Further studies have found that close proximity to dense road networks can result in higher crime rates as there is an easy escape point (Reid *et al*., 2014). Nevertheless, proximity to some roads can be seen as increasing one's liveability, as access to a higher density of minor suburban roads leads to increased walkability and a higher uptake of active lifestyles (Hooper *et al*., 2015; Sinclair and Zuidgeest, 2016; Tapsuwan *et al*., 2018). Due to some respondents relying on walking to shops, schools, work and public transport, the ideal distance to a main road could be shorter than what has been displayed in this study (Figure 5.11). Although there are positive attributes to being near a main road, the high level of noise pollution and risk of air pollution leads this study to rank proximity to major roads as a negative influence on liveability.

6.2.7 Proximity to Retail Facilities

Proximity to retail facilities has been analysed across several other indices (Coveney and O'Dwyer, 2009; Onnom *et al*., 2018; Higgs *et al*., 2019; Xin *et al*., 2021). These indices differ according to the perceived ideal distance to a retail facility; some find that within 1km is ideal, while others state that under 0.5km is ideal (Coveney and O'Dwyer, 2009; Onnom *et al*., 2018). Proximity to retail facilities is one of the most critical indicators influencing liveability (Figure 5.42). Proximity to retail facilities in Tshwane is broken down into several distance categories defined by the SACSC (Prinsloo, 2016).

This study identifies close proximity to a shop as increasing liveability, as it can increase the walkability and attractiveness of an area (Moroney, 2009; Öner, 2015). A distance of less than 2.5km is found to be an ideal distance to small shops in Tshwane, as identified by the SACSC;

this is 0.5km outside of the range identified by questionnaire respondents, whereby they find that 2km is ideal (Figure 5.30). The SACSC finds that the ideal distance to a larger shop is thought to be within 5km; however, respondents identify an ideal range to be within 3km (Figure 5.31). The ideal, moderate and too far to travel distance buffers provided in this study (Figures 5.12-5.20) change in size depending on the size and capacity of the retail facility; as the capacity of the retail facility increases, there could be fewer stores; however, the catchment area increases (Prinsloo, 2016).

Respondents state that the preferred travel distance to a small shop is between 1-2km, while the preferred travel distance to a larger shop is between 2-10km (Figure 5.32). These responses are similar to what has been found in other liveability indices, as in Australia, an ideal distance is 1km from a small shop and 2.5km from a large shop (Coveney and O'Dwyer, 2009; Higgs *et al*., 2019), while in Thailand an ideal distance is considered to be under 1.5km to a shop as determined by shop construction regulations (Onnom *et al*., 2018). These findings from the questionnaires confirm that the proximity to shops is a valuable indicator of liveability, and the results from this study align with what is found in other literature.

Proximity to retail facilities has been seen as advantageous in this study and other liveability indices (Namzi-Rad *et al*., 2012; Onnom *et al*., 2018; Higgs *et al*., 2019). However, other perspectives identify that proximity to retail facilities could potentially reduce the liveability of these areas (Sytsma *et al*., 2021; Xin *et al*., 2021). Convenient access to retail facilities has, for example, been associated with increased childhood obesity due to easy access to food (Xin *et al*., 2021). This is relevant in Tshwane; due to children walking to school, there is an increased likelihood that they will have easy access to retail facilities (Lucas, 2011; Draper *et al*., 2014). Questionnaire respondents indicated that they did not want to live close to retail facilities due to the potential for increased crime. This notion is supported by Sypion-Dutkowska and Leitner (2017) and Sytsma *et al*. (2021), who find that retail facilities can

indeed attract more crime. Further concerns for respondents around proximity to retail facilities are the potential for increased traffic congestion. Increased traffic congestion is a common problem around retail facilities that can hinder an area's liveability (Systematics, 2005; Song *et al*., 2019).

6.2.8 Flood and Fire Risk in Tshwane

Flood and fire risk is not commonly found in other liveability indices (Paul and Sen, 2020; EIU, 2021). The fire risk in South Africa has received more attention due to the recent Knysna and Cape Town fires (Forsyth *et al*., 2019; Gibson *et al*., 2022). The Knysna fire in 2017 resulted in over R3 billion in damages and expenses, with the insurance industry claiming approximately R2.2 billion (Forsyth *et al*., 2019). This high cost to insurance agencies and people proves that there is a need to identify high-risk areas, such as those dominated by thatch houses and informal settlements, to allow for the adaption of insurance policies and potentially inform people about areas in need of fire mitigation strategies (Odinma *et al*., 2013; Walls *et al*., 2017).

The risk of fires in Tshwane is measured by the number of thatch houses in an area. As the density of thatch houses increases, so does the risk of fire (Odinma *et al*., 2013). Other liveability indices have not assessed the risk of flood and fire on liveability, setting this study apart and being more tailored for specific regions (Onnom *et al*., 2018; Higgs *et al*., 2019; EIU, 2021). Although being in an area with high fire risk might not impact one's everyday liveability, as fires can destroy homes and businesses, they can drastically change a person's life and threaten their liveability (Adewale, 2018). Measuring fire risk allows insurance agencies to adjust the insurance rate-making process based on the level of risk (Hai-Yun, 2011), proving that understanding the level of fire risk is vital in measuring liveability for individuals and insurance agencies.

Flooding has impacted over 21 million people in South Africa over 35 years, resulting in approximately R58 billion in economic damages (Davis-Reddy *et al*., 2017). At the same time, individual flood events can cost accommodation establishments within a district municipality approximately R58.92 million (Fitchett *et al*., 2016). This study has measured the risk of pluvial flooding using the RiskScape database to identify water-ponding areas. Due to pluvial flooding resulting from surface runoff and improper drainage, there is little correlation between the amount of annual rainfall and the produced flood risk map (Schmitt and Scheid, 2020; Figure 5.28). Insurance of pluvial flooding events is uncommon and therefore results in higher repair costs for the businesses and individuals impacted by these events (Rosenzweig *et al*., 2018). By identifying the areas at higher risk of pluvial flooding, this research paper can determine what areas are at higher risk for individuals and whether people living in these areas should purchase specific flooding insurance.

6.2.9 Annual Rainfall

Due to other liveability indices focusing on the built environment and how liveability is affected by it, they do not include climatic factors (Shekhar and Kumari, 2018; Higgs *et al*., 2021). Understanding how annual rainfall can influence liveability is highly susceptible to the community's location and the amount of rainfall needed. Annual rainfall is displayed using different data sources (Figures 5.22, 5.23 and 5.24). Higher amounts of rainfall can lead to flooding and erosion, which would negatively influence the liveability of Tshwane (Nemutamvuni *et al*., 2020). While too much rainfall can cause significant damage to properties and the environment, insufficient rainfall can result in droughts that impact farmers and usable water availability for individual residents. This was underscored by the Cape Town Day Zero Drought, where city residents had to limit their water usage to 50 litres per day (Sousa *et al*., 2018). Droughts in Tshwane impact the farmers and population as prices for food

increase (Maponya *et al*., 2017). The impact that floods and droughts can have on people and businesses is immense, proving that there is a need to insure against these disasters (Pratiwi *et al*., 2020; Poontirakul *et al*., 2022).

Suburbs in the east of Tshwane experience higher amounts of annual rainfall and, therefore, might be at higher risk of floods. The recorded rainfall from SAWS stations is completed using a spatial interpolation technique (Figure 5.22). This explains why this Figure 5.22 is drastically different from Figures 5.23 and 5.24. Although some areas do not receive the highest amount of annual rainfall in Tshwane, they are still at risk of flooding, as there could be higher amounts of rainfall in one day (Flack *et al*., 2019).

6.2.10 Slope and Liveability

The topography of an area can influence a person's liveability, as most questionnaire respondents believe that slope affects liveability. Slope influences liveability as described by respondents; it can determine how houses are built and influence construction work; it impacts walkability as it is easier to walk on flatter roads, and it drastically influences the aesthetic views from a house or business. Similarly to flood and fire risk, the slope is not included in other liveability indices (Giap *et al*., 2014; Valcárcel-Aguiar *et al*., 2019).

Increased slope can lead to higher levels of erosion and soil degradation, potentially resulting in devastating mass movements such as landslides (Guerra *et al*., 2017). Increased slope can negatively influence liveability, as it can decrease walkability and make the area less hospitable overall (Rasli and Kanniah, 2018). Due to the variables discussed on how slope impacts liveability, there is a need for a more nuanced analysis of slope in Tshwane. Measuring how much slope is considered too much for walking or construction, and what amount of slope or

slope aspect is desirable in order to increase the aesthetics of the houses in an area, will allow for a specified slope index that can be used to measure liveability.

6.2.11 Average Temperature in Tshwane

Climatic conditions such as temperature can drastically influence a person's liveability; the EIU Global Liveability Ranking and Mercer Quality of Life rankings both include environmental factors such as temperature and humidity when developing a liveability index (Capitanio, 2018). However, other indices do not include these factors (Namzi-Rad *et al*., 2012; Valcárcel-Aguiar *et al*., 2019). Daily temperature's impact on liveability is highly dependent on each person, as indicated by the questionnaire responses (Figure 5.42). However, suitable temperature ranges can be identified with the use of metrics such as the Universal Thermal Climate Index or Humidex (Masterton and Richardson, 1979; Silva and Cavalcante, 2021; Khodadadi *et al*., 2022). Although this study assesses temperature and its impact on liveability, humidity also influences perceived and experienced thermal comfort (Kong *et al*., 2019).

This study highlights the average maximum and minimum temperatures in Tshwane, using a spatial interpolation technique to display the temperatures surrounding weather stations. Temperature indicators are found in few other liveability indices (EIU, 2021). Temperature extremes such as heatwaves can devastate people's lives and the economy and are expected to increase in frequency (van der Walt and Fitchett, 2021; 2022). Heatwaves result in higher health risks faced by people and can lead to catastrophic environmental damages if simultaneously occurring with a drought (Campbell *et al*., 2018; Messeri *et al*., 2019; Miralles *et al*., 2019). These drastic temperature extremes decrease liveability (Davis and Hanna, 2016); therefore, this study can determine what locations are more susceptible to higher temperature extremes by analysing the average temperature ranges in Tshwane, uncovering the differences in liveability based on temperature .

6.3 Comparison Between Other Indices in Tshwane.

Many other indices have been produced and implemented in Tshwane (van der Pas *et al*., 2015; Schmitz *et al*., 2018; Magidi and Ahmed, 2019; Dallimore *et al*., 2021). These prior liveability studies made use of variables such as neighbourhood cohesion, financial resources and community engagement (van der Pas *et al*., 2015; Dallimore *et al*., 2021), all of which were not used in this paper as the information was not attainable or was removed to fit the scope of the study. Liveability indices, such as that produced by the GCRO, find that the suburbs in the east of Tshwane have the lowest liveability scores, while suburbs in the south and southwest of Tshwane are shown to have the greatest liveability scores (Dallimore *et al*., 2021). These findings are mirrored within this research study, whereby suburbs in the east of Tshwane have the lowest liveability scores, and those in the central to southern regions have the highest scores (Figures 5.43 and 5.44). Although these findings are similar to the GCRO, the methods used within the GCRO are drastically different to this research study. The GCRO made use of approximately 2810 survey responses to analyse 19 different aspects of life in Tshwane, which include basic services, economics, violence, governance, social mobility, transport, demographics, health, politics, community, life satisfaction, COVID-19, crime and safety, food security, social cohesion, environmental risk, admin, dwelling and migration (Dallimore *et al*., 2021).

By measuring aspects such as social cohesion, governance and COVID-19, the GCRO Quality of Life Survey Six results would provide a more subjective perspective of liveability in Tshwane, as people's opinions of these aspects can vary drastically. Further similarities between this research study and the GCRO quality of life survey are access to healthcare facilities. The GCRO finds that regions in the far east of Tshwane are most likely to struggle with access to healthcare and make use of government healthcare facilities (Dallimore *et al*.,

2021). This is consistent with what has been found in this study, as only two hospitals are found in the east of Tshwane and one being a government hospital in the far east (Figure 5.8). The composite map (Figures 5.43 and 5.44) finds that wards in the east of Tshwane have low scores for proximity to healthcare facilities. These findings support what has been discussed within the GCRO Quality of Life Survey Six and demonstrate why wards in the far east of Tshwane have poor access to healthcare and those with access make use of government healthcare facilities. Other studies have found that equal access to healthcare facilities is intricately linked to the quality of life in an area and that in order to increase the quality of life, there needs to be good access to healthcare (Buss *et al*., 2020; Guida and Carpentieri, 2021).

Other studies have measured the liveability of regions in South Africa for South Africans over 60 years of age (van der Pas *et al*., 2015). Using questionnaires, their study assessed life satisfaction, home environment, neighbourhood environment, socio-demographic, and health variables (van der Pas *et al*., 2015). A ten-minute walk to a retail facility, healthcare facility or community centre is desirable for people over 60 years old; this is dependent on the individual and equates to between 200-750m in ten minutes (Forde and Daniel, 2021). These findings are significantly lower than what has been identified as an ideal distance to a healthcare facility or retail facility in this research study, as respondents indicate that between 1-2km is ideal (Figures 5.32 and 5.37).

A poverty index has highlighted that suburbs in the north-west and south-west of Tshwane have the greatest levels of poverty, while central to southern Tshwane is the most affluent (Katumba *et al*., 2019). Poverty was measured using a multidimensional poverty index for Gauteng (GMPI). Poverty is seen to have a negative impact on quality of life (Luckyardi *et al*., 2022). When the concept that poverty leads to decreased quality of life is applied to Tshwane, it indicates that the north and north-western suburbs in Tshwane have the lowest quality of life; however, this research study finds that the west-north-west of Tshwane has high levels of

liveability (Figure 5.44). Potential causes for this contradiction could be due to what has been used to measure poverty, such as population and housing density, access to water, sanitation and electricity, communication capabilities, food security, unemployment and level of education (Katumba *et al*., 2019). In contrast, this research study did not measure these.

6.4 Usability of the Liveability Index

6.4.1 The Insurance Sector

Liveability indices have many different uses, from being used to inform policy to specific audiences, which is considered to be groups of persons such as students or new home buyers, and businesses (Ichikawa *et al*., 2017; Higgs *et al*., 2019; Real *et al*., 2020). Although there is debate surrounding whether liveability indices should be used to inform policy (Conger, 2015; McArthur and Robin, 2019), this study avoids that by assessing the liveability of a specific area and not several different cities. Measuring an area's liveability can assure insurance agencies that new and existing infrastructure will be sustainable and resilient (Goodfellow-Smith *et al*., 2019). As the insurance industry in South Africa is worth approximately R1.6 trillion (Alhassan and Biekpe, 2016; Alhassan and Boakye, 2020), there is a need for accurate and relevant information to be available for insurance companies and consumers to make decisions. The integration of academic work into the insurance sector allows insurance companies to reduce the risk they face by being provided with sufficient relevant information (Mills, 2009).

Although one might think that the insurance sector is not influenced by proximity to retail facilities, education institutions, points of interest, hospitals, police stations, roads and parks: these liveability indicators provide insight into the regions with poor access to commonly used facilities. Therefore, highlighting the excessive travel distances that residents in these zones need to travel for essential goods and services. This is useful for insurance agencies that utilise

a usage-based vehicle policy cover, as it allows them to cross-check how much the client is paying and how far they are driving (Bian *et al*., 2018).

Understanding what areas are seen to be more liveable allows insurance agencies to design place-specific insurance policies, potentially leading to lower insurance premiums and less risk faced by the company (Miller *et al*., 2019). Although this is advantageous for insurance agencies, identifying highly liveable areas also indicates areas with higher potential for growth and new customers. Understanding where there is more potential for new customers subsequently allows insurance companies to use target-specific marketing campaigns to gain more clients (Jun *et al*., 2016).

6.4.2 Prospective Homebuyers

Liveability indices, when effectively communicated to the public in a user-friendly manner, have several advantages for individuals choosing where to live. This research study uses information on proximity to retail facilities, education institutions, hospitals, police stations, major roads, points of interest and parks when creating a final composite liveability map, all of which are valuable attributes when purchasing a new house or moving to a new area (Sarif *et al*., 2018; Thanaraju *et al*., 2019). Prospective homebuyers can use liveability indices to determine what areas are more suitable, and to weigh up the benefits and detriments of the proximity to a range of different facilities. Areas with higher liveability are considered healthier and attractive to prospective homebuyers (McCormack *et al*., 2021; Gunn *et al*., 2022).

6.4.3 Developers and Urban Planners

The third use for this liveability index is to inform developers and city planners. City planners and developers have used indices to improve future planning and the quality of life in urban

developments (Munawir and Koerniawan, 2018). By determining what areas are ‘good’ and ‘bad’ in terms of liveability, planners can be supported in decisions made for new developments to produce healthy cities (Onnom *et al*., 2018; Higgs *et al*., 2019; Valcárcel-Aguiar *et al*., 2019). By identifying the locations with high and low access to retail facilities, schools, points of interest and hospitals, developers and city planners can identify the areas without good and poor access. Areas identified as having poor access can subsequently be demarcated for future development.

6.4.4 Climate Change Adaption

Liveability can be drastically influenced by changes in climatic conditions (Liang *et al*., 2020; Lin *et al*., 2021). Hazards such as droughts, floods, heatwaves and wildfires are predicted to increase in intensity, frequency and duration (IPCC, 2022). By using this research study, one can identify locations with low liveability due to poor access to facilities. Thereafter, sustainable development in these areas could potentially attract people away from busy city centres and into more sustainable and environmentally friendly suburbs. Identification of areas with low liveability scores can be used to demarcate locations for more green open spaces. Identifying suburbs in need of green open spaces and the subsequent construction of these facilities is a valuable climate change adaptation and mitigation approach (Li *et al*., 2018).

6.5 Variables Not Included

This liveability index has used seven aspects that influence the liveability of Tshwane. However, when assessed against other liveability indices, there are different indicators that have not been included (Higgs *et al*., 2019; Dallimore *et al*., 2021). The uses of liveability indices influence the variables used. Indices that have been developed to inform policy, make use of indicators such as communication networks, cultural diversity, job security,

socioeconomic status and community participation; all of which provide relevant information to inform policy (Namzi-Rad *et al*., 2012; Dallimore *et al*., 2021). However, this liveability index was not intended to inform policy and therefore these indicators were not included as there are irrelevant to the current index.

Liveability indices that have been produced to assist businesses make use of indicators such as quality of healthcare, level of censorship, level of corruption, the threat of military conflict and quality of telecommunications to name a few (EIU, 2021). These indicators can potentially provide information on the quality of life of specific regions; however, they do not demonstrate the variation in liveability in more regional or suburban areas as was required for this index.

This liveability index has assessed proximity-based variables and how they influence liveability in Tshwane. Although all of the indicators used in this index are valuable in determining the overall accessibility of Tshwane, some indicators could not be used. Several other liveability indices have assessed the safety and level of crime in their analysis (Giap *et al*., 2014; Valcárcel-Aguiar *et al*., 2019). Crime has proved to be a pivotal determinant of liveability in Tshwane based on questionnaire responses. Crime analysis in Tshwane would entail categorising and mapping all crime events that occurred within Tshwane; including the number of homicides, drug offences, business crimes, petty criminal offences, violent crimes and sexual crimes. However, this was omitted from this liveability index due to scope limitations.

6.6 Application of the Index to Other Cities in South Africa

One of the aims of this study is to determine if the index can be applied to other regions in South Africa. Many of the indicators used within this index, such as proximity to schools, can be applied to other regions within South Africa. Obtaining the relevant information for creating

a liveability index would allow for the index to applied to other areas in South Africa. Expanding the index to other regions in South Africa, would be valuable for large national insurance agencies as it would provide more coverage of South Africa.

Expanding the index to other regions in South Africa is achievable, however, would need to be significantly adapted to suit other regions. There are vast differences between regions in South Africa, as cities and provinces have different political leaders (Mokgosi *et al*., 2017), and different budgets (DoE KZN, 2019; WCG, 2022). Indicators such as proximity to retail facilities would not be transferable to other regions in South Africa, due to the vast differences in public transport methods and accessibility, such as the Rea Vaya bus service in Johannesburg and the MyCiTi bus in Cape Town (Chakwizira *et al*., 2011; Cooke *et al*., 2018). These differences in transport would result in discrepancies between the desired travel distances within cities in South Africa. Similar issues arise when measuring proximity to parks or open spaces, as people in coastal regions could make use of beaches, therefore requiring further analysis and the development of new proximity buffers for swimming beaches and non-swimming beaches. Coastal regions face different levels of risk when compared to inland regions (Montgomery and Chakraborty, 2015), resulting in significant adjustment needed in order for the index to be applied to other areas within South Africa.

This demonstrates the complexity of applying an index to locations. Although there is potential for the index to be used in other regions in South Africa, substantial adaptions would need to be made in order for the index to be usable in those areas. Due to the index being designed specifically for Tshwane, it is tailored towards the perceived influences on liveability in Tshwane. This subsequently allows for the index to be used as a framework for the creation of other liveability indices in South Africa. Therefore, although the index cannot be implemented elsewhere in South Africa, it proposes a way forward for other liveability indices to be produced and highlights the need for updated, location specific information to be used.

6.7 Limitations of this Research Study

Liveability indices are often limited by the indicators they use and those they cannot. This study has primarily used proximity-based indicators. Although these provide an accurate image of what areas should have higher levels of liveability, public perception of these areas highlight contradictions. Due to the scope of this study, many indicators were excluded, while others that were used displayed clear limitations found during the processing and development of maps. Climatic data is often recorded from several weather stations, of which the majority has missing or incomplete information (e.g. Figures 5.22, 5.25 and 5.26). The composite maps developed (Figures 5.43 and 5.44) do not include climatic variables, as this data was either incomplete or unavailable, limiting the composite map to distance-specific variables only. Issues of data availability have been prevalent in other liveability indices (Valcárcel-Aguiar *et al*., 2019; Khorrami *et al*., 2021), indicating that it is not unique to this research study.

Methodological limitations are also prevalent across location-based liveability indices and are found throughout this study. Using hard thresholds when determining the level of access to a location provided definitive and more communicable results. However, they do not effectively measure access when compared to soft thresholds or accessibility through road networks (Higgs *et al*., 2019).

The study has focused on Tshwane as a whole, resulting in issues of scale arising, as the information is provided at the neighbourhood scale and aggregated into the ward scale to provide a more visually appealing and understandable map. Although helpful in displaying information, the ward scale is limited in its usability for residents of Tshwane, as suburbs and neighbourhoods are more commonly used scales. This study did not use indicators such as crime and service delivery due to scope limitations. Crime and service delivery is one of the most significant influences on liveability in Tshwane and South Africa, as displayed by

questionnaire results. This identifies that crime and service delivery should have been integrated into the index to provide more realistic, location-specific results.

The study has concentrated on the idea of liveability from an urban perspective and therefore assessed Tshwane based on this notion. However, rural and agricultural practices are found throughout Tshwane, and those perceptions of liveability are not represented in this index. The small sample size and this study's use of social media, and fieldwork to distribute questionnaires, subsequently limits the representation of residents from all across Tshwane. With a large portion of the respondents residing in the east of Tshwane, there is a significant lack of variation in respondents, further limiting the perceptions of the liveability of Tshwane.

As with most liveability indices, as information changes over time, the index becomes outdated and eventually irrelevant (Onnom *et al*., 2018). Due to liveability indices being commonly used for comparison and ranking of different cities and locations, applying this concept to one location brings with it its own biases for what is perceived to be good and bad liveability. Due to the nature of the questionnaire responses and the manner in which liveability is analysed and framed by the researcher, limitations in the form of bias are expected to be found throughout this study (Conger, 2015).

CHAPTER 7: CONCLUSION

7.1 Introduction

This study has introduced liveability indices in the global context and highlighted their potential uses for people and businesses. Liveability indices can provide valuable information to specific audiences and businesses and are often used as a tool for comparing different global cities; however, this carries with it significant limitations. The study explores liveability through accessibility to popular locations in Tshwane with the use of GIS mapping tools. While simultaneously distributing questionnaires that were used in the construction of the final liveability maps. The study has determined that the public perception of liveability in Tshwane is based on more than what has been analysed in this research. The following section provides a synthesis of the study by placing it amongst the current literature, and demonstrating what the key findings are. The achievement of the study aims and objectives are discussed individually before finalising with the potential direction for future research.

7.2 Study Synthesis

7.2.1 Study Outline

This research study has attempted to develop a liveability index for Tshwane. Through analysis of global liveability indices and the literature surrounding them, a liveability index that addresses how proximity to facilities in Tshwane has been produced. This allows users of the index to determine what suburbs and wards in Tshwane have higher levels of accessibility to commonly used facilities.

7.2.2 Key Findings

The research was determined by the quality and availability of data. The data provided by RiskScape provided accurate and updated information on the proximity to facilities, as well as the characteristics of these facilities. This information comprised the bulk of the data used in the study, which was processed and used for the creation of maps. Data analysis indicated that there are approximately 1794 data points that can be used to measure liveability in Tshwane. Of these 1794 points, there are 669 schools, 657 points of interest and 356 retail facilities. Although there is a large number of POIs, schools and retail facilities, there are only 49 hospitals, of which nine are government institutions. This highlights the potential need for more government healthcare facilities. This study has uncovered that proximity to healthcare facilities is the most influential factor in the liveability in Tshwane, while proximity to police stations is the least influential on liveability.

Results indicate that the northeast and east of Tshwane have poor access to all facilities measured in this study, demonstrating the need for growth and development of infrastructure to support the residents in these suburbs. The central and west of Tshwane have the greatest level of accessibility, making them the most liveable areas in Tshwane. However, when residents were asked what suburbs are perceived to be less liveable and why, stark contradictions appeared compared to what has been uncovered in the results.

Respondent's identification of the least liveable suburbs in Tshwane directly contradicted what had been displayed in the composite liveable map, stating that crime is the sole factor for that location's poor liveability. This uncovers apparent deficiencies in the governance and management of The City of Tshwane as although some locations have a high potential for liveability, when provided with a choice, residents do not want to live there due to the level of crime. This discovery uncovers the need for liveability indices to engage with the residents of

the study area and determine what factors are perceived to influence liveability the most. Although this index has been developed for use by the insurance industry, and is beneficial to some extent in displaying the accessibility of Tshwane and the locations in need of redevelopment, more in-depth analysis of each indicator is needed in order to provide accurate and functional results for use in the insurance sector.

7.3 Achievement of Study Aims

This research study had three primary aims, which involved the analysis of location specific data, the production of accessibility maps, the development and distribution of liveability questionnaires, the development of a composite liveability index, and the analysis and potential usability of the created index for use in other municipalities in South Africa. The degree to which each aim was achieved and the manner in which it was completed will be discussed.

1. *To develop a list of indicators through triangulation of what has been used in previous liveability indices, public perception, needs of the insurance industry and data availability.*

This aim required an in-depth analysis of the available data and what has been used to measure liveability in previous studies. Achieving this aim was accomplished by analysing over 25 different liveability indices, which had been produced globally and for use in Tshwane, subsequently allowing for the development and use, of commonly used indicators, as well as the inclusion of indicators not used in other studies. Literature analysis of the influences on liveability on the public was undertaken and used to review and tailor the selected indicators. Simultaneously, the risks faced by insurance agencies were analysed through the literature and provided valuable information for the addition of risk-associated indicators. Finally, the available data was scrutinised and used to eliminate indicators with insufficient data coverage, providing the final list of indicators used to measure the liveability in Tshwane.

2. *Determining a sui*table *weighting system to measure the selected indicators through analysis of previous liveability indices, public perception and needs of the insurance industry.*

Literature analysis of other liveability indices was used as a foundation to achieve this aim, while the final weighting system was constructed based on questionnaire responses identification of what indicators are more influential on their liveability. While the needs of the insurance sector were analysed, no significant need appeared, subsequently leading to the weighting system being based on previous liveability indices and the public perception of liveability in Tshwane.

3. Applying and testing the final liveability index against public perception of Tshwane and determining if the index can be applied to other municipalities across South Africa.

Achieving this aim resulted in the key finding of this study (that public perception of liveability in Tshwane is exclusively based on the level of crime in that area, and that all other indicators are disregarded when there is a high crime rate). With the completion of the weighted composite liveability map, this study identified the suburbs in Tshwane with the greatest levels of accessibility, indicating what locations could have higher levels of liveability. This composite map was compared to the results of the questionnaire to uncover the public perception of liveability in Tshwane. This subsequently resulted in the inability to apply the index to other municipalities in South Africa due to the strong influence of crime on liveability and this index's exclusion of crime indicators due to data and time restraints.

7.4 Directions for Future Work

The results uncovered in this research study highlight the potential for future research. As criminal statistics were not used in this study, there is a clear avenue for investigating how different crime rates and types of crime will influence the liveability of an area. While proximity to healthcare facilities is identified as highly influential to liveability in Tshwane, there is a lack of research into the level of accessibility that people have to these facilities, as the construction of government and private hospitals results in a divide between who does have access and who does not. Similar research can be discovered with access to schooling in South Africa; given the divide between public and private schooling, some students have high accessibility however potentially low acceptance.

Current academic liveability indices in South Africa are scarce. Although there is debate surrounding the comparison between cities in liveability indices, this largely surrounds the comparison between global cities. In contrast, country-specific indicators and data would mitigate the potential for western biases in liveability indices. There is a clear need for a comprehensive liveability index to be produced for South Africa that examines specific aspects of liveability, such as crime, climate, economic potential and accessibility, which is weighted based on public preferences.

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APPENDICES

Appendix A: Wits Ethics Committee for Human Research (Non-Medical)

Clearance Certificate



Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

R14/49 Fraser

CLEARANCE CERTIFICATE **PROTOCOL NUMBER: H22/02/7**

PROJECT TITLE and	The development of a liveability index for Johannesburg Pretoria to inform insurance practices
INVESTIGATOR(S)	Mr K Fraser
SCHOOL/DEPARTMENT	Geography, Archeology and Environmental Studies/
DATE CONSIDERED	18 February 2022
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal

EXPIRY DATE 17 March 2025



DATE 18 March 2022 **CHAIRPERSON**

_____

(Professor J Watermeyer)

cc: Supervisor : Professor J Fitchett

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. **I agree to completion of a regular progress report. For Minimal and Low studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.**

_____ 22 / 03 / 2022

Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix B: Participant Information Sheet

School of Geography, Archaeology and Environmental Studies

Private Bag 3, Wits 2050, South Africa Enquiries: **GEOGRAPHY:** TEL: +27 11 717-6503 • FAX: +27 086 651 6366

ARCHAEOLOGY: TEL: +27 11 717-6045 • FAX: +27 086 651 6366

http://www.wits.ac.za/geography/

24 January 2022

Dear participant

Participant Information Sheet: Understanding public perception of liveability

My name is Keegan Fraser, and I am studying towards my MSc in Geography at the University of the Witwatersrand. I am currently conducting a research project surrounding the liveability of suburbs across Gauteng. My project is titled 'The development of a liveability index for Tshwane to inform insurance practices'.

I am reaching out to you to complete a questionnaire regarding your perceptions of liveability of suburbs across Tshwane. These questions will provide insight into how people experience the places in which they live and what factors influence their quality of life. The questionnaire will take approximately 20 minutes to complete and involves several open-ended questions as well as multiple choice questions. Responses from the questionnaire will be used to corroborate a liveability index being developed for Tshwane, and if the results are confirmed to be consistent with public perception, the index can be applied to other regions in South Africa.

Confidentiality and anonymity can be guaranteed as the information you share will not include identifiable information. The final research report will include aggregated rather than individual responses, as the aim is to identify the perceived liveability of the suburb in which

you reside. Anonymity in the data collection process is guaranteed as the questions will be asked via Google surveys and no names, email addresses or phone numbers will be requested or automatically stored.

There will be no personal cost for you to participate and you will not receive any benefits upon completion of the questionnaire. There are no penalties if you choose not to participate or if you do not complete the survey. You and can withdraw from the questionnaire at any time.

If you have any questions during the survey or after completion about this study, please do not hesitate to contact me via the details listed below. This study will be written as a research report and will be available through the online university library website. If you wish to receive a short summary of the final research paper, please contact me through the details below. Any data collected throughout this research will be stored in a safe and secure computer for one year. If you have any complaints about the ethics procedures undertaken in this study, please contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrec-medical.researchoffice@wits.ac.za.

Kind regards,

Keegan Fraser

Keegan Fraser
1250795@students.wits.ac.za Ph: (+27) 071 855 9460

Professor Jennifer Fitchett
Associate Professor of Physical Geography University of the Witwatersrand
jennifer.fitchett@wits.ac.za
Ph: (+27) 011 717 6514

Appendix C: Questionnaire Layout

Liveability of Tshwane

Good day:

My name is Keegan Fraser, and I am currently enrolled for an MSc Geography at University of the Witwatersrand. I am currently conducting a research project surrounding the liveability of suburbs across Tshwane. My project is titled 'The development of a liveability index for Johannesburg and Pretoria to inform insurance practices', however, the survey group will only include residents in Tshwane. The purpose of this study is to determine how liveable different suburbs across Tshwane are, to help inform insurance practices.

I am inviting you to participate in an online questionnaire regarding your perceptions of liveability. These questions will provide insight into how people experience the places in which they live and what factors influence their quality of life. The questionnaire will take approximately 20 minutes to complete and involves several open-ended questions as well as multiple choice questions. Responses from the questionnaire will be crosschecked with the current liveability index developed for Tshwane, and if the results are confirmed to be consistent with public perception, the index can be applied to Johannesburg.

Confidentiality and anonymity can be guaranteed as the information you share will not be discussed or shared. The final report will not display any confidential information as the aim is to identify the perceived liveability of the suburb in which you reside. Anonymity in the data collection process is guaranteed as the questions will be asked via Google surveys and no names, email addresses or phone numbers will be requested. Completion and submission of the questionnaire will be taken as consent to participate.

There will be no personal cost for you to participate and you will not receive any benefits upon completion of the questionnaire. There are no penalties if you choose not to participate or if you do not complete the survey. You may skip any questions that you are unsure of or do not wish to answer and can withdraw from the questionnaire at any time.

If you have any questions during the survey or after completion about this study, please don't hesitate to contact me via the details listed below. This study will be written as a research report and will be available through the online university library websites. If you wish to receive a short summary of the final research paper, please contact me through the details below. Any data collected throughout this research will be stored in a safe and secure computer for five years. If you have any complaints about the ethics procedures undertaken in this study, please contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnonmedical@wits.ac.za

Kind regards,
Keegan Fraser
Telephone +27(0) 71 855 9460
Email 1250795@students.wits.ac.za

Consent

1. I consent to participate in this study

- [ ] Yes

2. Do you currently live in Tshwane?

- [ ] Yes
- [ ] No

Background information

3. How long have you lived in Tshwane?

- [ ] 0-2 years
- [ ] 3-5 years
- [ ] 6-8 years
- [ ] 9-11 years
- [ ] 12-14 years
- [ ] 15+ years

4. Which suburb do you live in?

5. How long have you lived in this suburb?

- [ ] 0-2 years
- [ ] 3-5 years
- [ ] 6-8 years
- [ ] 9-11 years
- [ ] 12-14 years
- [ ] 15+ years

6. Are you looking to move out of this suburb in the near future? (Next 18 months)

- [ ] Yes
- [ ] No

7. If yes, where do you want to move to?

- [ ] Another suburb in Tshwane
- [ ] Another location in Gauteng
- [ ] Another location in South Africa
- [ ] Abroad
- [ ] N/A
- [ ] Other:

Liveability

8. What do you understand by the term liveability?

9. What suburbs in Tshwane do you believe are the most liveable?

10. What factors make these suburbs the most liveable?

11. What suburbs in Tshwane do you believe are the least liveable?

12. What factors make these suburbs the least liveable?

13. A. When travelling to purchase basic groceries, (bread, milk, etc.) what do you believe is an ideal distance to travel? (km)

14. B. When travelling to purchase basic groceries, (bread, milk, etc.) what do you believe is the moderate/acceptable travel distance? (km)

15. C. When travelling to purchase basic groceries, (bread, milk, etc.) what do you believe is too far to travel? (km)

16. A. How close would you like to live to a small shop that would sell basic groceries (bread, milk, etc.)?

- 0-0.5km
- 0.5-1km
- 1-2km
- 2-5km
- 5-10km
- 10+km

17. B. What is the reason for you selection?

18. A. How do you travel to purchase these basic groceries?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Carpool
- [ ] Uber
- [ ] Public transport
- [ ] Other:

19. B. When travelling to purchase larger shopping items, (monthly shop, clothes, hardware, electronics, etc.) what do you believe is an ideal distance to travel (km)

20. C. When travelling to purchase larger shopping items, (monthly shop, clothes, hardware, electronics, etc.) what do you believe is a moderate/acceptable travel distance? (km)

21. D. When travelling to purchase larger shopping items, (monthly shop, clothes, hardware, electronics, etc.) what do you believe is too far to travel? (km)

22. A. How close would you like to live to a larger shopping centre (monthly shop, clothes, hardware, electronics, etc.)?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km

23. B. What is the reason for your selection?

24. C. How do you travel to purchase these larger shopping items?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Carpool
- [ ] Uber
- [ ] Public transport
- [ ] Other:

Travelling to schools

25. When travelling to a primary school, what do you believe is an ideal travel distance? (km)

26. When travelling to a primary school, what is a moderate/acceptable travel distance? (km)

27. When travelling to a primary school, what is too far to travel? (km)

28. If you currently have children at a primary school, how far away is the school from your home?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km
- ◯ N/A

29. How do your children travel to their primary school?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Carpool
- [ ] Uber
- [ ] Public transport
- [ ] N/A
- [ ] Other:

Travelling to high schools

30. When travelling to a high school, what do you believe is an ideal travel distance? (km)

31. When travelling to a high school, what do you believe is a moderate/acceptable travel distance? (km)

32. When travelling to a high school, what do you believe is too far to travel? (km)

33. If you currently have children at a high school, how far away is the school from your home?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km
- ◯ N/A

34. How do your children travel to their high school?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Carpool
- [ ] Uber
- [ ] Public transport
- [ ] N/A
- [ ] Other:

35. When travelling to a tertiary education facility (university, collage, etc.), what do you believe is an ideal travel distance? (km)

36. When travelling to a tertiary education facility (university, collage, etc.), what do you believe is a moderate/acceptable travel distance? (km)

37. When travelling to a tertiary education facility (university, collage, etc.), what do you believe is too far to travel? (km)

38. If you currently have children at a tertiary education facility, or attend a tertiary education facility how far away is this from your home?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km
- ◯ N/A

39. How do you or your children travel to your/their tertiary education facility (university, collage, etc.)?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Carpool
- [ ] Uber
- [ ] Public transport
- [ ] N/A
- [ ] Other:

police and healthcare

40. When travelling to a hospital, what do you believe is an ideal travel distance? (km)

41. When travelling to a hospital, what do you believe is a moderate/acceptable travel distance? (km)

42. When travelling to a hospital, what do you believe is too far to travel? (km)

43. A. How close would you like to live to a hospital?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km

44. B. What is the reason for your selection?

45. When you need to travel to a hospital for medical treatment, what mode of transport do you use?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Ambulance
- [ ] Uber
- [ ] Public transport
- [ ] Other:

46. When travelling to a police station, what do you believe is an ideal travel distance? (km)

47. When travelling to a police station, what do you believe is a moderate/acceptable travel distance? (km)

48. When travelling to a police station, what do you believe is too far to travel? (km)

49. A. How close would you like to live to a police station?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km

50. B. What is the reason for your selection?

51. How to you travel to a police station?

- [ ] Walk
- [ ] Cycle
- [ ] Private car
- [ ] Uber
- [ ] Public transport
- [ ] Other:

Public spaces

52. When travelling to a public park or open space, what do you believe is an ideal travel distance? (km)

53. When travelling to a public park or open space, what do you believe is a moderate/acceptable travel distance? (km)

54. When travelling to a public park or open space, what do you believe is too far to travel? (km)

55. A. How close would you like to live to a public park or open space?

- ◯ 0-0.5km
- ◯ 0.5-1km
- ◯ 1-2km
- ◯ 2-5km
- ◯ 5-10km
- ◯ 10+km

56. B. What is the reason for your selection?

57. How do you travel to a public park or open space?

- ☐ Walk
- ☐ Cycle
- ☐ Private car
- ☐ Uber
- ☐ Public transport
- ☐ Other:

Environmental and climatological factors

58. A. Do you believe that slope affects liveability?

- Yes
- No

59. B. Please explain your answer.

60. A. Do you believe that the amount of sunshine hours in a day affects your liveability?

- Yes
- No

61. B. Please explain your answer.

62. A. Do you believe that the amount of monthly rainfall affects your liveability?

- Yes
- No

63. B. Please explain your answer.

64. Do you believe that daily air temperature affects your liveability?

- Yes
- No

65. What do you find to be a good average daily temperature?

66. What do you find to be a moderate daily temperature (high)?

67. What do you find to be a moderate daily temperature (low)?

68. What do you find to be an unbearable daily temperature (high)?

69. What do you find to be an unbearable daily temperature (low)?

Importance of variables

70. Please rank each of these variables from very important through to very unimportant, in terms of how you perceive them to impact liveability (on a scale of one to five, where one is not important and five is very important)
Mark only one oval per row.

	1	2	3	4	5
Distance to a small shop	◯	◯	◯	◯	◯
Distance to a larger shop for a weekly or monthly shop	◯	◯	◯	◯	◯
Distance to a primary school	◯	◯	◯	◯	◯
Distance to a high school	◯	◯	◯	◯	◯
Distance to a tertiary education facility	◯	◯	◯	◯	◯
Distance to a hospital	◯	◯	◯	◯	◯
distance to a police station	◯	◯	◯	◯	◯
distance to a public park or open space	◯	◯	◯	◯	◯
Amount of slope	◯	◯	◯	◯	◯
Amount of daily sunshine hours	◯	◯	◯	◯	◯
Amount of daily rainfall	◯	◯	◯	◯	◯
Daily temperature	◯	◯	◯	◯	◯

71. Are there any variables that have not been listed that you think are important in determining liveability?

72. A. Do you think that liveability should influence insurance premiums?

- Yes
- No

73. B. Please support your answer.