ACCESSIBILITY TO SCHOOLING IN SOUTH AFRICAN RURAL AREAS

Source: - http://today.law.harvard.edu/whats-so-bad-about-a-10-mile-walk-to-school-two-views-of-educational-challenges-in-south-africa/

A dissertation submitted in partial fulfilment of the requirements for the degree of Master of Science in Civil Engineering

Compiled and Written by: Deisy Narcy (NRCDEI001)

Supervised by: Professor Marianne Vanderschuren

Department of Civil Engineering

University of Cape Town

March 2021

This MSc dissertation has been approved by:

Professor Marianne Vanderschuren

“Education is the most powerful weapon which you can use

to change the world”

Nelson Mandela

This MSc is dedicated to my family
for their unending support and faith in me

Declaration

I know the meaning of plagiarism and declare that all work in the document, save for that which is properly acknowledged, is my own. This dissertation has been submitted to the Turnitin module and I confirm that my supervisor has seen my report and any concerns revealed by such have been resolved with my supervisor.

.

Candidate:

Signed by candidate

[Deisy Onions Ismael Narcy]

Preface

This thesis is submitted in partial fulfilment of the requirements for the achievement of Master of Science Degree in Civil Engineering. It contains work completed from January 2017 to September 2019, under the supervision of Professor Marianne Vanderschuren. This thesis is the original work of the author, Deisy O.I Narcy. Full referencing is provided when work undertaken by others is used or mentioned.

In deciding to undertake a Master's in Science in Civil Engineering, I knew from the day that I had established firm footing in which path I ought to take that it would have to be related to Transport Engineering, a passion that has consumed me within the fundamental stages of my childhood where I was exposed to the developing and sometimes inadequate infrastructure of my native Mozambique and adopted home of Angola. What could not have been anticipated was that instead of furthering my research to discuss - in writing - the risk of sun glare in roadways (my undergraduate thesis topic), I would take a completely different route.

Throughout my earlier life and the countries I have lived in, I had been exposed to great poverty and inequality that continue to consume the lives of those who had not asked for its wrath. My heart interminably aches for the ones who reach out their hands in silent surrender and yet remain invisible to the world. As I became better versed in career possibilities, I began to consider civil engineers as more than just professionals but as altruists rebuilding nations damaged by decades of hate and greed. I had developed the inspiration and strength to defy my greatest fears and challenge my own thought processes. My choices have been guided by two questions: *what should I look at* and *what can I possibly do*? My desire to make a lasting impact has driven me this far.

The answers appealed to me as magnets of truth as I sat with my supervisor in search for a momentous light: Access to Education!

To talk about education is to talk about the development of an entire nation, it is at the very core of all future activities we will conduct. It is the root of our great scientists, doctors, engineers, and philosophers. Children living in rural areas (specifically in low-income households) are victims of their circumstances, as well as at the wrong end of social divide and, therefore, provide the key to challenging these difficulties (by providing access to education) - which is perhaps the way forward.

The hardships I faced when writing this thesis are far beyond what I could ever have predicted. Via this overwhelmingly strenuous process, I have learnt immensely and not only through an academic perspective but also at a personal level. I have learnt to celebrate every small achievement and overcome every overwhelming or seemingly miniscule challenge - as such I have found new insights regarding my technical and analytical abilities. Through it all, I am humbly thankful for this learning experience and unprecedentedly long journey. I am also thankful for those who made this journey easier or that, in a way, have lit the path when I found myself overcome by darkness.

I will forever convey the utmost respect and sincerest gratitude for my supervisor, Professor Marianne Vanderschuren. I feel very fortunate and blessed to have had the opportunity to experience the lasting effects of her consistent support and inspiration. Not once, throughout these years, has she lapsed in her virtue of patience and her native enthusiasm. Always infused with passion and motivation after our interactions, I now feel that I have a great role model to follow. Her high standards encouraged me to raise my own. Thank you.

I extend my thanks to my lovely copyeditor and friend, Caryn Tiana, who has gone far beyond expectation to deliver the greatest input and sentiments of encouragement. Your support throughout this journey is immeasurable! Thank you for the discussions, meetings and warmth.

To my dearest colleagues in the office, our well-founded interactions and insightful conversations have been invaluable toward this project. Thank you for your company in long hours and extended evenings of work as we slaved away within our starlit campus grounds.

Most importantly, I share my deepest appreciation and love for my family. Mom and Dad, you have done absolutely everything in your power and more to support my venerable fight in Cape Town. When I chose to continue my studies and to conquer one of my ultimate dreams, I never

imagined the milestones and difficulties I would have to face. In continuity, you have only ever offered me opportunity accompanied by undeniable love, support and encouragement.

During these long years I have felt your unshakable presence every day, as if you were holding my hand every step of the way. You have given me the opportunity to study within a field that I am so fiercely in love with, you have made it possible for me to conquer one more building block towards my aspirations without ever second guessing the cost or challenges it would present to you. You are my inspirations and I am who I am today, because of your sacrifice and commitment to my growth. I love you more than expression could succeed.

And lastly, I would like to thank my most faithful cheer leader, the one who never gave up on me even when I almost did:
Dear sister, you are such a beautiful blessing in my life. You have wiped my tears in moments of frustration and you have only shown me love and strength. Thank you for always being my beacon of hope and driving me towards success. My wish is to be that same anchor to you as you have been for me.

Deisy Onions Ismael Narcy

Cape Town, January 2019

Abstract

In developing countries rural communities are normally geographically isolated contributing to both poverty levels and the deficiency in the participation of social and economic activities. Accessibility to education constitutes one of the primordial links between the economic growth of a country and the development of high skilled population. Given South Africa's unique history, divisions throughout the landscape incapacitate inhabitants of rural communities in reaching opportunities and services, therefore, aggravating issues related to social exclusion and inequality.

This study aims to determine accessibility levels in South African rural regions by looking at different aspects that entangle the theory behind it, specifically: the zone attractiveness and impedance. With that in mind, the investigations carried out are firstly directed towards accessibility at the provincial level and thereafter a focus area is determined.

At the provincial level, it was found that the Northern Cape presented the greatest disadvantages. However, given insufficient resources and data related to this province, the Cape Winelands Municipality District was chosen as the area to extend the investigations.

When assessing the focus area, the study deployed a GIS-based analysis wherein potential and real accessibility were determined. Initially using the gravity measure, and subsequently using a survey carried out in the region.

The study has revealed that Stellenbosch and Robertson are the towns experiencing high accessibility levels. Notwithstanding, most principal towns still experience critically low accessibility indexes. The findings of this study can, therefore, be useful in indicating areas that need further studies or are experiencing disadvantages regarding accessibility.

Key words: spatial accessibility, education, inequality, rural areas, geographic information system

Table of Contents

List of Tables

List of Figures

List of Equations

Chapter 1

Introduction

"Where we live, work and play impacts our health and how we move within and between our communities is critical to improving quality of life and access to opportunity."

American Public Health Association

1.1 Background to Study

In developing countries, the geographical isolation of rural communities is a topic of constant debate, specifically denoting the severe accessibility restrictions faced, resulting in poverty levels. This isolation is a great contributing factor to deficiencies in the participation of social and economic activities (Vasconcellos, 1997).

Apart from the influence of the degree of accessibility in rural communities, rural development is also largely associated with the level of education of the population. Although not necessarily sufficient, educated populace are an important influencer for long-run economic growth, as well as good living standards and, therefore they are an indispensable tool for the development of communities (Glewwe and Muralidharan, 2016).

In apartheid South Africa, land use separation, social exclusion and fragmentation of population groups according to race and class were widely enforced (Bickford, 2013). Although contemporary South African cities have diverged from this trend, consequential factors of this spatial segregation are evident, specifically when looking at accessibility in rural areas (Mazaza, 2002). Transportation, time and spatial constraints – accessibility vital indicators – determine individual's productivity by the extent to which they can participate in activities (Odoki et al., 2001).

Having described education as one of the core productive activities that unleashes a country's economic growth, it is important to understand how the access to such institutions takes place in these areas. A recent study determines that 38% of educational costs are associated with transport, which makes up roughly 13% of the total household income (Rogan, 2006).

This demonstrates that the costs associated with educational activities are relatively high and can be unbearable in low-income regions. In fact, these costs normally leave poorest households choosing between giving an education to their children or meeting basic needs (Rogan, 2006).

Children within rural areas are, therefore, restricted when it comes to getting to and staying in school. When conducting an evaluation to determine the causes for such results, various studies normally account for social and economic contributing factors. These include: poor training and income of teachers, devalue of schooling within communities, low household income, insufficient physical and educational conditions as well as the needed help of children at home or work (Vasconcellos, 1997).

Notwithstanding, obstacles related to distance to schooling are normally neglected in available transportation and educational literature. However, the relationship between distance and schooling is particularly vital - specifically in rural areas - as schools are normally widely dispersed, increasing the number of not only direct costs (i.e. public transportation) but also indirect ones (Vasconcellos, 1997).

These indirect costs include factors, such as safety, reliability and travel times, being essentially what constitutes accessibility to educational institutions when including the spatial positioning of these institutions. Therefore, it is no surprise that concerns around access of learner transportation loom continuously, making headlines within South African news (Jacobs, 2018).

Hence, the access to schools is an important part of accessibility to indispensable activities, considered as a right or basic need in the contemporary society (Vasconcellos, 1997). It is, therefore, imperative to investigate the accessibility to schools in such underprivileged societies and determine gaps within, highlighting areas in South Africa that could possibly need urgent improvements.

1.2 Problem Statement

A pivotal factor for the economic and social growth of a country resides in transportation, as it enables the movement of goods and people. Transport enables greater trade activities as well as better living standards, through the improvement of access to social services, education, health, employment and markets (Potgieter et al., 2006). Based on this statement, it can be concluded that accessibility is a crucial factor for the development of South Africa.

Although the importance of accessibility cannot be neglected, the wealth of research exploring the provision of transport and access to basic activities and amenities within the rural areas, solely focuses on the social consequences, without looking microscopically at the level of access within these areas (Lucas, 2011). According to Bryceson et al (2008), many authors have questioned the appropriateness and effectiveness of major transport infrastructure projects in addressing the basic needs of a low-income population.

As previously mentioned, the post-apartheid era in South Africa suffered a great set of challenges within the education sector, which was one of the greatest examples of inequality and segregation in the country (Greenberg, 2006). Although the fragmented education system has encountered several changes redirecting it to an equitable, democratic and unified system, it still struggles to cater equally for all South Africans (Ahmed and Sayed, 2009).

According to the Nelson Mandela Foundation (2005), in poor rural communities the majority of children are receiving less than their right, having consequential results in their opportunities for development, competencies and lives. Although normally neglected or generally mistreated, accessibility to schools in rural areas is an important topic regarding accessibility to basic activities. Specifically because it has both, immediate economic and human benefits.

In a rare departure from previous studies, this research attempts to target and analyse similarly disadvantaged regions in order to identify critical accessibility gaps within the education system for the development of communities and equitable spaces in South Africa.

1.3 Research Objectives

The main objective of this dissertation is to analyse the various rural areas within South Africa and establish the different levels of accessibility to educational institutions, by the usage of accessibility measures that incorporate mobility characteristics. Several questions need to be answered before this main objective is addressed.

The development of this project will, therefore, take place in accordance with the following questions:

1. What is accessibility?
2. Which factors point to the level of accessibility?

3. How does the old South African regime impact the current access to schools in the country?
4. Which characteristics do rural areas present in South Africa?
5. What is the importance of education in society?
6. What is the relationship between access and education?
7. Which South African provinces' rural areas are the most disadvantaged with regards to schooling accessibility?
8. Which area should be focused on?
9. What are the characteristics of the focal area?
10. Which accessibility measure is the most appropriate for the area?
11. What is the level of accessibility to education institutions in the study area?
12. Are obtained results plausible?

1.4 Research Significance

As discussed, economic and social development of a country is directly dependant on the interconnectivity and accessibility within areas (Linard et al., 2012). However, the specific spatial distribution of populations and settlements within South Africa, wherein even new low-cost housing is far from urban centres and transport infrastructure, emanates an increase in average commuter distances (Vanderschuren, 2006).

In addition to this controversial issue, the lack of explicit data across Africa (normally outdated), provides insufficient detail to accurately quantify and measure population concentration and accessibility (Linard et al., 2012).

Moreover, the development of rural areas is tied to apron the access to numerous social and economic services, such as markets, water, fuel, education, health care, banking, etc. The inadequacy of transport systems, results in exorbitant travel times and transport costs, which can be a major contributor to poverty (Linard et al., 2012). Mechanisms for the assessment and analysis of transport projects and conditions cannot successfully determine accessibility indicators' levels to opportunities and their implications to this populational sector (Bocarejo and Oviedo, 2012).

Therefore, the purpose of this research will, ultimately, be aimed at contributing to the specific knowledge of the series of indicators linked with accessibility components within the urban transport domain, particularly those that pertain to travel time and transport costs through the

establishment of a basic relationship between accessibility and mobility. This research, will potentially generate methods to improve the current situation and expand the general knowledge associated with accessibility and social exclusion in South Africa.

1.5 Scope and Limitations

This research was limited to the results obtained from the surveys chosen to analyse the areas. Therefore, although inferences can be drawn from the results of this research for problems facing accessibility to schools in developing countries, any conclusions established will be specific to South Africa only.

Due to time and budget, aerial investigations were solely based on digital sources, such as Google Earth, as well as data available with regards to the spatial software used. Although the study comprised of South African rural areas, due to resources available, a case study area was determined. Therefore, a strong need and opportunity for further research on the topic is provided to include the public transport mode as part of the investigation.

In addition, the choice of study area, although not the most appropriate for the investigation, was constrained by available surveys already carried out, this was mostly due to the author's limited resources and funding.

Moreover, shortcomings within the methodology chosen were also identified; these comprised of weaknesses found in the gravity accessibility measure itself, as it considers the accessibility of the place rather than the individual, limiting therefore, the behavioural content within results.

Additionally, a standard value of home-based trips (apart from work trips) was used as the distance decay coefficient. This parameter conceptualises the degree to which distance influences the potential of usage by expressing how the increase of distance has an inverse effect on willingness to use a service/ participate in an activity. Its computation can be undergone by census, *Origin-Destination*, household and roadside surveys, formulas or it can be borrowed from another model or study area. Given that there were no resources allocated for this formulation, the author considered most appropriate utilising a standard value borrowed from another model, which is sufficient to portray the adequacy of the methodology carried out. However, the sensitivity of this parameter within results is not negligible and therefore, there is a call for further studies in determining distance decay parameters within a South African context.

Furthermore, the transportation analysis zones (TAZs) utilised to determine the accessibility index of the area were obtained from the CSIR. These zones were demarcated at a functional level where key socio-economic datasets were aligned at a meso-level. Although the shape of those zones where not uniform, all were approximately the same size ($50km^2$), allowing for more accurate accessibility results. Notwithstanding, throughout modelling these mesozones were not linked with a road network, calculations were solely done based on the Euclidian distances.

Although actual travel distance within a road network is a more accurate alternative, the aerial distances rendered sufficiently acceptable results, given that the accessibility index determined was then used for comparison purposes with the actual accessibility being experienced by civilians. This leaves opportunity for further studies within the field, utilising either a detour factor or the road network itself.

Moreover, other limitations and assumptions pertaining to this research were directly linked to the National Household Travel Survey (NHTS). These include (NHTS, 2013):

- A total of 51 341 households and/or dwelling units sampled,
- A survey conducted in 2013, and
  Only private households and residents in workers' hostels were considered not covering other collective living quarters.

Lastly, factors contributing to accessibility to analyse the study area will be limited to the questions conducted during the surveys used. Evidently, the scale of final results obtained on this research will directly be linked to the scale of questions asked within the surveys.

1.6 Approach

This research project consists of 10 core steps carried out partially or in parallel. These are split into preparatory and implementation steps. They are:

1. Familiarisation with the Concepts of Accessibility, its Indicators and Types of Measures

Reviewing the concept of accessibility, understanding the factors that could potentially influence its levels and the different ways to measure it was the first step undertaken to recognise and analyse accessibility in South African rural areas.

2. General Investigation of Transportation in a South African Context and the Underlying Relationship Between Accessibility and Education

A solid grounding in the South African background in terms of transportation and the historical consequences from the previous governmental regime was made, as well as the connection between accessibility and education. This grounding was established through the investigation of impacts in spatial distribution and structure by understanding the roots to deficiencies in the transportation sector, the current situation of accessibility to schools and the importance and impact of changes that could potentially occur if the problems of accessibility in rural areas were tackled.

3. Investigation of Existing Data

Given the limited resources during this study, no survey was conducted. Therefore, before choosing the methodology to be undertaken, a scan through all existing data related to the study and potential measures was done.

4. Determination of Appropriate Accessibility Measures to Investigation and Requirements

The choice of appropriate accessibility measures was carried out based on the data available for the investigation. Using that, two approaches for the analysis were chosen, one based on a survey and another one based on spatial data.

However, given the limitations, accessibility index calculation for the entire country was not possible. Consequently, a focal area was chosen.

5. Modelling Tool Selection

Taking into consideration the two approaches chosen, a modelling tool was selected to generate maps for the accessibility index within the two approaches

6. Investigation of South African Rural Communities Characteristics and Travel Patterns

Although an analysis could not be undertaken for the entire South African rural community, with the aid of the National Household Travel Survey (NHTS) travel patterns within these areas could

be established. Additionally, accessibility indicators for such regions were investigated in this phase.

7. Familiarisation with the Focus Area

The accuracy of any conclusions drawn in this report are hinged upon the knowledge of the different characteristics of the study area. Therefore, prior to any other undertaking, a review of the site chosen was conducted inclusive but not limited to determination of local municipalities and principal towns, education characteristics, economic performance and poverty.

8. Acquisition of Results and Illustration of Accessibility to School Within the Study Area

Based on the results maps of accessibility index were produced in order to demonstrate the accessibility levels' variations within the area.

9. Analysis of Results

Based on results acquired during the calculation of accessibility index and responses of survey utilised, conclusions regarding overall accessibility to schools within the country could be elaborated and ways of improvement on the way forward determined.

10. Report Writing

The final stage within this investigation was to document all relevant literature, methodologies and results for future reference in academia. This dissertation is the final product.

1.7 Content and Structure of the Thesis

This dissertation consists of the nine chapters of work carried out over the course of two years .

Chapter two consists of an overview of the accessibility concept and the different factors that contribute to its indication, as well as different types of measures established to determine its level within studies.

Chapter three places the concept of access to school within the historical, political and economic context of South Africa.

Chapter four tackles the challenges identified in accessibility to education.

Chapter five explores the process encompassing the methodology undertaken in the preparation of this dissertation, including the research approach.

Chapter six describes South African rural communities' characteristics and travel patterns and identifies the differences in accessibility indicators at a provincial level

In chapter seven an inspection into the study area is made, wherein characteristics of the area are described, including identification of local municipalities, topographical and climate conditions, as well as the socio-economic profile.

The following chapter (8) assesses the accessibility within the critical area and presents a discussion revolving around the results obtained.

This dissertation ends with chapter nine summarising the conclusions extracted from the analysis, ending with a list of recommendations for the future.

Chapter 2

Accessibility Theory

"Today, knowledge has power.
It controls access to opportunity and advancement".
-Peter Drucker

The accessibility concept has incessantly been considered vital to regional and transportation studies and its analysis continues to attract the core of urban and regional research endeavours (Páez et al., 2012). Therefore, it is no surprise that this concept is commonly used in several scientific fields, such as geography, urban and transport planning, contributing immensely to policy making procedures (Geurs and Van Wee, 2004).

Considered one of the crucial outputs of spatial development, an integrative device between transport networks and activities' geographical distribution, the value of accessibility has recently gained special attention on institutions that have been investigating how to implement it as a planning tool. (Páez et al., 2012).

The importance of accessibility has also been underlined by the emphasis on sustainable urban development as it contributes to the following aspects (Ford et al., 2015):

- Economic development, enabling the movement of goods and people to support the economy's functioning (Van Wee, 2011);
- Environmental objectives that include reducing the emission of greenhouse gases and pollutants based on the form that transport modes are used (Grengs, 2010); and
- Social equity, enabling the provision of access to all socio-economic groups to basic services, such as health care and education (Foth et al., 2013).

While the concept of accessibility has been present in various planning discourses in the past few years, their usage as performance indicators, for more concrete planning efforts was not always considered (Handy and Niemeier, 1997). The limited understanding of its measures can be blamed

for this gap, wherein simpler performance indicators such as the level of congestion or travel speeds were preferred (Geurs and Van Wee, 2004).

However, due to the challenges that emerged with the various contemporary issues revolving around the environment, economy and social efficiency, emphasis on the urgency for a more robust and specified implementation occurred (Páez et al., 2012).

The disadvantage of the previously established performance indicators was that they represented particular aspects that make part of a more intricate system. Contrarily, accessibility is able to establish - not only the combination of these two aspects - but also how individuals perceive and effectively utilise them (Páez et al., 2012).

This junction role of accessibility provides a meaningful correlation of residential and organisational sectors with transport and communication systems, enabling individuals to effectuate challenging distances and allowing them to engage in certain activities (Occelli, 2000).

Nevertheless, this junction feature of accessibility also creates a misconception that underlies the notion of accessibility. It highlights the vagueness associated with the term, oftentimes poorly defined, measured or constructed (Occelli, 2000).

In fact, accessibility is a complex term to define (Geurs and Van Wee, 2004). It is commonly experienced by individuals - with different characteristics, needs, abilities and opportunities – resulting in a substantial variation of the components that constitute its measures and formulation (Vandenbulcke et al., 2009).

Having taken the above into account, no consensus about the concept's formal definition and formulation has yet been established (Bhat et al., 2000; Vandenbulcke et al., 2009). The following section attempts to identify some of the most commonly used interpretations of the accessibility concept and combine them to draw a coherent and inclusive definition that is in line with the work being carried out in this research.

2.1 Accessibility Definitions

In science and research, several ways have been used to define accessibility. This is largely due to various approaches which can be used (Bocarejo and Oviedo, 2012). Although accessibility

appears to be an intuitive concept linguistically, it is complex and laborious to convert into an exclusive meaningful notion, given its ontology (Occelli, 2000).

Hansen (1959), defines accessibility based on the concept developed by Stewart (1948), wherein it is seen as a generalisation of the relationship 'population-over-distance' or 'population potential'. He describes accessibility as the 'potential of opportunities for interaction' which differs from other definitions that consider accessibility solely as the ease of interaction rather than the intensity of the possibility for interaction.

The definition used by Hansen (1959), therefore, regards accessibility as the measurement of the spatial distribution of activities, regulated based on desire or ability of individuals or organisations in order to vanquish spatial separation.

Differing from Hansen, Dalvi and Martin (1976) defined accessibility as 'the ease of reaching any area of activity (land use activity) using a particular transport system'. They considered three main components for the operational form of accessibility:

- Individuals, their purposes, preferences and decision-making process;
- Opportunities or possible activities, and the sensitivity of them towards the degree of attraction; and
- Transport systems and their ability to provide rapid and low-cost travel, as well as to overcome distance between different locations.

Thenceforth, accessibility was both looked upon as a tool capable of determining a subject's net utility within a certain location (Leonardi, 1978 cited in Cascetta et al., 2016) or solely through an individual's level perspective (Ben-Akiva and Bowman, 1995).

Contrariwise, Ben-Akiva and Bowman (1995) define accessibility solely at the individual level. They see it as the expected maximum utility value of an individual over the schedules available for the activity. Moreover, accessibility is looked at as a beneficial feature that, instead of only analysing the trips individuals take, its measures accommodate the desire of individuals to participate in various activities, combining such activities using trip chaining (Ben-Akiva and Bowman, 1995).

Other definitions that look at accessibility from a different perspective include the one given by Burns (1979), where accessibility is seen as 'the freedom to decide whether to participate in different activities or not', or the one given by Ben-Akiva and Lerman (1979), describing it as 'the overall benefit provided by any transportation system'.

It is unquestionable that there is a wide variety of interpretations revolving around the concept of accessibility. A more classical perspective of the definition, however, can be acquired within two pieces of literature: Morris et al., (1979), and Handy and Niemeier (1997), in which the accessibility is defined as the ease at which desired destinations are reached, given availability of opportunities and inherent impedance to the resources used to travel.

Based on this definition, it can be understood that accessibility essentially focuses on the effort necessary to overcome spatial separation between two locations, reflecting in this case the utility related to the travel between them (Morris et al., 1979; Handy and Niemeier, 1997).

Although a classical definiton has already been establised, Geurs and Ritsema van Eck (2001) developed the definition that, as some agree (Geurs and Van Wee, 2004; Bocarejo and Oviedo, 2012), is the most complete; since it embraces a variety of aspects:

'the extent to which the land-use transport system enables individuals or goods to reach activities or destinations by means of transport modes"

Underlying this definition and the ones given before, there are some constituents that can be extracted and that essentially form the basis of all the different definition fragments, namely (Occelli, 2000):

- An urban product – i.e. activities and services – spatially distributed in a region;
- A need or demand for those activities and services. People and organizations recognise the benefits involved in the access of these products and therefore are motivated to gain such access;
- The effort necessary to reach these activities or services at a certain time. This effort can be recognized as monetary, temporal or psycological; and
- A set of constraints strictly related to personal resources and household responsibilities.

Taking the different aspects that relate to the definitions of accessibility into account, it is clear that this concept can be considered an indespensable tool for the functioning and interaction of both urban and rural systems. (Occelli, 2000).

Similarly important is to understand accessibility not just as a clear entity (i.e. physical, social or economic), but rather an amalgamation of two spatial components: the spatio-temporal pattern of activities and the spatiofunctional pattern of interdependencies (Occelli, 2000). These components constitute essentially different perspectives that should be considered during any accessibility assessment and will therefore be designated indicators within further discussions in this study.

Section 2.2. will describe these indicators in detail.

2.2 Accessibility Indicators

Granted the complexity within the concept and definition of accessibility discussed previously, it is clear that such an intricate concept cannot be considered solely as one entity (Geurs and Van Wee, 2004). The well cited paper of Geurs and Van Wee (2004) thoroughly describes the various perspectives within the accessibility concept and clearly determines four specific and crucial indicators that effectively contribute to the theoretical understanding of accessibility measures (Geurs et al., 2015).

These indicators include (Boisjoly and El-Geneidy, 2016):

- Land use - referring to the location either of people or opportunities and their specific characteristics;
- Transport – widely used in mobility and accessibility studies, normally related to transport infrastructures or specification of modes;
- Temporal – includes scheduling of transit or activities and their availability throughout the day; and
- Individual – reflecting personal aspects that can affect traveling capacity or needs (i.e. factors, such as income, household composition, education, car ownership, age, gender, etc.).

Given their importance, an exhaustive description of each will be subsequently discussed.

2.2.1 Land-use

The land use indicator, also described as spatial, reflects a land-use system, wherein opportunities are distributed in space with their specific characteristics, capacity and quality (Geurs and Ritsema van Eck, 2001; Geurs, 2006) or wherein instead, the location or spatial distribution of the population is taken into consideration (Boisjoly and El-Geneidy, 2016). This component can essentially be split into two different elements (Geurs and Van Wee, 2004):

- The amount, quality and spatial distribution of opportunities supplied at each destination (social and recreational facilities, jobs, shops, health, etc.); and
- The spatial distribution of the demand for activities and their characteristics.

Figure 1, schematically represents this indicator showing that both the distribution of supplied opportunities and the demand for opportunities influence accessibility (Geurs and Ritsema van Eck, 2001).

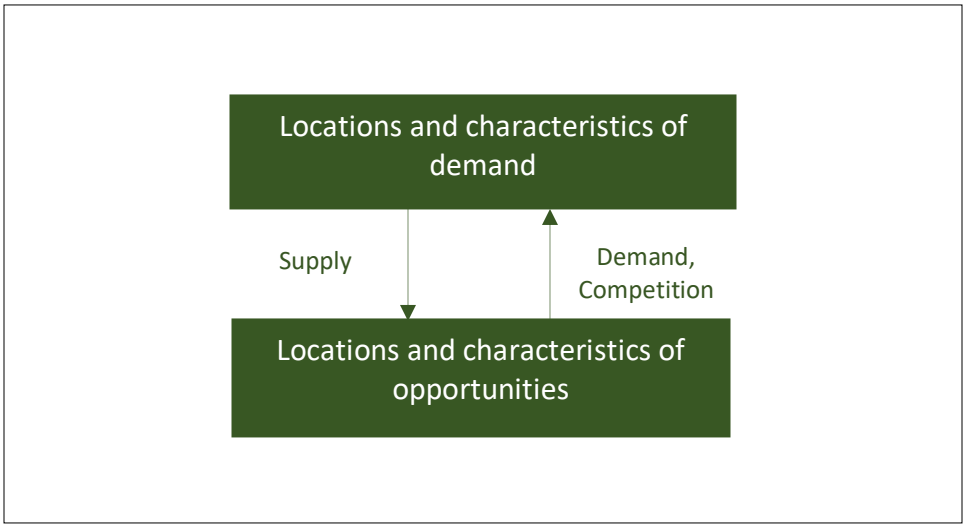


Figure 1. Spatial Indicator
(Based on Geurs and Ritsema van Eck, 2001)

Moreover, it reflects a system in which these two (supply and demand) may conflict and result in competitions for activities with limited capacity (i.e. jobs, hospital beds, school vacancies) (Geurs, 2006). In order to proceed with its evaluation, opportunities are normally weighed in terms of their attractiveness or competition effects (Cerdá, 2009).

This indicator of accessibility is of great importance when handling research studies and demarcating a certain area of interest. In some cases, the border of a country is taken as the

demarcation line, resulting in low levels of accessibility in regions close to the borders (Geurs and Ritsema van Eck, 2001).

According to Geurs and Ritsema van Eck (2001), three approaches can be used to identify the most appropriate demarcation:

- Representation of specific cities or regions using network nodes or centroids;
- Usage of raster-based Geographic Information Systems (GIS) technology; and
- A combination of the two approaches stated above.

When comparing the first two approaches, the last one is normally advisable since raster-based GIS normally contains geographical information that the nodal system fails to provide (i.e. the spatial organization within nodes). Ideally a combination between the two should be used for more critical and concise results (Geurs and Ritsema van Eck, 2001).

2.2.2 Transportation

The transport indicator reflects the transport system, normally defined as the disutility involved to travel from an origin to a destination through a specific mode. This disutility normally emerges from the conflict between the supply of infrastructure, including location and characteristics (e.g. highest travel speed, timetables for public transport, quantity of lanes, travel costs) and demand (related to both travel of goods or individuals) (Geurs and Van Wee, 2004). Figure 2 illustrates the transport indicator scheme.

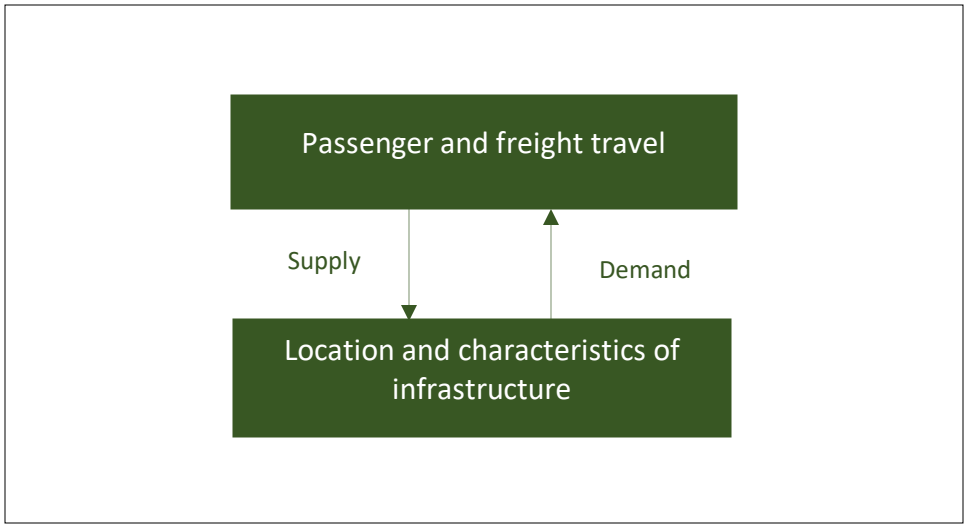


Figure 2. Transport Indicator
(Based on Geurs and Ritsema van Eck, 2001)

Four specific elements are normally used to assess and quantify the transportation indicator, namely (Handy and Clifton, 2000):

- Impedance factors;
- Level of Service (LOS) factors;
- Terminal factors; and
- Comfort factors.

These factors have different effects depending on the transport mode used (Geurs and Ritsema van Eck, 2001). Table 1 illustrates the different elements affecting each transport mode within different factors.

According to Handy and Clifton (2000), *impedance factors* are considered to be the most essential when it comes to automobile and transit (or public transport). These factors entail both distance and time, representing the disutility levels to travel to a certain destination through generalised travel costs (travel time and money spent), and in some cases topography.

An example of a generalised cost function (also called disutility function, c_{ij}) as follows: (Geurs and Ritsema van Eck, 2001):

Equation 1. Example of a disutility function

$$c_{ij} = v_m t_{ijm} + c_m d_{ijm} + u_m k_{ijm}$$

Where:

v_m= value of time
c_m= cost per kilometre
u_m= disutility of inconvenience
t_{ijm}= travel time from i to j
d_{ijm}= travel distance from i to j
k_{ijm}= convenience of travel from i to j

These types of travel cost functions (cij) are normally used in transport models when estimating spatial interactions between origins and destinations.

Table 1. Elements of Transport Indicators of Accessibility

		Automobile	Transit	Walking	Cycling
Impedance Factors	Distance	✓	✓	✓	✓
	In-vehicle time	✓	✓		
	Out-of-vehicle time	✓	✓	✓	✓
	Cost	✓	✓		
	Topography			✓	✓
Level of Service Factors	Volumes/crowding	✓	✓	✓	✓
	Signalisation	✓	✓	✓	✓
	Service frequency		✓		
	Hours of operation		✓		
	Directness of route	✓	✓	✓	✓
	Continuity of route	✓	✓	✓	✓
	Information availability		✓		
	Signage	✓	✓	✓	✓
	Facility widths	✓		✓	✓
	Vehicle design	✓	✓		✓
	Shelter		✓	✓	✓
	Benches		✓	✓	
Terminal Factors	Parking availability	✓	✓		✓
	Parking cost	✓	✓		
	Terminal locations		✓		
	Intermodal connections		✓	✓	✓
	Terminal design	✓	✓	✓	✓
Comfort Factors	Traffic speed	✓	✓	✓	✓
	Traffic volumes	✓	✓	✓	✓
	Pavement condition	✓	✓	✓	✓
	Lighting	✓	✓	✓	✓
	Weather	✓	✓	✓	✓
	Shade		✓	✓	✓
	Scenery	✓	✓	✓	✓
	Crime/police presence		✓	✓	✓
	Cleanliness		✓	✓	✓
	Conflicts with other modes	✓	✓	✓	✓
	Other users	✓	✓	✓	✓

(Adapted from Handy and Clifton, 2000)

Although impedance factors seem to be the most prominent for automobile and transit modes, the same does not apply for non-motorised transportation wherein environmental conditions play an equal role. Such environmental conditions are normally interlinked with *comfort factors* which include perceptions of safety, availability of shade, pavement conditions, lighting, weather conditions, scenery, and conflicts with other modes of transport and users (Handy and Clifton, 2000).

Comfort factors may also present significant importance for some drivers, apart from some of the components mentioned above which are applicable to them, specifically in their perception of accessibility: excessively high or low traffic speeds, traffic volumes and signage (Handy and Clifton, 2000).

Terminal factors are mostly associated with transit modes and include parking availability and cost, station condition (cleanliness, noise levels, temperature, seats comfort, etc.), station location and the intermodal connections. Applicability of such factors in other modes can be seen through Table 1 (Bhat et al., 2000).

Lastly, *Level of Service (LOS) factors* include characteristics directly related to the volume of traffic: operation, frequency and timelines of services, information timelines, signalisation, as well as vehicle design, availability of benches, availability of shelters and efficacy of route. Similar to the terminal factors, LOS factors are predominantly related to transit modes (Handy and Clifton, 2000).

2.2.3 Individual Indicator

Empirical evidence has repeatedly shown that individual accessibility is normally based on *inter alia*, an individual's traveling behaviour, mode choice, mandatory activities schedule, etc. (Weber and Kwan, 2002; Kim and Kwan, 2003; Kwan and Weber, 2008; Neutens et al., 2012).

This heterogeneity in the ability for individuals to participate in activities is what constitutes the individual indicator (Kim and Kwan, 2003; El-Geneidy et al., 2016). Here, the assumption that the individual's choice of an activity or travel alternative is made based on the maximum possible accessibility benefits (Hsu and Hsieh, 2004).

Characteristics related to transport modes in the sense of, for example being or not able to drive or borrow a car and having the necessary skills to qualify for opportunities near a person's residential area, are some of the aspects considered in this indicator (Van Wee and Geurs, 2011).

Dependent upon specific personal characteristics of individuals or population groups, the individual indicator specifically focuses on three main aspects: the unique abilities, opportunities, and needs based on their physical, demographic and socioeconomic conditions (Pyrialakou et al., 2016).

Figure 3 presents examples of influential individual characteristics within each of these three conditions.

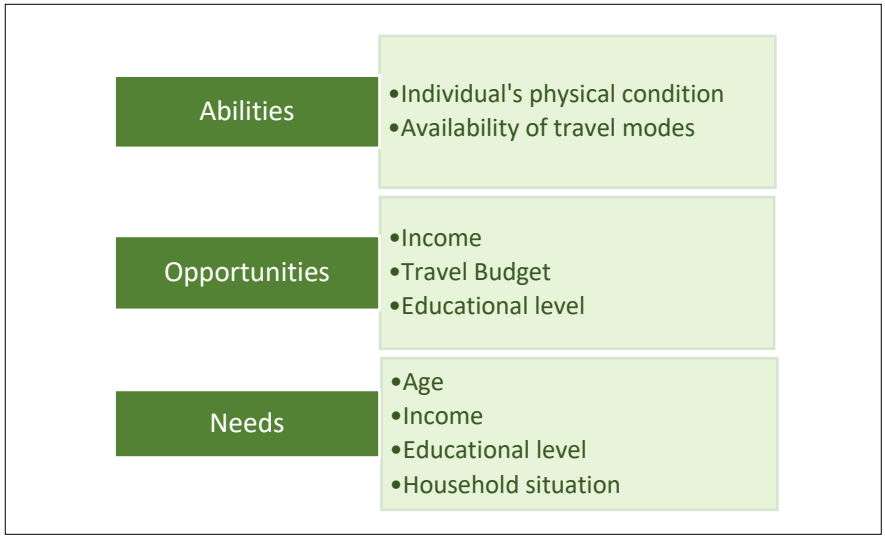


Figure 3. Influential Individual Characteristics
(Based on Van Wee and Geurs, 2011)

Taking the definition of *opportunities* in the transportation context from Bertolini et al. (2005), as the amount of activities (shopping, leisure, education, work, etc.) spatially available to people, it is clear that the income bracket to which a certain individual belongs to, and subsequently their budget to travel, will play a role in the possible opportunities attainable to them, together with their educational level influencing the type of activities they can engage in (Van Wee and Geurs, 2011).

The same applies to current individual *needs*, which equally depend on the income and educational level along with their age, household situation and others (Geurs and Ritsema van Eck, 2001).

Lastly, when looking at the third aspect within the individual indicator, a user's physical condition, as well as the transport modes available, are *abilities* essential to determine the types of mode choice possible to them (Van Wee and Geurs, 2011).

Having understood the different facets entailing this indicator of accessibility, it is relevant to recognise that with such personal sensitivity, same geographical areas and types of opportunities available can be dissimilar from one person to another (Kwan and Weber, 2008).

This repercussion leads to a strong influence in the total aggregate within an accessibility result, given that different segments of the population are inclined to different types of opportunities and may appraise the attractiveness of, and the impedance to, opportunities in exclusive ways (Handy and Niemeier, 1997; Geurs and Van Wee, 2004) .

Therefore, it is important to consider this indicator during measures, as even if the location of the point in question is constant, aggregation levels may change (Bhat et al., 2002). Arguably, however, due to the practical limits of the level of disaggregation, diminishing returns in terms of accuracy can be expected (Handy and Niemeier, 1997).

2.2.4 Temporal Indicator

Understanding human and environmental systems is a necessary condition to expand and comprehend the knowledge within the theoretical indicators of accessibility (Miller, 2017). Within these human systems, spatial and temporal constraints can be recognised, specifically because people can only be at one place at a time and activities normally take place at dispersed locations within a specific period of time (Hall, 1983; Fotini, 2017; Miller, 2017).

The temporal indicator, therefore, reflects these type of temporal constraints and variability (Geurs et al., 2015). Nevertheless, this specific indicator has recently gained attention amongst academia in transportation and geography, (Ettema et al., 2007; Schwanen and Kwan, 2008) although previously highlighted by a few authors (Burns, 1979; Kitamura and Kermanshah, 1984 according to Handy and Niemeier, 1997).

What initiated the interest of academia was the inherent difference within study results between the participation time of individuals in an activity and the opening times of each opportunity, implicitly demonstrating their activeness in accessibility measures (Handy and Niemeier, 1997; Kim and Kwan, 2003).

According to Handy and Niemeier (1997), temporal constraints should be taken into consideration in order to obtain 'constrained-choice sets' during activity-based analysis and bypass overestimations of accessibility within an area that can occur when all potential destinations are included, given that individuals might have their own personal constraints or the activities a limited operation time.

Evidently, it is important to situate human activities within context and understand the rooting of such variabilities. Restrains in participation can be associated with activities that compel presence (i.e. home, work) and time budget for the access and/or activity, subsuming the necessity of individuals to coordinate and connect these activities (Kim and Kwan, 2003; Litman, 2016; Miller, 2017).

This, in turn, can reduce the number of feasible opportunities within calculations, when there is a mismatch between facility trading hours and the arrival and departure times for activities (Kim and Kwan, 2003).

Miller (2017) classifies activities based on the time geography regime, as *fixed* or *flexible* depending on the scale of restrictions around them.

Figure 4 defines both activities separately, together with examples pertaining to each. Activities that are time adjustable or spontaneous are designated as *flexible* and activities that have set time boundaries are designated as *fixed* (Litman, 2016; Miller, 2017).

This classification intrinsically aids to diminish some of the complexities involved when calculating accessibility and including the temporal factor, as fixed activities require more fragmentation and extraction of significant times, in order to avoid overestimated results (Handy and Niemeier, 1997; Xu et al., 2015).

Moreover, Cerdá (2009) suggests a very basic calculation of accessibility in order to incorporate temporal aspects wherein a predetermined time of the day (i.e. morning peak) is chosen and the time-based constraints (i.e. store operating hours) built-in.

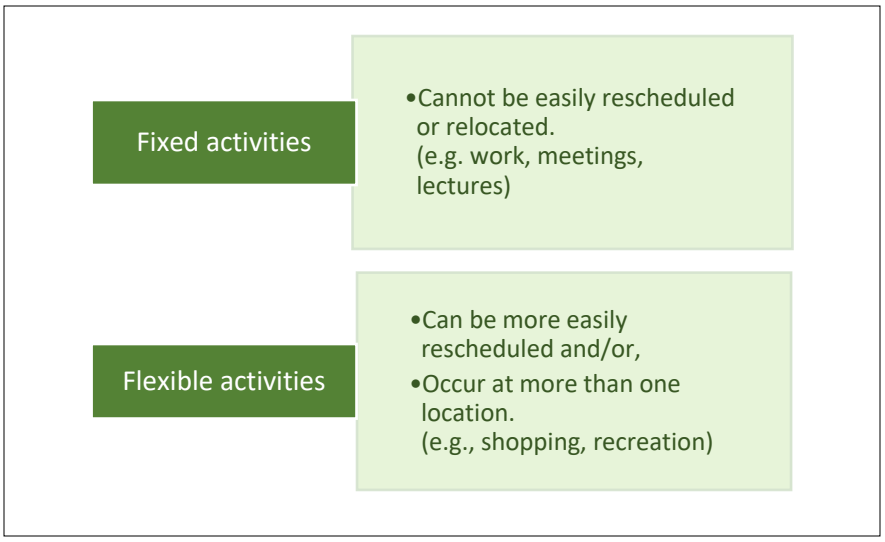


Figure 4. Type of activities based on time geography

(Based on Miller, 2017)

Nonetheless, the inclusion of this indicator within analysis still continues to affirm a laborious process. The estimation of the time-varying travel demand throughout the area of interest requires a significant amount of information regarding the social and demographic sectors of this same area (Hsu and Hsieh, 2004; Xu et al., 2015).

2.2.5 Interdependency and Synthesis of Accessibility Indicators

Accessibility, being a multifaceted concept, appeals the feverishness of researchers through the variety of approaches for development and modelling. Therefore, its complexity and underlying layers are undeniable (Geurs et al., 2015).

These intricate characteristics of the notion of accessibility allow for an interconnection between its different indicators, as well as with the concept itself, (Couclelis and Getis, 2000). Figure 5 illustrates these relationships.

Starting off with the land-use indicator that, as previously discussed, involves mainly the distribution of activities. Its connection with the travel indicator is due to its importance when determining the travel demand. Moreover, this same indicator could induce the application of time constraints which, in this case, are the basic constituents of the temporal indicator and influence people's opportunities (individual indicator) (Geurs and Van Wee, 2004).

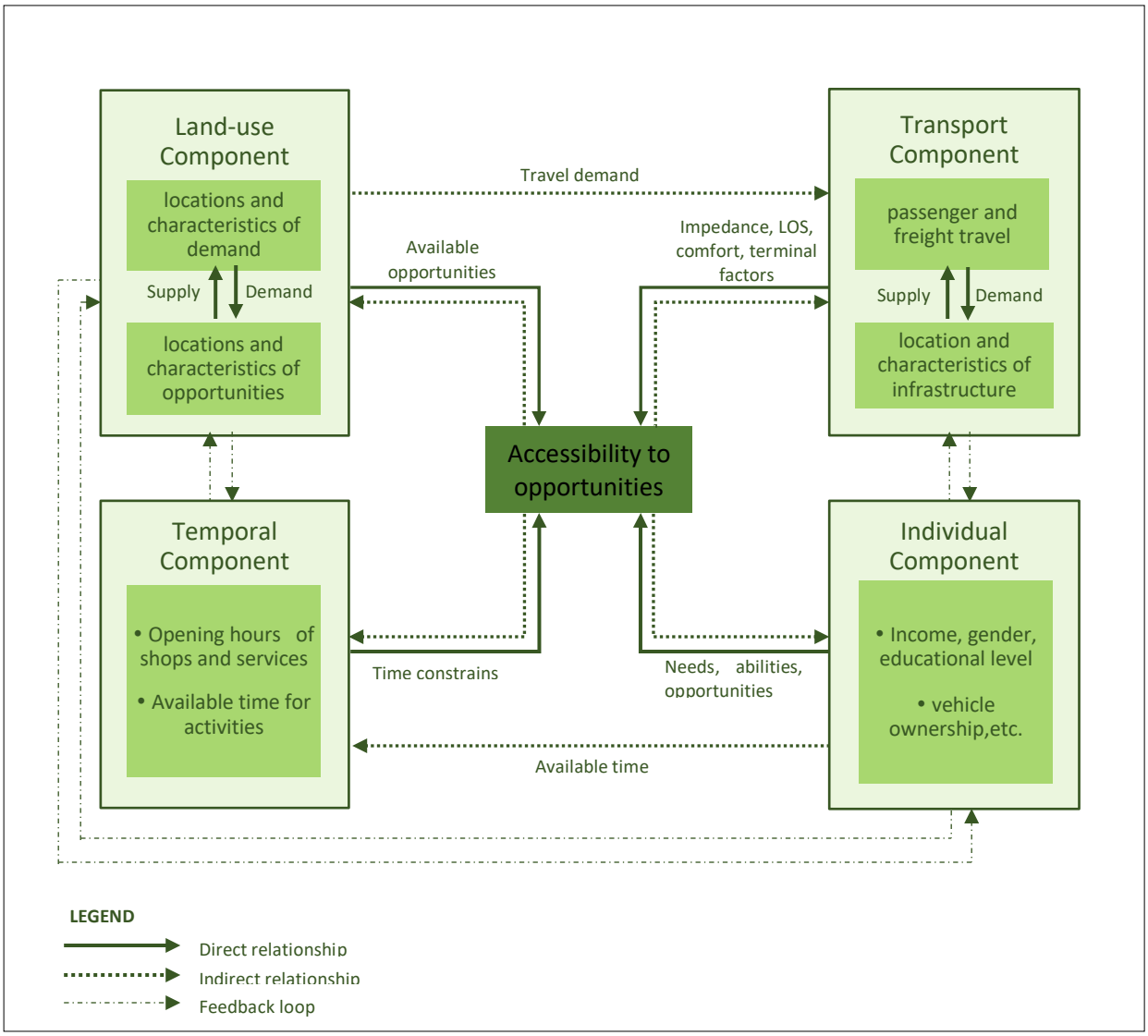


Figure 5. Relationship between accessibility components (indicators)

(Based on Geurs and Ritsema van Eck, 2001)

When looking at the individual indicator, it is clear that there is an immediate interaction with all other indicators: the needs, abilities and opportunities of a person influence the degree of travel disutility, giving it a valuation of time, cost and effort of movement, as well as the types of engaging activities and the specific time and duration to which these activities take place (Geurs and Ritsema van Eck, 2001).

Furthermore, when looking at the indicators regarding accessibility itself, although such components/indicators are immersed within its definition, they are not immune to its influence.

Accessibility is characterised by its spatial element factored for inhabitants and companies (land-use component relationship) that can sufficiently impact travel demand (transport component), as well as intervene in the availability of opportunities, both social and economic, and the time necessary for such activities (temporal component) (Geurs and Ritsema van Eck, 2001).

Ideally, following the definition of accessibility, all indicators should be incorporated within its measures. However, due to the complications involved during the practice, depending of on the type of approach chosen, applied accessibility only focus on one or more indicators. (Geurs and Van Wee, 2004).

The following section will, therefore, aim to describe the several accessibility measures and portray a linkage between these measures and the accessibility indicators involved within each type.

2.3 Overview of Accessibility Measures

Integrated transport and land use policies are essential for the sustainable development of a country, aiming to provide an inclusive society, strong economy and healthy environment. In order to take forward this agenda, it is essential to define a linkage between land use and transport. Accessibility measures are normally used to explicitly describe said link (Halden, 2013).

This was not always the case as measures used to conduct a transportation system evaluation were normally focused on the concept of *mobility* (Bhat et al., 2002). The differentiation between mobility and accessibility measures is not always clear and, therefore, it is necessary to understand both concepts clearly to not diverge into erroneous interpretations.

Mobility measures evaluate the movement ability, associating elements such as level of service, road capacity and design speed. Conversely, accessibility measures focus on the assessment of interaction potential, describing destinations spatial distribution, their quality and ease of access in reaching the desired destination. This, therefore, makes mobility simply an element of accessibility, as the latter includes a broader spectrum of factors affecting the ease or capacity to reach a location (Bhat et al., 2002; Boisjoly and El-Geneidy, 2016).

It is thanks to recent theoretical developments in the past few years within the range of accessibility analysis and applications to evaluate plans and assess performances in that accessibility measures

are now a useful complement and eventually an alternative to traditional mobility measures (Cerdá, 2009; Moniruzzaman and Páez, 2012).

Undeniably, accessibility and its measures are therefore the root to a sustainable development reflecting the various possibilities for activities available to people according to different areas (Handy and Clifton, 2000).

Despite the fact that the accessibility concept was originally introduced by transport planning literature, it has expanded and been adopted within many other scientific fields, inherently becoming an interdisciplinary concept that embraces a multitude of definitions (Bhat et al., 2002).

Translating the accessibility concept into a practical tool rises from the need to provide technical and decision support systems, contributing to a variety of applications, such as (Karou and Hull, 2014; Cascetta et al., 2016):

- The understanding and modelling of interactions between transport systems and land-use;
- The understanding and modelling of travel demand;
- Transportation projects efficacy assessment; and
- Overcoming optimal location problems for utilities and services.

Pirie (1979) also suggests that such measures are a mechanism to maintain a certain level of accessibility within an area reflecting the interaction between people and the built environment and identifying social inequities (cited in Curtis and Scheurer, 2010).

According to Litman (2003), the accessibility concept is the hardest to measure as it demands the analysis of land use, mobility, as well as its substitutes. Nevertheless, this same concept reflects the finest objective of transportation most accurately by upbringing the widest range of solutions for transportation problems within various study fields related to spatial and human behavioural conditions (Weibull, 1976; Litman, 2003).

Section 2.3.1 will further discuss the characteristics involved in the different types of measures.

2.3.1 Characteristics of an Accessibility Measure

Accessibility measures are applied as systematic decision support tools, contributing to a great number of interventions related to transportation and land use systems (Cascetta et al., 2016). Apart from the few characteristics discussed in the previous section, there are several primary criteria

proposed by a considerable number of researchers that constitute the basis of any accessibility measure (Weibull, 1976; Morris et al., 1979; Pirie, 1979; Bhat et al., 2002).

Taking into consideration the concept of accessibility and its specific correlation with the transportation system and land use patterns, it is agreed that, within accessibility measures, a responsive result should be based on changes of these two elements (Morris et al., 1979; Handy and Niemeier, 1997).

Weibull (1976) developed axioms to characterise and form the foundation of accessibility measures, which have now been adhered by several researchers (Koenig, 1980; Miller 1999; Tagore and Sikdar, 1996 cited in Bhat *et al.*, 2002).

These axioms include the following (Weibull, 1976):

- The measure's value should not be affected by opportunities listing order;
- The measure should not increase or decrease with increasing distances and attractions respectively; and
- Zero value opportunities should not be considered.

Although such axioms are considered necessary for a satisfactory accessibility measure, Weibull admits that they are somewhat arbitrary when it comes to their particular requirements (Davidson, 1977). Davidson (1977), therefore, proposes that an accessibility measure should additionally consider opportunities by all modes, and it should be increased if an extra mode -that does not disturb the others - is introduced.

Later on, Morris, Dumble and Wigan (1979) proposed other related parameters for accessibility measures. Their criteria included specifications that should be present within an accessibility measure, namely: a behavioural basis, technical feasibility and ease of interpretation.

Although there is a slight discordance amongst researchers as to which the first criteria should be, it is normally seen as the parameter that incorporates social-demographic factors influential to activity participation (Bhat et al., 2002).

The technical feasibility parameter highlights real-world measure applications based on academic literature. And lastly, having a measure that is easily interpretable enables policy-making procedures and public participation (Bhat et al., 2002).

Apart from the three aspects introduced by Morris, Dumble and Wigan (1979), additional criteria have been considered. Voges and Naudé (1983), for example, propose that a measure should be able to carry on evaluations along several different dimensions – making, in this case, disaggregation an important quality of these measures (Bhat *et al.*, 2002).

From the different characteristics suggested, it is clear that accessibility measures are based on the opportunities available and the various constraints (Morris et al., 1979).

Regardless of the different perspectives and characteristics proposed, Geurs and Van Wee (2004) determined five important behavioural features that should be included within a measure. These features should relate to:

1. Travel opportunities' changes, quality and impediment.
2. Land use changes.
3. Demand for activities constraints and changes.
4. Personal capabilities and constraints.
5. Personal access to travel and land use opportunities.

Most of the research and studies discussed here are solely within an academic context. Bertolini, le Clercq and Kapoen (2005) dive further into this and look at their application within practical policy making. One of the basic requirements for its efficiency within this sector is their consistencies with the uses and perceptions of the population apart from its transparency and legibility to understand.

Interestingly, these requirements fall in line with aspects considered by Morris, Dumble and Wigan (1979) discussed earlier. The great methodological challenge of these measurements, however, is finding the appropriate balance between the theoretical and the empirically sound ones (Bertolini et al., 2005).

Taken into consideration the ambiguity within the concept of accessibility, it is inevitable that variations in accessibility measures occur, especially because definitions of the concept are dependable on its intended application (Morris et al., 1979).

The next section will aim to discuss the range of accessibility measures more conventional and traditional to the main operational definitions of accessibility.

2.3.2 Conventional Forms of Accessibility Measures

The literature dedicated to accessibility matters has had a long history, especially by awakening the interest of researchers and planners who have carried out numerous studies on its distinctive measurements (Handy and Clifton, 2000; Jia Cui, 2014).

The curious application of this concept in an overwhelming number of scientific fields has not stopped the concept from its abstractive characteristics. After Hansen's (1959) seminal paper, the accessibility concept was seen both as a measure capable of determining a subject's total utility received (consumer surplus/net benefit) or as a measure of the average number of opportunities available to residents in a set of activities/or single activity (Leonardi, 1978; Wachs and Kumagai, 1973 cited in Cascetta et al., 2016).

This large scope within the concept of accessibility is at the root of the diversity found when classifying and establishing its measures (Handy and Clifton, 2000).

Within the work of Bhat et al. (2000) and Geurs and Ritsema van Eck (2001), types of accessibility measures are commonly identified and a discussion around its applications and limitations is made. They both distinguish three main categories: *infrastructure-based*, *activity based* and *utility-based measures*.

Contrariwise from both of these academic studies, Baradaran and Ramjerdi (2001) have categorised accessibility measures in five distinctive approaches: *travel-cost*, *gravity or opportunities*, *constraints-based*, *utility-based surplus* and *composite approach* (cited in Scheurer and Curtis, 2007).

More recently, Cascetta, Cartenì and Montanino (2016) broke down the measures in three levels. The first constituting *utility-based* and *opportunity-based*, the second distinguishing between *behavioural* and *non-behavioural* and lastly, the third concerning *individual's aggregation* or *disaggregation*.

This section will, therefore, attempt to produce an amalgamation and consolidation of these previous attempts to classify accessibility measures.

Classification of Accessibility Measures

Accessibility measures have been classified differently by several authors, due to the fact that it presents various factors influential for its determination (i.e. time, money, discomfort and risk), as described earlier in this chapter (Litman, 2003). Therefore, taking such complexity into consideration, it is important to choose a type of measurement classification that most accurately align with the type of research being carried out.

Before attempting to classify the different measurements within accessibility, it is crucial to understand the two basic components that all entail: the cost of travel (depending on the spatial distribution of opportunities and the travellers) and the condition (quality/quantity) of available opportunities (Páez et al., 2012).

Depending on the degree of detail to which such components can be deployed (network situation, modes of transportations and inherent mobility differences within individuals), accessibility can be measured using different perspectives (Islam et al., 2008 *in* Paez, Scott and Morency, 2012):

- Origin location;
- The originator;
- Potential trips; or
- Destination's stance on the aim of the trip.

Geurs van Wee and Ritsema van Eck (2001) adopted a broad-based review that considered various evaluation purposes within the accessibility measurements. For that reason, their classification will be adopted for this study.

According to them, there are three principal types of measurements:

- Infrastructure based;
- Activity-based; and
- Utility-based.

Each of those types will be described shortly within this section.

Infrastructure-based Accessibility Measures

Infrastructure-based measures relate to aspects, such as operating speed of the network and journey times. It is an essential measure for transport policy procedures pertinent to accessibility (Geurs and Wee, 2004).

These types of measures analyse the characteristics associated with the capacity and level of service of the infrastructure through studies related to the levels of congestion and average speed (i.e. transport facilities quality). It also uses measures of length, density, and traffic levels to acquire characteristics related to the infrastructure, such as the coverage, the capacity and its subsequent quality(Bocarejo and Oviedo, 2012).

Moreover, although the infrastructure-based measure provides valuable information with regards to the level of service, it does not associate the destinations of interest with the overall area. In addition, effects of possible improvements of levels of service in land-use patterns are not taken into consideration (Ewing, 1993).

Activity-based Measures

Also, designated location-based measures are based in spatial interacting factors and can be subdivided into distance measure, contour measure, potential measure, balancing factors and person-based measures. These will be described based on Geurs and Ritsema van Eck (2001) understanding.

Distance measure – associated with the degree to which two locations are connected and normally used in land-use planning to determine maximum acceptable travel time or distance.

Contour measure – also known as a designated *cumulative opportunity measure*, it focuses on the amount of opportunities that can be reached within travel time, distance or cost. For each zone, series of travel time/distance/cost contours are drawn and relevant opportunities within each contour counted.

This measure considers both the distance and the objective of a trip in the most simplistic manner. It defines the travel time or distance threshold based on the number of potential activities for the spatial unit's accessibility (Bhat, Handy, et al., 2000).

This measure is defined by the following equation:

Equation 2. Contour Accessibility Measure

$$A_i = \sum_j O_{jt}$$

Where:

A_i = accessibility of the zone i

O_{it}= opportunity that can be reached within threshold *t*

(Geurs and Ritsema van Eck, 2001)

Potential measure – also called *gravity-based measures*, predict the accessibility opportunities in zone i to other zones and evaluates the impact of land-use and transport aspects by using a distance decay function (Geurs, 2004). Hansen (1959) was the first author to apply this measure to estimate the opportunities accessibility. He defined accessibility as 'the potential for the interaction of opportunities (Geurs, 2001).

The initial form of this measure used the following equation:

Equation 3. Initial Potential Accessibility Measure

$$A_i = \sum_j a_j \, d_{ij}^{-b}$$

Where:

A_i = accessibility of the zone i

d_{ij}= distance between zones *i* and *j*

a_j = opportunities in j

This equation was then further adapted to best suit different scenarios (Geurs, 2001). The general description of a potential accessibility was then determined to be as follows:

Equation 4. General Potential Accessibility Measure

$$A_i = \sum_j = a_j f(d_{ij})$$

Where:

A_i = accessibility of the zone i

$f(d_{ij})$= distance decay function from zones i to j

a_j = attractiveness of zone (opportunities)

Furthermore, the cost function is normally defined in terms of travel time or distance from zone i to j. Although this is a good representation of accessibility, Bocarejo and Oviedo (2012) have adapted this equation to include an aspect that takes great importance in the developing world: affordability. This can be expressed by the percentage of an individual's income spent in transportation and takes the form of (Bocarejo and Oviedo, 2012):

Equation 5. Bocarejo and Oviedo (2012) adapted Cost Function

$$f(d_{ij}) = e^{-\beta C_{ij}} = e^{-\beta_1 C_t + \beta_2 C_c}$$

Where:

C_{ij} = generalised travel cost

C_t= travel time cost between *i* to *j*

C_c = percentage of the individual income spent on travelling

The first component of the generalised travel cost, Ct is directly correlated to variables associated with the individual/traveller. These include age, occupation, income level, etc. and variables associated with land use, such as the distribution of activities throughout the area. Moreover, it is also associated with supply variables that relate to the availability of transport modes and the speed travel (Bocarejo and Oviedo, 2012).

The other component, Cc, is associated with the supply and income level of the population, as to determine the affordability.

Balancing factors – also called competition factors, establish the competition on demand and supplied opportunities. They are often used in analysing job accessibility, where there is a

competition of workers for jobs and a competition of employers for employees (Geurs and Ritsema Van Eck, 2003).

Person-based measures – also denominated *space-time geography*, are accessibility measures that incorporate spatial and temporal constraints (Geurs 2004). It analyses activities available during the day and when individuals participate in those activities (Geurs and Ritsema Van Eck, 2003).

Utility-based measures

Consider accessibility as the output of a set of different choices. It addresses the process of decision making when choosing a set of options that satisfy the same need. They can be used to model the behaviour of the traveller and the overall benefits of various travellers in a transportation system (Geurs, 2004).

2.3.3 Limits and Challenges with Traditional Accessibility Measures

The measures of accessibility, although efficient to a certain extent, are uncapable of describing more sophisticated and complex behavioural phenomena regarding opportunities - that could include the influence of strong attractors compared to different alternatives as well as, the change in attractiveness when activities are accumulated in one area (Cascetta et al., 2016).

Moreover, with that said, it is clear that such methods cannot fully embrace an evaluation of accessibility that addresses the subject in a theoretically rigorous manner, bringing along limitations and encountering a few potential challenges (Baradaran and Ramjerdi, 2001; Cascetta et al., 2016).

Within the traditional measures described, the assumption that travellers care equally about the same activities and factors is relatively common, which neglects the fact that preferences and needs can vary from one household to another (Handy and Clifton, 2000).

The great challenge that comes when trying to incorporate these qualities into an assessment of accessibility is the data proving difficult to collect and, most of the time, not readily available. This constitutes an immense obstacle to the development of more practical measures (Handy and Clifton, 2000).

2.3.4 Accessibility Indicators and Measures Correlation

Ideally, an accessibility measure should incorporate all different accessibility indicators and elements into account. However, in practice given the different challenges encountered by each measure, only a few components are considered, depending on the perspective taken (Geurs and Van Wee, 2004).

As anteriorly described, four basic perspectives on measuring accessibility were identified.

Table 2 (Geurs and van Wee, 2004) attempts to provide a correlation between these four perspectives and the accessibility indicators introduced in Section 2.2.

Table 2. Perspectives on accessibility and indicators

Measures	Indicators			
	Transport	Land-use	Temporal	Individual
Infrastructure – based	Travelling speed: vehicle hours lost in congestion		Peak-hours period: 24-h period	Trip-based stratification, e.g. home-to-work, business
Location-based	Travel time and or costs between locations of activities	Amount and spatial distribution of the demand for and/or supply of opportunities	Travel time and costs may differ e.g. between hours of the day, between days of the week, or seasons	Stratification of the population (e.g. by income, educational level)
Person-based	Travel time between locations of activities	Amount and spatial distribution of supplied opportunities	Temporal constraints for activities and time available for activities	Accessibility is analysed at individual level
Utility-based	Travel costs between locations of activities	Amount and spatial distribution of supplied opportunities	Travel time and costs may differ e.g. between hours of the day, between days of the week, or seasons	Utility is derived at the individual or homogeneous population group level

(Adapted from Geurs and van Wee, 2004)

2.4 Résumé

The concept of accessibility is used in several scientific fields as it is considered vital to transportation and regional research. Due to its extensive usage wherein different approaches are taken, ways to define it are numerous.

Even though there are different definitions for the concept, four specific indicators contribute to the understanding of accessibility measures, namely: land-use, transport, time and individuals' behaviour. Based on that, there are three different types of measures: Infrastructure-based, Activity-based and Utility-based. Within these same measures, different variations are encountered.

Although the efforts are enormous to determine accessibility in different locations as realistically as possible, the challenges and limitations are inevitable. Even though each measure should incorporate all different indicators, only a few are considered. However, there is a definite link between different measures and indicators, given their unification to one specific concept.

Chapter 3

South African Context: Access to Schools

"We say to one another: I cannot be without you, without you this South African community is an incomplete community, without one single person, without one single group, without the region or the continent, we are not the best we can be..."

-South Africa's National Development Plan

3.1 Background

The conceptualisation of access to school must be placed within South African historical, political and economic context (Fataar, 1997). The historical context establishes the nature and extent of the problem whilst the current political and economic activities instigate the increase of transport needs (Fataar, 1997; Department of Transport, 2009). Moreover, the practices carried throughout South Africa's old regime resulted in great accessibility challenges to the majority of the society, affecting with this, the transportation of scholars to and from schools (Fataar, 1997). The objective of this chapter will be to untangle such statements in an attempt to answer the following questions:

- How has the old regime impacted the spatial distribution?
- How was the country structured during the old regime?
- Which characteristics do rural areas present in South Africa?
- What is the current state of the country's (and specifically rural areas) education?
- How can the increase in accessibility to schools contribute to the country's economy and development?

3.2 The Current State of South Africa

By the end of the millennium, the world watched on as South Africa transitioned from an oppressive Apartheid regime into a democratic state, created with the intentions of treating all its citizens equally. The new party began their rule in the hopes of creating a non-racial, non-sexist society, with emphasis placed on service delivery to those previously disadvantaged. A larger portion of the previously excluded population now has access to education, water, electricity,

health care, housing and social security. In addition, the poverty rate in the country has declined and average incomes have been growing steadily (National Planning Commission, 2011).

Despite this progress, South Africa remains a highly unequal society with a great portion of the population still trapped in poverty. Specifically, the greatest challenges may lie in reaching those who live in rural areas as these communities are often located far from existing infrastructure and resources. (Vanderschuren, 2017).

According to Gwanya (2010), the underdevelopment within rural areas can be blamed mostly on the previous political system of the country. This is principally understood by the way this system structured the access to economic opportunities and governmental services. It is, therefore, important to develop an understanding on how the urban planning of the "ancient" South Africa was put in place and how such structuring influenced accessibility within different areas. The next section of this chapter will deal with this matter.

3.3 Apartheid: Spatial Legacy

The concept of *Apartheid*, translating 'apartness' or 'separateness' in the Afrikaans and Dutch languages, refers to a legal system intentionally instituted to unequally separate the population based on race embedded in all spheres of social life (i.e. location of residence, education, workplace, etc.) (Badat Saleem, 2011; Clark and Worger, 2016). This policy was first introduced in South Africa in 1948 and comprised of multiple objectives, including (Charman et al., 2017):

- Enabling maximum political control by the state;
- Preventing the trespassing of township dwellers in adjacent land; and
- Fostering access to labour markets and independent businesses.

In order to accomplish such objectives, the policy had to put in place a spatial framework that would effectively allow this separateness. Moreover, specific characteristics of this policy should be considered.

3.3.1 The Characteristics of Apartheid

As McKendrick (1990) describes, the apartheid system enforced a separate development legacy in a systematic and barbaric manner that aimed to build an exceptional capitalist economy for only a few, by providing services for the 'fortunate minority' and disregarding the 'disadvantaged

majority' (Molefe, 1996; Gwanya, 2010). This system imposed the dispossession of assets from the black majority and simultaneously restricted the access to markets, infrastructure and education (Carter and May, 1999).

The apartheid system established a geographic differentiation within South Africa, constituting three types of spaces that embodied its own political, social and economic systems: urban areas, areas for commercial farming and homelands (i.e. small towns) (Gwanya, 2010).

Even though the system has now been abolished, it still continues to dominate the landscape by limiting social and economic mobility, as well as compacting socio-political interests, which prevent the vast majority's access to life opportunities (National Planning Commission, 2011). Consequently, inequality within rural regions has not yet been overcome or translated to differing class interests and the legacy of underdevelopment and poverty still prevails within these regions (Carter and May, 1999; Gwanya, 2010).

According to the National Planning Commission (2011), the key to the various challenges within the country require a step toward change in performance, and not only a single undifferentiated anti-poverty strategy to break the dynamic (Carter and May, 1999). Before establishing measures to counteract what remains of the legacy, it is important to understand the nature in which cities were build. Section 3.3.2 will, therefore, attempt to describe the structure and development during this epoch.

3.3.2 Structure of Cities during Apartheid and Evolution

It is no surprise that the apartheid city was the ultimate paradigm for urban exclusion and division (Pieterse, 2009). By boosting the segregation, fragmentation and splintering of different racial groups, intra-urban inequalities have been intensified (Graham and Marvin, 2001 in Pieterse, 2009). There is a substantial amount of literature that documents the spatial planning of the Apartheid regime (Berrisford, 2011). Within the periphery townships were established, which were often close to industrial centres and located significantly far from white neighbourhoods as well as central business districts (CBD), and therefore instigating strictly controlled access to land (Charman et al., 2017).

In order to sharpen the spatial divisive effects and reinforce boundaries of demarcation, railway-lines, bounded roads and highways were used, together with natural geographical features (i.e.

rivers, rock outcrops, ravines, etc.) or strips of undeveloped land (Charman et al., 2017). Using this concept, the cityscape was broken into neighbourhoods serviced only by a few transport corridors between urban areas, which allowed a limited and controlled mobility of the population (Charman et al., 2017).

Given such conditions, a radial design within cities was established. Figure 6 (page 40) illustrates this design and separations previously described.

This type of design resulted in a phenomenon resembling the North American profile, designated ‘edge city’ (Garreau 1991; Beauregard 1995). Furthermore, when looking at the contemporary challenges of this choice of design, it is clear that there is still a debilitation in local mobility and pedestrian travel, due to the insufficient transport corridors, specifically in intra-city access outside the CBD (Czeglédy, 2004).

Therefore, it is unquestionably clear that this regulating land tenure has had a severe impact in the creation of the contemporary problems South Africa is now facing. One approach that was taken to counteract such issues involved a reorganisation of the spatial reference frames based on statistical compilation methods (Vacchiani-Marcuzzo and Giraut, 2009). South Africa, consisting of nine provinces, essentially formed municipalities that - through exhaustive territorial grids - would associate the former homelands and non-municipalised spaces with other areas. Moreover, these municipalities were the basis to degenerate the placement during apartheid (Vacchiani-Marcuzzo and Giraut, 2009).

Figure 7 (page 41) demonstrates the spatial transition from the apartheid to the post-apartheid era.

When looking at the apartheid city layout, discontinuities through buffer zones can be seen between townships and Central Business Districts (CBDs). One of the great differences in the administrative criterion between the old and the current regime is that during the apartheid era South African municipalities covered solely urban agglomerations whereas the new municipal system extends far beyond the urban peripheries of metropolitan areas (Vacchiani-Marcuzzo and Giraut, 2009).

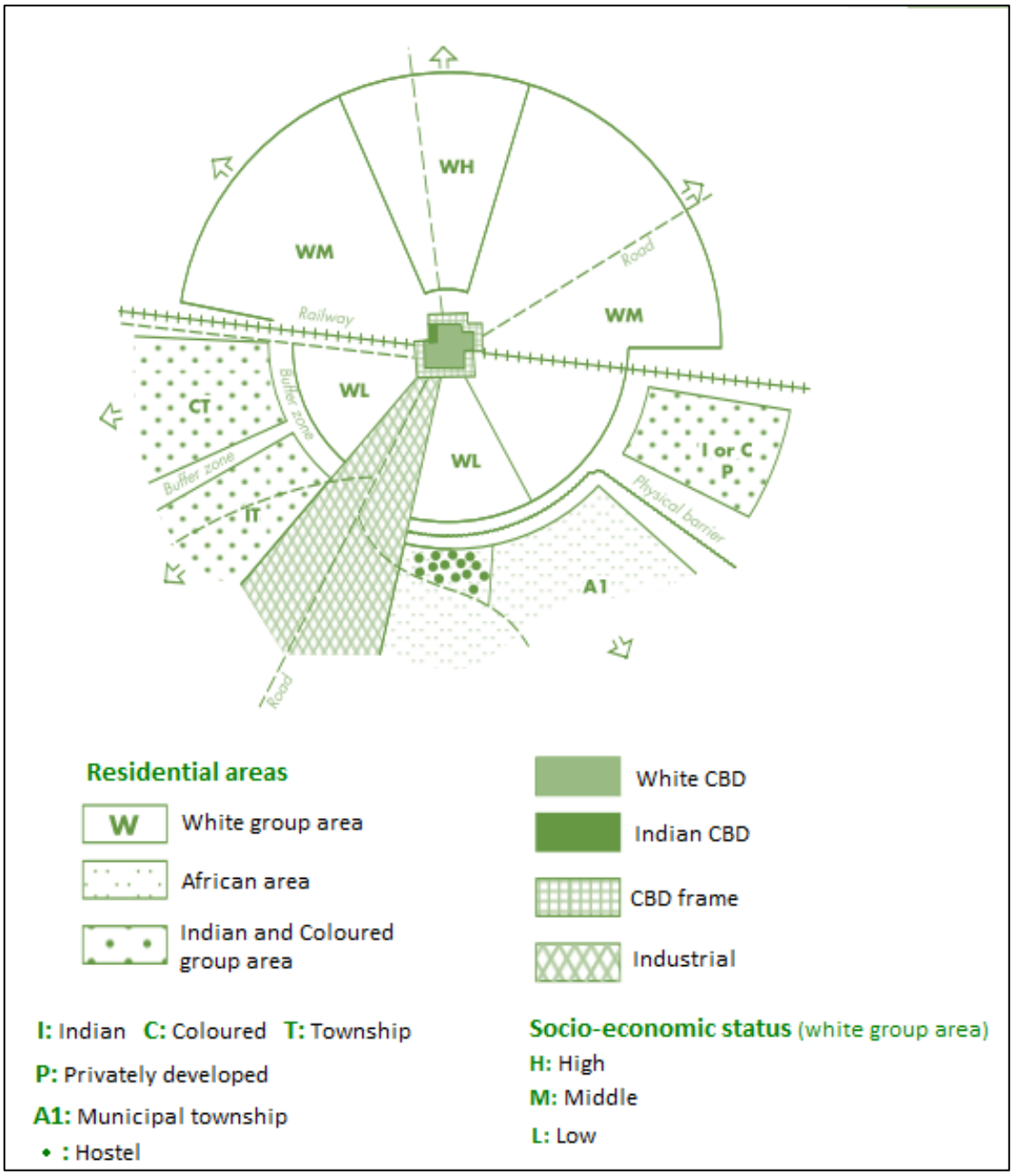


Figure 6. Spatial Planning and Structure of Apartheid

(Adapted from Davis,1981)

Although the efforts to reorganise the structure of the country are acknowledged, in an attempt to correct the segregation developed by buffer zones (see Figure 7), morphological discontinuities were generated within the urban areas, raising with this the issues around the nature of isolated (but still dependent) urban agglomerations. Due to this fact, concentrations of the population are

only found in certain areas, wherein neither attractive urban concentrations nor availability of services are found (Vacchiani-Marcuzzo and Giraut, 2009).

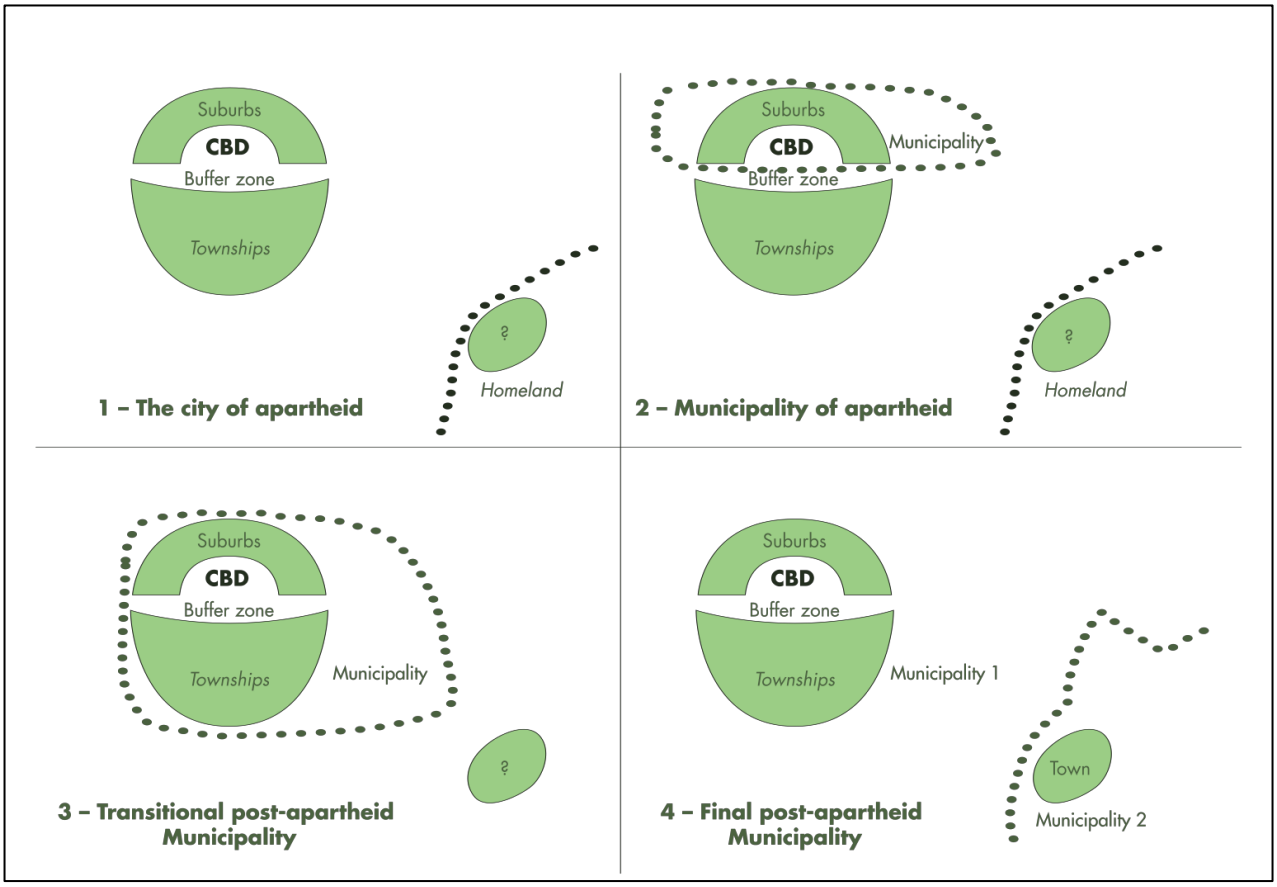


Figure 7. Succession of Municipal Systems from Apartheid
(Giraut, 2005)

Within this light, it is clear that the urbanisation of South Africa is a special and unique challenge. These discontinuities discussed are evidence of the lack of services and facilities within non-urban areas. Arguably, through urban decentralization the integration of urban transportation options may be the key to the development and unification of the country (Czeglédy, 2004). Therefore, *Section 3.4* will discuss the issues of transportation and access within the most disadvantaged communities (during and after apartheid).

3.4 South African Rural Areas – An Issue of Access

Within developing countries, rural areas are normally distinguished by their low access to facilities compared to large towns and other urban conurbations (Fataar, 1997). This leads to stagnated or

declining economic activities level within these areas resulting from the poor accessibility, relatively long distances, difficulties in logistics, low population densities and lack of scale of economies. In this context, South Africa is no exception (Molefe, 1996; Fataar, 1997).

Although recognised as an upper-middle income country, the legacy of apartheid has contributed to many of the contemporary issues and challenges faced (Carter and May, 1999). Evidence can be found in the number of people currently placed in areas critically inaccessible and consequently, living in poverty (Department of Transport, 2009). Therefore, the reconstruction and development of the country is tied in with social inclusion and shared prosperity (Gwanya, 2010). Before looking at solutions to contemporary problems, it is important to understand the current challenges faced by South African rural areas. These include the unsustainable use of natural resources, lack of access to socio-economic activities, lack of access to basic services (i.e. water), as well as difficulties in the development of agriculture, low literacy and skills, issues in land tenure, restitution and others (Gwanya, 2010).

Having said that, it is clear that the poverty facing rural areas in South Africa is due to the way the old regime framed the access to services and opportunities (Gwanya, 2010). According to J. Farrington and C. Farrington (2005), accessibility is the principal factor that determines the rural reality. It aids in demystifying different types of regions and interpreting different experiences within various social groups.

The issues faced by developing communities in South African rural areas are legitimate and substantial. The absence of efficient access to services leaves communities with limitations to participate in the mainstream economy, accentuating their isolation. If measures are not put in place radically, South Africa will continue to socio-economically deprive individuals (Mahapa and Mashiri, 2001).

Notwithstanding the great efforts to diminish discrepancies caused by apartheid, registered gaps continue to grow between rural and urban people. Within the various activities influenced by transport conditions and accessibility, schooling is essential as it shapes rural people's quality of life, both in the present and future (Vasconcellos, 1997). It is taking this statement to heart that the next section follows. Therein, discussions around South Africa's education system and challenges are made, as well as the description of the state of education within the country's rural areas.

3.5 Education System in South Africa

Throughout this chapter it has been made evident that the inequality left by apartheid is unquestionable. What is interesting to consider is that this same inequality has been greatly enduring in education (van der Berg, 2007). The human capital differentials have been described as "*apartheid's footprints in the sand of poverty and inequality"* (Simkins, 1998 in van der Berg, 2007). In addition, education variations contribute to the differential in earnings that are usually referenced as labour market discrimination (van der Berg, 2007).

Naturally, education is essential for the long run development of human resources, aggrandising the economy and democratising the state and, most importantly, to meet basic human needs (Badat Saleem, 2011). Nonetheless, the inherent patterns from the old regime of disadvantage and advantage continue to shape and condition the capabilities and capacities of institutions (Badat Saleem, 2011).

The racially segregated schools during the old regime, wherein under-resourcing of black schools was eminent, still contribute to the imbalance in white and black levels of education (van der Berg, 2007). Fleisch (2008) described the South African education system as '*a crisis*', as it is essentially dysfunctional (Letseka, 2014). Firstly, the apartheid ideology attributed education institutions to different racial groups based on economic and social functions of each that would give prevalence to the regime order. These fundamental differences constituted the principal basis of inequalities (Badat Saleem, 2011).

In spite of the fact that measures have been implemented to counteract such conditions - founded in the principles of non-racism, non-sexism, redress and equity, poor teaching and learning make it inevitable that such measures will still take long to be realised. These conditions are specifically accentuated in various historically disadvantaged schools, and constitute the majority of the rural areas education (Gordon and Qiang, 2000). Under those circumstances the nature to understand and investigate such conditions in rural areas arises. This will receive special attention in the next section.

3.5.1 Current State of Education in South African Rural Areas

In South Africa, about 15.9 million people still live in poverty wherein 69% are located in rural areas (National Treasury, 2011). Within these areas, education is still differentiated by the low

enrolment, high dropout rates, unequal gender distribution, low qualified teachers and limited resources (Gordon and Qiang, 2000). The young democracy in the country underlines many of the challenges experienced in these locations (Hlalele, 2012).

The shape of education in rural areas has been in line with the political and economic goals of colonialism and thereafter apartheid, wherein policies of dispossession, systematic exclusion from opportunities and resettlement were implemented (Hlalele, 2012). Preceding the creation of the *South African Schools Act,* rural areas were solely serviced by former homeland schools. Despite the fact that schools in farms and tribal trust lands presented a number of similar features (i.e. isolation, infra-structural constraints and high levels of poverty), the framing policies presented substantial differences between the two (Gordon and Qiang, 2000). It is therefore clear that apart from the issues that face rural schools worldwide, the deprivation of schooling during the apartheid system has caused great repercussions, creating a complex and unique challenge country wide (Paxton, 2015).

Furthermore, the Ministry of Education (2005) argues that the problems being experienced in rural South African areas are widespread through various degrees in previously disadvantaged communities (Hlalele, 2012). In fact, given the lack of opportunities that parents of scholars must have experienced, the illiteracy within these areas negatively impacts the development of schools, as sourcing of teachers become a rather difficult task (du Plessis, 2014).

Apart from the issues stated, other features that highlight the disadvantages pertaining to these areas include: long distances to towns, lack of or inoperable conditions of roads and bridges leading to schools, limited access to Information Communications Technologies (ICTs), lack of educational facilities relative to demand, detrimental economic status, food security, as well as insufficient access to lifelong learning opportunities (Hlalele, 2012). Additionally, other aspects that contribute to the lack of education in these areas relate to the inadequate infrastructure, lack of professional help and learning materials, lack of qualified teachers, unreasonable ratio of teachers and learners besides the prioritisation of domestic chores versus school attendance, the limit of social and economic opportunities, low salaries, working conditions, cost of education, etc. (Hlalele, 2012; du Plessis, 2014).

According to Sauvageot and da Graca (2007) the educational development has been held back mainly by poverty, hunger and underdevelopment. Moreover, the issue of access to schools is

greatly accentuated and, as a consequence, need further intervention. The Ministerial Committee on Rural Education (MCRE) acknowledges the disadvantages verified in schools of rural communities and indicates the obligation to address such issues in order to achieve social justice (Hlalele, 2012).

It is evident that the education system within rural areas is suffering a great deal of disturbances that impede its well-functioning. These disturbances may constitute as one of the underlying obstacles in furthering economic growth and development of the country. Taking the contents of this section into consideration and the number of challenges faced by the South African education system, the study of the importance of education and accessibility is discussed in the next chapter.

3.6 Résumé

To understand the concept of access to school within a country, the historical, political and economic backgrounds must be investigated. The historical context provides information on the nature of the problem, while the current economic and political activities determine the demands for transportation.

When specifically looking at South Africa and its unique history through the apartheid regime, it is clear that accessibility challenges to the majority of its society were (and still are) encountered, including the transportation to and from schools, especially in rural areas. This issue is directly linked to the underdevelopment within these areas, which can also be blamed towards that same system's structure. Therefore, understanding the old urban planning is crucial when conducting studies for this country.

Given the geographic differentiations imposed before 1994, the country now requires reparative performance - not only in a single but a multifaceted anti-poverty strategy in order to overcome the ramifications observed post-Apartheid.

Chapter 4

Accessibility and Education

"Knowledge is power. Information is liberating.
Education is the premise of progress, in every society, in every family."
Kofi Annan

To date, literature centred in accessibility has continuously demonstrated the interest within academics in the realm of looking at differential access to numerous types of services and facilities. Interestingly, scant research has been devoted to investigate the relationship between accessibility and schools (Talen, 2001). This chapter serves to provide a linkage between these two concepts, attempting to finally school some light on the concept of education, the influence of access and its possible consequences when the lack of it is encountered (i.e. social exclusion).

It is in this realm that this chapter will begin to describe the greatest challenges in education within the society. Furthermore, the challenges of access to education will be described and finally social exclusion will be tied up and reviewed with regard to these two concepts.

4.1 The Concept of Education and its Importance in Developing Countries

It is undeniable that education is a right for all children, as well as an important investment sector. The latter is justified by the prospects it can give to alleviate poverty and transform these disadvantages into prosperity, giving people the specific skills they need (CGD, 2002). In addition, it constitutes the basis for health, stability and peace in the world (JICA, 2002). Other advantages of education include the aid in developing an individual's personality by revealing ancestors' wisdom, norms and values - besides promoting learning strategies for modern science, technology and environmental conservation (JICA, 2002).

Based on information collected by various economists and researchers, education increases workers' productivity and subsequently, their incomes. This forms the base of evidences that contribute to the affirmation that education can, in turn, lead to a decrease in poverty (Damon et

al., 2016). Apart from the societal benefits associated with poverty alleviation, a fast growing set of literature has established the capital impact education has in a great range of personal activities and decisions (Lochner, 2011). As such, a fast paced growing set of work suggests that education can affect personal and social outcomes, such as criminal behaviour, quality of life, mortality and democratic participation - offering with this, a wide range of benefits far beyond the labour market productivity (Lochner, 2011). This shows that education contributes, at a country level, to the increase in economic growth (Hanushek and Woessmann, 2015).

Therefore, it is evident that investments in skills and human capital through the expansion and improvement of education are crucial. This is specifically more important in developing countries, where the need to move towards the path for development is clear (Damon et al., 2016). Although increase in funding for education has been taking place in developing countries, such investments focus primarily in the building and staffing of schools, without looking at other aspects that may contribute to students' attendance and enrolment (Glewwe et al., 2011).

Moreover, when taking a closer look at factors that can contribute to the educational enhancement of a community, a great set of evidence shows that distance to schools, the reduction in school fees, improvement in the quality of education opportunities and other direct and indirect costs of schooling have a non-negligible impact in the enrolment and attendance of learners in schools (Glewwe et al., 2011).

Interestingly, many of the factors described above are directly linked with the concept of accessibility. It is within this light that the need to further understand the many facets that access to schools presents emerges. Taking this into consideration, the next section of this chapter will attempt to further unravel the topic in order to comprehend the impact and the greatest challenges faced by access to education within the development of communities.

4.2 Role of Access to Education in the Development of a Country

The importance of access to schools is undeniable when looking at its profound centrality within the social, political and economic aspects. The dramatic effect that rises within the spatial interaction between home, school and the community is far from inconsequential (Talen, 2001). Nutley (1984) and Barwell et al. (1985) argue that transportation and infrastructure are essential

for the acquisition of basic needs. Vasconcellos (1997) goes one step further and specifically denotes that the access to schools contributes to the accessibility of services.

In general, physical accessibility is seen as a key component to quality of life when looking at an intra-urban level (Pacione, 1989). The significance of accessibility stems from its role in the population's welfare, since the spatial structure of cities is a contributor to the redistribution of real income based on the hidden effect of differential accessibility (Pacione, 1989).

The issue in many developing countries, and specifically in rural areas, is normally associated with supply constraints. When looking at the access to schools, Vuri (2010) concludes that the difficulties associated with it in terms of long distance to the closest school or the elevated traveling costs are non-negligible. In addition, the direct (tuition fees, traveling times) and indirect (opportunity costs – i.e. time spent in school instead of other activities) schooling costs may contribute to the reason why attendance of children to schools in many developing countries is challenged (Vuri, 2010). For example, in most rural areas the costs of transportation to school are far beyond other expenditures, including the cost of food (Rural Challenge Policy Program, 1999b in Talen, 2001). It is within this context that the importance to commit to such discussions should be considered.

Moreover, when looking at the current challenges of modern society as well as the necessity to acquire sophisticated knowledge, it is important that schools reach an ampler range of students (Darling-Hammond, 2003). Talen (2001) identifies three important reasons for the study of school accessibility, namely:

- The degree of inequity between children residing in different areas;
- The implications in terms of social equity; and
- The potential student performance depending on it.

Taking the abovementioned into consideration, it is no surprise that social, political and economic problems may yield from the limited access to education. Consequently, if the progress of access to education stagnates or fails, the economic growth and prosperity in developing countries will be bound to end. This could implicate a greater gap between the rich and the poor in increasing worldwide inequality, and with that, culminating global despair (Weisbrot et al., 2001).

One way to start diving into further details is to understand the effect that schools or educational institutions have in communities, specifically rural ones – since disadvantages are mostly encountered in these areas.

4.2.1 Schools and the Community

The relationship between schools and their surrounding neighbourhood or community is of vital importance. Above their instrumental objectives, schools encompass communal identity and religion (Talen, 2001). Within the rural communities, schools are the primary civic institution, a 'natural repository of sacred involvement' as referred to by Janowitz and Suttles (1978). Nonetheless, education must not only be valued by the community and people but as a public justice, it should be advanced and preserved. As a matter of fact, the act of introducing education is an empowering process as it is at the heart of enhancing the natural capabilities of individuals within whole societies (Hlanze and Mkhabela, 1998).

Consequently, schools' proximity to the community present a paramount role. The highlight within school accessibility surges when this emphasis of schools as places of specific and intensive social meaning is made. Naturally, access to schools comes along when debates of the central purpose of schools emerges (Talen, 2001). Given its unique history and sharp separations between different neighbourhoods, South Africa presents a great setting to understand such interconnections, especially when comparing rural and urban communities (Zoch, 2017).

According to the Department of Transport (2009), there is a great set of challenges facing scholars that urge for a speedy response. Scholars residing in rural areas normally face a great set of barriers to accessing schools. Such include: distances to schools and back, unsafe roads, costly transport and other issues regarding security. Understanding the greatest challenges for those rural communities is the first step to the alleviation of issues that revolve around them. Section 4.2.2 focuses in determining the greatest challenges facing the rural sector when looking at education.

4.2.2 Challenges of Education in the Rural Sector

Within rural communities the lack of accessible education leads to penalties that go far beyond the cost of inconvenience of travel (Pacione, 1989). More disadvantaged groups are vulnerable to spatial disparities and other economic concerns within the field of education (Pennington et al., 2006). Additionally, a geographical dispersion that may occur within a small population may result

in negative connotations, as the social characteristics that arise between communities and schools may be broken when distances between schools and its learners become abnormally high (i.e. as much as 10 km) (Pennington et al., 2006; Holloway and Jöns, 2012).

Such distances to schools demonstrate the scarcity of educational institutions within these areas. Therefore, when looking at the ratio between teacher versus learner, the geographical and demographical limitations of rural areas may contribute to the difficulty in recruiting skilled and specialised school staff (Burde and Linden, 2011). Apart from these limitations, previous studies have demonstrated that aspects related to individual's qualities (i.e. age, gender, parity), the household parental education level, socio-economic status, environment, linguistic barriers and transportation, can all account to lower student enrolment and attendance (Williams and Wang, 2014; Huisman and Smits, 2015).

These are some of the challenges that manifest when looking at the development of education in the rural sector, the greatest one of them all being the social disparity and exclusion from the rest of society when the objectives of education are not well met. The difficulty in translating an individual from rural communities to acquire the same education as urban citizens, when costs, safety, transportation, security issues are faced, is clear. Moreover, potential outcomes of such disparity lead to low skilled workforces, high poverty, lower student opportunities, disconnections between schools and communities and an elevated number of dropouts to early workforce entry (Williams, 2012). This constitutes the basis for the next section.

4.2.2.1 Equity Concerns: Right to Education and to be Transported

In modern society, exclusion from the participation of political, economic, social and cultural life is one of the greatest concerns (UNESCO, 2005). The levels of exclusion in cities can, to a large extent, be reproduced by inequalities within transport-related infrastructure and services (Manderscheid, 2009). Due to the geographical isolation faced by rural areas in developing countries, severe accessibility constraints and low supply of transport occurs, causing a depression in their economic development (Vasconcellos, 1997). The prevailed unequal and low access levels within different social groups show the importance attached to equity (Nutley, 1984). In large part, accessibility is an indicator to the value of an area, as it can reveal the intensity of development as

well as the number of economic and social activities that can take place (Wachs and Kumagai, 1973).

Therefore, the notion of equity comes in handy with the concept of accessibility. The linkage between those two aspects are the primordial blocks to evaluate the spatial pattern or distribution of public services, including education institutions (Talen, 2001). It is in this light that the importance to determine the distribution of levels of accessibility takes a stand. In low income areas, the socially vulnerable populations are forced to withstand negative effects as previously described (Guzman et al., 2017).

Notwithstanding, due to the fact that higher accessibility level locations are cheaper to service, investments tend to be made in the most favoured places, thereby increasing the discrepancies between high and low access groups (Nutley, 1984). Sadly, although many authors advocate in favour of acknowledging transport accessibility as a right, specifically in developing countries where the gap is significantly bigger, political constraints and economic grounds make this suggestion inadmissible (Button, 1982).

4.3 Résumé

There is a lack of research devoted to investigating the relationship between accessibility and schools. Within this subject it is important to understand the concept of education, the influence of access and the possible consequences when there is lack of it thereof.

Education is a civil right to all children and an important investment sector, as it contributes to the alleviation of poverty and increase in people with higher skills. Factors that contribute to the educational enhancement of a community include: distance to schools, reduction of school fees, and increase in quality of education opportunities. These factors are greatly related to accessibility.

In rural areas, the spatial interaction between home and school extend to the realm of communal identity and religion. They are the primary civic institution and a ‘natural repository of sacred involvement’. However, in these areas the geographical dispersion that may occur result in great traveling distances breaking these social characteristics.

Moreover, the scarcity of such institutions in those areas can be the result of these extensive traveling distances and may result in a low teacher versus learner ratio. These are some of the

challenges of the development of education in the rural sector, the greatest one being social exclusion and disparity compared to the rest of society.

Chapter 5

Methodology

"We must revisit the idea that science is a methodology and not an ontology. "

Deepak Chopra

5.1 Background

From the literature reviewed in this thesis it can be analytically concluded that accessibility within transportation research is an imperative component in deciphering the many transport challenges faced by modern society.

Accessibility in itself is an important evaluation criterion when measuring the spatial separation of human activities. It has the ability to generate solutions and influence infrastructure development planning by pinpointing areas or population groups currently underprovided (Morris et al., 1979).

The need for further academic research into the application of this concept in the context of South Africa and its distinguishable layout is, therefore, clear and essentially urgent for spatial interventions and the development of the country.

This chapter will describe and discuss the procedures that encompass the methodology undertaken in the preparation of this dissertation. It will start with a broad overview of the research approach carried throughout, and thereafter detail the specific processes comprised within the method.

5.2 Research Approach

It has been the academic conclusion thus far that the estimation of physical access remains inaccurate in various developing countries, as conventional methods are rarely appropriate (Tanser et al., 2006). Notwithstanding, when addressing issues relevant to rural areas - apart from the

typical social and economic factors - distance-related obstacles (especially to schooling) are often disregarded (Vasconcellos, 1997).

Such distance-related issues are directly related to the concept and analysis of accessibility (both temporal and spatial), along with the problems of welfare and social inequalities in the access of public services (Vasconcellos, 1997). Moreover, socially vulnerable groups and low-income populations are normally the ones forced to experience negative effects, such as poor quality transport, extended traveling times and greater exposure to pollution and traffic accident risks (Titheridge, 2014; Guzman et al., 2017).

It is within this basis - looking at both socially disadvantaged groups and the limited access to education - that the methodology carried out for this investigation was developed. In this scope the approach chosen looks at different accessibility aspects, entangling them with both the conceptual framework and theory behind the study. This section aims to describe such processes.

5.2.1 Conceptual framework and theoretical underpinning

Building on the consolidated review of accessibility measurements described in Chapter 2, it can be understood that any typical measure involves two indispensable parts, namely: the transport element and the activity element. As described earlier, the transport element is normally associated with the level of impedance or difficulty of travel experienced, and the activity element is concerned with the opportunities that are available within the area of interest.

It is, therefore, no surprise that the methodology being carried out in this research will comprise of the two main elements known to be influential to any accessibility measurement. *Figure 8* illustrates the research framework.

The zone attractiveness will focus on the type of attractiveness being undertaken in this investigation (i.e. educational activities or school coverage) and the impedance will look at the monetary (associated with the level of affordability individuals have for the mode of transport utilised) and generalised travel costs (time and distance to reach destination from origin).

Ultimately, the wrong combination of these indicators could lead to detrimental transportation conditions and therefore, result in low accessibility levels. In fact, results obtained throughout this research could point out most disadvantaged and underprivileged areas and, in that way, underline social and spatial inequalities consequential of the distribution of accessibility to schools.

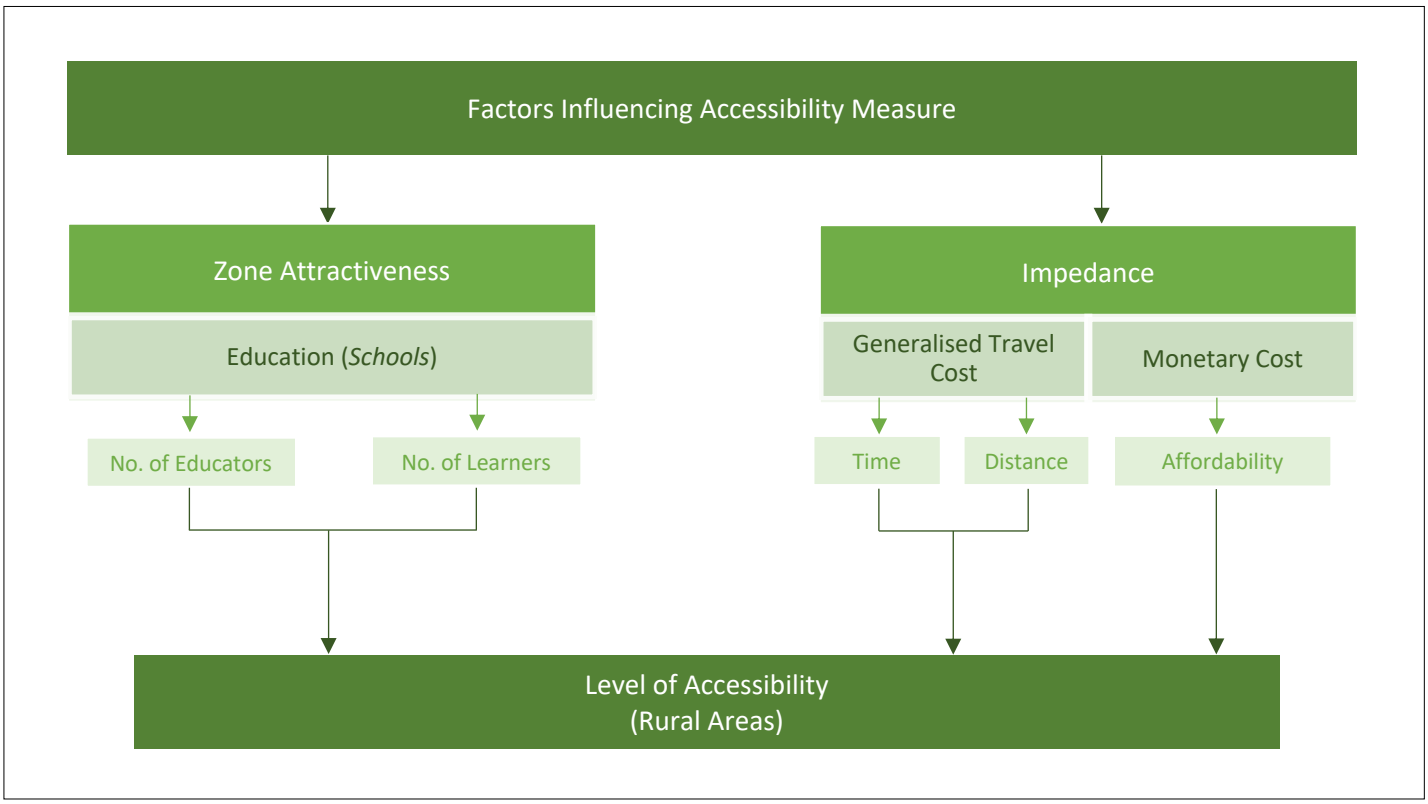


Figure 8. Conceptual Framework

5.3 Research Process

Before jumping ahead to the research process carried out in this study, it is important to understand all subjectivities that the 'research process' itself carries out.

According to Parahoo (2014), a research process entails a series of tasks and actions from a project's inception to its conclusion, in order to propose a way to adequately answer the research question. It includes the thinking process, assumptions incorporated and the theoretical background established during the process.

Different research projects require different types of research design, depending on the nature of the problems posed by each project (Walliman, 2011).

There are three interrelated activities normally segmented within the process, namely (Denzin and Lincoln, 1994): articulation of researchers' personal viewpoint, decisions and strategies of enquiry within the theoretical perspective and data collection and analysis decisions.

In general, there are four chronological phases normally carried out during a research process (Parahoo, 2014):

- Identification of the research question;
- Collection of relevant data;
- Analysis of collected data; and
- Dissemination of findings.

Structured using the same principle, the research process for this thesis is shown in *Figure 9*. The layout within this section will present discussions following this same structure.

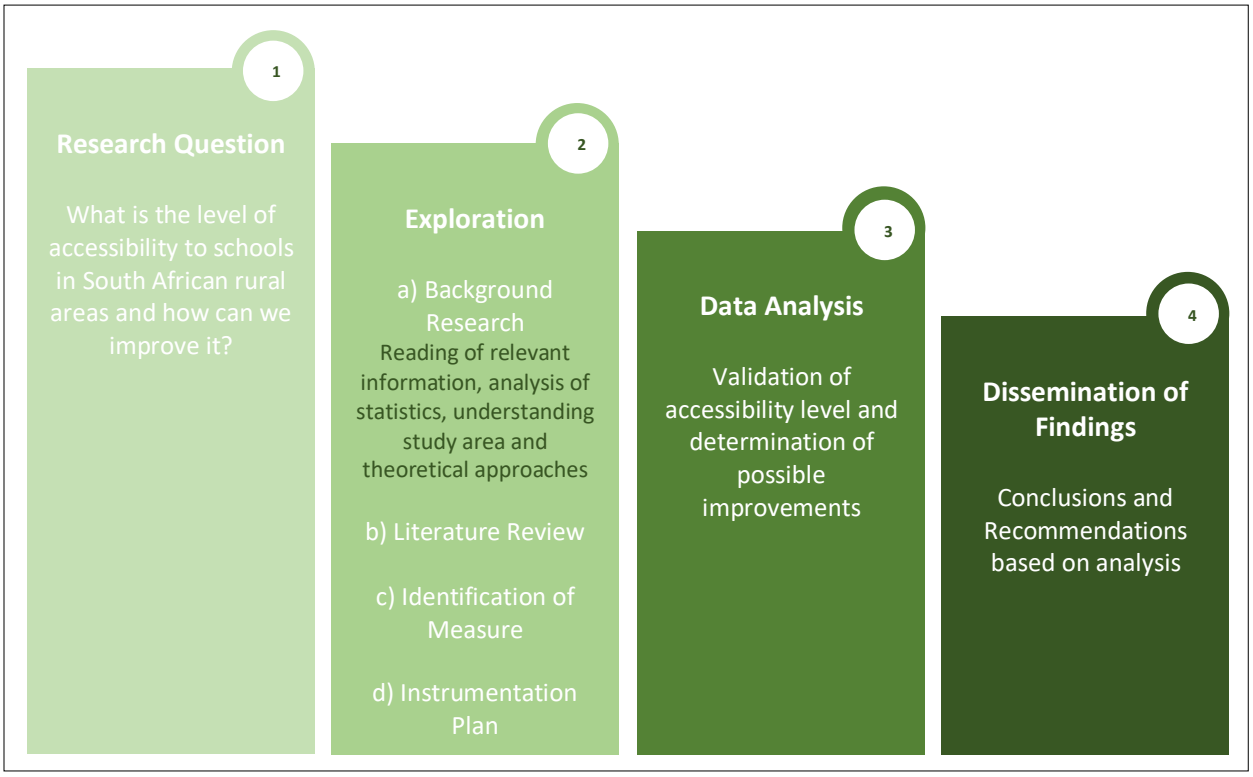


Figure 9. Research Process Structure

5.3.1 Formulation of the Research Question

The principal research question that underlies this study attempting to resolve fundamental societal challenges is as follows:

"What is the level of accessibility to schools in South African rural areas?"

5.3.2 Exploration and Data Acquisition

Having established the fundamental question that motivated the research, the data acquisition process could be carried out. This process involved segmenting data to provide a holistic view of accessibility itself and identifying the correct procedure to follow in order to answer the principal question.

As such, it included:

- Background research to provide a scope of the influence of accessibility within a society, the inequity issues that can arise when low levels of accessibility are encountered and to provide information pertaining to both South Africa's current and previous states regarding transportation and accessibility;
- An exhaustive literature review of the existing work on the concept of accessibility, incorporating the definition and identification of different indicators and measures available;
- Identification of the most appropriate measure to determine the index of accessibility; and
- An instrumentation plan wherein the appropriate sources of information and tools are identified to provide a resolution to the research question.

Taking into consideration that both the background and literature review data have already been presented in the preceding sections of this report, the following section shall limit itself to the elaboration of the approaches to measure chosen, together with the instrumentation plan developed.

5.3.3 Approaches to Measure Spatial and Qualitative Accessibility

Given the vast literature reviewed in this study it is evident that regional disparities within South Africa and the provision of Education Services is of concern. Understanding that low-income population in rural areas are the most socially excluded, the approaches chosen for this analysis will predominantly revolve around this specific disadvantaged group. Moreover, apart from the availability of schools in the area, the actual service delivery and performance is important to the measure, as it also contributes to greater inequalities. In this light two different approaches were used to analyse accessibility, one focusing on the potential accessibility and the other focusing on the real accessibility.

Based on the different measures reviewed and the resources available to the author, the gravity measure was established as the most appropriate to calculate the potential accessibility. This method is frequently used in geography and urban planning to analyse spatial interactions through the inclusion of distance decay effects, accounting for both the service agglomerations and the proximity to population, through travel costs. It is, generally, expressed by *Equation 3* (previously shown in Chapter 2):

$$A_i = \sum_j a_j \, d_{ij}^{-b}$$

Where:

A_i = accessibility of the zone i

d_{ij}= distance between zones *i* and *j*

a_j = attractiveness or size of facilities in j

b = gravity decay coefficient

Looking at *Equation 3,* data requirements include the attractions' size and location as well as the distance between zones in the study area. Although the attractions element within the gravity measure normally only reflects the number of activities within a zone, given the nature of the study, as well as the available resources for each school, it was decided that the quality of education should also constitute part of the attractiveness of each school. Therefore, the measure of attractiveness of each school was calculated using the following ratio:

Equation 6. Attractiveness

$$a_j = \frac{No.of\ Educators}{No.of\ Learners}$$

Furthermore, it was important to determine the value of the gravity decay coefficient (***b***) - often called travel friction - as it describes the difficulty of travel based on the costs. However, the complexity associated with the calculation of this coefficient is undeniable, as it might take a series of mathematical forms (Guagliardo, 2004). Therefore, based on Martin and McGuckin (1998) a value of **1.285** was assumed for this coefficient, as it is the recommended standard for home-based trips.

As a result, within this measure the higher the values of A_i the closer and more attractive the facilities are (LaMondia et al., 2010).

The second approach for this study involved determining real accessibility within the study area. The aim of this second approach is to comprehend the discrepancies, if any, between the potential accessibility of the area versus the accessibility being experienced. This posed the greatest challenge within this research, as the resources and surveys available to the author were highly limited.

It is based on this reason that the focal area for the calculation of the accessibility index was chosen to be the Cape Winelands District, although the whole of South Africa is considered the basis of this study. What was then decided was to first use the resources available to process the indicators of accessibility to schools within the context of rural areas at a national level and then embark on the calculations of accessibility levels using approach 1 and 2 for the focused area.

5.3.4 Instrumentation Plan

The instrumentation plan carried out within this research consisted of three main phases, namely:

- Research tool identification;
- Collection of data; and
- Processing of data.

These phases will be thoroughly described within this section.

5.3.4.1 Research Tool Identification

The identification of adequate tools required to successfully answer a research question is essential to the development of this, and all, dissertations. Consequently, a number of factors were considered when selecting the appropriate tools for the analysis and measurement of accessibility to schools within rural areas.

One of the greatest objectives of this research was to identify areas, if any, wherein access to schools is restricted or low in South Africa. Therefore, it was imperative to utilise a tool with the ability to integrate geographically referenced data and illustrate relationships and trends over space and time. Equally important to the choice of tool was its accessibility and availability, as the author's resources were limited.

Following a process of exploration possibility and elimination thereafter, ArcGIS was identified as the most suitable software program as it allows planners to manage and analyse data in a variety of land use and transportation characteristics - contributing to neighbourhood accessibility (Handy and Clifton, 2000). The capabilities of ArcGIS are further reviewed in the next section of this dissertation.

5.3.4.2 ArcGIS Capabilities in Accessibility Analysis

The collection, manipulation and analysis of spatial and non-spatial data is an integral part of accessibility analysis. Geographic Information Systems (GIS) are computer-based systems that are acknowledged as a key to the integration and analysis of spatial data that can generate extensive database relationships (Jamtsho and Corner, 2014)

GIS software enables the efficient ease of capturing, storage, update, manipulation, analysis and display of various geographic referenced information, as well as the rapid comparison of data from different populations. The implementation of these systems in data analysis allows consistency when perceiving the data. Other relevant benefits of these types of systems include the facilitation of geo-referenced data usage and thus enabling connections of results and other inputs in the decision-making process. Such platforms enable policy makers and researchers to represent data and aid in their interpretation (Jamtsho and Corner, 2014).

ArcGIS is an integrated collection of GIS software developed by the Environmental Systems Research Institute (ESRI), which allows users to author, map, analyse, share, manage and publish geographic information (Turkienicz et al., 2008). It being a GIS system with both spatial and network analysis functions, as well as the ability to map values and link them to georeferenced socioeconomic and infrastructure data, the software's popularity within the transportation planning field is evident (Liu and Zhu, 2004).

It is in this realm that this software provides mechanisms to integrate and present databases that embody numerous variables besides investigating statistical relationships. Taking into consideration the different indicators that can allow for the evaluation and measurement of accessibility, this spatial analysis tool can be valuable to produce and identify relationships amongst them, as well as to present results through analysis in a visually appealing form through high-impact maps (Nykiforuk, 2008).

This system is comprised by three core components: *ArcCatalog* (used to browse, explore and manage maps and spatial data), *ArcMap* (used to visualize spatial data, perform spatial analysis and create maps) and *Arc Toolbox* (interface to access data conversion and analytics) (Schneider, et al., 2012).

Based on ESRI (2005), the following are the main capabilities of the software:

Spatial Analysis – ability to produce computational analysis of geographic patterns.

Contents – presents different base maps pertaining to an interactive digital atlas.

Real-Time GIS – sensor data can be merged with spatial data to form an interactive map for real time decision making.

Geo-design – design of geographic information that closely follow natural systems.

Data Management – inbuilt functionality that facilitates efficient and intuitive data management.

When looking at currently available GIS-based techniques that allow the measuring of accessibility, the options are numerous. Such techniques include: ratio of provider-to-population, calculation of distance to closest provider, computation of travel time average to provider, gravity-based, two step floating catchments area, kernel density and the space-time technique (Jamtsho and Corner, 2014).

Based on the readily available information of the country and the data collected, the techniques that were used to decipher the levels of access within South African rural areas included the computation of the average travel time to schools and the kernel density of schools determined. The next portion of this section will be aimed at describing the methods used for the production of the mapping of accessibility levels.

5.3.4.3 Accessibility Mapping

The accessibility mapping was developed using the software chosen to conduct the spatial data analysis (ArcGIS). A raster surface was created for both approaches in which results could be interpolated and distributed throughout the whole area. The GIS model's spatial interpolation uses an advanced methodological concept and are based on the interconnectivity of different operations, namely:

- Data entry – transformation of data into adequate format;
- Geoprocessing;

- Geo-visualisation: treatment of data based on spatial model chosen; and
- Output – via thematic maps.

Within the various types of interpolation ArcGIS offers, the Inverse Distance Weighting (IDW) spatial analyst tool in ArcMap was established as the most appropriate. This tool uses a deterministic and non-linear interpolation wherein the weighted average of the sample values is distributed across the non-sampled locations. The denomination given for this method is based on *Tobler's first law of geography* (Griffin and Gruver, 2018):

"The similarity of two locations should decrease with increasing distance".

Under this tool the estimation of cells' values is done by weighting measured values (calculated points) of geometric data around each processed cell. This will result in having points located closer to the measured cells which have greater influence within the weighting calculations (Nusret and Dug, 2012). Correspondingly, variables within the map decrease with an increase in distance from the sampling cells. This just means that the tool conducts mathematical interpolations where the closer values are more related than further values (Johnston, 2004).

Figure 10 illustrates how the interpolation works; given the four values of cells within the surface could be attributed values demonstrated in colour scale.

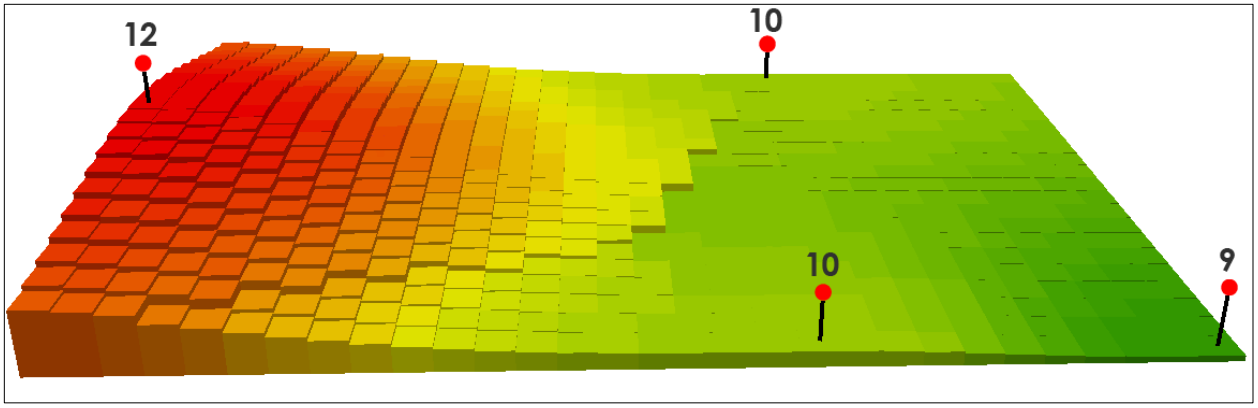


Figure 10. Illustration of Interpolation Technique

In order to achieve sufficiently accurate results within the two approaches used in this project, the surface generated was rasterised into cells. Each cell was assigned a calculated value from the

interpolation of the twelve (12) closest data points. The calculation carried out by the software was based in the following equations (Johnston, 2004):

Equation 7. Interpolation Predicted Value

$$Z(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

Where:

$Z(s_0)$ – Predicted value of location s_0

N – Number of sample points measured that surround $Z(s_0)$

$Z(s_i)$ – Value observed at location s_i

λ_i – Weight assigned to point in location i

The weight assigned to each point is calculated using:

Equation 8. Weight to Each Point

$$\lambda_i = \frac{d_{i0}^{-p}}{\sum_{i=1}^{N} d_{i0}^{-p}}$$

Where:

d_{i0} – distance between points i and 0, and

p – is a reducing factor based on the distance.

And:

Equation 9. Sum of Weight to Each Interpolation Point

$$\sum_{i=1}^{N} \lambda_i = 1$$

During the analysis p was set to a value of 2, meaning that the weighting would present an exponential decrease as the distance between points *0* and *i* increased. Throughout the mapping of

the areas of interest, the impedance used for the accessibility value was based on the two approaches established, firstly the reported time taken to reach *educational institutions* and then the measure of potential accessibility based on the gravity model.

An example of the calculations effectuated by the software are shown in Appendix A.

5.3.5 Data Collection

Before describing the inputs chosen for this research it is important to understand the different types of methods available for collection. The method of data collection is solely a technique used in the collection of empirical data (i.e. how researchers get their data). There are six major forms of collection: questionnaires, interviews, focus groups, tests, observation and secondary data (i.e. personal and official documents, physical data or archived research data) (Johnson and Turner, 2003). Given the monetary and temporal limitations of this research, a secondary data method was chosen to be the most effective and viable since it is readily available.

5.3.5.1 Input Data Requirements

In order to investigate spatial accessibility to schools in rural areas based on the approaches chosen, three main types of data were required for the focused location and characteristics of scholars, the travel times to reach schools in different location and the actual location of education facilities.

Apart from that, various accessibility indicators had to be analysed at a national level, in order to conceive a more generalised result for the study first (as mentioned in Section 5.3.3). Therefore, to explore and enrich insights into opportunities and accessibility existent to such opportunities, the National Household Travel Survey (NHTS) 2013 was used. This would constitute the basis for the first set of input required. Within this survey the modal split, traveling times and affordability to school transport were analysed for each province's rural areas and critical zones were determined.

Subsequently, based on the input requirements for the focusing area calculations and analysis, the National Schools database in GIS for the country was used and extracted from the Department of Education. This set was useful to identify the densification of opportunities within each province (i.e. number of schools available within each area).

Moreover, it was necessary to establish a form to measure distances from households to different schools in order to utilise the Gravity Measure. Given the conditions, the Council for Scientific and Industrial Research (CSIR) GIS database was used, wherein the total area was further divided into equal smaller areas entitled Meso-zones, which included the number of households and population.

Lastly, apart from the datasets mentioned, in order to compare potential to real accessibility of the focusing area, a Cape Winelands District Travel Survey conducted by the University of Cape Town was used. Here, traveling times to school in different areas of the district were obtained and imported to the software.

The following sections will further describe the surveys and datasets used in more detail.

National Household Travel Survey, 2013

(Based on van StatsSA, 2015)

The National Household Travel Survey (NHTS), was strategically aimed at providing insights into traveling characteristics and patterns (i.e. travel modes used, times and costs associated with different types of trips.), as well as transport problems within South African households.

It serves as the basis for the measurement and definition of Key Performance Indicators for land passenger transport and it, therefore, primarily covers land transport travel including both motorised and non-motorised transport.

Within the domains of interest, travel related not only to education but work, business, leisure and migration of individuals is encompassed. It is important to notice that questions relating to education and work are associated with a randomly selected day.

Moreover, apart from traveling characteristics, this survey presents socio-economic information about households, as well as demographic profiles.

Although its usefulness is unquestionable, this survey does not present any spatial data that allows for the analysis of the information on ArcGIS. Consequently, in order to determine the accessibility index of the focusing area, Meso-zones were used in combination with the data for schools archived in the Department of Education.

CSIR Meso-zones

(Based on Mans et al., 2015)

The development of Meso-zones surges from the need to align spatial and temporal data to support a range of planning activities, as they constitute a functional demarcation of a range of key socio-economic datasets for spatial analysis. Although these zones are not uniform in shape they each were aimed to be at approximately the same size: 50 km^2. Figure *11* demonstrates these zones within the focusing area and the centroids derived by them.

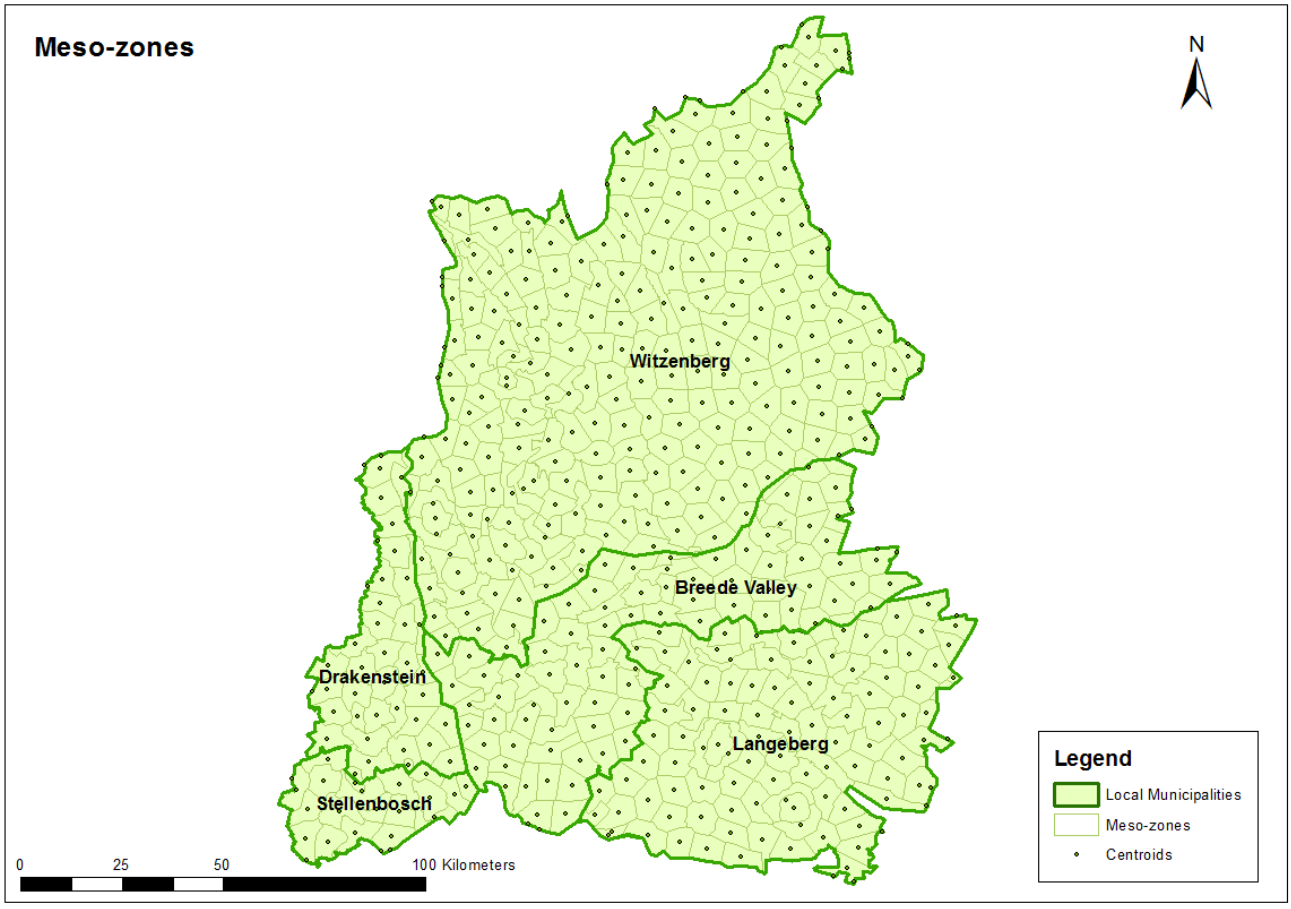


Figure 11. Cape Winelands District Meso-zones and Centroids

As it can be seen in the Figure 11, the zones were divided in such a way that they completely fit the municipalities. Each zones' boundaries are correspondent with travel barriers, such as rivers, mountains, etc. In addition, these zones tend to reduce several problems that are encountered when working with spatially portrayed socio-economic data, allowing more spatially specific maps that better demonstrate the location and extent of features or activity.

Another advantage of using this set of data, wherein zones are almost equally sized, is that it allows more accuracy and modelling interaction between units when doing analysis of accessibility from either regional or national level.

The various datasets assigned to the zones are based on an algorithm developed by the CSIR. In order to calculate the population distribution, 1996 (*EA*s), 2001(*SP*s), 2011 (*SP*s) and 2016 (*SP*s), population figures are used as input datasets and realigned statistically based on the Spot Building Count (*SBC*) by ESKOM.

Using this data and the centroids generated, it was possible to establish an Origin-Destination Matrix from each centroid to the various schools within the District, in order to utilise the Gravity Measure for the calculation of the accessibility level within the focusing area.

In order to compare these results with real accessibility being experienced, another survey was used. This will be described in detail in the next section.

Cape Winelands Survey (CWS), 2015

(Based on van Cuyck, 2015)

This survey was conducted in 2015 by Marc van Cuyck (University of Cape Town) and aimed at assessing the transport and accessibility needs of the households within the Cape Winelands District Municipality in relation to their location to different destinations. It involved running a close-ended questionnaire for the participants' last trip made to a specific domain. Although the results for this type of survey may be skewed, it was highly structured allowing great link between the data collected and the investigation being conducted.

The questionnaire was constituted of five main categories:

- Administrative and background information;
- Household demographics;
- Domains and destinations;
- Traveling to and from destinations; and
- Other destinations (reporting of domains highly inaccessible).

Moreover, given the large-scale study area, a stepwise and random geographical sampling method was used to select the villages under the spatial frame of the entire CWDM. The loss of accuracy using this method was deemed negligible.

The questionnaire presented a 95% confidence level. Given the number of households within the study area (198 265 – *in 2014*) a minimum sample size of 71 was determined using the following equation:

Equation 10. Sample Size

$$n = \frac{Z^2 p(1 - p)}{a^2}$$

Wherein, *n* represents the calculated minimum sample size, Z is a value determined by the level of confidence, p is the probability and a is the margin of error.

Within the Cape Winelands District Municipality, five (5) local municipalities were surveyed, namely: Breede Valley, Langeberg, Witzenberg, Drakenstein and Stellenbosch. *Table 3* shows the final breakdown of settlements surveyed.

Table 3. Settlements Surveyed
(Adapted from van Cuyck, 2015)

Local Municipality	Settlement	No. Surveys	Local Municipality	Settlement	No. Surveys
Breede Valley	De Doorns	2	Drakenstein	Gouda	1
Breede Valley	Rawsonville	2	Drakenstein	Hermon	2
Breede Valley	Touws River	3	Drakenstein	Paarl	8
Breede Valley	Worcester	4	Drakenstein	Saron	3
Langeberg	Ashton	2	Drakenstein	Simondium	1
Langeberg	Bonnievale	1	Drakenstein	Wellington	7
Langeberg	McGregor	1	Drakenstein	Windmeul	1
Langeberg	Montagu	2	Stellenbosch	Franschhoek	3
Langeberg	Robertson	3	Stellenbosch	Groendal	1
Witzernberg	Ceres	5	Stellenbosch	Groot Drakenstein	1
Witzernberg	Op-Die-Berg	2	Stellenbosch	Klapmuts	2
Witzernberg	Prince Alfred Hamlet	3	Stellenbosch	Pniel	1
Witzernberg	Tulbagh	3	Stellenbosch	Raithby	1
Witzernberg	Wolseley	3	Stellenbosch	Stellenbosch	6
Total no. Surveys	74				

5.3.6 Data Processing

The procedures that encompass this study comprise of three principal phases. Figure 12 demonstrates the structure followed within the processing of data in this dissertation.

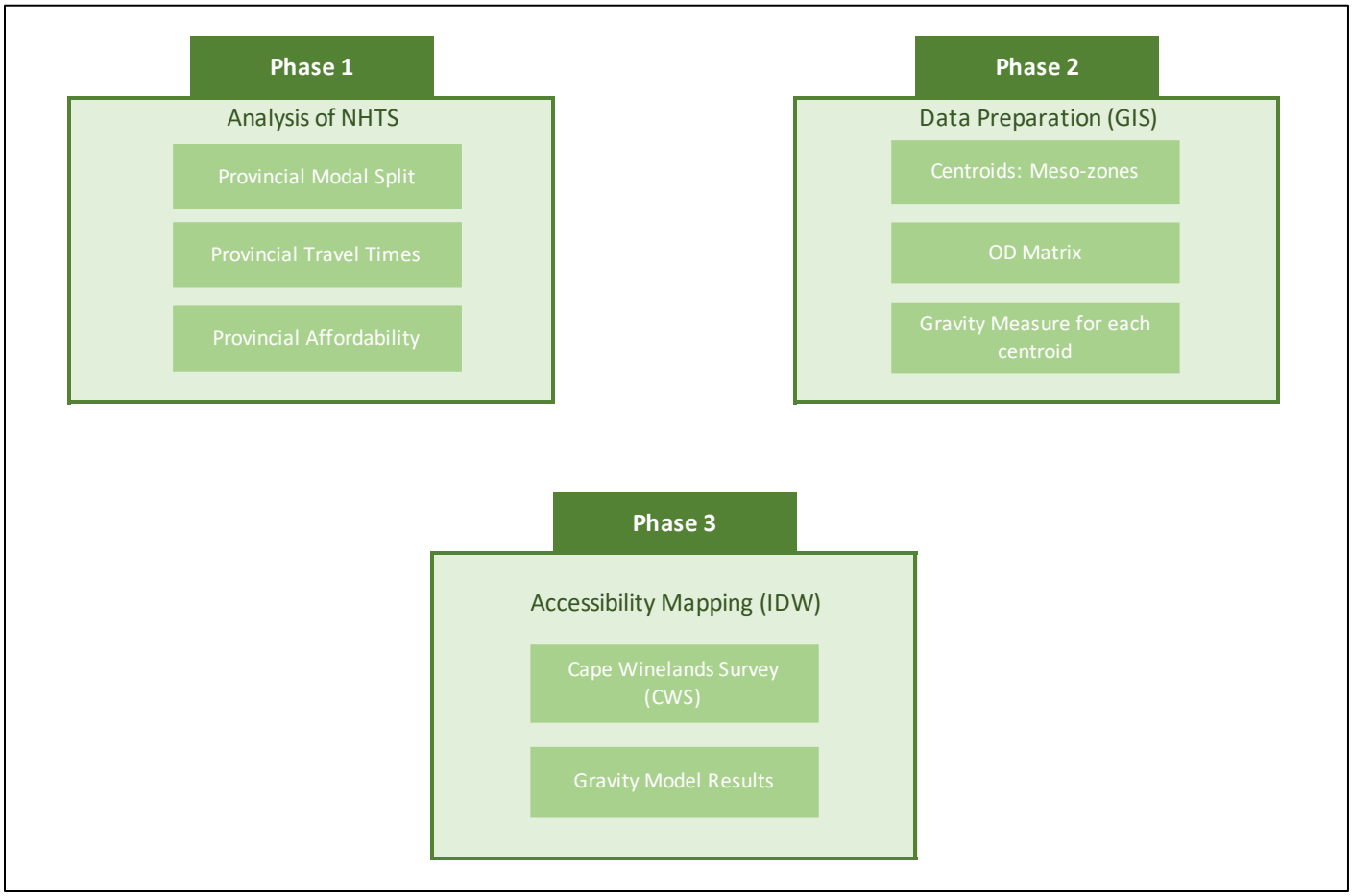


Figure 12. Study Phases

5.3.6.1 Phase 1: Analysis of NHTS

Given that both the income and multidimensional poverty and inequality vary significantly throughout the country's municipalities, it was decided that it would be best to investigate the various characteristics of travel patterns at the provincial level first. Within this phase the NHTS was used to analyse various accessibility indicators such as the travel time, modes used and how affordable such modes were compared to the overall income of each household.

Within this phase, regions with critical results for accessibility indicators could be acquired, with that determining areas of greater concern.

5.3.6.2 Phase 2: Data Preparation

Taking into consideration that the focusing area chosen for this study was the Cape Winelands District, it was necessary to prepare the data for the Mapping.

Approach 1: Gravity Model – Potential Accessibility

In order to conduct the necessary calculations for the GM it was first important to establish the centroids within each Meso-zone. Thereafter, the dataset from the Department of Education was imported to the software and a matrix could be generated from all the origins (centroids) to all the destinations/opportunities (schools).

Following the OD matrix, the accessibility index for each centroid was established using the procedures described in section 5.3.3. These results were then attributed to the centroids of the focusing area.

Approach 2: Cape Winelands Survey

Data preparation for this phase was not necessary since the survey presented spatial coordinates for each household interviewed, therefore direct importation of results into ArcGIS was possible and interpolation could be generated.

5.3.6.3 Phase 3: Accessibility Mapping

Using the interpolation method described in section 5.3.3 accessibility levels could be determined throughout the whole study area.

Mapping was generated for both *Approach 1* and *Approach 2*.

5.3.7 Analysis of Data

Taking into consideration the results of the phases conducted before, a comparative analysis was done based on the results of the GM and the CWS. Here differences between the potential accessibility of the area and the real accessibility experienced could be identified, showing areas for possible improvements.

5.4 Résumé

The estimation of physical access in most developing countries continues to suffer from inappropriate geographical techniques. Moreover, apart from the socio-economic factors, identifying distance-related obstacles are vital when addressing issues in rural areas. Looking at both socially disadvantaged groups and the limited access to education, the methodology carried out for this investigation aimed at looking at different aspects, entangling them with both the conceptual framework and theory behind accessibility. As a result, two main elements influential to any accessibility measurement are taken into consideration: the zone attractiveness and the impedance.

The research process undertaken in this study naturally starts off with the research question, *"What is the level of accessibility to schools in South African rural areas?"* and ends off with the dissemination of findings. In order to achieve results at a national level, the NTHS is used to compare different accessibility indicators at rural provincial level. In addition, based on the resources available, the Cape Winelands District is further investigated by the generation of accessibility maps (using ArcGIS) for both real accessibility and potential accessibility.

These two different kinds of accessibility are then compared in order to establish areas for improvement where the gap of accessibility could be reduced.

Chapter 6

South African Rural Communities' Characteristics and Travel Patterns

The aim of this thesis is to investigate the levels of accessibility to schools within South African rural areas. Analysing the levels of information of the issues concerning the country and taking into consideration the literature review, it appears to be beneficial to focus on accessibility first at provincial level, since there is a great discrepancy of access to services within the country's provinces and even municipalities; and then deepen the study further by investigating the suggested focus area. The questions that need to be answered in this chapter are:

- How are schools dispersed throughout South Africa?
- How are accessibility indicators behaving in each province of South Africa?
- What provinces are the most disadvantaged?

Based on the general study encapsulated in this thesis, the identified knowledge gaps described earlier and the availability of data for analysis, this chapter aims to describe the current situation of the country in terms of the various aspects that could indicate accessibility inadequacies.

6.1 Background

South Africa, and many other societies worldwide, uphold the issue of inequality between well-resourced urban communities and the neglected rural areas. These vast incongruities are specifically well known in the provision of and access to education (Hlalele, 2012). Notwithstanding, education is at the core of developing high skills, enabling people to diverge from unemployment, low incomes, ill-health and poor housing (Lucas, 2012). Therefore, it is important to study the travel patterns of households and factors that influence them, considering that it is within this avenue that socio-economic development can take place (Luke and Pisa, 2018).

Based on the literature review, accessibility can be studied using different indicators. Although there are various aspects that could point out to accessibility levels, given the complexities associated with them, this project will be solely focusing on: modal choice, affordability and travel times, as determined in Chapter 5.

This chapter will start by describing the different provinces in South Africa, then the different accessibility indicators will be discussed at the provincial level and afterward, critical areas with regards to accessibility will be identified.

6.2 Characteristics of South Africa

South Africa is a country comprised of nine provinces, each with its own executive council, premier and legislature, namely:

- Eastern Cape;
- Free State;
- Gauteng;
- Kwazulu-Natal;
- Limpopo;
- Mpumalanga;
- Northern Cape;
- North West; and
- Western Cape.

See Figure 13 (page 74) for distribution of the country's province boundaries.

As seen also in Figure 13, there are great differences between the sizes of each province. Gauteng is the smallest province followed by Mpumalanga, the other provinces cover approximately 8% to 14% of South Africa's total land area each. Moreover, the population within different provinces also varies significantly. KwaZulu-Natal, although the third smallest province, has the greatest number of inhabitants, whereas Northern Cape that constitutes a third of the entire South African land area, has the smallest population.

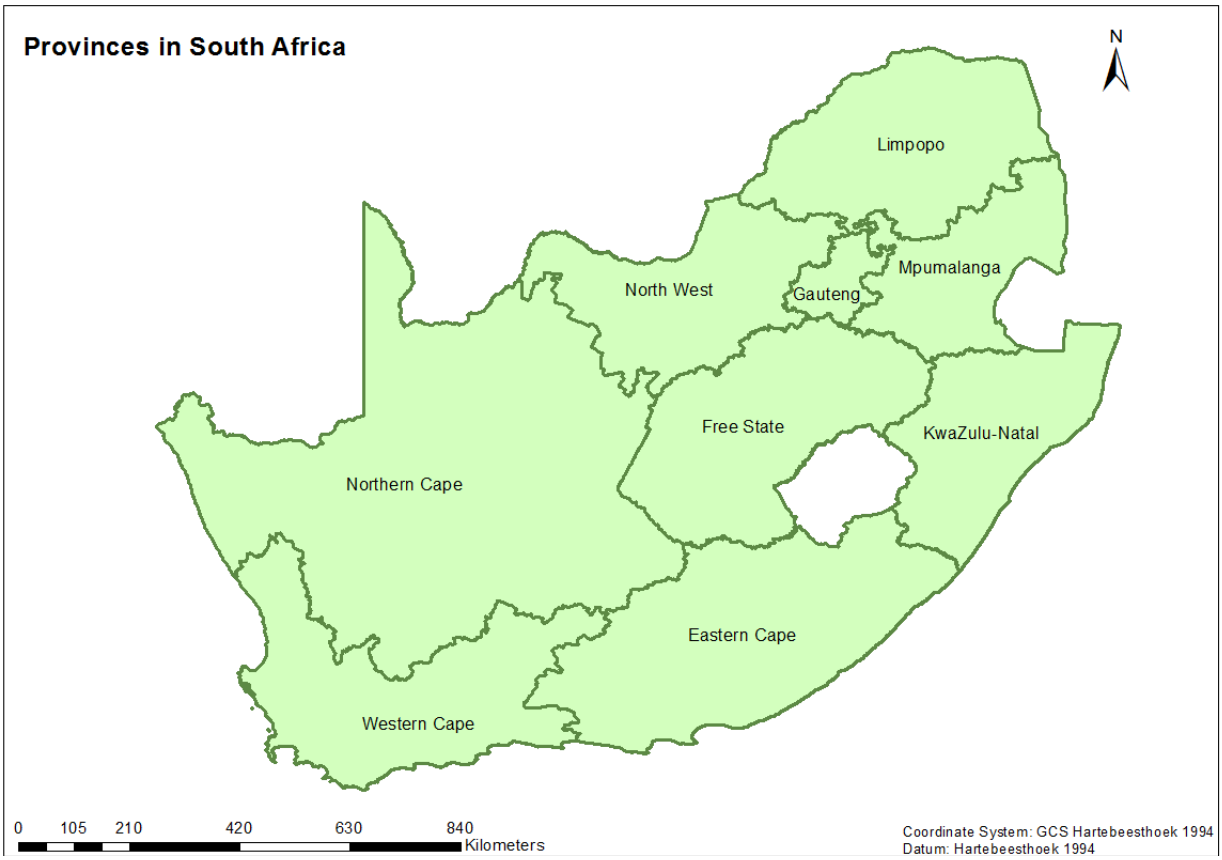


Figure 13. South African Provinces

Other general characteristics that constitute the basis of South African provinces are summarised in *Table 4.* South Africa General Characteristics, each corresponding to one province.

Table 4. South Africa General Characteristics

Province	Capital	Total Population	Area (km^2)	Total Area	Population density	Share of total GDP
Eastern Cape	Bisho	14.6%	168 966	13.9%	41/km^2	8.1%
Free State	Bloemfontein	6.2%	129 825	10.6%	23/km^2	5.5%
Gauteng	Johannesburg	20.1%	16 548	1.4%	576/km^2	33.3%
KwaZulu-Natal	Pietermaritzburg	20.9%	94 361	7.7%	105/km^2	16.7%
Limpopo	Polokwane	11.3%	125 755	10.3%	43/km^2	6.7%
Mpumalanga	Nelspruit	6.4%	76 495	6.3%	46/km^2	6.8%
Nothern Cape	Kimberley	2.3%	372 889	30.5%	3/km^2	2.4%
North West	Mafikeng	7.1%	106 512	8.7%	32/km^2	6.3%
Western Cape	Cape Town	10%	129 462	10.6%	37/km^2	14.5%

Moreover, given the nature of this research, it is important to understand how rural areas are distributed within the country. As discussed in Chapter 3, preceding the apartheid system, a large-scale re-demarcation of municipal boundaries took place. However, through this process administrative distinctions between urban and rural areas were removed, causing issues when defining rural areas.

Therefore, in 1997 the Rural Development Plan defined rural areas as those areas sparsely populated wherein farming or dependence on natural resources takes place, as well as the presence of large settlements in former homelands. In addition, the Department of Cooperative Governance used different land aspects such as: the number of poor households, their proportion with access to services and information on capital, to group municipalities in seven different categories shown and defined in *Table 5*.

Table 5. Categories of Municipalities
(Adapted from National Treasury, 2011)

Class	Characteristics	No.
Metros	Category A Municipalities	6
Secondary cities (B1)	All local municipalities referred to as secondary cities	21
Large towns (B2)	All local municipalities with an urban core. There is huge variation in population sizes amongst these municipalities and they do have large urban dwelling population	29
Small towns (B3)	No large as core urban settlement. Typically with relatively small population, wherein a significant portion is urban and based in one or more small towns. Rural areas in this category are characterised by commercial farms, since their economies are largely agricultural.	111
Mostly rural (B4)	Characterised by the presence of one or more small towns, communal land tenure and villages or scattered dwellings, typically located in former homelands	70
Districts (C1)	Not water service providers	25
Districts (C2)	Water service providers	21

Considering the characteristics given in *Table 5*, rural municipalities are, therefore, categorised as B3 and B4 taking into consideration the rural development framework. The distribution of rural areas is mostly concentrated in Limpopo, KwaZulu-Natal, Eastern Cape and Northern Cape, although Western Cape, Free State, Mpumalanga and North West also host some. Figure 14 demonstrates the distribution of rural areas in each province.

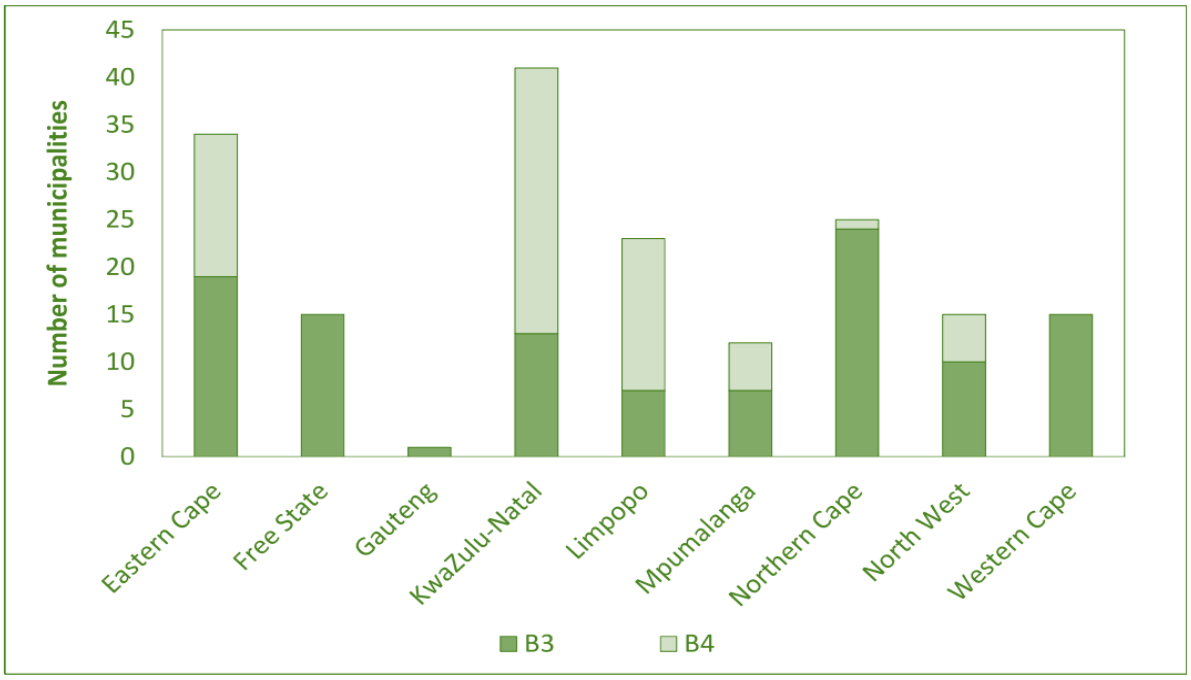


Figure 14. Provinces Rural Areas
(Adapted from National Treasury, 2011)

6.3 Education Characteristics within Provinces

Contained within this section are data comparing educational attainment, literacy, population group, geography as well as age, focusing mainly on rural areas within different provinces. This section aims to tackle issues that can significantly impact the development of the country including the low graduate outputs, the youth unemployment trap and the low post-secondary school attendance.

According to the Department of Education (2005), South African rural communities continue to be disadvantaged when compared to urban areas (Hlalele, 2012). Making a comparison of the different geo-types available could potentially point out the most disadvantaged areas in terms of education provision. Figure 15 shows the literacy status within different geo-type areas and different age groups. As it can be seen, older individuals are the most illiterate and this could be explained by the epoch in which they were born – during the apartheid era.

Moreover, it is also clear that urban areas contain the least number of illiterate populations. Therefore, in an attempt to counteract and understand the current and unequal situation of the country, the necessity of further studies looking at areas B3 and B4, as characterised in Section 6.2, is clear.

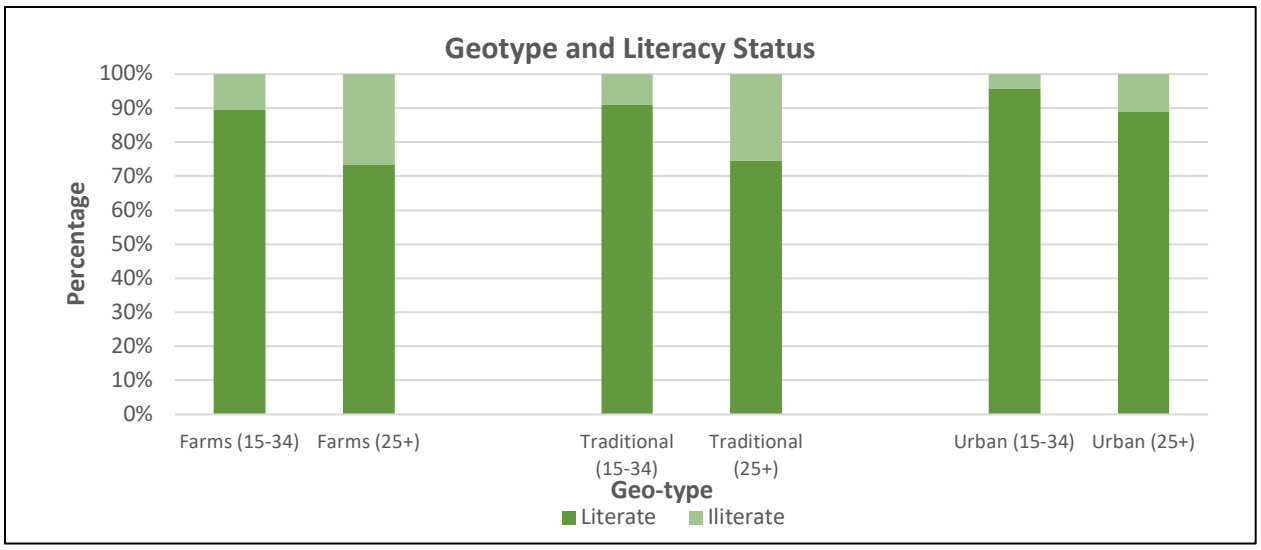


Figure 15. Geo-type of Area and Literacy Status
(Based on NHTS, 2013)

Motala, et al. (2009) argue that full attendance, specifically in Grades 1 to 9 (achieving universal primary education), and gender equity are considered critical to reduce poverty in the country. Furthermore, when looking at the gender split between individuals attending any educational institution in rural areas, it can be seen that the difference is quite unnoticeable. Figure 16 illustrates this by province, wherein apart from the Northern Cape and Gauteng, discrepancies are close to null.

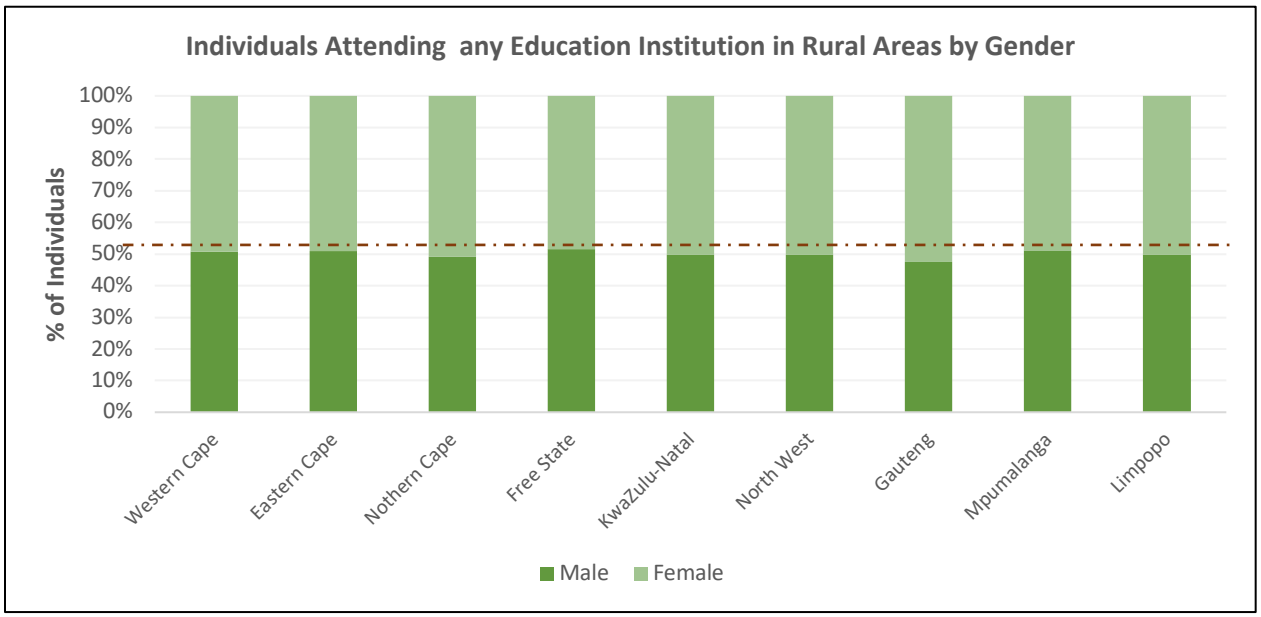


Figure 16. Gender Split between Individuals in Rural Areas Attending any Education Institution
(Based on NHTS, 2013)

On the other hand, when looking at literacy or education attainment Figure 17 shows that there is a significant number of individuals in rural areas with no schooling at all, the Northern Cape possessing the highest level of illiteracy. Interestingly, when looking at the whole of South Africa only about 7% of individuals present no schooling (StatsSA, 2016). This means that a great portion corresponds to individuals living in rural/disadvantaged areas. In addition, it also confirms the suspicions of low secondary school enrolment and the subsequent (youth) trap that is consequential of this nature.

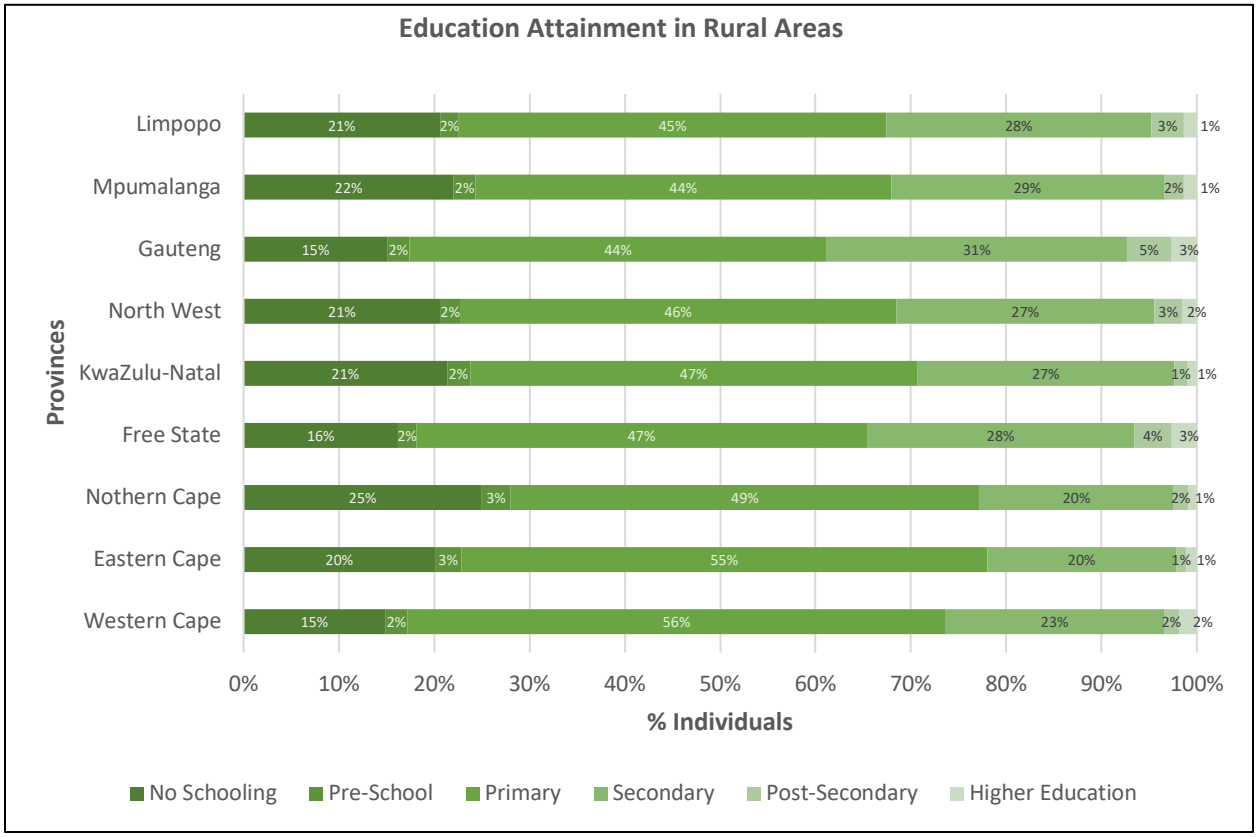


Figure 17. Education Attainment in Rural Areas
(Based on NHTS, 2013)

Therefore, it is clear that the participation in educational institutions is varying and dependent on the region and the population group in South Africa. Primary and secondary education are relatively well developed in contrast with the post-secondary education level, this could be justified by the long distances learners have to travel to continue studying. Looking at solely rural areas, provinces with higher literacy percentage include Gauteng, Western Cape and Free State. Nonetheless, compared to the other provinces, the variations observed are to some extent similar.

The results discussed so far demonstrate the slow progression of children specifically in poor or non-urbanised areas, causing distinct socio-economic repercussions. Looking at the entire country, the gross enrolment rate within different educational phases varies considerably within different provinces. Figure 18 shows such differences, with associated trend line averages.

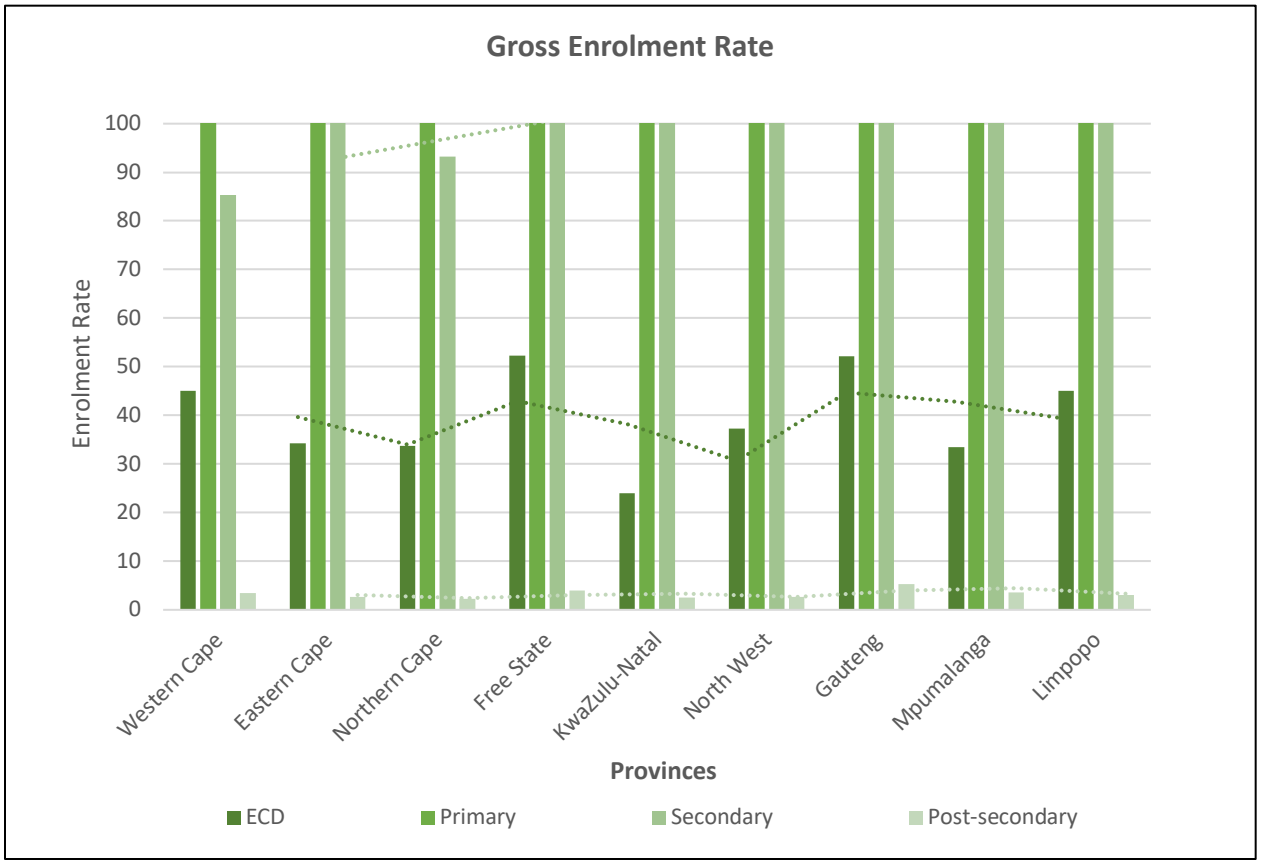


Figure 18. Gross Enrolment Rate per Province
(Based on StatsSA, 2016)

As it can be seen, when looking at the Early Childhood Development (ECD) enrolment rates, only the Free State and Gauteng are above 50%. This is disconcerting as this program attempts to reduce remedial action costs for school retention and introduce learning to pre-primary schooling, providing a stronger foundation. Moreover, primary schooling gross enrolment rate per province is extremely high. This suggests that the number of pupils enrolled is close to the full target.

In addition, most provinces presented exceptionally high enrolment rates for secondary education, similar to primary. However, the Western Cape and Northern Cape still have not fully achieved the targeted expected, meaning that there is either a high impact of grade repetition or supply has

not been well met. Nevertheless, the greatest concern still lies in post-secondary education, as only an average of less than 5% of the population within provinces undertake the next step.

In order to better understand the configuration and distributions of schools within the country, schools' density within South Africa is shown in Figure 19. It can be seen that agglomerations of schools are predominantly in Gauteng and KwaZulu-Natal in comparison to the Western Cape and Northern Cape, which are the provinces with less school density. This is quite interesting as those same provinces are the ones with the least enrolment rates for secondary education. Further investigations are, therefore, advised within this context.

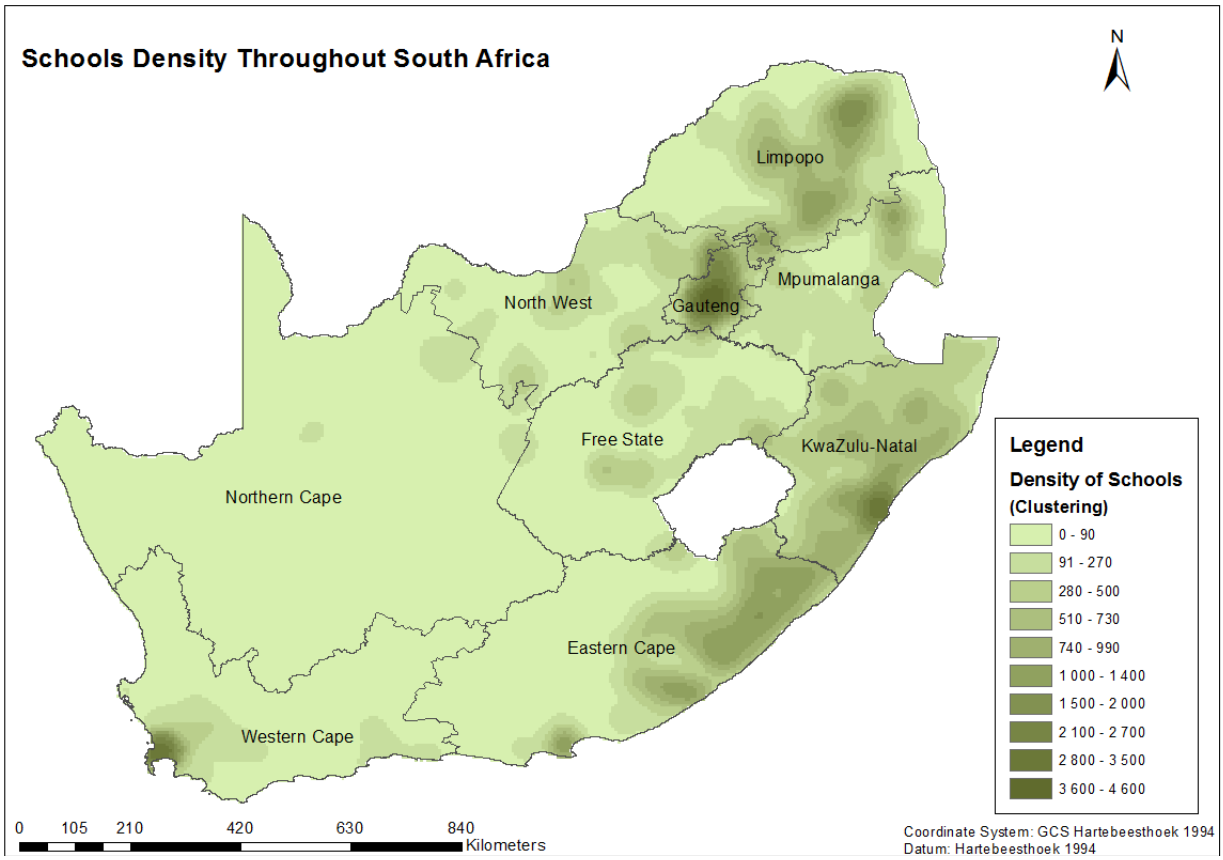


Figure 19. Schools Density Throughout South Africa
(Based on Department of Education Database)

From the discussions and analysis given in this section it is clear that there are still obstacles to be overcome to ensure learning deficiencies in the country. Present generations' futures are inevitably dependent on their access to schooling. The behaviour and travel patterns of learners constitute one of the bases for the further investigation of aspects associated with this topic. The next section will look at this matter.

6.4 General Travel Patterns to Schools

The travel patterns scholars normally effectuate to their educational institutions is dependent on the interaction between several factors operating at different levels, such as environmental, economic, geographic and social, that influence not only the behaviour of this generation but also the travel of society in the future (Easton and Ferrari, 2015). Moreover, various programmes and strategies have been focusing on children's travel to school as it is significant for a number of reasons (Morris et al., 2001).

Firstly, given the peak times wherein school journeys normally take place, strategies can potentially be put in place for shared services (improved public transport services or car-pooling) or increased efficiency of safety programs. This shows that the concerns within these travel patterns may present different objectives, ones focusing on road safety and others looking at personal security and related travel demand management, as well as behavioural change agendas (Morris et al., 2001).

This section aims to identify different travel patterns to schools in South African rural areas, including the choices that children make in commuting, the effects of distance according to those choices, the correlation of traveling distances and availability of affordable mode choices.

Before jumping ahead to further studies, it is important to understand how travel behaviour works, as it can be underpinned by both fixed aspects such as age, gender, etc. or random effects, including distance to school preferences, etc. (Easton and Ferrari, 2015). Tranter (1995) and Hillman et al. (1990) consider the mobility of children dependent on levels at which scholars are permitted to:

- Use bicycles on main roads;
- Cross main roads alone;
- Travel alone; and
- Travel at night.

Although these factors have been pointed out they are significantly difficult to investigate and would require further surveys. Therefore, it will not be included in the scope of this study. However, what is important to take into consideration is the focus on low-income population, where options are rather limited. Apart from what has already been discussed, rural areas suffer from great traveling distances and times due to dispersion of facilities and the concept of

amalgamation of schools. Consequently, this next Section will focus on issues revolving around this situation, which are directly linked to accessibility indicators discussed in Chapter 2. This will be based on results of the NHTS, which precedes this Section.

6.4.1 Accessibility Indicators and Other Travel Aspects in Rural Areas

Accessibility, as described earlier, is normally defined as a measure of spatial separation between activities (Morris et al., 1979). Geurs and Van Wee (2004) defined four main indicators of accessibility: land-use, transportation, temporal component and individual component. It is, therefore, clear that accessibility is both a function the efficiency of transport systems and land-use distribution (Morris et al., 1979). Apart from the aspects already discussed, this Section has an objective to untangle some of these indicators through the analysis of travel patterns to schools in rural areas.

A useful and simplified way to analyse these indicators is through making reference of the aspects Bocarejo and Oviedo (2012) considered vital, namely: modal choice, travel time and affordability that can be recognised as having an impact on travel behaviour and activity patterns (Wee et al., 2013). These features constitute the most important within this study given the population group being focused on.

The National Household Travel Survey is an important tool in conducting this analysis, as its objectives on travel behaviour and subsequent responses go in line with the objectives of this section. Therefore, investigations in this work will be using this survey to extract relevant information. Analysis will start by modal choice patterns, followed by travel times experienced and finalised by affordability to travel.

6.4.1.1 Modal Choice

There is a whole collection of social, economic, cultural and environmental factors that influence the traveller's choice of mode, such include travel time, cost, waiting time, ease of transfers, etc. (Minal, 2014). Essentially, modal choice is effectuated by a whole variety of interrelated factors to larger or smaller extents, within a subconscious or conscious process that include both subjective and objective determinants (De Witte et al., 2013).

In rural areas, the long distances experienced to reach schools have led to the tendency of commuters travelling to school by motorised means rather than walking or cycling (Easton and Ferrari, 2015). In South Africa, apart from the Western Cape, walking remains the main mode of travel as it can be seen in Figure 20 that shows the split for each province's rural areas' travel modes to school.

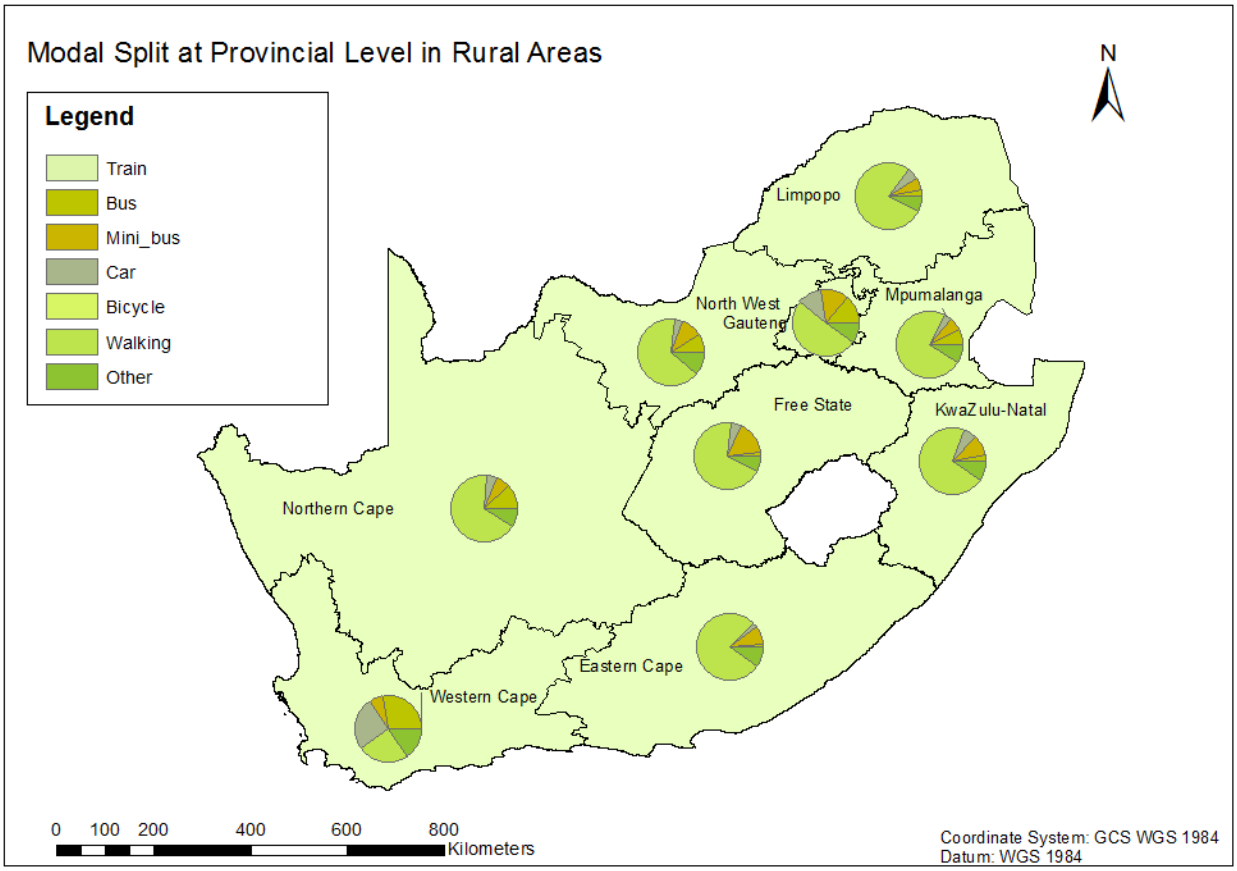


Figure 20. Modal Split at Provincial Level in Rural Areas
(Based on NHTS, 2013)

Furthermore, when investigating the different reasons for walking, more than 70% of the population in rural areas answered that the school is nearby, followed by almost 10% admitting that the public transport available is expensive, as it can be seen in Figure 21. This leaves warranted questioning on what nearby is considered and how far is too far, as well as the inclusivity of sustainable public transport systems.

Additionally, when specifically looking at the Western Cape, there are recent trends that have been suggested as influencers of the usage of private cars for the transportation of children to school. These include: the increase in travel distances, people's perception of security (i.e. fear of crime), traffic safety - specifically when residential streets present a considerable amount of traffic, as well as other concerns of parents, such us having their children use public transport when coming home (especially at night) (Morris et al., 2001).

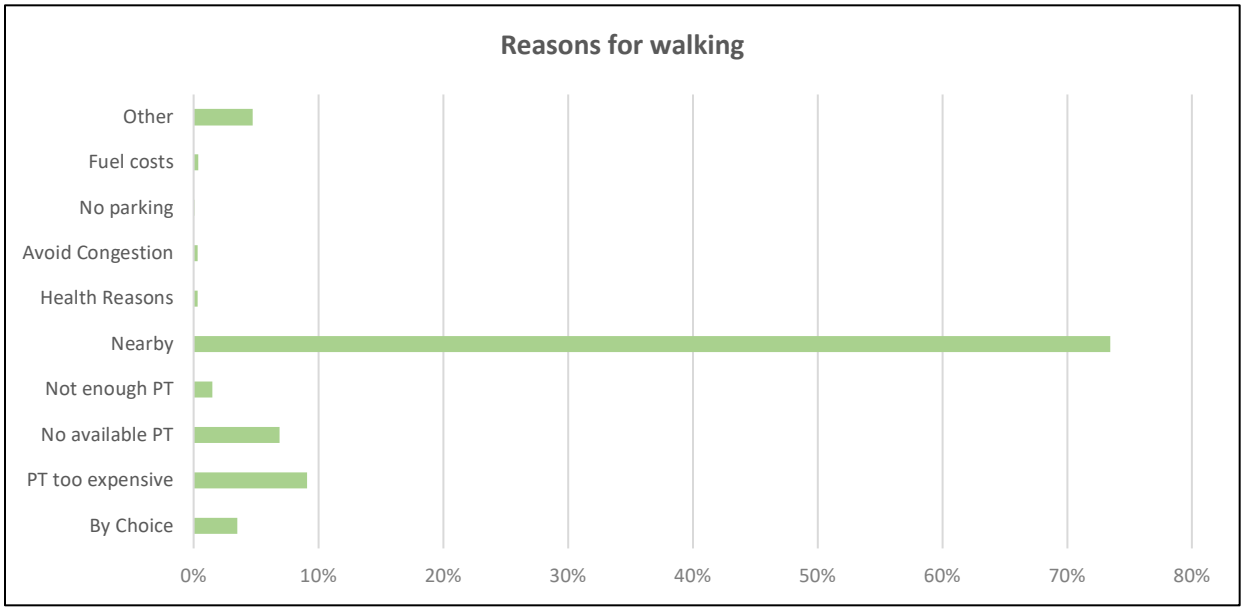


Figure 21. Reasons for Walking to School (Rural Areas)
(Based on NHTS, 2013)

Moreover, the dispersion of patterns in land use and complexity of activity patterns have contributed to the reliance on private vehicles. However, in recent studies it has been suggested that the car usage in children's mobility can result in negative influences to their personal, intellectual, psychological and even physical development, due to the lack of regular exercise (Moore, 1986; Tranter, 1995; Hillman, 1997 in Morris, Wang and Lilja, 2001).

At the heart of it, besides the negative influence on children's development, the usage of cars constitutes a paradoxical situation as mobility increases but actual accessibility potentially decreases, constituting a great threat to sustainable development (European Union, 2000).

This is why it is important to understand what actually constitutes these modal choices. In order to further evaluate student mobility, travel times were considered influential in transport decision making and will therefore be subsequently discussed.

6.4.1.2 Travel Time

As discussed in Chapter 1 travel time constitutes one of the main indicators of accessibility. When looking at travel times to schools in rural South African, it can be seen that Gauteng, Kwazulu-Natal, Eastern, Northern and Western Cape populations present a majority in taking 30 minutes or more to reach educational institutions. Figure 22 shows this interesting finding.

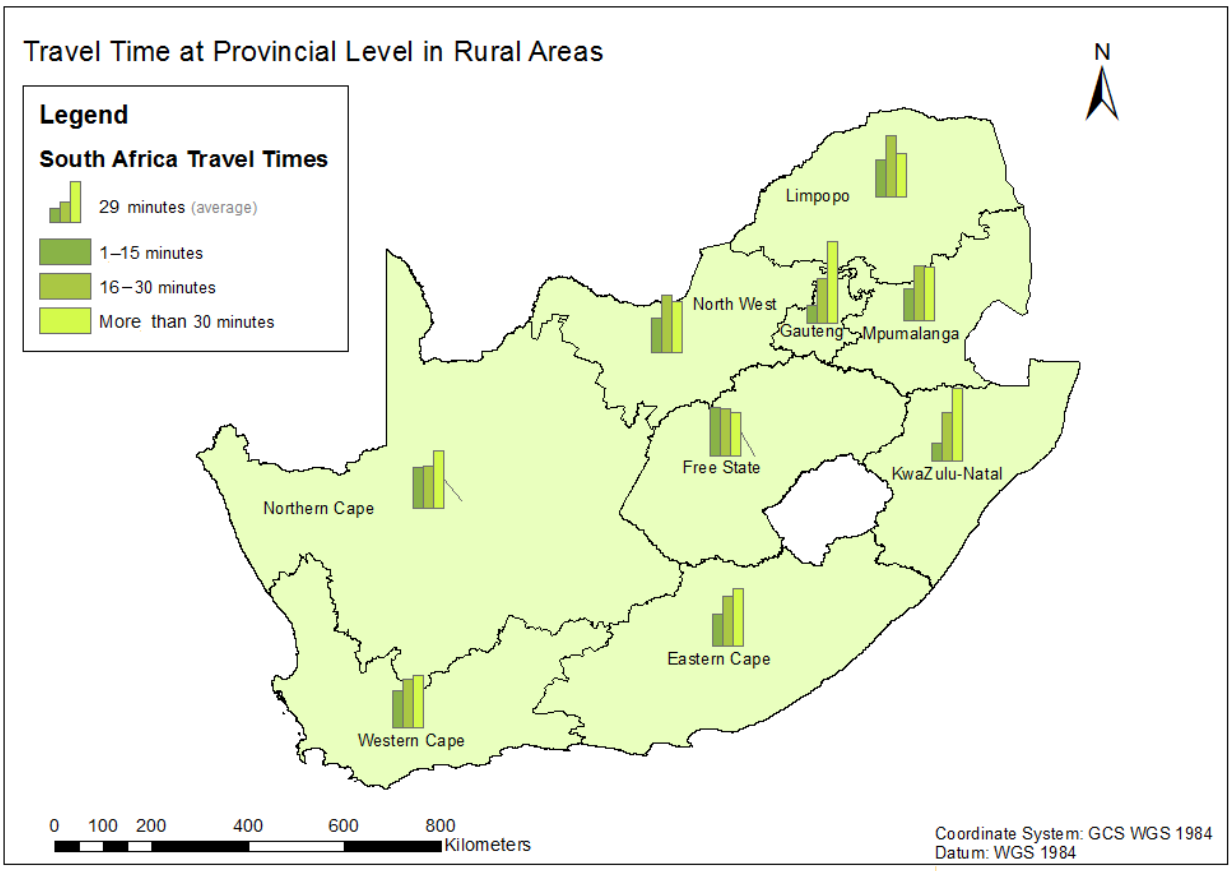


Figure 22. Travel Time to School at Provincial Level in Rural Areas
(Based on NHTS, 2013)

When looking solely at travel time greater than 30 minutes, as shown in Figure 23, it can be understood that between 35% and 50% of the population in different provinces are experiencing such lengthy travel times.

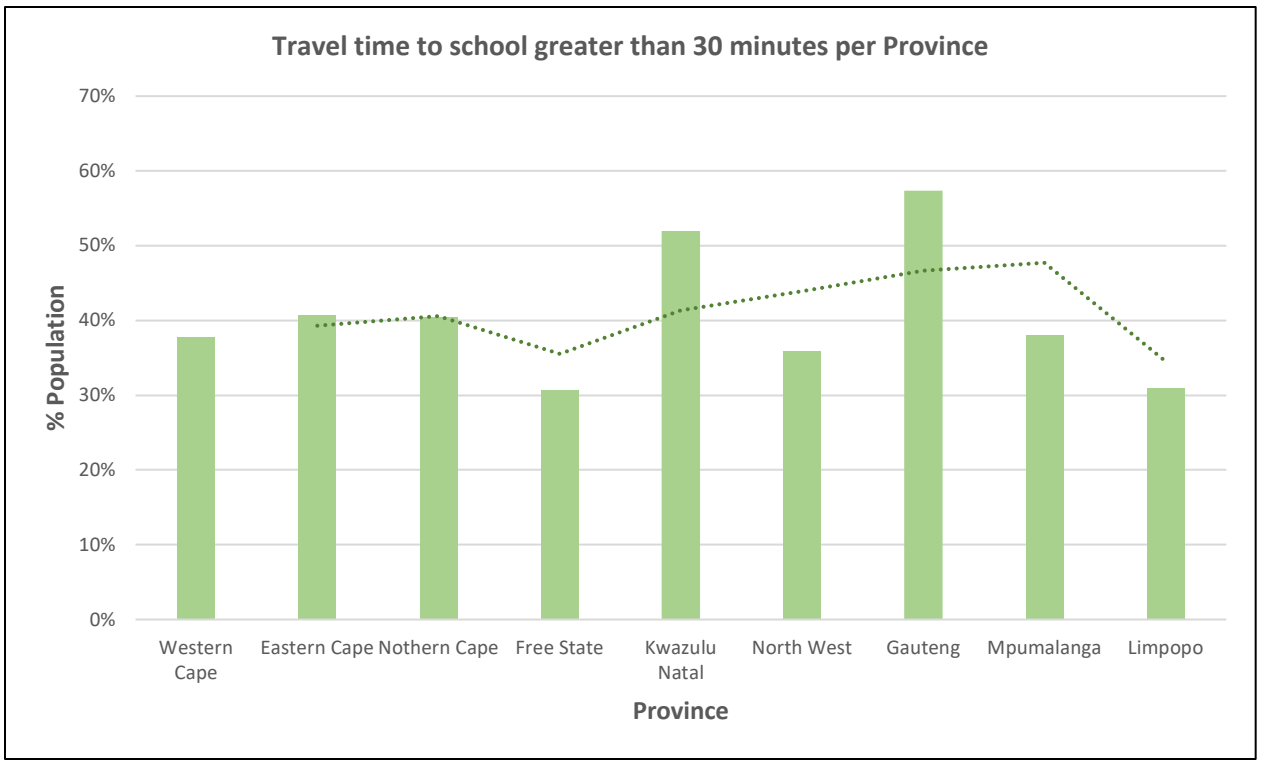


Figure 23. Travel Time to School Greater than 30 Minutes per Province
(Based on NHTS, 2013)

Given the results discussed in the previous section, and how respondents argued that walking to school was their choice, due to proximity, the question rises on the perception of distance by these same respondents. In school travel studies, planners have established that 15 minutes is the maximum acceptable walkable time relative to a distance of about four hundred (400) meters (Cole et al., 2007). Moreover, several studies have questioned distance and travel time perception and have concluded that such judgement is directly related to the knowledge of environmental features, personal and trip characteristics (Horning et al., 2008). In addition, research has compared these perceptions with the feature accumulation hypothesis that states that:

"Distances are perceived as longer when there is more information to remember about an environment (i.e. intersections, slopes and turns)"

Using this theory, it can be argued that, due to location of residents in rural areas, wherein larger buildings, and plenty more open spaces are present, these could have the tendency to underestimate distances, as opposed to urban residents (Horning et al., 2008).

The following section will attempt to investigate another important indicator (according to Bocarejo and Oviedo, 2012) that influences accessibility.

6.4.1.3 Affordability

The affordability patterns of specifically low-income groups and disadvantaged areas are crucial to the overall sustainability of transportation. When the costs of certain modes of transportation exceed the affordability amount, chain reactions could be aggravated as that implies diminished access to possible opportunities and triggering with that the concept of socio-economic exclusion (Nyarirangwe and Mbara, 2000). It is, therefore, important to understand how affordable levels of transport are within provinces, especially in rural areas, since those are normally secluded from urbanised spaces.

However, the results obtained using the NHTS (2013) rendered inconclusive, as information was not available for all provinces. Consequently, comparison at provincial level could not be done.

6.5 Résumé

The issues of inequality between well-resourced urban communities and neglected rural areas is experienced worldwide and quite prominent in the access to education. Based on the literature reviewed in Chapter 2, there are various indicators that could point out to accessibility levels. Within this chapter essentially two were fully discussed: modal choice and traveling times, since the data for affordability analysis was rendered inconclusive.

South Africa is a country comprised of nine provinces, in which concentration of rural areas is extensive in Limpopo, KwaZulu-Natal, Eastern Cape and Northern Cape. When looking at literacy levels within the country, urban areas contain the least illiterate populations, pointing to the need to further understand the level of access to education in the other underprivileged areas.

Within the country, concentration of schools is higher in Gauteng and KwaZulu-Natal, wherein the Western and Northern Cape possess the least schools. Which is an interesting result given that enrolment rates to those same provinces are lowest, compared to other provinces.

Moreover, when looking at the modal split within every province it was found that, apart from the Western Cape, walking was the most used mode. Respondents have stated that such mode was used given the proximity to schools. However, when looking at travel times the same was not

concluded, as about 35% - 50% of the population are experiencing traveling times greater than 30 minutes.

Chapter 7

Cape Winelands Municipality: Case Study Area

Analysing the knowledge levels in South Africa and taking into consideration the discussions in previous chapters, it is clear that there are a set of parameters necessary for any calculation of accessibility levels within a location. Nonetheless, based on the knowledge gaps identified concerning South Africa, the available data and resources - a focal area was selected: *The Cape Winelands District Municipality (CWDM)*.

This chapter describes the various characteristics regarding the chosen area, such as its environmental context and socio-economic profile, as well as, the various challenges currently being faced. It begins by describing general characteristics of the area, followed by an overview of different environmental conditions. The chapter concludes with a discussion on the various social and economic aspects being experienced.

7.1 General Characteristics

Covering 21 473 km^2 of South Africa and previously known as the Boland District Municipality, the Cape Winelands District (CWD) makes up part of the six district municipalities within the Western Cape, subdivided by five local municipalities, namely:

- Witzenberg Local Municipality;
- Drakenstein Local Municipality;
- Stellenbosch Local Municipality;
- Breede Valley Local Municipality; and
- Langeberg Local Municipality.

The distribution of these local municipalities within the area is show in Figure 24. Within them, reside a total of 18 principal towns as illustrated in Appendix D.

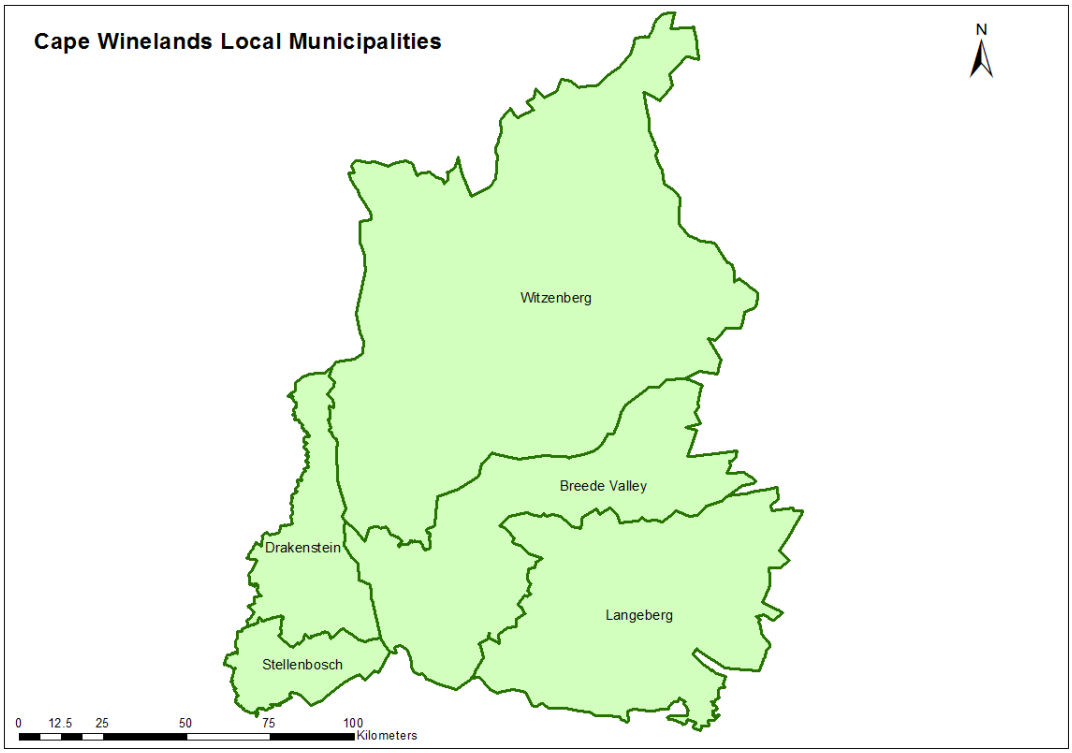


Figure 24. Cape Winelands Local Municipalities

The area is often considered as one of the 'most precious' of South Africa's rural and small-town sub regions, due to its magnificent scenery, heritage significance and superb wine productions (see Figure 25) (Western Cape Government, 2018). Its intense and diverse level of development as well

Figure 25. Cape Winelands Picture

as other characteristics of the area will be described in detail within the subsequent sections, starting off with its various environmental conditions and finishing off with the current challenges being faced by the region.

7.2 Environmental context

Within this Section, various physical characteristics of the CWD will be discussed including: topographical conditions, climate characteristics and the ecosystem specific to the area. The importance of such aspects is seen on the direct effects they present to settlement patterns, tourism and especially the economic activity of the district (specifically agriculture and associated production) (Cape Winelands District Municipality, 2012).

This section will begin with a description of the topological conditions of the area.

7.2.1 Topographical conditions

As partially shown in Figure 25, the Cape Winelands is surrounded by mountainous terrain, which constitutes one of the most prominent characteristics of the region. The river valleys that are also present in the area constitute one the wealth providers for the district's economy (Cape Winelands District Municipality, 2012).

7.2.2 Climate characteristics

The Cape Winelands District Municipality is characterised by Mediterranean climate conditions. These conditions have relatively cold to moderate pluvial winters, and hot and dry summers. These climatologically differences have a direct impact on the agriculture of the sub-regions (Cape Winelands District Municipality, 2012).

7.2.3 Ecosystems and biodiversity

Although the wild life and floral kingdom in the area are well conserved by both public and private nature areas, this region is susceptible to two big threats to the biophysical environment (Cape Winelands District Municipality, 2012):

- Over consumption of water; and
- Degrading water quality: caused by the informal settlements, farming activities, unsuitable sewage removal and leaching land-fill sites.

The ecosystem within the region is in great danger due to human activity, specifically that which had been previously stated. There is a need for immediate interventions to avoid crisis on the ecosystem services that sustain the economic development and quality of life within the district (Cape Winelands District Municipality, 2012).

Although environmental characteristics are undeniably important when investigating an area, understanding the spatial patterns, previous and current changes, is crucial to underpinning accessibility issues. Therefore, the next section will discuss this topic.

7.3 Spatial Patterns

The geography of a region plays an important role in providing access to people and services which consequently contribute to the development process (Linard et al., 2012). The spatial structuring and the transport system of each city is primordial to the provision of access. The understanding of the evolution of spatial patterns and current urban forms is crucial to pinpoint the different accessibility challenges an area may present (Rode and Floater, 2014).

It is within this realm that in this section an attempt is made to unravel the spatial evolution of the Cape Winelands, understand the current urban form and unravel issues related to urban sprawl.

7.3.1 Evolution

Spatial patterns and evolution constitute one of various aspects that should be investigated during the research of accessibility within an area as stated above (Wang et al., 2016). Furthermore, implications of size, structure and human activity within spaces should be further investigated, specifically within the context of developing countries (Sharmeen and Houston, 2019). Therefore, a brief description of the spatial evolution of the Cape Winelands is made in this section.

Historically, one of the key characteristics that constituted the Cape Winelands is the location of settlements adjacent to transport and fluvial systems. In 1679, the need to further explore more arable conditions, led to the discovery of the valley where Stellenbosch is located upon today (Stellenbosch Drie Eeue, 1979 in Lutz de Wet, 2016). Simon van der Stel instigated the settlement of the area which later transformed into a prosperous farming land (Lutz de Wet, 2016).

The growth that took place after that settlement included settlements of French colonists that further developed the viniculture. The further enlargement and growth within the area is arguably

shaped according to the topography and river corridors that resembles a star-form urban pattern (Stellenbosch Municipality, 2014).

The next section will elaborate on the characteristics of this type of urban pattern.

7.3.2 Structure and Urban Form

Different forms of urban development impact differently on accessibility (Felcman and Šilha, 2016). These two concepts - accessibility and urban form - are primordial in developing economic benefits through agglomeration effects and networking advantages (Rode and Floater, 2014). As previously determined, the study area is characterised by a star-shaped urban form. This type of structure is normally identified by concentrations of development in transport corridors/routes that normally start on a one-lot deepening into a grid system. Additionally, it can normally constitute a strong urban core that presents secondary centres of significant but moderate density dispersed through the main radial roads (Jamal, 2017). Figure 26 shows this basic structure.

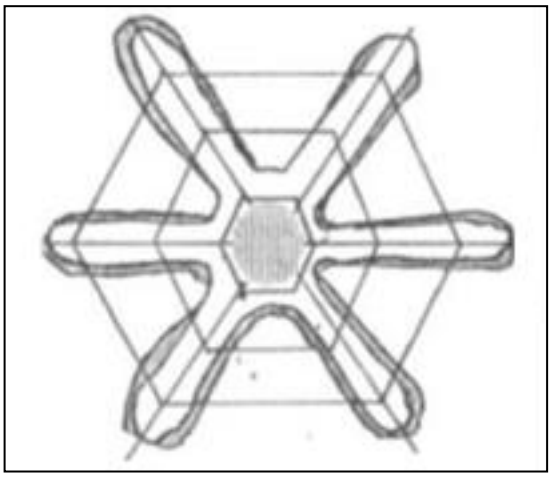


Figure 26. Star-shaped Urban Form
(Lutz de Wet, 2016)

Within the context of the study area, this structure is not legible and its neighbourhoods are disintegrated. Therefore, the following challenges were identified regarding the development through this form (Lutz de Wet, 2016):

- The quality of public realm and spaces is detracted,
- Safety and security for the communities is not provided,

- The inefficient movement system impedes the accessibility to opportunities and public facilities,
- Lack of critical mass of intensity, diversity and adaptability,
- Informality is not recognised, and
- Undermining of heritage character of the Cape Winelands.

In addition, urban sprawl is a phenomena that seems to be highly prominent in the area and as some argue, a cause for limited accessibility (Linard et al., 2012). Therefore, given this relation with accessibility, the next section will attempt to elaborate on the matter within the study area's context.

7.3.3 Urban Sprawl

The irregular star-shaped urban pattern discussed previously, wherein scattered and fragmented configurations are identified, is an indicator of urban sprawl (Sims and Mesev, 2011; Musakwa and van Niekerk, 2014). Harvey and Clark (1971) characterised sprawl as the scattering of urban settlements and then more recently, Altshuler and Gomez-Ibanez (1993) extended this definition by describing sprawl as the establishment of continuous low density of residential settlements within the metropolitan fringes (Sims and Mesev, 2011).

Cervero (2002) identifies urban sprawl as one of the indicators of poor accessibility. This type of urban growth has been one the most critical challenges of the area, starting from the 1970s and prevailing until today. This is seen by the large extensions of scenic and agricultural land that are being developed in low density neighbourhoods (Lutz de Wet, 2016). Nonetheless, these neighbourhoods are mostly dependant on private motor vehicles since they are not entirely linked to any linear movement system (be it rail or road based public transport). Therefore, the level of congestion within the Cape Winelands is extremely high, having increased significantly throughout the past few years (Lutz de Wet, 2016).

Moreover, this growth of unplanned informal settlements, wherein access to public transport routes are not available, also gives strain to the wilderness, eco-systems and other arable land or natural resources within the area (Lutz de Wet, 2016).

It is therefore clear, that issues related to the spatial structure within the area are present. However, understanding these is just, but one of the first pillars in describing the study area. Within the next

section, the demographics of the Cape Winelands will be discussed. This will include population numbers, density, age and gender profiles, as well as education characteristics and current economic performance.

7.4 Socio-economic profile

The purpose of this socio-economic profile is to describe the demographics, the current education situation, as well as economic performance of the area. The data and analysis here will be based on the NHTS (unless otherwise stated) and will present a context and baseline to further analyse these aspects with regards to accessibility levels. The intent here is to establish a foundation to understand the current situation of the area.

7.4.1 Demographics

According to the Cape Winelands District IDP (2016), there are 831 716 people (218 620 households) that live within the area, making it the second largest populated district and constituting with that, 13.2 % of the entire population in the province. However, despite this significant percentage, the population growth rate within the area is currently only at 0.8% (Cape Winelands District Municipality, 2012), different than the prediction of earlier studies (2,1%) and well below the national average (1.16%) (CWD Spatial Development Framework, 2009). Additionally, this growth is not evenly distributed within the five local municipalities, having

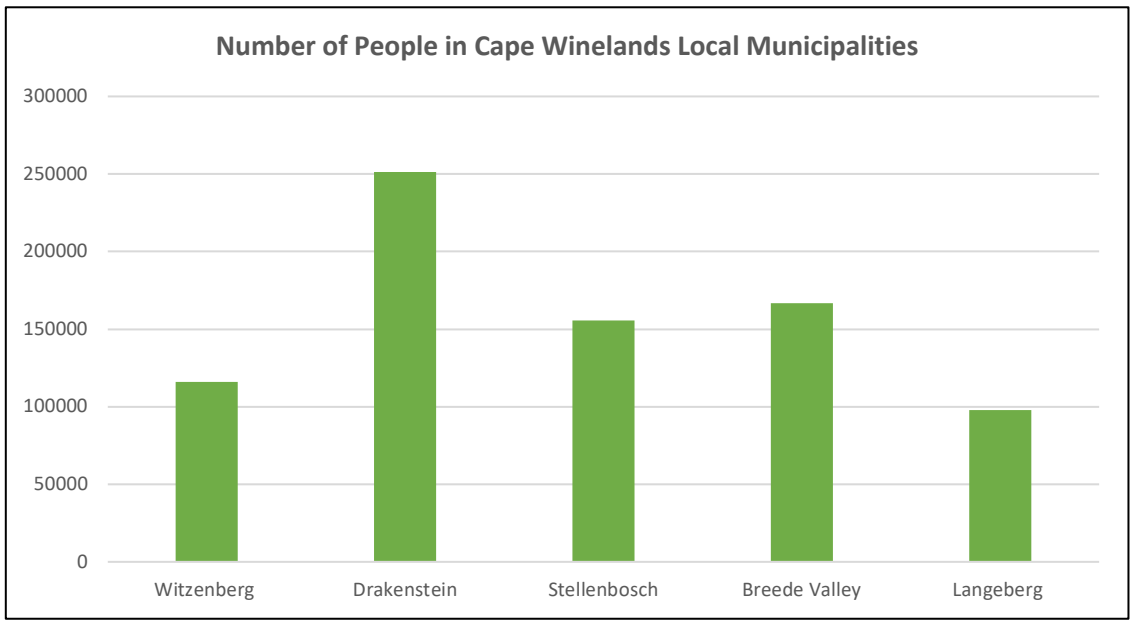


Figure 27. Number of People in Cape Winelands Local Municipalities
(Adapted from Cape Winelands District Municipality, 2012)

Drakenstein and Breede Valley the greatest joint shares according to the Census 2011 and Langeberg the least prominent. Figure 27 shows the distribution of the population within the different local municipalities of the district.

Another consideration when investigating the demographics of an area is its densification. From Figure 28 it can be seen that largest densities are located in Stellenbosch and Drakenstein, the smallest and highly populated local municipalities. Although Breede Valley is the second most populated region, its areal distribution presents less densification, potentially indicating urban sprawl. Notably, Witzenberg is the least densified area, given its extensive area and low number of people resident. This shows that analysis and results within the north of Witzenberg are almost insignificant and should not be taken as the major concern.

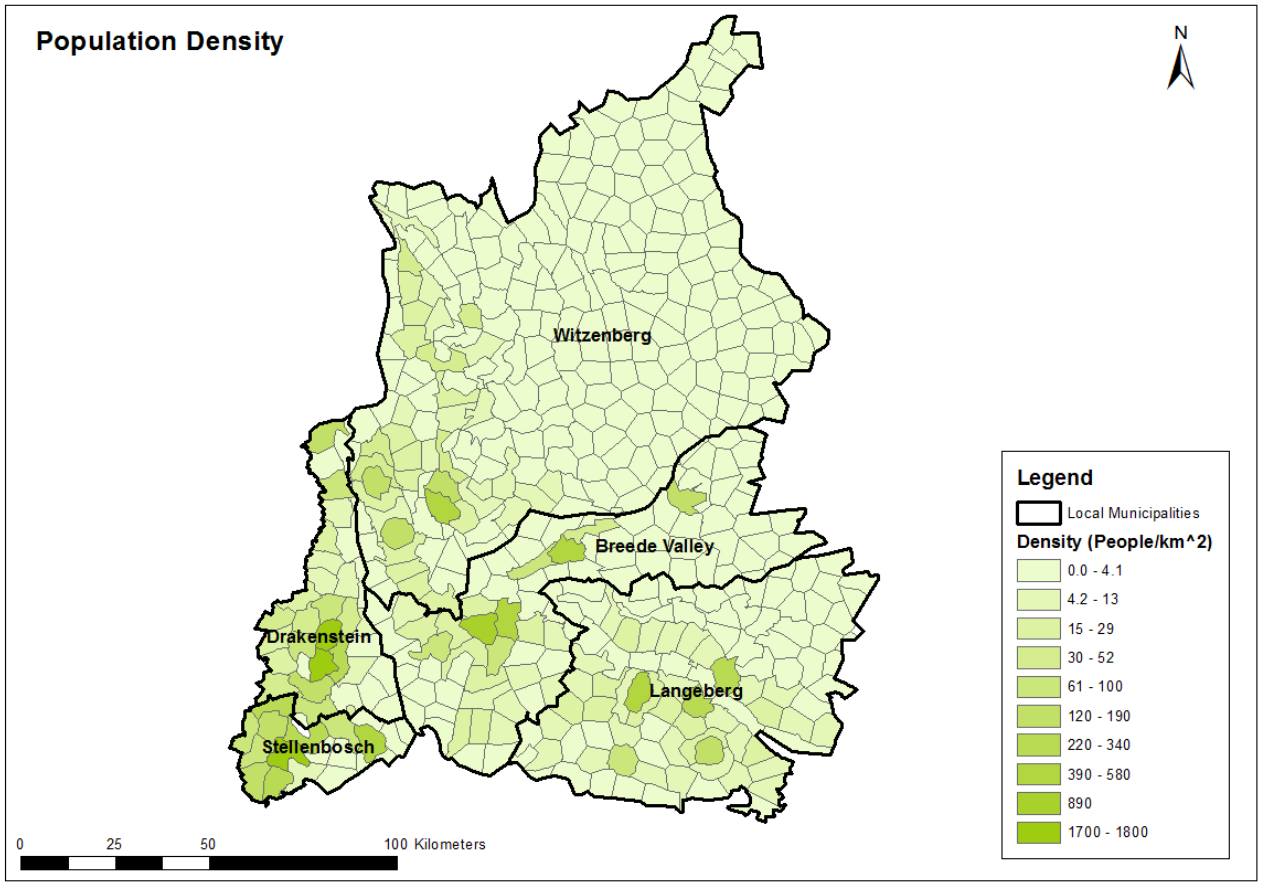


Figure 28. Population Density Distribution in Cape Winelands
(Based on Census, 2011)

Apart, from the distribution of the population within the Cape Winelands, the age constitutes a resourceful aspect that can assist in targeting and identifying specific characteristics of the district.

When looking at male and female distribution, the split is fairly equal wherein 50.5% is female and 49.5% male, resembling the results achieved in Chapter 6 for each province.

Figure 29 illustrates the population pyramid for this District Municipality. The wide bottom base and the gradual narrowing towards older ages, indicates higher death rates in the later groups, which naturally represents healthy demographics trend (Cape Winelands District Municipality, 2012).

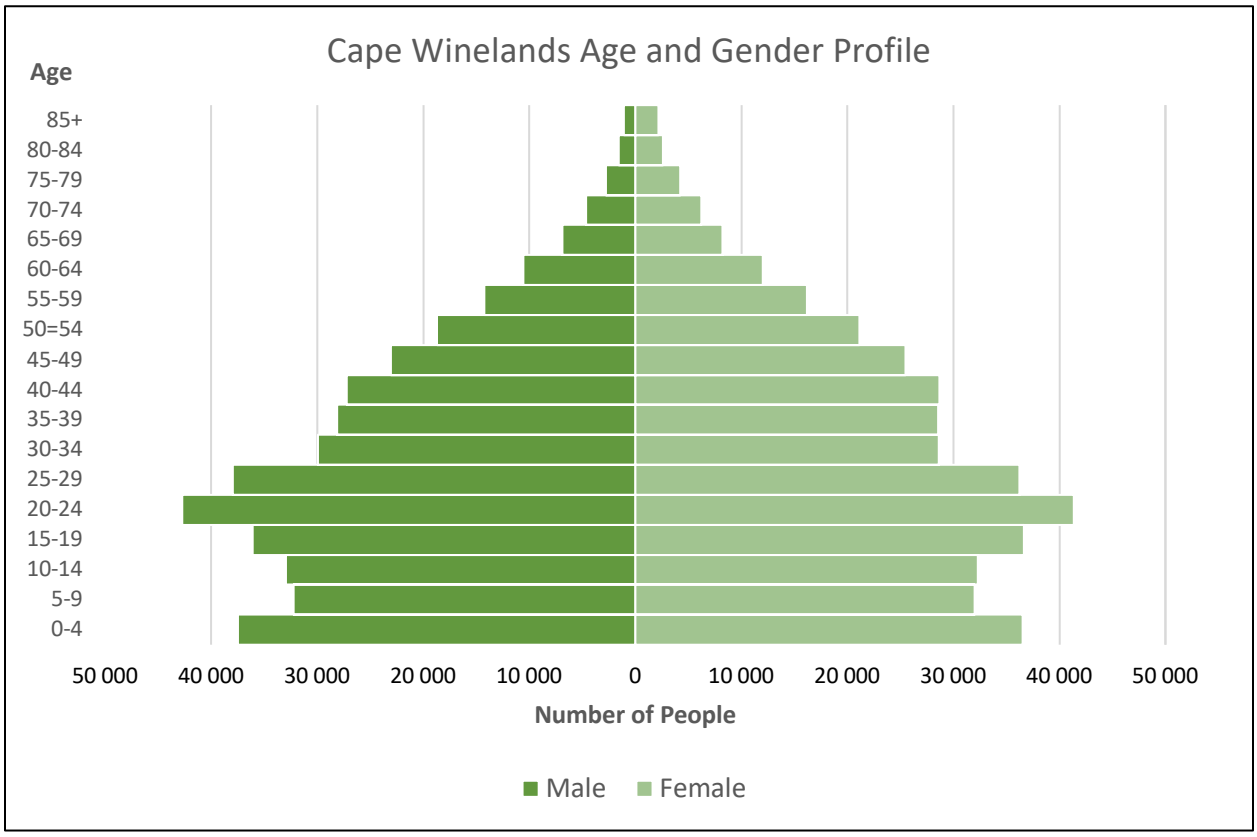


Figure 29. Cape Winelands Age and Gender Profile
(Adapted from Cape Winelands District Municipality, 2012)

Additionally, the age profile structured within an area provides great insight on the marketable cluster, helping determine the Potentially Economic Active people (PEA) and allowing the establishment of possible policy changes (Cape Winelands District Municipality, 2012).

There are three main categories that normally group ages by its cohorts, namely:

1. Children: 0 -14 years
2. Economically active population: 15 – 64 years
3. Pensioners: 65 years and above

The distribution of such categories in the Cape Winelands District Municipality can be seen in Figure 30. Moreover, 17.5% of the population fall within the 5 to 14 year old age bracket, which is a significant number of residents still possibly undertaking their studies and, therefore, showing the need to address possible accessibility issues (Cape Winelands District Municipality, 2012).

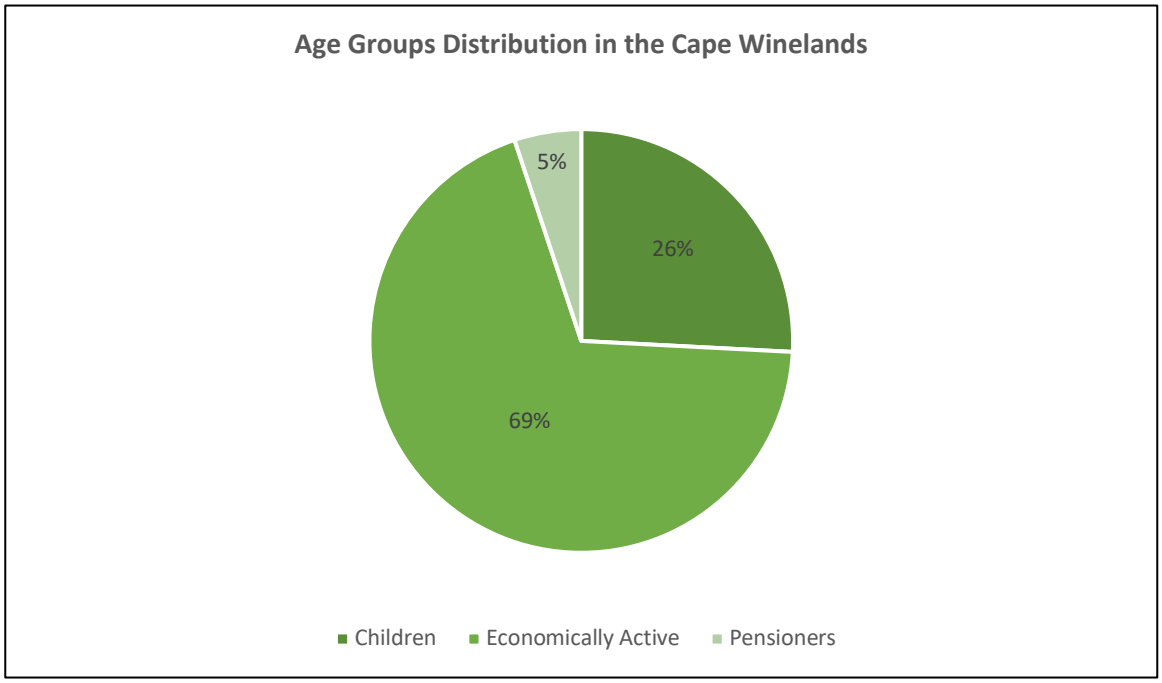


Figure 30. Age Groups Distribution in the Cape Winelands
(Adapted from Cape Winelands District Municipality, 2012)

7.4.2 Education Characteristics

Education is one of the indicators for human development, as it has a direct influence on the ability to choose between different career paths and on a person's income. The district has 276 schools wherein 188 declare "no fees". Moreover, the region presents various further post-secondary education facilities, such as the Boland College and the Stellenbosch University (URBAN-ECON, 2011). Figure 31 illustrates the distribution of schools within the area. It can be seen that greater clustering is located within Drakenstein and Stellenbosch, in accordance with the density of the population shown earlier in Figure 28.

Furthermore, when looking at the education levels in the region - although the majority of the population has some education level, there are still 7.6% with no schooling experience. Apart from this, 25.4% and 28% have not completed their primary and secondary studies respectively

(URBAN-ECON, 2011). This means that more than 50% of the population cannot benefit from higher education. Taking this into consideration, the next sections will describe the current economic situation of the district and its challenges.

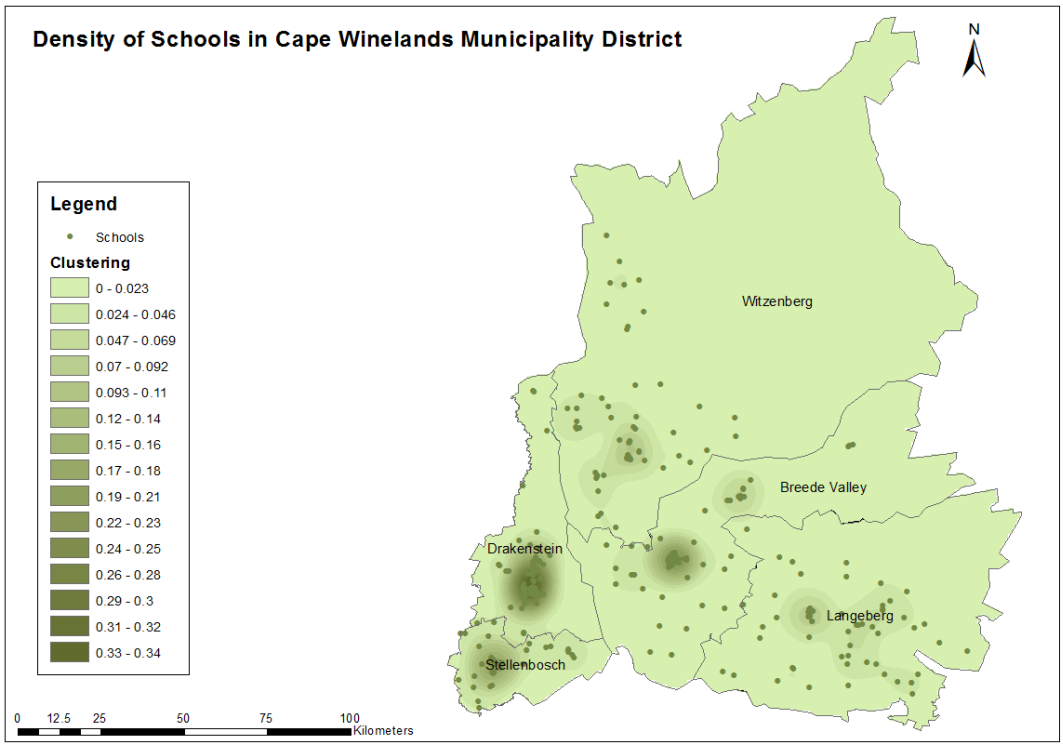


Figure 31. Density of Schools in CWD
(Based on Department of Education)

7.4.3 Performance and Economic Development

The economic development of any region is heterodox and, therefore, subjected to the environment and the skills available within itself (Wyngaard, 2006). The Cape Winelands District Municipality's (CWDM's) economic growth is mostly dependent on the agricultural sector that contributes about 14% of the region's GDP and represents around 38% of the labour force (Cape Winelands District Municipality, 2012). At the provincial level, the district contributes 11.2% of the overall economic output, which makes it the second largest economic contributor - following the City of Cape Town (Western Cape Government Provincial Treasury, 2018).

Apart from the agricultural sector, the district is well known for its natural beauty, wine and subsequently well-developed tourism (Boulle and Newton, 2007). Moreover, its proximity to two major harbours in the province and to an extensive market make it a well-placed district in economic participation (URBAN-ECON, 2011). However, the economic performance within the

region is unsystematic in all municipalities, given the size and extent of the area that it comprises. Nonetheless, this unsystematic distribution of opportunities contributes to a part of the population being highly skilled and increasing the value of land for housing and farming, and the other part being low-income and struggling with poor services access and living standards (URBAN-ECON, 2011).

There are five primary functional regions within the Cape Winelands that have distinct economic value chains, namely (Boulle and Newton, 2007):

- Stellenbosch;
- Paarl, Wellington and surrounding farm lands;
- Hex River Valley and De Doorns;
- Tulbagh and Ceres; as well as
- Montagu and Robertson.

Table 6 summarises their economic values based on Boulle and Newton (2007).

Table 6. CWD Economic Functional Regions

Functional Region	Economic Value
Stellenbosch	Economic gateway due to proximity to Cape Town Metropole; provision of services to rural population; regional education hub
Paarl Wellington and surrounding farm lands	Hubs of wine and agritourism; provision of services to rural community and agricultural industry
Hex River Valley and De Doorns	Production of fruits; conducive to the development of agritourism
Tulbagh and Ceres	Well-known production of fruits; extensive agri-processing capacity
Montagu and Robertson	Producer of wine and table grapes

Additionally, 77% of the building activity within the CWDM is concentrated in only two municipalities: Stellenbosch and Drakenstein. In their totality, they account for 70% of the total industrial space (Rode Plan, 2010). Consequently, the budget totals for these two urbanised municipalities is much different than for the remainder three more rural municipalities (Rode Plan, 2010).

7.5 Poverty and Challenges

When determining the poverty levels in a community, income-levels are seen as an indication and foundation for the analysis. Moreover, such income-levels can be the bridge to understand the economic behaviour (Cape Winelands District Municipality, 2012).

One way to determine a household income of all members is by looking at the labour remuneration, transfers from government, incorporated businesses and sources. Within the CWD, 27.3% of the households fall within poverty levels, earning between R0 to R42000 annually (as seen in Figure 32). Nonetheless, the middle-income group still remains the highest group in the area, as 62.7% of the households fall between this range (R42 001 – R360 000) (URBAN-ECON, 2011).

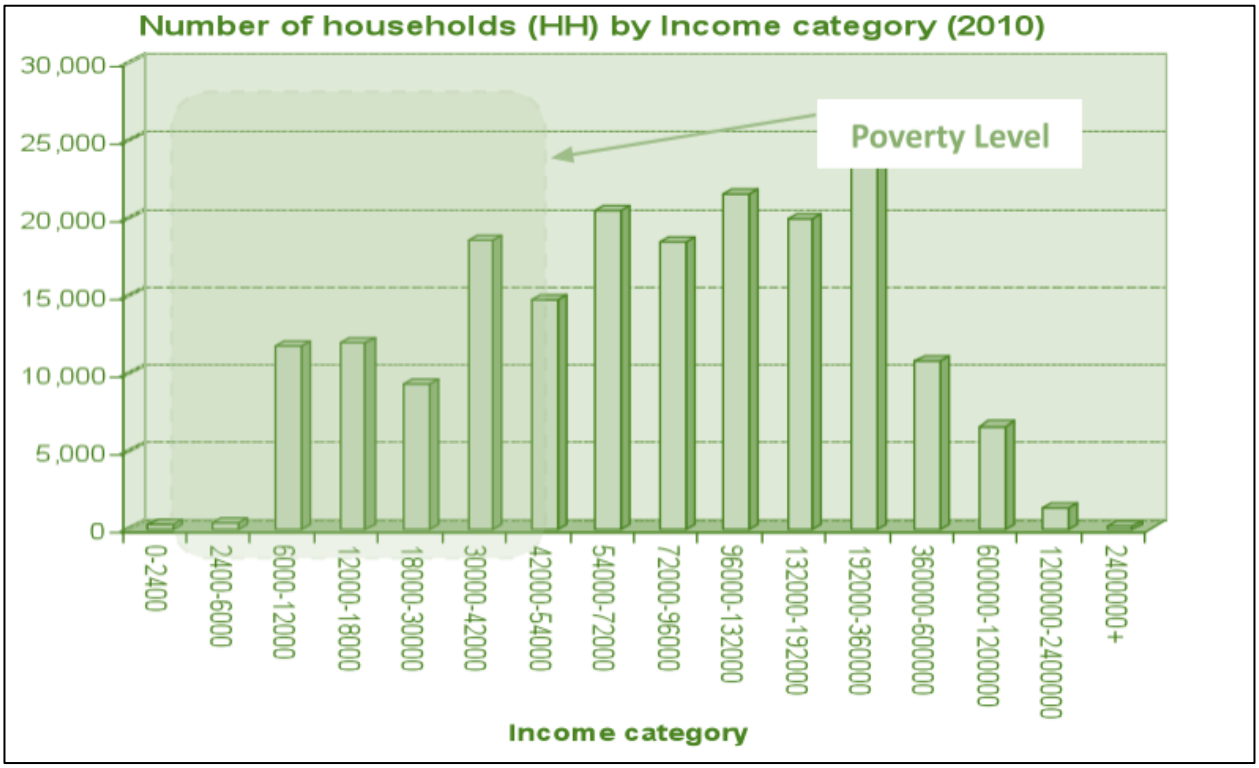


Figure 32. Number of HH by Income Category in CWD
(Source: Global Insight Regional eXplorer Database, 2012)

Additionally, lower income levels will not improve until household members achieve higher skills through training and better education that will allow them into higher skilled economic sectors (Cape Winelands District Municipality, 2012).

These groups may account for one of the biggest challenges in the area: crime and drug addiction (URBAN-ECON, 2011).

7.6 Résumé

The CWDM covers 21 473 km^2 of South Africa and is divided into five local municipalities, namely: Witzenberg, Drakenstein, Stellenbosch, Breed Valley and Langeberg. The region is well known for its mountainous terrain and river valleys, that are a great asset to the economy of the district. Moreover, the Mediterranean climate characteristic of the area has its impact on the agriculture practiced in the sub-regions – source of one of its greatest economic treasures.

Apart from those characteristics, the geography of the region plays an enormous role in the provision of access to people and services (Linard et al., 2012). The Cape Winelands has been historically developed through settlements along transport and fluvial systems, this resulted in a star-shaped urban form that renders many challenges to the area, being urban sprawl a specific one (Lutz de Wet, 2016).

When looking at the demographics within the area, there are 831 716 people (218 620 households) currently living in the area, comprising 13.2% of the entire population of the province, making this district the second largest contributor (Cape Winelands District Municipality, 2012)

However, when looking at one of the most important indicators of social development (i.e. education), there are still 7.6% of the population with no formal schooling experience and about 50% with incomplete studies, hindering individuals from employment opportunities or undertaking post-secondary education (URBAN-ECON, 2011).

The district contributes 11.2% of the overall provincial economic output and is led by five regions with great economic values within different sectors - from tourism to production of fruits (Boulle and Newton, 2007). However, the area still experiences a significant amount of household members living within or below the poverty level bracket. This may contribute to two of the greatest challenges within the region: drug usage and high crime levels.

Chapter 8

Study Results and Assessment

This chapter provides an overview of the different levels of accessibility to schools verified in the Cape Winelands District Municipality. The inputs to this process of accessibility quantification included travel time, distance, as well as the attractiveness of each school. These inputs were used to calculate the index based on two different methods: gravity model (to determine potential accessibility given the existing schools); and measured travel time (given the real accessibility based on travel time). These two alternative methods lead to the accumulation of results illustrated in maps generated using ArcGIS.

As previously discussed in Chapter 5, given the scarcity of the data available, the choice of area to place emphasis on was limited. The types of schools considered were primary and secondary in addition to combined schools that were incorporated in the analysis of the two. For further clarification, the database of schools used for the analysis are found in Appendix C.

Preceding the calculation and analysis of the accessibility index for the different types of schools, this chapter will give an overview of the proximity of schools to each centroid established (database given in Appendix A), as well as the spatial variation of attractiveness of different schools based on parameters established in Chapter 5.

A framework of the analysis presented on this chapter is given in Figure 33.

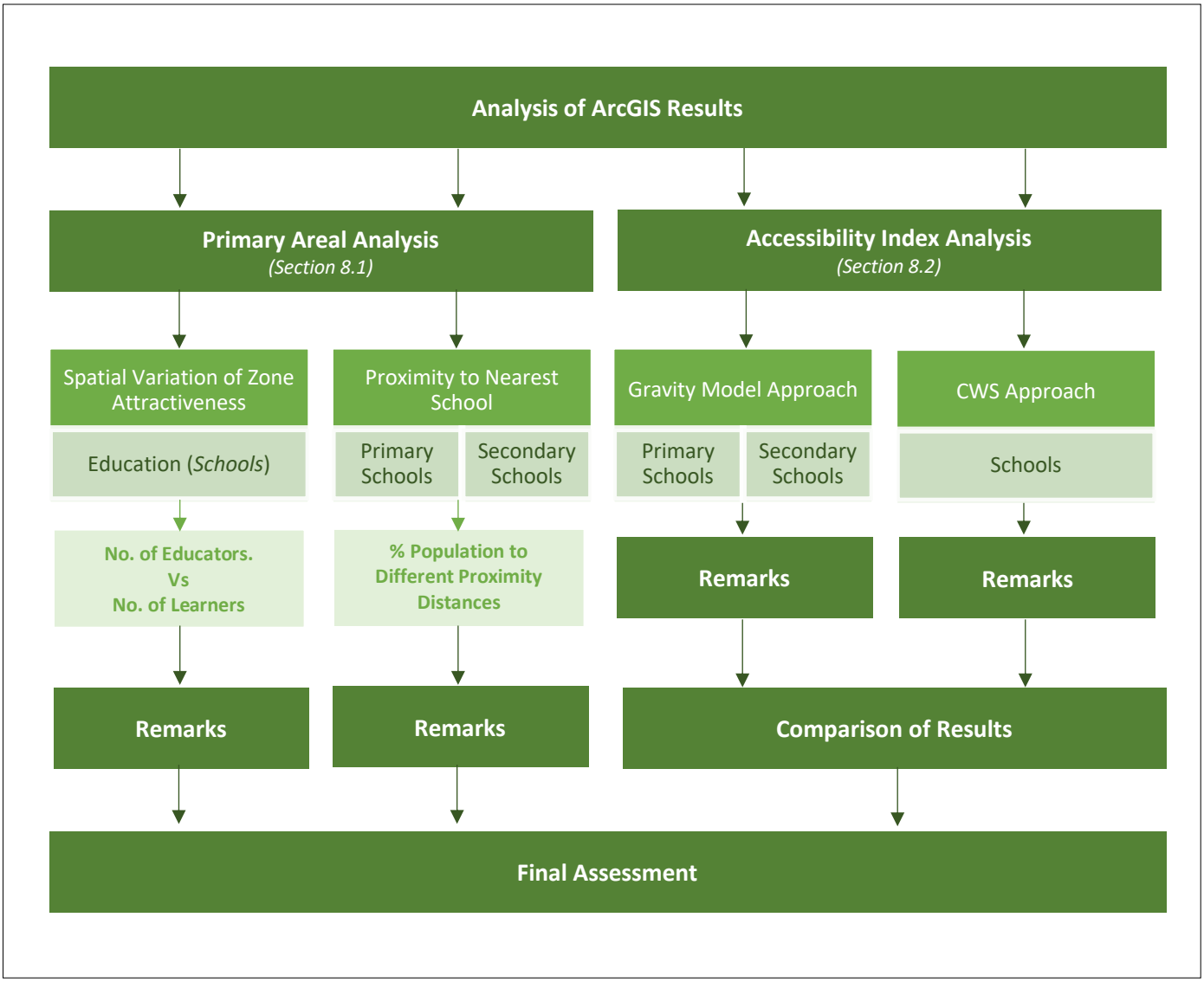


Figure 33. Analysis Framework

8.1 Primary Areal Analysis

Prior to the calculation and mapping of the accessibility index within the Cape Winelands Municipality, a spatial analysis was conducted. The data acquired was the basis for this primary investigation. In this section a review will be made in relation to the results obtained.

Initially, proximity to nearest schools will be determined. This will be done, not by using the road network of the area, but through a straight-line basis, from the centroid of each meso-zone (database found in Appendix A) to the nearest school. Although results are not strictly accurate, they give an indication of the number of people schools can serve through a radial reach. Moreover,

it is also known that not the entire population within the area is in need of such services, therefore, the number of households at radial reach will also be indicated.

After this, variation of attractiveness of each school will be illustrated within a map. This will aid the identification of the most enticing schools and determine schools that have a greater need for improvement. Thereafter, attractiveness will be evaluated through the ratio of educators to students attending (determined in Chapter 5).

Given this description, proximity to nearest school will be analysed in the following section.

8.1.1 Proximity to Nearest School

Looking at the map in Figure 34 and Figure 35 (page 107) it can be seen that minimal (less than 1500 meters) radial distances to primary schools and secondary schools are located in the surroundings of the municipality's principal towns. This is a predictive result as schools would mainly be located in those towns. However, when comparing the spread between the two maps, it is evident that primary schools reach a far greater area of acceptable distance than secondary schools.

Moreover, summary statistics of these distances are shown in *Table 7*. On average, proximity distances to primary and secondary schools is about 20 km and 24 km, respectively. This demonstrates that there is difference of approximately 5 km between school types. However, these distances include the entirety of the district municipality, and the spread of population has shown that greatest density is similarly located in the principal towns. For that reason, Figure 36 and Figure 37 show the percentage of population and households having different distance brackets.

Table 7. Summary Statistics of Radial Distances from Centroids to Schools

	Proximity Distance (meters)				
School Type	Minimum	Maximum	Mean	Average	Standard Deviation
Primary	245,9	108700	18450	19931	21750
Secondary	298,7	110000	22920	24436	21080

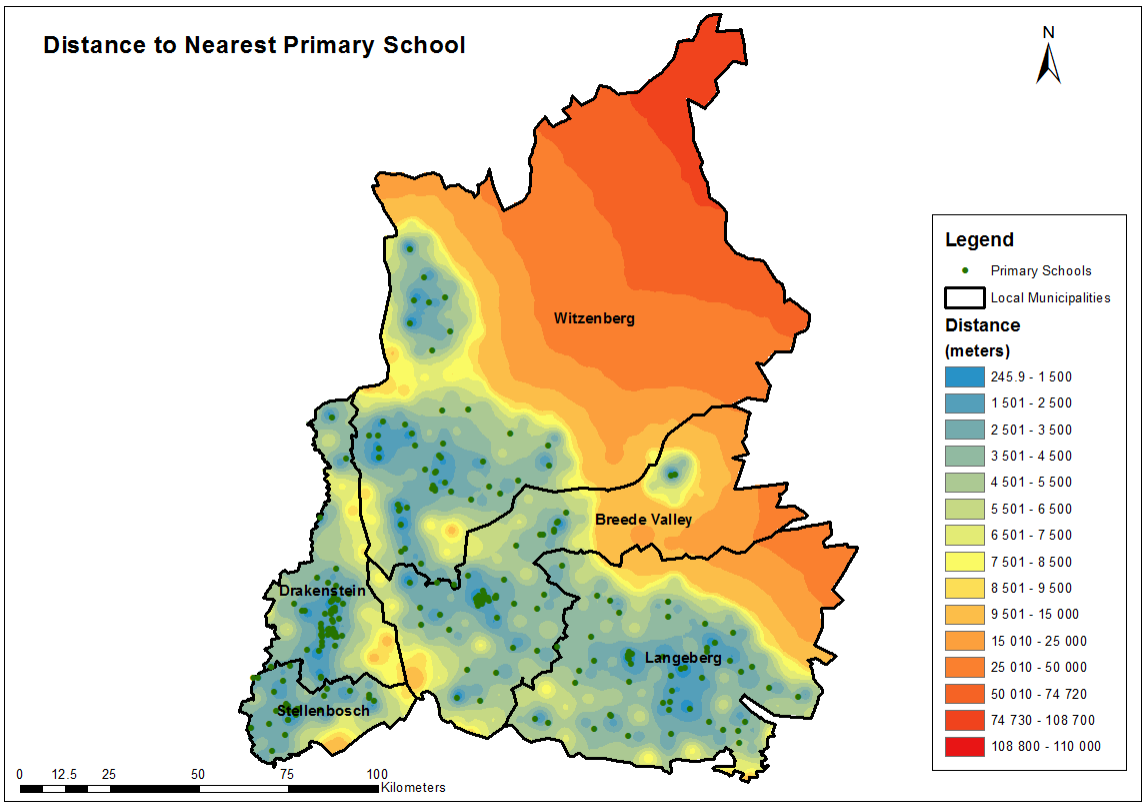


Figure 34. Distance to Nearest Primary School from Centroids

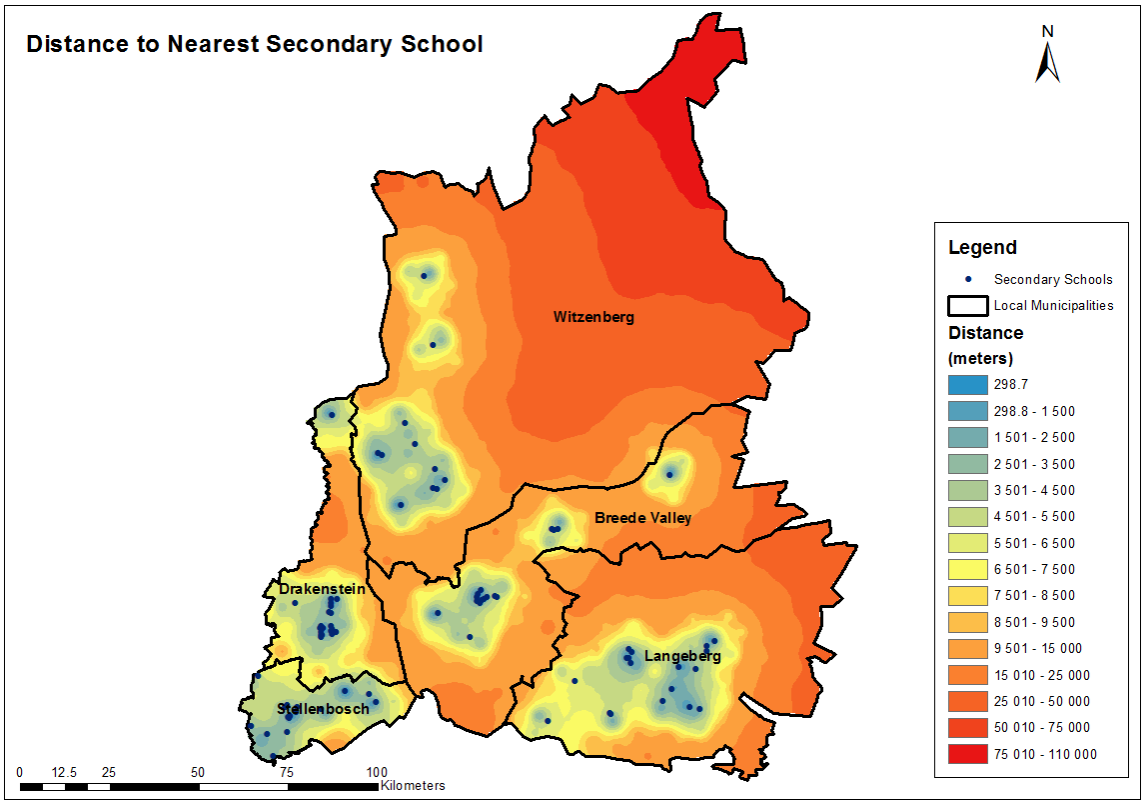


Figure 35. Distance to Nearest Secondary School from Centroids

It can be seen in Figure 36 that 28% of the population has a radial distance of 800 to 1200 meters to both primary and secondary schools. In addition, only 5% and 17% of the population are impacted by distances greater than 3.6 km for primary and secondary schools, respectively. This indicates that a majority of the population benefit from the location of schools within the district.

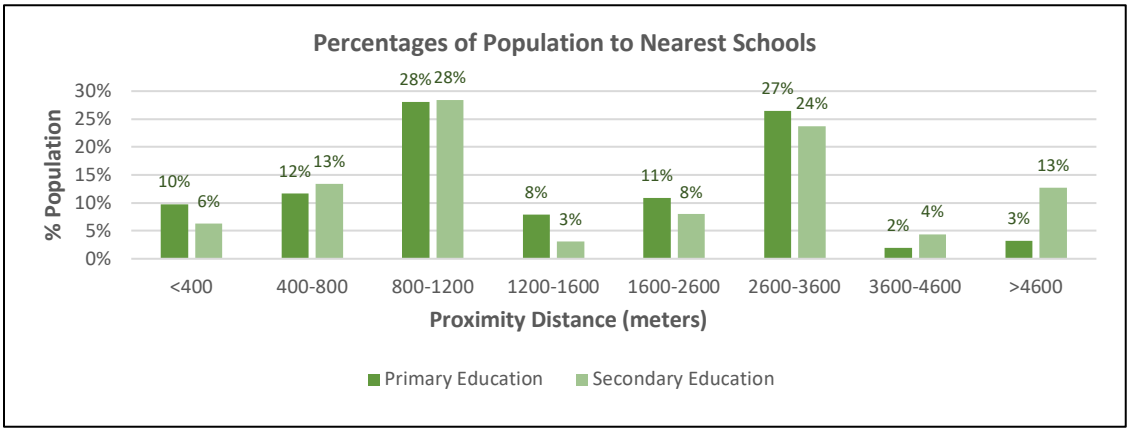


Figure 36. Percentage of Population to Nearest Schools

The same occurs when looking at the number of households benefiting from those distances as shown in Figure 37. However, in this case the number of households for secondary education with radial distances greater than 3.6 kilometres is of 21%. This bears a considerable amount of people experiencing issues with regards to proximity to schools.

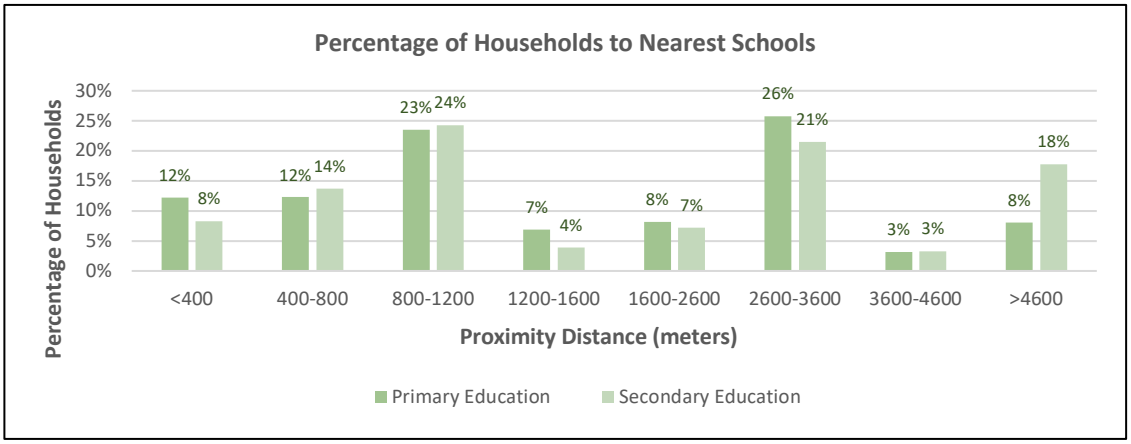


Figure 37. Percentage of Households to Nearest Schools

The cumulative frequency of the population to different distances is shown in Figure 38 and Figure 39 for Primary and Secondary Schools, congruently. In these charts it can be seen that most people experience a proximity of 10km or below to schools, thereafter, the decrease is significantly high as distances increase.

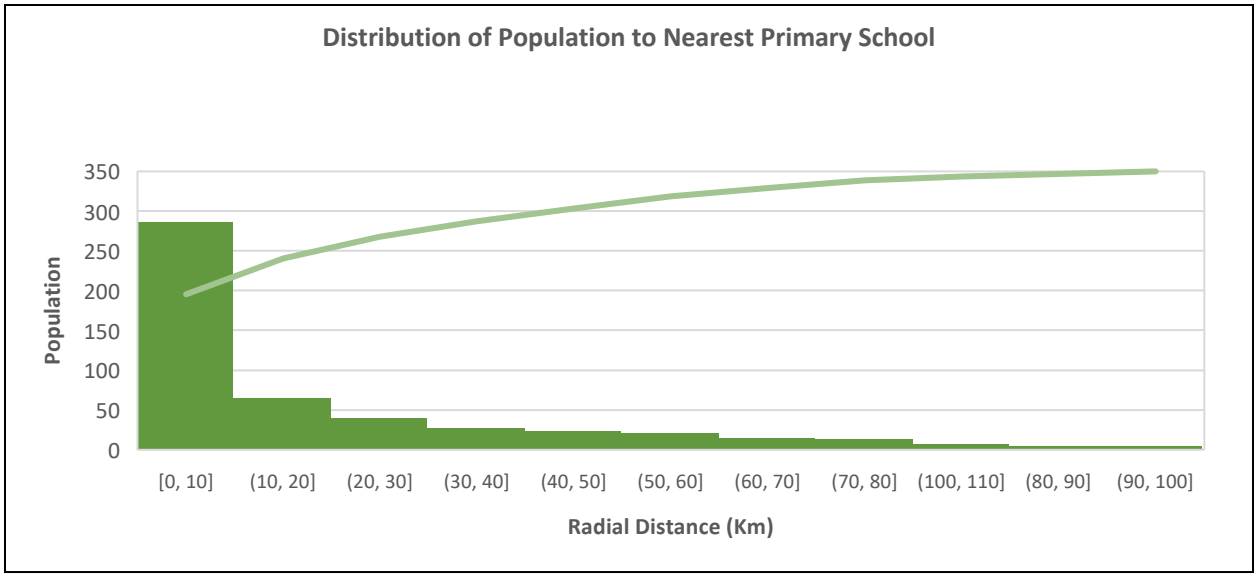


Figure 38. Distribution of Population to Nearest Primary School

The increase in frequency is insignificant for primary schools. However, for secondary schools this tendency extends further into 20 km.

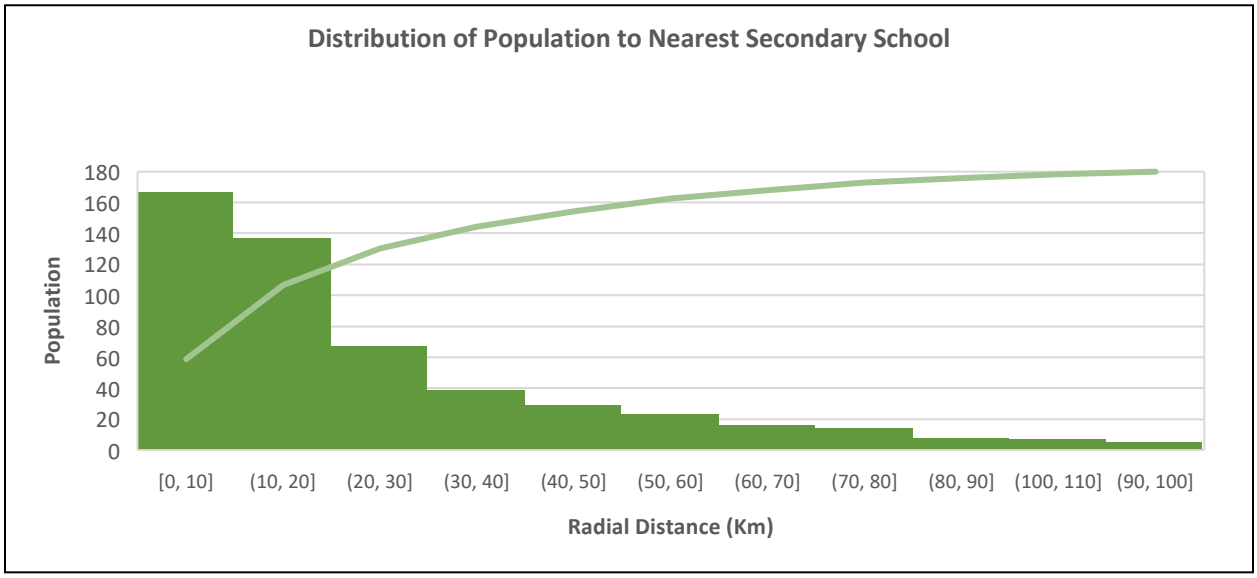


Figure 39. Distribution of Population to Nearest Secondary School

8.1.2 Attractiveness Variation of Schools

There is no doubt that a place's attractiveness and development is highly dependent on the probability of individuals to utilise the amenities available (Öner, 2017). Considering the dependency of population's decision to attend a certain school, it was found that attractiveness to

such schools was an indispensable indicator of accessibility. With this in mind, this Section attempts to extrapolate the attractiveness of schools (a_j) based on Equation 6 shown in Chapter 5:

$$a_j = \frac{No.of\ Educators}{No.of\ Learners}$$

It was determined that for better visual understanding, the results obtained for each school should be illustrated based on gradual proportion. This means that the greater the bracket of attraction within a school, the more expanded the symbol.

Considering the fact that within this analysis primary and secondary schools were both looked at in order to provide a more stable grounding regarding the matter, this Section will first discuss primary schools' attractiveness and thereafter, secondary schools. One detail that is important to mention is the disproportionality of the number of primary schools (233) to secondary schools (83). This means that the limitations imposed between the two are not efficiently comparable.

8.1.2.1 Primary Schools

Figure 40 illustrates the level of attractiveness of the 233 primary schools present within the district. Looking at the map, it can be seen that the distribution of attractiveness is highly spaced out through the entire area. This is a great indication to conserve the idea that the dispersion is uniform, giving the travellers the benefit of having a different set of choices.

Nevertheless, there are still quite a lot of schools that require attention - although they are existent, they may not be able to provide minimal standards. Looking at the minimal bracket verified during the calculations (1:30 – 1:42), 1 (one) educator is assigned to approximately 42 learners in 1 (one) of the schools, a ratio that secedes the norm of 1:30 for these institutions in South Africa determined by the Department of Education. Within this bracket 10 (ten) schools are present, encasing 4% of the entire number of primary schools in the district. Given these characteristics, further attention should be directed towards them in order to avoid compromising a few students.

Potential further improvement indication can be analysed by comparing the schools and relative ratios (see Table 8).

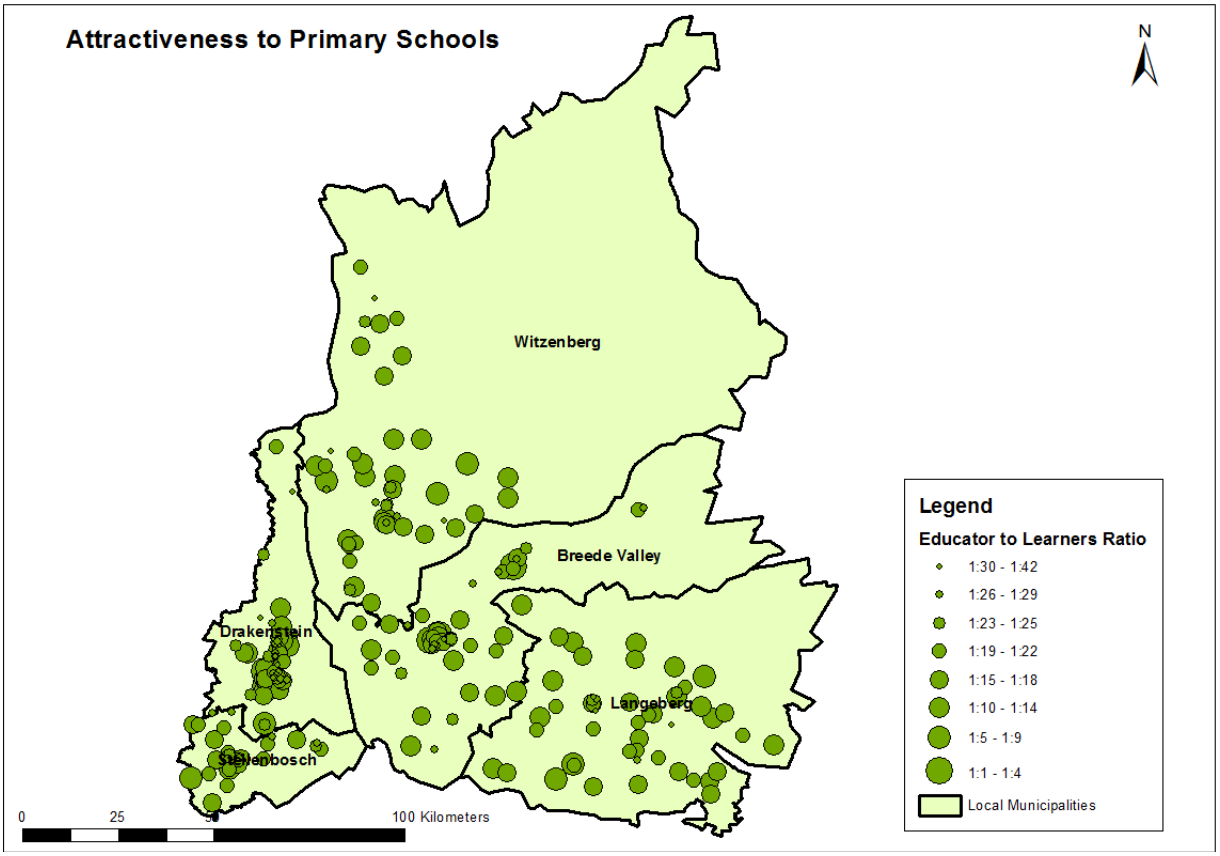


Figure 40. Attractiveness to Primary Schools

Table 8. Primary Schools Requiring Further Improvements

Ratio	Primary School Name	Local Municipality	Town
1:31	Bergrivier Ngk Primary	Drakenstein	Wellington
	Montrouge Vgk Primary	Witzenberg	Tulbagh
	Roodewal Primary	Breede Valley	Worcester
	Dalweide Primary	Drakenstein	Paarl
	Dagbreek Ls	Langeberg	Robertson
1:32	Boy Muller Primary	Witzenberg	Ceres
	Nkqubela Primary	Langeberg	Robertson
	Mary Help Of Christians Primary	Drakenstein	Paarl
1:33	Wanganella Ngk Primary	Witzenberg	Ceres
1:42	Stockwell Ngk Primary	Langeberg	Montagu

Given the featured results within primary schools, it might be of interest to further observe secondary schools and possibly establish a comparison between those two school phases.

8.1.2.2 Secondary Schools

Unlike the primary schools described previously, the level of attractiveness between the different local municipalities is comparatively uneven. Using Figure 41 to demonstrate this discrepancy, it can be understood that Stellenbosch presents the highest number of secondary schools with high attractiveness. This may be attributed to the presence of the University of Stellenbosch in the area.

Moreover, the degree of dispersion of schools within Drakenstein is highly disconcerting, given that greatest attractions are mainly centralised in Mbekweni towards Paarl (see Appendix D for location of cities within the area). This shows that people residing in Wellington have lesser opportunity of attending quality education.

Additionally, a difference that can be seen when looking at these institutions is the minimal bracket. Similar to primary schools, about 4% of secondary institutions fall out of the maximum ratio. For future reference in possible improvements a list is presented in Table *9*.

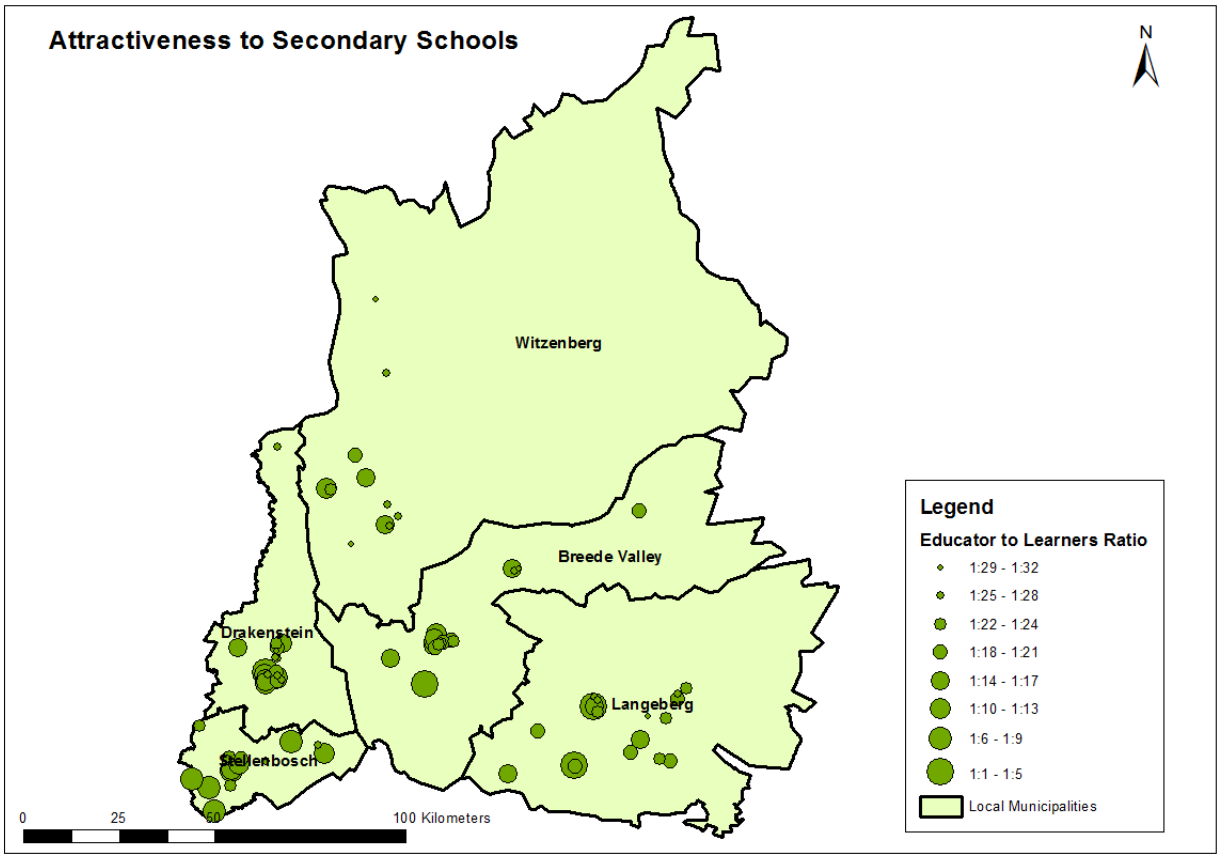


Figure 41. Attractiveness to Secondary Schools

Table 9. Secondary Schools Requiring Further Improvements

Ratio	Secondary School Name	Local Municipality	Town
1:31	Wellington Secondary	Drakenstein	Wellington
	Wolseley Sek.	Witzenberg	Tulbagh
1:32	Boy Muller	Witzenberg	Ceres

8.2 Analysis of Accessibility Index

As previously discussed, accessibility is directly related to the opportunities an individual possesses given its location to assume certain activities. This means that the land use and transport connections can participate in ways to handle and observe this concept (Rajendran et al., 2013).

There is no doubt that within rural areas sprawl of the population hinders access for the majority of inhabitants. Therefore, their choice in services is compromised - especially in low-income regions (Haynes et al., 2003). In the previous section, a primary areal analysis was conducted for two aspects that contribute a great deal in value towards accessibility analysis, namely: proximity (i.e. distance) and the attractiveness of schools. Within the previous analysis, some of the deficiencies within the study area have already been identified.

Given the importance that accessibility has in helping adjust and better accommodate under-served regions, this section will take one step further - diving into more solidified evaluations (Rajendran et al., 2013). Two main approaches will be used (shown in Figure 33):

- Approach 1: Usage of gravity measure; and
- Approach 2: Evaluation of survey conducted using travel time.

Approach 1 will be discussed initially, followed by Approach 2. Still, within this Section a comparative analysis of the results acquired will be made.

8.2.1 Gravity-based Approach

The gravity-based measurement is typically used to represent accessibility of opportunities, with distance decay taken into consideration. Moreover, the activities typically analysed are given a rate linked to the willingness that the population have to participate in them.

Earlier in Section 8.1.2, the means to determine attraction to schools had been described. In addition, given the extent that the scope of this research embraces, primary and secondary schools were mapped separately.

Within the first map, illustrated in Figure 42, it can be seen that accessibility is especially high and predominantly throughout the main towns of the district, namely: Stellenbosch, Wolseley, Worcester, De Doorns, Robertson and all main towns in Drakenstein (for better visuals see Appendix E). This could also be the case given the number of schools that can be found in those areas. Additionally, further north of Witzenberg the accessibility levels are incredibly low. This could justify the lack of schools within the area. However, such results are understandable, due to the low population density within this area.

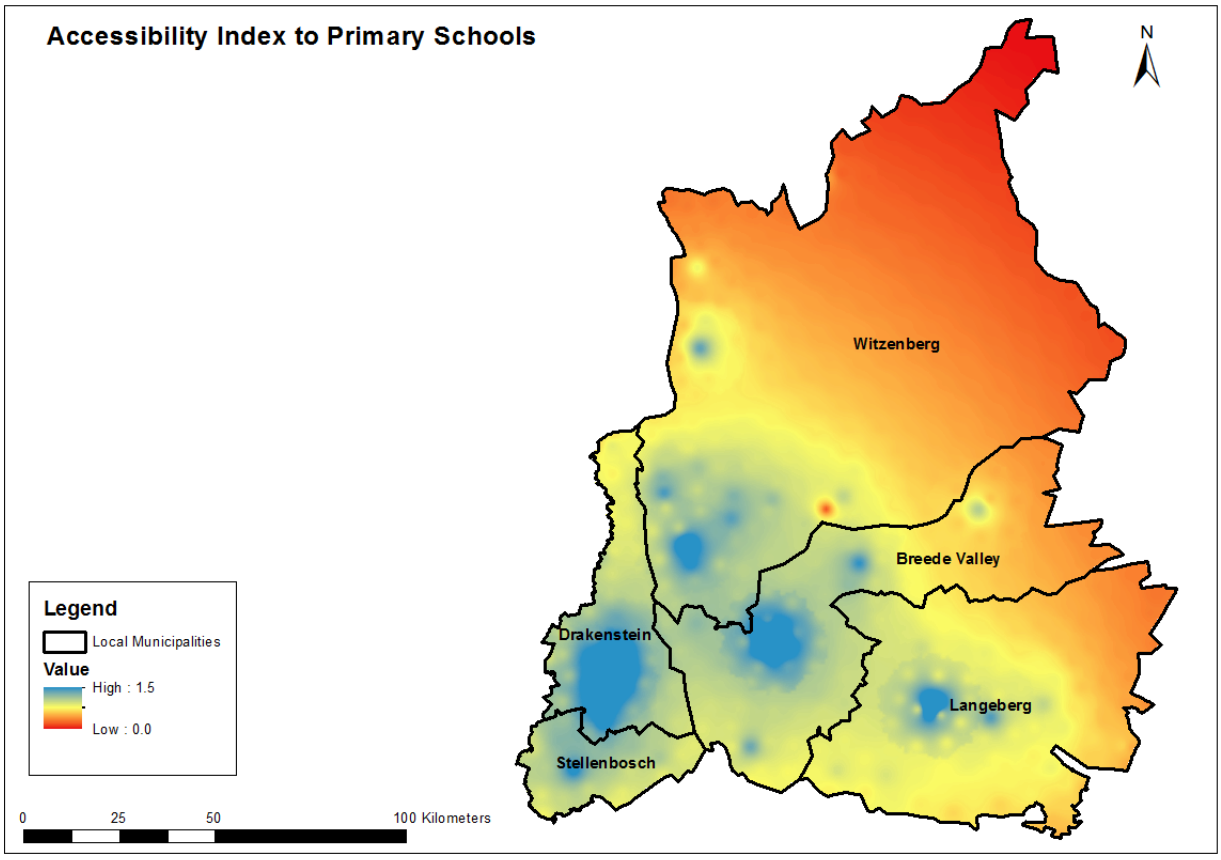


Figure 42. Accessibility Index to Primary Schools

When comparing Figure 42 to Figure 43 related to secondary schools, it can be seen that the level of access to secondary schools is more restricted in relation to the access to primary schools. However, when solely comparing the access within Stellenbosch it can be seen that greater access

to secondary education can be verified. One reason that this may occur is the location of the University of Stellenbosch within the region and, therefore, allowing a link from secondary to tertiary education.

Notwithstanding, apart from Stellenbosch and Drankenstein, only Robertson and Worcester present high accessibility values to secondary schools. The rest of the towns sit in between moderate and moderate to high accessibility to secondary schools. Naturally, up north Witzenberg same results are verified given the lack of infrastructure and demands for this service.

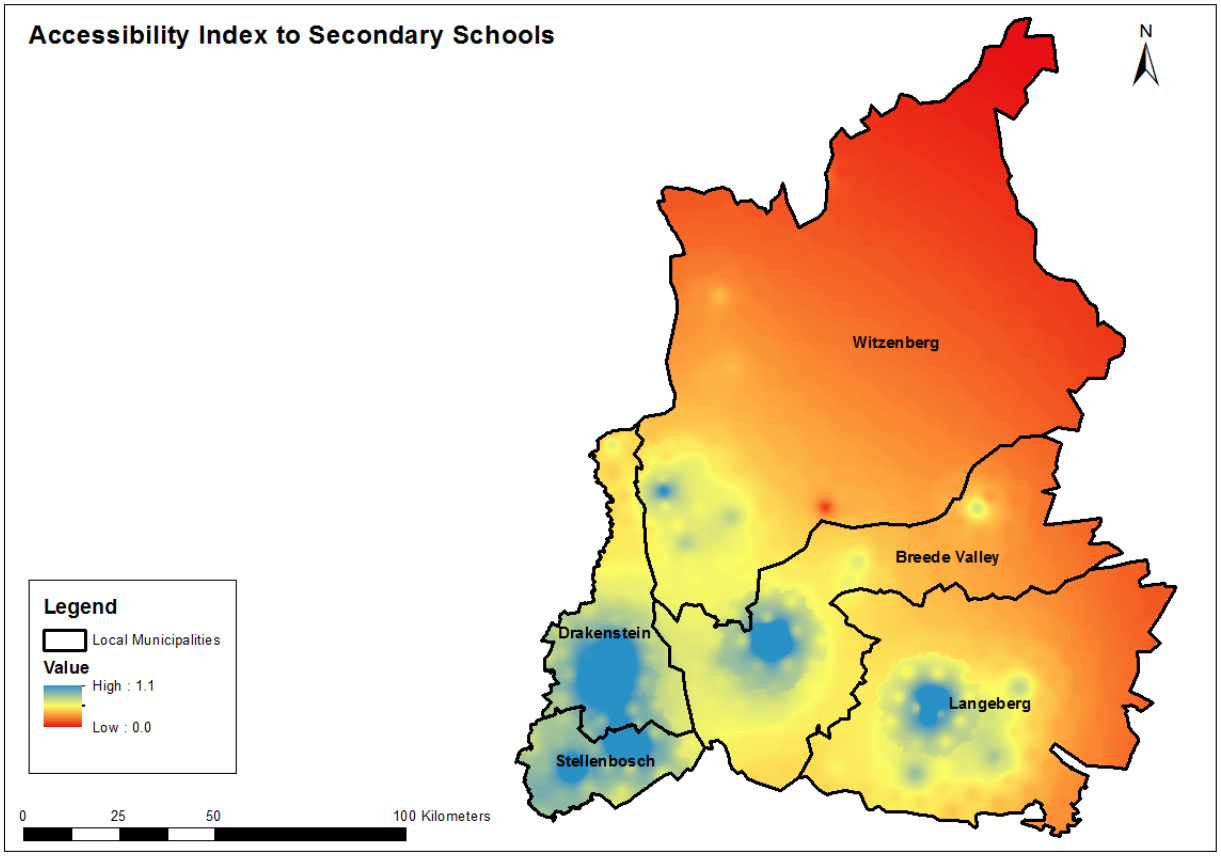


Figure 43. Accessibility Index to Secondary Schools

The key to be remembered in these two maps is the discrepancy of opportunities available to primary schools and secondary schools, showing the need for greater advancement. Moreover, what is also important to note is the population density shown earlier within this area (Chapter 7).

Given the disproportion of the population distribution within the area, the values of accessibility were distributed in Figure 44 according to the number of households experiencing it. For simplicity

purposes the levels of accessibility were divided into four brackets, shown in *Table 10*. These brackets were created based on the minimum, maximum, and average values.

Table 10. Accessibility Levels Range

Level	Accessibility Index Range
Extremely Low	0,0 - 0,08
Moderate	0,08 - 0,4
Moderate +	0,4 - 0,8
High	0,8 - 1,5

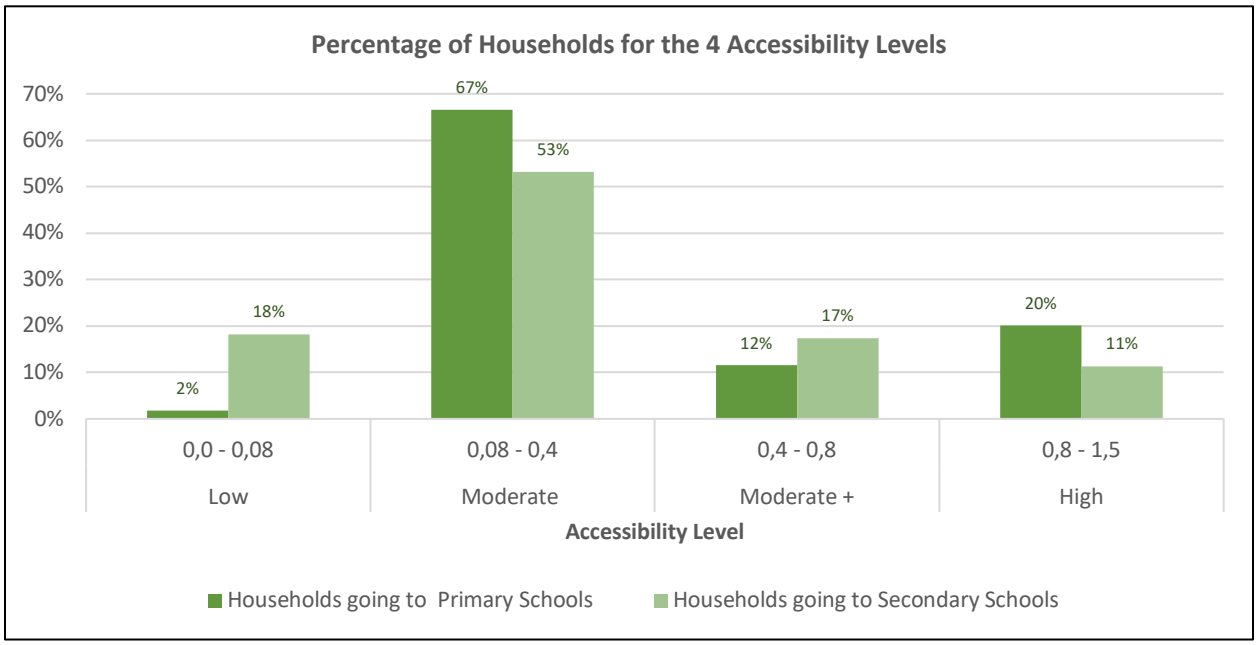


Figure 44. Percentage of Households for the 4 Accessibility Levels

As it can be seen, the two accessibility maps - previously shown in Figure 42 and Figure 43 - demonstrate a relatively similar distribution to the results obtained in Figure 44. However, although such results correspond accordingly, the limitations of the gravity model should not be forgotten. Therefore, Section 8.2.2 attempts to unravel this further to more realistic results experienced by the population rather than the theoretical computations provided in this section.

8.2.2 Cape Winelands Survey Approach

So far, various forms have been used to indicate the potential accessibility levels given the proximity to the institutions, as well as the attractiveness considered in the study. However, it is important to understand that, although the potential accessibility can indicate or point to possible

issues, it might not point out to the issues currently being experienced - especially when looking at other indicators of accessibility that may contribute to the issue.

Although there are a few indicators yet to be entirely investigated, such as affordability and transportation - apart from the proximity to schools, further information was acquired regarding the traveling time to institutions. However, the survey obtained was solely related to this aspect (travel time) with no other information corresponding to modes of transport used, income levels or type of school phase being frequented. Nonetheless, an accessibility map was produced to highlight the problematic areas based on this indicator, shown in Figure 45.

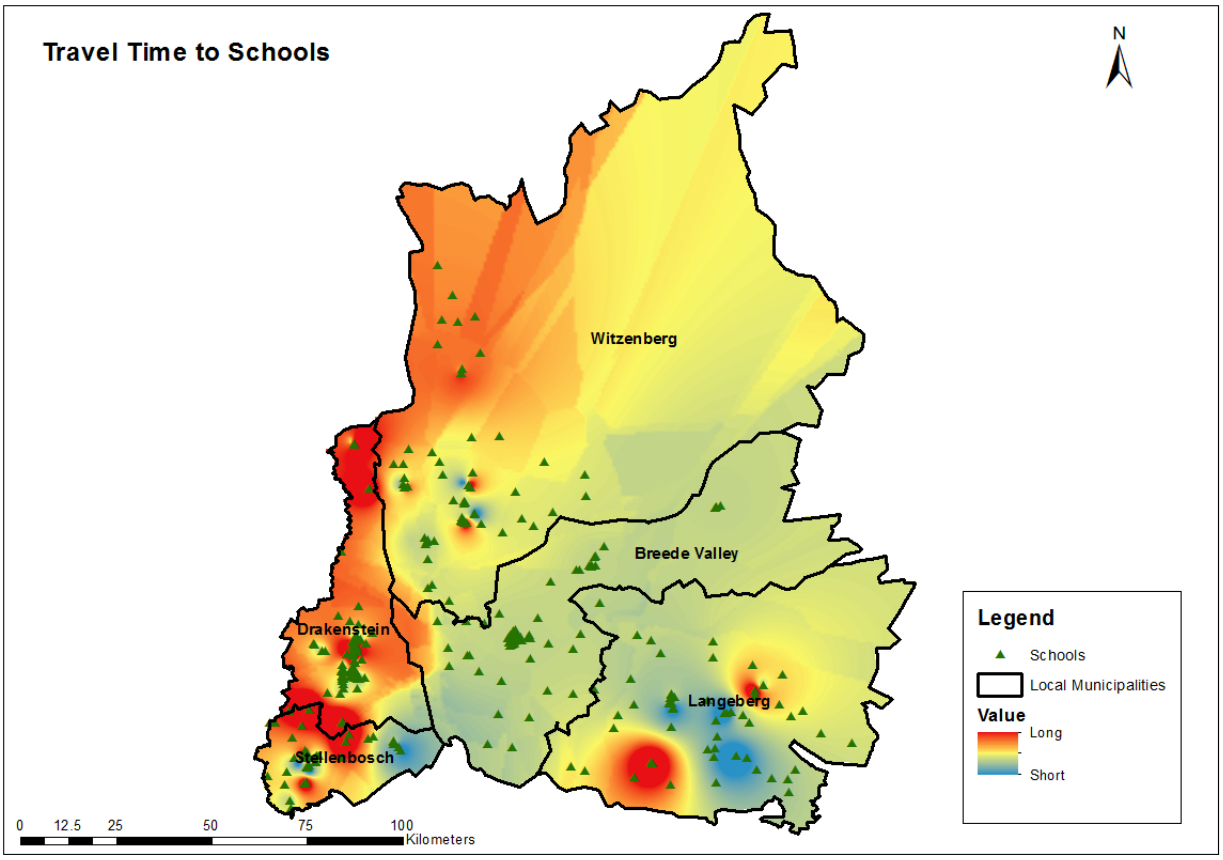


Figure 45. Travel Time to Schools based on CWS

Observably, contrary from the results acquired for the gravity model, the population is experiencing a rather problematic issue with traveling times. Apart from similar results in Stellenbosch and Robertson, most principal towns are experiencing critical results. This could be that although the proximity to schools is relatively good, an issue around transportation or

infrastructure might be influencing accessibility. Further discussions will be made in the subsequent section in order to compare the two types of results acquired.

8.2.3 Comparison of Results Acquired

One way of understanding the discrepancies within the results acquired using the gravity model (potential accessibility) and the travel times (experienced accessibility) can be seen in Figure 46. Result differences are shown clearly, wherein although less than 45% differences are prevalent, a great portion still has differences of 36% to 45%. This could be that although the area has great potential of access to schools, with regards to both their location and quality, the access being experienced by scholars is completely different.

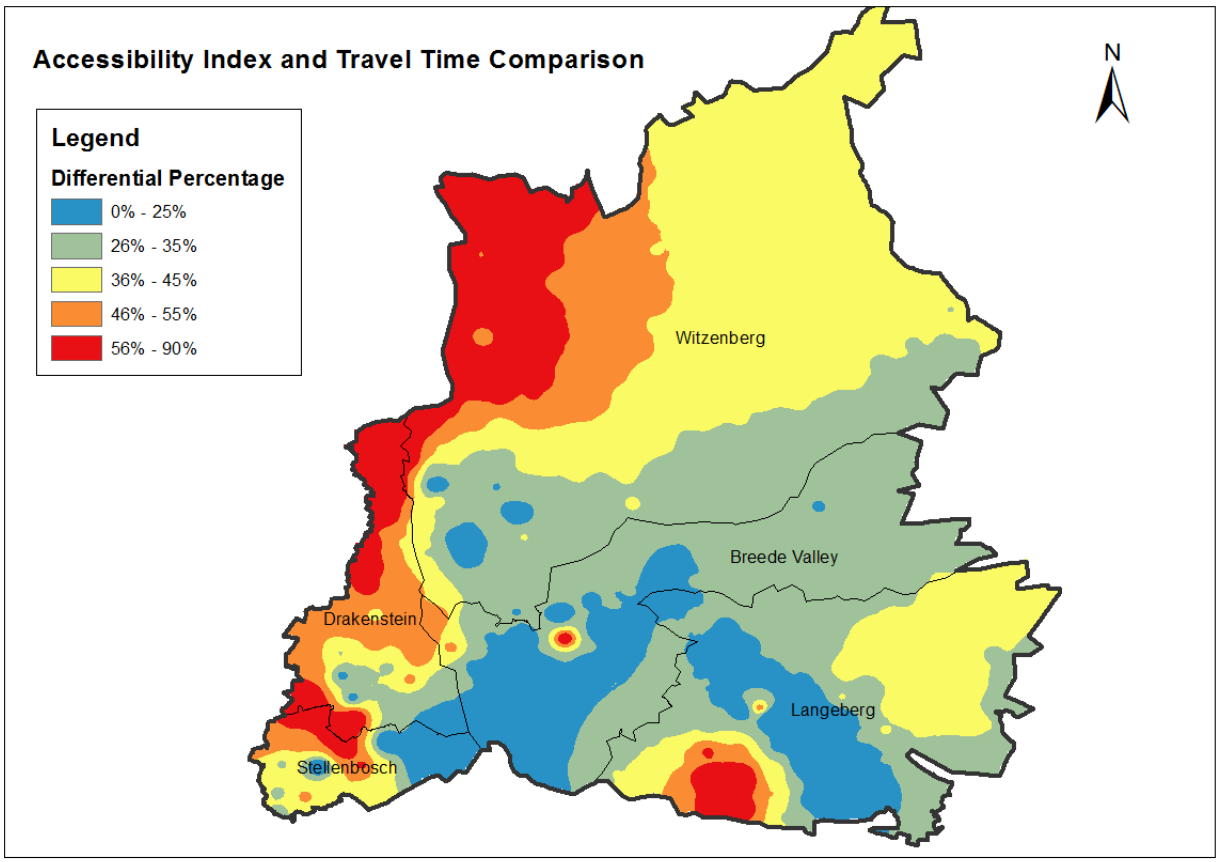


Figure 46. Accessibility Index and Travel Time Comparison

Further studies are therefore necessary to unravel other accessibility indicators that might influence this discrepancy in results such as transportation. Sadly, the data obtained for the purposes of this research does not present any information involving this indicator.

8.3 Final Assessment

The issue of accessibility is a rather complex concept. As earlier established in Chapter 2, there are several aspects contributing to its measures. The evaluation carried out in this chapter focused mainly on three indicators: proximity to schools, attractiveness of educational institutions and traveling times experienced.

Results have shown that, although potential accessibility levels experienced by the majority of the population are moderate, the real accessibility experienced shows different results. Moreover, the discrepancy in the provision of primary and secondary schools should also be assessed further.

The town of Stellenbosch is the region where the best accessibility levels are experienced, shown in both potential and real accessibility maps. On the other hand, the north of Witzenberg is the area experiencing the lowest accessibility results. However, this area is highly unpopulated which indicates that it is not the most critical issue experienced in the area.

Furthermore, exceptionally critical areas are: McGregor, Montagu, Franschoek, Mbekweni, Wellington, Ceres, Prince Alfred Hamlet and Wolseley, due to the discrepancy results of potential and real accessibility experienced. These towns constitute 44% of the entirety of principal towns in the district.

So far, it can be said that the level of inaccessibility experienced within the area is rather high, provisions should be made to counteract such results through further investigations that can determine all the issues contributing to such negative outcomes, starting off by looking at another accessibility indicator: Transportation and its conditions.

8.4 Résumé

This chapter discussed and reviewed different levels of accessibility to schools verified in the Cape Winelands District Municipality. This process comprised of two different steps, firstly a primary spatial analysis was done were two different indicators of accessibility were looked at: proximity to schools and attractiveness of institutions. After that, the gravity model was used to calculate accessibility within the area to both primary and secondary schools. And lastly, these results were compared to the real accessibility being experienced in the area, using the Cape Winelands Survey (CWS).

On average, 28% of the population present a radial distance of 800 to 1200 meters in closest proximity to both primary and secondary schools. Furthermore, only 5% and 17% of the population experience radial distances greater that 3.6 km (standard advisable for traveling distance), showing that most of the population benefit from the location of schools in terms of proximity.

Looking at the attractiveness of schools based on the ratio of educators available to learners, 4% of both primary and secondary schools fall behind the minimal standard of 1:30. Although the results verified within the primary areal analysis present some negative results, overall they present beneficial aspects. However, the issue arises when utilising the two approaches defined to look at potential and real accessibility: the gravity model and the CWS.

When comparing these two approaches it was found that Stellenbosch and Robertson were the main towns experiencing the highest accessibility levels. Nonetheless, most principal towns are still experiencing critical results, regardless of how positive the results for the primary analysis were. Exceptionally critical areas include: McGregor, Montagu, Franschoek, Mbekweni, Wellington, Ceres, Prince Alfred Hamlet and Wolseley, constituting 44% of the entire district.

Given the positive outcomes of the potential accessibility, an issue that might revolve around the levels actually experienced might relate to transportation or infrastructure. For this reason, it is suggested that further studies in this regard should be made.

Chapter 9

Conclusions and Recommendations

"The future depends on what we do in the present"
-Mahatma Gandhi

9.1 Conclusions

The level of accessibility to services has been proven to be imperative to transportation, as well as regional research and analysis. In rural communities, the topic is of constant debate, since its restrictions can contribute to deficiencies in the participation of social and economic activities. Apart from that, education lies at the core of a country's development and economic growth. It is in this realm that the investigation in this thesis takes place. Within this context, the intention for this research project was to both understand and analyse the contributors to accessibility measures in order to develop a method to evaluate the levels of accessibility to schools in rural and disadvantaged areas. The purpose of this undertaking was twofold, as it would contribute to the specific knowledge of indicators and mechanisms to measure this concept, whilst simultaneously identifying underprivileged areas and highlighting regions that could possibly need urgent improvements in South Africa.

The underlying premise of this work was that there would be elevated issues of accessibility in rural communities, since they are generally separated or excluded from activities and society. Therefore, a holistic analysis had to be conducted where various accessibility indicators could be used to determine its measures, whilst comparing potential versus real accessibility and with that enabling the analysis of results and the development of conclusions.

Ultimately, this study was based upon the principles of the accessibility theory in conjunction with the usage of ArcGIS software, in order to produce maps identifying the different levels of accessibility within the focal area. Initially, there were several questions posed in order to develop the objectives set out for this research. These questions are addressed as follows:

What is accessibility?

There have been several ways used to define the accessibility concept within the scientific community. This is largely dependent on the various approaches used (Bocarejo and Oviedo, 2012). Given its ontology, this concept is very difficult and complex to translate into a single meaningful notion, even though linguistically it appears to be a simple and intuitive concept (Occelli, 2000).

Within literature, various authors have attempted to portray and define accessibility. However, the divergence in concepts is inevitable, given that different authors consider and interpret its values differently, some seeing it as the ease of interaction and others as the intensity of the possibility for interaction. Moreover, other definitions take a step further and include within the transport system: expected maximum utility value based on schedules available and an individual's freedom to decide to participate in an activity or not.

Nonetheless, two pieces of literature give a more conventional perspective in which accessibility is defined as the ease at which desired destinations are reached, given a number of opportunities available and inherent impedance to the resources used to travel from origin to destination (Morris et al., 1979; Handy and Niemeier, 1997). However, Geurs and Ritsema van Eck (2001) developed a definition that, as some agree, is the most complete as it embraces a variety of aspects: *'the extent to which the land-use transport system enables individuals or goods to reach activities or destinations by means of transport modes"*

Which factors point to the level of accessibility?

The complexity within the definition of accessibility is undeniable. Granted, the concept should not be considered solely as one entity. Geurs and Van Wee (2004) defined four essential indicators that can point towards the levels of accessibility, namely: land use, transport, temporal and individual. Boisjoly and El-Geneidy (2016) described these indicators rather well. Land-use refers to the location of the people or opportunities; transport is related to transport infrastructure or specification of modes; temporal includes transit or activities schedules, as well as their availability within the day; and lastly, individual reflects personal aspects of the travellers, such as their socio-economic status, needs or capacities to travel.

How does the old South African regime impact the current access to schools in the country?

The old South African regime established a geographic differentiation based on its own political, social and economic systems that produced space divisions within the country (Gwanya, 2010). Although the system has now been abolished, its legacy still persists with regard to the country's landscape. This, in turn, has several impacts on the social and economic mobility limits it imposes, as well as the compaction of socio-political interests that leave the vast majority's access to life opportunities scarce (National Planning Commission, 2011). Naturally, the inequality experienced within rural regions has not yet been overcome or translated to differing class interests (Carter and May, 1999; Gwanya, 2010).

Which characteristics do rural areas present in South Africa?

Despite the progress in the country, a great share of the population is still trapped in poverty. The greatest challenges lay in rural communities which are often located far from existing infrastructure and resources (Vanderschuren, 2017). That being taken into consideration, rural areas still present underdeveloped characteristics and limited structured access to economic opportunities and governmental services, education institutions being one of the greatest (Gwanya, 2010).

What is the importance of education in society?

Education encompasses children's basic rights, avowing prospects towards poverty alleviation and transformation towards prosperity. Moreover, a fast paced set of work suggests that education can affect both social and personal outcomes by influencing criminal behaviour, quality of life, mortality and even democratic participation – and therefore, offering a large range of benefits far greater than solely labour market productivity (Lochner, 2011). Evidently, it can be said that at a country level, education contributes toward the increase in economic growth (Hanushek and Woessmann, 2015).

What's the relationship between access and education?

Factors that contribute to the educational enhancement of a community are directly linked to distance to schools, fees, quality of education - not excluding other direct and indirect costs of schooling that impact the enrolment and attendance of learners in those institutions (Glewwe et al., 2011). In turn, many of these factors are interrelated with the concept of accessibility. The dramatic effect that rises within the spatial interaction between home, school and the community is far from inconsequential (Talen, 2001). Nutley (1984) and Barwell et al. (1985) argue that transportation and infrastructure are essential for the acquisition of basic needs. Vasconcellos (1997) goes one step further and specifically denotes that the access to schools contributes to the accessibility of services.

Which South African provinces' rural areas are the most disadvantaged with regards to schooling accessibility?

The distribution of rural areas is mostly concentrated in Limpopo, KwaZulu-Natal, Eastern Cape and Northern Cape, although the Western Cape, Free State, Mpumalanga and North West also host some. Within those areas the Western and Northern Cape possess the least concentration of schools and enrolment rates. Moreover, when looking at literacy levels and education attainment, there is a significant number of individuals with no schooling at all - especially in the Northern Cape. Interestingly, apart from the Western Cape, walking is the dominating mode of travel in those communities. However, although respondents describe proximity to school as the reason for using this mode, it was found that Gauteng, KwaZulu-Natal, Northern and the Western Cape populations take 30 minutes or more on average to reach schools.

Looking at all these results, it is clear that the Northern Cape is the most disadvantaged province.

Which area should be focused on?

Given results acquired, the Northern Cape is the most disadvantaged province and, therefore, the one in need of greater attention. However, given the limitations of the research and the availability

of data, the Western Cape was chosen as the point of interest - more specifically the Cape Winelands Municipality District.

What are the characteristics of the focal area?

The Cape Winelands District Municipality (CWDM) covers 21 473 km^2 of South Africa and is divided into five local municipalities, namely: Witzenberg, Drakenstein, Stellenbosch, Breed Valley and Langeberg. The region is well known for its mountainous terrain and river valleys which are a great asset to the economy of the district. Moreover, the Mediterranean climate characteristic of the area has its impact on the agricultural practices of the sub-regions – source of one of its greatest economic treasures.

There are about 218 620 households currently residing in the area and comprising 13.2% of the entire population of the province making this district the second largest contributor. Moreover, when looking at one of the most important indicators of human development (i.e. education), there are still 7.6% with no schooling experience and about 50% with incomplete studies, hindering them from opportunities to undertake post-secondary education.

Although the district contributes approximately 11.2% of the overall provincial economic output, the area still experiences a significant amount of household members sitting within the poverty level bracket, this may contribute to two of the greatest challenges within the region: drug usage and high crime levels.

Which accessibility measure is the most appropriate for the area?

Taking into consideration that socio-economic factors together with distance-related obstacles are vital when addressing rural areas, the accessibility measure that would appropriately carry out the study would have to look at different aspects - entangling both the conceptual framework and theory behind accessibility with the current conditions being experienced in the area.

As a result, two main elements were considered to be at the core of the study, namely: the zone attractiveness level and impedance. Given the resources available, ArcGIS was selected as the best software to be used by utilising the gravity-based measure to establish the potential accessibility and a survey conducted in the area to determine the real accessibility being experienced.

What is the level of accessibility to education institutions in the study area?

On average, 28% of the population live about 800 to 1200 meters from a primary and secondary schools and only 5% and 17% of the population experience distances greater than the standard advisable to primary and secondary schools, respectively. This shows that the majority of the population benefits from the location of schools in the area in terms of proximity.

Moreover, when looking at the attractiveness of schools in terms of quality of education, it was found that 4% of both primary and secondary schools are outside the range of minimal standard of 1 educator to 30 learners. Even so, despite the slight negative output, the schools present positive results.

Although both indicators of the gravity-based model and the results itself are positive when compared to the actual accessibility being experienced through the survey, it was found that most principal towns are experiencing negative results.

Are the results obtained plausible?

The results obtained during the study are considered to be plausible given the current situation of the country. This is best exemplified by the results obtained in Stellenbosch that run through a much larger advantage compared to other towns, especially considering that this municipality is well-known for its academic benefits.

Furthermore, recognising that the legacy of apartheid still remains within a spatial perspective, the results shown correlate with these same advantages. Although, given that the development of these types of institutions is undeniable in those areas, there are still issues related to the access of those same institutions.

Therefore, the methodology conducted throughout the study can be implemented in further studies, more so if the recommendations indicated are taken into consideration.

9.2 Reflection

The study concluded during the compilation of this dissertation produced a number of contributory findings that could potentially influence further research and expand the knowledge in current accessibility conditions within South Africa.

This study has shown that there is great severity with regards to the data available or surveys undertaken in rural areas that are related to transport patterns. Moreover, through this research the greatest disadvantaged province in the entire country was established: Northern Cape. Notwithstanding, the study area chosen was the Cape Winelands District Municipality, which is located in the Western Cape. The choice of this study area was not evident to the author, which with the funding provided and scarce resources of travel surveys, was the best option found.

The investigation resulted in outcomes that can possibly contribute to the development of strategies of the transport and accessibility conditions throughout this area. Although structures have been put in place to reduce the inequality within rural communities, it has been found that traveling is still an identified issue in those areas.

The proximity and the quality of education based on standardised aspects are not sufficient, as provision of transport or alternatives have yet to be put in place to preferably deliver those services to the most needed population.

Nonetheless, the results obtained from this research may be subjected to changes if the shortcomings of the model are reconsidered. The distance decay parameter was borrowed from another model, this in turn may lead to differences in the result. The best would have been to develop a parameter for that area, which goes in line with its different characteristics. Moreover, considering the road network of the area rather than the Euclidean distance could have slightly impacted the results found.

Other considerations that could have influenced differences within the gravity model and the survey undertaken may be related to other aspects that respondents may associate to accessibility, such as costs involved, comfort, etc. Moreover, the attractiveness of schools was calculated based on a ratio of number of teachers to learners, however, this assumption may not be the base of what the population of the area might consider as primordial.

9.3 Recommendations

The findings of this thesis indicate that it is important to consider accessibility when looking at the provision of education as implementing the services without means to reach those same services is ultimately not viable. The limitations of this research are accurately described throughout the dissertation, therefore, the primordial step is to conduct reliable surveys within South African rural areas, as a way to finally identify the greatest areas of concern.

Moreover, the surveys should include data related to various indicators of accessibility, such as the money spent each month in relation to income (to determine affordability); the number of students within households; the level of demand within those areas, etc.

Further studies should be carried out in relation to other accessibility measures and indicators (specifically *Transportation Indicator*) in order to verify differences within the outputs encountered. Although gravity models can provide a great indication of the potential access within a region, they do not factor in the population present in the area. Therefore, measures that account for such aspects should be ideal.

Bibliography

Ahmed, R. and Sayed, Y. (2009) 'Promoting access and enhancing education opportunities? The case of "no-fees schools" in South Africa'. doi: 10.1080/03057920902750467.

Badat Saleem (2011) 'Redressing the Colonial/Apartheid Legacy: Social Equity, Redress, and Higher Education Admissions in Democratic South Africa', *Equalizing Access*, pp. 121–151. doi: http://hdl.handle.net/10962/d1015852.

Baradaran, S. and Ramjerdi, F. (2001) 'Performance of Accessibility Measures in Europe', *Journal of Transport and Statistics*, 4(3), pp. 31–48.

Ben-Akiva, M. E. and Bowman, J. L. (1995) *Activity based disaggregate travel demand model system with daily activity schedules*. Massachusetts.

Ben-Akiva, M. E. and Lerman, S. R. (1979) 'Disaggregate Travel and Mobility-Choice Models and Measures of Accessibility', in Hensher, D. A. and Storper, P. R. (eds) *Behavioural Travel Modelling*. London.

van der Berg, S. (2007) 'Apartheid's enduring legacy: Inequalities in education', *Journal of African Economies*, 16(849–880), pp. 1–35. Available at: https://www.saide.org.za/resources/Library/VanderBerg - Apartheid%27s Enduring Legacy.pdf.

Berrisford, S. (2011) 'Unravelling Apartheid Spatial Planning Legislation in South Africa', *Urban Forum*, 22(3), pp. 247–263. doi: 10.1007/s12132-011-9119-8.

Bertolini, L., le Clercq, F. and Kapoen, L. (2005) 'Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward', *Transport Policy*, 12, pp. 207–220. Available at: https://ac.els-cdn.com/S0967070X05000193/1-s2.0-S0967070X05000193-main.pdf?_tid=ea0f8829-0990-429f-be23-1dc740c1acb4&acdnat=1523037245_050bf70e9937be2c3bd05f16adce16f6 (Accessed: 6 April 2018).

Bhat, C., Handy, S., *et al.* (2000) *Accessibility Measures: Formulation Considerations and*

Current Applications. Texas.

Bhat, C., Kara Kockelman, *et al.* (2000) *Urban Accessibility Index: Literature Review*. Austin.

Bhat, C. *et al.* (2002) *Development of an Urban Accessibility Index: Formulations, Aggregation, and Application*. Austin.

Bocarejo, J. P. and Oviedo, D. R. (2012) 'Transport accessibility and social inequities: a tool for identification of mobility needs and evaluation of transport investments', *Journal of Transport Geography*, 24, pp. 142–154. doi: 10.1016/j.jtrangeo.2011.12.004.

Boisjoly, G. and El-Geneidy, A. (2016) 'Daily fluctuations in transit and job availability: A comparative assessment of time-sensitive accessibility measures', *Journal of Transport Geography*, 52, pp. 73–81. doi: 10.1016/j.jtrangeo.2016.03.004.

Boulle and Newton (2007) *Drakenstein Local Economic Development Strategy*. Available at: http://www.drakenstein.gov.za/docs/Documents/Strategy Oct 2006.pdf.

Burde, D. and Linden, L. (2011) 'The Effect of Proximity on School Enrollment: Evidence from a Randomized Controlled Trial', *York University*, (May). Available at: http://sticerd.lse.ac.uk/seminarpapers/dg11052009.pdf%5Cnhttp://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.415.622.

Burns, L. D. (1979) *Transportation, Temporal and Spatial Components of Accessibility*. Lexington, Massachusetts: Lexington Books.

Button, K. (1982) *Transport Economics*. London: Heinemann.

Cape Winelands District Municipality (2012) *Cape Winelands District Municipality 2012/13 - 2016/17: Integrated Development Plan*. Available at: http://www.fewlbnexus.uct.ac.za/sites/default/files/image_tool/images/91/Part One of Two CWDM 2012-17 IDP.pdf.

Carter, M. R. and May, J. (1999) *Poverty, Livelihood and Class in Rural South Africa*, *World Development*. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.893.4228&rep=rep1&type=pdf.

Cascetta, E., Cartenì, A. and Montanino, M. (2016) 'A behavioral model of accessibility based on

the number of available opportunities', *Journal of Transport Geography*, 51, pp. 45–58. doi: 10.1016/j.jtrangeo.2015.11.002.

Cerdá, A. (2009) *Accessibility: A Performance Measure for Land-use and Transportation Planning in the Montréal Metropolitan Region*. McGill University. Available at: http://tram.mcgill.ca/Teaching/srp/documents/Assumpta.pdf.

CGD (2002) 'Education and the Developing World', in *Rich world, poor world: A guide to global development*, pp. 30–33. Available at: https://www.cgdev.org/files/2844_file_EDUCATON1.pdf.

Charman, A. *et al.* (2017) 'POST-APARTHEID SPATIAL INEQUALITY: OBSTACLES OF LAND USE MANAGEMENT ON TOWNSHIP MICRO-ENTERPRISE FORMALISATION Sustainable Livelihoods Foundation 2 Sustainable Livelihoods Foundation A Report by the Sustainable Livelihoods Foundation', (August). Available at: http://livelihoods.org.za/wp-content/uploads/2018/05/Post-Apartheid_Spatial_Inequality.pdf.

Clark, N. L. and Worger, W. H. (2016) *South Africa: The Rise and Fall of Apartheid*. 3rd edn. London: Routledge.

Cole, R. *et al.* (2007) 'Residential proximity to school and the active travel choices of parents', *Health Promotion Journal of Australia*, 18(2), pp. 127–134. doi: 10.1071/HE07127.

Couclelis, H. and Getis, A. (2000) 'Information, place, cyberspace and accessibility', in Janelle, D. G. and Hodge, D. C. (eds) *Information, Place and Cyberspace*, pp. 3–12. doi: 10.1007/978-3-662-04027-0.

Curtis, C. and Scheurer, J. (2010) 'Planning for sustainable accessibility: Developing tools to aid discussion and decision-making', *Progress in Planning*, 74(2), pp. 53–106. doi: 10.1016/j.progress.2010.05.001.

Czeglédy, A. P. (2004) 'Getting Around Town: Transportation and the Built Environment in Post-Apartheid South Africa', *City & Society*, 16(2), pp. 63–92. doi: 10.1525/city.2004.16.2.63.

Dalvi, M. Q. and Martin, K. M. (1976) 'THE MEASUREMENT OF ACCESSIBILITY: SOME PRELIMINARY RESULTS', *Transportation*, 5. Available at: https://link.springer.com/content/pdf/10.1007%2FBF00165245.pdf (Accessed: 8 April 2018).

Damon, A. *et al.* (2016) *Education in Developing Countries What Policies and Programmes Affect Learning and Time in School?* Available at: http://www.oecd.org/derec/sweden/Rapport-Education-developing-countries.pdf.

Darling-Hammond, L. (2003) 'Access to Quality Teaching: An Analysis of Inequality in California's Public Schools', *Santa Clara Law Review*, 43, pp. 1045–1184. doi: 10.3366/ajicl.2011.0005.

Davidson, K. B. (1977) 'Accessibility in transport/land-use modelling and assessment', *Environment and Planning A*, 9, pp. 1401–1416. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.470.1101&rep=rep1&type=pdf (Accessed: 16 April 2018).

Denzin, N. K. and Lincoln, Y. S. (1994) *Handbook of Qualitative Research*. SAGE Publications.

Department of Transport (2009) *REPUBLIC OF SOUTH AFRICA*. Available at: http://pmg-assets.s3-website-eu-west-1.amazonaws.com/docs/100914finaldraft_0.pdf (Accessed: 22 October 2018).

Easton, S. and Ferrari, E. (2015) 'Children's travel to school-the interaction of individual, neighbourhood and school factors', *Transport Policy*. Elsevier, 44, pp. 9–18. doi: 10.1016/j.tranpol.2015.05.023.

El-Geneidy, A. *et al.* (2016) 'The cost of equity: Assessing transit accessibility and social disparity using total travel cost', *Transportation Research Part A: Policy and Practice*. Elsevier Ltd, 91, pp. 302–316. doi: 10.1016/j.tra.2016.07.003.

Ettema, D., Schwanen, T. and Timmermans, H. (2007) 'The effect of location, mobility and socio-demographic factors on task and time allocation of households', *Transportation*, 34, pp. 89–105. doi: 10.1007/s11116-006-0007-3.

Farrington, J. and Farrington, C. (2005) 'Rural accessibility, social inclusion and social justice: Towards conceptualisation', *Journal of Transport Geography*, 13(1 SPEC. ISS.), pp. 1–12. doi: 10.1016/j.jtrangeo.2004.10.002.

Fataar, A. (1997) *ACCESS TO SCHOOLING IN A POST-APARTHEID SOUTH AFRICA: LINKING CONCEPTS TO CONTEXT*. Available at:

https://link.springer.com/content/pdf/10.1023%2FA%3A1003075806523.pdf (Accessed: 22 October 2018).

Felcman, J. Ĝ. and Šilha, M. (2016) 'Transit Oriented Development in Mid-Size Cities : A Star-Shaped Urban Form Promoted', *Smart Cities Symposium Prague*.

Ford, A. *et al.* (2015) 'Transport Accessibility Analysis Using GIS: Assessing Sustainable Transport in London', *ISPRS International Journal of Geo-Information*, 4(1). doi: 10.3390/ijgi4010124.

Foth, N., Manaugh, K. and El-Geneidy, A. M. (2013) 'Towards equitable transit: Examining transit accessibility and social need in Toronto, Canada, 1996-2006', *Journal of Transport Geography*, 29, pp. 1–10. Available at: http://www.sciencedirect.com/science/article/pii/S0966692312003067 (Accessed: 8 April 2018).

Fotini, M. (2017) 'A new anthropocentric approach in accessibility analysis: the activity space and the accessibility measures', *Transportation Research Procedia*, 24, pp. 491–498. doi: 10.1016/j.trpro.2017.05.088.

Geurs, K. (2006) *Accessibility, Land Use and Transport: Accessibility Evaluation of Land-use ... - Karst Geurs - Google Books*. Delft: Uitgeverij Eburon. Available at: https://books.google.co.za/books?id=-KTB5M71McYC&pg=PA83&lpg=PA83&dq=(a)+land+use,+that+is,+the+amount,+characteristics,+and+spatial+distribution+of+opportunities,+(b)+transport,+that+is,+the+travel+impedance+between+origin+and+destination+locations+(trav (Accessed: 8 February 2018).

Geurs, K. T., De Montis, A. and Reggiani, A. (2015) 'Recent advances and applications in accessibility modelling', *Computers, Environment and Urban Systems*, 49, pp. 82–85. doi: 10.1016/j.compenvurbsys.2014.09.003.

Geurs, K. T. and Ritsema van Eck, J. R. (2001) *Accessibility measures: review and applications*. Bilthoven.

Geurs, K. T. and Ritsema Van Eck, J. R. (2003) 'Evaluation of accessibility impacts of land-use scenarios: the implications of job competition, land-use, and infrastructure developments for the Netherlands', *Environment and Planning B: Planning and Design*, 30, pp. 69–87. doi:

10.1068/b12940.

Geurs, K. T. and Van Wee, B. (2004) 'Accessibility evaluation of land-use and transport strategies: review and research directions', *Journal of Transport Geography*, 12, pp. 127–140. doi: 10.1016/j.jtrangeo.2003.10.005.

Glewwe, P. *et al.* (2011) 'School Resources and Educational Outcomes in Developing Countries: A Review of the Literature from 1990 to 2010'. doi: 10.3386/w17554.

Glewwe, P. and Muralidharan, K. (2016) 'Improving Education Outcomes in Developing Countries: Evidence, Knowledge Gaps, Policy Implications', in *Hanbook of the Economics of Education*. Elsevier, pp. 653–672. Available at: https://ac.els-cdn.com/B9780444634597000105/1-s2.0-B9780444634597000105-main.pdf?_tid=eb3358d9-26ab-4e65-accc-8389422926db&acdnat=1540212375_6d9f393f55bc74e52ebc93334fb50f1a (Accessed: 22 October 2018).

Gordon, A. and Qiang, W. (2000) *Education in Rural Areas of Chine and South Africa: Comparative Perspectives on POlicy and Educational Management*. Available at: https://pdfs.semanticscholar.org/536c/b6e6968af45a5511af1907f7c36c7e749dce.pdf (Accessed: 25 October 2018).

Grengs, J. (2010) 'Job accessibility and the modal mismatch in Detroit', *Journal of Transport Geography*, 18, pp. 42–54. doi: 10.1016/j.jtrangeo.2009.01.012.

Griffin, A. and Gruver, A. (2018) *EOG 486: Cartography and Visualization: Inverse Distance Weighting*, *Pennsylvania State University*. Available at: https://www.e-education.psu.edu/geog486/node/1877 (Accessed: 2 December 2018).

Guagliardo, M. F. (2004) 'Spatial accessibility of primary care: concepts, methods and challenges', *International Journal of Health Geographics*, 3(3). Available at: https://ij-healthgeographics.biomedcentral.com/track/pdf/10.1186/1476-072X-3-3 (Accessed: 17 April 2018).

Guzman, L. A., Oviedo, D. and Rivera, C. (2017) 'Assessing equity in transport accessibility to work and study: The Bogotá region', *Journal of Transport Geography*. Elsevier Ltd, 58, pp. 236–246. doi: 10.1016/j.jtrangeo.2016.12.016.

Gwanya, T. T. (2010) ‘A Model for the Comprehensive Rural Development Programme’, *RIMISP*.

Halden, D. (2013) ‘Using accessibility measures to integrate land use and transport policy in Edinburgh and the Lothians’, *Transport Policy*, 9, pp. 313–324. doi: 10.1016/S0967-070X(02)00017-3.

Hall, R. W. (1983) ‘Travel outcome and performance: The effect of uncertainty on accessibility’, *Transportation Research Part B*, 17(4), pp. 275–290. doi: 10.1016/0191-2615(83)90046-2.

Handy, S. L. and Clifton, K. (2000) *Evaluating Neighborhood Accessibility: Issues and Methods Using Geographis Information Systems*. Texas.

Handy, S. L. and Niemeier, D. A. (1997) ‘Measuring accessibility: An exploration of issues and alternatives’, *Environment and Planning A*. doi: 10.1068/a291175.

Hansen, W. G. (1959) ‘How Accessibility Shapes Land Use’, *Journal of the American Institute of Planners*, 25(2), pp. 73–76. doi: 10.1080/01944365908978307.

Hanushek, E. and Woessmann (2015) *The Knowledge Capital of Nations: Education and the Economics of Growth*. Cambridge: MIT Press.

Haynes, R., Lovett, A. and Sunnenberg, G. (2003) ‘Potential accessibility, travel time, and consumer choice: geographical variations in general medical practice registrations in Eastern England’, *Environment and Planning A*, 35, pp. 1733–1750. doi: 10.1068/a35165.

Hlalele, D. (2012) ‘Social justice and rural education in South Africa’, *Perspectives in Education*, 30(1), pp. 111–118.

Hlanze, Z. and Mkhabela, L. (1998) *Beyond Inequalities. Women in Swaziland*. Southern African Research & Documentation Centre, Zimbabwe.

Holloway, S. L. and Jöns, H. (2012) ‘Geographies of education and learning’, *Transactions of the Institute of British Geographers*, 37(4), pp. 482–488. doi: 10.1111/j.1475-5661.2012.00542.x.

Horning, J., El-Geneidy, A. and Krizek, K. J. (2008) ‘Perceptions of walking distance to neighborhood retail and other public services’, *Proceedings of the 87th meeting of the Transportation Research Board*, (January).

Hsu, C. I. and Hsieh, Y. P. (2004) ‘Travel and activity choices based on an individual accessibility

model', *Papers in Regional Science*, 83(2), pp. 387–406. doi: 10.1007/s10110-004-0197-z.

Huisman, J. and Smits, J. (2015) 'Keeping Children in School: Effects of Household and Context Characteristics on School Dropout in 363 Districts of 30 Developing Countries', *SAGE Open*, 5(4), pp. 1–33. doi: 10.1177/2158244015609666.

Jamal, H. (2017) *Land Use Patterm: Basic Urban Form Conceptual Frameworks*. Available at: https://www.aboutcivil.org/urban-land-use-patterns.html (Accessed: 28 March 2019).

Jamtsho, S. and Corner, R. J. (2014) 'EVALUATION OF SPATIAL ACCESSIBILITY TO PRIMARY HEALTHCARE USING GIS', in *ISPRS Technical Commission II Symposium*. Toronto. doi: 10.5194/isprsannals-II-2-79-2014.

Janowitz, M. and Suttles, G. D. (1978) *The Social Ecology of Citezenship*, *The Management of Human Services*. Edited by R. Sarri and Y. Hansenfeld. New York: Columbia University Press.

Jia Cui, Y. B. (2014) 'A GIS-based Approach to the Characterisation of Spatial Accessibility to Primary Health Care Facilities in the Melbourne Metropolitan Area'. Available at: https://researchbank.rmit.edu.au/eserv/rmit:160794/Cui.pdf (Accessed: 17 April 2018).

JICA (2002) *Effective Approaches in Basic Education*, *Approaches for Systematic Planning of Development Projects*. Available at: https://www.jica.go.jp/jica-ri/IFIC_and_JBICI-Studies/english/publications/reports/study/topical/spd/pdf/chapter1.pdf.

Johnson, B. and Turner, L. A. (2003) 'Handbook of Mixed Methods in Social & Behavioral Research', in Tashakkori, A. and Teddllie, C. (eds) *Handbook of Mixed Methods in Social & Behavioral Research*. SAGE Publications, pp. 297–321.

Johnston, K. (2004) *ArcGIS 9*, *ESRI*.

Karou, S. and Hull, A. (2014) 'Accessibility modelling: Predicting the impact of planned transport infrastructure on accessibility patterns in Edinburgh, UK', *Journal of Transport Geography*. Elsevier Ltd, 35, pp. 1–11. doi: 10.1016/j.jtrangeo.2014.01.002.

Kim, H. M. and Kwan, M. P. (2003) 'Space-time accessibility measures: A geocomputational algorithm with a focus on the feasible opportunity set and possible activity duration', *Journal of Geographical Systems*, 5(1), pp. 71–91. doi: 10.1007/s101090300104.

Kwan, M. P. and Weber, J. (2008) 'Scale and accessibility: Implications for the analysis of land use-travel interaction', *Applied Geography*, 28(2), pp. 110–123. doi: 10.1016/j.apgeog.2007.07.002.

LaMondia, J. J., Blackmar, C. E. and Bhat, C. R. (2010) 'Comparing Transit Accessibility Measures:A Case Study of Access to Healthcare Facilities'. Available at: https://trid.trb.org/view/1092808.

Letseka, M. (2014) 'The Illusion of Education in South Africa', *Procedia - Social and Behavioral Sciences*. Elsevier B.V., 116, pp. 4864–4869. doi: 10.1016/j.sbspro.2014.01.1039.

Linard, C. *et al.* (2012) 'Population Distribution, Settlement Patterns and Accessibility across Africa in 2010', *PLoS ONE*, 7(2). doi: 10.1371/journal.pone.0031743.

Litman, T. (2003) 'Measuring transportation: Traffic, mobility and accessibility', *ITE Journal (Institute of Transportation Engineers)*, 73(10), pp. 28–32.

Litman, T. A. (2016) 'Accessibility for Transportation Planning: Measuring People's Ability to Reach Desired Goods and Activities', *Transportation Research Board*.

Liu, S. and Zhu, X. (2004) 'Accessibility Analyst: an integrated GIS tool for accessibility analysis in urban transportation planning', *Environment and Planning B: Planning and Design*, 31, pp. 105–124. doi: 10.1068/b305.

Lochner, L. (2011) 'Non-production benefits of education: Crime, Health, and Good Citizenship', *NBER Working Paper No. 16722*, 34(2), pp. 281–293. doi: 10.1080/01402390.2011.569130.

Lucas, K. (2011) 'Making the connections between transport disadvantage and the social exclusion of low income populations in the Tshwane Region of South Africa', *Journal of Transport Geography*, 19, pp. 1320–1334. doi: 10.1016/j.jtrangeo.2011.02.007.

Lucas, K. (2012) 'Transport and social exclusion: Where are we now?', *Transport Policy*. Raje, 20, pp. 105–113. doi: 10.1016/j.tranpol.2012.01.013.

Luke, R. and Pisa, N. (2018) 'the Spatial Trend Associations Between Socio- Economic Factors and Households ' Travel Pattern in Gauteng', in *37th Annual Southern African Transport Conference (SATC*. Pretoria, pp. 418–427. Available at:

http://www.satc.org.za/assets/2b_pisa.pdf.

Lutz de Wet, B. F. (2016) *What Approach to Development in the Cape Winelands: An identification & exploration into urban form - Planning for future growth and change in the Cape Winelands Region*. University of Cape Town. Available at: https://open.uct.ac.za/bitstream/handle/11427/23773/thesis_ebe_2016_de_wet_barend_frederik_lutz.pdf?sequence=1.

Mahapa, S. M. and Mashiri, M. (2001) 'Social exclusion and rural transport : Gender aspects of a road improvement project in Tshitwe , Northern Province Social exclusion and rural transport : gender aspects of a road improvement project in Tshitwe , Northern Province', *Development Southern Africa*, 18(3), pp. 365–376. doi: 10.1080/0376835012007002.

Manderscheid, K. (2009) 'Integrating space and mobilities into the analysis of social inequality', *Distinktion*, 10(1), pp. 7–27. doi: 10.1080/1600910X.2009.9672739.

Mans, G. *et al.* (2015) *Spatial Temporal Evidence for Planning - South Africa*, *CSIR*. Available at: http://stepsa.org/socio_econ.html (Accessed: 6 December 2018).

Martin, W. A. and McGuckin, N. A. (1998) *Travel Estimation Techniques for Urban Planning*, *Transportation Research Board*. Washington DC. doi: 10.1080/15472450490437753.

Miller, H. J. (2017) 'Time geography and space–time prism', *International Encyclopedia of Geography: People, the Earth, Environment and Technology, 1*. John Wiley & Sons, Ltd. doi: 10.1002/9781118786352.wbieg0431.

Minal, C. R. S. (2014) 'Mode Choice Analysis: The Data, The Models and Future Ahead', *Internasional Journal for Traffic and Transport Engineering*, 4(3), pp. 269–285. doi: 10.7708/ijtte.2014.4(3).03.

Molefe, S. P. (1996) 'Rural Development in South Africa : Implications for Social Work Practice', *Journal of Social Development in Africa*, 11(2), pp. 21–31. Available at: https://pdfs.semanticscholar.org/79b1/70e43d89d2599d0127df3c99aba0df985351.pdf.

Moniruzzaman, M. and Páez, A. (2012) 'Accessibility to transit, by transit, and mode share: application of a logistic model with spatial filters', *Journal of Transport Geography*. Elsevier Ltd, 24, pp. 198–205. doi: 10.1016/j.jtrangeo.2012.02.006.

Morris, Dumble and Wigan, M. R. (1979) ‘Accessibility indicators for transport planning’, *Transportation Research Part A: General*, 13(2), pp. 91–109. doi: 10.1016/0191-2607(79)90012-8.

Morris, J. M., Dumble, P. L. and Wigan, M. R. (1979) ‘ACCESSIBILITY INDICATORS FOR TRANSPORT PLANNING’. Pergamon Press Lid, pp. 91–109. Available at: http://projectwaalbrug.pbworks.com/f/Transp+Accessib+-+Morris,+Dumble+and+Wigan+(1979).pdf (Accessed: 8 April 2018).

Morris, J., Wang, F. and Lilja, L. (2001) ‘School Children’s Travel Patterns – A Look Back and A Way Forward’, *Transport Engineering in Australia*, 7(1/2), p. 15/25. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.477.2330&rep=rep1&type=pdf.

Motala, S., Dieltiens, V. and Sayed, Y. (2009) ‘Comparative Education Physical access to schooling in South Africa: mapping dropout, repetition and age-grade progression in two districts’. doi: 10.1080/03050060902920948.

Musakwa, W. and van Niekerk, A. (2014) ‘Monitoring Urban Sprawl and Sustainable Urban Development Using the Moran Index : A Case Study of Stellenbosch , South Africa’, *International Journal of Applied Geospatial Research*, 5(September), pp. 1–20. doi: 10.4018/ijagr.2014070101.

National Planning Commission (2011) *Our future - make it work*. doi: ISBN: 978-0-621-41180-5.

National Treasury (2011) ‘Delivering municipal services in rural areas Introduction’, in *Local Government Budgets and Expenditure Review*. National Treasury. doi: 10.1016/S0196-0644(81)80018-2.

Nelson Mandela Foundation (2005) *Emerging Voices Researched for the Nelson Mandela Foundation by the HSRC and the EPC A Report on Education in South African Rural Communities Emerging Voices*. Cape Town. Available at: www.hsrcpress.ac.za (Accessed: 23 October 2018).

Neutens, T. *et al.* (2012) ‘An analysis of day-to-day variations in individual space-time accessibility’, *Journal of Transport Geography*, 23, pp. 81–91. doi: 10.1016/j.jtrangeo.2012.04.001.

Nusret, D. and Dug, S. (2012) ‘Applying the Inverse Distance Weighting and Kriging Methods of the Spatial Interpolation on the Mapping the Annual Precipitation in Bosnia and Herzegovina’,

International Environmental Modelling and Software Society (iEMSs) 2012 International Congress on Environmental Modelling and Software Managing Resources of a Limited Planet, (i), p. 7. Available at: https://www.e-education.psu.edu/geog486/node/1877.

Nutley, S. D. (1984) 'Planning for rural accessibility provision : welfare , economy , and equity', *Environment and Planning A*, 16(1976), pp. 357–376.

Nyarirangwe, M. and Mbara, T. (2000) 'Public Transport Service Modal Choice, Affordability and Perceptions in an Unpalatable Economic Environment: The case of an Urban Corridor in Harare (Zimbabwe)', in *26th Southern African Transport Conference*. Pretoria: Document Transformation Technologies cc, pp. 26–34. Available at: https://repository.up.ac.za/bitstream/handle/2263/6007/075.pdf?sequence=1&isAllowed=y.

Nykiforuk C, F. L. (2008) *Exploring the utilization of geographic information systems in health promotion and public health*, *Technical report #08-001*.

Occelli, S. (2000) 'Revisiting the Concept of Accessibility: Some Comments and Research Questions', in Janelle, D. G. and Hodge, D. C. (eds) *Information, Place and Cyberspace*. Berlin: Springer, pp. 279–302.

Odoki, J. B., Kerali, H. R. and Santorini, F. (2001) 'An integrated model for quantifying accessibility-benefits in developing countries', *Transportation Research Part A*, 35, pp. 601–623. Available at: https://ac-els-cdn-com.ezproxy.uct.ac.za/S0965856400000100/1-s2.0-S0965856400000100-main.pdf?_tid=e3df8ef0-0ccb-11e8-b879-00000aacb362&acdnat=1518093228_7276169c260ecff55854ab8d52ff6b1f (Accessed: 8 February 2018).

Öner, Ö. (2017) 'Retail city : the relationship between place attractiveness and accessibility to shops Retail city : the relationship between place attractiveness and accessibility to shops', *Spatial Economic Analysis*, 12(1), pp. 72–91. doi: 10.1080/17421772.2017.1265663.

Pacione, M. (1989) 'Access to urban services — the case of secondary schools in Glasgow', *Scottish Geographical Magazine*, 105(1), pp. 12–18. doi: 10.1080/00369228918736746.

Páez, A., Scott, D. M. and Morency, C. (2012) 'Measuring accessibility: positive and normative implementations of various accessibility indicators', *Journal of Transport Geography*, 25, pp.

141–153. doi: 10.1016/j.jtrangeo.2012.03.016.

Parahoo, K. (2014) *Nursing Research: Principles, Process and Issues*. 3rd edn. London: Palgrave Macmillan.

Paxton, C. (2015) *Possibilities and constraints for improvement in rural South African schools*. University of Cape Town. Available at: https://nicspaull.files.wordpress.com/2016/01/paxton-possibilities-and-constraints-for-improvement-in-rural-south-african-schools-final-incl-corrections.pdf.

Pennington, K., Williams, M. R. and Karvonen, M. (2006) 'Challenges facing rural community colleges: Issues and problems today and over the past 30 years', *Community College Journal of Research and Practice*, 30(8), pp. 641–655. doi: 10.1080/10668920600746086.

Pieterse, E. (2009) 'Post-Apartheid Geographies in South Africa: why are urban divides so persistent', *Interdisciplinary Debates on Development and Cultures: Cities in Development - Spaces, Conflicts and Agency*, p. 15.

Pirie, G. H. (1979) 'Measuring Accessibility: A Review and Proposal', *Environment and Planning A*, 11(3), pp. 299–312. doi: 10.1068/a110299.

du Plessis, P. (2014) 'Problems and Complexities in Rural Schools: Challenges of Education and Social Development', *Mediterranean Journal of Social Sciences*, 5(20), pp. 1109–1117. doi: 10.5901/mjss.2014.v5n20p1109.

Potgieter, C., Pillay, R. and Rama, S. (2006) *Women, Development and Transport in Rural Eastern Cape, South Africa*. Cape Town.

Pyrialakou, V. D., Gkritza, K. and Fricker, J. D. (2016) 'Accessibility, mobility, and realized travel behavior: Assessing transport disadvantage from a policy perspective', *Journal of Transport Geography*, 51. doi: 10.1016/j.jtrangeo.2016.02.001.

Rajendran, P., K, B. B. and Sanjay Kumar, V. S. (2013) 'Public Transport Accessibility Index for Thiruvananthapuram Urban Area', *IOSR Journal of Mechanical and Civil Engineering*, 7(4), pp. 2320–334. Available at: www.iosrjournals.org.

Rode, P. and Floater, G. (2014) 'ACCESSIBILITY IN CITIES : TRANSPORT AND URBAN

FORM', (November), pp. 1–61.

Rode Plan (2010) *Cape Winelands District Spatial Development Framework 2009/2010*.

Rogan, M. J. (2006) *Dilemmas in Learner Transport: An Impact Evaluation of a School Transport Intervention in the Ilembe District, KwaZulu-Natal*. Available at: http://sds.ukzn.ac.za/files/Rogan_dissertation.pdf (Accessed: 22 October 2018).

Scheurer, J. and Curtis, C. (2007) 'Accessibility Measures: Overview and Practical Applications'. Available at: http://urbanet.curtin.edu.au/ (Accessed: 17 April 2018).

Schwanen, T. and Kwan, M.-P. (2008) 'The Internet, mobile phone and space-time constraints', *Geoforum*, 39, pp. 1362–1377. doi: 10.1016/j.geoforum.2007.11.005.

Sharmeen, N. and Houston, D. (2019) 'Spatial Characteristics and Activity Space Pattern Analysis of Dhaka City , Bangladesh', (1971). doi: 10.3390/urbansci3010036.

Sims, S. and Mesev, V. (2011) 'Measuring Urban Sprawl and Compactness: Case Study Orlando, USA', in *Proceedings of the 25th International Cartographic Conference*. Paris.

Stewart, J. Q. (1948) 'Demographic Gravitation: Evidence and Applications', *Sociometry*, 11(2), pp. 31–58.

Talen, E. (2001) 'School, community, and spatial equity: An empirical investigation of access to elementary schools in West Virginia', *Annals of the Association of American Geographers*, 91(3), pp. 465–486. doi: 10.1111/0004-5608.00254.

Tanser, F., Gijsbertsen, B. and Herbst, K. (2006) 'Modelling and understanding primary health care accessibility and utilization in rural South Africa: An exploration using a geographical information system', *Social Science & Medicine*, 63, pp. 691–705. doi: 10.1016/j.socscimed.2006.01.015.

Titheridge, H. (2014) *Transport and Poverty A review of the evidence*.

Turkienicz, B., Gonçalves, B. B. and Grazziotin, P. (2008) 'CityZoom: A Visualization Tool for the Assessment of Planning Regulations', *International Journal of Architectural Computing*, 6(1), pp. 79–95. doi: 10.1260/147807708784640144.

UNESCO (2005) *Guidelines for Inclusion: Ensuring Access to Education for All*. Paris. Available

at: http://www.ibe.unesco.org/sites/default/files/Guidelines_for_Inclusion_UNESCO_2006.pdf (Accessed: 22 October 2018).

URBAN-ECON (2011) *Cape Winelands District Municipality Information*, *English*. Available at: http://en.wikipedia.org/wiki/Cape_Winelands_District_Municipality.

Vacchiani-Marcuzzo, C. and Giraut, F. (2009) *Territories and Urbanisation in South Africa: Atlas and geo-historical information system (DYSTURB)*. Available at: https://archive-ouverte.unige.ch/unige:5410/ATTACHMENT01.

Vandenbulcke, G., Steenberghen, T. and Thomas, I. (2009) 'Mapping accessibility in Belgium: a tool for land-use and transport planning?', *Journal of Transport Geography*. Elsevier Ltd, 17(1), pp. 39–53. doi: 10.1016/j.jtrangeo.2008.04.008.

Vanderschuren, M. (2006) *INTELLIGENT TRANSPORT SYSTEMS FOR SOUTH AFRICA IMPACT ASSESSMENT THROUGH MICROSCOPIC SIMULATION IN THE SOUTH AFRICAN CONTEXT*. University of Cape Town and University of Twente.

Vasconcellos, E. A. (1997) 'Rural transport and access to education in developing countries: policy issues', *Journal of Transport Geography*, 5(2), pp. 127–136. Available at: https://ac.els-cdn.com/S0966692396000750/1-s2.0-S0966692396000750-main.pdf?_tid=b281e3e4-4316-4fd8-9358-ae645bb38462&acdnat=1540197076_4ec4f7017db71c0cf77cd295cf9fdb68 (Accessed: 22 October 2018).

Vuri, D. (2010) 'The Effect of Availability of School and Distance to School on Children's Time Allocation in Ghana', *Labour*, 24(SUPPL. 1), pp. 46–75. doi: 10.1111/j.1467-9914.2010.00499.x.

Wachs, M. and Kumagai, T. G. (1973) 'Physical Accessibility As a Social Indicator', 7, pp. 437–456.

Walliman, N. (2011) *Research Methods: the basics*. London: Routledge. Available at: https://edisciplinas.usp.br/pluginfile.php/2317618/mod_resource/content/1/BLOCO 2_Research Methods The Basics.pdf (Accessed: 1 January 2019).

Wang, J. *et al.* (2016) 'Measuring time accessibility and its spatial characteristics in the urban areas of Beijing', *Journal of Geographical Sciences*, 26(12), pp. 1754–1768.

Weber, J. and Kwan, M.-P. (2002) 'Bringing Time Back In: A Study on the Influence of Travel Time Variations and Facility Opening Hours on Individual Accessibility', *The Professional Geographer*, 54(2), pp. 226–240. doi: 10.1111/0033-0124.00328.

Van Wee, B. (2011) *Transport and Ethics: Ethics and the Evaluations of Transport Policies and Projects*. Edited by K. Button. Edward Elgar Publishing Limited.

Van Wee, B. and Geurs, K. (2011) 'Discussing Equity and Social Exclusion in Accessibility Evaluations', *EJTIR Issue*, 11(4), pp. 350–367. Available at: www.ejtir.tbm.tudelft.nl (Accessed: 6 February 2018).

Wee, B. Van, Geurs, K. and Chorus, C. (2013) 'Information, communication, travel behavior and accessibility', *Journal of Transport and Land Use*, 6(3), p. 1. doi: 10.5198/jtlu.v6i3.282.

Weibull, J. W. (1976) 'An Anxiomatic Approach to the Measurement of Accessibility', *Regional Science and Urban Economics*, 6, pp. 357–379. Available at: https://ac.els-cdn.com/0166046276900314/1-s2.0-0166046276900314-main.pdf?_tid=6fd1346b-3c2c-46c2-af50-d98144213ca6&acdnat=1523808272_27b3e81decadb5e74a9e3cd5be1a74c4 (Accessed: 15 April 2018).

Weisbrot, M. *et al.* (2001) *The scorecard on globalization 1980-2000*, *Center for Economic Policy and Research*.

Western Cape Government (2018) 'Western Cape Land Use Planning : Rural Guidelines', (January).

Western Cape Government Provincial Treasury (2018) *Provincial economic review and outlook 2018*. Cape Town. Available at: http://www.finance.gpg.gov.za/GDFDocuments/PERO/Provincial Economic Review Outlook 2012.pdf.

Williams, S. E. (2012) 'Accessibility to Public High Schools and School Performance in Metropolitan Baton Rouge, Louisiana 1990-2010'.

Williams, S. and Wang, F. (2014) 'Disparities in accessibility of public high schools, in metropolitan Baton Rouge, Louisiana 1990-2010', *Urban Geography*, 35(7), pp. 1066–1083. doi: 10.1080/02723638.2014.936668.

De Witte, A. *et al.* (2013) 'Linking modal choice to motility: A comprehensive review', *Transportation Research Part A: Policy and Practice*, 49, pp. 329–341. doi: 10.1016/j.tra.2013.01.009.

Wyngaard, A. T. (2006) *An Introduction to Economic Development in the Western Cape*. Available at: https://www.westerncape.gov.za/text/2006/2/economicdevelopment.pdf.

Xu, W. (Ato) *et al.* (2015) 'Transit accessibility measures incorporating the temporal dimension', *Cities*, 46, pp. 55–66. doi: 10.1016/j.cities.2015.05.002.

Zoch, A. (2017) *The Effect of Neighbourhoods and School Quality on Education and Labour Market Outcomes in South Africa*, *Stellenbosch Economic Working Papers: WP08/2017*. doi: https://doi.org/10.1111/aeq.12181.

Summary

The geographical isolation of rural communities in developing countries raises severe accessibility constraints that contribute to poverty levels and the deficiency in the participation of social and economic activities (Vasconcellos, 1997). Apart from the influence of the degree of accessibility, rural development is linked to the level of education of the population contributing to long-run economic growth as well as good living standards (Glewwe and Muralidharan, 2016).

Several scientific fields consider accessibility as a vital concept in transportation and regional research. Given its extensive usage and approaches, various ways are used to define it. This gives rise to diversions within different definitions since, depending on the author, interpretations of its values vary. Nonetheless, Geurs and Ritsema van Eck (2001) developed a definition that is in line with what most researchers agree upon as it embraces a multitude of aspects. To the researchers mentioned, accessibility can be defined as follows:

"the extent to which the land-use transport system enables individuals or goods to reach activities or destinations by means of transport modes"

Given the variations and complexity within the definition of accessibility, the concept should not solely be considered as one entity but rather an amalgamation of constituting aspects. Geurs and Van Wee (2004) defined four essential indicators that could point towards the levels of accessibility, namely: *land use, transport, temporal* and *individual*. *Land-use* refers to the location of the people or opportunities; *transport* is related to transport infrastructures or specification of modes; *temporal* includes transit or activities schedules, as well as their availability within the day; and lastly, *individual* reflects personal aspects of the travellers such as their socio-economic status, needs or capacities to travel.

When observing accessibility within South Africa, the country's unique history within the Apartheid regime largely contributes towards the different challenges being encountered in rural areas. The geographic differentiation based on the political, social and economic systems produced space divisions within the country that still prevail (Gwanya, 2010). This landscape imposes great limitations in mobility, leaving the majority of the population with scarce access to opportunities including transportation to and from schools.

Furthermore, the alleviation of poverty and increase of high skilled population is related to the extent of investments in education. Distance to schools, reduction in schools' fees, and increase in the quality of education opportunities are some of the associated accessibility factors. In rural areas, the spatial interaction between home and school extends into communal identity and religion, affecting both social and personal outcomes such as criminal behaviour, quality of life, mortality and even democratic participation (Lochner, 2011). Consequently, it can be said that at a country level education contributes towards the increase in economic growth as well as accessibility of services (Vasconcellos, 1997; Hanushek and Woessmann, 2015).

For this reason, the scarcity of such institutions in rural areas could result in great traveling distances which consequently results in a low teacher versus learner ratio, contributing to the disparity and inequality of these communities compared to the rest of society.

The methodology carried out for this investigation aimed at observing different aspects which involved both the conceptual framework and the theory behind accessibility. Two main elements influential to any accessibility measurement were taken into consideration: the zone attractiveness and the impedance. The research process initiated with the research question: *"What is the level of accessibility to schools in South African rural areas? "*and ended off with the dissemination of findings. In order to achieve results at a national level, the NTHS was used to compare different accessibility indicators at rural provincial level. In addition, based on the resources available, the Cape Winelands District had been further investigated by generation of accessibility maps (using ArcGIS) for both real accessibility and potential accessibility. These two dissimilar types of accessibility were then compared in order to establish areas for improvement where the gap of accessibility could be reduced.

Before proceeding towards accessibility levels' calculations, it is important to investigate some of the general characteristics of the country. South Africa is comprised of nine provinces, in which concentration of rural areas is extensive in Limpopo, KwaZulu-Natal, Eastern Cape and Northern Cape. When looking at literacy levels within the country, urban areas contain the least illiterate populations indicating the need to further understand the level of access to education in the other underprivileged areas.

Higher concentration of schools are located in Gauteng and KwaZulu-Natal - contrary from the Western and Northern Cape that possess the least. Similarly, enrolment rates for these two

provinces are the lowest, when compared to the rest. Furthermore, it was found that apart from the Western Cape, walking was the primary mode of travel. Although travellers described proximity as the main reason for using this mode, it was found that Gauteng, KwaZulu-Natal, Northern and Western Cape populations take 30 minutes or more to reach schools. Nevertheless, given all results obtained, the Northern Cape was found to be the most disadvantaged province.

While this province deserves the greatest attention, the lack of data available and resource limitations did allow for further investigations. Due to this condition, the Cape Winelands District Municipality was the rural area chosen for this research as the amount of information and records available were sufficient for assessments.

The study area covers 21 473 km^2 of South Africa and is divided into five local municipalities, namely: Witzenberg, Drakenstein, Stellenbosch, Breed Valley and Langeberg. The region is well known for its mountainous terrain, river valleys and Mediterranean climate that are a great asset to the economy of the district. Conversely, when looking at education in the area, there are still 7.6% of the population with no schooling experience and about 50% with incomplete studies.

In spite of the fact that the district contributes towards 11.2% of the overall provincial economic output, there are still a great number of households' members sitting within the poverty level bracket.

The results shown with regard to the different accessibility levels to schools in the CWDM were compiled in two different parts. Firstly, a primary spatial evaluation was made (looking at proximity to schools and attractiveness of these institutions) and then calculations of accessibility index were made based on the gravity measure and experienced travel times using CWS. The ArcGIS software was used to compute and illustrate results obtained.

On average, 28% of the population present a radial distance of 800 to 1200 meters to both closest primary and secondary schools. Furthermore, only 5% and 17% of the population experience radial distances greater that 3.6 km (standard advisable for traveling distance), showing that most of the population benefit from the location of schools in terms of proximity.

Looking at the attractiveness of schools based on the ratio of educators available to learners, 4% of both primary and secondary schools fall behind the minimal standard of 1:30. Although the results verified within the primary areal analysis present some negative results, overall, they

present beneficial aspects. However, the issue arises when utilising the two approaches defined to look at potential and real accessibility: the gravity model and the CWS.

When comparing these two approaches it was found that Stellenbosch and Robertson were the main towns experiencing the highest accessibility levels. Nonetheless, most principal towns are still experiencing critical results regardless of how positive the results for the primary analysis were. Exceptionally critical areas include: McGregor, Montagu, Franschoek, Mbekweni, Wellington, Ceres, Prince Alfred Hamlet and Wolseley, encompassing 44% of the entire district.

Given the positive outcomes of the potential accessibility, any issue affected by the levels experienced may relate to transportation infrastructure or affordability. For this reason, it is suggested that further studies in this regard should be made.

Disjointedly, it is recommended that in further studies surveys within South African rural areas should be made in order to acquire sufficient data to process such measurements within the entire country, especially the Northern Cape province which seems to be the most affected region. Moreover, apart from travel times within those areas, survey answers should include data related to various indicators of accessibility including the money spent each month in relation to income, the number of students within households, the level of demand in those areas, etc.

Above all, other types of accessibility measures should be investigated and compared in order to portray similarities and differences in results between them.

Glossary

CSIR – Council of Scientific and Industrial Research

CWD – Cape Winelands District

CWDM – Cape Winelands District Municipality

CWS – Cape Winelands Survey

EA – Environmental Assessment

ESKOM – Electricity Supply Commission

GDP -Gross Domestic Product

GIS – Geographic Information System

IDP – Integrated Development Plan

NA – Not Applicable

OD – Origin - Destination

Appendix A: Meso-zones Centroids Details

Centroid ID	Meso ID	Area (m2)	No HH	No. People	Index Primary Schools	Index Secondary Schools
0	2010_22983	50745026	2	5	0,05	0,02
1	2010_23960	45654521	23	78	0,10	0,04
2	2010_22079	48721391	4	3	0,03	0,01
3	2010_23559	57958574	97	18	0,13	0,05
4	2010_24467	45049079	831	3886	0,14	0,09
5	2010_23890	48393642	24	85	0,08	0,03
6	2010_23999	46217321	5	3	0,04	0,02
7	2010_21466	57040301	5	23	0,02	0,01
8	2010_22766	48737069	37	161	0,07	0,02
9	2010_23666	42676660	73	850	0,12	0,05
10	2010_23933	34921150	4	0	0,04	0,01
11	2010_24452	48180467	169	454	0,11	0,08
12	2010_22843	42158709	3	0	0,06	0,02
13	2010_23854	36621182	144	0	0,16	0,06
14	2010_21195	56140346	1	2	0,02	0,01
15	2010_23118	42611784	3	26	0,09	0,03
16	2010_22574	43670716	125	1213	0,12	0,02
17	2010_23061	49927105	2	3	0,05	0,02
18	2010_21224	51161891	1	1	0,02	0,01
19	2010_21962	51527516	2	2	0,03	0,01
20	2010_23733	54509734	504	7	0,16	0,05
21	2010_22868	49268104	2	3	0,06	0,02
22	2010_23108	48864409	2	1	0,05	0,02
23	2010_23767	47336814	15	0	0,07	0,03
24	2010_23504	54929885	4	10	0,04	0,02
25	2010_23426	44610493	1238	5915	0,25	0,06
26	2010_21699	50679070	4	1	0,03	0,01
27	2010_24577	22897794	27	6	0,11	0,04
28	2010_23470	51999431	52	293	0,03	0,01
29	2010_22772	49611003	2	3	0,04	0,01
30	2010_24227	44916882	17126	82494	0,98	0,75
31	2010_22754	54513759	2	4	0,06	0,02
32	2010_24256	46316170	143	262	0,23	0,12
33	2010_23319	49420216	14	3	0,09	0,03
34	2010_23707	49639973	90	0	0,17	0,05
35	2010_23501	42010225	4	1	0,04	0,02
36	2010_23662	53019492	141	524	0,19	0,05
37	2010_22550	49324217	2	1	0,03	0,01
38	2010_23086	43090808	2	4	0,08	0,02
39	2010_22560	40753880	105	10	0,07	0,02
40	2010_21318	55091837	5	20	0,02	0,01
41	2010_21855	50299709	4	21	0,03	0,01
42	2010_23974	43583854	5	2	0,07	0,02
43	2010_24482	56166718	2392	19161	0,22	0,12
44	2010_24541	48525600	100	68	0,10	0,06
45	2010_24454	43642845	52	0	0,12	0,05
46	2010_22959	56017157	3	4	0,07	0,02
47	2010_22006	50596179	3	3	0,03	0,01
48	2010_24339	56383135	151	483	0,16	0,07
49	2010_23543	50312141	70	293	0,16	0,04
50	2010_23136	51366733	4	10	0,05	0,02

51	2010_22541	45946064	2	1	0,04	0,01
52	2010_23130	47836489	165	179	0,12	0,04
53	2010_22919	41155893	112	0	0,09	0,03
54	2010_22197	51382359	2	4	0,03	0,01
55	2010_22609	43549573	4	0	0,06	0,02
56	2010_23449	52234321	19	60	0,09	0,03
57	2010_24656	43412137	5	3	0,10	0,04
58	2010_22447	50079462	2	5	0,05	0,02
59	2010_23758	43121542	1144	3461	0,18	0,05
60	2010_22669	26185469	61	4	0,09	0,02
61	2010_24703	50611032	120	0	0,11	0,07
62	2010_24294	43277400	113	227	0,16	0,05
63	2010_22462	43658708	2	2	0,03	0,01
64	2010_23885	55993342	225	0	0,18	0,06
65	2010_23884	34659210	316	4	0,17	0,05
66	2010_21966	50761998	32	0	0,04	0,01
67	2010_24591	27763702	47	39	0,12	0,07
68	2010_22120	43459371	28	0	0,05	0,02
69	2010_23008	44786472	3	1	0,04	0,01
70	2010_23293	51645338	8	39	0,11	0,03
71	2010_24654	51106258	93	67	0,08	0,03
72	2010_24578	48128637	55	215	0,13	0,05
73	2010_23958	45530474	5	14	0,05	0,02
74	2010_22046	54997866	35	88	0,04	0,01
75	2010_24292	52436270	6	2	0,05	0,02
76	2010_23738	51242390	103	0	0,17	0,06
77	2010_24629	55834172	169	553	0,10	0,04
78	2010_22937	27703651	54	102	0,09	0,03
79	2010_23473	49019695	18	84	0,08	0,03
80	2010_24248	19632077	43	14	0,37	0,30
81	2010_24295	52011288	5717	26145	1,06	0,82
82	2010_24504	42989118	469	785	0,10	0,12
83	2010_23335	49363834	140	1502	0,25	0,07
84	2010_24041	44583808	373	1525	0,24	0,13
85	2010_23052	38150744	76	191	0,10	0,04
86	2010_23719	49486456	5	14	0,06	0,02
87	2010_22649	40487592	22	0	0,07	0,02
88	2010_23556	56114089	459	194	0,24	0,08
89	2010_22283	42073217	2	0	0,04	0,02
90	2010_23936	54139537	27	12	0,17	0,05
91	2010_22631	48691003	2	2	0,04	0,01
92	2010_22295	44562743	2	0	0,04	0,01
93	2010_23027	48901657	2	2	0,04	0,02
94	2010_22042	47399639	30	465	0,04	0,02
95	2010_23866	49089990	5	9	0,06	0,02
96	2010_24043	47522723	401	2238	0,15	0,08
97	2010_22812	47695875	2	2	0,03	0,01
98	2010_24066	55634522	6	8	0,06	0,02
99	2010_22184	32858723	21	36	0,05	0,02
100	2010_24371	56634644	122	73	0,11	0,04
101	2010_23805	53209258	6	23	0,05	0,02
102	2010_22744	34775391	72	24	0,07	0,02
103	2010_24344	53481109	80	41	0,06	0,02
104	2010_22511	35528827	19	0	0,07	0,02
105	2010_24610	55370138	108	267	0,06	0,02
106	2010_24097	44408405	5	0	0,09	0,03
107	2010_24277	42156156	124	674	0,15	0,06

108	2010_22449	52212930	5	12	0,05	0,02
109	2010_21804	49776214	1	4	0,05	0,02
110	2010_24085	49092948	162	873	0,15	0,04
111	2010_24334	46264793	109	46	0,15	0,07
112	2010_24684	47655824	59	10	0,08	0,04
113	2010_22562	43497034	2	0	0,04	0,02
114	2010_22877	38758768	75	0	0,08	0,03
115	2010_23343	43861612	37	0	0,15	0,04
116	2010_23168	46950637	2	9	0,08	0,02
117	2010_21361	50886831	1	4	0,03	0,01
118	2010_23207	53402602	3	4	0,11	0,03
119	2010_23728	53125822	16	35	0,07	0,03
120	2010_23251	49183381	5	10	0,04	0,02
121	2010_21972	21241027	13	57	0,04	0,01
122	2010_24690	44625528	104	153	0,07	0,02
123	2010_21669	49820417	4	2	0,02	0,01
124	2010_22988	55680814	43	0	0,09	0,03
125	2010_21295	42861684	4	9	0,02	0,01
126	2010_22599	56830621	12	83	0,06	0,02
127	2010_23942	30737672	166	49	0,17	0,06
128	2010_23833	43891302	203	1252	0,21	0,06
129	2010_23560	43751217	93	1125	0,19	0,05
130	2010_22855	35726559	37	6	0,08	0,02
131	2010_23671	53098755	16	32	0,08	0,03
132	2010_24498	49487182	197	569	0,12	0,07
133	2010_21419	56229387	5	0	0,02	0,01
134	2010_24618	43487069	54	270	0,10	0,05
135	2010_21974	40716077	26	46	0,04	0,01
136	2010_23605	48143831	15	73	0,07	0,03
137	2010_24260	43755989	194	0	0,12	0,06
138	2010_22267	53568137	4	36	0,04	0,02
139	2010_22262	44285615	3	2	0,04	0,01
140	2010_24285	42680762	114	571	0,14	0,06
141	2010_21166	53011786	5	20	0,02	0,01
142	2010_23580	54319185	95	165	0,17	0,05
143	2010_24492	56481514	86	0	0,07	0,02
144	2010_23423	45505148	5	0	0,05	0,02
145	2010_23578	48764651	5	14	0,04	0,02
146	2010_21894	53293129	1	2	0,04	0,01
147	2010_23687	47945031	5	22	0,05	0,02
148	2010_22603	49019071	2	14	0,05	0,02
149	2010_22585	33476784	12	1094	0,07	0,02
150	2010_24422	44158268	414	1085	0,12	0,09
151	2010_23827	42848197	66	3	0,14	0,04
152	2010_23208	48879503	3	24	0,12	0,03
153	2010_24243	33915594	115	20	0,17	0,07
154	2010_23382	48415967	5	24	0,07	0,02
155	2010_23022	47661170	44	297	0,10	0,03
156	2010_24418	31232756	6	0	0,13	0,06
157	2010_24533	45651332	1528	7463	0,10	0,08
158	2010_24373	51233918	129	558	0,14	0,05
159	2010_21349	52552626	5	2	0,02	0,01
160	2010_22128	39815511	2	6	0,03	0,01
161	2010_21522	56994816	5	6	0,03	0,01
162	2010_23414	45698860	1738	7912	0,32	0,22
163	2010_22387	44528881	2	5	0,03	0,01
164	2010_23899	43062604	22	6	0,09	0,03

165	2010_24129	55286436	6	21	0,07	0,02
166	2010_23619	18836016	22	31	0,11	0,03
167	2010_24612	46513190	116	301	0,10	0,03
168	2010_24579	47969942	130	14	0,11	0,04
169	2010_21116	52260121	4	0	0,02	0,01
170	2010_21820	49470517	4	2	0,03	0,01
171	2010_24738	47305054	27	70	0,06	0,02
172	2010_23276	35996659	130	170	0,15	0,05
173	2010_24376	49850792	194	751	0,13	0,05
174	2010_22732	57461385	16	363	0,07	0,02
175	2010_22971	48849042	143	20	0,10	0,03
176	2010_22712	33159929	12	99	0,08	0,02
177	2010_22693	51515856	2	3	0,04	0,01
178	2010_22724	49014166	2	3	0,05	0,02
179	2010_22007	51940452	4	15	0,03	0,01
180	2010_24075	45601663	128	213	0,11	0,04
181	2010_23534	57175910	21	8	0,11	0,03
182	2010_24290	50643748	138	223	0,14	0,05
183	2010_24132	52810105	6	2	0,10	0,03
184	2010_21859	50704668	4	10	0,03	0,01
185	2010_22709	54471866	134	1404	0,29	0,03
186	2010_21531	51890802	5	26	0,02	0,01
187	2010_23397	50899653	5	34	0,07	0,03
188	2010_22112	56970181	3	2	0,03	0,01
189	2010_22644	43915699	2	2	0,03	0,01
190	2010_22608	42317516	2	0	0,03	0,01
191	2010_23420	40011436	43	169	0,16	0,03
192	2010_23904	43191286	152	205	0,16	0,07
193	2010_24175	54564290	235	1008	0,23	0,12
194	2010_24004	42229781	5	2	0,08	0,03
195	2010_24449	55529186	138	283	0,12	0,05
196	2010_23059	52071697	4	14	0,04	0,02
197	2010_24640	55069124	1048	7907	0,13	0,16
198	2010_24098	46020662	87	373	0,12	0,04
199	2010_24653	50190691	3	0	0,12	0,07
200	2010_23749	47307244	107	5	0,18	0,06
201	2010_24515	57075699	3192	25019	0,19	0,15
202	2010_23217	42302781	162	1324	0,17	0,04
203	2010_22286	48664787	18	8	0,05	0,02
204	2010_21955	44005520	4	4	0,03	0,01
205	2010_24615	34761164	158	74	0,10	0,04
206	2010_23681	56620017	6	9	0,06	0,02
207	2010_22156	40823024	2	0	0,04	0,01
208	2010_24159	58509011	111	650	0,14	0,08
209	2010_24633	16360163	19	9	0,10	0,04
210	2010_23399	49009612	16	0	0,08	0,03
211	2010_23776	53763286	17	47	0,10	0,03
212	2010_23603	50903743	5	0	0,05	0,02
213	2010_22978	50629141	2	5	0,05	0,02
214	2010_24399	55650011	792	4653	0,41	0,13
215	2010_23663	55677055	2102	10057	0,60	0,11
216	2010_24345	52023161	141	53	0,14	0,05
217	2010_24280	44639910	208	486	0,14	0,10
218	2010_24358	55919496	54	198	0,06	0,02
219	2010_23872	46688755	5	0	0,04	0,02
220	2010_23552	55052485	61	503	0,17	0,06
221	2010_22663	50235647	3	17	0,03	0,01

222	2010_23830	28767306	62	4	0,16	0,06
223	2010_24415	54636153	83	552	0,08	0,02
224	2010_23286	22428996	88	24	0,12	0,04
225	2010_22842	49968560	2	2	0,04	0,02
226	2010_23820	50583417	16	6	0,08	0,03
227	2010_23455	26813420	37	131	0,22	0,04
228	2010_24574	46591696	105	389	0,10	0,04
229	2010_24188	50155854	6	89	0,11	0,03
230	2010_23765	50009300	6	5	0,04	0,01
231	2010_24470	52462341	864	6599	0,24	0,12
232	2010_24657	48953141	1116	11933	0,16	0,13
233	2010_22145	57907627	4	4	0,04	0,01
234	2010_23447	50617870	92	606	0,17	0,04
235	2010_23288	47319347	5	17	0,05	0,02
236	2010_22174	51297661	118	6	0,04	0,02
237	2010_24058	55940705	610	1374	0,20	0,07
238	2010_24713	34510658	6293	31706	0,11	0,11
239	2010_22783	57547651	369	2306	0,10	0,03
240	2010_24323	56963468	358	2523	0,19	0,10
241	2010_22301	42923829	2	5	0,03	0,01
242	2010_23433	52888928	650	3653	0,12	0,04
243	2010_23826	54305124	133	0	0,18	0,06
244	2010_23898	43649704	340	855	0,20	0,06
245	2010_24250	50622071	38	176	0,17	0,08
246	2010_24160	44363765	701	3727	0,38	0,20
247	2010_24440	52570593	165	1019	0,27	0,05
248	2010_22366	38038736	49	10	0,06	0,02
249	2010_23112	56645022	106	408	0,08	0,03
250	2010_21803	54202890	4	12	0,03	0,01
251	2010_24557	32767347	162	33	0,18	0,11
252	2010_21252	51841776	5	0	0,02	0,01
253	2010_22711	49835057	2	5	0,05	0,02
254	2010_24212	43319298	124	0	0,12	0,05
255	2010_22001	57015293	5	11	0,04	0,01
256	2010_22860	50090987	2	5	0,05	0,02
257	2010_23712	25750921	8	28	0,13	0,04
258	2010_20936	42627842	6	10	0,02	0,01
259	2010_21778	49502655	4	1	0,03	0,01
260	2010_24496	10891646	90	0	0,23	0,13
261	2010_22246	34256502	25	83	0,05	0,02
262	2010_23506	52614711	115	473	0,10	0,04
263	2010_21467	55639748	5	33	0,03	0,01
264	2010_21951	49618175	4	14	0,03	0,01
265	2010_24233	41009059	92	11	0,19	0,11
266	2010_24016	40516423	113	4	0,16	0,05
267	2010_21937	43841083	16	8	0,04	0,01
268	2010_22638	49278540	2	5	0,04	0,01
269	2010_22530	50108335	2	3	0,03	0,01
270	2010_22499	43507032	2	3	0,03	0,01
271	2010_23982	47944845	251	58	0,18	0,06
272	2010_24168	49657714	156	3807	0,29	0,10
273	2010_22430	48905794	2	2	0,03	0,01
274	2010_22840	50573863	2	1	0,04	0,02
275	2010_23732	39506937	77	50	0,15	0,05
276	2010_24493	51546453	66	208	0,11	0,05
277	2010_23629	51825313	287	0	0,16	0,04
278	2010_22760	49785150	2	3	0,04	0,02

279	2010_23428	32297428	137	510	0,16	0,07
280	2010_22856	48886597	2	8	0,05	0,02
281	2010_24563	54788424	7	3	0,10	0,04
282	2010_23305	56588127	106	208	0,10	0,04
283	2010_23644	42043447	462	1463	0,12	0,03
284	2010_24546	55941710	66	452	0,14	0,06
285	2010_23224	49559446	2	0	0,06	0,02
286	2010_23725	53091002	338	919	0,38	0,06
287	2010_24485	50566961	73	205	0,12	0,06
288	2010_24189	55348182	6	29	0,06	0,02
289	2010_24008	39686618	20	9	0,10	0,04
290	2010_23381	37799544	4	1	0,05	0,02
291	2010_22404	43535996	16	8	0,06	0,02
292	2010_24740	51624591	30	78	0,06	0,02
293	2010_22369	39594796	2	0	0,04	0,01
294	2010_21773	48742786	4	1	0,03	0,01
295	2010_22292	48077646	2	2	0,03	0,01
296	2010_23116	56789385	221	9	0,10	0,04
297	2010_23435	17350761	111	0	0,19	0,06
298	2010_22561	45700185	2	4	0,04	0,02
299	2010_23951	42737644	271	884	0,17	0,08
300	2010_24230	53868004	9	2	0,07	0,02
301	2010_23290	49951419	5	0	0,07	0,02
302	2010_22595	46560596	2	7	0,05	0,02
303	2010_21031	49427570	4	6	0,02	0,01
304	2010_23938	42303007	78	457	0,13	0,04
305	2010_23070	47983825	2	8	0,07	0,02
306	2010_23869	40017077	4	6	0,04	0,01
307	2010_24392	51121239	302	1248	0,14	0,06
308	2010_22194	50020262	2	3	0,03	0,01
309	2010_23934	50560160	6	15	0,08	0,03
310	2010_21715	49462802	4	0	0,03	0,01
311	2010_22816	44182432	2	4	0,03	0,01
312	2010_24232	45085322	180	746	0,20	0,12
313	2010_22859	41171508	121	44	0,09	0,03
314	2010_23348	53549830	46	65	0,12	0,03
315	2010_23158	39273879	77	11	0,10	0,04
316	2010_24209	54816807	123	101	0,15	0,05
317	2010_24321	49481413	53	0	0,18	0,09
318	2010_23617	12351020	17	16	0,16	0,04
319	2010_22381	23374940	1	0	0,05	0,02
320	2010_23187	43637878	2	4	0,09	0,03
321	2010_22930	50144556	151	928	0,09	0,03
322	2010_24483	41412549	12	85	0,12	0,05
323	2010_23178	49247964	2	5	0,07	0,02
324	2010_21595	50882996	4	0	0,03	0,01
325	2010_23959	52370935	274	888	0,20	0,07
326	2010_24390	46029043	52	6	0,15	0,07
327	2010_22084	50473107	19	0	0,04	0,01
328	2010_24632	52977654	66	0	0,09	0,04
329	2010_24481	42699766	146	284	0,10	0,04
330	2010_24229	55696718	2677	12002	0,12	0,10
331	2010_24300	49513059	73	208	0,09	0,02
332	2010_23570	52074334	80	452	0,12	0,05
333	2010_22920	48771376	2	2	0,04	0,01
334	2010_22399	47969304	2	4	0,04	0,01
335	2010_24142	44322934	158	794	0,17	0,10

336	2010_24156	52095339	1160	3372	0,21	0,12
337	2010_23213	40972718	162	4	0,14	0,04
338	2010_24414	43298398	85	268	0,11	0,05
339	2010_24120	43764627	15830	74041	0,67	0,40
340	2010_22114	31193923	11	24	0,04	0,02
341	2010_23488	38993199	4	6	0,05	0,02
342	2010_21897	51932191	3	6	0,03	0,01
343	2010_21618	53042881	4	4	0,03	0,01
344	2010_24214	38113605	135	0	0,12	0,06
345	2010_24445	43539135	100	0	0,11	0,07
346	2010_22441	52652103	4	6	0,03	0,01
347	2010_21978	57115972	5	5	0,03	0,01
348	2010_24499	36592941	21	29	0,13	0,07
349	2010_24642	49803617	136	304	0,08	0,02
350	2010_22903	48557009	2	1	0,04	0,01
351	2010_24293	46681858	45	37	0,04	0,02
352	2010_23563	52730097	16	123	0,08	0,03
353	2010_22065	47058813	2	2	0,03	0,01
354	2010_24147	49868095	127	506	0,11	0,04
355	2010_24015	57518035	3972	33553	0,28	0,10
356	2010_24282	30903802	79	0	0,16	0,07
357	2010_23474	54552057	82	1048	0,15	0,06
358	2010_23917	54389638	156	136	0,20	0,06
359	2010_21645	48861178	4	7	0,03	0,01
360	2010_22817	54753683	29	78	0,07	0,02
361	2010_24105	45016388	107	514	0,16	0,05
362	2010_24407	44767707	1695	12319	0,21	0,10
363	2010_24187	31486141	94	7	0,17	0,07
364	2010_24297	47522222	143	367	0,16	0,04
365	2010_24271	49031192	115	318	0,18	0,06
366	2010_23859	51612048	16	76	0,10	0,03
367	2010_22728	48150866	2	3	0,05	0,02
368	2010_23437	54317598	1607	6346	0,18	0,08
369	2010_24564	44587471	39	13	0,15	0,09
370	2010_24471	39706971	31099	140140	0,14	0,08
371	2010_22279	48009306	109	6	0,05	0,02
372	2010_23160	43802323	9	109	0,11	0,03
373	2010_24628	53389908	392	428	0,15	0,11
374	2010_24068	56566932	15068	50342	1,45	0,91
375	2010_21387	47671267	1	5	0,03	0,01
376	2010_24426	57113752	87	293	0,08	0,02
377	2010_24528	42548744	150	644	0,11	0,03
378	2010_23575	30389376	29	42	0,13	0,05
379	2010_24172	48939540	94	0	0,14	0,05
380	2010_24446	47679913	140	1127	0,14	0,05
381	2010_22616	32671120	2	10	0,05	0,02
382	2010_21673	57274063	5	5	0,03	0,01
383	2010_22276	53677798	2	7	0,04	0,02
384	2010_22264	46032686	2	8	0,03	0,01
385	2010_22555	43512060	107	552	0,10	0,02
386	2010_23050	48675606	2	7	0,06	0,02
387	2010_23283	48635701	159	973	0,20	0,07
388	2010_24164	51953594	127	161	0,21	0,10
389	2010_24080	55721594	65	74	0,14	0,04
390	2010_24710	34998081	29	48	0,11	0,07
391	2010_23238	48607345	2	0	0,07	0,02
392	2010_24545	51606427	78	51	0,05	0,02

393	2010_22480	57030626	21	119	0,06	0,02
394	2010_24182	52691083	187	135	0,18	0,06
395	2010_24026	42839648	5	11	0,07	0,02
396	2010_23567	56305343	6	29	0,06	0,02
397	2010_24061	23374527	157	239	0,21	0,09
398	2010_22414	43807121	80	284	0,07	0,03
399	2010_22075	57645415	5	1	0,04	0,01
400	2010_21983	47548215	4	1	0,03	0,01
401	2010_23980	54668268	27	131	0,13	0,04
402	2010_24362	49608152	121	17	0,23	0,12
403	2010_24432	51523025	95	247	0,12	0,05
404	2010_22778	19593897	57	77	0,10	0,03
405	2010_23263	49792776	5	32	0,05	0,02
406	2010_22985	49114752	2	12	0,06	0,02
407	2010_21610	55954713	5	0	0,03	0,01
408	2010_24320	57036692	1735	10785	0,48	0,21
409	2010_23955	49069724	5	0	0,05	0,02
410	2010_24479	10635771	52	16	0,23	0,12
411	2010_24593	51296152	175	525	0,09	0,02
412	2010_24060	53226938	371	876	0,23	0,09
413	2010_24552	44864706	983	4700	0,17	0,12
414	2010_24278	54524147	230	1072	0,18	0,11
415	2010_24174	43158700	1290	11310	0,41	0,21
416	2010_22906	48033347	2	3	0,06	0,02
417	2010_23846	26582136	137	0	0,22	0,07
418	2010_24569	52148767	536	3156	0,11	0,13
419	2010_23723	49687611	3387	19433	0,35	0,07
420	2010_23792	54832695	17	6	0,08	0,03
421	2010_22154	51755682	11	9	0,04	0,02
422	2010_22395	43198393	2	2	0,03	0,01
423	2010_24398	41395355	2	11	0,13	0,06
424	2010_21956	50073036	3	1	0,03	0,01
425	2010_22233	55240098	20	12	0,05	0,02
426	2010_24000	45935234	23	0	0,09	0,03
427	2010_23197	46045496	186	752	0,12	0,05
428	2010_22424	43202143	74	752	0,06	0,02
429	2010_23731	36134363	4	0	0,04	0,01
430	2010_22482	51723497	2	7	0,04	0,01
431	2010_22340	57236292	21	16	0,05	0,02
432	2010_23929	52550700	26	0	0,14	0,04
433	2010_23081	53641608	206	721	0,11	0,03
434	2010_23774	48327449	58	4	0,16	0,05
435	2010_23513	52728328	6683	25215	0,30	0,10
436	2010_23691	56352110	6	14	0,04	0,02
437	2010_23049	33937201	101	0	0,09	0,03
438	2010_22126	51721817	4	11	0,04	0,01
439	2010_23018	57150142	202	827	0,09	0,04
440	2010_22304	48159284	2	1	0,03	0,01
441	2010_24191	53605478	80	377	0,14	0,05
442	2010_22024	35111595	13	40	0,04	0,01
443	2010_24001	45780738	306	1026	0,30	0,10
444	2010_24645	44609628	34	0	0,11	0,05
445	2010_24012	44996810	619	2892	0,28	0,10
446	2010_23864	48762898	114	555	0,17	0,07
447	2010_22368	49444238	2	5	0,04	0,01
448	2010_24046	40841646	4	1	0,04	0,01
449	2010_21823	56099768	3	0	0,04	0,01

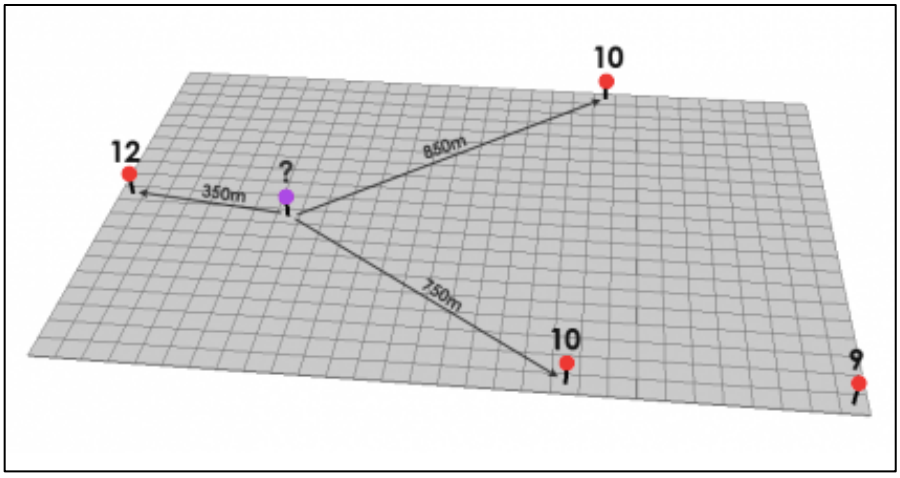
450	2010_23520	15925601	51	0	0,17	0,06
451	2010_24352	44862916	564	1138	0,12	0,07
452	2010_24024	43893721	524	2289	0,25	0,10
453	2010_23427	34681086	13	54	0,11	0,03
454	2010_24450	29025449	19	49	0,18	0,10
455	2010_23680	10440514	13	0	0,20	0,06
456	2010_21069	48821655	4	15	0,02	0,01
457	2010_24384	50215957	104	768	0,12	0,03
458	2010_24333	48534891	62	0	0,14	0,06
459	2010_24484	25688457	0	0	0,12	0,06
460	2010_22929	55846614	4	12	0,08	0,02
461	2010_21826	50278592	4	10	0,03	0,01
462	2010_24104	54117653	211	0	0,17	0,07
463	2010_23017	34528417	2	3	0,04	0,01
464	2010_21206	42056094	3	3	0,02	0,01
465	2010_23184	57631597	1711	8667	0,12	0,07
466	2010_21183	55096748	5	0	0,02	0,01
467	2010_22986	49934166	2	2	0,04	0,02
468	2010_23037	41592669	118	0	0,09	0,03
469	2010_21903	50244764	4	0	0,03	0,01
470	2010_22329	39819386	49	13	0,06	0,02
471	2010_23813	44864646	118	579	0,14	0,06
472	2010_24006	56829326	291	481	0,23	0,06
473	2010_24565	57922095	15562	103138	0,39	0,41
474	2010_24101	47882762	72	405	0,12	0,04
475	2010_24434	6318783	16	101	0,20	0,11
476	2010_22692	49497309	2	8	0,03	0,01
477	2010_22736	52832415	4	0	0,07	0,02
478	2010_22797	49002479	3	8	0,03	0,01
479	2010_23121	50548102	2	6	0,06	0,02
480	2010_23775	47404467	5	19	0,05	0,02
481	2010_23297	54856185	61	244	0,14	0,03
482	2010_24660	48126552	59	0	0,09	0,05
483	2010_21581	47429064	4	3	0,03	0,01
484	2010_24625	53366288	43	24	0,09	0,04
485	2010_21054	55219839	1	2	0,02	0,01
486	2010_22028	49442095	2	5	0,03	0,01
487	2010_24469	57817708	601	5275	0,21	1,07
488	2010_24064	47690092	172	694	0,19	0,06
489	2010_21418	47434717	4	5	0,02	0,01
490	2010_23191	48413802	3	1	0,05	0,02
491	2010_24336	48938010	2845	11485	0,31	0,08
492	2010_23492	51783599	16	158	0,07	0,03
493	2010_22575	48975183	2	4	0,04	0,01
494	2010_24096	50359821	6	3	0,05	0,02
495	2010_23614	48582437	58	0	0,15	0,04
496	2010_22410	41032428	2	2	0,04	0,01
497	2010_22739	48235278	4	0	0,06	0,02
498	2010_23900	50465440	6	8	0,05	0,02
499	2010_23214	43560372	281	1745	0,16	0,05
500	2010_23405	45491055	3	0	0,04	0,02
501	2010_23978	48824669	219	0	0,17	0,07
502	2010_24195	56790890	6	11	0,05	0,02
503	2010_22484	33762518	64	0	0,07	0,02
504	2010_23836	54632685	6	7	0,06	0,02
505	2010_23685	42643329	13	120	0,10	0,03
506	2010_23222	43402697	4	27	0,13	0,04

507	2010_22247	37102976	30	1727	0,11	0,02
508	2010_22639	46632686	2	2	0,03	0,01
509	2010_22377	52380342	119	9	0,05	0,02
510	2010_24288	48322482	230	787	0,16	0,13
511	2010_22501	43174373	3	2	0,05	0,02

Appendix B: Calculation of Inverse Distance Weighting

(Source: https://gisgeography.com/inverse-distance-weighting-idw-interpolation/)

In this example three (3) closest points are considered.



To determine the unknown point the following equation is used:

$$z_x = \frac{\sum_{i=1}^{n}\left(\frac{z_i}{d_i^p}\right)}{\sum_{i=1}^{n}\left(\frac{1}{d_i^p}\right)}$$

Where:

z_x – unknown value of point x

z_i – value of point i

d_i – distance of point i to point x

n – number of closest points taken into consideration

p – power

Therefore, when using power of 1:

$$z_x = \frac{\frac{12}{350} + \frac{10}{850} + \frac{10}{750}}{\frac{1}{350} + \frac{1}{850} + \frac{1}{750}} = 11.1$$

Appendix C: Database of Schools

Source: Western Cape Education Department

PART I

FID	Institution Name	Sector	Phase	Specialisation	Ownership
0	Tandfontein Ngk Prim.	Public	Primary	Ordinary	Farm
1	Boy Muller Prim.	Public	Combined	Ordinary	State
2	De Meul Ngk Prim.	Public	Primary	Ordinary	Farm
3	Rietfontein Ngk Prim.(Worc)	Public	Primary	Ordinary	Farm
4	Voorsorg Ngk Prim.	Public	Primary	Ordinary	State
5	Kromlin Prim.	Public	Primary	Ordinary	Farm
6	Boplaas Ngk Prim.	Public	Primary	Ordinary	Farm
7	Skurweberg Sek.	Public	Secondary	Ordinary	State
8	Koue Bokkeveld Ls.	Public	Primary	Ordinary	State
9	Piet Hugo Gedenk Ngk Prim.	Public	Primary	Ordinary	Farm
10	Driefontein Ngk Prim.	Public	Primary	Ordinary	Farm
11	Roodezandt Sek.	Public	Secondary	Ordinary	State
12	Saron Prim.	Public	Primary	Dance	State
13	Montrouge Vgk Prim.	Public	Primary	Ordinary	Church
14	Die Eike Vgk Prim.	Public	Combined	Ordinary	Farm
15	Agterwitzenberg Vgk Prim.	Public	Primary	Ordinary	Church
16	Welgemoed Ngk Prim.	Public	Primary	Ordinary	Farm
17	Twee Jonge Gezellen Vgk Prim.	Public	Primary	Ordinary	Farm
18	Drostdy Sskv Prim.	Public	Primary	Ordinary	State
19	Koelfontein Ngk Prim.	Public	Primary	Ordinary	Farm
20	Paardekloof Ngk Prim.	Public	Combined	Ordinary	Company
21	Matjiesrivier Ngk Prim.	Public	Primary	Ordinary	State
22	Rijk Tulbagh Privaatskool	Independent	Primary	Ordinary	Private
23	Tulbagh Hs.	Public	Secondary	Ordinary	State
24	Waveren Hs	Public	Secondary	Dance	State
25	St. Mark's Prim. (Worc)	Public	Primary	Ordinary	State
26	Tulbagh Primary	Public	Primary	.	.
27	Bakerville Prim.	Public	Primary	Ordinary	State
28	F.D. Conradie Ls.	Public	Primary	Ordinary	State
29	Northridge Ngk Prim.	Public	Primary	Ordinary	Farm
30	Laastedrif Ngk Prim.	Public	Primary	Ordinary	Farm
31	Fairfield Ngk Prim.	Public	Primary	Ordinary	Farm
32	Bella Vista Hs.	Public	Secondary	Ordinary	State
33	Bella Vista Prim.	Public	Primary	Ordinary	State
34	Mooi-Uitsig Prim.	Public	Primary	Ordinary	State
35	Touwsrivier Ls.	Public	Primary	Ordinary	State
36	Steenvliet Prim.	Public	Primary	Ordinary	State
37	De Kruine Sek.	Public	Secondary	Ordinary	State
38	Britsum Ngk Prim.	Public	Primary	Ordinary	Farm
39	Iingcinga Zethu Sec	Public	Secondary	Ordinary	State
40	Nduli Primary	Public	Primary	Ordinary	State
41	Ceres Lions Pre-Prim.	Independent	Primary	Ordinary	.
42	Wanganella Ngk Prim.	Public	Primary	Ordinary	Farm
43	Gericke Ls.	Public	Primary	Ordinary	State
44	Morrisdale Prim.	Public	Primary	Ordinary	State
45	Charlie Hofmeyr Hs.	Public	Secondary	Maths Science And Technology	State
46	Ceres Prim.	Public	Primary	Ordinary	State

47	Ceres Sek.	Public	Secondary	Ordinary	State
48	Achtertuin Ame Prim.	Public	Primary	Ordinary	Church
49	Welvaart Ngk Prim.	Public	Primary	Ordinary	Farm
50	Ezelfontein Ngk Prim.	Public	Primary	Ordinary	Farm
51	Wolseley Ls.	Public	Primary	Ordinary	State
52	Wolseley Sek.	Public	Secondary	Ordinary	State
53	Errie Moller Ngk Prim.	Public	Primary	Ordinary	Farm
54	Witzenberg Prim.	Public	Primary	Ordinary	State
55	W.F. Loots Prim.	Public	Primary	Ordinary	State
56	Rabie Prim.	Public	Primary	Ordinary	State
57	Rondeheuwel Prim.	Public	Primary	Ordinary	.
58	Sibabalwe Prim.	Public	Primary	Ordinary	State
59	La Plaisante Ngk Prim.	Public	Primary	Ordinary	State
60	Bonne Esperance Prim.	Public	Primary	Ordinary	Church
61	Hexrivier Opvoedkundige Sentrum	Independent	Primary	Ordinary	.
62	Hexvallei Hs.	Public	Secondary	Ordinary	State
63	Van Cutsem Combined	Public	Secondary	Ordinary	State
64	F.J. Conradie Prim.	Public	Primary	Ordinary	State
65	Hexvallei Sek.	Public	Secondary	Ordinary	State
66	Orchard Prim.	Public	Primary	Ordinary	Church
67	Iris Qwela Prim	Public	Primary	Ordinary	State
68	Sandhills Ngk Prim.	Public	Primary	Ordinary	Farm
69	Breerivier Ls.	Public	Primary	Ordinary	State
70	Petra Gedenk Prim.	Public	Primary	Ordinary	State
71	Botha's Halte Ngk Prim.	Public	Primary	Ordinary	Trust
72	Groenberg Ngk Prim.	Public	Primary	Ordinary	Church
73	Keerom Sskv Prim.	Public	Primary	Ordinary	Farm
74	Bergrivier Ngk Prim.	Public	Primary	Ordinary	Church
75	Brandwacht Ngk Prim.	Public	Primary	Ordinary	Church
76	Glen Heatlie Ame Prim.	Public	Primary	Ordinary	Church
77	Soetendal Ngk Prim.	Public	Primary	Ordinary	Church
78	Slanghoek Ngk Prim.	Public	Primary	Ordinary	Farm
79	Wysersdrift Prim.	Public	Primary	Ordinary	Farm
80	Voor-Groenberg Ngk Prim.	Public	Primary	Ordinary	Church
81	Bet-El Prim.	Public	Primary	Ordinary	Church
82	Worcester-Noord Prim.	Public	Primary	Ordinary	State
83	Montana Hs.	Public	Secondary	Ordinary	State
84	Wagenmakersvallei Ngk Prim.	Public	Primary	Ordinary	Church
85	Hugo Rust Laerskool	Public	Primary	Ordinary	State
86	Lifestyle Christian Academy	Independent	Primary	Ordinary	.
87	Worcester-Oos Ls.	Public	Primary	Ordinary	State
88	Pauw Gedenk	Public	Primary	Ordinary	State
89	Leipzig Sskv Prim.	Public	Primary	Ordinary	Farm
90	Worcester Voorb.	Public	Primary	Ordinary	State
91	Worcester Gimnasium	Public	Secondary	Computer; Maths Science And Technology	State
92	Siyafuneka Prim.	Public	Primary	Ordinary	State
93	Wellington Prim.	Public	Primary	Ordinary	State
94	Worcester Ls.	Public	Primary	Ordinary	State
95	Hugenote Prim.	Public	Primary	Ordinary	State
96	G.B. Batt Ngk Prim.	Public	Primary	Ordinary	Church
97	Roodewal Prim.	Public	Primary	Ordinary	State
98	Zwelethemba High	Public	Combined	.	.
99	St. Albans Prim.	Public	Primary	Ordinary	State
100	P.J.B. Cona Prim.	Public	Primary	Ordinary	State
101	Hugenote Hs.	Public	Secondary	Ordinary	State
102	Alfred Stamper Pub. Prim.	Public	Primary	Ordinary	State
103	Lanner House	Independent	Primary	Ordinary	Private

104	Bergrivier Sek.	Public	Secondary	Business, Commerce, Management	State
105	Drostdy Hts.	Public	Secondary	Ordinary	State
106	Vusisizwe Sec	Public	Secondary	Ordinary	State
107	Esselenpark Prim.	Public	Primary	Ordinary	State
108	Hillcrest Prim.	Public	Primary	Ordinary	State
109	Worcester Ngk Oefen Prim.	Public	Primary	Ordinary	Church
110	Worcester Sek.	Public	Secondary	Arts And Culture	State
111	Worcester Mos Prim.	Public	Primary	Ordinary	Church
112	Alfons Prim.	Public	Primary	Ordinary	State
113	De Tuinen Prim.	Public	Primary	Ordinary	State
114	Esselenpark Sek.	Public	Secondary	Computer; Business, Commerce, Management	State
115	Boland Landbouskool	Public	Secondary	Ordinary	State
116	Hexpark Prim.	Public	Primary	Ordinary	State
117	Worcester Rk Prim.	Public	Combined	Ordinary	Church
118	Blouvlei Akademie Vir Christelike Onderwys	Independent	Primary	Ordinary	.
119	Koo Ls.	Independent	Primary	Ordinary	Private
120	Weltevrede Sek.	Public	Secondary	Ordinary	State
121	Somerset High	Public	Combined	.	.
122	Victoriapark Prim.	Public	Primary	Ordinary	State
123	Riverview Prim.	Public	Primary	Ordinary	State
124	Pietersfontein Ngk Prim.	Public	Primary	Ordinary	Church
125	Overhex Ngk Prim.	Public	Primary	Ordinary	Church
126	Bre ├½Rivier Hs.	Public	Secondary	Maths Science And Technology	State
127	Wellington Sec.	Public	Secondary	Ordinary	State
128	Wellington Prep.	Independent	Primary	Ordinary	Farm
129	Van Wyksvlei Primary	Public	Primary	Ordinary	State
130	Avian Park Prim.	Public	Primary	Ordinary	State
131	Goudini Bad Ngk Prim.	Public	Primary	Ordinary	Private
132	Windmeul Prim.	Public	Primary	Ordinary	State
133	Slot Van Die Paarl Prim.	Public	Primary	Ordinary	State
134	Langabuya Prim.	Public	Primary	Ordinary	State
135	Newton Prim.	Public	Primary	Ordinary	State
136	Nuystasie Ngk Prim.	Public	Primary	Ordinary	Church
137	Imboniselo Prim.	Public	Primary	Ordinary	State
138	Nieuwe Drift Prim.	Public	Primary	Ordinary	State
139	Mbekweni Prim.	Public	Primary	Ordinary	State
140	Ihlumelo Jun Sek	Public	Secondary	Ordinary	State
141	Desmond Mpilo Tutu Sec.	Public	Secondary	Maths Science And Technology	State
142	Goudini Hs.	Public	Secondary	Ordinary	State
143	Rawsonville Prim.	Public	Primary	Ordinary	.
144	Concordia Ngk Prim.	Public	Primary	Ordinary	Church
145	Dal Josaphat Prim.	Public	Primary	Ordinary	Church
146	Dalweide Prim.	Public	Primary	Ordinary	State
147	Aan De Doorns Ngk Prim.	Public	Primary	Ordinary	Church
148	Groenheuwel Prim	Public	Primary	Ordinary	State
149	Keisie Vgk Prim.	Public	Primary	Ordinary	Church
150	Noord-Eind Prim.	Public	Primary	Ordinary	State
151	Lorraine Ngk Prim.	Public	Primary	Ordinary	Farm
152	New Orleans Sek.	Public	Secondary	Dance	State
153	Tersia Theron Privaatskool	Independent	Combined	Ordinary	.
154	New Orleans Prim.	Public	Primary	Dance	State
155	Orleansvale Prim.	Public	Primary	Ordinary	State
156	Baden Ngk Prim.	Public	Primary	Ordinary	Church
157	Noorder-Paarl Sek.	Public	Secondary	Ordinary	State

158	Gimnasium Hs. (Paarl)	Public	Secondary	Ordinary	State
159	Charleston Hill Prim.	Public	Primary	Ordinary	State
160	Charleston Hill Sek.	Public	Secondary	Ordinary	State
161	W.A. Joubert Prim.	Public	Primary	Ordinary	State
162	Magnolia Prim.	Public	Primary	Ordinary	.
163	Weltevrede Ngk Prim.	Public	Primary	Ordinary	Church
164	Paarlzicht Prim.	Public	Primary	Ordinary	State
165	Al-Azhar Institute Of Paarl	Independent	Secondary	Ordinary	Church
166	Nederburg Prim.	Public	Primary	Ordinary	State
167	Mary Help Of Christians Prim.	Independent	Primary	Ordinary	Church
168	Ebenezer Prim.	Public	Primary	Ordinary	State
169	Labori Hs.	Public	Secondary	Computer	State
170	Drakenstein Prim.	Public	Primary	Ordinary	State
171	Paulus Joubert Sek.	Public	Secondary	Ordinary	State
172	Gimnasium Prim.	Public	Primary	Ordinary	State
173	Carnegie House Preparatory (Paarl)	Independent	Primary	Ordinary	Private
174	Paulus Joubert Prim.	Public	Primary	Dance	State
175	William Lloyd Prim.	Public	Primary	Dance	State
176	Klein Nederburg Sek.	Public	Secondary	Maths Science And Technology	State
177	La Rochelle Girls Prim.	Public	Primary	Ordinary	State
178	La Rochelle Meisies Hs.	Public	Secondary	Ordinary	State
179	Sonop Prim.	Public	Primary	Ordinary	State
180	Hoer JONGENSKOOL PAARL	PUBLIC	SECONDARY	ORDINARY	STATE
181	Amstelhof Prim.	Public	Primary	Ordinary	State
182	L.K. Zeeman Prim.	Public	Primary	Ordinary	State
183	Paarl Boys' Prim.	Public	Primary	Ordinary	State
184	Rietvlei Nr 2 Ngk Prim.	Public	Primary	Ordinary	Church
185	Paarl Girls Hs.	Public	Secondary	Ordinary	State
186	Brandvlei Youth Centre	Independent	Secondary	Ordinary	State
187	Vinkrivier Prim.	Public	Primary	Ordinary	State
188	The Oaks Preparatory And College	Independent	Primary	Ordinary	.
189	Heritage House Independent	Independent	Primary	Ordinary	.
190	Ronwe Prim.	Public	Primary	Ordinary	State
191	Ashbury Prim.	Public	Combined	Ordinary	State
192	Bergendal Sskv Prim.	Public	Primary	Ordinary	Farm
193	Nieuwe Morgen Prim.	Public	Primary	Ordinary	State
194	Eilandia Ngk Prim.	Public	Primary	Ordinary	Farm
195	Courtrai Prim.	Public	Primary	Ordinary	State
196	W.A. Rossouw Prim.	Public	Combined	Ordinary	State
197	Scherpenheuwel Prim.	Public	Primary	Ordinary	State
198	Langeberg Sek.	Public	Secondary	Maths Science And Technology	State
199	Dagbreek Ls	Public	Primary	Ordinary	State
200	Montagu Ls.	Public	Primary	Ordinary	State
201	Vergesig Prim.	Public	Combined	Ordinary	State
202	Montagu Hs.	Public	Secondary	Ordinary	State
203	De Villiers Laer.	Public	Primary	Ordinary	State
204	Klaasvoogds Prim.	Public	Primary	Ordinary	State
205	Robertson Voorb.	Public	Primary	Ordinary	State
206	Robertson Ls.	Public	Primary	Ordinary	State
207	Robertson Hs.	Public	Secondary	Ordinary	State
208	Robertson Logos Christian	Independent	Secondary	Ordinary	Private
209	Klapmuts Prim.	Public	Primary	Ordinary	State
210	Joostenberg Sskv Prim.	Public	Primary	Ordinary	Farm
211	Huguenoot Vgk Prim.	Public	Primary	Ordinary	Church
212	A.F. Kriel Vgk Prim.	Public	Primary	Ordinary	Church
213	Nkqubela Prim.	Public	Primary	Ordinary	State
214	Masakheke Combined	Public	Secondary	Ordinary	State

215	H.M. Beets Prim.	Public	Primary	Ordinary	State
216	Talana Ngk Prim.	Public	Primary	Ordinary	Church
217	Ashton Ls.	Public	Primary	Ordinary	State
218	H. Venter Prim.	Public	Primary	Ordinary	State
219	Ashton Sek. Skool	Public	Secondary	Ordinary	State
220	Riverside Sskv Prim.	Public	Primary	Ordinary	Farm
221	Lemoenpoort Prim.	Public	Primary	Ordinary	Farm
222	Ashton Public Combined	Public	Secondary	Ordinary	State
223	Lofdal Christian Academy	Independent	Primary	Ordinary	.
224	Simond Privaatskool	Independent	Primary	Ordinary	Trust
225	Lawrensia Prim.	Public	Combined	Ordinary	State
226	Rietvlei Nr 1 Ek Prim. (Montagu)	Public	Primary	Ordinary	Church
227	Simondium Prim.	Public	Primary	Ordinary	State
228	J.J. Rhode Prim.	Public	Primary	Ordinary	State
229	Prospect Ngk Prim.	Public	Primary	Ordinary	Church
230	Stockwell Ngk Prim.	Public	Primary	Ordinary	Church
231	Uitnood Ngk Prim.	Public	Primary	Ordinary	Farm
232	Le Chasseur Vgk Prim.	Public	Combined	Ordinary	Church
233	Nondzame Prim. (S.A.)	Public	Primary	Ordinary	State
234	Koelenhof Rk Prim.	Public	Primary	Ordinary	Church
235	Wemmershoek Prim.	Public	Primary	Ordinary	State
236	Bridge House	Independent	Secondary	Ordinary	.
237	Wardia Vgk Prim.	Public	Primary	Ordinary	Church
238	Dalubuhle Prim.	Public	Primary	Ordinary	State
239	Goudmyn Prim.	Public	Combined	Ordinary	Church
240	Pniel Prim.	Public	Primary	Dance	State
241	Groendal Sek.	Public	Secondary	Ordinary	State
242	Groendal Prim.	Public	Primary	Ordinary	State
243	Stettyn Prim.	Public	Primary	Ordinary	Private
244	Wes-Eind Prim.	Public	Primary	Ordinary	State
245	Fransie Du Toit Ngk Prim.	Public	Primary	Ordinary	Church
246	Pieter Langeveldt Prim.	Public	Primary	Ordinary	State
247	Bo-Doornrivier Prim.	Public	Primary	Ordinary	State
248	Rietenbosch Prim.	Public	Primary	Ordinary	State
249	Franschhoek Hs.	Public	Secondary	Ordinary	State
250	Cloetesville Hs.	Public	Secondary	Computer	State
251	Wakkerstroom-Oos Ngk Prim.	Public	Primary	Ordinary	Farm
252	Vision Afrika Primary	Independent	Primary	Ordinary	.
253	Cloetesville Prim.	Public	Primary	Ordinary	State
254	Makupula Sec.	Public	Secondary	Ordinary	State
255	Kayamandi Sec.	Public	Secondary	Ordinary	State
256	Wakkerstroom-Wes Prim.	Public	Combined	Ordinary	State
257	Idasvallei Prim.	Public	Primary	Ordinary	State
258	Luckhoff Sek.	Public	Secondary	Maths Science And Technology	State
259	Bruckner De Villiers Prim.	Public	Primary	Ordinary	State
260	Kayamandi Prim.	Public	Primary	Ordinary	State
261	Ikaya Prim.	Public	Primary	Ordinary	State
262	Devonvallei Prim.	Public	Primary	Ordinary	State
263	P.C. Petersen Prim.	Public	Primary	Ordinary	State
264	St. Idas Rk Prim.	Public	Primary	Ordinary	.
265	Kylemore Sek.	Public	Secondary	Ordinary	State
266	A.F. Louw Ls.	Public	Primary	Ordinary	State
267	Stellenbosch Hs.	Public	Secondary	Ordinary	State
268	Bonnievale Prim.	Public	Combined	Ordinary	State
269	Stellenbosch Ls.	Public	Primary	Ordinary	State
270	Maraisdal Ngk Prim.	Public	Primary	Ordinary	Farm
271	Bonnievale Hs.	Public	Secondary	Ordinary	State
272	Paul Roos Gimnasium	Public	Secondary	Computer	State

273	Bloemhof Hs.	Public	Secondary	Ordinary	State
274	Eikestad Ls.	Public	Primary	Ordinary	State
275	Mc Gregor Waldorf	Independent	Combined	Ordinary	.
276	Rhenish Girls' Hs.	Public	Secondary	Ordinary	State
277	Rhenish Prim.	Public	Primary	Ordinary	State
278	Mcgregor Prim.	Public	Combined	Ordinary	State
279	Willem Buchholz Ngk Prim.	Public	Primary	Ordinary	Farm
280	Vlottenburg Prim.	Public	Primary	Ordinary	Farm
281	Mount View Education Centre	Independent	Combined	Ordinary	.
282	Retreat Ngk Prim.	Public	Combined	Ordinary	Church
283	Middelrivier Prim.	Public	Primary	Ordinary	State
284	Gelukshoop Ngk Prim.	Public	Primary	Ordinary	Private
285	Stellenzicht Sek.	Public	Secondary	Ordinary	State
286	Weltevrede Ngk Prim. (Roberts)	Public	Primary	Ordinary	Farm
287	Weber Gedenk Ngk Prim.	Public	Primary	Ordinary	Church
288	Stellenbosch Waldorf	Independent	Secondary	Ordinary	Private
289	Welville Ek Prim.	Public	Primary	Ordinary	Church
290	Bruintjiesrivier Ek Prim.	Public	Primary	Ordinary	Church
291	Boesmansrivier Ngk Prim.	Public	Primary	Ordinary	Church
292	Buffelskloof Sskv Prim.	Public	Primary	Ordinary	Farm
293	Waboomsheuwel Ngk Prim.	Public	Primary	Ordinary	Farm
294	Raithby Prim.	Public	Primary	Ordinary	Church
295	Somerset College	Independent	Secondary	Ordinary	.

PART II

FID	Exdept	Longitude	Latitude	L. Municipality	Address
0	House Of Representatives(Hor)	19,25	-32,77	Witzenberg	M.J Persens
1	House Of Representatives(Hor)	19,29	-32,84	Witzenberg	T Persens
2	House Of Representatives(Hor)	19,35	-32,89	Witzenberg	F. Ludick
3	House Of Representatives(Hor)	19,26	-32,90	Witzenberg	M Mars
4	House Of Representatives(Hor)	19,30	-32,90	Witzenberg	J.C.T. Ockhuis
5	House Of Representatives(Hor)	19,25	-32,95	Witzenberg	Jf. Pieters
6	House Of Representatives(Hor)	19,36	-32,98	Witzenberg	A.G. Coetzee
7	House Of Representatives(Hor)	19,31	-33,01	Witzenberg	H. Pieterse
8	Cape Education Department(Ced)	19,31	-33,02	Witzenberg	Wp Van Der Merwe
9	House Of Representatives(Hor)	19,34	-33,17	Witzenberg	G. Kortje
10	House Of Representatives(Hor)	19,41	-33,17	Witzenberg	G.S Ockhuis
11	House Of Representatives(Hor)	19,01	-33,18	Drakenstein	A.M.O. Beerwinkel
12	House Of Representatives(Hor)	19,01	-33,19	Drakenstein	Hh Lesch (Waarnemend)
13	House Of Representatives(Hor)	19,16	-33,20	Witzenberg	J.J. Van Wyngaardt
14	House Of Representatives(Hor)	19,22	-33,21	Witzenberg	R.E. Cupido
15	House Of Representatives(Hor)	19,25	-33,23	Witzenberg	M.J. Davids
16	House Of Representatives(Hor)	19,54	-33,24	Witzenberg	M.M Syster
17	House Of Representatives(Hor)	19,12	-33,24	Witzenberg	J.C. Krieger (Waarnemend)
18	House Of Representatives(Hor)	19,14	-33,24	Witzenberg	J Krige
19	House Of Representatives(Hor)	19,34	-33,26	Witzenberg	T.J. Du Plessis
20	House Of Representatives(Hor)	19,25	-33,26	Witzenberg	J. Hofmeester
21	House Of Representatives(Hor)	19,65	-33,27	Witzenberg	J.P. Franse
22	Western Cape Education Department	19,14	-33,27	Witzenberg	J Smit
23	Cape Education Department(Ced)	19,14	-33,28	Witzenberg	A Van Der Merwe (Waarnemend)
24	House Of Representatives(Hor)	19,15	-33,29	Witzenberg	A.M. Michaels
25	House Of Representatives(Hor)	19,33	-33,29	Witzenberg	A. Struis
26	Wce	19,14	-33,29	Witzenberg	Moses
27	House Of Representatives(Hor)	19,05	-33,29	Drakenstein	N.C. Baadjies
28	Cape Education Department(Ced)	19,33	-33,29	Witzenberg	J.M. Esterhuizen
29	House Of Representatives(Hor)	19,46	-33,30	Witzenberg	L.D. Strauss
30	House Of Representatives(Hor)	19,66	-33,32	Witzenberg	S Hardneck
31	House Of Representatives(Hor)	19,28	-33,32	Witzenberg	A.H Geldenhuys
32	Western Cape Education Department	19,31	-33,33	Witzenberg	B.J. Leendertz
33	House Of Representatives(Hor)	19,31	-33,33	Witzenberg	H Brown
34	House Of Representatives(Hor)	19,31	-33,33	Witzenberg	C.E. Kayer
35	Cape Education Department(Ced)	20,03	-33,34	Breede Valley	B.P. Du Plessis
36	House Of Representatives(Hor)	20,02	-33,35	Breede Valley	G Marries
37	House Of Representatives(Hor)	20,02	-33,35	Breede Valley	Bp Willemse
38	House Of Representatives(Hor)	19,56	-33,35	Witzenberg	H. Farmer-Mei
39	Department Of Education And Training(Det)	19,34	-33,35	Witzenberg	E. Mgoboza
40	Department Of Education And Training(Det)	19,34	-33,36	Witzenberg	S.S. Tisana
41	Western Cape Education Department	19,31	-33,36	Witzenberg	Dippenaar
42	House Of Representatives(Hor)	19,47	-33,37	Witzenberg	M. Frieslaar
43	Cape Education Department(Ced)	19,30	-33,37	Witzenberg	E.J. Riekert
44	House Of Representatives(Hor)	19,31	-33,37	Witzenberg	H.J. Fredericks
45	Cape Education Department(Ced)	19,30	-33,37	Witzenberg	M. Michau
46	House Of Representatives(Hor)	19,31	-33,38	Witzenberg	D Koopman
47	House Of Representatives(Hor)	19,32	-33,38	Witzenberg	R.S. Balie
48	House Of Representatives(Hor)	19,36	-33,38	Witzenberg	D.A. Gatyene

49	House Of Representatives(Hor)	19,51	-33,39	Witzenberg	J.J. Johnson
50	House Of Representatives(Hor)	19,42	-33,40	Witzenberg	I De Wee
51	Cape Education Department(Ced)	19,20	-33,41	Witzenberg	H Mostert
52	House Of Representatives(Hor)	19,21	-33,42	Witzenberg	R.F. Vergotine
53	House Of Representatives(Hor)	19,23	-33,42	Witzenberg	K. Arendse
54	House Of Representatives(Hor)	19,20	-33,42	Witzenberg	J.A. Mcclune
55	House Of Representatives(Hor)	19,20	-33,43	Witzenberg	Dj Faroo
56	House Of Representatives(Hor)	19,70	-33,44	Breede Valley	M. Olivier
57	House Of Representatives(Hor)	18,96	-33,44	Drakenstein	M.L. Hendricks
58	Department Of Education And Training(Det)	19,68	-33,46	Breede Valley	E. Gayiya
59	House Of Representatives(Hor)	19,21	-33,46	Witzenberg	M.P Seroot
60	House Of Representatives(Hor)	19,68	-33,46	Breede Valley	R.E. Paulse
61	Western Cape Education Department	19,67	-33,48	Breede Valley	Bauermeister
62	Cape Education Department(Ced)	19,66	-33,48	Breede Valley	T.A. Scheepers
63	Department Of Education And Training(Det)	19,68	-33,48	Breede Valley	M Bushwana
64	House Of Representatives(Hor)	19,67	-33,48	Breede Valley	M.E.A. Hendricks
65	House Of Representatives(Hor)	19,67	-33,48	Breede Valley	Ala Mei
66	House Of Representatives(Hor)	19,64	-33,49	Breede Valley	J Harmse
67	Department Of Education And Training(Det)	19,63	-33,49	Breede Valley	Ms Mtamo
68	House Of Representatives(Hor)	19,55	-33,52	Breede Valley	P. Weber
69	Cape Education Department(Ced)	19,22	-33,52	Witzenberg	P.J. Smit
70	House Of Representatives(Hor)	19,21	-33,53	Witzenberg	Wb Springveldt
71	House Of Representatives(Hor)	19,26	-33,56	Witzenberg	Nd Pedro
72	House Of Representatives(Hor)	19,01	-33,57	Drakenstein	G. Samson
73	House Of Representatives(Hor)	19,69	-33,57	Langeberg	E. Le Roux
74	House Of Representatives(Hor)	18,95	-33,59	Drakenstein	R Swarts
75	House Of Representatives(Hor)	19,41	-33,59	Breede Valley	S Gallie
76	House Of Representatives(Hor)	19,52	-33,60	Breede Valley	C.D.J. January
77	House Of Representatives(Hor)	18,98	-33,60	Drakenstein	E.B. Lategan
78	House Of Representatives(Hor)	19,23	-33,61	Breede Valley	Ce Visagie
79	House Of Representatives(Hor)	19,31	-33,61	Breede Valley	A Valley
80	House Of Representatives(Hor)	19,01	-33,61	Drakenstein	C.J. Driver
81	House Of Representatives(Hor)	19,37	-33,61	Witzenberg	J.E. Joubert
82	Cape Education Department(Ced)	19,45	-33,63	Breede Valley	P Borcherds
83	Cape Education Department(Ced)	19,45	-33,63	Breede Valley	Gd Biesenbach
84	House Of Representatives(Hor)	19,05	-33,63	Drakenstein	P Solomons
85	Cape Education Department(Ced)	19,00	-33,64	Drakenstein	Jf Bruwer
86	Western Cape Education Department	19,45	-33,64	Breede Valley	J Kim
87	Cape Education Department(Ced)	19,45	-33,64	Breede Valley	Jn Van Leeuwen
88	House Of Representatives(Hor)	19,00	-33,64	Drakenstein	J.C. Williams
89	House Of Representatives(Hor)	19,64	-33,64	Breede Valley	H.G Johnson
90	Cape Education Department(Ced)	19,44	-33,64	Breede Valley	R. Smit
91	Cape Education Department(Ced)	19,44	-33,64	Breede Valley	Ca Schoeman
92	Department Of Education And Training(Det)	19,49	-33,64	Breede Valley	N.C. Damane
93	House Of Representatives(Hor)	19,00	-33,65	Drakenstein	W.R. Appollis
94	Cape Education Department(Ced)	19,43	-33,65	Breede Valley	A. Peens
95	Cape Education Department(Ced)	19,01	-33,65	Drakenstein	Hw Schemper
96	House Of Representatives(Hor)	19,79	-33,65	Langeberg	A.A.G. Blaauw
97	House Of Representatives(Hor)	19,47	-33,65	Breede Valley	A E Van Der Merwe
98	Wce	19,49	-33,65	Breede Valley	Claassen
99	House Of Representatives(Hor)	19,00	-33,65	Drakenstein	H.A.T. Bailey
100	Department Of Education And Training(Det)	19,49	-33,65	Breede Valley	N.F Matross
101	Cape Education Department(Ced)	19,01	-33,65	Drakenstein	W.J.A. Moolman

102	Department Of Education And Training(Det)	19,49	-33,65	Breede Valley	Pt Mtamo
103	Western Cape Education Department	19,43	-33,65	Breede Valley	Wd Middleton
104	House Of Representatives(Hor)	18,99	-33,65	Drakenstein	G Julies
105	Cape Education Department(Ced)	19,43	-33,65	Breede Valley	Aw Underhay
106	Department Of Education And Training(Det)	19,49	-33,65	Breede Valley	N.M. Makoetlane
107	House Of Representatives(Hor)	19,46	-33,65	Breede Valley	P.J. Hoffman
108	House Of Representatives(Hor)	18,99	-33,65	Drakenstein	Tj De Jongh
109	House Of Representatives(Hor)	19,45	-33,65	Breede Valley	P Kemp
110	House Of Representatives(Hor)	19,46	-33,65	Breede Valley	Swi Brown
111	House Of Representatives(Hor)	19,45	-33,65	Breede Valley	F Ismail
112	House Of Representatives(Hor)	18,88	-33,65	Drakenstein	A.E. Sauls
113	House Of Representatives(Hor)	19,45	-33,66	Breede Valley	W.S.C. Bailey
114	House Of Representatives(Hor)	19,46	-33,66	Breede Valley	J. Adriaanse
115	Cape Education Department(Ced)	18,88	-33,66	Drakenstein	C Fourie
116	House Of Representatives(Hor)	19,47	-33,66	Breede Valley	C.D Ontong
117	House Of Representatives(Hor)	19,45	-33,66	Breede Valley	W.A. Issel
118	Western Cape Education Department	19,03	-33,66	Drakenstein	Crafford
119	Cape Education Department(Ced)	19,83	-33,66	Langeberg	F.W. Nieuwenhuis
120	House Of Representatives(Hor)	18,99	-33,66	Drakenstein	O Monis (Acting)
121	Wce	19,43	-33,66	Breede Valley	Schroeder
122	House Of Representatives(Hor)	19,44	-33,66	Breede Valley	R Titus
123	House Of Representatives(Hor)	19,45	-33,66	Breede Valley	J.L. Titus
124	House Of Representatives(Hor)	20,01	-33,66	Langeberg	J. January
125	House Of Representatives(Hor)	19,54	-33,66	Breede Valley	D. Sauer
126	House Of Representatives(Hor)	19,44	-33,66	Breede Valley	K Paulse
127	Western Cape Education Department	18,99	-33,67	Drakenstein	H Cupido
128	Western Cape Education Department	19,01	-33,67	Drakenstein	M. Aubin
129	Western Cape Education Department	19,00	-33,67	Drakenstein	H Bailey
130	Western Cape Education Department	19,43	-33,67	Breede Valley	C.C.S Africa
131	House Of Representatives(Hor)	19,26	-33,67	Breede Valley	M Phillips
132	House Of Representatives(Hor)	18,90	-33,67	Drakenstein	Cj Moses
133	Cape Education Department(Ced)	18,91	-33,67	Drakenstein	C.H. Fourie
134	Department Of Education And Training(Det)	18,99	-33,67	Drakenstein	N.M. Ndzuzo
135	House Of Representatives(Hor)	19,01	-33,67	Drakenstein	L.C. Truter
136	House Of Representatives(Hor)	19,61	-33,68	Breede Valley	S Karriem
137	Department Of Education And Training(Det)	18,99	-33,68	Drakenstein	G.N Nomandla
138	House Of Representatives(Hor)	18,97	-33,68	Drakenstein	J. Bam
139	Department Of Education And Training(Det)	18,99	-33,68	Drakenstein	M.N Njenxa
140	Western Cape Education Department	18,99	-33,68	Drakenstein	Lc. Bhunguzana
141	Department Of Education And Training(Det)	18,99	-33,68	Drakenstein	N.J. Allah
142	Cape Education Department(Ced)	19,31	-33,69	Breede Valley	B. Oosthuizen
143	House Of Representatives(Hor)	19,32	-33,69	Breede Valley	Dp Fortuin
144	House Of Representatives(Hor)	19,86	-33,69	Langeberg	A.R. Sauer
145	House Of Representatives(Hor)	19,02	-33,69	Drakenstein	A.P. Fortuin
146	House Of Representatives(Hor)	18,99	-33,70	Drakenstein	E Johannes
147	House Of Representatives(Hor)	19,49	-33,70	Breede Valley	De Jacobs
148	Western Cape Education Department	19,00	-33,70	Drakenstein	D.L. Ceasar
149	House Of Representatives(Hor)	20,01	-33,70	Langeberg	Se Benjamin
150	Cape Education Department(Ced)	18,96	-33,71	Drakenstein	A.A. Verhoog
151	House Of Representatives(Hor)	19,26	-33,71	Breede Valley	R.P.M. Abrahams
152	House Of Representatives(Hor)	18,99	-33,72	Drakenstein	D. Von Willingh
153	Western Cape Education Department	18,96	-33,72	Drakenstein	T. Theron

154	House Of Representatives(Hor)	18,99	-33,72	Drakenstein	H.F Adonis
155	House Of Representatives(Hor)	19,00	-33,72	Drakenstein	H.E. Cairncross
156	House Of Representatives(Hor)	20,12	-33,72	Langeberg	He Snyman
157	House Of Representatives(Hor)	18,97	-33,72	Drakenstein	Dc Mathys
158	Cape Education Department(Ced)	18,96	-33,72	Drakenstein	Ej Bateman
159	House Of Representatives(Hor)	18,98	-33,72	Drakenstein	V.E. Parrott
160	House Of Representatives(Hor)	18,99	-33,72	Drakenstein	D.M. October
161	Cape Education Department(Ced)	18,97	-33,72	Drakenstein	Lc Mouton
162	House Of Representatives(Hor)	19,00	-33,73	Drakenstein	C.J. Carolissen
163	House Of Representatives(Hor)	19,35	-33,73	Breede Valley	Ab Abrahams
164	House Of Representatives(Hor)	18,99	-33,73	Drakenstein	Mj Julies
165	Western Cape Education Department	18,99	-33,73	Drakenstein	Z Moerat
166	House Of Representatives(Hor)	19,00	-33,73	Drakenstein	Mp Lawrence
167	Western Cape Education Department	18,99	-33,73	Drakenstein	B.K. Fortuin
168	House Of Representatives(Hor)	18,99	-33,73	Drakenstein	F.C. Matthee
169	Cape Education Department(Ced)	18,96	-33,73	Drakenstein	J Batt
170	Cape Education Department(Ced)	18,98	-33,73	Drakenstein	S.J. Hoffmann
171	House Of Representatives(Hor)	19,01	-33,73	Drakenstein	T. Kearns
172	Cape Education Department(Ced)	18,96	-33,73	Drakenstein	M.V. Carstens
173	Western Cape Education Department	18,96	-33,73	Drakenstein	S Carnegie
174	House Of Representatives(Hor)	19,00	-33,73	Drakenstein	G.J. Isaacs
175	House Of Representatives(Hor)	19,00	-33,73	Drakenstein	P.E. Lourens
176	House Of Representatives(Hor)	18,99	-33,74	Drakenstein	M Banda
177	Cape Education Department(Ced)	18,97	-33,74	Drakenstein	Ca Van Zyl
178	Cape Education Department(Ced)	18,96	-33,74	Drakenstein	A Lochner
179	House Of Representatives(Hor)	19,02	-33,74	Drakenstein	Rld Davey
180	Cape Education Department(Ced)	18,96	-33,74	Drakenstein	Da Swart
181	House Of Representatives(Hor)	19,00	-33,74	Drakenstein	C.G. De Jager
182	House Of Representatives(Hor)	19,01	-33,74	Drakenstein	Me Williams
183	Cape Education Department(Ced)	18,97	-33,74	Drakenstein	H. Bester
184	House Of Representatives(Hor)	20,20	-33,74	Langeberg	R. Carelse
185	Cape Education Department(Ced)	18,96	-33,74	Drakenstein	M Van Zyl
186	Western Cape Education Department	19,41	-33,75	Breede Valley	Y Freysen-Hugo
187	House Of Representatives(Hor)	19,78	-33,75	Langeberg	Mj Munnik
188	Western Cape Education Department	18,96	-33,75	Drakenstein	T. Strack
189	Western Cape Education Department	18,96	-33,76	Drakenstein	Meyer
190	House Of Representatives(Hor)	19,00	-33,76	Drakenstein	W.P.J Cupido
191	House Of Representatives(Hor)	20,15	-33,77	Langeberg	Jj Pekeur
192	House Of Representatives(Hor)	18,92	-33,77	Drakenstein	N Abrahams
193	House Of Representatives(Hor)	19,54	-33,77	Breede Valley	E.E. Willemse
194	House Of Representatives(Hor)	19,67	-33,77	Langeberg	A.M. Ferus
195	Cape Education Department(Ced)	18,96	-33,77	Drakenstein	R Stoltz
196	House Of Representatives(Hor)	20,12	-33,78	Langeberg	A.C Fielies
197	House Of Representatives(Hor)	19,61	-33,78	Breede Valley	Mjm Visagie
198	House Of Representatives(Hor)	19,89	-33,79	Langeberg	A.A Landman
199	House Of Representatives(Hor)	19,89	-33,79	Langeberg	N.J. Padiachy
200	Cape Education Department(Ced)	20,13	-33,79	Langeberg	J Kruger
201	House Of Representatives(Hor)	19,90	-33,79	Langeberg	A.Q. Lucas
202	Cape Education Department(Ced)	20,12	-33,79	Langeberg	J.J. Spies
203	House Of Representatives(Hor)	19,88	-33,79	Langeberg	Rcc Sampson
204	House Of Representatives(Hor)	19,99	-33,80	Langeberg	J.J. Damons
205	Cape Education Department(Ced)	19,89	-33,80	Langeberg	S. Prins
206	Cape Education Department(Ced)	19,89	-33,81	Langeberg	S.S. Weyers
207	Cape Education Department(Ced)	19,89	-33,81	Langeberg	H. Gonzales
208	Western Cape Education Department	19,88	-33,81	Langeberg	T Lloyd
209	House Of Representatives(Hor)	18,86	-33,81	Stellenbosch	R.B. Frans
210	House Of Representatives(Hor)	18,81	-33,81	Drakenstein	C. Bergstedt

211	House Of Representatives(Hor)	19,78	-33,81	Langeberg	A.C. Pikaan
212	House Of Representatives(Hor)	20,19	-33,81	Langeberg	Sm Soldaat
213	Western Cape Education Department	19,89	-33,82	Langeberg	M.S Mtamo
214	Department Of Education And Training(Det)	19,90	-33,82	Langeberg	A. Carolus
215	House Of Representatives(Hor)	19,40	-33,83	Breede Valley	M Grove
216	House Of Representatives(Hor)	20,26	-33,83	Langeberg	Z.M. King
217	Cape Education Department(Ced)	20,06	-33,83	Langeberg	Jc Burger
218	House Of Representatives(Hor)	20,05	-33,83	Langeberg	J.E. De Koker
219	House Of Representatives(Hor)	20,04	-33,83	Langeberg	P Buis
220	House Of Representatives(Hor)	19,74	-33,84	Langeberg	Hpj Adendorff
221	House Of Representatives(Hor)	19,49	-33,84	Breede Valley	S. Witbooi
222	Department Of Education And Training(Det)	20,09	-33,84	Langeberg	Ip Lyon
223	Western Cape Education Department	18,75	-33,84	Stellenbosch	M Frederick
224	Western Cape Education Department	18,96	-33,84	Drakenstein	P Collins
225	House Of Representatives(Hor)	18,77	-33,84	Stellenbosch	E.D. Peters
226	House Of Representatives(Hor)	20,23	-33,84	Langeberg	C. Swanepoel
227	House Of Representatives(Hor)	18,96	-33,84	Drakenstein	W.C. Keet
228	House Of Representatives(Hor)	18,84	-33,85	Stellenbosch	E.P. Adams
229	House Of Representatives(Hor)	20,01	-33,85	Langeberg	E.C. De Bruyn
230	House Of Representatives(Hor)	20,11	-33,85	Langeberg	Br Jonas
231	House Of Representatives(Hor)	19,89	-33,86	Langeberg	L Lottering
232	House Of Representatives(Hor)	19,73	-33,86	Langeberg	C. Fortuin
233	Department Of Education And Training(Det)	18,98	-33,87	Stellenbosch	D.N. May
234	House Of Representatives(Hor)	18,81	-33,87	Stellenbosch	C.S. Mandes
235	House Of Representatives(Hor)	19,05	-33,88	Stellenbosch	Ca Boonzaaier
236	Western Cape Education Department	19,03	-33,88	Stellenbosch	M Russel
237	House Of Representatives(Hor)	20,31	-33,88	Langeberg	A.F. Valentine
238	Department Of Education And Training(Det)	19,10	-33,89	Stellenbosch	N.L. Mbenenge
239	House Of Representatives(Hor)	20,02	-33,89	Langeberg	F. Fredericks
240	House Of Representatives(Hor)	18,97	-33,89	Stellenbosch	R.W. November
241	House Of Representatives(Hor)	19,10	-33,89	Stellenbosch	M.H. Kulsen
242	House Of Representatives(Hor)	19,10	-33,89	Stellenbosch	N.I. Afrika
243	House Of Representatives(Hor)	19,37	-33,90	Breede Valley	V.V.Z. Wilson
244	House Of Representatives(Hor)	19,12	-33,90	Stellenbosch	L.L. Cyster
245	House Of Representatives(Hor)	20,40	-33,90	Langeberg	K.H. Deetloff
246	House Of Representatives(Hor)	18,85	-33,91	Stellenbosch	Ae Daries
247	House Of Representatives(Hor)	19,44	-33,91	Breede Valley	Dl Marries
248	House Of Representatives(Hor)	18,86	-33,91	Stellenbosch	R.B. Van Rooyen
249	Cape Education Department(Ced)	19,12	-33,91	Stellenbosch	Jj Cilliers
250	House Of Representatives(Hor)	18,85	-33,91	Stellenbosch	De Andrews
251	House Of Representatives(Hor)	20,01	-33,91	Langeberg	C Conradie
252	Western Cape Education Department	18,85	-33,92	Stellenbosch	Slabber
253	House Of Representatives(Hor)	18,85	-33,92	Stellenbosch	A.M. Samuels
254	Western Cape Education Department	18,85	-33,92	Stellenbosch	C.B. Ndlebe
255	Department Of Education And Training(Det)	18,85	-33,92	Stellenbosch	M.L. Ntshanga
256	House Of Representatives(Hor)	19,99	-33,92	Langeberg	F. Abrahams
257	House Of Representatives(Hor)	18,88	-33,92	Stellenbosch	H.S. Titus
258	House Of Representatives(Hor)	18,88	-33,92	Stellenbosch	C.V. Hendrikse
259	House Of Representatives(Hor)	18,89	-33,92	Stellenbosch	F.C. September
260	Western Cape Education Department	18,85	-33,92	Stellenbosch	M Mdekazi
261	Department Of Education And Training(Det)	18,85	-33,92	Stellenbosch	N.R. Mgijima
262	House Of Representatives(Hor)	18,82	-33,92	Stellenbosch	R Newman

263	House Of Representatives(Hor)	18,95	-33,92	Stellenbosch	P. Van Der Westhuizen
264	House Of Representatives(Hor)	18,88	-33,92	Stellenbosch	G.M. Rippenaar
265	House Of Representatives(Hor)	18,96	-33,92	Stellenbosch	J Arendse
266	Cape Education Department(Ced)	18,86	-33,92	Stellenbosch	C Solomons
267	Cape Education Department(Ced)	18,88	-33,93	Stellenbosch	A.J Van Wyk
268	House Of Representatives(Hor)	20,07	-33,93	Langeberg	Jj Marthinus
269	Cape Education Department(Ced)	18,88	-33,93	Stellenbosch	Hh De Villiers
270	House Of Representatives(Hor)	20,01	-33,94	Langeberg	U.M. Joubert
271	Cape Education Department(Ced)	20,10	-33,94	Langeberg	J.C. Els
272	Cape Education Department(Ced)	18,86	-33,94	Stellenbosch	J Van Der Westhuizen
273	Cape Education Department(Ced)	18,86	-33,94	Stellenbosch	W Van Heerden
274	Cape Education Department(Ced)	18,85	-33,95	Stellenbosch	B.B. Aucamp
275	Western Cape Education Department	19,83	-33,95	Langeberg	K. Van Rooyen
276	Cape Education Department(Ced)	18,86	-33,95	Stellenbosch	Eh Slabber
277	Cape Education Department(Ced)	18,86	-33,95	Stellenbosch	Sa Tarr
278	House Of Representatives(Hor)	19,83	-33,95	Langeberg	D. Kraukamp
279	House Of Representatives(Hor)	19,60	-33,95	Langeberg	Jp Swanepoel
280	House Of Representatives(Hor)	18,80	-33,96	Stellenbosch	R. Dreyer
281	Western Cape Education Department	18,74	-33,96	Stellenbosch	Rm Reddy
282	House Of Representatives(Hor)	19,64	-33,97	Langeberg	E.L. Booysen
283	House Of Representatives(Hor)	20,24	-33,97	Langeberg	R. Segelaar
284	House Of Representatives(Hor)	20,13	-33,97	Langeberg	S. Rossouw
285	House Of Representatives(Hor)	18,85	-33,98	Stellenbosch	L.A. Allies
286	House Of Representatives(Hor)	19,78	-33,98	Langeberg	Ap October
287	House Of Representatives(Hor)	18,85	-33,98	Stellenbosch	B.C. Williams
288	Western Cape Education Department	18,79	-33,99	Stellenbosch	T Coombes
289	House Of Representatives(Hor)	20,17	-33,99	Langeberg	E. Mentoor
290	House Of Representatives(Hor)	20,22	-33,99	Langeberg	A. Willemse
291	House Of Representatives(Hor)	20,01	-33,99	Langeberg	B. Mabombo
292	House Of Representatives(Hor)	19,88	-34,00	Langeberg	H. Du Plessis
293	House Of Representatives(Hor)	20,22	-34,02	Langeberg	L Felix
294	House Of Representatives(Hor)	18,81	-34,02	Stellenbosch	A.W. Olivier
295	Western Cape Education Department	18,81	-34,04	Stellenbosch	D. Wynne

PART III

FID	Suburb	StreetAddr	No Fees	No. Educators	No. Learners	Attraction Ratio
0	Ceres	Tandfontein	Yes	6	126	1:21
1	Ceres	Boy Muller	Yes	4	127	1:31
2	Ceres	De Meul Plaas	Yes	2	41	1:20
3	Ceres	Rietfontein Boerdery	Yes	3	71	1:23
4	Ceres	Voorsorg	Yes	3	53	1:17
5	Ceres	Kromfontein	Yes	7	123	1:17
6	Ceres	Boplaas	Yes	7	124	1:17
7	Ceres	R303 Citrusdal Pad	Yes	35	925	1:26
8	Ceres	Protealaan	No	10	175	1:17
9	Ceres	Elandsfontein	Yes	8	114	1:14
10	Prince Alfred Hamlet	Driefontein	Yes	4	53	1:13
11	Saron	Minnaarstraat	Yes	30	752	1:25
12	Saron	Hoofweg	Yes	62	1259	1:20
13	Tulbagh	Montrouge	Yes	8	246	1:30
14	Ceres	Die Eike Plaas	Yes	12	249	1:20
15	Ceres	Vgk Kerk Die Eike Rd	Yes	7	85	1:12
16	Ceres	Olckersia, Dro ├½hoek	Yes	2	18	1:9
17	Tulbagh	Twee Jonge Gezellen-Landgoed	Yes	15	211	1:14
18	Tulbagh	Kaaldraai-Plaas	Yes	4	86	1:21
19	Prince Alfred Hamlet	Koelfontein	Yes	6	79	1:13
20	Ceres	Paardekloof Landgoed	Yes	13	188	1:14
21	Ceres	Matjiesrivier	Yes	5	65	1:13
22	Tulbagh	Rijks Ridge	No	13	92	1:7
23	Tulbagh	Markstraat	No	30	346	1:11
24	Tulbagh	Ryk Tulbaghstraat	Yes	61	1384	1:22
25	Prince Alfred Hamlet	Reidstraat	Yes	44	1024	1:23
26	Tulbagh	27 Station Road	No	15	434	1:28
27	Gouda	Petuniastraat 609	Yes	20	601	1:30
28	Prince Alfred Hamlet	Kerkstraat 25	No	17	298	1:17
29	Ceres	Northridge Farms	Yes	3	23	1:7
30	Ceres	Laastedrift	Yes	3	36	1:12
31	Ceres	Fairfield Plaas	Yes	2	57	1:28
32	Bella Vista	Frieslandstraat	Yes	42	1111	1:26
33	Bella Vista	Waboomstraat	Yes	37	906	1:24
34	Bella Vista	Langstraat	Yes	39	879	1:22
35	Touwsrivier	Suidstraat	Yes	28	735	1:26
36	Touwsrivier	Kerkstraat	Yes	35	680	1:19
37	Touwsrivier	Skoolstraat	Yes	27	548	1:20
38	Ceres	P/A H De Kock	Yes	6	91	1:15
39	Nduli	Bokoloshe Avenue	Yes	27	701	1:25
40	Ceres	Chris Hani Drive	Yes	33	901	1:27
41	Ceres	REIDSTRAAT;CERES;CERES;6835	No	3	17	1:5
42	Ceres	Wanganella Plaas	Yes	5	163	1:32
43	Ceres	Owenstraat	No	57	610	1:10
44	Ceres	Vosstraat 21 21	Yes	38	1025	1:26
45	Ceres	Van Riebeeckstraat 17	No	35	580	1:16
46	Ceres	Lylestraat	Yes	28	504	1:18
47	Ceres	Gardenialaan	Yes	48	1278	1:26
48	Ceres	Buchuland	Yes	10	180	1:18
49	Ceres	Welvaart	Yes	3	54	1:18
50	Ceres	Ezelfontein	Yes	7	102	1:14
51	Wolseley	Millstraat 24 24	No	12	129	1:10

52	Wolseley	Malvastraat	No	25	783	1:31
53	Wolseley	Waverley	Yes	7	137	1:19
54	Wolseley	Angelierstraat	Yes	46	860	1:18
55	Wolseley	Vierdelaan	Yes	33	657	1:19
56	De Doorns	Buffelskraal-Wes	Yes	14	356	1:25
57	Wellington	Rondeheuwel	Yes	9	221	1:24
58	De Doorns	Voortrekker Road	Yes	14	251	1:17
59	Wolseley	La Plaisante	Yes	6	118	1:19
60	De Doorns	Bo-Voortrekkerweg	Yes	17	436	1:25
61	De Doorns	.	No	13	37	1:2
62	De Doorns	Voortrekkerweg 22	No	30	470	1:15
63	De Doorns	N 1 National Road	Yes	47	1389	1:29
64	De Doorns	Glenco Road	Yes	66	1306	1:19
65	De Doorns	Glencoweg	Yes	53	1372	1:25
66	Worcester	Sunnyside	Yes	37	820	1:22
67	Worcester	Moredou	Yes	11	288	1:26
68	Worcester	Amandelrivier	Yes	15	388	1:25
69	Worcester	Goedgeloof Plaas	No	4	49	1:12
70	Worcester	Hoofstraat	Yes	13	293	1:22
71	Worcester	Boesmansvlei	Yes	9	150	1:16
72	Wellington	Upper Hermon way Groenberg	Yes	12	156	1:13
73	Montagu	Keerom Plaas	Yes	2	20	1:10
74	Wellington	Haaskraalpad	Yes	3	93	1:31
75	Brandwacht	Brandwachtweg	Yes	7	155	1:22
76	Worcester	Tweefontein	Yes	12	212	1:17
77	Wellington	Soetendal	Yes	12	334	1:27
78	Rawsonville	Driefontein	Yes	12	254	1:21
79	Gouda	Groenvlei	Yes	12	196	1:16
80	Wellington	Oakdene	Yes	7	77	1:11
81	Worcester	Olifantsberg	Yes	5	139	1:27
82	Worcester	Jakarandalaan	No	45	743	1:16
83	Worcester	Kluestraat	No	34	397	1:11
84	Wellington	Vrugbaar Bovlei	Yes	11	290	1:26
85	Wellington	Jan Van Riebeeckstraat	No	34	618	1:18
86	Worcester	84 Riebeeck Street	No	15	47	1:3
87	Worcester	Sutherlandstraat	No	44	656	1:14
88	Wellington	Melling Street	No	21	583	1:27
89	Worcester	Sonja Plaas	Yes	3	52	1:17
90	Worcester	Tulbaghstraat 110	No	31	689	1:22
91	Worcester	Tulbaghstraat 0	No	69	956	1:13
92	Zweletemba	15314 Bentele Street	Yes	43	1082	1:25
93	Wellington	Voorstraat	Yes	43	1097	1:25
94	Worcester	Krigestraat	No	46	838	1:18
95	Wellington	Genl. Hertzoglaan	No	59	673	1:11
96	Montagu	Laatsrivier	Yes	4	63	1:15
97	Worcester	Neethlingstraat	Yes	30	915	1:30
98	Zweletemba	Imingcunube Street	Yes	7	147	1:21
99	Wellington	Voorstraat	Yes	58	1401	1:24
100	Zweletemba	850 Mayinjana Ave	Yes	41	967	1:23
101	Wellington	Blouvleiweg	No	55	778	1:14
102	Zweletemba	Theoha Avenue	Yes	42	1026	1:24
103	Worcester	Distillery Road	No	31	64	1:2
104	Wellington	Champagneweg	No	48	1077	1:22
105	Worcester	Somersetstraat 40	No	58	946	1:16
106	Zweletemba	Cona Avenue	Yes	60	1306	1:21
107	Worcester	Van Huyssteenlaan 99	Yes	52	1142	1:21
108	Wellington	Blignautstraat	Yes	46	1244	1:27

109	Worcester	Greystraat 11	Yes	39	831	1:21
110	Worcester	Stynderstraat	Yes	63	1335	1:21
111	Worcester	Africastraat 110	Yes	16	291	1:18
112	Paarl	P/A Hoer Landbouskool	Yes	10	231	1:23
113	Worcester	Cupidostraat	Yes	29	647	1:22
114	Worcester	Buitenkantstraat	No	65	1465	1:22
115	Paarl	Agter-Paarl	No	21	342	1:16
116	Worcester	H/V Westminister En Walthamst.	Yes	28	589	1:21
117	Worcester	169 Parker Street	Yes	29	635	1:21
118	Wellington	.	Yes	8	42	1:5
119	Montagu	Koo	No	3	41	1:13
120	Wellington	Bloekomlaan	No	35	708	1:20
121	Worcester	c/o Villiersdorp Rd & Main Rd	No	9	153	1:17
122	Worcester	Rainierstraat 81	Yes	41	1096	1:26
123	Riverview	Swartstraat	Yes	24	673	1:28
124	Montagu	Pietersfontein Plaas	Yes	3	38	1:12
125	Worcester	Nooitgedacht Plaas	Yes	17	354	1:20
126	Worcester	Noblestraat	No	65	1385	1:21
127	Wellington	Davidslaan	Yes	37	1132	1:30
128	Wellington	Diemersfontein Estate	No	9	185	1:20
129	Wellington	H/V Maylaan & Crawfordstraat	Yes	40	717	1:17
130	Worcester	100 Albatros Street	Yes	43	1171	1:27
131	Rawsonville	Die Eike	Yes	5	62	1:12
132	Paarl	Vrygunspad	Yes	25	403	1:16
133	Paarl	Hoofweg	No	9	118	1:13
134	Mbekweni	Mafila Street	Yes	49	1388	1:28
135	Wellington	Valleistraat	Yes	41	878	1:21
136	Worcester	Oude Schuur	Yes	5	99	1:19
137	Mbekweni	Thembelihle Street	Yes	46	1399	1:30
138	Paarl	Wynkelder Pad	Yes	18	416	1:23
139	Paarl	Pinzi Street	Yes	46	1245	1:27
140	Mbekweni	Zingisani	Yes	48	1230	1:25
141	Mbekweni	Funda Street	Yes	44	1242	1:28
142	Rawsonville	Van Riebeeckstraat 39	No	27	414	1:15
143	Rawsonville	De Novastraat	Yes	33	742	1:22
144	Montagu	Koo	Yes	9	135	1:15
145	Paarl	Dalweg	Yes	33	663	1:20
146	Paarl	Simfonielaan	Yes	40	1223	1:30
147	Worcester	Aan De Doorns Plaas	Yes	13	164	1:12
148	Paarl	19 Symphony Avenue	Yes	43	1282	1:29
149	Montagu	Goedemoed	Yes	9	141	1:15
150	Paarl	Hoofstraat	No	42	629	1:14
151	Rawsonville	Lorraine Plaas	Yes	11	233	1:21
152	Paarl	Suikerboslaan	Yes	70	1487	1:21
153	Paarl	Alphorex Plaas	No	25	33	1:1
154	Paarl	Wilgerlaan	Yes	27	577	1:21
155	Paarl	Duikerlaan 0	Yes	32	938	1:29
156	Montagu	Baden	Yes	4	55	1:13
157	Paarl	Berlynstraat	Yes	50	1225	1:24
158	Paarl	Hoofstraat 416	No	79	1020	1:12
159	Paarl	Hilarislaan 0	Yes	37	1033	1:27
160	Paarl	Van Der Stelstraat	Yes	39	1060	1:27
161	Paarl	Stirlingstraat	No	27	379	1:14
162	Paarl	Magnoliastraat	Yes	30	705	1:23
163	Rawsonville	Louwshoek	Yes	9	210	1:23
164	Paarl	Lantanastraat	Yes	45	1159	1:25
165	Paarl	Lappert Street	No	42	369	1:8

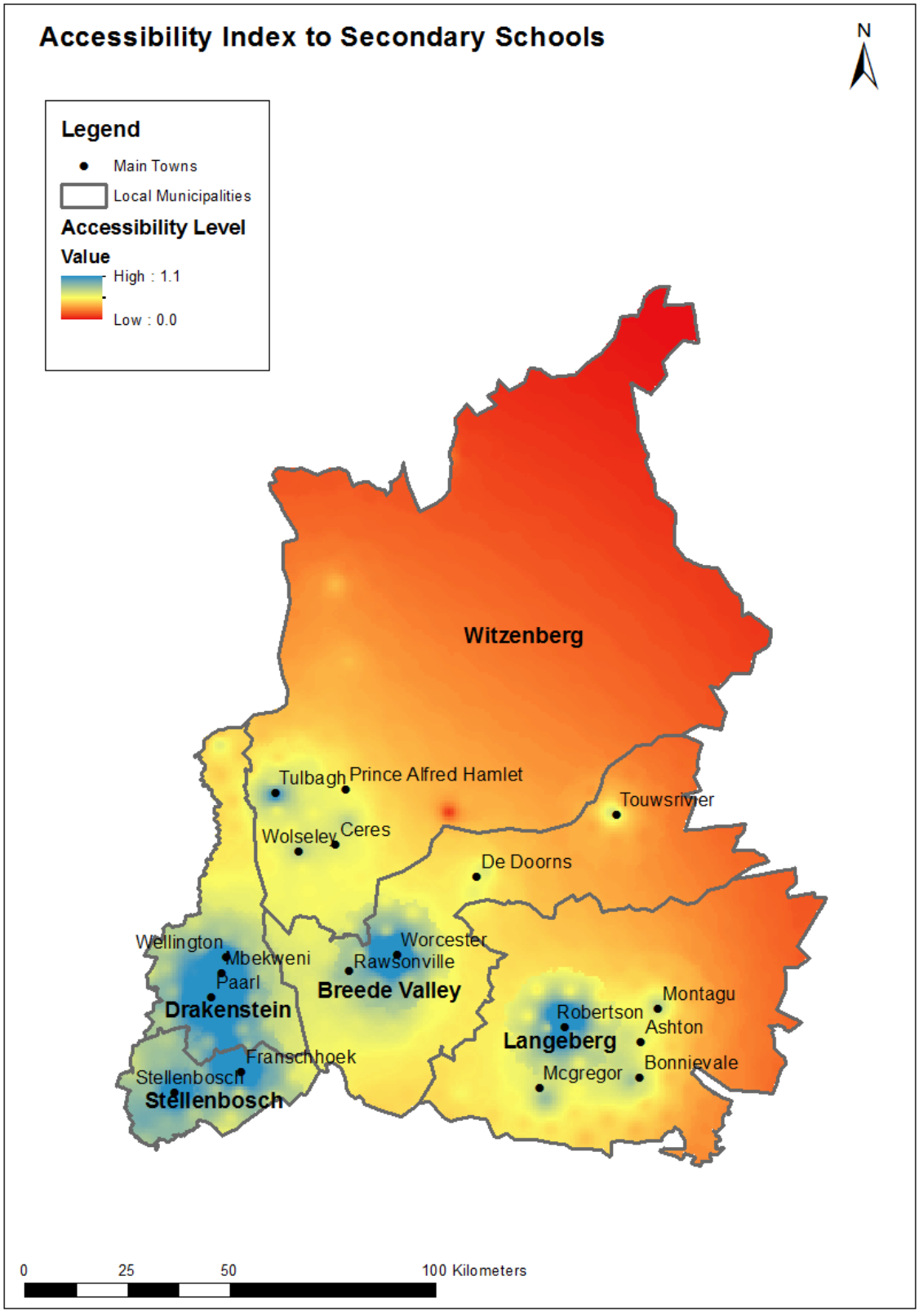
166	Paarl	Bo - Solomon Street	Yes	38	805	1:21
167	Paarl	Barbarossa Street	No	21	668	1:31
168	Paarl	Klein Drakensteinweg	Yes	33	873	1:26
169	Paarl	Gimnasiumstraat	No	34	509	1:14
170	Paarl	Uysstraat	No	23	300	1:13
171	Paarl	Beukesstraat	Yes	48	1346	1:28
172	Paarl	Hoofstraat	No	48	698	1:14
173	Paarl	7 Van Der Lingen Street	No	8	49	1:6
174	Paarl	Beukesstraat 10	Yes	45	1150	1:25
175	Paarl	Maasdorp Street	No	38	938	1:24
176	Paarl	Newmanstraat	No	64	1312	1:20
177	Paarl	Faurestraat	No	31	338	1:10
178	Paarl	Faurestraat	No	48	563	1:11
179	Paarl	Keur Wederweg	Yes	12	307	1:25
180	Paarl	Auretstraat	No	58	842	1:14
181	Paarl	Kwikkiestraat	Yes	36	767	1:21
182	Paarl	Suikerbekkiestraat	Yes	14	218	1:15
183	Paarl	Devine Street	No	35	504	1:14
184	Montagu	RIETVLEI 2	Yes	4	30	1:7
185	Paarl	Hoogstraat 1	No	71	761	1:10
186	Worcester	Brandvlei Prison	Yes	9	37	1:4
187	Robertson	Vinkrivier	Yes	6	60	1:10
188	Paarl	5 Rozenburg Street	No	4	15	1:3
189	Southern Paarl	.	No	10	59	1:5
190	Paarl	Lustiganpad	Yes	10	183	1:18
191	Montagu	Eikelaan	Yes	47	1032	1:21
192	Paarl	Suid Agter-Paarl Pad	Yes	19	439	1:23
193	Worcester	Alfalfa	Yes	9	154	1:17
194	Robertson	Heartstone Vineyards	Yes	5	72	1:14
195	Paarl	Montreuxstraat	No	40	652	1:16
196	Montagu	Wilhelm Theyslaan	Yes	26	661	1:25
197	Worcester	Scherpenheuwel	Yes	7	90	1:12
198	Robertson	George-Weg	Yes	64	1671	1:26
199	Robertson	Heidelaan	Yes	36	1123	1:31
200	Montagu	Langstraat 54	No	25	358	1:14
201	Robertson	Jasmynstraat 21B	Yes	37	955	1:25
202	Montagu	Kohlerstraat 2	No	27	525	1:19
203	Robertson	Loopstraat 64	Yes	42	1051	1:25
204	Robertson	Pk Klaasvoogds	Yes	12	206	1:17
205	Robertson	Reitzstraat 50	No	22	333	1:15
206	Robertson	Dirkie Uysstraat	No	20	372	1:18
207	Robertson	Dirkie Uysstraat 0	No	30	496	1:16
208	Robertson	63 Hope Street	No	26	131	1:5
209	Paarl	Merchantstraat	Yes	55	1485	1:27
210	Paarl	Joostenbergplaas	Yes	24	648	1:27
211	Robertson	Goree	Yes	8	159	1:19
212	Montagu	Derdeheuwel	Yes	5	55	1:11
213	Nkqubela	33 Mokweni Street	Yes	31	1000	1:32
214	Nkqubela	Peter Street	Yes	24	543	1:22
215	Worcester	Kweekkraal Moddergat	Yes	4	67	1:16
216	Montagu	1 Talana	Yes	4	66	1:16
217	Ashton	Georgestraat	No	12	213	1:17
218	Ashton	Olienstraat	Yes	53	1061	1:20
219	Ashton	Gladiolilaan	Yes	37	1091	1:29
220	Robertson	Nerina	Yes	4	42	1:10
221	Worcester	Lemoenpoort	Yes	4	95	1:23
222	Zolani	Mketsu Avenue	Yes	57	1343	1:23

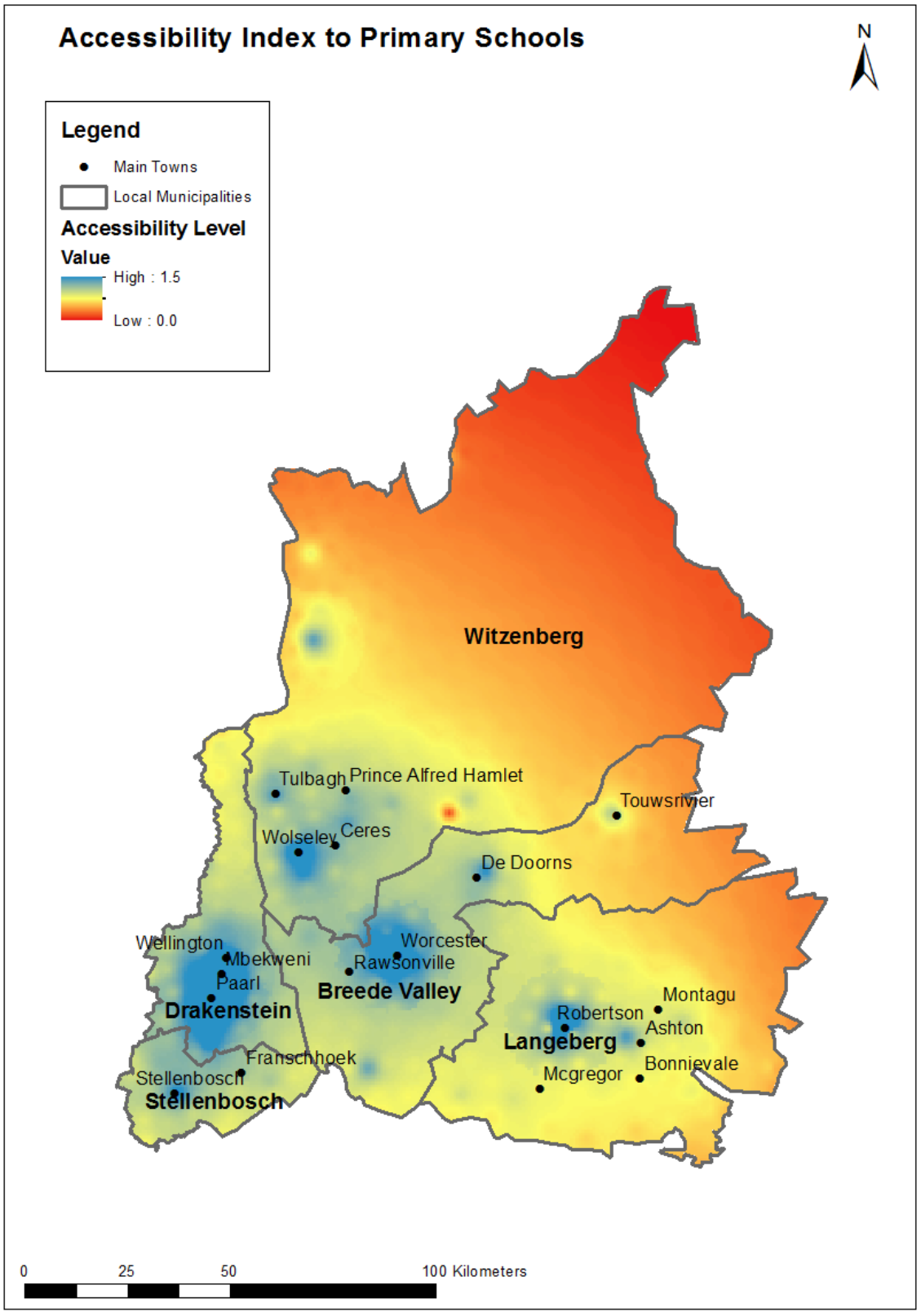
223	Kraaifontein	Bella Vista Road	No	8	128	1:16
224	Paarl	Hoofweg R 45	No	15	112	1:7
225	Kuilsrivier Nu	De Novo	Yes	21	470	1:22
226	Montagu	Rietvlei	Yes	4	56	1:14
227	Paarl	Hoofweg	Yes	29	672	1:23
228	Stellenbosch	Vaaldraaipad	Yes	12	262	1:21
229	Ashton	Excelsior Plaas	Yes	10	195	1:19
230	Ashton	Stockwell	Yes	4	168	1:42
231	Robertson	Uitnood	Yes	6	112	1:18
232	Robertson	Le Grand Chasseur	Yes	10	207	1:20
233	Paarl	Pniel Road	Yes	10	272	1:27
234	Stellenbosch	Kromme Rhee Weg	Yes	46	790	1:17
235	Franschoek	Franschhoekweg R45	Yes	24	417	1:17
236	Franschoek	Waterval Farm Off R45	No	100	702	1:7
237	Montagu	Op Barrydale Pad	Yes	3	58	1:19
238	Groendal	Angelier Road	Yes	25	736	1:29
239	Ashton	Goudmyn	Yes	4	64	1:16
240	Pniel	Hoofweg	Yes	36	771	1:21
241	Franschoek	Jafthassingel	Yes	32	823	1:25
242	Franschoek	Skoolstraat	Yes	39	989	1:25
243	Worcester	Stettyn Vineyards	Yes	7	100	1:14
244	Franschoek	Dirkie Uysstraat	Yes	26	514	1:19
245	Montagu	Scheepersrust	Yes	4	42	1:10
246	Cloetesville	Langstraat	No	36	681	1:18
247	Worcester	Highlands Plaas	Yes	3	78	1:26
248	Cloetesville	Langstraat 90	No	41	989	1:24
249	Franschoek	Akademie Street	No	31	415	1:13
250	Cloetesville	Currystraat	No	48	1126	1:23
251	Bonnievale	Wolvendrift	Yes	4	89	1:22
252	Kaya Mandi	.	No	4	99	1:24
253	Cloetesville	Currystraat	Yes	35	702	1:20
254	Kayamandi	P O Box 993	Yes	28	741	1:26
255	Kaya Mandi	Old Corobrick Road	Yes	42	1026	1:24
256	Robertson	Wakkerstroom-Wes	Yes	32	644	1:20
257	Idasvalley	Bloekomlaan	No	34	900	1:26
258	Idasvalley	Bloekomlaan 167	No	48	966	1:20
259	Idasvalley	Hectorstraat	Yes	17	312	1:18
260	Kayamandi	Remaining Farm Erf 183	Yes	46	1269	1:27
261	Kaya Mandi	Mjandana Street	Yes	56	1522	1:27
262	Stellenbosch	Devonvalleiweg	Yes	13	203	1:15
263	Kylemore	Gousblomstraat	Yes	28	527	1:18
264	Idasvalley	Luckhoffstraat 7-9	Yes	12	269	1:22
265	Kylemore	Skoolstraat	Yes	30	812	1:27
266	Stellenbosch	La Collineweg 1	No	40	667	1:16
267	Stellenbosch	Jannaschstraat	No	58	580	1:10
268	Happy Valley	Newcrossstraat	Yes	52	1148	1:22
269	Stellenbosch	Endlerstraat 0	No	55	910	1:16
270	Bonnievale	Maraisdal	Yes	3	83	1:27
271	Bonnievale	Van Der Merwestraat 6	No	30	595	1:19
272	Stellenbosch	Suidwal	No	98	1203	1:12
273	Stellenbosch	Kochstraat	No	60	682	1:11
274	Stellenbosch	Doornboschstraat	No	44	820	1:18
275	Mcgregor	C/O Voortrekker & Loop Street	No	22	117	1:5
276	Stellenbosch	Koch Street	No	76	718	1:9
277	Stellenbosch	Doornbosch Street	No	67	671	1:10
278	Mcgregor	Buitekantstraat	Yes	25	494	1:19
279	Robertson	Sewefontein	Yes	7	97	1:13

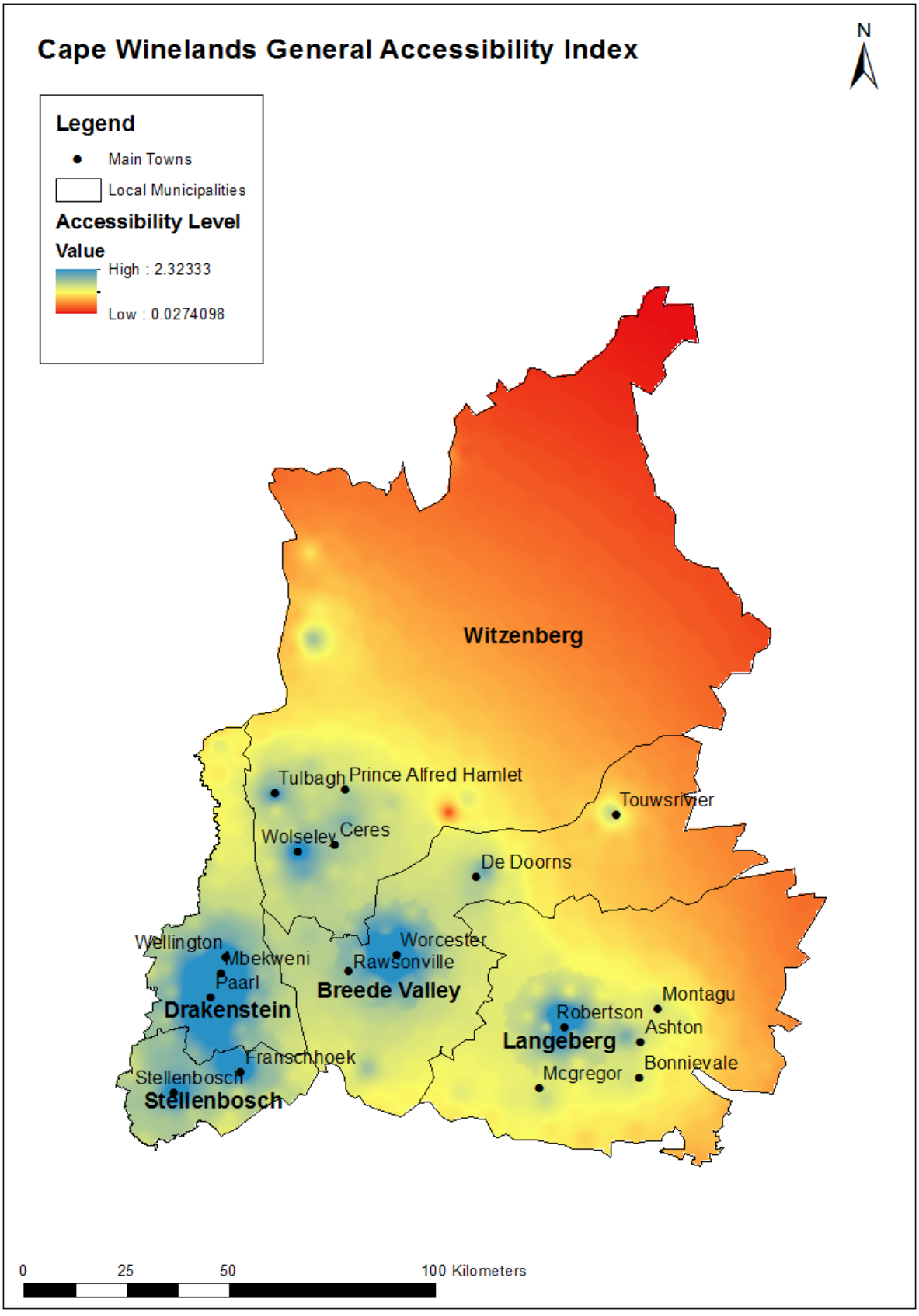
280	Stellenbosch	Vlottenburg Rd	Yes	25	489	1:19
281	Stellenbosch	Cnr Polkadraai & Vlaeberg Rd	No	5	37	1:7
282	Robertson	Agterkliphoogte	Yes	3	50	1:16
283	Bonnievale	Farm Middelrivier	Yes	3	46	1:15
284	Bonnievale	Na-Die-Oes	Yes	7	112	1:16
285	Jamestown	Tribute Laan	Yes	27	600	1:22
286	Mcgregor	Takkap	Yes	4	20	1:5
287	Jamestown	Tribute Street Jamestown	Yes	30	609	1:20
288	Stellenbosch	Spier Winefarm	No	34	255	1:7
289	Bonnievale	Welville Plaas	Yes	3	63	1:21
290	Bonnievale	Posbus 150	Yes	7	121	1:17
291	Bonnievale	Oudekraal	Yes	8	145	1:18
292	Mcgregor	Buffelskloof	Yes	2	29	1:14
293	Bonnievale	Waboomsheuwel	Yes	6	91	1:15
294	Rathby	Watsonweg	Yes	9	164	1:18
295	Somerset West	Vredelus Farm	No	168	1076	1:6

Appendix D: Cape Winelands Principal Towns

Appendix E: Accessibility Index Including Towns (Mapping)




Accessibility Index to Primary Schools
N
Legend
Main Towns
Local Municipalities
Accessibility Level
Value
High : 1.5
Low : 0.0
Witzenberg
Tulbagh
Prince Alfred Hamlet
Touwsrivier
Wolseley
Ceres
De Doorns
Wellington
Mbekweni
Worcester
Rawsonville
Paarl
Breede Valley
Drakenstein
Montagu
Robertson
Ashton
Langeberg
Franschhoek
Bonnievale
Stellenbosch
Mcgregor
Stellenbosch
0
25
50
100 Kilometers


Cape Winelands General Accessibility Index
N
Legend
Main Towns
Local Municipalities
Accessibility Level
Value
High : 2.32333
Low : 0.0274098
Witzenberg
Tulbagh
Prince Alfred Hamlet
Touwsrivier
Wolseley
Ceres
De Doorns
Wellington
Mbekweni
Worcester
Rawsonville
Paarl
Breede Valley
Drakenstein
Montagu
Robertson
Ashton
Langeberg
Franschhoek
Bonnievale
Stellenbosch
Mcgregor
Stellenbosch
0
25
50
100 Kilometers