The Conservative City

An analysis of the urban morphological development of Cape Town, South Africa with a specific focus on emergent spatial and mobility systems that generate the opportunity for multi-racial co-presence.

by

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Abstract

Although Apartheid officially ended in 1994, scant empirical evidence exists into spatial factors which may serve to afford the generation of racial heterogeneity. This research, centred on Cape Town, as a primary case study is an empirical examination of the relationship between demographic racial integration and urban configuration in South African cities. The principal argument of this dissertation is that the spatial configuration and mobility systems of an urban environment can either reinforce existing racial homogeneity or allow for the creation of new networks of racial heterogeneity. Furthermore, it is argued that within this context, urban systems, which emerged organically, have the strongest relation with demographic racial integration.

The research required a methodological approach which could encompass both physical and behavioural aspects. The precise descriptions offered by the evidence-based research techniques of space syntax allowed for a configurational understanding of both the spatial and social aspects of this study. A morphological analysis of Cape Town confirmed that, on a global scale, the city remains predominantly racially and economically stratified. Despite the global trend of segregation, a local analysis of demographic racial integration, revealed that, residential racial heterogeneity is emerging in particular neighbourhoods. Through a compendium of neighbourhood case studies, specific spatial morphological characteristics were identified and shown to have a relation with demographic residential racial integration. Furthermore, the research examined mobility systems, from the perspective of how they may provide affordances for the creation of multi-racial co-presence, with an emphasis on the minibus taxi system. Whilst this system has widely been stigmatised as chaotic and haphazard, the evidence has shown it to possess an intrinsic spatial and social logic, forming the largest network of accessibility in the city. Finally, this dissertation draws a series of conclusions which lead to a broad set of proposed recommendations.

Keywords: space syntax, South Africa, racial integration, spatial configuration, minibus taxis, mobility systems, emergent systems, evidence-based research

Table of Contents

List of Figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Epilogue

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Chapter One

Introduction

1.1 Introduction

On the eve of South Africa's new democracy in 1994, there was a great sense of hope and aspiration for the country. The South African Constitution, founded on the values of equality, instituted freedom of expression, movement and residence, rights which had been previously denied to the vast majority of the nation. This aspiration was embodied by the term, the *rainbow nation*, coined by Nobel Peace Prize Laureate, Archbishop Desmond Tutu. The concept of the *rainbow nation* was intended to encapsulate a vision of unity and implied radical transformation.

In spite of these elevated intentions, it is however, well established that South African cities remain profoundly divided and unequal. The persistence of produced, distorted settlement patterns characterised by social segregation and physical fragmentation has been well documented (Pieterse, 2009, Parnell and Robinson 2012, *State of South African Cities Report,* 2016). The post-Apartheid neoliberal investments of the private sector into the developed centres and the State's allocation of housing on the urban periphery has widened the geography of poverty. The net result is that there is considerable continuity with past development patterns (Turok, 2001:2366).

This research does not seek to reiterate these findings, but rather aims to explore the relationship between demographic racial integration, as opposed to segregation, and emergent urban phenomena in South African cities. Nabeel Hamdi (2004:xvi), considered a pioneer of participatory planning, defines *emergence* as systems which draw on local elements rather than the power of the elite and have the ability to organise and become more sophisticated. Hamdi advocates that skilful practitioners need to understand the interdependence between design and emergence. Helie (2009:79) uses Friedrich A. von Hayek's (Hayek, 1973) theory of a *spontaneous order* to explain how a city can arise if by an act of nature, "*spontaneous order* arises

when multiple actors spontaneously adopt a set of actions that provides them with a competitive advantage, and this behaviour creates a pattern that is self-sustaining, attracting more actors and growing the pattern… The spontaneous order is a by-product of individuals acting in pursuit of some other end". Helie (2009:79) argues that, in this way, cities appear as agglomerations of individually initiated buildings, connected by natural movement paths which eventually become densely populated streets.

In order to explore the relationship between demographic racial integration and emergent urban phenomena, Cape Town, the oldest city in South Africa, has been chosen as the primary case study. The research will be primarily conducted using the evidence-based research techniques of Space Syntax (Hillier and Hanson, 1984). Space syntax is a theory and methodology that is centred on understanding the relationship between society and space (Dhanini, Tarkhanyan and Vaughan, 2017:56). It is based on the premise that the structure of space is a product of social structures, but can also in turn reflect back and influence the structure of society.

The overarching aim of this study would be to identify emergent social, spatial and mobility systems, which create opportunities for co-presence and encounter between different racial groups in space and if further developed may become catalysts for transformation within the city of Cape Town and possibly more broadly...

Figure 1: Nelson Mandela & Desmond Tutu celebrating SA winning the Rugby World Cup (1995)
Source: AFP/Getty

1.2 Background

Turok (2001:2366) describes Cape Town as a "starkly polarised city"; wealthy and prosperous suburbs are juxtaposed against overcrowded, poverty stricken dormitory settlements. The affluent suburbs reside near the coast on the base of the mountain and the poverty stricken predominantly in an area known as the *Cape Flats*, topographically flat, sandy, flood-prone and approximately 25 km from the economic heart of the city.

Figure 2: Aerial view of Cape Town
Source: Google Earth

The development of Cape Town is set against a background of hundreds of years of colonial practices, which began when it was first colonised by the Netherlands in 1652 and the British Crown in 1785. An outbreak of the bubonic plague in 1902, propelled the expulsion of all Black residents, by city officials, to a peripheral location known as *Ndabeni* (Maylam, 1995:24). Discriminatory racial policies of urban segregation were formally instituted through the *Native Land Act* of 1913, the *Native Urban Areas Act* of 1923 and the overarching political system of Apartheid in 1948. Peripheral townships were denied economic development, creating severely distorted settlement patterns. The *Group Areas Act* of 1950 legitimised racial classification of

neighbourhoods and instituted the forceful removal of people of colour from inner-city suburbs. The *Pass Laws* disenfranchised people of colour, stripped them of their citizenship and designating them to rural territories on the periphery of the country, known as the *Bantustans*. Apartheid officially ended in 1994, with South Africa's first democratic election. The Ministry for Provincial Affairs and Constitutional Development (1998:24) declared that spatial integration of settlements is critical to enhance economic efficiency, facilitate the provision of affordable services, reduce the costs households incur through commuting and enable social development.

Figure 3: Aerial view of *Hout Bay* and *Masiphumele Informal Settlement*
Source: http//:millifoto.com

1.3 Research Questions and Hypothesis

The overarching question of this research is: Considering South Africa's long history of top-down urban policy centred on racial segregation, what spatial and mobility systems have emerged that may create opportunities for co-presence and encounter between different racial groups in space? In order to answer this question, it is firstly vital to develop a conceptual framework for the spatial configuration of Cape Town. To do this, it is necessary to make connections between Cape Town's urban development and the larger context of colonial and postcolonial urbanisation in Africa. This is essential to understand how African cities have developed inherently differently and for inherently different purposes to cities of the Global

North. Whilst this study has chosen Cape Town as a case study, it endeavours to contribute to the broader literature on urban development within the African continent.

To respond to the overarching question, this study attempts to answer four specific research questions. The first research question will consider: what was the effect of 20th Century Modernist planning on Cape Town and whether it was used to reinforce discriminatory racial ideology? The second research question is: what is the relationship between the present-day spatial configuration of Cape Town and economic and demographic racial distribution? These questions are necessary to understand how the spatial configuration of the city, developed over time through planned and unplanned urban interventions and how this may relate to present demographic racial distribution. They will be explored, in Chapter 4, through a morphological assessment of Cape Town's spatial development through three, crucial time periods, which have been identified through a historical analysis, depicted in *Figure 5*.

Hillier and Netto (2002:182) advocate that a city is ordered according to how a culture seeks to restrain or generate co-presence. They propose that a city is composed of two broadly different spatial elements; *background* and *foreground networks*. The *foreground network* is generative in nature, aiming to maximise co-presence and the *background network* is conservative, aiming to restrict co-presence and preserve culture. *Figure 4* displays grey-scaled syntactical maps of Tokyo and London, the central, darker dense street network in both of these configurations, represents the *foreground network* and the less dense, lighter street network, the *background network*.

Drawing from this, the hypothesis is: the planning of South African Cities prioritised the *foreground network* to make the city functional on a global scale, but used the *background network* as a device to create enclaves of spatial and social segregation, instead of a complementary system to the foreground network. Thus, the spatial structure, as a socio-spatial artefact, will continue to reinforce racial and economic division through clearly spatially delineated, racially homogenous, spatially correspondent neighbourhoods.

Figure 4: Grey scale syntactical maps of Tokyo and London's street network
Source: Vaughan (2007:220)

The third research question focuses on: what is the relationship between the spatial configuration of Cape Town and demographically racially integrated neighbourhoods? This question will be explored in Chapter 5 through the identification of specific neighbourhood case studies, in order to understand the relationship between local spatial phenomena and racial integration. It is hypothesised that residential demographic racial integration will be emerging in neighbourhoods which have spatially interconnected street networks and thus probably developed prior to 20th Century modernist planning. These interconnected street networks will give rise to greater land use diversity, pedestrian movement and mobility accessibility.

The final research question is: does informal transport, as opposed to formal transport, as a bottom-up response to the general top-down planning of South African cities possess a generative relationship with demographic racial heterogeneity in Cape Town? This question will be explored primarily in Chapter 6, through an analysis of formal and informal modes of transport on both global and local scales. It is hypothesised that the flexibility of informal mobility has allowed it to emerge in response to everyday need, forming connections between racially homogenous communities, providing the opportunity for the creation of new multi-racial networks.

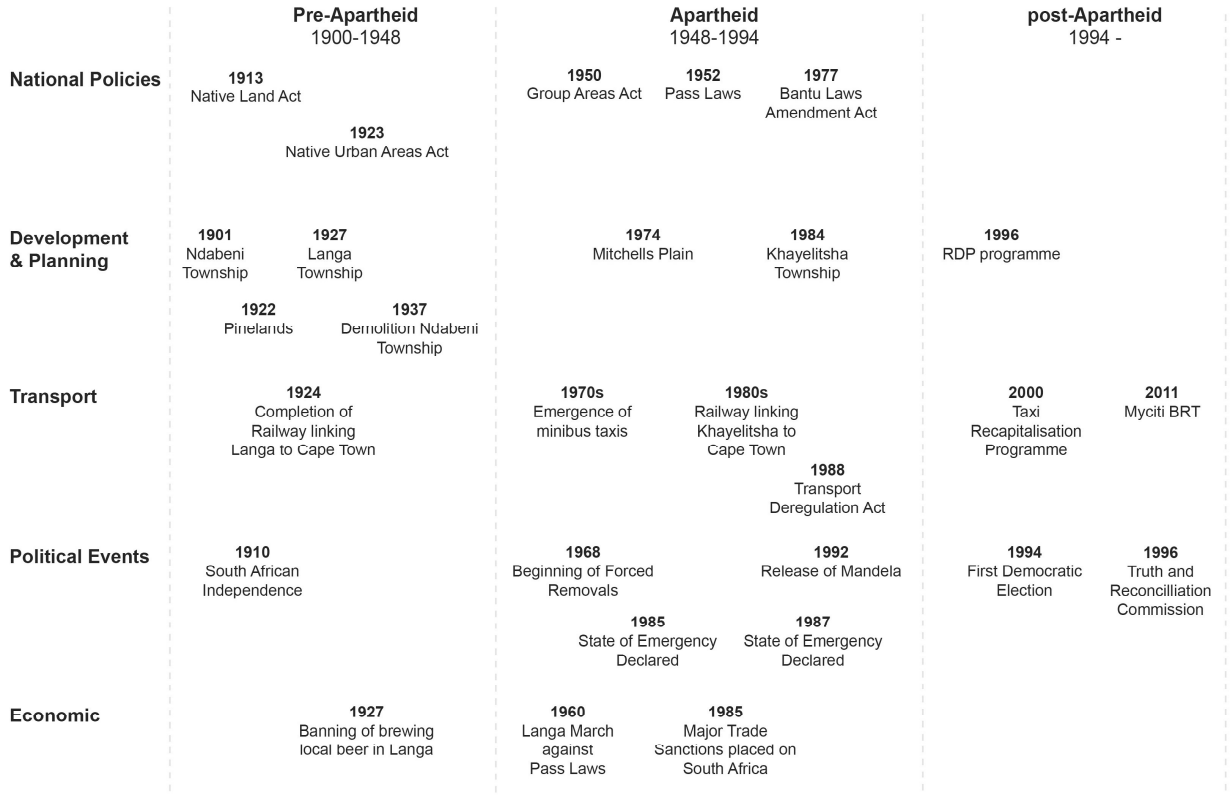


Figure 5: Historical Timeline of Development in South Africa
Source: Diagram by Author

1.4 Theoretical and Methodological Concerns

This section provides a brief introduction to the theoretical and methodological concerns, which will be explained in more detail in Chapter 3. This study requires a strong understanding of both spatial and sociological factors. Therefore, it is important to select a range of methodologies that encompass both material and behavioural factors. The evidence-based research techniques of space syntax, combine the physical and social city, connecting one to the other. It sets out tools linked to a set of theories and the two together give rise to a set of interpretive models (Vaughan, 2007:207). Space syntax research has shown that the spatial configuration of a street network is a major factor in shaping movement flows and thus the emergence of patterns of co-presence (Hillier et al.,1993; Hillier and Iida, 2005; Penn et al., 1998). Co-presence may not directly lead to social interaction, but it is an important sociological and psychological resource in itself (Hillier, 1989:13).

A quantitative approach to racial integration will be required, which encompasses multiple racial groups at a neighbourhood scale, whilst taking into account the racial composition of the larger geographic area. Choropleth mapping will allow for the overlaying of different data sets

through geo-location. Statistical analysis will be used to quantify the strength of relationships between these associated variables. Data pertaining to the routes, stops and major interchanges of informal and formal modes of transport will be required in order to understand and quantify the relation between the structure of mobility systems and racial integration.

1.5 Dissertation Overview

In this dissertation, Chapter 1 provides a general overview to the contextual and theoretical underpinnings of this study. Chapter 2 will then proceed to establish a conceptual model of colonial and post-colonial cities in relation to South African urban development and seeks to identify urban morphological characteristics which may have a relationship with the emergence of racial integration. Chapter 3 will outline the methodological framework for the study and where specific data has been sourced. Chapter 4 will analyse the urban morphology of Cape Town over three time periods, with a specific emphasis on the implementation of modernist urban interventions and how the present-day spatial configuration of the city relates to racial and economic distribution. Chapter 5 will perform a comparative study of specific neighbourhood case studies of racial integration and segregation, in order to deduce if any patterns in spatial morphology emerge. Chapter 6 will explicitly focus on mobility systems, especially the emergent minibus taxi system and how it may be creating or reinforcing existing patterns of racial integration/segregation. Finally, Chapter 7 will summarise the findings with the intention of forming an overarching conclusion.

Chapter Two

Literature Review

2.1 Introduction

In order to evaluate the relationship between emergent spatial and mobility phenomena and racial heterogeneity, it is firstly vital to develop a conceptual framework for the spatial structure of Cape Town. To do this, it is necessary to draw on a wider context of literature on colonial and postcolonial urbanisation in Africa to understand the relationship between discriminatory ideology and the morphological development of African cities born out of colonial processes. It is, thus, imperative to develop a theoretical model based on the premise that African cities have developed inherently differently and for inherently different purposes to cities of the Global North. Traditional theories, therefore, which work well when conceptualising and understanding cities of the Global North, may be used inappropriately or may not be applicable in cities of the Global South (Parnell, Robinson, 2012:596).

An examination of racial integration will be undertaken to understand how, as a social phenomenon, this concept, central to this thesis, has previously been studied and defined. Furthermore, this discussion seeks to realise how co-presence may be an important social resource in the development of trans-racial solidarity. It proceeds to develop a contextual background through a review of specific urban morphological phenomena that has previously been suggested to have a relation with demographic racial integration. Finally, this review, seeks to shed light on how access to mobility may be a source of agency in overcoming spatial barriers, which were intended to enforce racial division, with a specific emphasis on the emergent minibus taxi system.

2.2 The Colonial City: underlying ideologies of control

Significant urbanisation in Africa only truly began following the *Berlin Conference* of 1884 - 1885, a meeting between European powers which compelled these nations to occupy their specific territories or potentially lose their colonies. This suggests that colonial cities were

developed, initially, purely out of a desire by imperial powers to claim territory and not out of organic processes of urban development (King, 2015:35).

Myers (2011:51) argues that colonialist African cities were fundamentally different to European cities, as these were never intended to be centres of industry, but were created to act primarily as bureaucratic capitals and store or extract resources for exportation. This meant that urbanisation in Africa predominantly happened along the coast and adjacent to places of resource extraction. Cape Town, presents a primary example of this, having emerged as a key trading post and administrative capital along the shipping *Spice Trade Route* which extended from Europe to Asia around the continent of Africa. With the discovery of gold and diamonds in the 19th Century, railway lines were built from the mining towns of Kimberley and Johannesburg to export these resources by sea.

Underpinning the development of colonial cities were ideologies of race, class, and culture which governed who should be in the city and where they could reside (Myers, 2011:53). Colonialism led to an African urban landscape characterised by segregation and high levels of inequality. The colonial world was a world of polarities, divided into areas and facilities for natives to the region and areas and facilities for Europeans (King, 2015:34). This system of segregation reinforced social and racial hierarchy, enabling the colonial regime as well as the metropolitan power and elites, to accumulate resources (Myers, 2011:51). Planning policies and legislation were used as instruments of power and domination (Njoh, 2009). One example of this is during the colonial rule of the city of Lusaka in Zambia, black people were only allowed to reside there, if they lived in the compound of their white employer (Myers, 2011:30).

King (2015:32) proposes that there were three phases which were crucial in conceptually understanding the development of colonialist cities, particularly in the British colonies:

1. The initial phase being when settlements and cities were laid out according to principles, designed to ensure military and political dominance.
2. The second phase began in the early twentieth century and coincided with the development of the formally established practice of "town planning" theory, legislation and professional knowledge. In this phase, the *Master Plan* was the key concept.
3. A third, postcolonial, and neo-colonial phase following independence, which tends to continue colonial practices.

2.2.1 Tools of Colonisation

King (2015:33) proposes that the *Master Plan* became "the great instrument of power" for controlling the occupation of land. In the colonies, the *Master Plan*, excluded disorder, the poor, and especially squatter settlements. Furthermore, the introduction of Western-style dwellings and architecture brought with it new models and materials of construction. For centuries, indigenous people had used vernacular materials, the introduction of pre-fabricated iron-work, glass and later cement, undermined local building practices. Decision-makers looked upon self-built settlements on the city's fringe, as backward and unacceptable. These houses were condemned as slums and the large contribution of their residents to the city's economy and daily life ignored (King, 2019:36).

Swanson (1977:394), writing about South Africa, argues that the quest for "sanitation" by authorities became a guise for social control. Colonial powers classified vernacular forms of shelter as unhealthy and overcrowded. Minimal, detached housing units, surrounded by light, air and open space emerged as replacements. This quest for sanitation became a disguise for building demolition, exclusion and segregation.

Coetzer (2013:136), in his book *Building Apartheid*, specifically shows how the *Garden City Movement* provided a rationalising discourse, prior to the implementation of Apartheid, through which the question of where and how people should live was to be resolved in Cape Town through the design of the neighbourhoods of *Pinelands* and *Langa* (refer to *Figure 6*).

2.2.2 The Apartheid City

The Apartheid regime emerged out of colonial planning and ideology and perhaps presented the most extreme formalisation of top-down urban legislation driven by racist ideology on the African continent. Two of the most severe policies implemented were the *Group Areas Act* (1950), which racially zoned neighbourhoods and instituted forced removals and the *Pass Laws* (1950s), which disenfranchised people of colour.

Davies (1981) developed a theoretical model for the apartheid city. The model shows the White business district surrounded by segregated White residential areas, with physical barriers and buffer zones utilised to segregate neighbourhoods of non-White zoning (refer to Figure *7*). The diagram shows how concepts, which began with the garden city model, such as clearly

delineated spatial zones and a mono-centric central business district, were distorted in the apartheid city to create a racially segregated environment, which economically and spatially favoured White people.

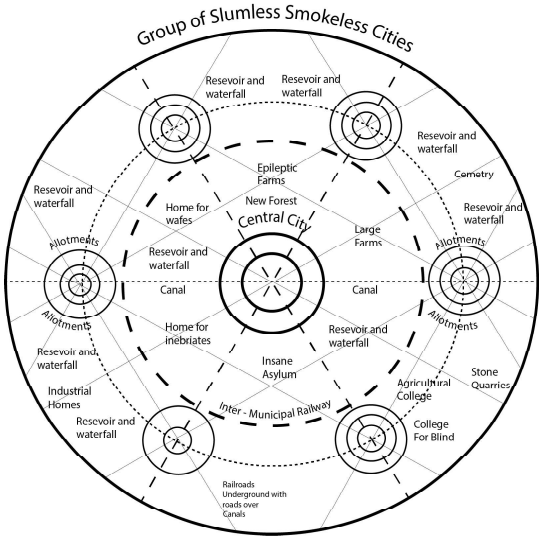


Figure 6: Diagram of Garden City model
Source: Diagram by Author, copy of Ebenezer Howard's (1898) *Garden City model*

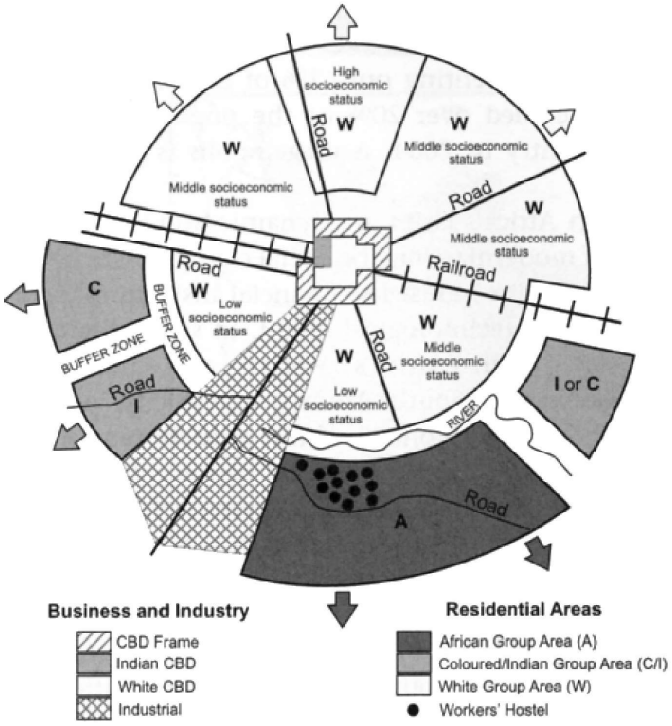


Figure 7: Diagram of the Apartheid City model
Source: Davies (1981:61)

2.3 The Post-colonial city: rapid urbanisation and informality

Most African countries gained their independence in the later half of the 20th Century, refer to *Figure 8*. According to the *UN Habitat Report* (2010a), Africa is the fastest urbanising continent in the world, which has resulted in a crisis of housing and infrastructure across the continent. An important aspect of the post-colonial city has been the rise of informality, which will be explored subsequently. Following this, a discussion of the post-apartheid city will be presented, so that it may be understood in relation to themes of this broader context.

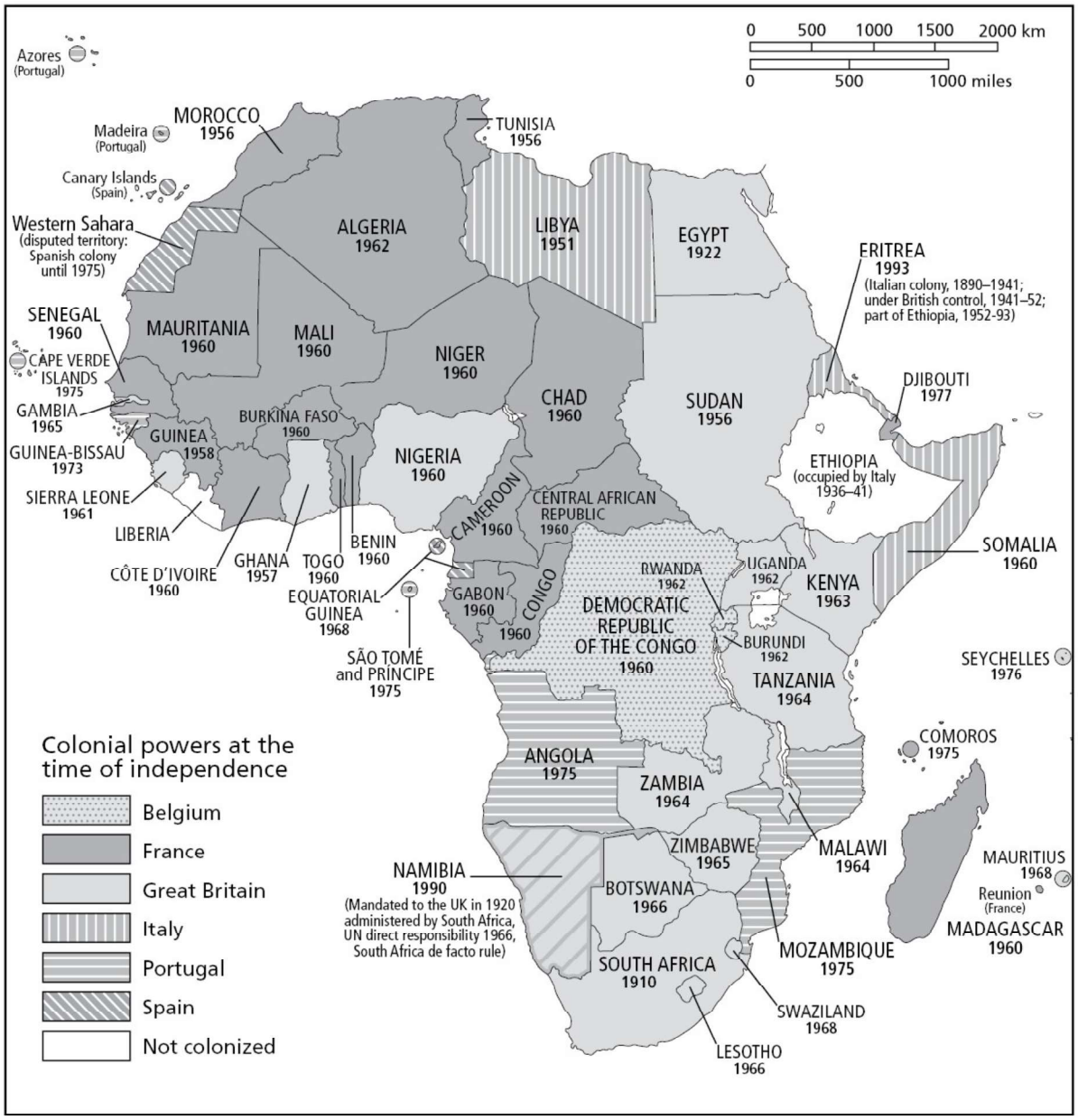


Figure 8: Dates of Independence of African countries
Source: https://www.ucldigitalpress.co.uk/Book/Article/43/68/0/

2.3.1 Informality

The high level of informality within African cities, is strongly linked to rapid urbanisation. The *International Labor Organisation* (*ILO*) popularised the concept of informal work in a well-publicised report on Kenya in 1972. Theoretical models of the time expected the informal sector to shrink with increasing industrialisation and economic growth. Contrary to assumptions, the informal sector has continued to grow (Miraftab, Kudva, 2015:92). The latest *ILO* report shows that two billion people work informally, most of them in emerging and developing countries.

Many western experts believed that irregular and illegal settlements were inherently anarchic and dysfunctional. However, research has shown that informal methods of regulation and enforcement can sustain effective markets even without state recognition and enforcement. Significantly, however, they can also create opportunities for slumlords (Perlman 1987; Malpezzi 1999: 1795, 1822–4).

Miraftab and Kudva (2015:93) propose three distinguishing characteristics which need to be emphasised in relation to the informal economy:

1. The informal economy is not something separate from the regular economy and neither can survive without the other.
2. The informal economy is not just produced and supported by the poor and the destitute.
3. The informal sector is not regulated by the state. Labour laws, taxation, workplace safety, mandated benefits, and insurance policies are rarely, if ever, enforced. However, while the informal economy is not regulated, it is often policed and is a profitable source of income for bribed government officials, the political system, and the black market.

2.3.2 Post-Apartheid urban morphology

From 1991 to 1996, the population of Black South Africans in urban areas increased by about 27% and South Africa's urban population grew by 4.3% to 56% between 1996 and 2001 (Odindi, Mhangara, Kakembo, 2012:1). This unprecedented growth led to the emergence of large informal settlements following the general trend of rapid urbanisation across the African continent. The Government's primary response has been to implement the *The Reconstruction and Development Programme* (*RDP*) which has provided over three million houses for the urban

poor. However, Osman and Karusselt (2008:2) argue that whilst South Africa has had success in the rapid delivery of houses, the CBD as well as new commercial centres, transport routes and the less economically affluent townships remain disconnected fragments. As Osman and Karusselt (2008:2) observe: "While the current government intended to remedy this inherited fragmentation, they remained preoccupied with meeting quotas rather than developing quality environments". *The State of the South African City Report* (2016:51) echos these sentiments, noting, "The housing subsidy programme appears to have locked people into undesirable locations and maintained their existence at the margins of urban life and many urban residents continue to feel alienated from the city, as if they are not full urban residents".

Figure 9: Example of RDP Houses in South Africa
Source: https://careerslist.co.za/2019/05/06/how-to-own-an-rdp-house-in-south-africa/

Whilst the South African government is trying to find new ways of rearranging cities to encourage racial integration, ordinary people are reusing and remaking urban space at a rapid pace (Robinson, 1998:170). Robinson (1998:168) draws from Lefevre's conceptualisations of *representational space* in writing about the potential for transformation in South African cities, observing "It offers a promising tale on how we might imagine spaces changing. Every time we move around the city we potentially use spaces differently, imagine them differently. Walking down the street differently. Walking past another person next to me and then far away..." The transition from Apartheid urban space to something else, draws our attention from the "fixing

moment" of these historically divided cities to experiences of mobility, interaction and the dynamism of spaces (Robinson, 1998:163).

2.4 Racial heterogeneity within the context of society-space paradigm

Racial integration has been conceptualised as firstly, a social condition and secondly as a demographic condition (Motech, 1972). Racial integration, as a social condition, goes beyond the pure mixing of races, but involves positive interpersonal contact, primary group interaction and transracial solidarity and assimilation. While the social view of integration is useful, it presents methodological problems of quantification, other than at a very small case study scale, and thus demographic racial integration becomes more useful as a research tool (Smith, 1998:3). Racial integration studies are criticised by Maly (2000:38), as firstly being focussed on indices of segregation, as opposed to being studied as a complex social phenomenon in itself, and secondly for not incorporating multiple racial groups. The *Entropy Index* has been used to measure racial integration of multiple groups, however it does not account for the context of the larger geographical area and assumes that all racial groups should be equal in their distribution. Maly (2000:40) proposes the use of the *Neighbourhood Diversity Index*, as an additional measure of racial integration which includes multiple groups and takes into account the racial composition of the larger geographical area.

Whilst the *Neighbourhood Diversity Index* is useful in measuring demographic racial integration, it does not account for spatial factors that may be associated with its emergence. In attempting to understand the relationship between spatial networks and the emergence of racial heterogeneity, it seems necessary to adopt a broader relational and configurational outlook. Space Syntax offers a theoretical and methodological approach to understanding space and society from a configurational perspective (Hillier and Hanson, 1984:2). Hillier and Hanson (1984:18) did not advocate that architecture could directly cause human behaviour, however they asserted that there is always a strong relation between spatial form and the ways in which encounters between people are generated and controlled. They interpret functionalist sociologist, Emile Durkheim's, two fundamentally different principles of social solidarity, *organic solidarity* based on interdependence through differences and *mechanical solidarity* based on integration through similarities of belief and group structure, as profoundly spatial. They propose that *organic solidarity* requires integrated and dense space, whilst *mechanical solidarity*, segregated and dispersed space. From this hypothesis, it suggests that the apartheid city was one based on mechanical solidarity, requiring a segregated and dispersed spatial form.

Furthermore it suggests that places of racial integration, will most likely be spatially dense and integrated.

Hillier (1993) proposes through the *theory of natural movement*, that the spatial network of the street layout in itself produces *attraction inequalities*, which generate or restrict co-presence. In space syntax theory, co-presence is seen as an important social resource (Hillier, 1989:11). It has even been argued that an important social function of a city is to structure co-presence among people from different social categories (Hanson and Hillier, 1987). Whilst co-presence does not necessarily translate into social cohesion, it is an important sociological and psychological phenomenon which may increase the likelihood of social interaction (Hillier, 1989:11). If we accept this, we can begin to examine factors which may aid in the generation co-presence.

A study conducted by Klinenburg (2005) on heat-related neighbourhood mortality rates during the 1995 *Chicago Heatwave Crisis*, through the examination of neighbourhood case studies, argued that place, specific social ecology and its effects on social practices account for disparity in mortality rates between them. Klinenburg (2005) attributes lower mortality rates to the informal social support that was generated by chance encounters from the neighbourhood's vibrant and bustling streets. Hillier and Hanson (1987:257) argue, through their analysis of *Bethnal Green*, in *East London* and *West End*, in *Boston*, that the structuring of physical space played a vital role in generating and controlling some aspects of community life. They propose that the lack of a clear boundary and internal hierarchy of space allowed for the informal meeting of people, which strengthened community ties. Furthermore, they make an example of *Greenleigh*, a council estate in *Bethnal Green*, which they suggested actually had the reverse effect by deteriorating societal ties through its isolated spatial configuration.

Vaughan (2015) shows through her studies of the ethnic market space, that public space can be used as a meeting point of interaction between cultures, observing, "Of all opportunities in the public sphere, economic exchange is arguably the most important between migrant and host culture, since while it requires acquaintance and trust, it remains a rational transaction" Vaughan (2015:36). More broadly, land-use diversity has been advocated to promote co-presence in cities. Jane Jacobs (1961:63), believed that land-use diversity is essential to sustain city safety, public contact and cross-use. Jacobs' argument was clear, heterogeneous land-use enables different activities to take place at different times, affording greater opportunity for co-presence. The configurational properties of urban space are also emphasised by Dewar and

Todeschini (2004:87), who make the distinction between a *road* and a *street*. The *road*, they argue, is uni-functional, existing for the single purpose of maximising vehicular movement. A *street*, on the other hand, is a concept of multi-functionality, a social space, in which movement channels are seen as public spaces which have a relation with a variety of activities.

2.5 Networks of mobility in relation to racial heterogeneity

An understanding of mobility flows and their potential to aid in the transformation of South African cities, is particularly important as planners had worked for decades to homogenise and separate space. Recently, networks of mobility, which flow, both virtually and physically, has gained attention in sociology for granting agency between the intersection of objects and people (Latour, 2005, Urry, 2007, Thrift, 2008). Urry (2010:348) criticises 20th Century sociology for disregarding geographical intersections of region, city and place, making reference to Bauman's (1987) ideas on the *gardening state,* which is governance that presumes conceptual concern with pattern, ordering and what is growing and should be "weeded out". Urry (2010:348) uses the example of the Berlin Wall to show how the state tried to "garden the people of society", as the Berlin Wall existed primarily to restrict movement.

A specific study of relevance was conducted by Rokem and Vaughan (2018), their research showed that urban segregation in Jerusalem may be transformed by public transport networks, through linking separated urban areas and bringing diverse ethnic actors within close proximity of each other. Gambill's research (2018) emphasised how access to transportation in Cape Town is bounded by economic precursors and that access to the public railway system is directly correlated with opportunity for employment. Gambill's (2018) research suggested that the strengthening of mobility opportunities would enable the creation of a more sustainable city. However, Gambill's (2018) study did not take into account the role of the paratransit minibus taxi system, which has generally attracted little attention in the field of urban research (Agbiboa, 2019:6).

Minibus taxis (taxis) are a flexible mode of paratransit transport, that are 'alternatively regulated' through a multiplicity of rules, institutions and actors beyond the state (Meagher, 2011; Roitman, 2006). The word *paratransit* is used, as whilst minibus taxis operate largely within the informal economy, they are subject to certain state regulations. The taxi industry initially emerged illegally in the late 1970s as a fully Black-owned industry, when lucrative employment opportunities for Black South Africans were virtually non-existent, as they were

denied the opportunity of effective participation in most spheres of the economy (Jefthas, 2002:7). Taxi-owners defied strict Apartheid laws until the system was legalised in 1988 (refer to *Figure 10*).

According to the *National Household Travel Survey* (2013:6), minibus taxis are the dominant mode of public transport across South Africa with a 69% usage share, followed by buses at 20.2% and trains at 9.9%. Taxis are not government subsidised, nor do they have an integrated fare system or separate lanes for priority (Bruun, Del Mistro, Venter and Mfinanage, 2016:33).

Despite the chaos that is commonly associated with informal/paratransit transport services in African cities, there is a "logic of practice" that organises the sector and keeps the city alive (Agbiboa, 2019:6). African cities work amidst the perceived chaos and we could gain a better understanding of them by studying how an apparently chaotic sector "acquires a structure of intelligibility and intentionality" (Agbiboa, 2019:6).

Figure 10: Timeline of Minibus Taxi development
Source: Diagram by Author

2.6 Discussion

The spatial configuration of African cities did not emerge randomly, but has been influenced by hundreds of years of underlying classicist and racist ideology. Cities under colonial rule were never intended to be industrial centres, but were developed as bureaucratic capitals. The ideological informants which influenced the development of South African cities were not unique, however they may present the most extreme examples of racial and economic polarisation due to the severity of Apartheid laws. Rapid urbanisation has resulted in the vast expansion of large informal settlements across Africa. *The Reconstruction and Development Programme* (RDP) in South Africa, introduced in 1995 after the inauguration of President

Nelson Mandela as the first democratically elected president, provided over three million houses for the urban poor, but has continued to reinforce the marginalisation of poor residents, through the spatial location of houses on the urban periphery.

The social view of racial integration and assimilation is important, however it presents methodological problems of quantification and thus demographic racial integration becomes more useful as a research tool. The *Neighbourhood Diversity Index* is a measure of demographic residential racial integration that takes into account multiple racial groups and the racial composition of the larger geographical area. Multi-racial co-presence does not translate directly into multi-racial assimilation, however it is an important sociological phenomenon in itself which has the potential to generate social interaction. Factors which may influence the emergence of transracial co-presence include spatial configuration, economic activity, land-use diversity and mobility. Furthermore, the minibus taxi system which has emerged through a bottom-up process may be serving to connect areas of racial division, more effectively than formal modes of transport due to its flexibility and ability to adapt according to need.

Chapter Three

Methodology

3.1 Introduction

The following chapter provides a detailed account of the methodological framework through which the research was conducted. It begins with an overview of the overarching methodological approach and proceeds to explain the exact methods used to prepare, aggregate and process the selected variables. Furthermore, it makes reference to the original source of data sets and establishes the research limitations.

The research required a methodological approach which could encompass both physical and behavioural aspects in order to shed light on the relationship between urban phenomena and demographic racial integration. The impacts of apartheid planning and the persistent racial segregation in South African cities has been well documented, however very little insight into the geography of demographic racial integration using empirical data exists. The precise descriptions offered by the evidence-based research techniques of space syntax allow for a configurational understanding of both the spatial and social aspects of this study. Space syntax is centralised on the idea that the structure of space is a product, and in turn influencer of social structures and interaction (Dhanini, Tarkhanyan and Vaughan, 2017:56). Co-presence, generated through the pervasive centralities of the street network, is seen as an important social resource, with the potential to develop social solidarity (Hillier, 1989, 1993, 1996).

Cape Town, as the oldest city in South Africa, was chosen as the principal case study. The study adopted an empirical, quantitative approach at a city-wide and neighbourhood scale. It encompassed a three-fold process of firstly recognising the impacts of changing pervasive centralities on the spatial form and urban morphological development of Cape Town. Secondly, it was necessary to gain insight into the nature of demographic racial integration, which could occur either in the form of residentially heterogenous neighbourhoods or through the everyday act of multi-racial co-presence, implying a process of cross-pollination of agents

through the spatial network. Finally, the spatial and social data was to be integrated to reach an overarching understanding of the relation between emergent spatial phenomena and demographic racial integration.

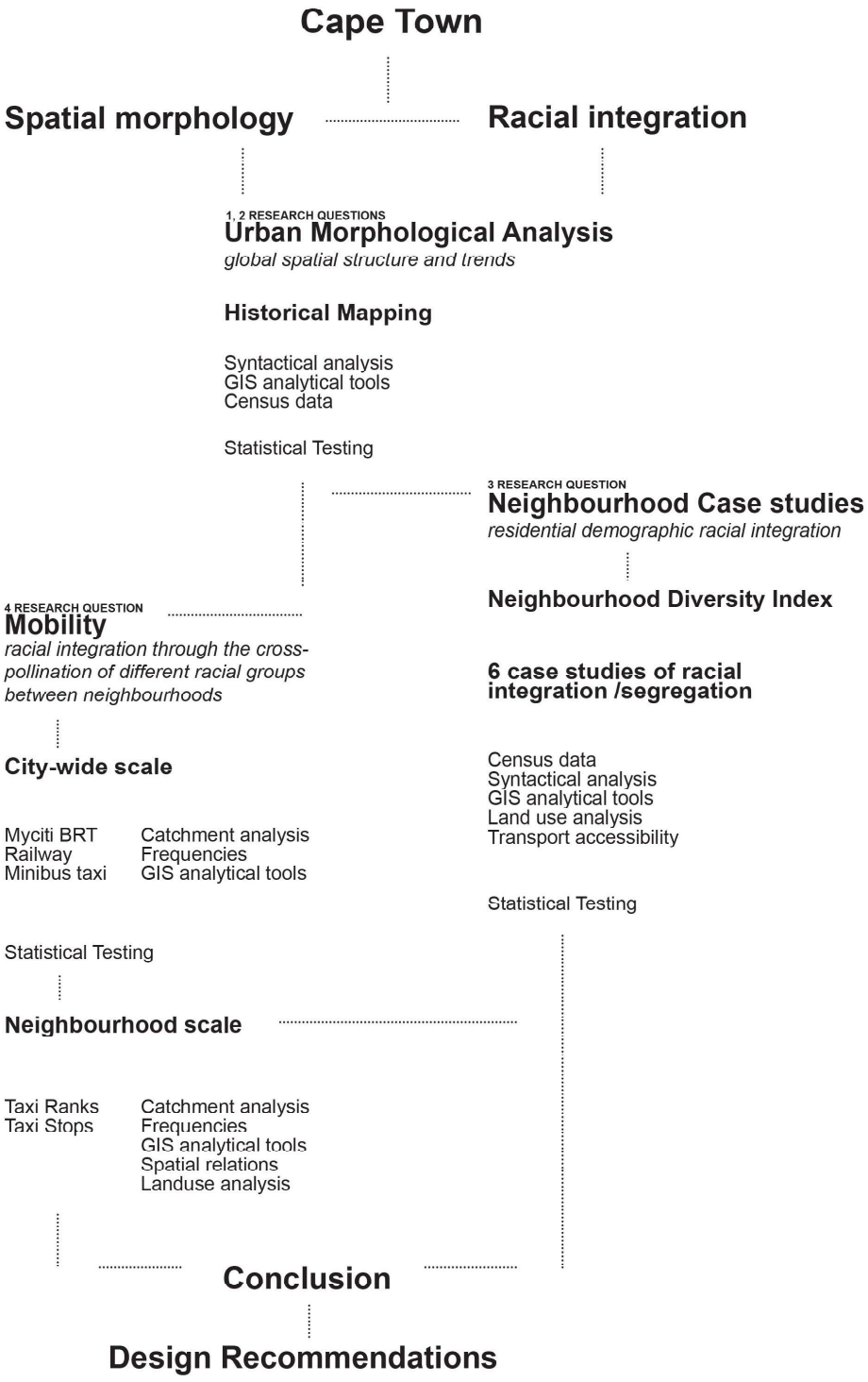


Figure 11: Diagram of methodological process
Source: Author

3.2 Urban morphological development of Cape Town

In order to assess the implications of urban policy and changing pervasive centralities on the street network development, angular segment analysis was performed on simplified road centre line (RCL) maps of Cape Town pertaining to the three, crucial historical time periods of pre-Apartheid (1940), Apartheid (1980) and post-Apartheid (2016). The simplification of road centre line street network representation has been shown to enhance the accuracy of the analysis (Kolovou et al., 2017). The vectorised road centre line models of Cape Town were originally processed by Gambill (2018) through geo-referenced historical imagery on QGIS. These were further adjusted on QGIS using geo-referenced historical images and the plugin, *Open Street Maps* to achieve a greater level of accuracy. Angular segment analysis was performed on the vectorised maps in *Depthmap* software at a range of radii and the spatial data was normalised for ease of comparison (refer to, *Figure 12)*. Subsequently, the graph analysis was imported and stylised in QGIS. The spatial data was aggregated to derive mean values of normalised *integration* and *choice* at selected radii for every neighbourhood in Cape Town. The street network length of the road centre line maps was calculated using QGIS analytical tools to measure Cape Town's network growth over time.

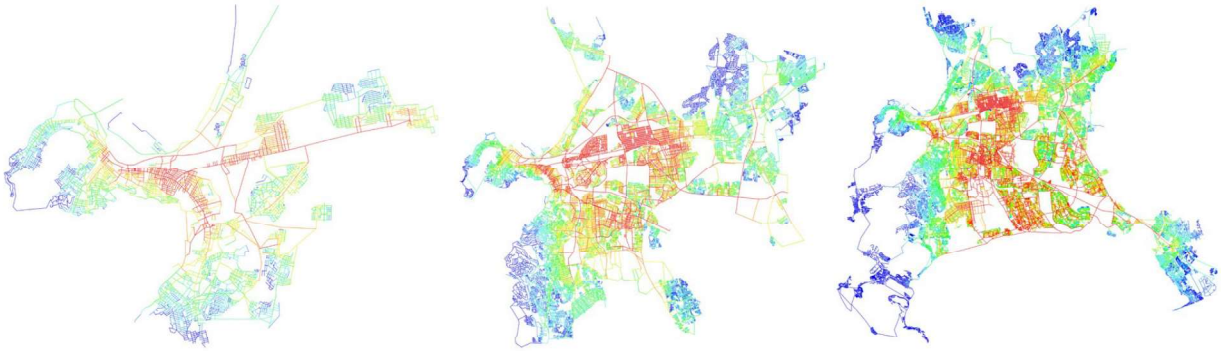


Figure 12: Syntactical analysis of 1940, 1980 and 2016 vectorised maps of Cape Town's road network. Source: Author

Angular segment analysis is a process of analysis used to evaluate the spatial structure of the street network; it is a graph based parameter which measures how many least angular paths lie between every pair of segments within a given distance. The way in which distance is measured in the street network using space syntax techniques is not metric, but is done by calculating the angular change when moving from one street segment to another. The reasoning behind this is it approximates people's actual experience of moving through the urban environment from space to space rather than from intersection to intersection (Dhanani et al., 2017:60).

Two principal measures of the spatial network are *choice* and *integration*. *Integration* refers to angular closeness centrality, which measures the reciprocal of the sum of the shortest path between every origin to every destination, in other words the potential of movement to a street segment (*to-movement*), due to its angular proximity to all other segments within a specified radius (Freeman, 1977; Hillier and Iida, 2005). The higher an integration value is for a street segment, the more likely it is to become a destination within the spatial network. *Choice*, on the other hand, refers to angular betweenness centrality, which measures how many times paths overlap between all pairs of origins and destinations and thus the potential of moving through a street segment (*through-movement*), due to its falling on the shortest angular path between all other segments within a specified search radius (Freeman, 1977; Hillier and Iida, 2005). Therefore, the higher the choice value of a street segment, the more likely it is to be used as a through-movement path on a journey.

Normalisation of angular choice and integration measures were introduced by Hillier *et al.* (2012), as they have the advantages of exposing the inner structure of urban form and enabling comparisons between street configurations in between different cities, as well as within different locations in a single city (Al-Sayed, Turner, Hillier, Iida, Penn, 2014:77). The normalised angular choice and integration measures are named NACH and NAIN, respectively. The formulas used for normalisation are depicted below.

NACH = logCH+1/logTD+3
NAIN = NC^1.2/TD

3.3 Geo-location of census data

The primary source of data on racial and economic distribution was derived from the South African National Census (2011). Census data was obtained from *Statistics South Africa* and aggregated to a neighbourhood scale using the software, *Supercross*. This was imported into QGIS and linked to a geolocated polygon map of Cape Town's neighbourhoods. Choropleth maps were created to visualise the data according to geographic location. A choropleth map is a thematic map which illustrates variables in proportion to their measurement through a colour gradient.

3.4 Analytical comparison of neighbourhood case studies of racial homogeneity and heterogeneity

The city wide racial composition of Cape Town is: 42% Coloured, 39% Black, 16% White, 2% Other and 1% Indian. It is important to note, that unlike the American term, the term *Coloured* is not offensive and is the name of an actual mixed-race group who are descendants of Black, White, Malaysian, Indian and the native Khoi San. The term is used within official government documents and is embraced by this community. Furthermore, in most South African cities the Black Race is the predominant population group, deeming Cape Town to be demographically unique.

In order to identify relational links between spatial characteristics and demographic racial integration it was necessary to select a compendium of contrasting neighbourhood case studies, the *Neighbourhood Diversity Index* was used as a basis for case study selection. The *Neighbourhood Diversity Index* (*ND Index*) is a measure developed by the sociologist Michael T. Maly (2000) for studying racial integration. The *ND Index* focuses on racial integration at a neighbourhood scale and allows researchers to include multiple racial and ethnic categories whilst adhering to a comparable understanding of integration by referencing the racial composition of the larger geographic area that the neighbourhood is placed within (Maly, 2000:37). The formula for the *ND Index* is depicted below. An important aspect of the formula is that the **absolute values** were applied, in other words if there was an instance in which a larger value was subtracted from a smaller value, the negative sign was disregarded.

ND = (Cw - Tw) + (Cb - Tb) + (Cc - Tc) + (Ci - ti) + (Co - To)

Cw = city wide percentage of White population (16% in Cape Town)
Cb = city wide percentage of Black population (39% in Cape Town)
Cc = city wide percentage of Coloured population (42% in Cape Town)
Ci = city wide percentage of Indian population (1% in Cape Town)
Co = city wide percentage of Other population (2% in Cape Town)

Tw = neighbourhood percentage of White population
Tb = neighbourhood percentage of Black population
Tc = neighbourhood percentage of Coloured population
Ti = neighbourhood percentage of Indian population

To = neighbourhood percentage of Other population

The city-wide and neighbourhood data on the composition of racial population was derived from the South African National Census (2011). The *ND Index* formula was applied to the census data in the software *Excel,* resulting in an *ND Index* for every neighbourhood in Cape Town. The larger the *ND Index* is for a neighbourhood, the more racially segregated that neighbourhood is and the lower the index, the more racially integrated it is. For the purpose of statistical analysis, the *ND Index* was inverted, so that if any positive statistical correlations emerged they indicated a positive relationship with racial integration, as opposed to racial segregation. It is also imperative to note, that this Index can only be used to compare neighbourhoods within a city and entire cities with each other.

From this process, six neighbourhoods of residential racial heterogeneity and homogeneity were selected. A series of spatial factors with readily available data, identified in the *Literature Review* were examined in each of the case studies. They included, integration and choice measures of the street network, analysis of local barriers to access, land-use composition and public transport accessibility. Spatial data sets were constructed from shape-files imported into QGIS, which were downloaded from the *City of Cape Town's Open Data Portal*.

3.5 Evaluation of mobility networks in relation to racial heterogeneity

In order to evaluate patterns of accessibility, three modes of public transport were selected, with a specific emphasis on the under-researched paratransit minibus taxi. The railway and Myciti BRT systems are formal modes of public transport which are operated by government agencies. The locations of their stops, stations and routes were obtained from the *City of Cape Town's Open Data Portal* in shape-file format and imported into QGIS. The exact location of the paratransit minibus taxi routes, stops and ranks were derived from data sets provided in the form of geolocated shape-files by the company, *Whereismytransport*. It is of significance for this study that *Whereismytransport* conducted a month of observation analysis in 2017, which involved the procurement of paid volunteers to identify, ride and map every taxi route and stop in Cape Town.

Using QGIS analytical tools the frequency of stops, stations and ranks of each mode of transport was aggregated to a neighbourhood scale. This was used as an indicator of activity, accessibility and potential affordance for the emergence of multi-racial co-presence created by a

specific mode of transport. The underlying premise being that if a transport system fails to service a neighbourhood, or merely travels through a neighbourhood, but fails to stop there, it does not contribute to the emergence of co-presence in that neighbourhood. Furthermore, the systems were evaluated specifically to determine if they were providing affordances for new networks of racial heterogeneity or reinforcing existing networks of racial homogeneity, by only servicing certain kinds of neighbourhoods.

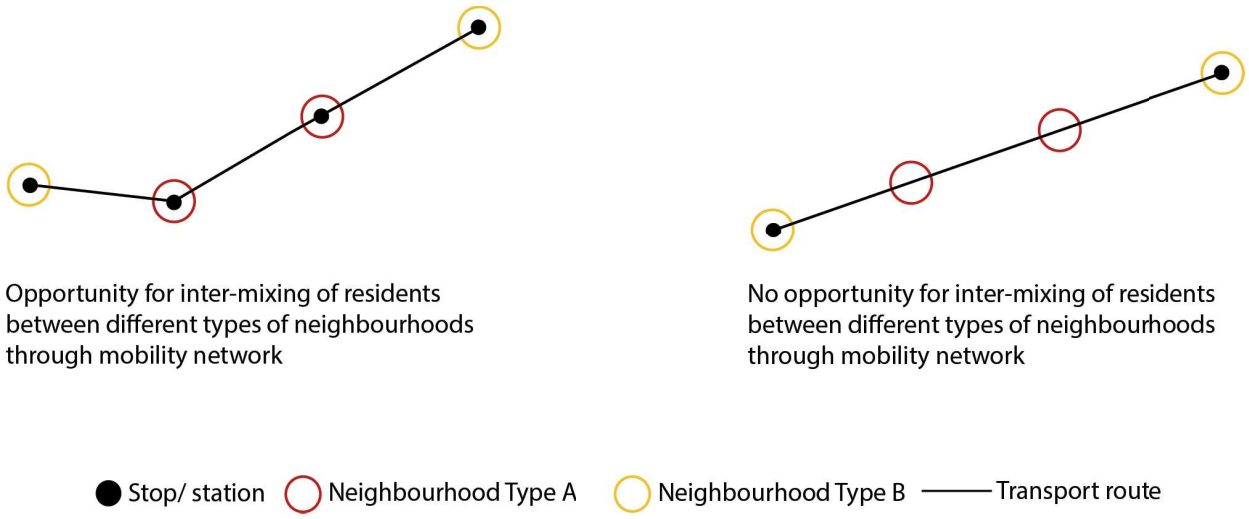


Figure 13: Diagram illustrating conceptual premise behind how a network of mobility may create opportunity for multi-racial co-presence
Source: Author

3.6 Transport Catchment Analysis

Railway stations, Myciti BRT and paratransit minibus taxi stops were overlaid on the vectorised simplified road centre line network of Cape Town in QGIS. Using the *Space Syntax Toolkit* plugin, catchment analysis was employed to quantify and visualise walking accessibility of the transport networks within the street layout. Analytical tools in QGIS enabled the calculation of the length of the catchment networks and thus a comparison of accessibility of each transport mode.

3.7 Statistical Analysis

A variety of data sets were aggregated to neighbourhood level and exported to csv files to test the statistical strength of relational links between them in the software *SPSS*. *Bivariate Correlation Analysis* was employed to determine if a statistically significant relationship existed between two sets of variables. A statistically significant positive correlation, (above 0.01), is a

measure which indicates a relationship in which both variables move in the same direction and concurrently increase or decrease. On the other hand, a statistically negative correlation (above -0.01) indicates that the variables have a relationship in which they move in opposite directions; as one variable increases or decreases, the other variable does the opposite.

The variables with the strongest bivariate correlations were chosen for *Multiple Linear Regression Analysis.* In each constructed model, an independent variable was specified and multiple dependent variables were chosen. The coefficient of determination (R^2) specifies how well the model accounts for the variability in the data and therefore summarised the explanatory power of the regression model, where a value closer to 1 was indicative of a good model fit.

3.8 Photographs

Photographs taken by the Author and obtained from Google Street View were employed to convey the character and atmosphere of specific areas within Cape Town.

3.9 Research limitations

Limitations were imposed on the research by availability of data sets. Census data in South Africa is aggregated to a neighbourhood scale. If the census data had been at street level, it would have enabled a more nuanced research approach and the linking of specific street segment values with social statistical data. Whilst land-use zoning of plots has been mapped in Cape Town, the majority of building footprints and their heights has not been recorded, meaning that an empirical understanding of building density could not be taken into account. Furthermore, there are certain areas within the street network, particularly informal settlements, which are not included in the road-centre line network originally derived from the *City of Cape Town's Open Data Portal*.

3.10 Summary of research questions and analysis

Figure 14, provides an overarching summary of the research questions, indicating the specific chapter that each of them were addressed in and the type of data and method of analysis utilised. *Figure 15* provides an overarching summary of where data was sourced from, the format it was in and how complete it was.

Research Questions	Chapter	Data format	Data Analysis
What was the effect of 20th Century Modernist planning on Cape Town and was it used to reinforce discriminatory racial ideology?	Chapter 4	Historical vectorised maps, Census Data	Normalised Integration and Choice Analysis, Choropleth mapping
What is the relationship between the present day spatial configuration of Cape Town and economic and demographic racial distribution?	Chapter 4	Street network, Census data, Landuse Data, Geolocated neighbourhood boundaries	Normalised Integration and Choice Analysis, Choropleth mapping, Statistical testing
What is the relationship between the spatial configuration of Cape Town and demographically racially integrated neighbourhoods?	Chapter 5	Geolocated neighbourhood boundaries, Street network, Census data, Landuse Data, Transport data, Literary sources	Neighbourhood Diversity Index, Normalised Integration and Choice Analysis, Choropleth mapping, Statistical testing
Does informal transport, as opposed to formal transport, as a bottom-up response to the general top-down planning of South African cities possess a generative relationship with demographic racial heterogeneity in Cape Town?	Chapter 6	Street network, Census data, Landuse Data, Transport data, Geolocated neighbourhood boundaries, Literary sources	Catchment Analysis, QGIS count tools to sum the total frequencies of stops and stations per neighbourhood
Considering South Africa's long history of top-down urban policy centred on racial segregation, what spatial and mobility systems have emerged that may create opportunities for co-presence and encounter between different racial groups in space?	Through all Chapters and in Conclusion	See above	See above

Figure 13 : Summary of research questions and analysis
Source: Author

Data Source	Where Sourced	How captured	How complete	Date
Census Data	Statistics South Africa	CSV files	Complete, but not at street segment level	2011
Vectorised historical maps	Vendela Gambill	Historical maps imported into QGIS and vectorised	Complete, but needed adjustments	2018
Neighbourhood and Ward Boundaries	Statistics South Africa	shapefiles	Complete and linked to neighbourhood boundaries used with Census data	2011
Landuse data	Cape Town Municipality Open Data Portal	shapefiles	Complete for plots, but not for actual buildings	2018
Street network	Cape Town Municipality Open Data Portal	shapefiles	Moderately complete, does not include informal settlements	2016
Location of railway lines and stops	Cape Town Municipality Open Data Portal	shapefiles	Complete	2018
Location of BRT routes and stops	Cape Town Municipality Open Data Portal	shapefiles	Complete	2018
Location of taxi routes, ranks and stops	Whereismytransport company	shapefiles	Complete	2017

Figure 14 : Summary of data sources and format
Source: Author

Chapter Four

Urban morphological development of Cape Town

4.1 Introduction

In order to evaluate the relationship between mobility, spatial systems and demographic racial heterogeneity, it is crucial to gain an understanding of the urban morphological development of Cape Town's spatial configuration. The urban morphological development of Cape Town will be examined primarily in the 20th Century and also in the 21st Century, through the development of its street network from the three, pivotal time periods of *pre-Apartheid, Apartheid* and *post-Apartheid*. These phases represent important turning points in South African history, characterised by stark changes in the political regime, however they are not intended to be conceived in isolation, but rather as a progression or heightening of the previous period. This study has approached the analysis with an emphasis on neighbourhood development, due to urban policy historically being centred on the racial zoning of individual neighbourhoods. Furthermore, it aims, in part, to link Cape Town's urban morphogenesis with broader conceptualisations of colonial and postcolonial development in Africa (Myers, 2011, Coetzer, 2013, King, 2015). In addition, the study will explore the geography of economic and racial distribution across the city, which will provide a necessary contextual background to the examination of specific neighbourhood case studies in the subsequent chapter. The first research question to be explored in this chapter: how were modernist urban planning interventions used to enforce colonial and apartheid discriminatory ideology? The second research question is: what is the relationship between the present day spatial configuration of Cape Town and economic and racial distribution?

4.2 Pre-Apartheid Urban Morphology

4.2.1 Angular Segment Analysis: Integration and Choice

The globalised Normalised Integration Angular Segment Analysis (NAIN Rn) of Cape Town's 1940 street network shown in *Figure 17*, indicates that the spatial form was influenced by the

contours of the land, floodplains and coastline. Closeness centrality (*to-movement*) is shifting away from the historic Central Business District (CBD) to the neighbourhoods of *Woodstock, Observatory* and *Maitland*. The suburbs of *Pinelands* and *Langa* are placed on the urban periphery, clearly isolated and separated from the organic street network. As Nicholas Coetzer explained in his book, *Building Apartheid* (2013:136), *Pinelands* and *Langa* were both modelled on planning principles derived from the *Garden City Movement*, which valorised the English village and most importantly provided rationalising discourse through which the question of how and where people should live was to be resolved. *Pinelands* quickly became reserved for White people only, whilst *Langa* was intentionally built for the growing Black working force, visualised in *Figure 16* (Coetzer, 2013:193). Although these neighbourhoods are located alongside each other, they are clearly delineated as two separate network agglomerations.

Globalised Normalised Angular Choice Segment Analysis (NACH Rn) reveals that *Voortrekker Road* and *Main Street* possess strong betweenness centrality (*through-movement*). These streets historically connected Cape Town to nearby villages and towns, prior to the construction of highways and national routes. The singular segments connecting *Pinelands* and *Langa* to the city, possess high betweenness centrality, indicative of the reliance on these routes for access.

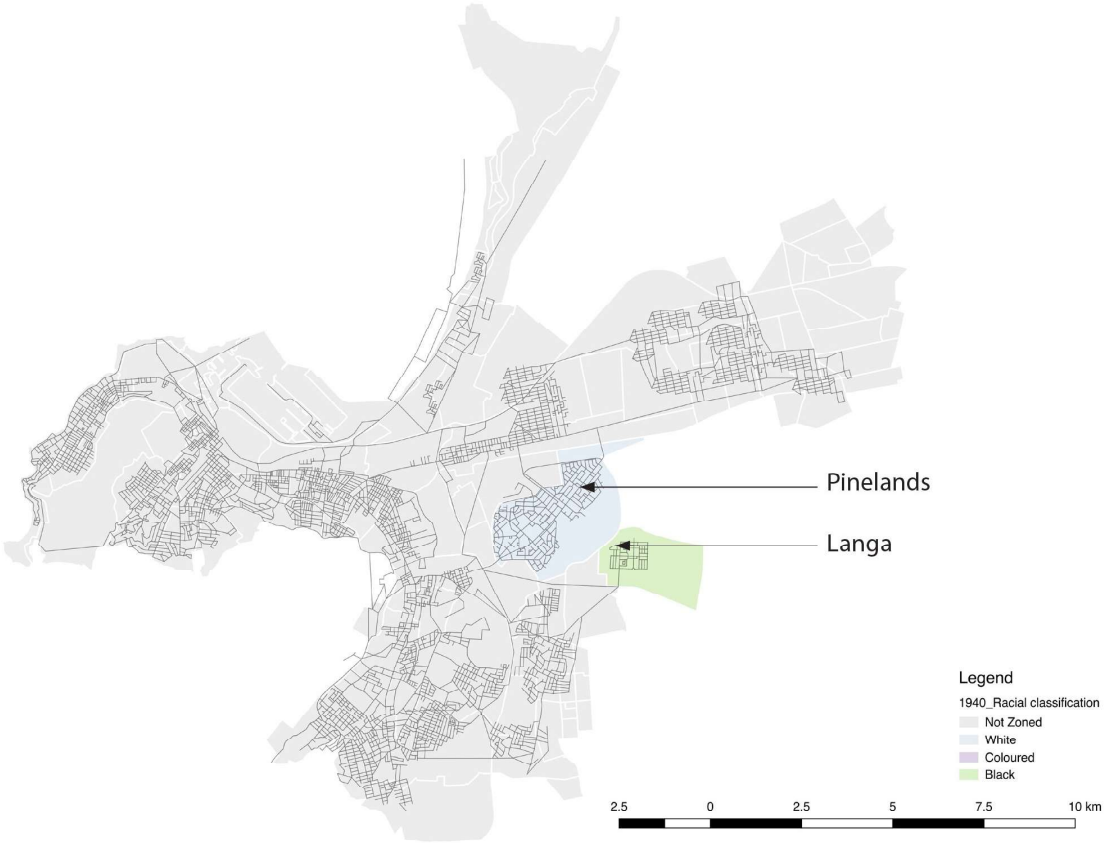


Figure 16: Visualisation of racially zoned neighbourhoods in Cape Town (1940)
Source: Analysis by Author

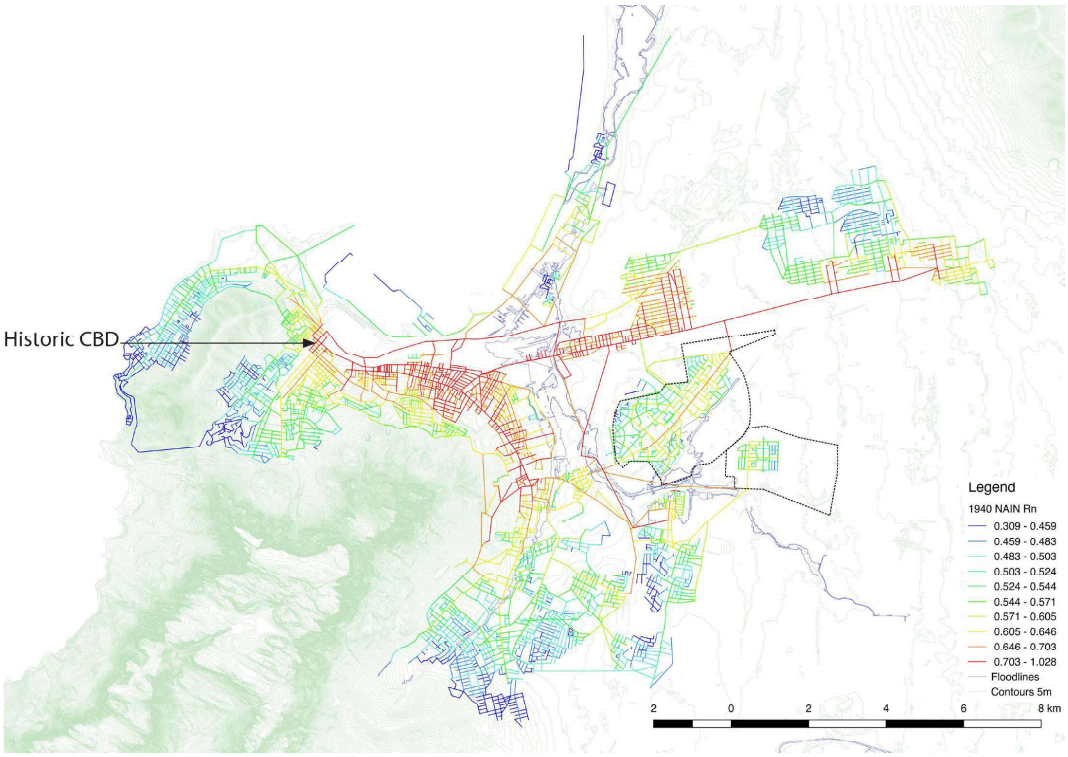


Figure 17: Angular Segment Analysis, Normalised Integration 1940 map of Cape Town at Radius N.
Source: Analysis by Author

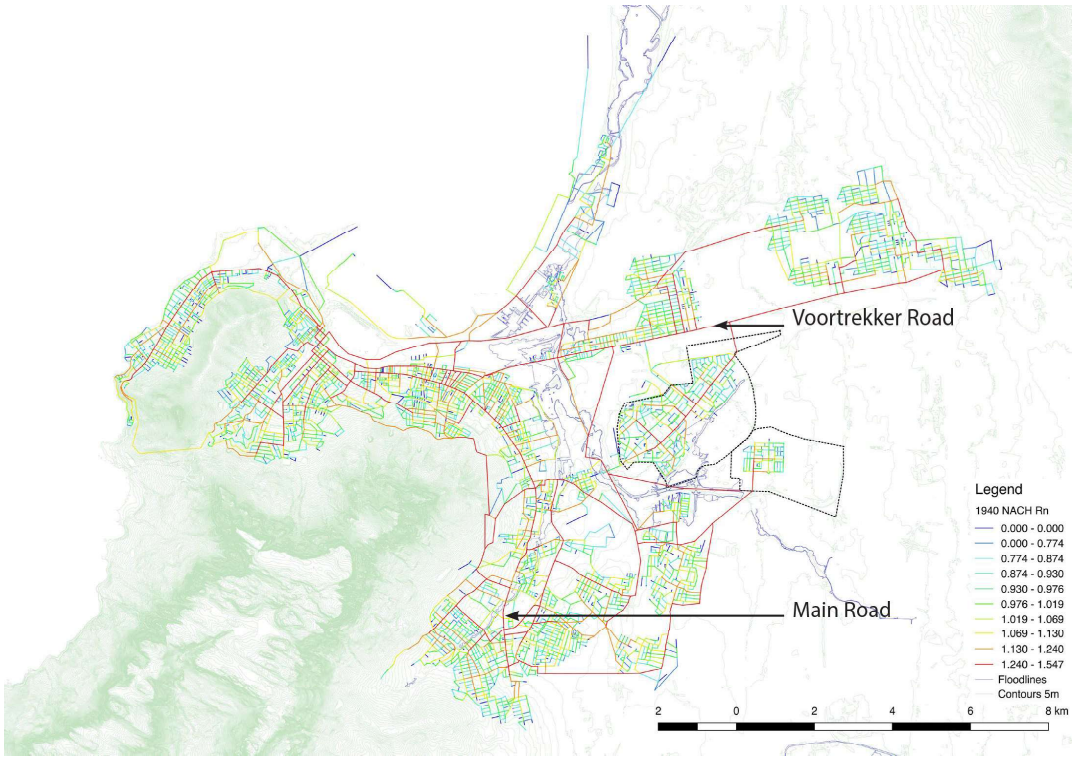


Figure 18: Angular Segment Analysis, Normalised Choice 1940 map of Cape Town at Radius N.
Source: Analysis by Author

4.3 Apartheid Urban Morphology

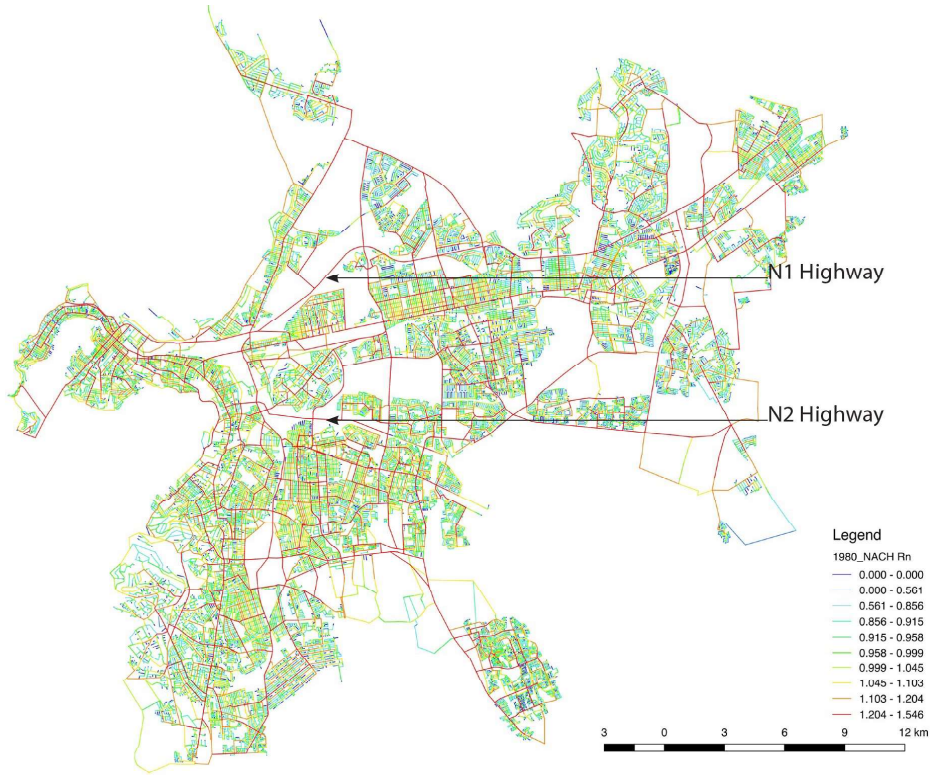
By 1980, Apartheid had been in existence for 31 years. One of the most devastating policies implemented during this period was the *Group Areas Act* of 1950, which enabled the National Government to racially classify specific neighbourhoods and invoked the forced removal of thousands of mostly non-White residents from inner-city neighbourhoods. Platzky and Walker (1984:1) reported that from 1960 to 1982 approximately 3.5 million South Africans were forcibly removed from their homes and relocated to barren and uninhabitable areas.

An analysis of segment length reveals that the street network from 1940 to 1980 grew five and a half times. This tremendous growth is symptomatic of the development of new settlements created to house forcefully removed people of colour from the inner-city.

4.3.1 Angular Segment Analysis: Integration and Choice

The analysis of NAIN at Rn (*Figure 21*) indicates that closeness centrality has continued to shift from the CBD. Closeness centrality emanates from *Voortrekker Road*, it links the city to the Northern suburb of *Bellville* developed as a secondary economic centre, during the 1970s. The White, affluent Southern suburbs are clearly isolated. The township of *Nyanga*, built for the growing Black population in 1949 and *Mitchells Plain*, developed to house forcefully removed Coloured people from inner-city areas such as *District Six*, have been located on the urban periphery with limited access and egress points.

The analysis of NACH at Radius n (*Figure 19*), emphasises the strong betweenness centrality of the *N1* and *N2* Highways which were constructed during the 1950s. In effect, their positioning has placed a global reliance on the automobile. At NACH R5000 (*Figure 20*), the *N1* and *N2* lose their betweenness centrality, which suggests at a more local scale, they become barriers to movement. Pedestrians are unable to cross these highways and therefore they serve to fragment the city form, blocking the natural movement of people from one neighbourhood to the next.



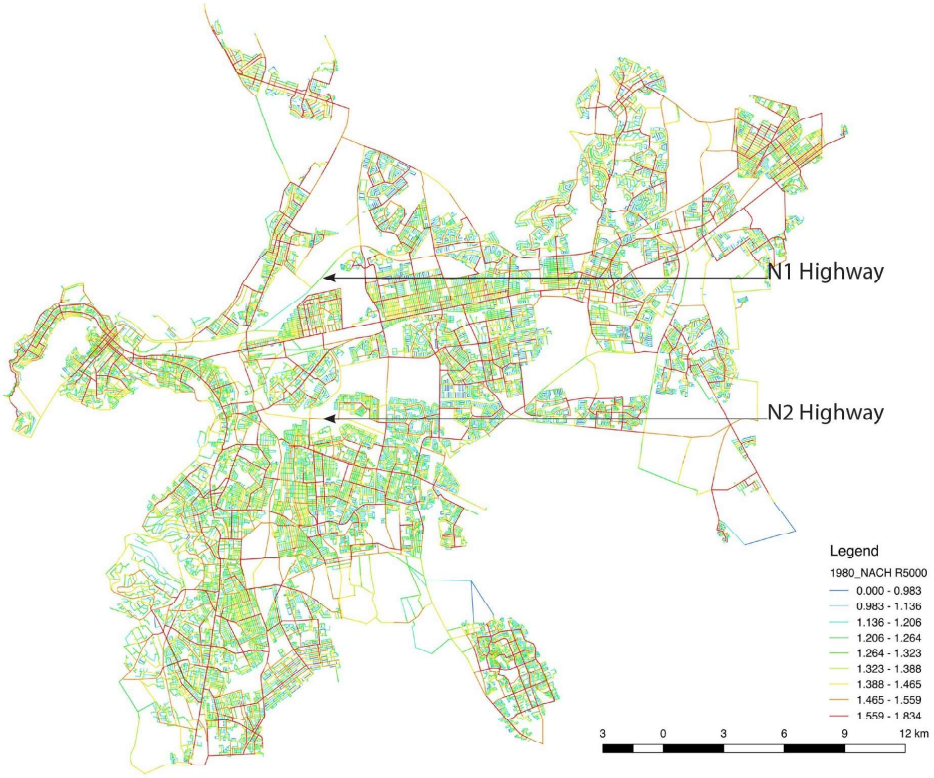


Figure 19: Angular Segment Analysis, Normalised Choice 1980 map of Cape Town at Radius N.
Source: Analysis by Author

Figure 20: Angular Segment Analysis, Normalised Choice 1980 map of Cape Town at Radius 5000
Source: Analysis by Author

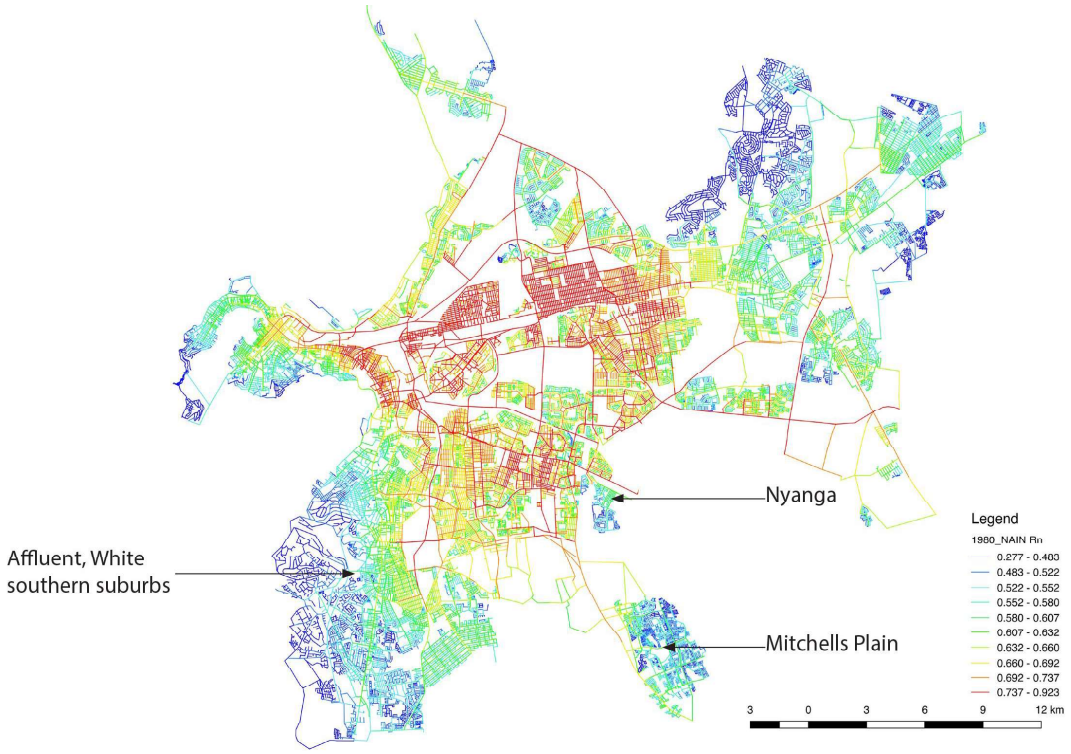


Figure 21: Angular Segment Analysis, Normalised Integration 1940 map of Cape Town at Radius N.
Source*: Analysis by Author*

4.3.2 Racial zoning and centrality

Figure 22, depicts the racial zoning of neighbourhoods implemented by the notorious *Group Areas Act* (1950). Remarkably, the neighbourhood of *Woodstock* was never officially racially classified, allowing it to remain one of the only multi-racial areas in the country (Garside, 1993). With the growth of the city, the Black township of *Langa* is no longer positioned on the urban periphery, however it has been effectively enclosed by urban elements such as highways, greenbelts and railway lines. This trend can be observed in other neighbourhoods such as the Black township of *Nyanga* and the newly built Coloured township of *Mitchells Plain*. The analysis depicted in *Figure 22*, indicates that not only were neighbourhoods racially zoned through legislation, but that urban components were used shrewdly to spatially demarcate and separate them.

An analysis of global closeness centrality in the different racially classified neighbourhoods, reveals that the mean integration value for White neighbourhoods was 0.57, for Coloured neighbourhoods it was 0.67 and Black neighbourhoods, 0.66. This indicates that on average, the White neighbourhoods were in the most segregated parts of the street network in 1980.

Figure 22: Visualisation of racially zoned neighbourhoods in Cape Town (1980)
Source: Analysis and visualisation by Author

4.4 Post-Apartheid Urban Morphology

During Apartheid, Black South Africans were stripped of their South African citizenship and were made citizens of one of the ten *Bantustans*, known more informally as the "homelands", which were set up as rural, racially homogenous territories on the outskirts of South Africa. When Apartheid ended in 1994, the citizenship of Black South Africans was reinstated causing a vast migration into urban centres from the former *Bantustans*.

An analysis of Cape Town's street segment length reveals that from 1980 to 2016 it more than doubled. This confirms that urbanisation has been happening at a faster rate, as is approximately one and a half times more than the growth Cape Town experienced from 1940-1980. The accelerated expansion of townships and informal settlements, follows the trend of rapid urbanisation across Africa. In 2011, the population of Cape Town was 3740025, an increase of 29.3% since 2001, and the number of households was 1068572, an increase of 37.5% since 2001 (South African National Census Data, 2011).

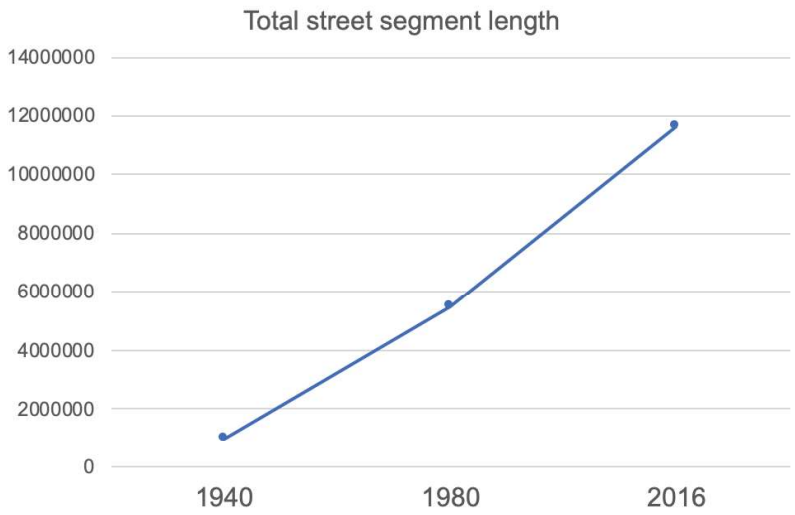


Figure 23: Graph depicting segment length growth of Cape Town's Street network
Source: Analysis by Author

4.4.1 Angular Segment Analysis: Integration and Choice

The 2016 syntactical analysis of NAIN at Rn (refer to *Figure 24)* reveals that Cape Town's CBD is spatially isolated, undersized and globally inaccessible. Factors which have exacerbated this condition are rapid urban development and the topographic geography. However, at a more local scale (refer to *Figure 25)* a contrasting picture emerges, the CBD and southern suburbs heat up, gaining in closeness centrality. Isolation emerges in the neighbourhoods along the N2,

which globally possess high closeness centrality. This is indicative of local morphological barriers restricting potential access.

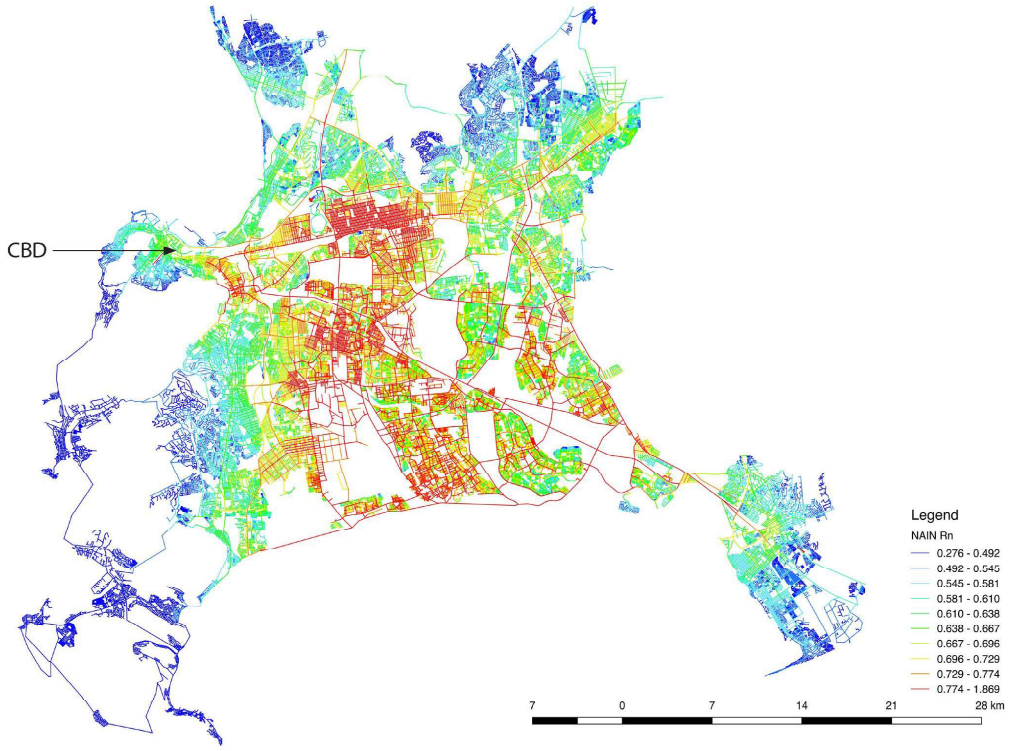
The analysis of NACH at Rn (*Figure 26*), indicates a similar trend to the 1980 street network, with the national highways of the *N1* and *N2* retaining their strong betweenness-centrality. However, once again, at a more local scale of R5000 their betweenness centrality decreases, refer to *Figure 27*. At NACH Rn, *Voortrekker* and *Main Road* also possess high betweenness centrality, but at a more local scale of R5000, unlike the *N1* and *N2*, their betweenness centrality is retained, perhaps indicative of higher intelligibility.

This phenomenon, further illustrated in *Figure 28*, depicts a typical highway in Cape Town composed of multiple lanes of two way traffic, no crossings for pedestrians, are adjacent to lengthy green belts and imposed on the landscape. *Figure 29,* conversely, shows how the old main streets of *Voortrekker* and *Main Road* have a relationship with the built environment and allow for pedestrian movement. They are emergent routes, which developed over a long period of time and seem to be acting as integrating mechanisms. This provides evidence that the highways, whilst providing global connections, serve to fragment the city form, restricting local movement and globally enforcing a reliance on the automobile.

4.4.2 Racial and economic distribution

Choropleth mapping of statistics derived from the South African National Census (2011), illustrated in *Figures 32, 33 and 34* display a visualisation of racial distribution across the city. What this reveals is that the racial geography of the city remains predominantly clustered and segregated in space. Whilst the CBD is relatively racially mixed, the neighbourhoods directly adjacent to it are predominantly White. The historically Coloured and Black townships also remain persistently racially segregated. This analysis indicates an almost city-wide condition of what Hillier and Hanson (1984, 1987) referred to as *spatial correspondence*. Territory is clearly demarcated along racial lines; there is a correspondence between racial identity and spatial areas.

Income distribution, shown in *Figure 35,* indicates a trend of income recession with distance from the CBD and a concentration of wealth in areas which have a predominantly White population. These observed trends will be tested statistically subsequently.



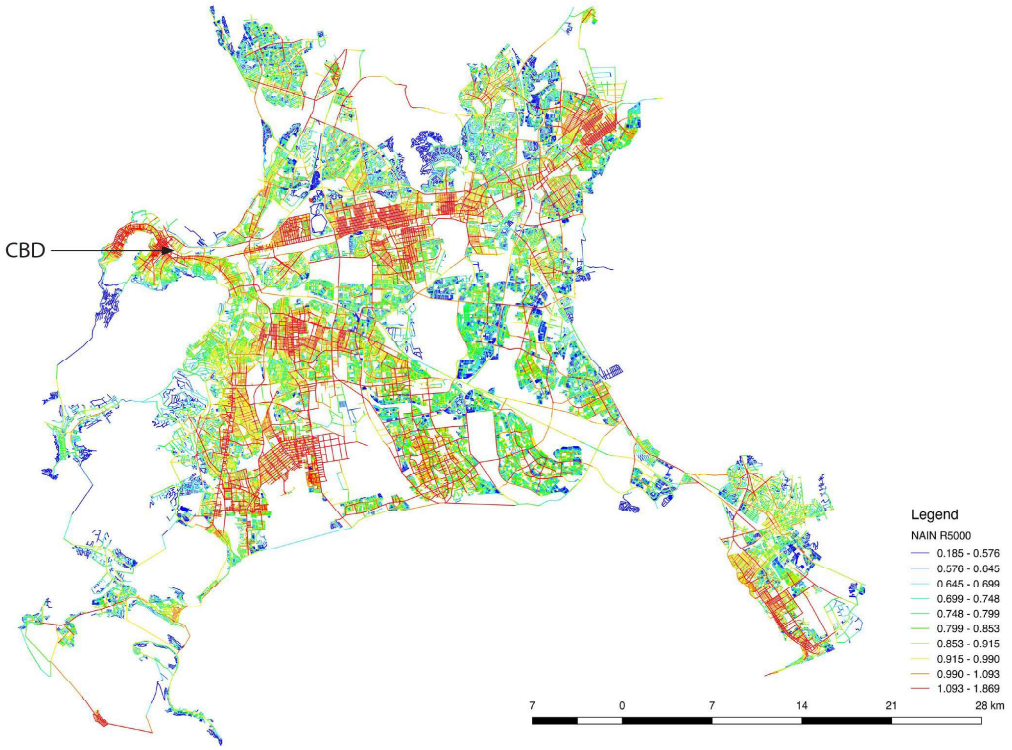
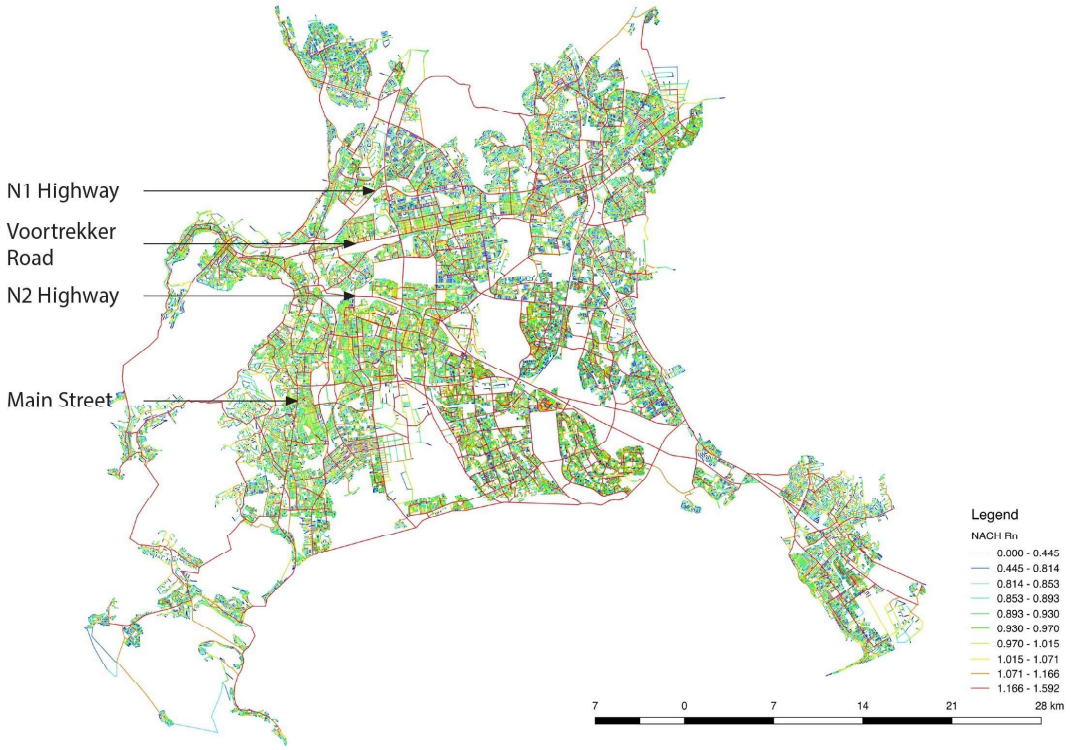


Figure 24: Angular Segment Analysis, Normalised Integration 2016 map of Cape Town at Radius N.
Source: Analysis by Author

Figure 25: Angular Segment Analysis, Normalised Integration 2016 map of Cape Town at Radius 5000
Source: Analysis by Author



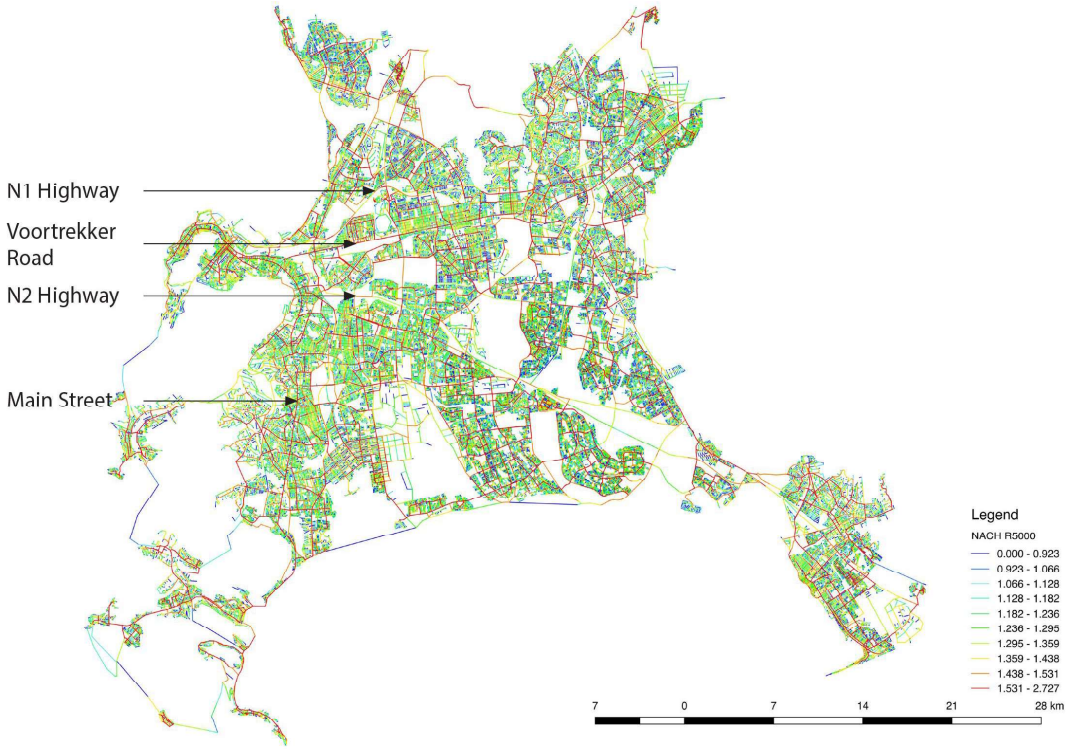
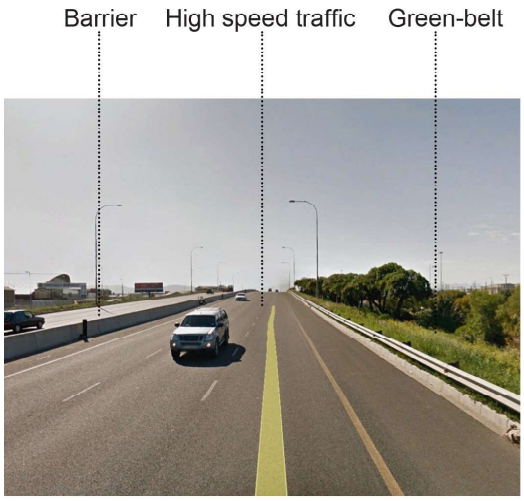
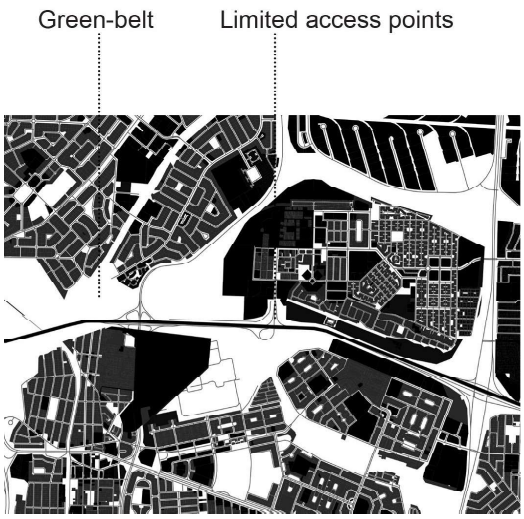


Figure 26: Angular Segment Analysis, Normalised Choice 2016 map of Cape Town at Radius N.
Source: Analysis by Author

Figure 27: Angular Segment Analysis, Normalised Choice 2016 map of Cape Town at Radius 5000
Source: Analysis by Author





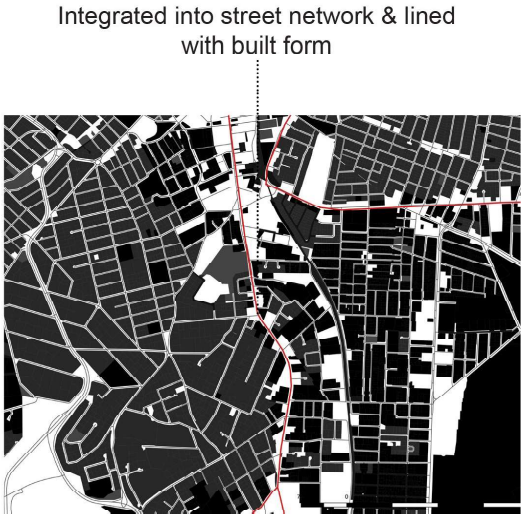
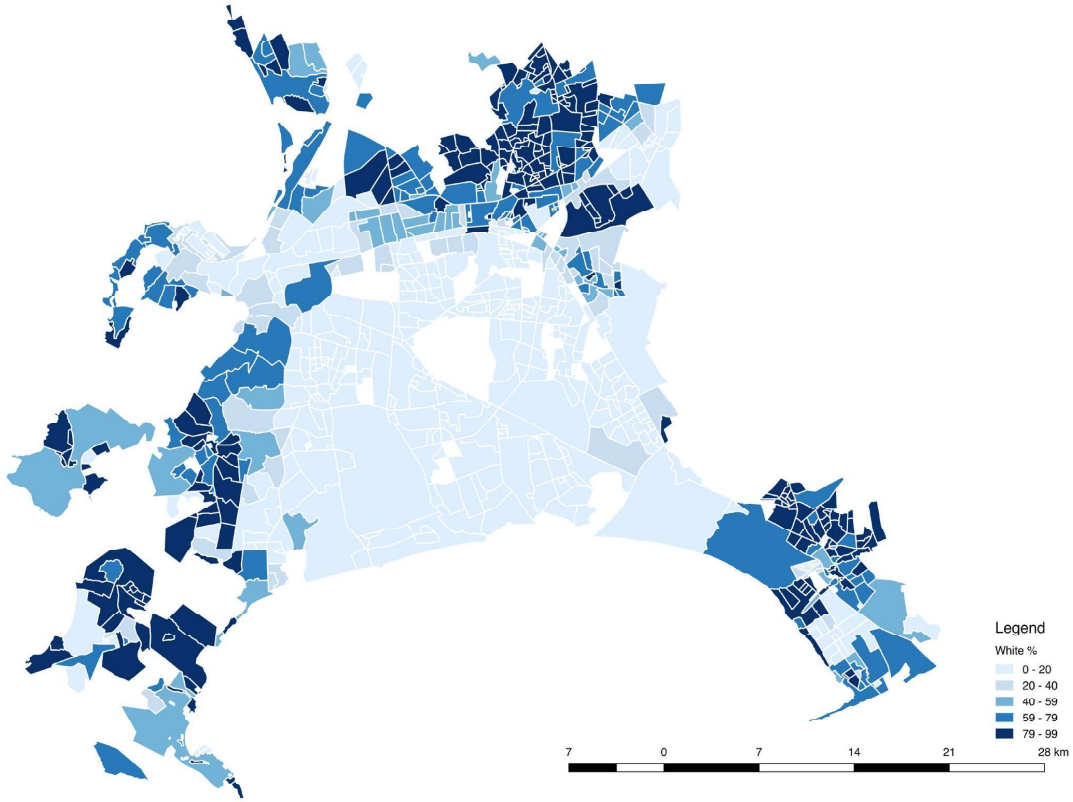


Figure 28: Photograph of the N2 Highway in Cape Town
Source: Google Earth, diagram by Author

Figure 29: Photograph of Main Street in Cape Town
Source: Google Earth, diagram by Author

Figure 30: Diagram depicting spatial relations of N2 Highway in Cape Town
Source: GIS files obtained from *Cape Town's Open Data Portal,* visualisation by Author

Figure 31: Diagram depicting spatial relations of Main Street in Cape Town
Source: GIS files obtained from *Cape Town's Open Data Portal,* visualisation by Author



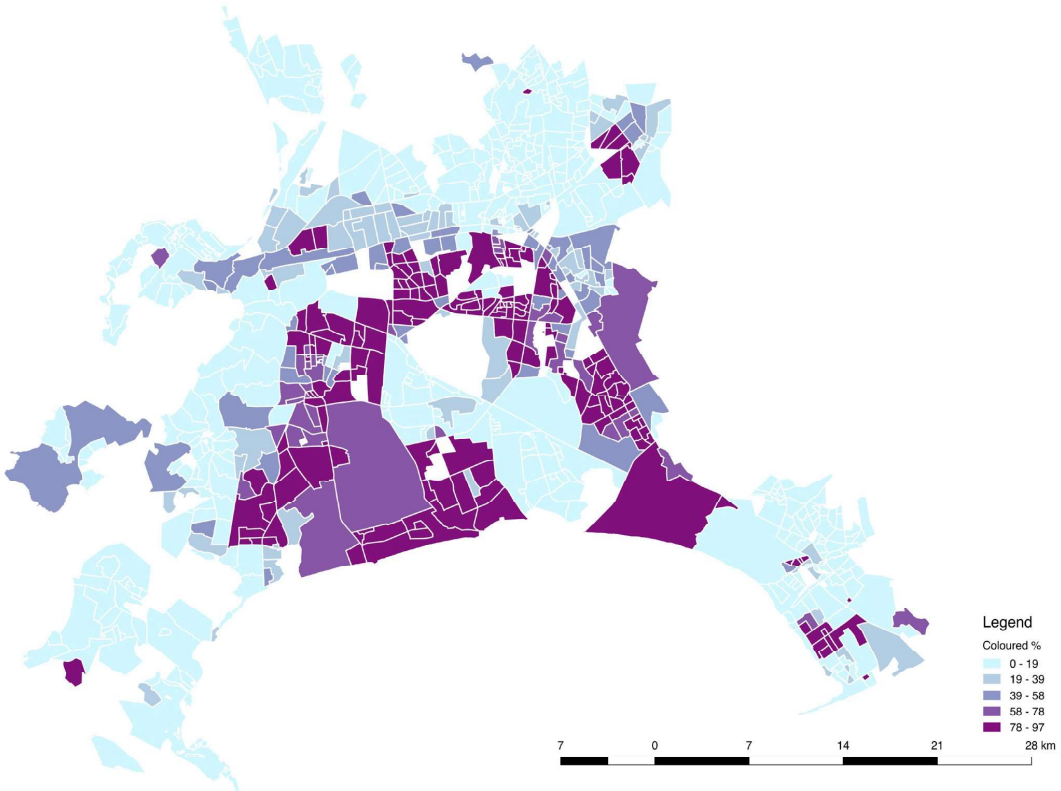
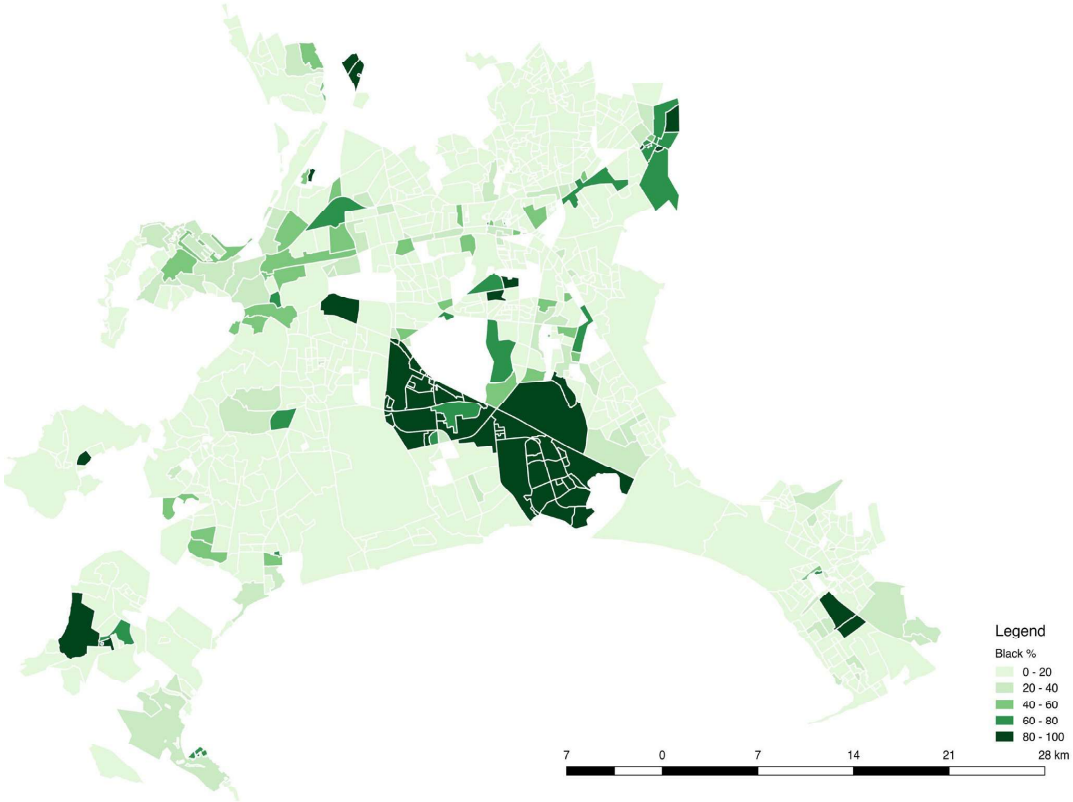


Figure 32: Neighbourhoods visualised according to concentration of White people residing in them
Source: South African Census Data (2011), visualised by Author

Figure 33: Neighbourhoods visualised according to concentration of Coloured people residing in them
Source: South African Census Data (2011), visualised by Author



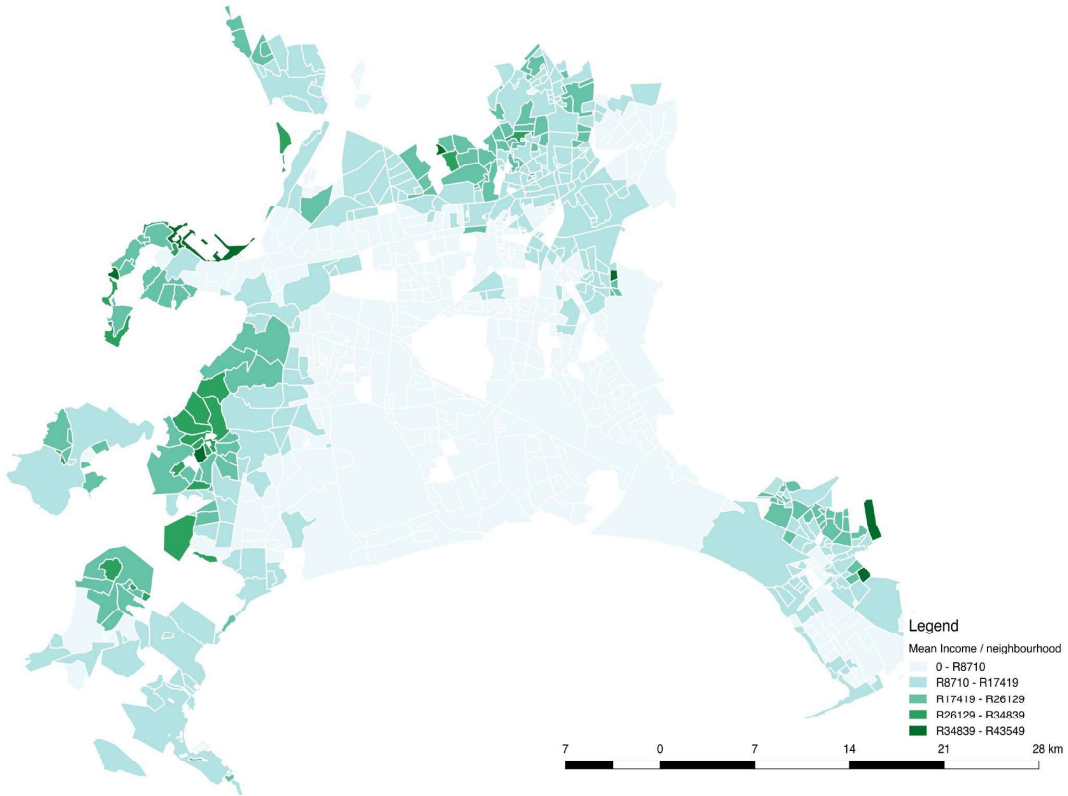


Figure 34: Neighbourhoods visualised according to concentration of Black people residing in them
Source: South African Census Data (2011), visualised by Author

Figure 35: Neighbourhoods visualised according to mean Income distribution
Source: South African Census Data (2011), visualised by Author

4.4.3 Statistical Testing

In order to assess the strength of relationships between Race, syntactical values and Income, each of the variables is tested using Bivariate (Pearson) Correlation analysis. Whilst closeness centrality has significant correlations with Race and Income at a multitude of different radii, the strongest correlations are at Radius n. There were mildly significant correlations at NACH Rn only.

Mean NAIN Rn vs White %	- .627**
Mean NAIN Rn vs Coloured %	.472**
Mean NAIN Rn vs Black %	.376**
Mean NAIN Rn vs Mean Income % %	- .606**
Mean NACH Rn vs. White %	-.110**
Mean NACH Rn vs. Mean Income %	-.093**
Mean Income vs White %	.798**
Mean Income vs Coloured %	- .581**
Mean Income vs Black %	- .376**

** Statistically significant to the 0.01 level

A multiple linear regression model is constructed with the variables which had the highest significant correlations. The coefficient of determination (R^2) is an indication of how well the model accounts for the variability in the data, where the value closer to 1 is indicative of a good model fit. The model which gave the highest R^2 value is summarised below, showing that 65% of mean income in a neighbourhood can be accounted for by the percentage of White people living in that neighbourhood and the mean NAIN Rn value of that neighbourhood.

Independent Variable:	Mean Income per neighbourhood	
Dependent Variables:	White %	*.798***
	Mean NAIN Rn	*-.606***
R^2 Value:		.655

4.5 Discussion

The City of Cape Town emerged organically emanating from the coastline, as a key trading post. During the 20th Century, modernist principles of urban planning evolved out of the *Garden City Movement*, which became a mechanism for control and segregation. The concurrent technological developments of motorised transport and railway infrastructure allowed urban dwellers for the first time to work in the city, without actually having to live there. The implementation of highways has caused a city-wide reliance on motor vehicular transport. Whilst on a global scale the highways possess high betweenness centrality, on a local scale the highways are prohibiting neighbourhood accessibility.

Cape Town's growth was accelerated during Apartheid through the implementation of the *Group Areas Act*, which was responsible for the racially homogenous developments of *Mitchells Plain* and *Khayelitsha*. At the ending of Apartheid, when movement controls were lifted, thousands of people migrated from rural areas causing the rapid development of informal settlements. This has resulted in a CBD that has a globally spatially isolated and inaccessible location. More problematically, organic land-use development was restricted by Apartheid planning and enforced a mono-centric city form. There is a misalignment between land use patterns and spatial structure; on a global scale Cape Town does not follow Hillier's (1996) *Theory of the Movement Economy*.

The statistical analysis has shown that the geography of Race and Income is encoded in the spatial structure. The best predictors for Mean Income are the percentage of White people in a neighbourhood and Mean NAIN Rn value. In stark contrast, Mean Income, negatively correlated with Black and Coloured population groups, with the strongest negative correlation in predominantly Coloured areas. This provides evidence that race and economic distribution are deeply entrenched in Cape Town's Street network.

Chapter Five

A comparative analysis of neighbourhoods of residential homogeneity and heterogeneity

5.1 Introduction

In order to evaluate if there is a relationship between the spatial configuration of Cape Town and residentially racially integrated neighbourhoods it is necessary to select a compendium of neighbourhood case studies. Whilst the global analysis conducted in Chapter 4 has provided an overarching view, an analysis of the internal structure of the local neighbourhood will allow for a more nuanced understanding of the internal dynamics and factors which may be contributing to the emergence of residential racial integration. South African National Census data (2011) will be used to derive the demographic racial composition of every neighbourhood and the *Neighbourhood Diversity Index* (*ND Index*) subsequently applied as a measure for demographic racial integration, which will form a basis for the case study selection. The primary question that will be addressed in this chapter is: what is the relationship between the spatial morphological structure of Cape Town and demographically residentially racially integrated neighbourhoods?

The approach is focused on specific spatial morphological characteristics which previous research, referred to in the *Literature Review*, has suggested may have a relationship with demographic racial integration and multi-racial co-presence. The factors examined are, Integration and Choice measures of the street network, analysis of local barriers to access, land-use composition and public transport accessibility. These factors will then be evaluated for statistical testing. They also have the advantage of being constructed from readily available data sets provided by the *City of Cape Town's Open Data Portal*. It was established in the previous chapter that the morphology of most neighbourhoods in Cape Town was strongly influenced by clear urban delineation, deeming the neighbourhood to be an appropriate unit of analysis.

5.2 Background to case studies

According to the South African National Census (2011), Cape Town's city-wide demographic racial composition is 42% Coloured, 39% Black, 16% White, 2% Other and 1% Indian. In addition, the Census data also provides the racial composition for each individual neighbourhood in Cape Town. This data is then processed to create *Neighbourhood Diversity (ND) Indices* for every neighbourhood, visualised in *Figure 36,* which allows for a comparative measure between the racial composition of the neighbourhood unit and the overall racial composition of the city. The higher the *ND Index* is, the more racially segregated the neighbourhood is and therefore the more the neighbourhood differs from the overall racial composition of Cape Town. Conversely, the lower the *ND Index* is, the more similar the neighbourhood is to the overall racial composition and therefore it is more racially integrated. For the purpose of this study, the *ND Index* has been inverted so that if any positive statistical correlations emerge, they indicate a positive correspondence with racial integration, as opposed to segregation.

The neighbourhoods of *Woodstock*, *Wynberg*, *Maitland, Langa, Nyanga* and *Camps Bay* were selected, the first three possess high inverted *ND Indices*, indicating high demographic racial integration and the last three possess low inverted *ND Indices*, indicating low demographic racial integration. In order to provide the reader with necessary contextual insight, a summary of the historical development and pertinent social statistical data for each of the cases is presented (refer to *Figure 37*).

A historical review reveals that the neighbourhoods of racial integration, emerged organically prior to the 20th Century, whereas the neighbourhoods of racial segregation were founded during the 20th Century. *Wynberg* began as a garrison town in 1795 and *Woodstock* and *Maitland* as neighbourhoods in 1840 and 1862 respectively. *Langa* is the oldest existing Black township in Cape Town, built in 1927 for 5000 Black labourers and designed by the British Architect, Albert John Thompson. Thompson had previously aided in the design of *Letchworth and Hampstead Garden Cities,* whilst employed by Raymond Unwin's office in London (Coetzer, 2013:192). *Nyanga* is the second oldest Black township, founded in 1949 to house the growing Black population in *Langa* (Turok, 2001:2351). *Camps Bay* was developed in the 1970s as an affluent White suburb (Oldfield, 2001:193).

Social statistics derived from Census (2011) data reveals relative consistency between *Woodstock*, *Wynberg* and *Maitland*, summarised in *Figure 37*. Whereas in *Langa*, *Nyanga* and *Camps Bay*, there are vast polarities. For example, *Langa* and *Nyanga* are 99% Black with population sizes of 52401 and 26278 respectively, whereas *Camps Bay* is 78% White and has only 2773 residents.

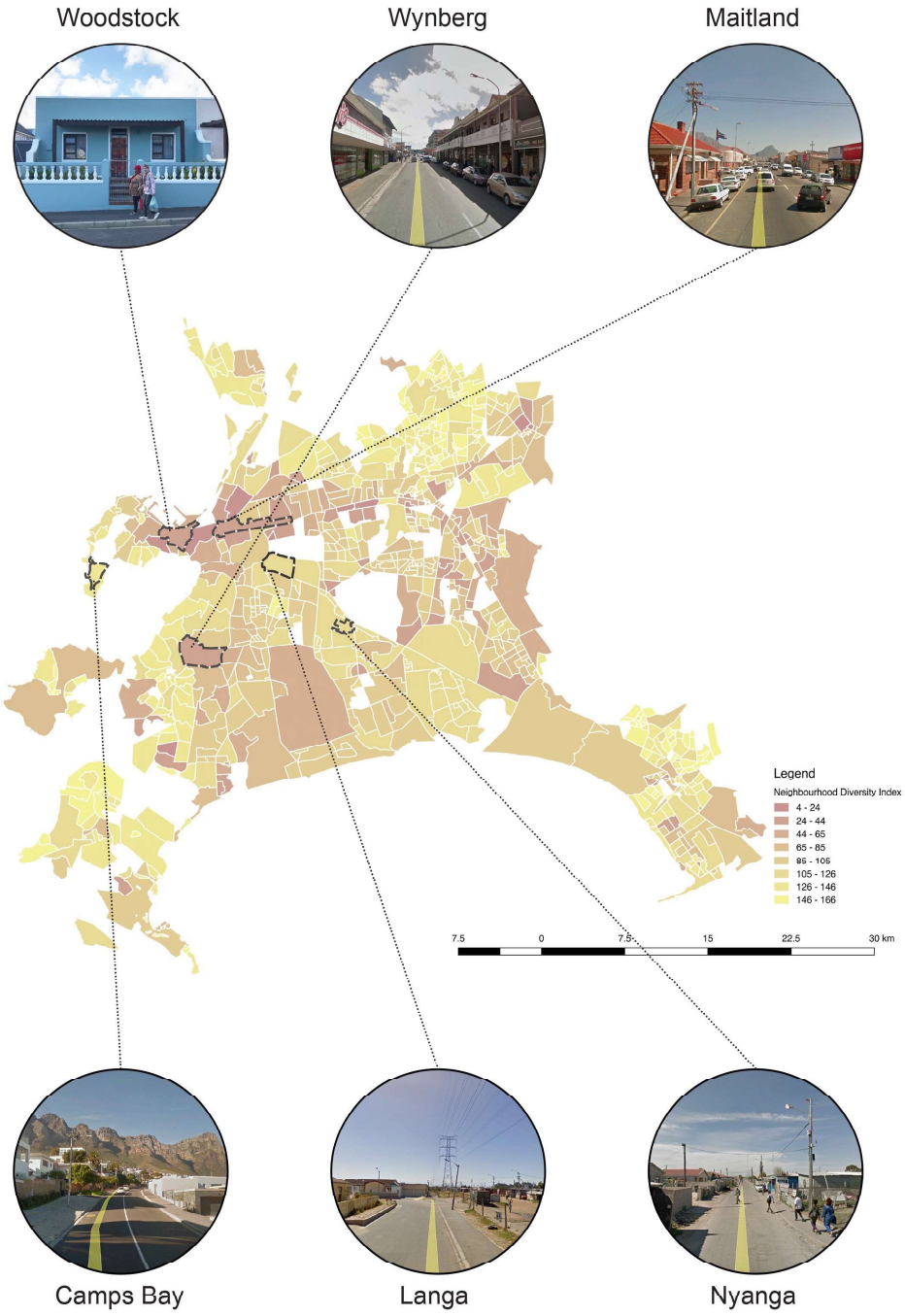


Figure 36: Visualisation of *ND Index* and diagram indicating the locations of selected the case studies
Source: Author and *Google Earth*

Furthermore, the average income of a person residing in *Woodstock, Wynberg* and *Maitland* is R9171, R5853 and R3305 respectively. Whereas, *Langa* and *Nyanga* possess the lowest mean incomes of only R1383 and R967 per person, per month and *Camps Bay* the highest average income of R24238 per person, per month.

	Neighbourhood Diversity Index	Total Population	Mean income	Racial Composition	Racial Zone under Aparheid	Date founded
Woodstock	138	9345	R5853/pp	51% C, 29%B, 12% W, 3% I, 5% O	Never zoned	1840
Wynberg	132	14472	R9171/pp	46% C, 21%B, 24% W, 3% I, 6% O	White	1795
Maitland	140	9782	R3305/pp	50% C, 42%B, 3% W, 2% I, 3% O	Coloured	1862
Langa	46	52401	R1383/pp	99% Black	Black	1927
Nyanga	46	26278	R967/pp	99% Black	Black	1949
Camps Bay	40	2773	R24238/pp	78% White	White	1970's
Cape Town, city-wide averages	61	4501/neighbourhood		42% C, 39%B, 16% W, 1% I, 2% O		1649

Figure 37: Table depicting pertinent background information to neighbourhood case studies
Source: South African Census (2011), visualised by Author

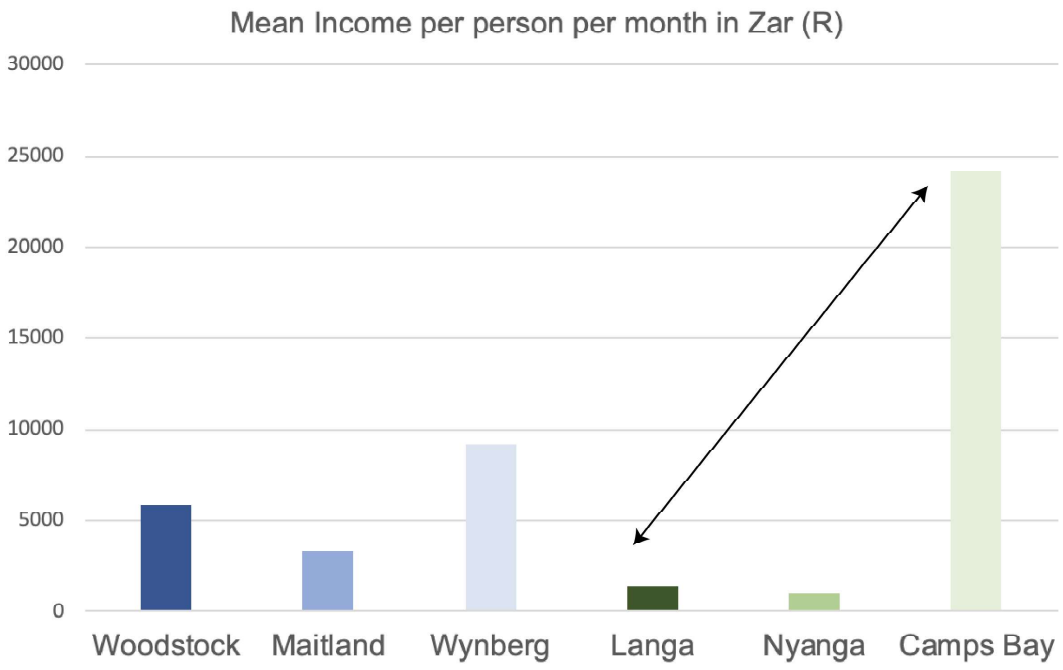


Figure 38: Graph of mean income values, per neighbourhood
Source: *Statistics South Africa*, South African Census (2011), visualised by Author

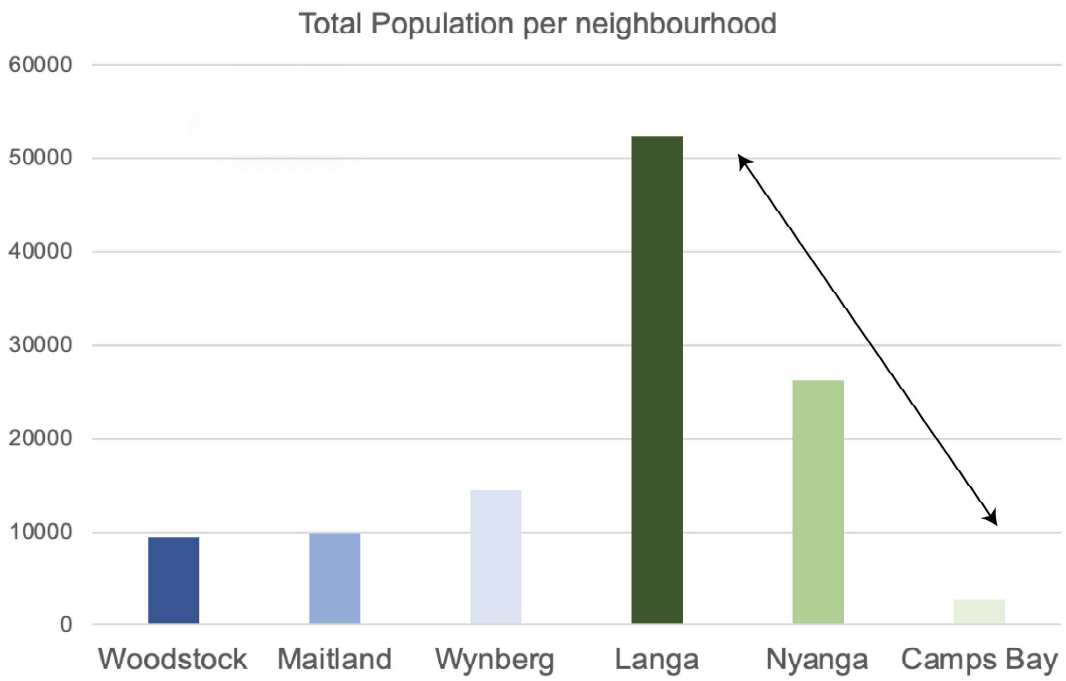


Figure 39: Graph of total population count per neighbourhood
Source: *Statistics South Africa*, South African National Census (2011), visualised by Author

5.3 Angular segment analysis: integration and choice

In order to examine the non-discursive spatial aspects of these settlements, it is necessary to conduct a syntactical analysis. The advantage of the multi-scalar methodology is that it allows for the identification of pervasive centralities, which refers to the function of centrality in cities that pervades the urban grid in a more intricate way than merely a hierarchy of locations but allows for an understanding of multi-scale centrality (Hillier, 2009:6).

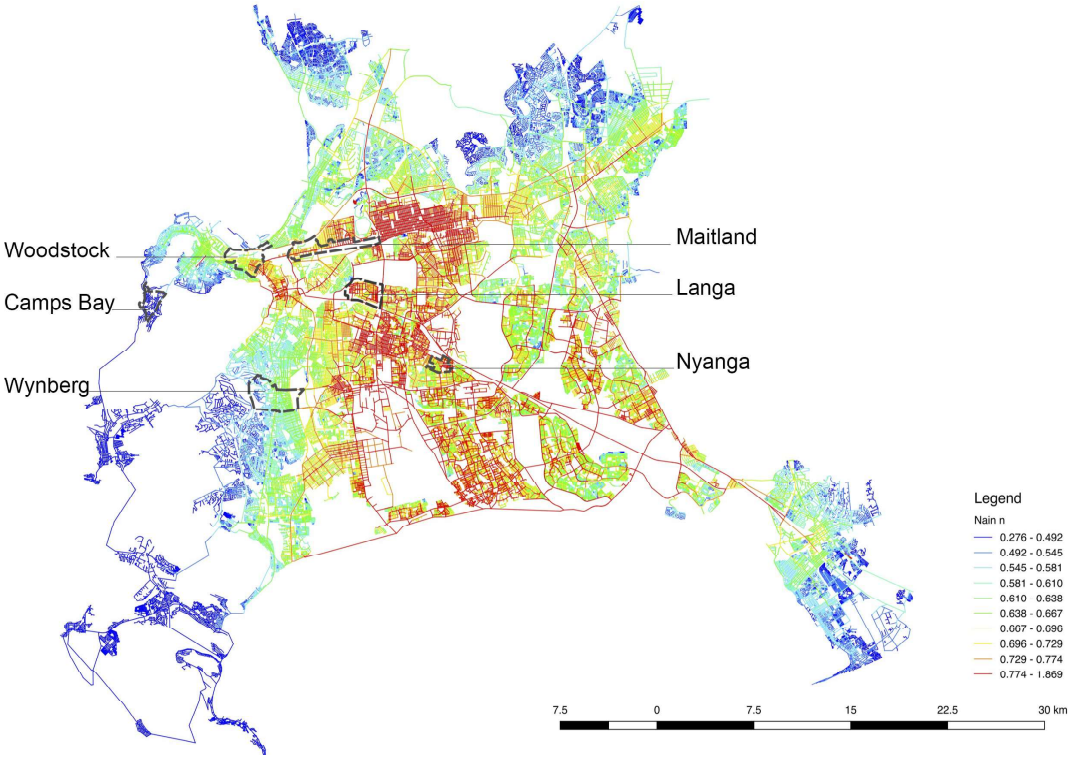
Angular segment analysis is performed to calculate the Normalised Integration (closeness centrality) and Normalised Choice values (betweenness centrality) for the street network in order to identify emergent patterns. The specific radii that were selected for discussion below, were done so on the basis of statistical testing. Bivariate (Pearson) Correlation analysis was used to test the syntactical data against the inverted *ND Index*. The mean values for Normalised Integration (NAIN) and Choice (NACH) of the street network of every single neighbourhood for a multiplicity of radii from 400 m to Radius n, were calculated and statistically tested. It was found that Normalised Integration (NAIN) had significant correlations at all radii, but most strongly at Radius n with a correlation of 0.455**, Radius 10000 with a correlation of 0.347** and Radius 5000, with a correlation of 0.313**. It was found that Normalised Choice (NACH) only had a significant correlation at Radius N of 0.129**.

Inverted ND Index vs NAIN Rn	*0.455***
Inverted ND Index vs NAIN R10000	*0.347***
Inverted ND Index vs NAIN R5000	*0.313***
Inverted ND Index vs NACH Rn	*0.129***

An examination of closeness centrality reveals *Camps Bay* to have a highly isolated structure at all radii, reinforcing the finding in the previous chapter which showed a strong negative correlation between *closeness centrality* and percentage of White people residing in a neighbourhood, refer to *Figure 40*. *Langa* and *Nyanga* at NAIN Rn, possess high closeness centrality being relatively geometrically central. However, they become more isolated at R10000 and R5000, suggesting that local barriers are impacting the attraction qualities of their spatial strcutures. *Maitland*, *Woodstock* and *Wynberg*, whilst possessing moderate closeness centrality at NAIN Rn, gain closeness centrality at NAIN R10000 and even more so at NAIN R5000, emanating from the main streets which continuously connect them to the broader network of Cape Town (visualised in *Figure 41* and *Figure 42)*.

At a global scale of Radius n, all of the neighbourhoods possess at least one strong *through-movement* route (refer to *Figure 43*). The main streets running through *Maitland, Wynberg* and *Woodstock* have the strongest betweeness centrality. The segments with the strongest betweeness centrality in *Langa* and *Nyanga*, connect to the *N2*, an arterial highway, suggesting that *through-movement* in these neighbourhoods is reliant on vehicular transport. The segment with the highest betweeness centrality in *Camps Bay*, is also an arterial vehicular route, again indicating a reliance on the automobile.

In summary, the evidence suggests that highways and vehicular arterial routes are serving as local barriers to access and *to-movement* potential in the neighbourhoods of racial segregation. Whereas, the main streets in *Woodstock, Wynberg* and *Maitland*, are acting as global and local integrators. These local, morphological conditions will subsequently be explored in more detail.



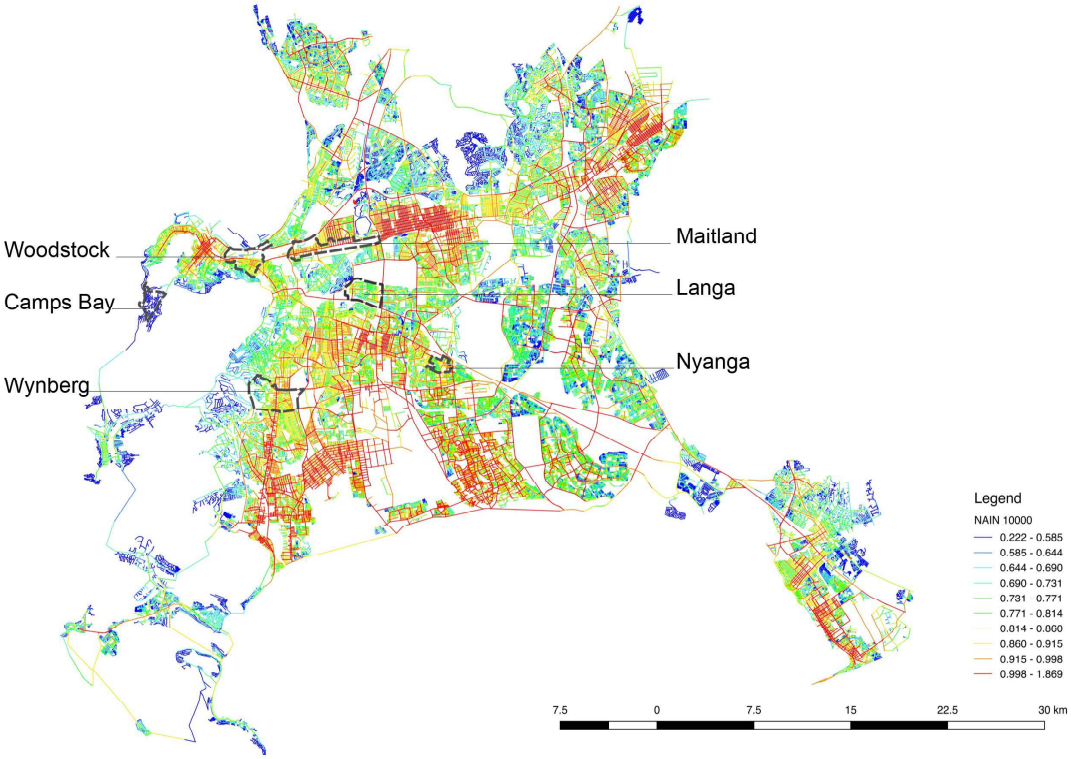


Figure 40: Angular Segment Analysis, Normalised Integration 2016 map of Cape Town at Radius n.
Source: Analysis by Author

Figure 41: Angular Segment Analysis, Normalised Integration 2016 map of Cape Town at R10000m.
Source: Analysis by Author

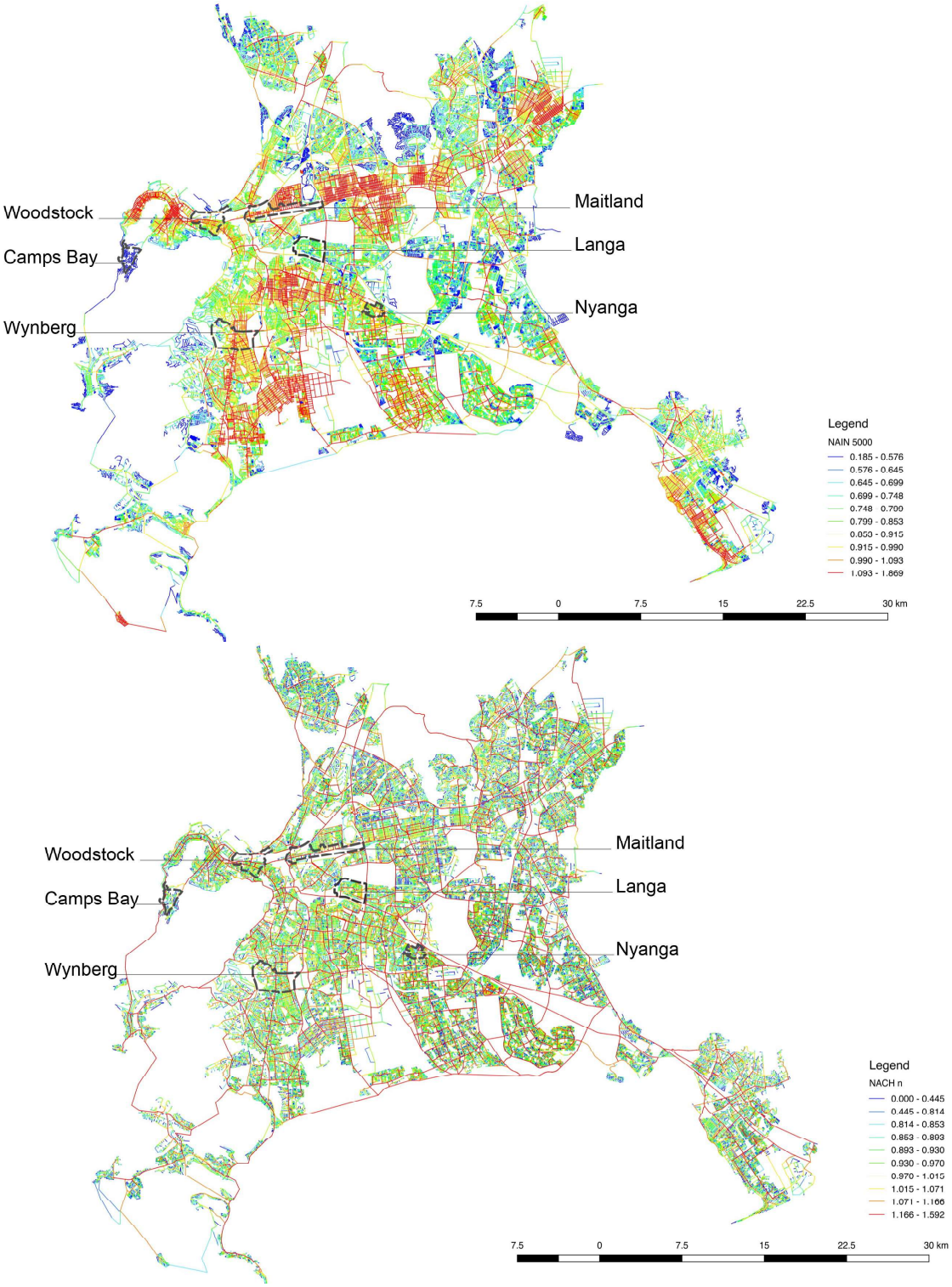


Figure 42: Angular Segment Analysis, Normalised Integration 2016 map of Cape Town at R5000m
Source: Analysis by Author

Figure 43: Angular Segment Analysis, Normalised Choice 2016 map of Cape Town at Radius n
Source: Analysis by Author

5.4 Local morphological barriers to access

The use of buffer zones was established to be key in the formation of the *apartheid city* (Davies, 1981:69). These were to serve not only as spatial boundaries, but to inhibit contact and interaction between racial groups. An examination of local conditions in *Langa* and *Nyanga* reveal that they are cellular agglomerations, confined by cemeteries, highways and industrial infrastructure, refer to *Figure 44*. *Camps Bay* built on the slopes of Table Mountain, whilst less conspicuously contained, is bounded by topography and the coastline.

An examination of *Woodstock, Wynberg* and *Maitland* reveals growth limitations on one axis, by either highways, natural topography or railway infrastructure, but on the opposite axis, they are continuously connected to the broader network by streets. In the case of *Woodstock,* the streets of *Victoria* and *Albert Road,* connect it continuously with the economic centre and towards the northern and southern suburbs, refer to *Figure 44*. In *Wynberg*, *Main Street*, which eventually becomes *Victoria Road*, connects it towards the CBD and Simon's Town. In *Maitland*, *Voortrekker Road* connects directly with the Eastern suburbs and the CBD.

5.5 Land-use analysis

To gain insight into the everyday activities of residents, it is essential to understand the mix and diversity of land-use in each of the neighbourhoods. There is a stark contrast in the land-use zoning of the neighbourhoods of racial homogeneity and heterogeneity. *Woodstock, Wynberg* and *Maitland*, possess significant percentages of mixed and business land-use zoning. *Woodstock* is composed of 29%, *Maitland* 37% and *Wynberg* 14% mixed and business land-use. In comparison, *Langa, Nyanga* and *Camps Bay* are over 95% residential (refer to *Figure 46*). Furthermore *Langa* and *Nyanga* are composed of predominantly incremental housing, which are partially legal structures made of concrete blocks and corrugated iron, an undeniable symptom of the persistence of poverty in these areas.

The results of this analysis are unsurprising as the syntactical analysis previously revealed the strength of *closeness centrality* embedded in the spatial structure of *Maitland, Woodstock* and *Wynberg* at R10000 and R5000. This indicates that land use within these neighbourhoods is following Hillier's (1996) *theory of the movement economy*; micro-economic activities are taking advantage of the high natural movement generated through the spatial composition of the street network.

Figure 44: Analysis of morphological barriers and connectors
Source: *Google Earth,* visualised by Author

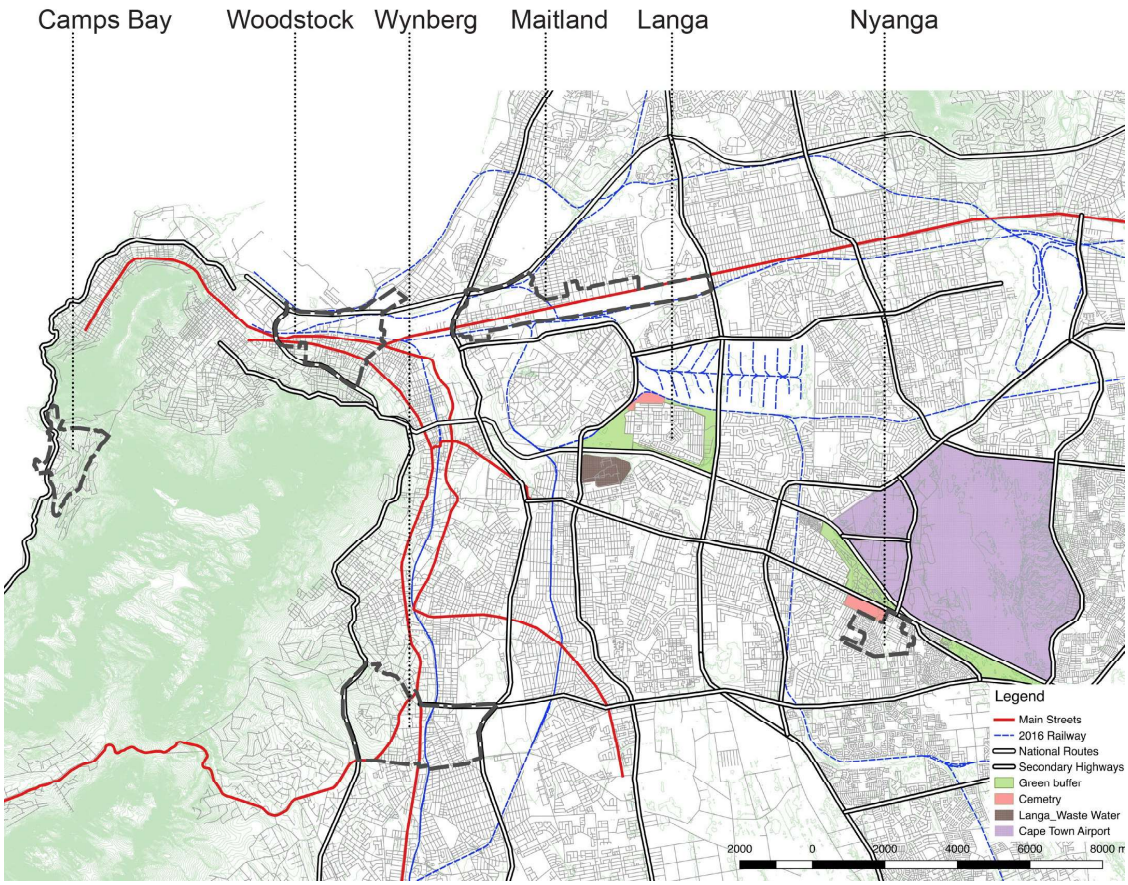


Figure 45: Analysis of morphological barriers and connectors
Source: Diagram by Author

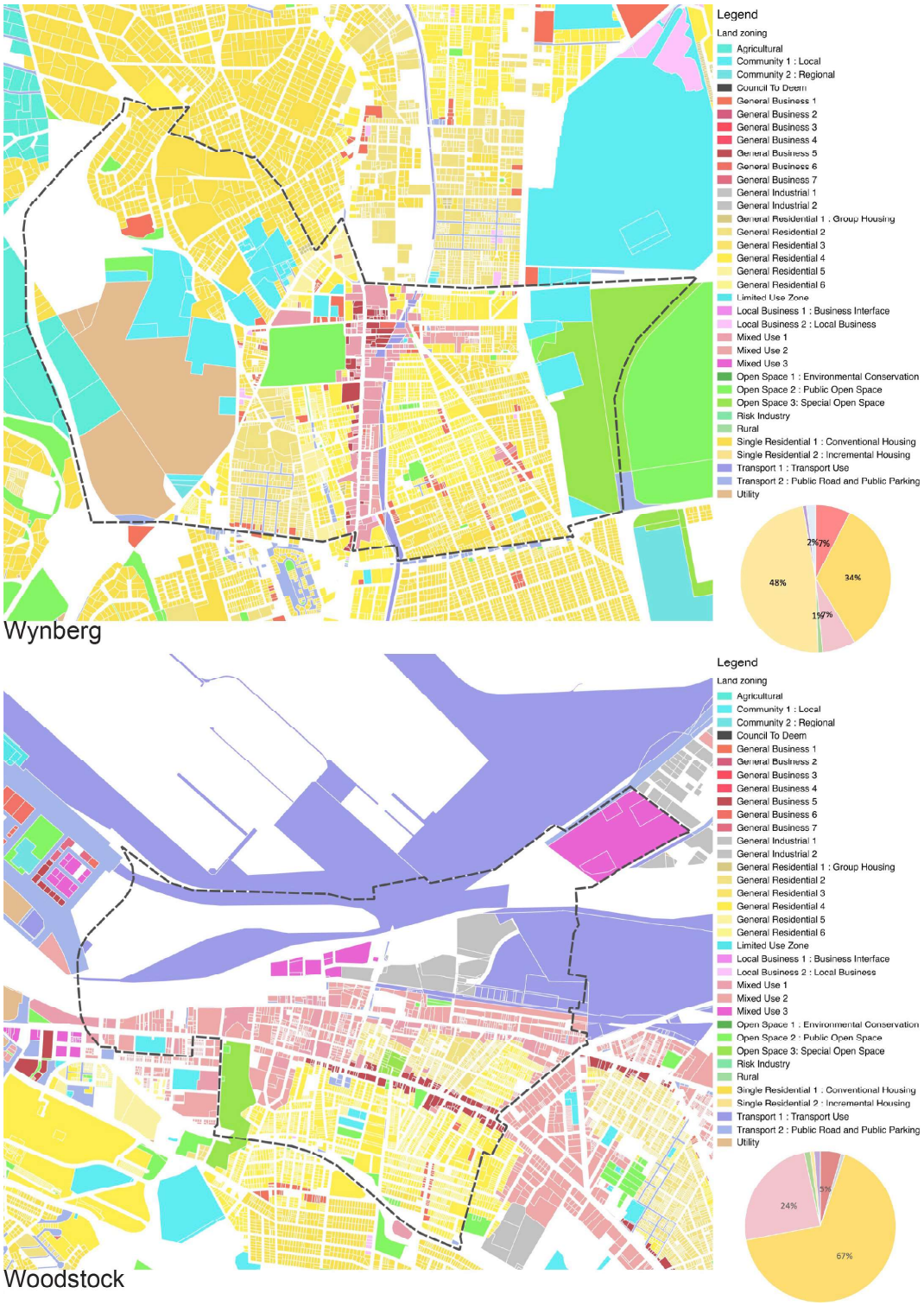


Figure 46: Analysis of land use zoning in *Woodstock* and *Wynberg*
Source: Data derived from *Cape Town's Open Data Portal*, visualised by Author

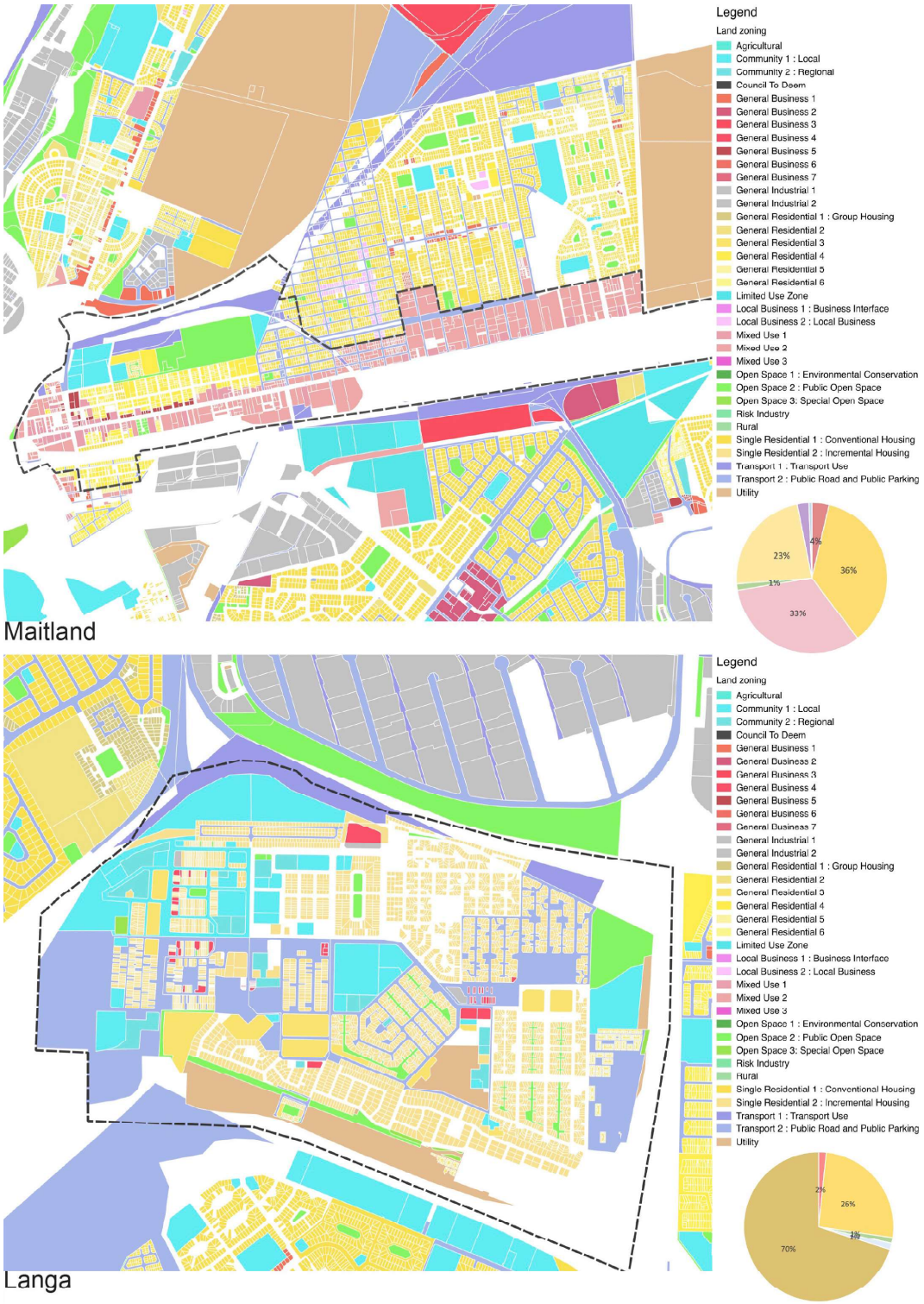


Figure 47: Analysis of land use zoning in *Maitland* and *Langa*
Source: Data derived from *Cape Town's Open Data Portal*, visualised by Author

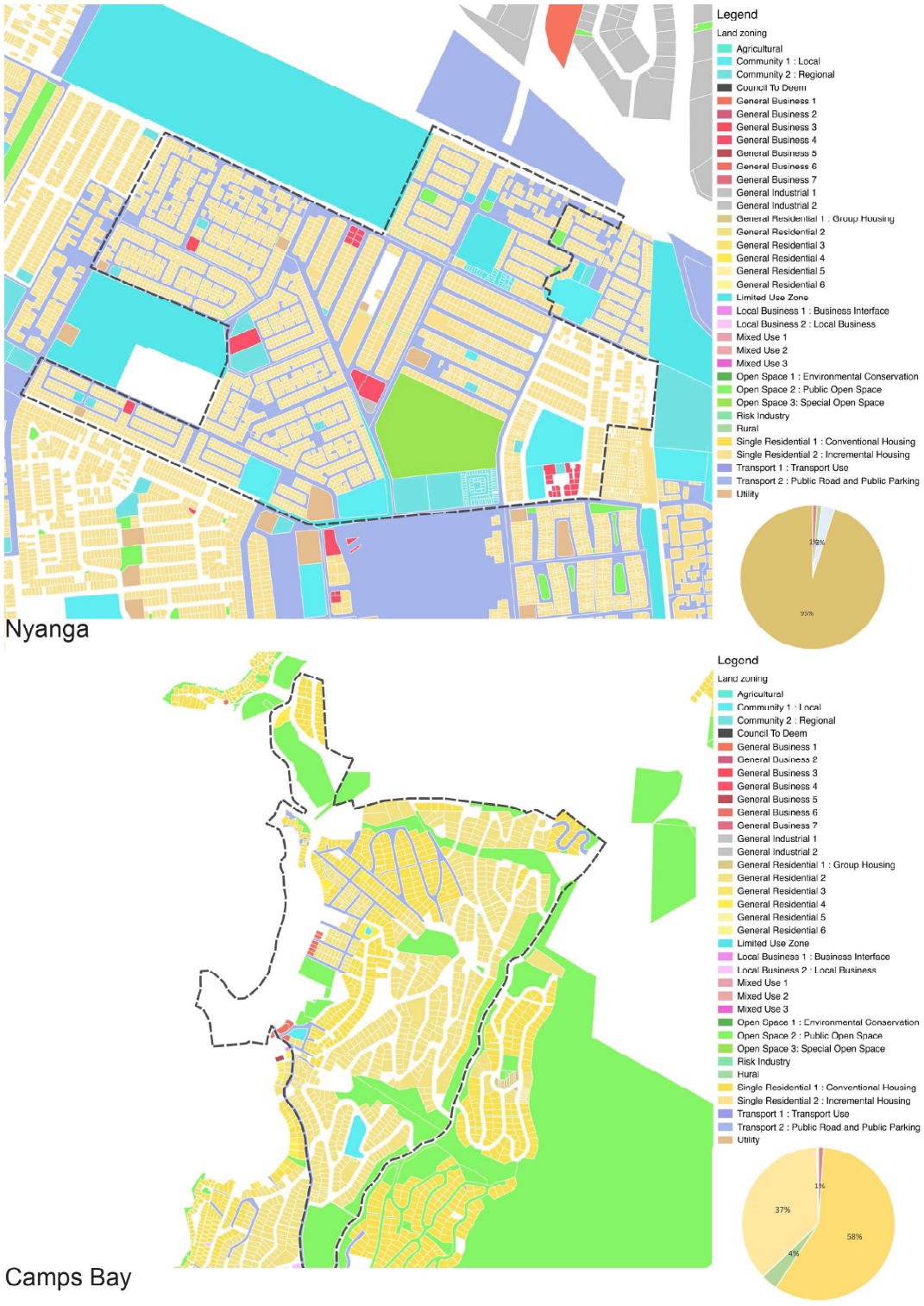


Figure 48: Analysis of land use zoning in *Nyanga* and *Camps Bay*
Source: Data derived from *Cape Town's Open Data Portal*, visualised by Author

5.6 Transport accessibility

Access to transportation will influence not only how residents access the broader city, but to what extent their neighbourhoods are accessible to the wider population of Cape Town.

This simple quantification of mobility infrastructure, depicted in *Figure 49*, has shown that *Woodstock, Wynberg* and *Maitland* have access to the railway network with at least two stations each. Comparatively, *Langa* is the only case study of racial segregation that has access with one railway station. The quantification of Myciti BRT stops revealed that *Camps Bay* possesses the highest frequency of stops with a total of fifty-one, this is a bit incongruous considering it has the smallest population. *Woodstock* has thirty-one stops and *Maitland* six. *Langa*, *Nyanga* and *Wynberg* have no access to the Myciti BRT system. According to data provided by *Whereismytransport*, all of the neighbourhoods are serviced by the paratransit minibus taxi, with the highest frequencies of stops being in *Wynberg*, *Woodstock* and *Maitland*.

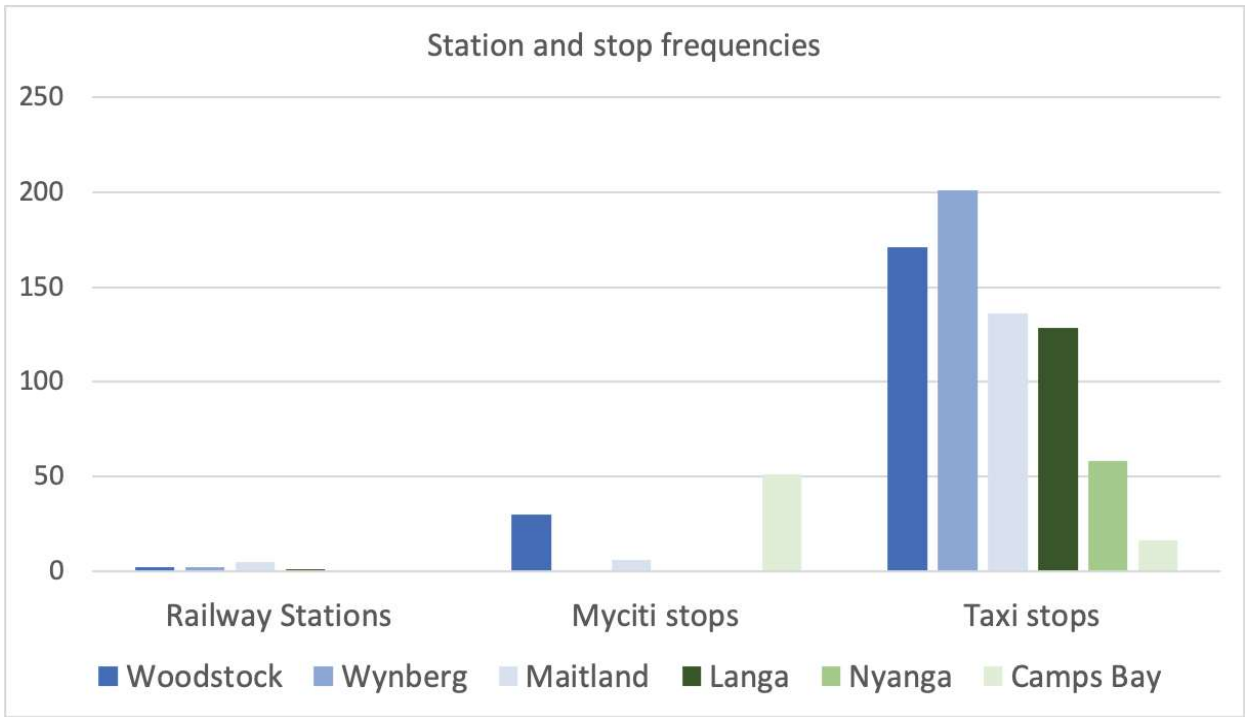


Figure 49: Analysis of access to transport through station and stop frequencies
Source: Data derived from *Cape Town's Open Data Portal* and *Whereismytransport*, visualised by Author

5.7 Statistical testing

In order to assess the strength of relationships between the variables discussed and residential neighbourhood integration, each of the variables is tested using Bivariate (Pearson) Correlation analysis against the *ND Index*.

A summary of the statistically significant correlations are presented below. As previously stated, the highest correlation between the inverse *ND Index* and closeness centrality was with NAIN Rn and the only significant correlation with betweenness centrality was with NACH Rn. There is an inverse correlation between the inverse *ND Index* and mean income per neighbourhood, of -0.5**, suggesting that neighbourhood integration decreases as the average income increases. There is also an inverse relationship between the percentage of Residential land use zoning against the inverse *ND Index*, of -0.337**, indicating a moderate relationship between an increase in non-residential activity and racial heterogeneity. There were no significant correlations between the Myciti bus stop frequencies and the inverse *ND Index*, but there were almost identical correlations between the frequency of railway stations and the frequency of minibus taxi stops against the inverse *ND Index*.

Inverted ND Index vs NAIN Rn	*0.455***
Inverted ND Index vs NAIN R10000	*0.347***
Inverted ND Index vs NAIN R5000	*0.313***
Inverted ND Index vs NACH Rn	*0.129***
Inverted ND Index vs Residential % :	*- 0.337***
Inverted ND Index vs. Mean Income :	*- 0.5***
Inverted ND Index vs. Railway station:	*0.215***
Inverted ND Index vs.Taxi stop count:	*0.216***

A multiple linear regression model was constructed. The coefficient of determination (R^2) is an indication of how well the model accounts for the variability in the data, where the value closer to 1 is indicative of a good model fit. The model which gave the highest R^2 value is summarised below, showing that almost 40% of residential racial integration can be attributed to these values.

Dependent Variable:	Inverse ND Index	
Independent Variables:	Mean NAIN Rn	*0.49***

Mean Income	*- 0.5***
Residential %	*- 0.337***
Taxi Count	*0.215***
R^2:	*0.39*

5.8 Discussion

Apartheid planning is embedded in the spatial structure of Cape Town, however it is a city which is in transformation. Racial heterogeneity is slowly emerging and this research has by no means meant to suggest that it is an exact science. The evidence, however, does indicate a relationship between local accessibility, connectivity and residential racial heterogeneity. It has shown that spatial isolation does correspond with racial homogeneity; barriers to access are imposed by local physical boundaries and enforce a reliance on vehicular movement. Furthermore it reinforces Hillier and Hanson's (1987:251) research which advocated that non-correspondence systems have a robustness that highly structured systems lack. Perhaps by virtue of the neighbourhoods of racial integration developing organically prior to the 20th Century they are connected to the broader spatial network through continuously connected streets, as opposed to highways, generating a non-correspondence model of racial heterogeneity. The streets possess strong closeness and betweenness centrality and are embodied social spaces, allowing for pedestrian movement and micro-economic activity, which corresponds to Hillier's (1996) *theory of the movement economy*. The statistical analysis has shown that almost 40% residential racial integration can be accounted for by non-residential land-use, mean income, frequency of minibus taxi stops and mean NAIN measures. Whilst the city is only experiencing residential demographic racial integration on a small scale, it does suggest that if these urban morphological factors are prioritised, it could aid in the development of this social phenomenon.

Another aspect of racial heterogeneity is the everyday multi-racial co-presence achieved through mobility, which would allow for a process of cross-pollination between residential neighbourhoods. This requires further understanding and will be analysed in the next chapter, with a particular emphasis on minibus taxi, which was found to serve all the neighbourhood case studies to the highest degree.

Chapter Six

Transport as an integrator: the minibus taxi industry

6.1 Introduction

The urban morphological assessment of Cape Town's development in Chapter 4 confirmed it to be predominantly composed of clearly delineated neighbourhood agglomerations of racial and economic homogeneity. However, the more local analysis in Chapter 5, identified neighbourhoods of demographic racial heterogeneity and a series of relational spatial characteristics. In this context, another under-researched aspect of racial heterogeneity, is the everyday multi-racial co-presence achieved through mobility, which could allow for a process of cross-pollination of different racial groups between neighbourhoods. Previous studies have shown how access to mobility can be imperative in overcoming social, ethnic and economic exclusion and segregation in cities (Legeby, 2013, Vaughan and Rokem, 2018, Gambill, 2018).

The aim of this chapter is to analyse to what extent the accessibility network of the minibus taxi (taxi) system may be supporting the emergence of multi-racial co-presence. In order to do this, its operational capacity is firstly compared with the railway and Myciti Bus Rapid Transport (BRT) systems through catchment analysis of a ten minute walking distance (800 m) from the stops and stations on the street network. Secondly, a statistical analysis is employed to quantify relations between transport and social variables. Thirdly, the taxi system is analysed at the scale of the neighbourhood, to gain insight into its affinity with local socio-spatial ecologies. The main question addressed in this chapter is: does informal transport, as opposed to formal transport, as a bottom-up response to the general top-down planning of South African cities possess a generative relationship with demographic racial heterogeneity in Cape Town?

6.2 Background

To understand the nature of the paratransit minibus taxi (taxi) system, it is necessary to unpack its organisational structure. The organisational structure of the taxi system is relatively complex and hierarchical, refer to *Figure 50*. The user pays the fare to the driver of the taxi vehicle. In

most instances, the driver does not own the vehicle, but is paid an hourly fee or a fee based on commission by the owner of the vehicle. The owner of the vehicle may own one, two or a fleet of taxis. The owner receives all of the fares but is responsible for the maintenance of the vehicle and has to legally belong and pay fees to a taxi association, which can be in the region of R50000-R80000 for a once off joining fee (Kerr, 2017:6). There are 102 separate taxi associations in Cape Town (*Operating License Strategy Report*, 2014:4). A taxi association is responsible for one or a number of taxi ranks, which are taxi interchanges, in which multiple routes converge and interchange. The taxi associations apply and pay for *Operating Licences* from the Provincial Government, which are granted to them for a period of ten years, which they distribute to the taxi owners, allowing them to legally operate on specific routes. Whilst the Provincial Government grants *Operating Licenses* for specific routes, the routes are specified by the taxi association in response to user demand, making it an incredibly demand-responsive and flexible system, which can easily expand, as opposed to government deciding on the routes themselves. Governing bodies of the taxi associations include *SANTACO* on a national level and the *Western Cape Regional Taxi Council* on a provincial level. Bruun, Del Mistro, Venter and Mfinanage (2016:33) note various operational and management deficiencies of the taxi system. Firstly they note the unreliability of the system, due to it operating without separate lanes or signal priority in mixed traffic. Secondly they state that users are reluctant to make connections due to taxi fares not being integrated. Finally, they critique the taxi system for stopping at what they believe to be random locations on roads, becoming safety hazards and causing delays.

The railway system which was first implemented in the 19th Century has experienced rapid decline since the 1990s, due to underinvestment and vandalism (Bruun, Del Mistro, Ventre and Mfinanga, 2016:29). The Myciti Bus Rapid Transport (BRT) system was implemented in Cape Town in 2011, with more routes opened in 2013. The implementation of the system was inspired by the successes of BRT systems in Latin America (Behrens, Ferro, 2019:99). The BRT has physically separated lanes to prevent congestion and delays, pre-boarding fare controls and level boardings to minimise dwell times at trunk stations and branded feeder and trunk services with integrated ticketing to facilitate seamless bus transfers within a “closed system” (Schalekamp, Golub, Behrens, 2016:111). The BRT was initially envisioned to be implemented in a series of phases and eventually replace paratransit services on specific routes. (Schalekamp and McLachlan, 2016:181). However, only phase 1a has been implemented.

COUNCILS/ UNIONS ⟷ **TAXI ASSOCIATION** ⟷ **GOVERNMENT**

SANTACO

- Governs all associations in the country

Western Cape Regional Taxi Council

- Governs all associations in the province

- Manage specific Taxi Ranks
- Determines and "owns" specific routes
- Possess operating licences which are granted to taxi owners
- Set fare prices

Taxi Owner

- Owns Vehicle
- Responsible for vehicle maintenance
- Granted Operating License from Taxi Association
- Pays fees to Taxi Association
- Receives fares

Taxi Driver

- Collects Fares
- Paid a wage/ commission

User

- Pays Fare

National Goverment

- National Policy

Provincial Goverment

- Grants OR License

Figure 50: Organisational structure of paratransit minibus taxi system
Source: Diagram by Author

Figure 51: Train, minibus taxi and Myciti BRT bus
Source: Diagram by Author

6.3 City-wide analysis

According to data obtained from the *City of Cape Town's Open Data Portal*, the railway system has 92 stations and 6 separate lines. The railway predominantly follows the development of the city along *Voortrekker* and *Main Road*. The highest frequency of stations is along *Main Road*, connecting the CBD to the historically affluent southern suburbs and the seaside towns of *Kalk Bay*, *Fish Hoek* and *Simon's Town*. The catchment analysis of stations along *Main Road*, shown in *Figure 54*, shows a relatively complete and connected network of catchment. In comparison, the catchment analysis of the shorter and newer line, which connects the historically Black and Coloured suburbs of *Langa, Manenburg*, *Mitchells Plain* and *Khayelitsha*, shows a disconnected and fragmented network. This is indicative of the fragmented morphology of these neighbourhoods, but also suggests that there are an inadequate number of stations and that they have been badly positioned. The catchment analysis of all stations is displayed in *Figure 54* and reveals that only 8% of Cape Town's street network is within walking distance of a railway station.

According to data obtained from the *City of Cape Town's Open Data Portal*, the BRT has 1810 stops and 131 different routes. As can be seen in *Figure 55*, the routes and bus stops are predominantly clustered in the CBD and the northern suburbs towards *Table View*. The catchments reveal a vast disconnect on the routes which connect *Khayelitsha* and *Mitchells Plain* with the City Centre. Many neighbourhoods which could be served by the BRT are bypassed, such as *Gugulethu*, *Langa* and *Athlone*. According to the catchment analysis depicted in *Figure 57*, only 14% of Cape Town's Street network is in walking distance of a BRT stop.

According to primary data collected by the company, *Whereismytransport*, the taxi system possesses over 639 different routes, 67 taxi ranks and 8943 stops, as can be seen in *Figure 58*. Although the *N1*, serves as a major trunk route for the taxis, it has almost no stops along it, showing that it offers little opportunity for co-presence or pedestrian activity. *Voortrekker* and *Main Road*, in comparison, possess hundreds of stops, indicating continuous activity and thus greater potential for multi-racial co-presence. The catchment analysis, reveals that 60% of Cape Town's Street network is within walking distance of a taxi stop (*Figure 60*). The operational capacity of the taxi-system is far greater than the BRT or railway systems, having a network catchment over 4 times more than the BRT network and over 7 times more than the railway.

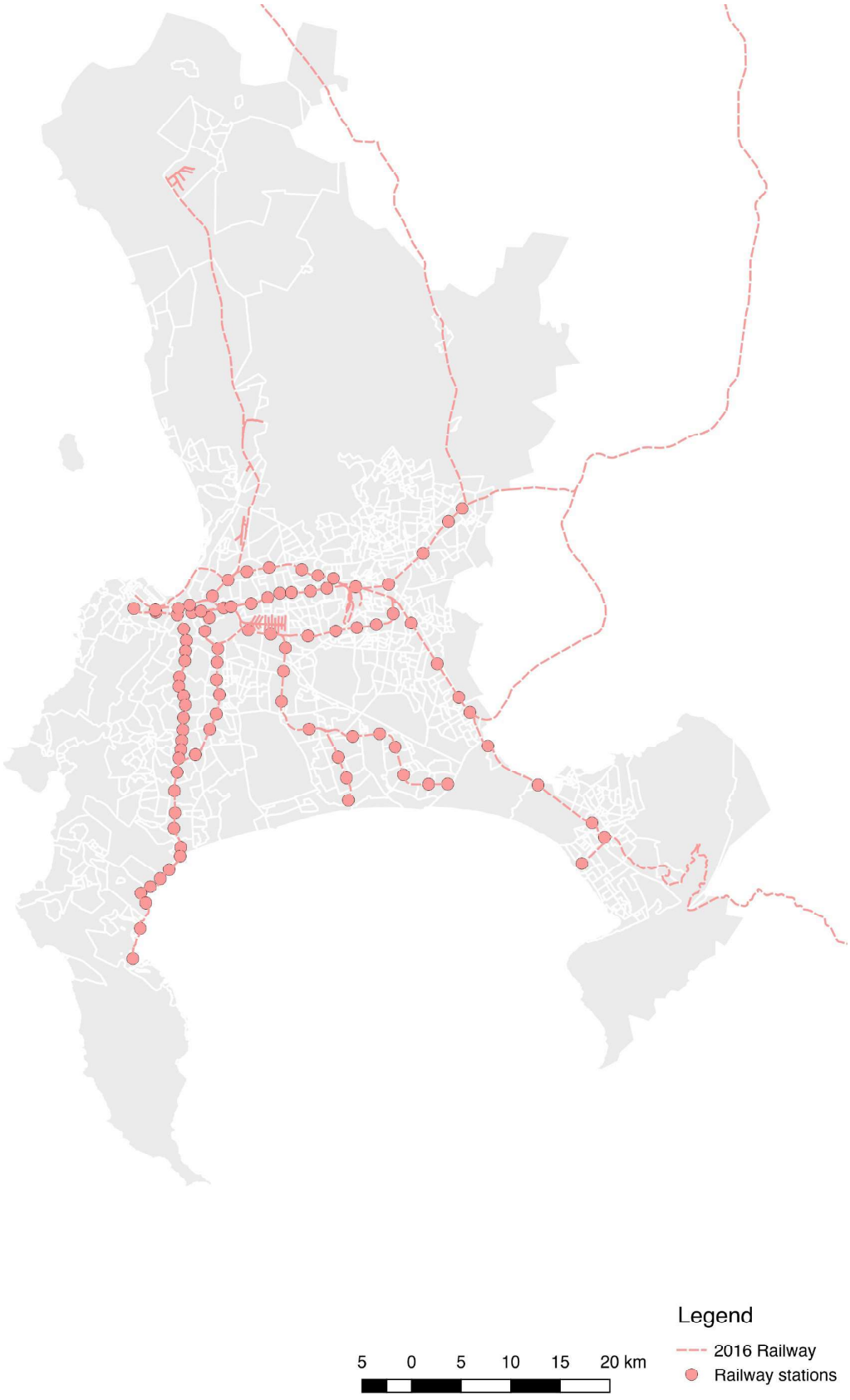


Figure 52: The 2016 Railway network
Source: *Cape Town Open Data Portal*, visualisation by Author

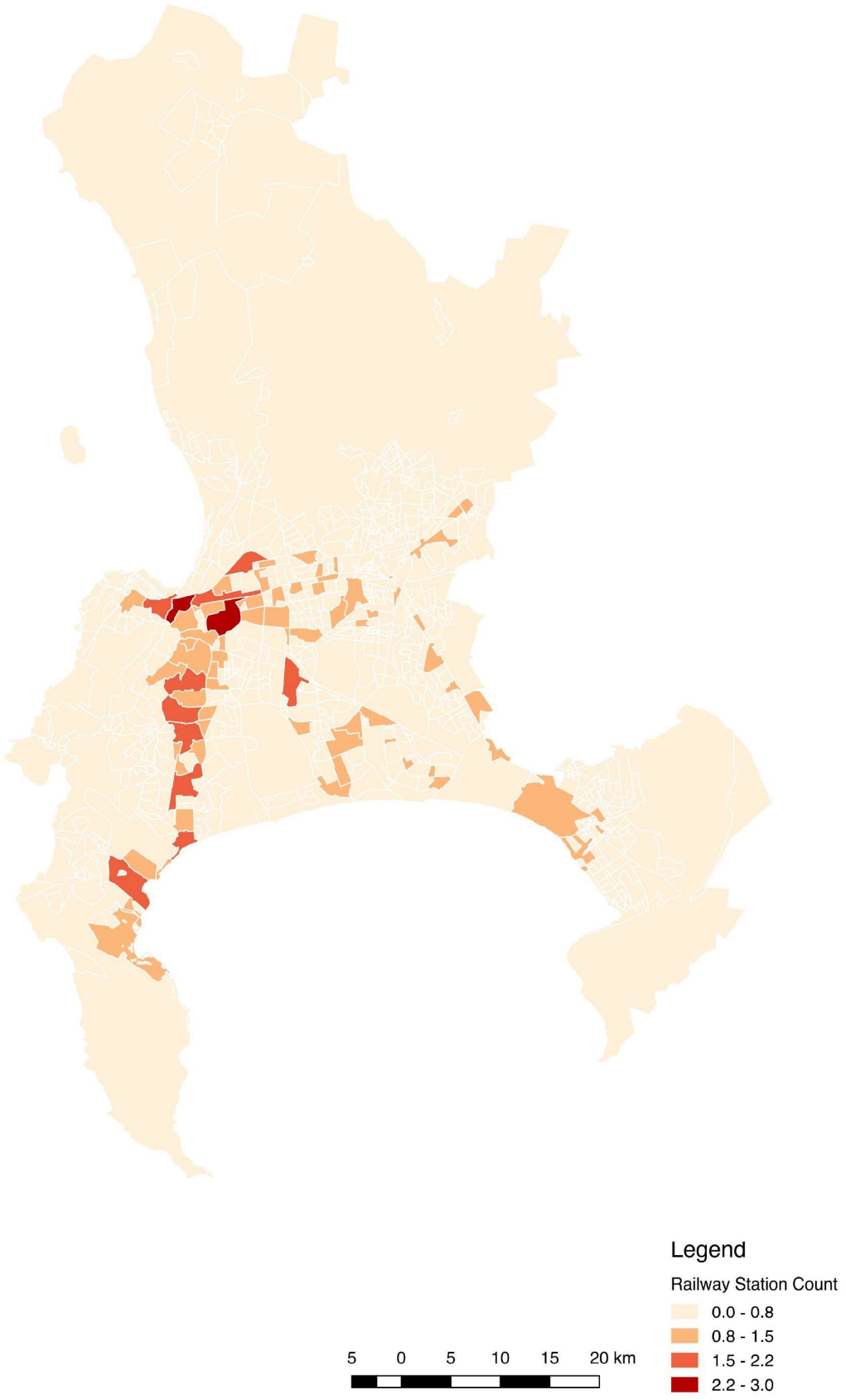


Figure 53: Railway station count per neighbourhood in Cape Town
Source: Analysis by Author

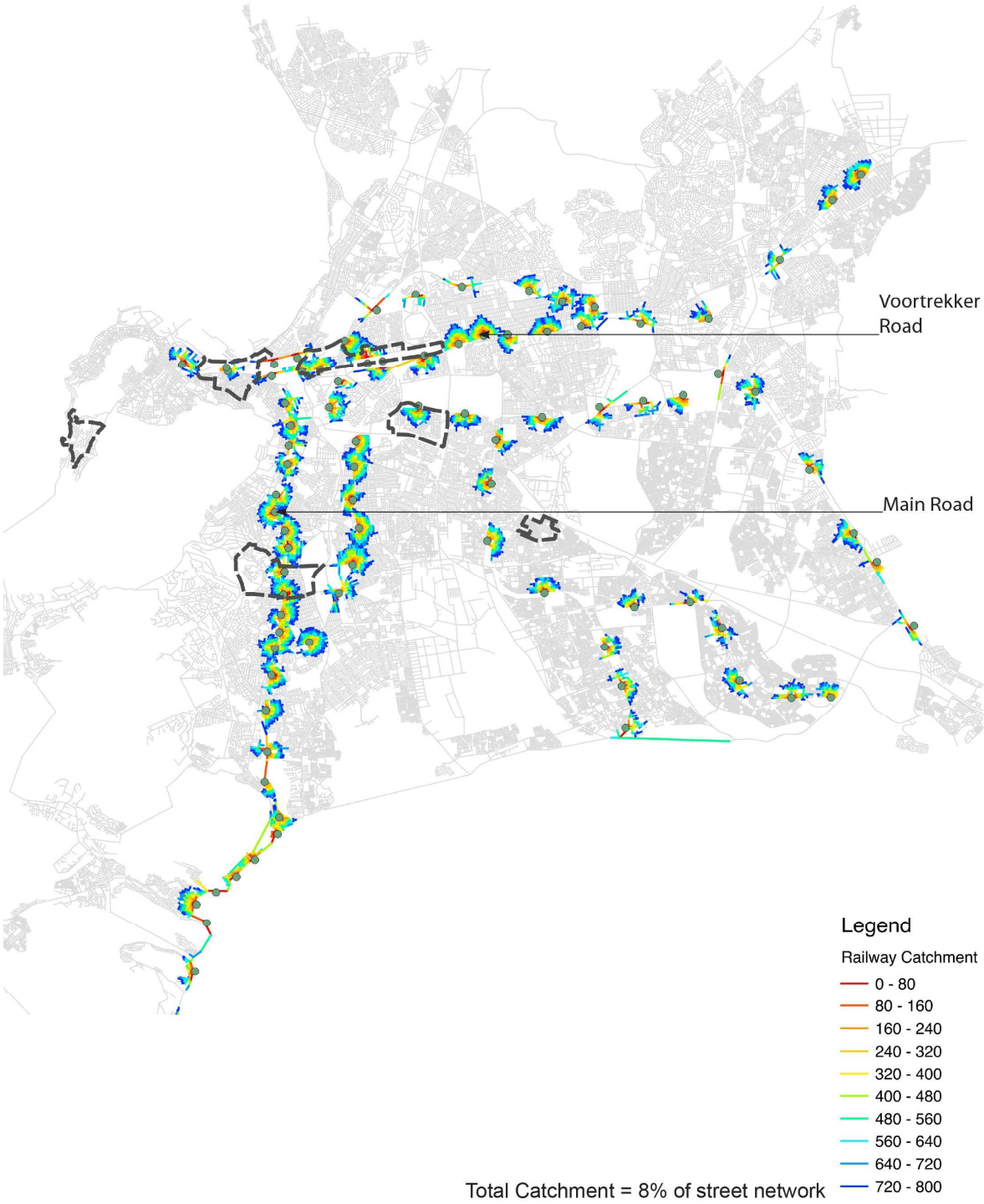


Figure 54: Catchment analysis of every railway station of a ten-minute walking distance (800 m)
Source: Analysis by Author

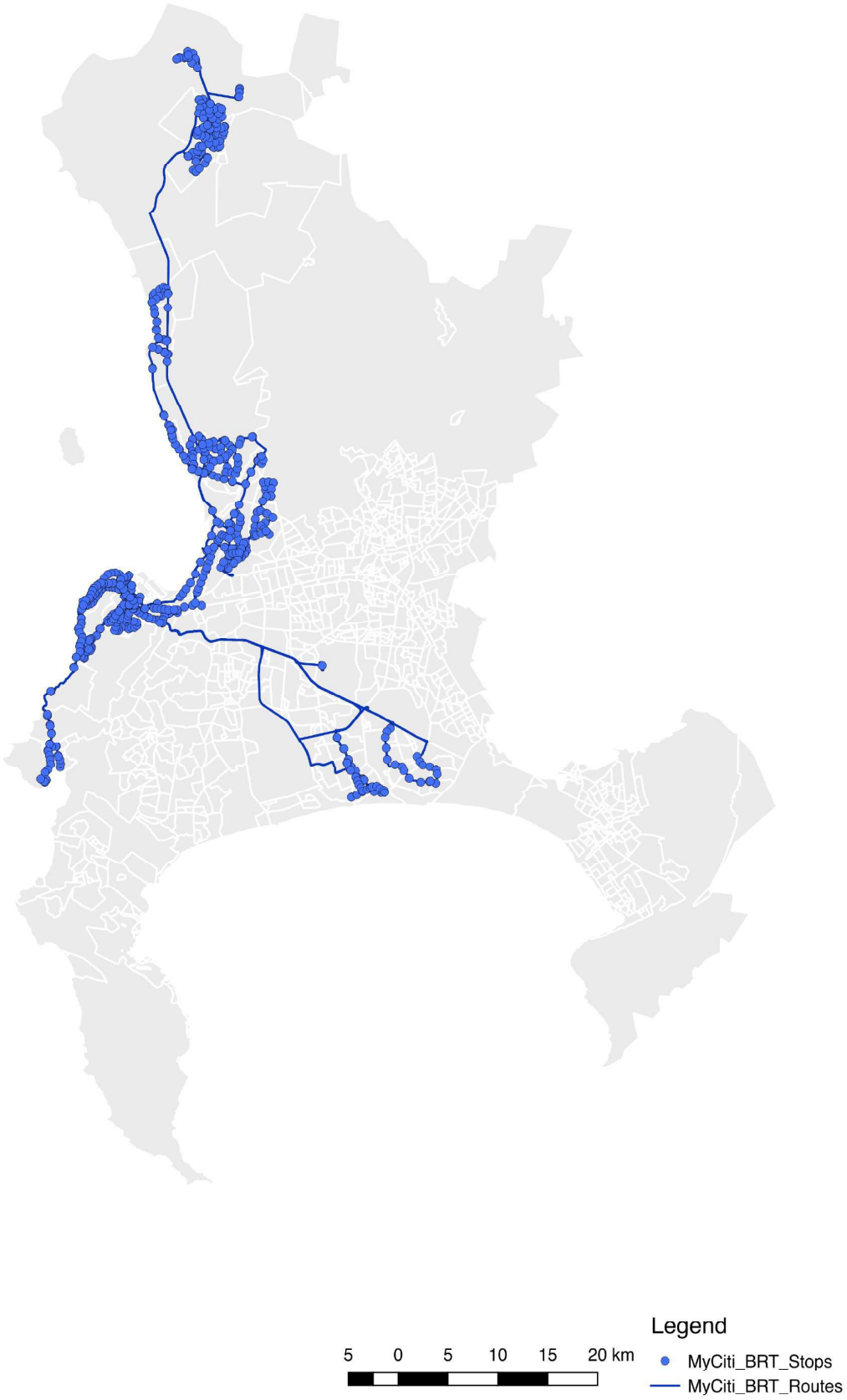


Figure 55: Myciti BRT routes and stops
Source: Cape Town Open Data Portal, visualisation by Author

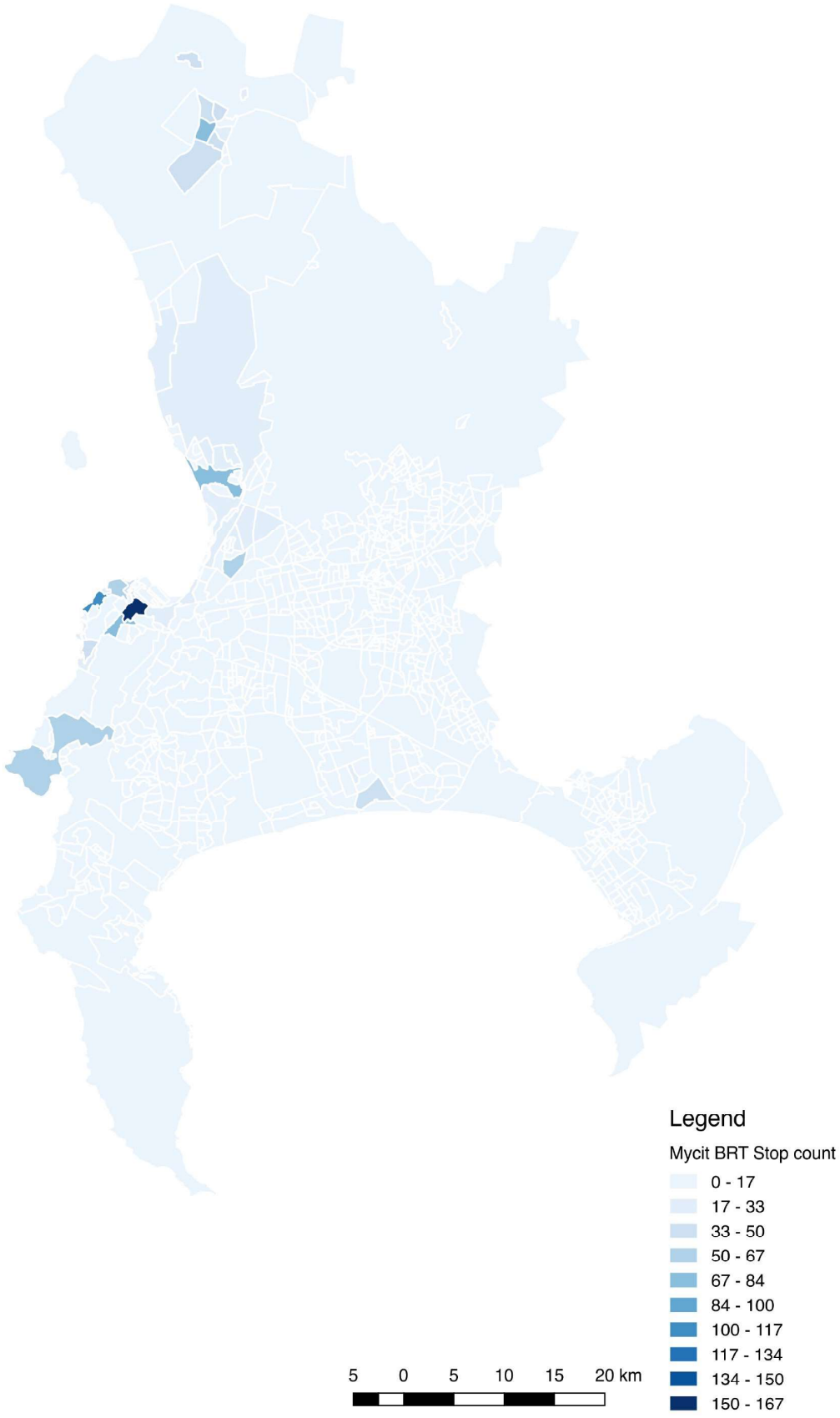


Figure 56: Myciti BRT stop count per neighbourhood in Cape Town
Source: Analysis by Author

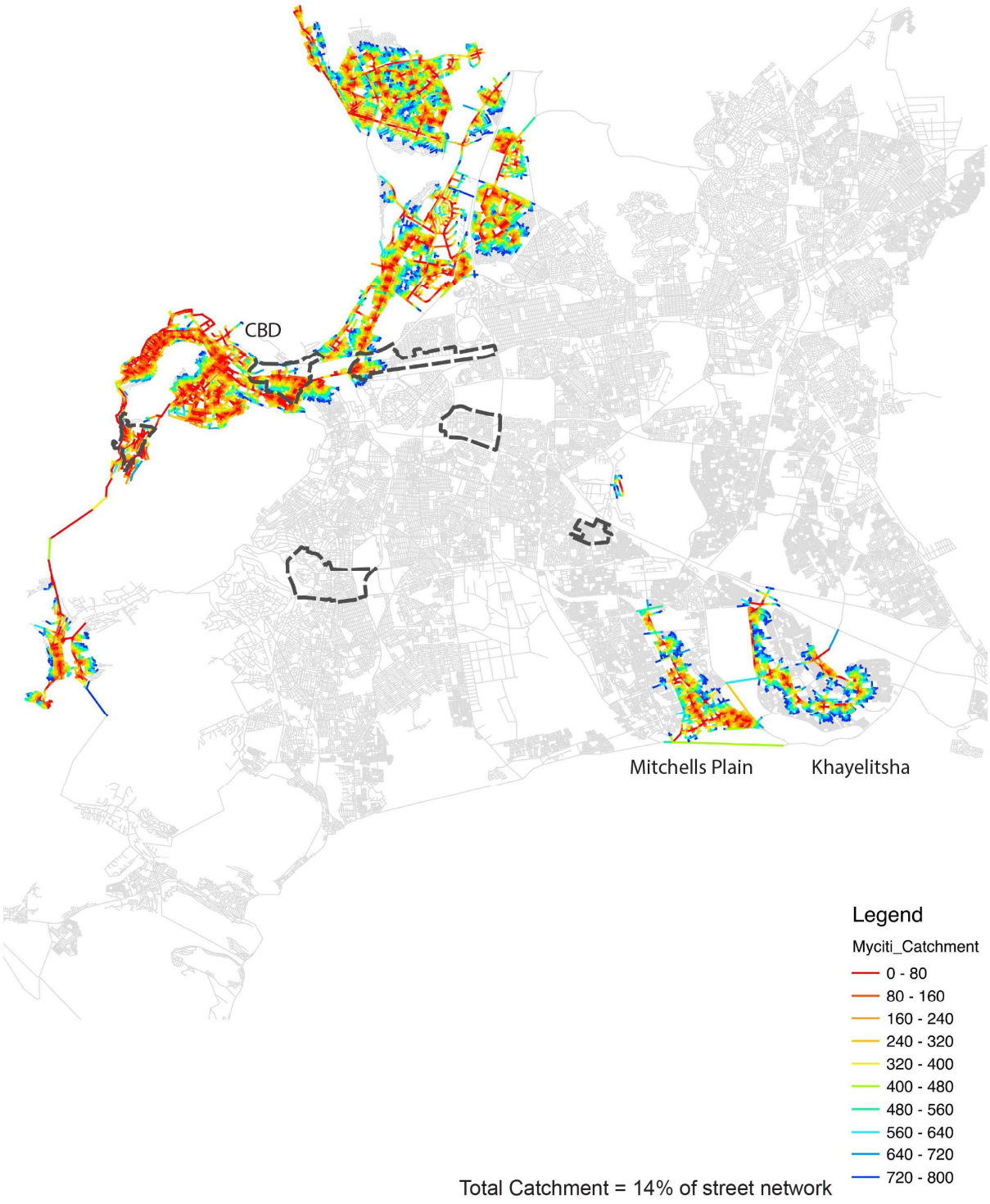


Figure 57: Catchment analysis of every Myciti BRT stop of a ten-minute walking distance (800 m)
Source: Analysis by Author

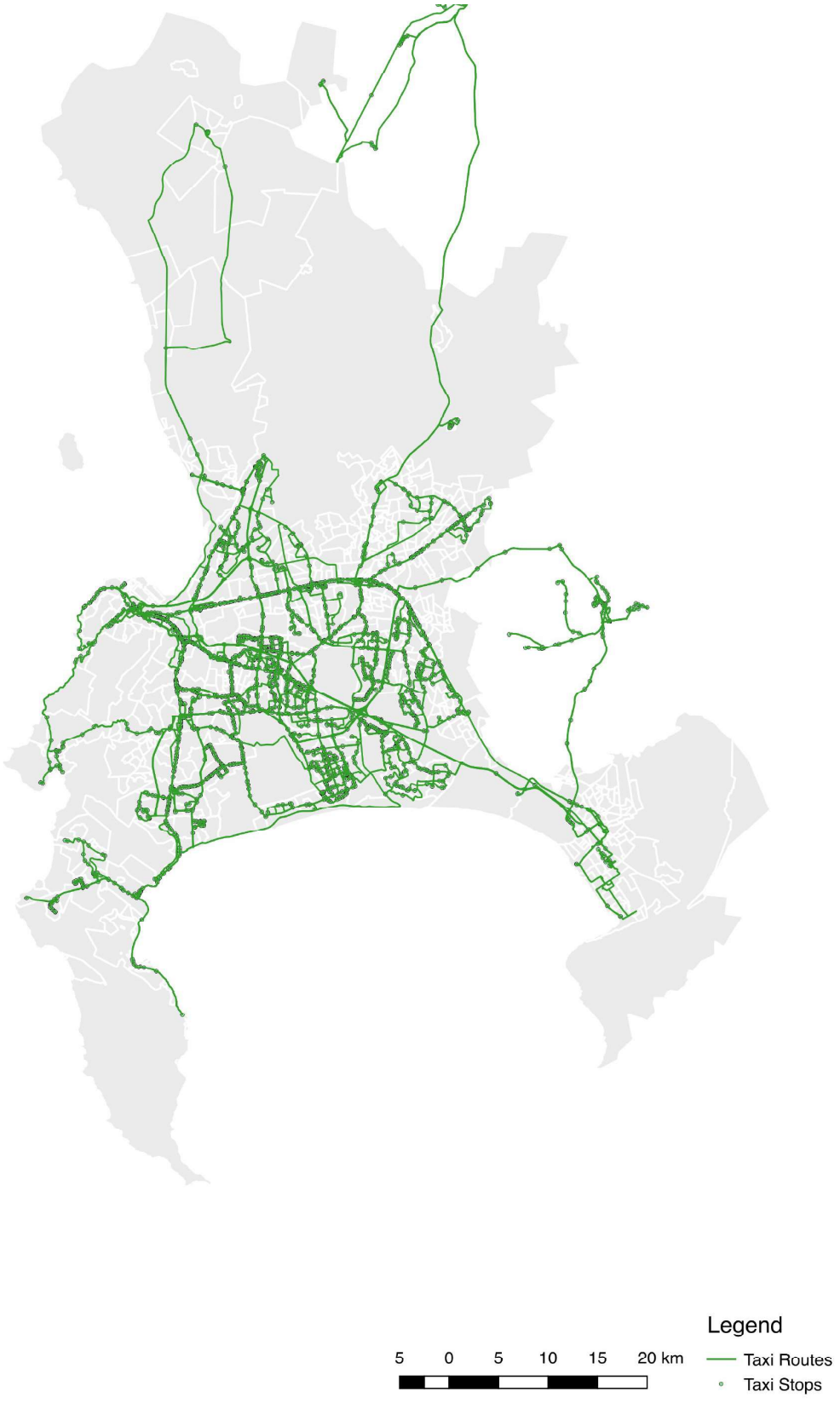


Figure 58: Minibus taxi routes and stops
Source: *Whereismytransport,* visualisation by Author

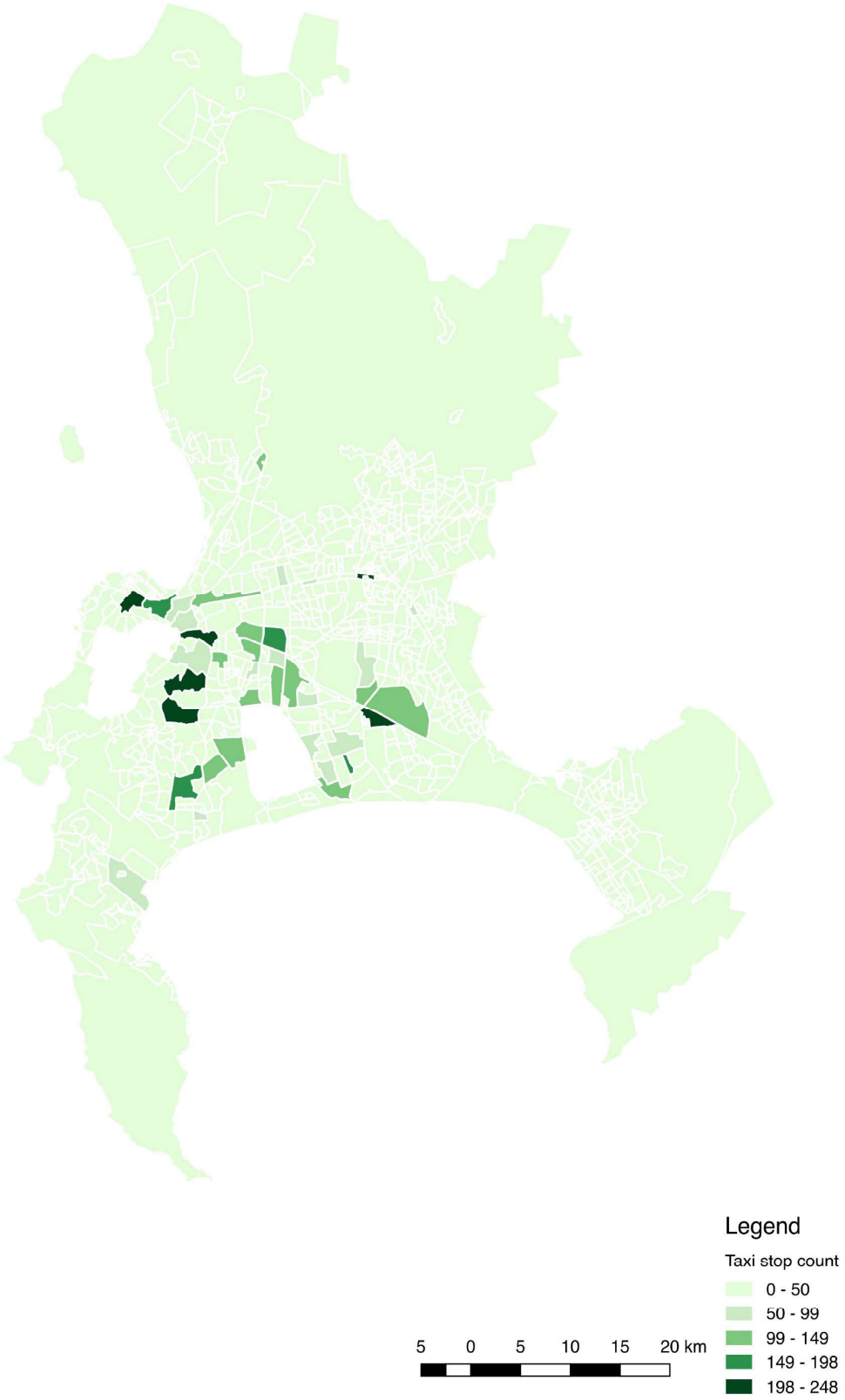


Figure 59: Minibus taxi stop count per neighbourhood in Cape Town
Source: Analysis by Author

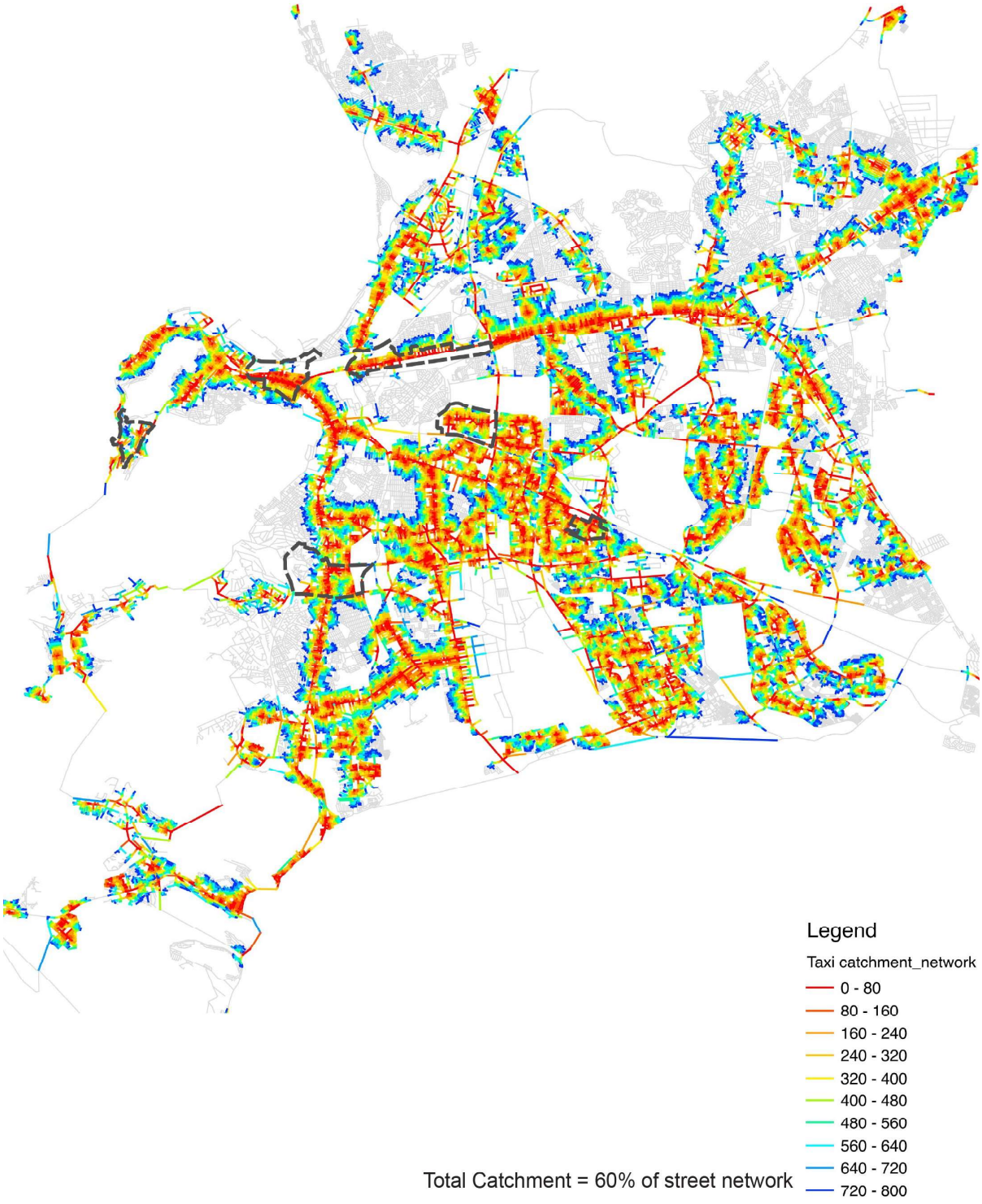


Figure 60: Catchment analysis of every minibus taxi stop of a ten-minute walking distance (800 m)
Source: Analysis by Author

6.3.1 Statistical analysis

In order to assess the strength of relationships between the affordance created for co-presence by transport accessibility within a neighbourhood and the social and spatial ecology of that neighbourhood, a compendium of variables have been selected for statistical testing.

Bivariate correlation analysis is used to identify statistically significant relationships between a range of social and spatial variables and the frequency of stops recorded in every single neighbourhood in Cape Town for BRT, taxi and railway networks. The underlying premise is that, the more stops or stations that a neighbourhood has, the greater the opportunity for co-presence in that neighbourhood. If a route simply moves through, but fails to stop in a neighbourhood, that route does not contribute in any form to potential co-presence. Variables tested included population counts, land use counts and mean syntactical values for every neighbourhood. A summary of the statistically significant bivariate correlations and multiple linear regression models, for each mode of transport, is presented below.

6.3.1.1 Railway

Bivariate Correlation Analysis

Railway Station Frequency vs. Business, Mixed, Community Land-use count	*0.439***
Railway Station Frequency vs. Taxi Stop Count	*0.443***
Railway Station Frequency vs. Total White Population	*0.301***
Railway Station Frequency vs. NAIN R1200	0.165**
Railway Station Frequency vs. Total Coloured Population	*0.095***
Railway Station Frequency vs. Total Black Population	0.096**
Railway Station Frequency vs. Total Population	0.093**

***statistically significant to the 0.01 level*

6.3.1.2 Myciti BRT

Bivariate Correlation Analysis

BRT stop count vs Total White Population	*0.415***
BRT stop count vs Business and Mixed Land Use Count	*0.589***

BRT stop count vs Mean Income	*0.120***

***statistically significant to the 0.01 level*

Multiple Linear Regression

The variables with the highest correlations are used to create a model for multiple linear regression. The *BRT stop count* is the Dependent Variable and the *Total White population, Business, Mixed and Community land-use* frequency and *Minibus taxi stop counts* are the Independent Variables.

Dependent variable:	BRT stop count	
Independent Variables:	Total White Population	*0.415***
	Business and Mixed land use count	*0.589***
R^2 Value:		***0.462***

This statistical model produced an R^2 value of 0.462, indicating that 46% of the frequency of BRT stops in a neighbourhood can be attributed to the total population of White people and Business and Mixed land use plot count.

6.3.1.3 Minibus Taxi

Bivariate Correlation Analysis

Taxi stop Count vs. Frequency of Business, Mixed and Community Land use count	*0.622***
Taxi stop Count vs. Frequency of railway stations	*0.443***
Taxi stop Count vs. Total Population	*0.577***
Taxi Stop Count vs. Black Population	*0.394***
Taxi Stop Count vs. Coloured Population	*0.374***
Taxi Stop Count vs. White Population	*0.150***
Taxi Stop Count vs. Mean Income	*- 0.172***

***statistically significant to the 0.01 level*

Multiple Linear Regression

A model of multiple linear regression is constructed with the factors that had the highest significant correlations. The *frequency of taxi stops* is the Dependent Variable and the frequency of *Business, Mixed, Community zoned land use, railway stations* and the *total population per neighbourhood* are the Independent Variables.

Dependent Variable:	Taxi stop count	
Independent Variables:	Business, Mixed and Community land use count.	*0.622***
	Railway Station Count	*0.443***
	Total Population	0.577**
R^2 Value:		***0.59***

This statistical model reaped an R^2 value of *0.59*, indicating that almost 60% of the frequency of stops in a neighbourhood can be attributed to the combined frequency of Business, Mixed and Community land use plots, railway stations and total population size of that neighbourhood.

6.4 Meso-scale analysis

Global-scale analysis is useful to achieve an overarching understanding of the operational capacity of the minibus taxi in relation to network of accessibility and the emergence of multi-racial co-presence. However, in order to gain insight into the taxi system on a local scale, it is necessary to link it to the case studies of *Woodstock, Wynberg, Maitland, Camps Bay, Langa* and *Nyanga*. This will offer insight into the everyday local encounters and experiences of a resident.

6.4.1 Taxi stops

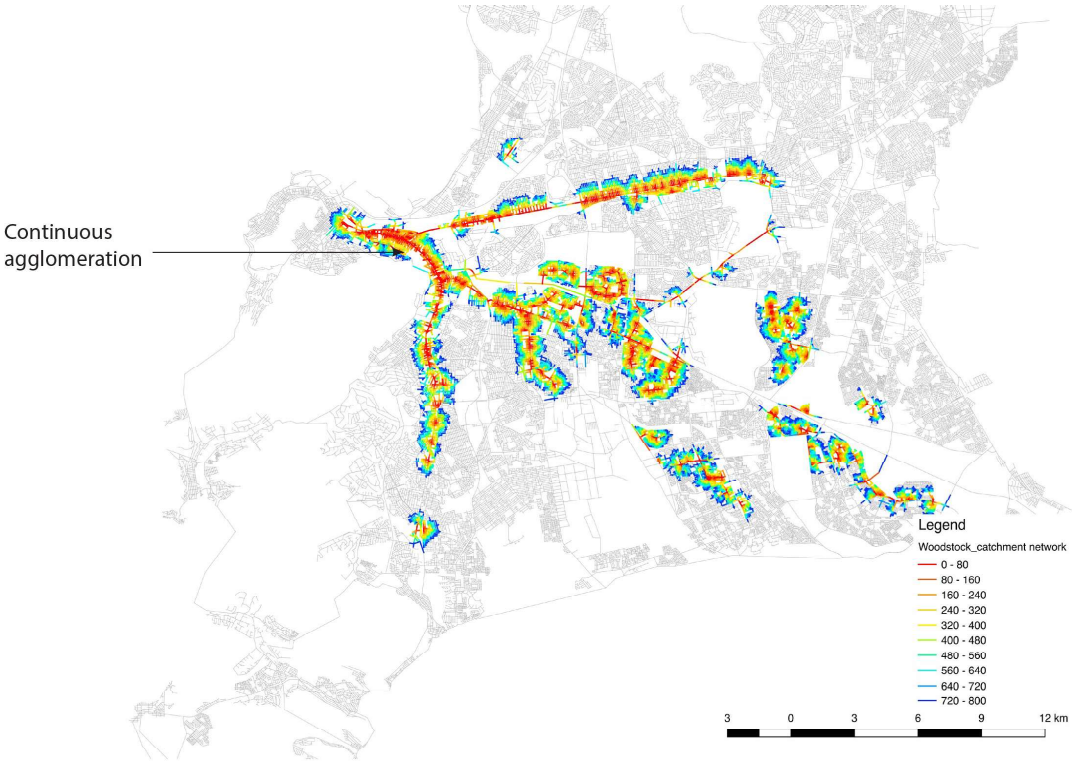
The catchment on every stop that is part of a taxi route that passes through each of the neighbourhoods of a ten minute walking distance on the street network is analysed. This is to understand which areas of the city are within walking distance to a person living in one of these neighbourhoods through only one trip taken on a taxi. Taxi's do not have an integrated fare system, which deters users from making interchanges (Bruun, Del Mistro, Venter and Mfinanage, 2016:33).

The catchments associated with *Woodstock, Wynberg* and *Maitland* are composed of a relatively continuously connected networks, indicating an uninterrupted frequency of activity that emanates from each of these neighbourhoods, refer to *Figure 62, Figure 64* and *Figure 63*.

Furthermore the analysis reveals that *Woodstock* has access to 16%, *Wynberg* 10.7% and *Maitland* 5% of the spatial network through only one trip taken on a taxi.

In contrast, the catchments associated with *Langa*, *Nyanga* and *Camps Bay* are composed of predominantly disconnected networks, refer to *Figure 65, Figure 66* and *Figure 67*. This is indicative of fragmented activity, imposed by local morphological barriers. For example when catchments from stops in *Langa* and *Woodstock* are compared (refer to *Figure 61*) the catchments from *Woodstock*, reveal a pattern of network agglomeration. Whereas in *Langa*, the catchments are clearly restricted by the *N2* and green belts which form local barriers. Only 0.89% of the street network is available through one trip from *Camps Bay*, 3% from *Langa* and 5% from *Nyanga*.

Figure 61: Comparison of the visualised form of catchments of every stop in *Langa* and *Woodstock*
Source: Analysis by Author



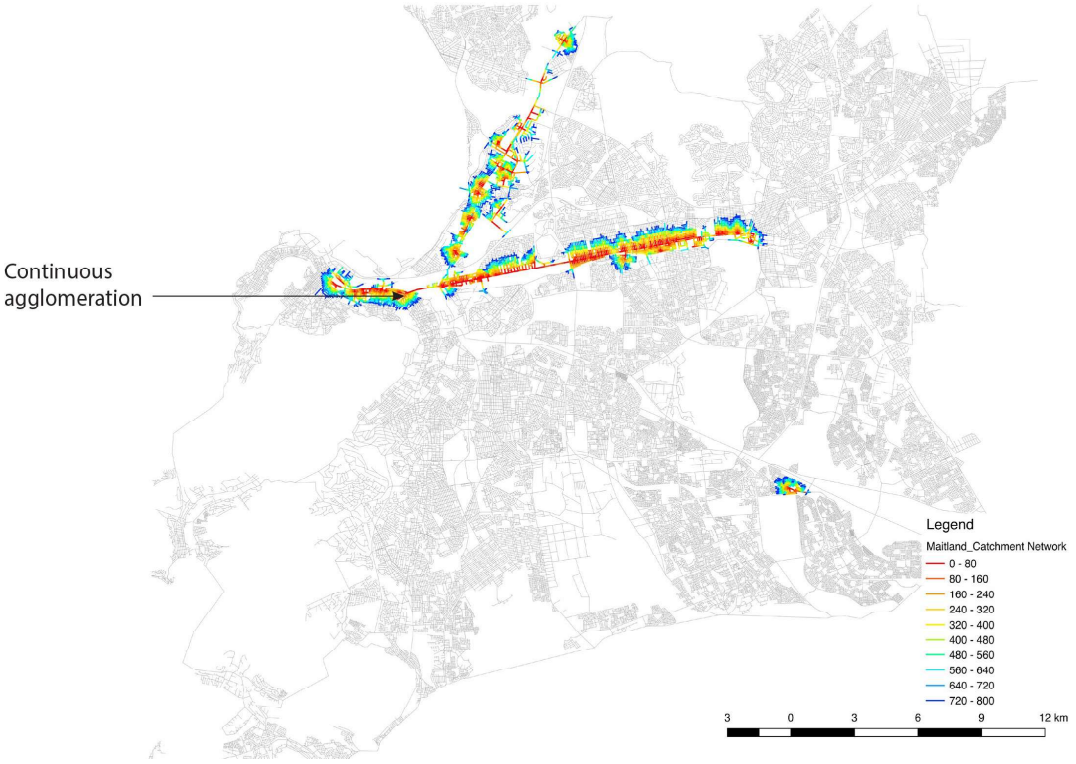
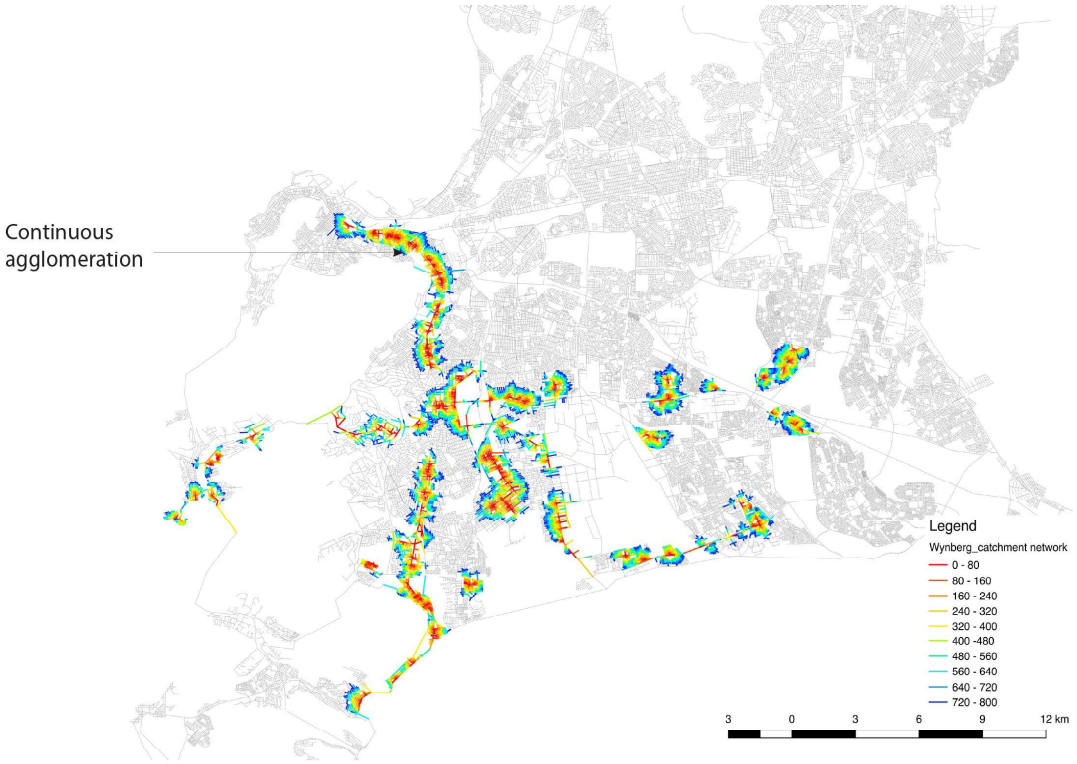


Figure 62: Catchment analysis of 800 m on all stops accessible from *Woodstock* through 1 taxi ride
Source: Analysis by Author

Figure 63: Catchment analysis of 800 m on all stops accessible from *Maitland* through 1 taxi ride
Source: Analysis by Author



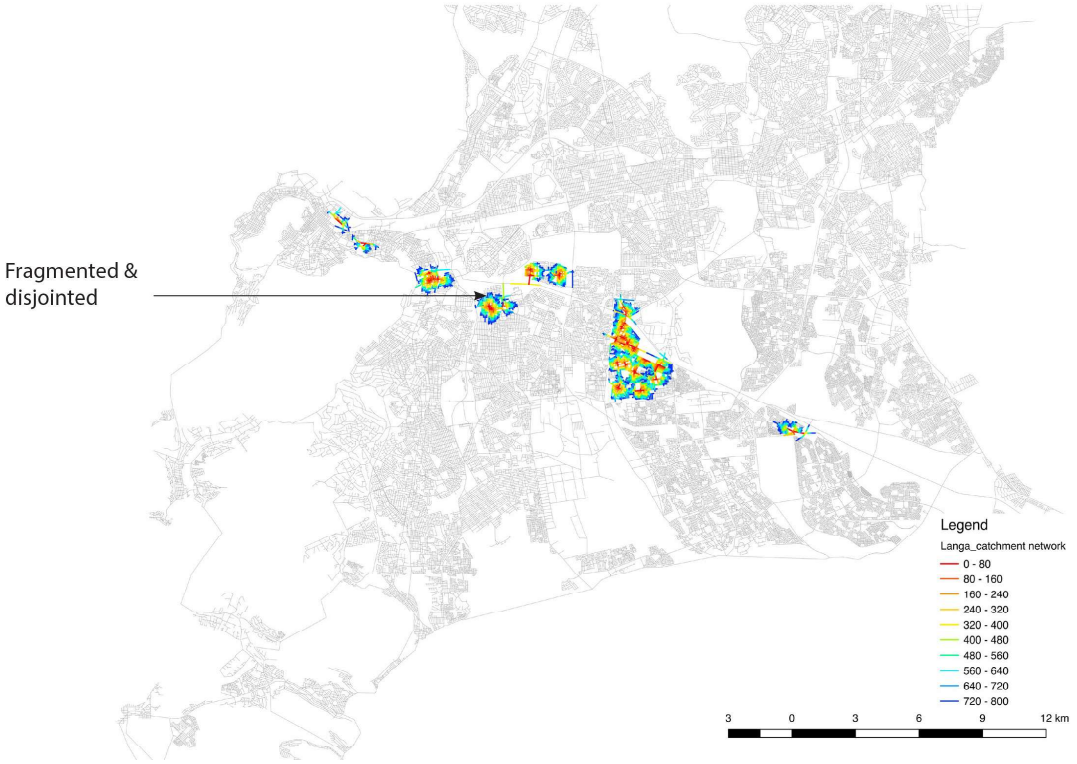
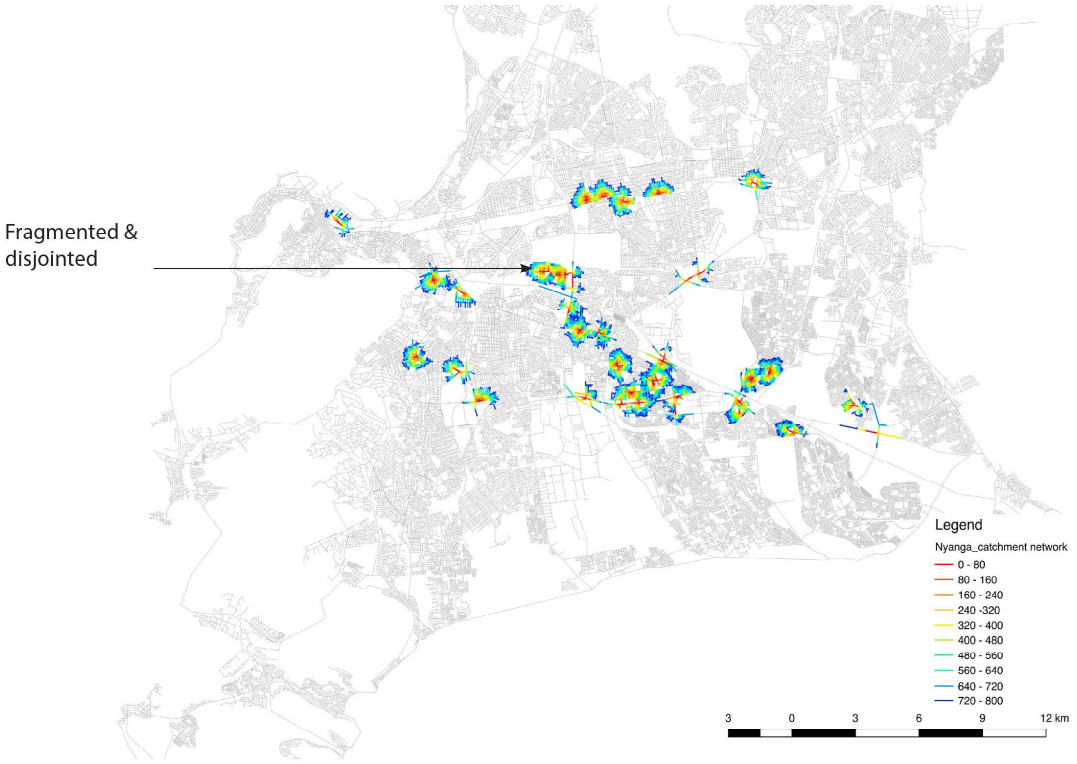


Figure 64: Catchment analysis of 800 m on all stops accessible from *Wynberg* through 1 taxi ride
Source: Analysis by Author

Figure 65: Catchment analysis of 800 m on all stops accessible from *Langa* through 1 taxi ride
Source: Analysis by Author



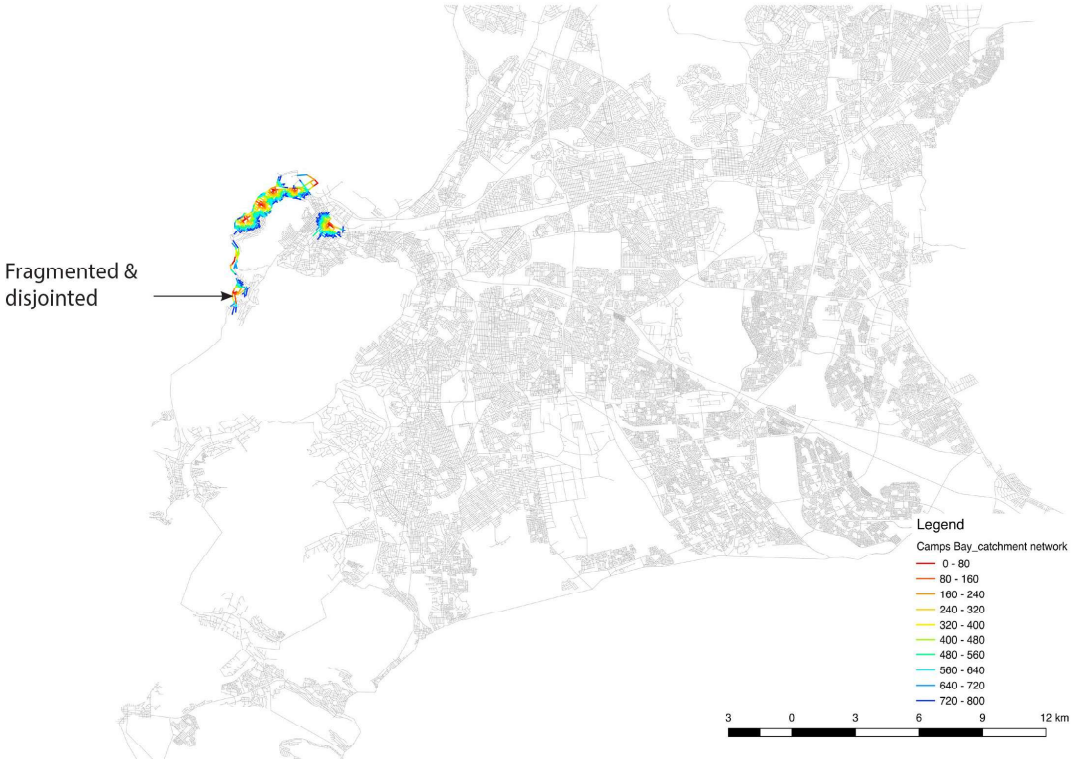


Figure 66: Catchment analysis of 800 m on all stops accessible from *Nyanga* through 1 taxi ride
Source: Analysis by Author

Figure 67: Catchment analysis of 800 m on all stops accessible from *Camps Bay* through 1 taxi ride
Source: Analysis by Author

6.4.2 Taxi ranks

Taxi ranks are important nodal points of interchange, where multiple routes converge, making it necessary to include them within the analysis. All of the case studies, according to the data supplied by *Whereismytransport*, possess taxi ranks, except for *Woodstock*, which is most likely serviced off by the CBD taxi rank.

The locations of the taxi ranks are depicted in *Figure 69*. They are all located just off of segments with high *through-movement* potential and generally adjacent to a railway station. Interestingly in *Langa*, the taxi rank is not located next to the railway station, which is in a spatially isolated position, but rather it is in a more optimal spatial location alongside a segment with the highest *through-movement* potential in the neighbourhood.

The land use patterns surrounding the taxi ranks are analysed and reveal a pattern of land use diversity (refer to *Figure 71*). Interestingly, even in *Langa* and *Nyanga*, informal traders have set up shops in old shipping containers and informal structures, refer to *Figures 72* and *73*. This indicates that they are capitalising on the essential movement of people as they walk from the taxi rank to home and vice-versa.

Figure 68: Example of a Taxi rank
Source: Google Earth

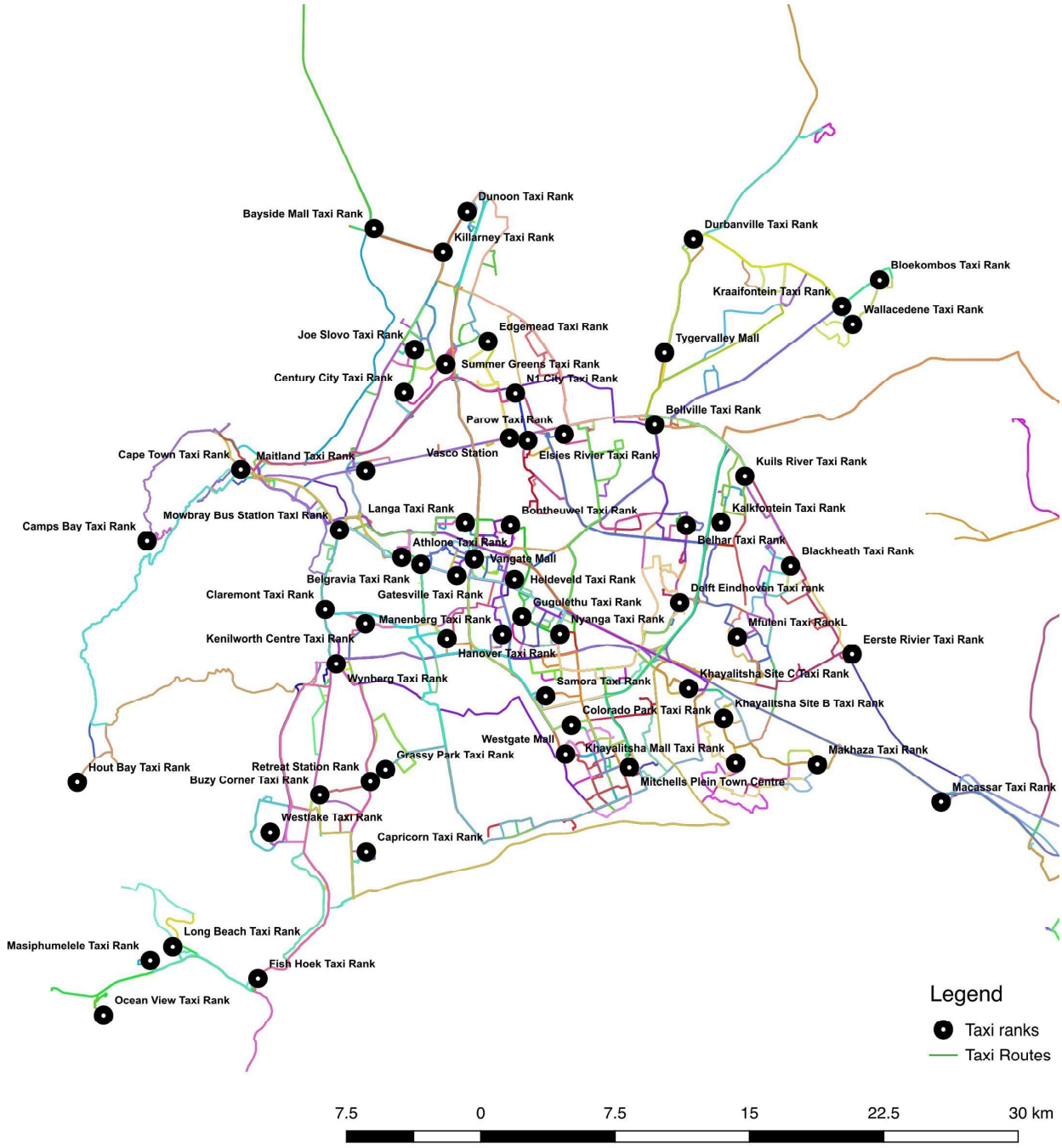


Figure 69: Taxi routes and ranks
Source: *Whereismytransport,* visualisation by Author

Figure 70: Location of taxi ranks in relation to railway stations and properties of the street network
Source: Analysis by Author

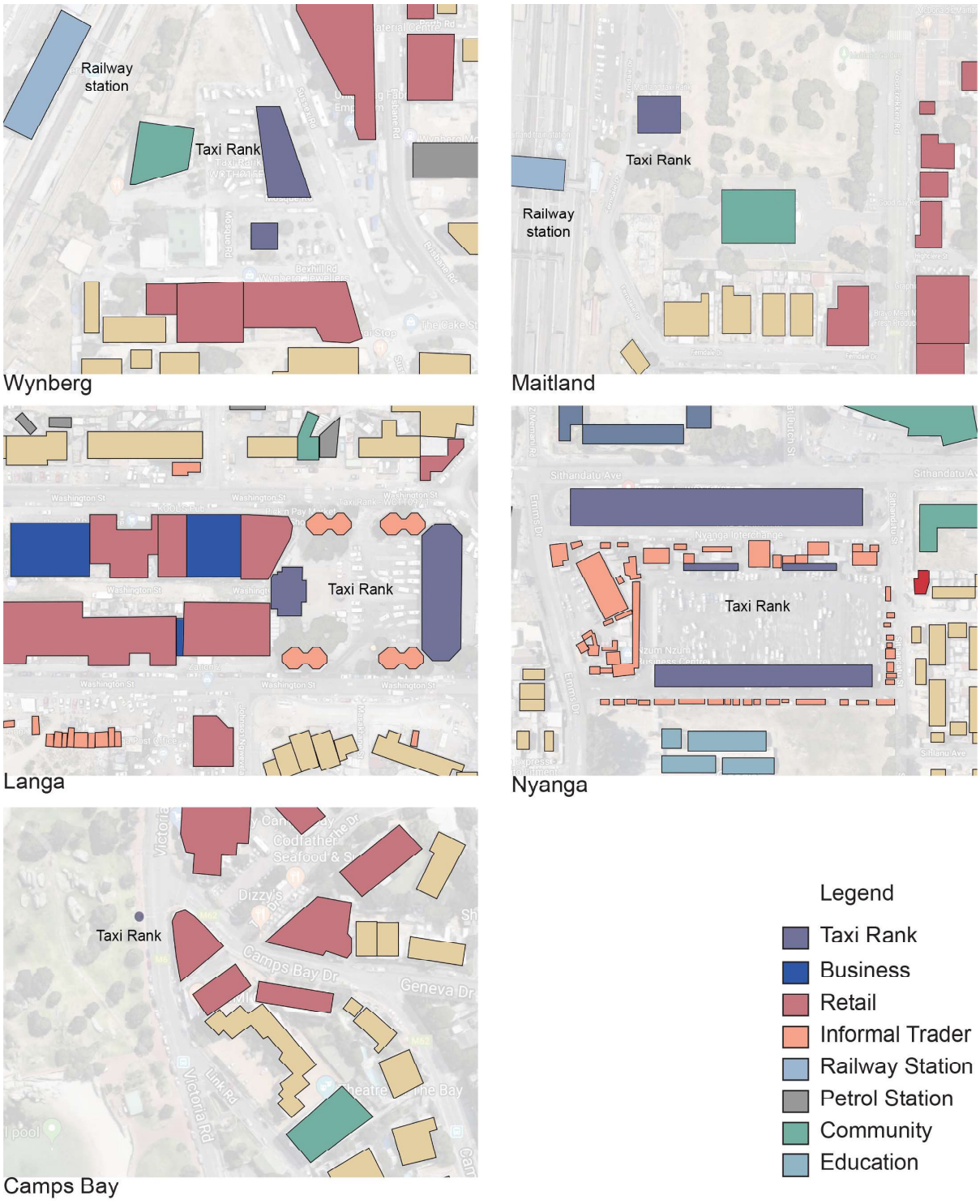


Figure 71: Land use zoning around taxi ranks in neighbourhood case studies
Source: Analysis by Author

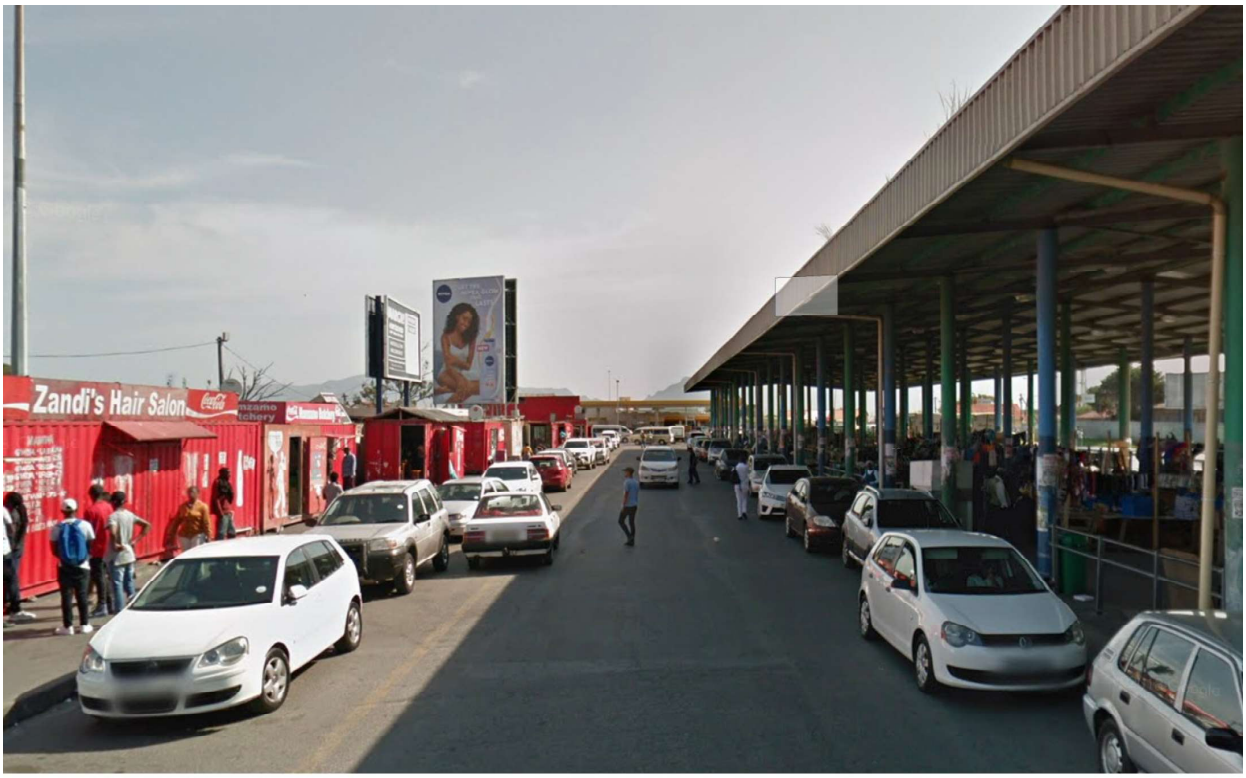


Figure 72: Photograph of informal shop traders around the *Nyanga Taxi Rank*
Source: Google Earth

Figure 73: Photograph of informal shop traders around the *Langa Taxi Rank*
Source: Google Earth

6.5 Discussion

There is great opportunity for enhancement of the taxi network as it already has a far wider network of accessibility than the BRT and railway systems, with 60% of the street network within walking distance of a taxi stop. Measures to increase its operational efficiency could include designated taxi lanes, the introduction of an integrated fare system and a digital rating and registration network to increase safety and provide marketing and branding opportunities (see the *Epilogue* for a detailed guideline of recommendations).

The statistical analysis has dispelled the myth that taxis stop sporadically and that their routes are haphazard and random. It shows they are part of the spatial ecology of the city, responding to real factors such as land-use activity, density of people and are naturally working in conjunction with the railway system. The taxi system has significant correlations with all racial population groups and the strongest relation with density of people by neighbourhood, suggesting it is providing opportunities for new networks of racial heterogeneity to emerge. The railway system has very weak relations with Coloured and Black populations, but a much stronger relationship with the White population, which is not surprising considering it was implemented prior to the ending of Apartheid. The BRT, implemented in 2010, only had a significant correlation with the White population and no other racial groups, this indicates that the government is still prioritising developed, historically White areas, reinforcing patterns of racial homogeneity.

On a local scale it is apparent that the morphology of the street network impacts local accessibility patterns of the taxi. In *Maitland, Woodstock* and *Wynberg* there was a pattern of continuity that emerged from the catchments, whereas in *Langa, Nyanga and Camps Bay* they form fragmented agglomerations as a result of the morphological barriers that are imposed on these neighbourhoods. Analysis of the position of taxi ranks reveals that they have a relation with a diversity of land-use and the emergence of informal traders who are taking advantage of the movement economy created by people walking from the taxi rank to home. Measures to upgrade taxi rank infrastructure, through private and public investment, including in the development of the small businesses that already exist around them could form a potential strategy for development within historically disadvantaged neighbourhoods.

Chapter Seven

Conclusion and Discussion

7.1 Introduction

This dissertation has addressed a series of research questions that were centred on the relation between urban morphology, mobility systems and demographic racial integration. The first research question was concerned with if and whether, 20th Century Modernist planning was used as a tool to reinforce racial discrimination. The second focused on the affinity between the present-day spatial configuration of Cape Town and economic and demographic racial distribution. The third question, concentrated on the relationship between the configuration of spatial phenomena and residential demographic racial integration and the fourth on the role of informal transport, as opposed to formal modes of transport, in providing opportunity for racial integration. The following chapter will provide a comprehensive overview in order to answer the overarching research question which was: considering South Africa's long history of top-down urban policy centred on racial segregation, what spatial and mobility systems have emerged that may create opportunities for co-presence and encounter between different racial groups in space?

As South Africa moves towards the vision of multi-racial solidarity, encapsulated by Archbishop Desmond Tutu through the phrase, the *rainbow nation*, the everyday occurrence of multi-racial co-presence becomes an important prerequisite. Whilst the intent has not been to suggest that a specific type of spatial environment deterministically translates into the emergence of racial integration, the research has shown that particular spatial ecologies do have a relation with residential demographic racial integration and that networks of mobility infrastructure can either reinforce existing patterns of racial homogeneity or allow for new networks of racial heterogeneity to potentially emerge.

7.2 Urban morphology: unlocking potentials in the spatial network

There is a general consensus in space syntax literature that most cities, with all their differences, to some degree approximate a pattern, which Hillier (2016:200) referred to as the *generic city*. The *generic city* is the idea that a street network links the buildings in a city through a dual system made up of two subsystems with their own generic properties (Hillier, 2016:200). These include a *foreground network* of linked centres driven by micro-economic activity which seeks to maximise movement and co-presence and a *background network,* driven by socio-cultural residential processes, which typically seeks to diffuse and structure movement in the image of cultural ideas expressed through residence. The underlying premise is that there is an embedded social logic in the structure of city forms. Hillier (2016:200) employed the examples of the spatial networks of *Denver* in the USA and *Shiraz* in Iran, which are culturally, geographically and geometrically very different, but exhibit the qualities of the *generic city.*

Unlike these two examples, globally, the spatial configuration of Cape Town's Street network, presents an inverse of the social logic expressed within the *generic city*. In Cape Town, what typically appears on a segment map as the *foreground network*, is predominantly residential space and the *background network*, is largely composed of micro-economic activity. Unlike the *generic city*, underpinning the development of the *apartheid city* were ideologies of race, class, and culture; institutionalised discriminatory urban policy insured exclusion through restrictions on access and organic land use development. The masterplan was indeed the "great instrument of power" King (2015:33). These spatial conditions have been exacerbated through the growth of informal settlements propelled by the migration of rural dwellers from the *Bantustans* after 1994, following general trends of rapid urbanisation across Africa. There is a misalignment between land use patterns and spatial structure; on a global scale Cape Town does not follow Hillier's (1996) *Theory of the Movement Economy*.

The vast polarities in characteristics of the spatial network at different radii are symptomatic of access restricted by local morphological barriers. The strength of the closeness centrality of many optimally positioned neighbourhoods at Radius n, dissipates at local scales. An approach to transformation needs to include a systematic evaluation of these barriers using methods such as those employed in this dissertation on a case study basis to explore ways in which they could be transformed into potential vehicles for accessibility, housing and microeconomic development. This reinforces that the State's focus on housing alone through the *RDP* programme is misplaced. The persistence of poverty is reinforced by structural, spatial barriers implemented through top-down, modernist urban interventions that enforce a reliance on

motorised transport and discourage natural through-movement which could develop local economies. The statistical analysis revealed that the best predictors for *Mean Income* are the percentage of White people in a neighbourhood and Mean NAIN Rn value of that neighbourhood's street network. In stark contrast, *Mean Income*, negatively correlated with the percentage of Black and Coloured population groups in a neighbourhood, with the strongest negative correlation in predominantly Coloured areas. This provides evidence that race and economic distribution are entrenched in Cape Town's Street network. The configuration of the street network, on a global scale, acts as a vehicle for mechanical solidarity, composed of segregated and dispersed spatial form.

Despite this global trend of economic and racial segregation, one positive finding did emerge. The old, emergent streets of *Voortrekker* and *Main Road* retain their closeness and betweenness centrality across the radii, forming integrators in the network. Characteristics of these streets could be enhanced through investment and careful planning interventions , involving local communities to optimise their embedded spatial characteristics as social and economic generators.

7.3 Residential racial integration

The neighbourhood case studies of demographic residential racial integration, developed prior to the 20th Century and thus before the adoption of official practices of town planning. They emerged out of organic processes, whereas the neighbourhoods of racial segregation were decisively planned. The summary of social statistical data revealed that the case studies of racial segregation, present vast polarities, whereas the neighbourhoods of demographic racial integration had more uniform social features.

Woodstock, Wynberg and *Maitland* are continuously connected by *Voortrekker and Main Road* and as a result their spatial structure retains its *closeness centrality* across the radii, suggesting higher intelligibility. Conversely, *Langa, Nyanga* and *Camps Bay* are cellular agglomerations, bounded by man-made and natural morphological barriers. There is a stark contrast in the land-use zoning of the neighbourhoods of racial homogeneity and heterogeneity. Whilst *Woodstock, Wynberg* and *Maitland*, possess significant percentages of mixed and business land-use zoning, *Langa, Nyanga* and *Camps Bay* are predominantly residential. Access to mobility also seemed to be a factor, neighbourhoods of racial integration had greater accessibility to railway and minibus taxis.

The statistical analysis showed that almost 40% of residential racial integration can be accounted for by non-residential land-use, mean income, frequency of minibus taxi stops and mean NAIN measures. Whilst the city is only experiencing residential demographic racial integration on a small scale, there is potential to enhance these characteristics, to unlock economic and social capital, as well as to employ these principles as a basis for incremental transformation in other neighbourhoods.

7.4 Mobility: connecting previously divided actors

The paratransit minibus taxi provides the largest network of accessibility across the City, with 60% of the street network in an 800 m walking distance from a taxi stop. In comparison, the Myciti BRT and railway systems are vastly inadequate with only 8% and 14% of the street network within walking distance of a railway station and BRT stop, respectively. Whilst the planned railway and BRT systems have a statistically significant relationship with the percentage of White people living in a neighbourhood, the taxi system has statistically significant relationships with all racial groups and the strongest relationship with the density of population in a neighbourhood.

The emergent taxi stops are not random or sporadic, but respond to real factors. Taxi ranks, which exist as primary interchanges, are an intricate part of local spatial ecologies and informal traders are capitalising on the emergence of necessary movement patterns that people take to the taxi ranks. There needs to be an acknowledgement that the taxi industry as an intricate part of the spatial and social ecology of the city. Investment in the operating functionality of the taxis and carefully planned infrastructural developments to enhance the emergent conditions, as outlined in the *Epilogue* of this dissertation, could catalyse transformation.

7.5 Planned vs. emergent phenomena

Planned processes in the *apartheid city* were historically used to control and racially segregate. Whereas the research has suggested that the spatial network associated with the organic city and the emergent minibus taxi system is more generative of racial integration. Drawing on ideas from Hillier's (1989:12) paper, *Architecture of the Urban Object*, the *apartheid city* is far less concerned with the production of everyday life and more concerned with the formal production of social structures. Its spatial structure was changed in the 20th Century from an instrument of pervasive, but variable co-presence, to a symbolically ordered ideological

landscape expressive of the forms of power in society (Hillier, 1989:12). The N2 highway is a major axis across the city with no buildings on it and it approximates itself as a convex space, instead of penetrating many convex spaces. Whereas *Voortrekker* and *Main Road* are social spaces, lined with everyday buildings and intersected by public spaces.

The minibus taxi system is an intrinsic part of everyday life in Cape Town through which agency of movement, opportunity for interaction and economic survival is granted to the most disadvantaged communities. As a result of its emergent nature and not despite its emergent nature, it responds to real needs, as opposed to factors construed by a singular master planner.

7.6 Conclusion

Although the urban morphology of Cape Town presents an extreme example of racial and economic polarisation due to the severity of Apartheid laws, the ideological informants behind its development are not unique. The majority of African cities are in a process of rapid urbanisation, possess historically separate native and colonial quarters and are positioned on the coastline, initially founded as trading posts. The evidence from this study has suggested that bottom-up urban processes are responding far more effectively to the needs of everyday life; solutions are emerging from communities themselves. Urban informality has traditionally been rejected by government, planners and developers. A radical paradigm shift is required: governments need to acknowledge, learn from and find ways to enhance the latent economic and social potential of emergent processes. In addition, issues of spatial justice are inherently related to the configurational properties of the street network and thus, this needs to be taken into account when developing a strategy for urban transformation. Further research into African cities is needed, in order to inform policy that ensures sustainable and equitable future development practices, that do not mimic the top-down planning of the colonial past.

It is time to acknowledge emergent processes, to realise, "The interdependence between design and emergence" Hamdi (2000:xv). There is a relationship between emergent processes and racial integration, which if replicated and further enhanced could catalyse transformation, within Cape Town and possibly more broadly. The advantage of an evidence based approach to planning could enable design interventions to be driven by more objective and equitable intentions, rather than the historically ideologically skewed beliefs, which were used as a basis for planned segregation.

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Epilogue

The following guidelines have been formed from the conclusions drawn from the investigations of this dissertation. This set of recommendations is envisioned to be employed by both private and public actors and prioritised incrementally according to importance and resource allocation. The intention is that they form a guide to enhance the emergent processes identified in this study in order to catalyse the development of a more racially integrated, equitable and sustainable urban environment.

1. Transformation of urban morphological barriers

Urban morphological barriers were employed to enforce systemic racial segregation in Cape Town. A strategy to transform the city from a series of fragmented and globally racially homogenous agglomerations to an interconnected, multi-racial network, would require a systematic evaluation, on a case basis, of the relationship between the interface of the street network, built form and morphological barriers. These barriers may manifest in greenbelts, highways, industrial infrastructure and topography. This could allow for the unlocking of latent economic and social capital, particularly within neighbourhoods that possess optimal global positions of high closeness centrality, but are limited by local barriers to access, such as *Langa*. Design interventions could be strategically implemented to enhance the characteristics of the existing street network and potentially transform physical boundaries into opportunities for connection, economic development and housing.

Two examples of such an approach are presented subsequently. *Figure 74* depicts the design proposal for a project currently under construction in Medellin, which buries a highway underneath an elevated park. *Figure 75* depicts an elevated pedestrian sky garden designed by MVRDV in Seoul, South Korea, which allows pedestrians to be connected to different parts of the city over existing highways.

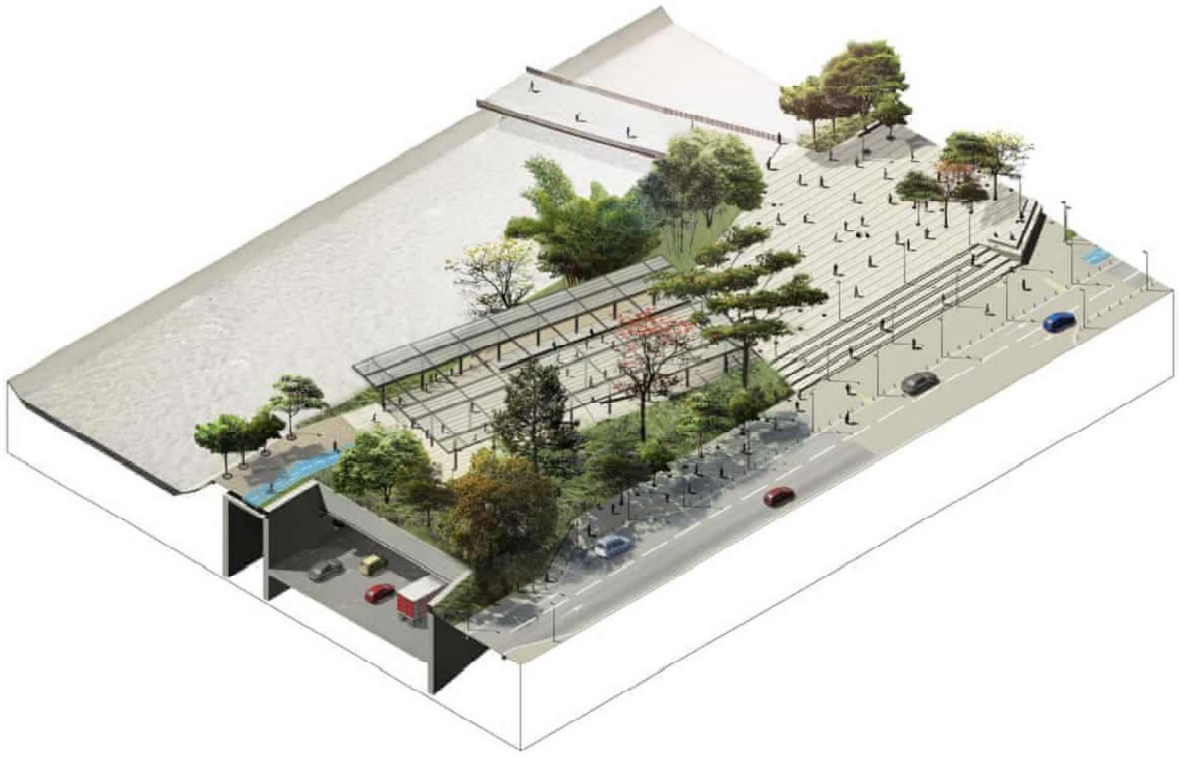


Figure 74: Proposal for a buried highway in Medellin, Columbia
Source: https://www.theguardian.com/cities/2015/medellin-bury-highway-urban-intervention

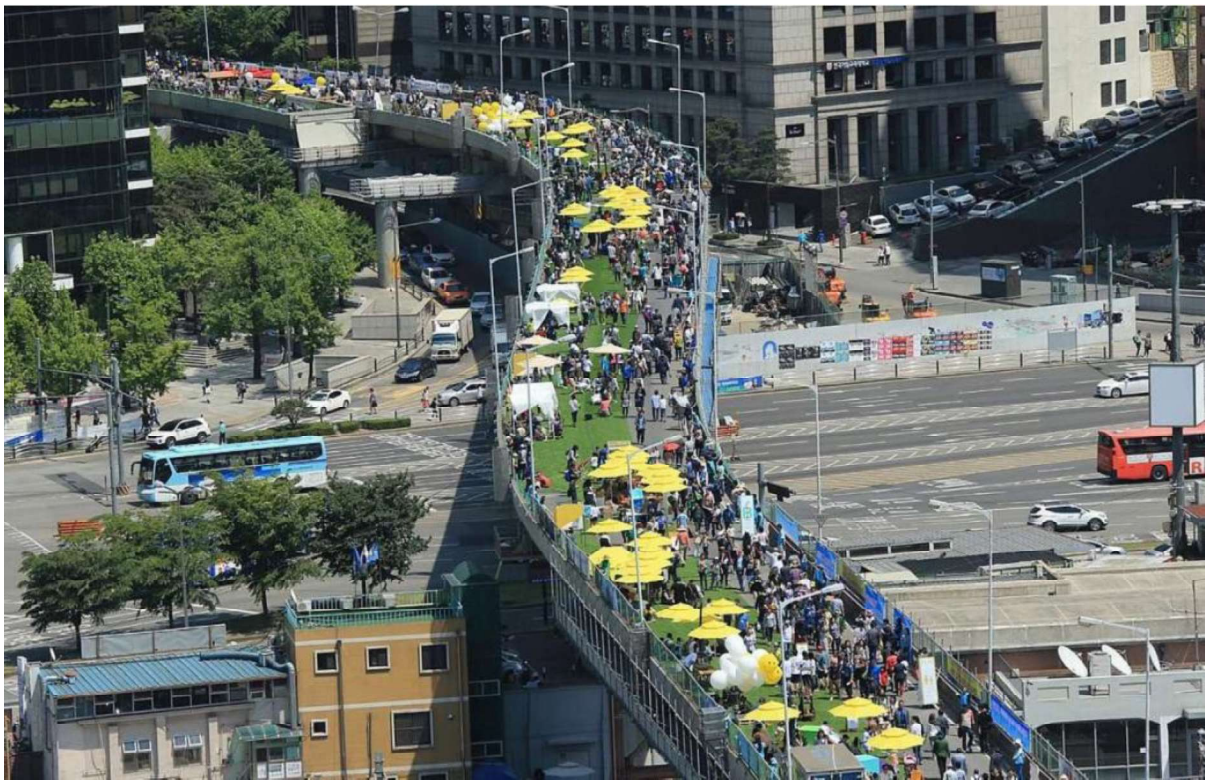


Figure 75: Pedestrian sky-garden over highways in Seoul, South Korea
Source: https://www.straitstimes.com/asia/east-asia/embracing-parks-heart-and-seoul

2. Enhancement of streets

Voortrekker and *Main Road* have a structure of intelligibility across the radii, which have allowed them to emerge as social spaces, lined with a diversity of land use plots. Furthermore, this investigation revealed that they have a relation with neighbourhoods of demographic racial integration. Their embedded spatial characteristics of high closeness and betweenness centrality could be enhanced through densification of built form, investment into mixed-use and retail development and the upgrading of the street landscape through planting, street furniture, lighting and strategically implemented shared spaces. *Figures 76* and *77* are examples of street landscapes which embody the characteristics described above.

Figure 76: Street landscape
Source: Niels de Vries, Flickr

Figure 77: Street landscape
Source: https://www.discovercharlottetown.com/blog/swoon-worthy-streetscapes-of-charlottetown/

3. Land Use diversity

Apartheid planning insured that land use zoning was strictly controlled, which has resulted in a city that has an emphasis on a singular CBD and a global misalignment between land use and characteristics of the spatial network. Furthermore, the frequency of residential land use, on a neighbourhood scale, was found to have an inverse correlation with demographic racial integration; residentially homogenous neighbourhoods are indicative of racial homogeneity. This suggests that a commitment towards land use diversity could form an integral part of a strategy towards developing a more racially integrated city.

This could be encouraged through the revisal of the City's lengthy and costly approach to land use rezoning, which discourages developers. The embedded characteristics of the spatial network could be used as a measure to assess the appropriateness of rezoning applications, according to Hillier's (1996, 1993) *theory of the movement economy*, to fast-track the process. Density bonuses could be granted, to allow developers to build more densely then normally permitted in exchange for providing a certain percentage of mixed use or community

functions. Specific zoning quotas could also be implemented, which may require new construction projects to include a certain percentage of non-residential functions.

4. **Enhancement of existing Taxi infrastructure**

The minibus taxi system is the most accessible form of transport in Cape Town. Despite the stigma of chaos associated with the industry, it has been statistically shown to possess an embedded spatial and social logic. A range of measures could be implemented to enhance the latent potential of this emergent system.

Urban Interventions

- In order to maximise accessibility, it is imperative that taxi ranks are strategically positioned within the street network, to serve the greatest area of catchment.

- Efficient flows of taxis and people can be optimised through the design and upgrading of the layout of taxi ranks. The addition of street furniture, greenery and lighting may also enhance their social capital and pedestrian safety.

- Enhancement of the most used routes taken by pedestrians to the taxi ranks. This may include investment into existing small businesses and informal traders, which could form part of a larger strategy to unlock latent economic and social potential in historically disadvantaged neighbourhoods.

- Prioritisation of taxis through shared use of road lanes which have been specifically reserved for BRT only. As resources are made available, designated lanes can be expanded to more routes. This would be a truly democratic approach, enabling the transport system that serves the widest population to be given priority, enhancing its safety, efficiency and reducing congestion.

Administrative

- The development of an integrated fare system could allow for multiple interchanges to be made by the user at no extra cost in designated zones and the digital tracking of fares

by taxi associations and owners.

- A digital database of taxi drivers and owners which allow for individual reviews by the user would render taxi drivers accountable for bad conduct and driving.

- A branding and marketing strategy, undertaken by taxi associations and governing bodies, could serve to attract public and private investment.

5. Railway and BRT infrastructure

Statistical analysis of the railway and BRT systems has suggested that they reinforce racially homogeneous networks. In order to enhance and expand the accessibility of the railway in historically non-White neighbourhoods additional railway stations could be implemented along existing lines, particularly on the lines which connect *Mitchells Plain* and *Khayelitsha*. If funding becomes available, new railway routes could be introduced.

There needs to be a rethinking of the positioning of current routes and stops that the BRT services. For example, one of the neighbourhoods which possesses the highest number of stops is *Camps Bay*. This seems misplaced when one considers that *Camps Bay* is predominantly residential, has a population of only 2500 and is one of the most affluent neighbourhoods in the city, implying high car ownership.

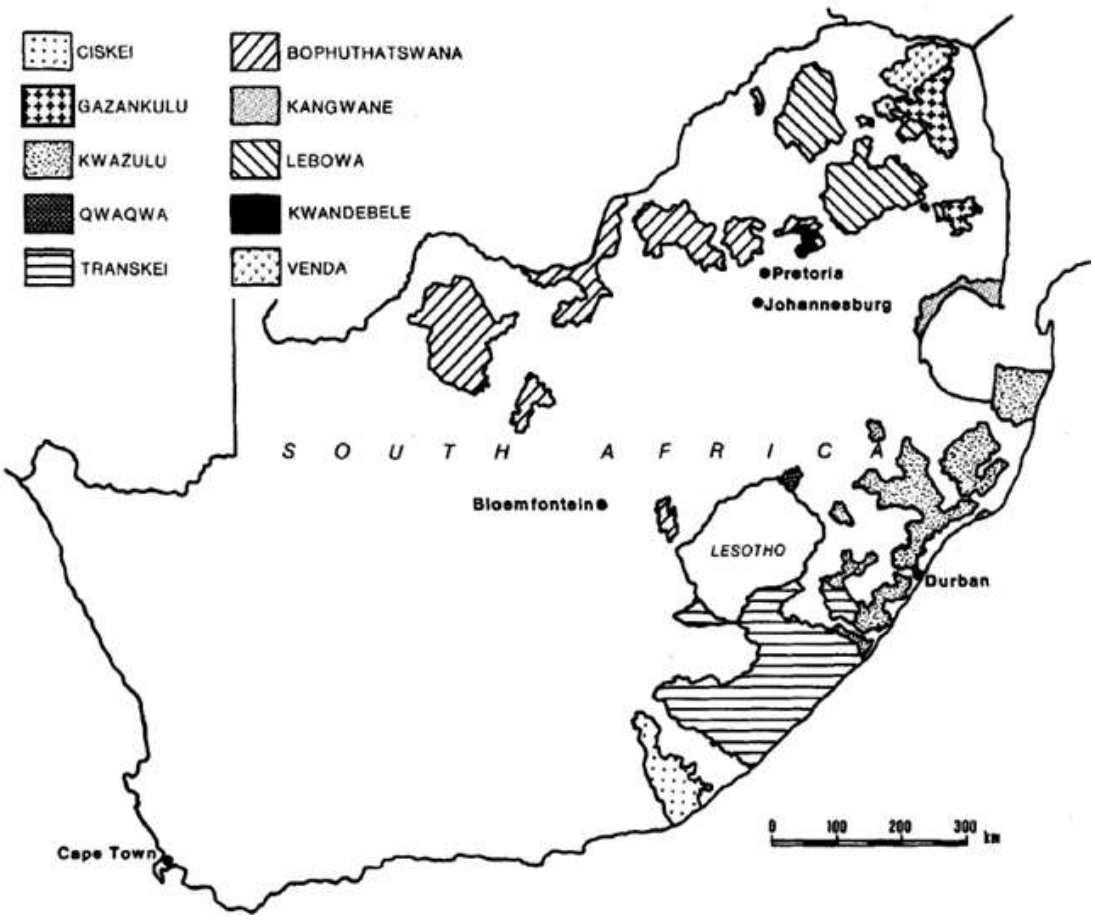
Conclusion

In conclusion, it is suggested that all proposed design interventions are tested using evidence-based design research techniques such as those employed in this thesis. In a complex urban landscape, such as Cape Town, this will increase the potential for success of any design proposal. Furthermore, in order to ensure a democratic approach towards the design process, local participation of community members and organisations is imperative.

Appendices

Appendix a

Location of former *Bantustans*



Appendix B

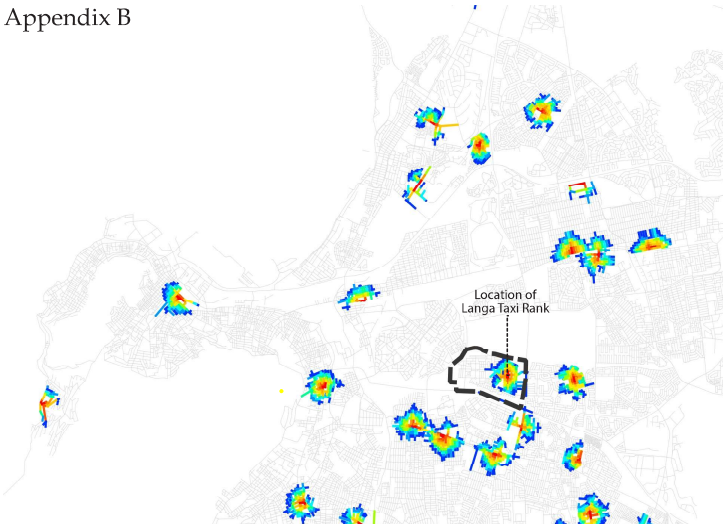


Figure 1: Catchments of ten minute walking distance of taxi ranks on street segments in Cape Town

The catchment analysis of taxi ranks across Cape Town, in *Figure 1*, illustrates how they already exist as attractors. Enhancement of this existing, emergent condition poses a bottom-up and contextually sensitive approach to transformation.

The evidence derived from the research of my dissertation suggested that taxi ranks, as major internodal transport interchanges, which attract vast amounts of people, might present a strategy for transformation in socio-economically and spatially disadvantaged neighbourhoods in Cape Town, South Africa. The upgrading of taxi ranks and enhancement of their latent potential through investing in the emergent informal traders who exist around taxi ranks, may serve as a catalyst for transformation.

This proposal has used Langa's taxi rank, as an example to showcase how evidence based analysis, may inform design decisions. Angular Segment Analysis at a Radius of 800m was used, as a measure to evaluate how the upgrading of a taxi rank and its layout, may enhance its existing potential as a centre for activity and economy. An analysis was conducted on the existing street layout and subsequently on the proposed street layout, which informed a design diagram. The design proposal remains diagrammatic and would require further development, through observation analysis of the site and consulation with the local community and Langa Taxi Association. It adopts, the shipping container, as a modular unit for construction, which could allow for incremental development of the scheme, over time.

A STRATEGY TO TRANSFORM LANGA

TITLE: Langa Taxi Rank Proposal Scheme
SITE: Langa, Cape Town, South Africa

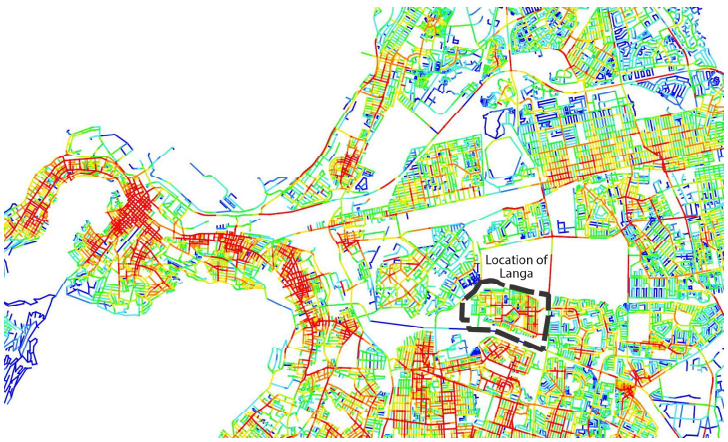


Figure 2: Angular Segment Analysis R800, Cape Town, South Africa

Figure 3: Angular Segment Analysis R800, of Langa as it exists

Figure 4: Angular Segment Analyis R800, of Langa with proposed design layout of its taxi rank

Figure 3, depicts the Angular Segment Analysis of Langa at Radius 800, as it currently exists. This shows that the location of the taxi rank, is naturally within a zone of high closeness centrality. *Figure 4*, shows how the reconfiguration of the taxi rank and surrounding shops, could not only enhance, its closeness centrality, but the closeness centrality of the entire zone it is located within.

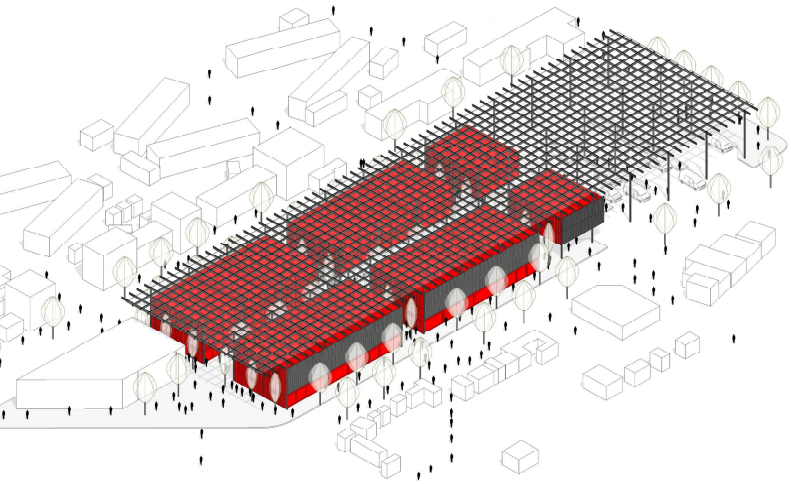


Figure 5: 3D Axonometric diagram of the site and proposed development

Figure 6: Shipping containers, a modular system for construction, inexpensive, sustainable and allows for incremental development

Figure 5, is an an axonometirc diagram of the scheme which could be generated from the layout tested using space syntax analytical techniques. The development has thoroughfares, which allow movement through and between it, which become extensions of existing street segments. It is composed of modular units, in the form of shipping containers, designed according to their dimensions and unified by an overarching roof structure, which would provide necessary shade to people waiting for taxis. The taxi rank itself would have to be carefully designed according to observation analysis and in conjunction with Langa's Taxi Association.

Figure 6, displays the shipping container, as a unit of construction. It offers an efficient and affordable solution to the construction of this proposed development

Figure 7, is a 3D diagram which illustrates the zoning of the proposed scheme. It is a mixed use development, in order to encourage a multiplier affect of the street layout and attract activity at different times of the day. It is envisioned as a meeting point within the urban fabric which would serve the people of Langa and potentially attract people more broadly.

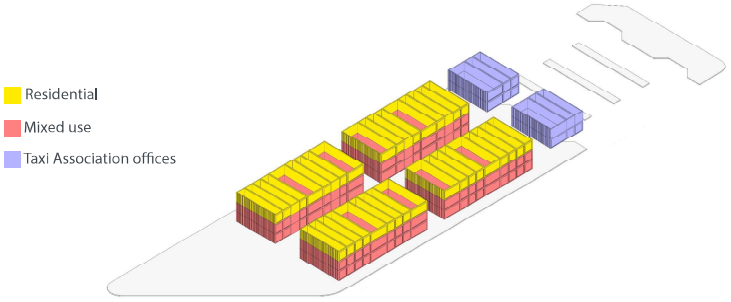


Figure 7: Zoning of Mixed-use Taxi Rank development