THE EXTENT OF URBAN DENSIFICATION IN STELLENBOSCH

by

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Declaration

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Abstract

There is a perpetual burden to supply accommodation to increasing population numbers in Stellenbosch. The most ideal way in which the property market is able to cater for this demand is through the development of high-density accommodation (Donaldson & Morkel 2012). Densification is a national spatial strategy aimed at integrating cities socially and spatially (Stellenbosch Municipality 2012a). However, there is a notion that densification in Stellenbosch is implemented in an ad hoc manner due to the lack of adequate policies regulating development in the town (Donaldson & Morkel 2012). What the impact may be on urban space is not known yet. Thus, it was regarded as valuable to determine the extent of urban densification in order to minimise undesired spatial consequences for future generations.

Through quantitative data, the study aimed to determine where, to what extent and why densification took place in a selected area of Stellenbosch from 2000 to 2016. The study objectives were to identify properties on which densification had taken place, to identify the most prominent methods implemented towards densification, to map the changes in residential density, to identify existing policy documents and to make recommendations for the densification and future growth of the town. The study primarily focused on changes in residential densities, e.g. where there was a single dwelling unit in the past there now are multiple dwelling units on the same plot. Commercial and industrial units were excluded from the study. Sites that were under construction were included based on the planned number of units. The study entails a literature review and the compilation of quantitative data from Stellenbosch Municipality.

The extent of densification was calculated by dividing the number of dwelling units by the hectares of land (du/ha = density). Based on the findings, the study concludes that densification has been a prominent feature in all the zones under study since 2000, excluding Zones 16 and 30. Due to several factors, the zones in the study area provide an obvious choice for densification in Stellenbosch. These factors relate to proximity and need for convenience, the existing infrastructure, housing demand and supply, as well as the availability of land and subsequent development opportunities. The results indicate that, although there are areas where no consolidation occurred, the consolidation of properties remains the most prominent method of densification since 2000. This is followed by the construction of additional dwelling units and the construction of multiple attached dwelling units. The study suggests that, although spatial planning policies exist in Stellenbosch, they may not be adequate and/or sufficiently enforced.

The study recommends that the Municipality should identify suitable locations for densification and identify Council-owned land that is available for the development or redevelopment of new and existing buildings. Available land should be re-zoned, where necessary, in line with specifically drafted planning strategies for a given area. Incentives should be used as a tool to encourage developers to develop land if it meets the developmental guidelines determined by the context-specific planning strategies. Guidelines should ideally incorporate the holistic principles of densification, such as socio-economic integration, mixed use, sustainable transport, appropriate densities, sense of community, environmental consciousness and functional viability.

Keywords

Densification, Density, Dwelling units, Land use, Residential, Stellenbosch

Opsomming

Stellenbosch staar ’n voortdurende uitdaging in die gesig om verblyf aan die groeiende aantal inwoners te verskaf (Donaldson & Morkel 2012). Die beste manier om hierdie vraag na verblyf aan te spreek is deur die oprig van hoëdigtheid verblyf. Verdigting is ’n nasionale ruimtelike strategie wat beoog om stede ruimtelik en sosiaal te integreer (Stellenbosch Municipality 2012a). Daar word egter beweer dat verdigting in Stellenbosch op ’n ad hoc manier geïmplementeer word as gevolg van ’n tekort aan toepaslike riglyne om ontwikkeling in die dorp te reguleer (Donaldson & Morkel 2012). Wat die impak op die stedelike ruimte sal wees, is tans onbekend. Dit is dus waardevol om die mate van stedelike verdigting te bepaal om ongewensde ruimtelike gevolge vir die nageslag te minimaliseer.

Deur kwantitatiewe data beoog die studie om te ontleed waar, tot watter mate en hoekom verdigting plaasgevind het in die area wat afgebaken word deur Merrimanlaan, die R44, die R310 en Simonsbergweg vanaf die jaar 2000 tot 2016. Die doel van die studie was om erwe te identifiseer waar verdigting plaasgevind het, om te identifiseer watter metodes geïmplementeer is om verdigting te bereik, om die verandering in verdigting te karteer, om bestaande beleidsdokumente met betrekking tot verdigting te identifiseer en terselfdertyd voorstelle te maak vir die verdigting en toekomstige groei van die dorp. Die studie fokus primêr op die verandering van residensiële verdigting, bv. waar daar ’n enkele woonhuis in die verlede was, is daar nou veelvuldige wooneenhede op dieselfde erf. Industriële en kommersiële eenhede word dus nie in berekening geneem nie. Die studie behels ’n literatuuroorsig, sowel as ’n samestelling van kwantitatiewe data wat deur die Munisipaliteit van Stellenbosch beskikbaar gestel is.

Die mate van verdigting is bereken deur die hoeveelheid wooneenhede te deel deur die hektaar land waarop die eenhede gebou is (du/ha = verdigting). Die bevindinge van die studie bewys dat verdigting ’n prominente rol gespeel het met betrekking tot al die sones in die studiegebied sedert die jaar 2000, met die uitsondering van Sones 16 en 30. As gevolg van verskeie faktore is die sones in die studiegebied ’n logiese keuse vir verdigting in Stellenbosch. Hierdie faktore sluit in nabyheid en die behoefte aan gemak, die bestaande infrastruktuur, die vraag en aanbod van behuising, asook die beskikbaarheid van grond en gevolglike ontwikkelingsgeleenthede. Die resultate dui voorts aan dat, alhoewel konsolidasie nie in al die gebiede plaasgevind het nie, konsolidasie steeds die prominentste metode van verdigting sedert 2000 was. Die tweede prominentste metode was die konstruksie van addisionele wooneenhede, gevolg deur die konstruksie van veelvuldige gekoppelde wooneenhede.

Die studie stel voor dat, alhoewel ruimtelike beplanningsbeleide vir Stellenbosch bestaan, dit nie altyd volledig is of ten volle afgedwing word nie. Die studie beveel aan dat die Munisipaliteit toepaslike grond vir verdigting identifiseer en dat enige Raadsgrond vir ontwikkeling en herontwikkeling van nuwe en bestaande geboue geïdentifiseer en beskikbaar gestel word. Waar moontlik moet beskikbare grond in lyn met die opgestelde beplanningstrategieë van toepassing op ‘n spesifieke area hersoneer word. Aansporings kan gebruik word as ’n instrument om ontwikkelaars aan te moedig om grond binne die ontwikkelingsriglyne te ontwikkel, soos voorgeskryf deur konteks-spesifieke beplanningstrategieë. Riglyne moet die holistiese beginsels van verdigting soos sosio-ekonomiese integrasie, gemengde gebruik, omgewingsbewustheid, volhoubare vervoer, toepaslike digtheid, gemeenskapsgevoel en funksionele uitvoerbaarheid in aanmerking neem.

Trefwoorde

Digtheid, Landgebruik, Residensiëel, Stellenbosch, Verdigting, Wooneenhede

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Acronyms

ANC	African National Congress
CBD	Central Business District
CCDP	City of Cape Town Densification Policy
CGA	Centre of Geographical Analysis
CITP	Comprehensive Integrated Transport Plan
CTDP	City of Cape Town Densification Policy
DA	Democratic Alliance
DDS	Draft Densification Strategy
DEADP	Department of Environmental Affairs and Development Planning
DFA	Development Facilitation Act
DOE	Department of Energy
DPH	Dwelling Units Per Hectare
DU	Dwelling Units
FAR	Floor Area Ratio
FSR	Floor Space Ratio
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning Systems
IDP	Integrated Development Plan
IP	Infrastructure Plan
IZS	Integrated Zoning Scheme
LDO	Land Development Objectives
LUMS	Land Use Management Systems
LUPA	Land Use Planning Act
MXD	Mixed Use Development
NEMA	National Environmental Act
OECD	Organization for Economic Co-operation and Development
OSR	Open Space Ratio
PPH	Persons Per Hectare
SDF	Spatial Development Framework
SU	Stellenbosch University
SPLUMA	Spatial Planning and Land Use Management Act

TOD	Transit Orientated Development
UGB	Urban Growth Boundaries
UN	United Nations
UN-Habitat	United Nations Centre for Human Settlements
USA	United States of America
VMT	Vehicle Miles of Travel
WCSD	World Commission on Sustainable Development
ZRS	Zoning Regulation Scheme

CHAPTER 1: RESEARCH CONTEXT

1.1 INTRODUCTION

According to the United Nations (UN), roughly three-quarters of the worlds' population will be living in cities by 2050 (United Nations 2010). The growth in urbanisation is evident when these figures are viewed against the comparative figures for the previous years. According to the World Bank (2016) and the United Nations Centre for Human Settlements (UN-Habitat), approximately 47% of the world's population lived in urban areas in 2000, while 53.4% lived in urban areas in 2014 (UN-Habitat 2001, 2004; World Bank 2016).

This is not a new trend. It is important to acknowledge that the world has been going through urbanisation for centuries, placing an assortment of pressures on the carrying capacity of cities to accommodate the rapidly growing number of urbanites (Gleeson 2012; UN-Habitat 2001, 2004). The economic shift from state-controlled to a more market-orientated economy in the past two decades resulted in many African cities facing rapid spatial expansion, coupled with population growth rates often greatly exceeding those of more developed regions (Arku 2009; Ballard 2004). It is inevitable that cities experience spatial expansion to accommodate growing population densities; however, it is believed that they grow too much spatially, or that growth is not managed in a sustainable manner (Behan, Maoh & Kanoroglou 2008; Holden & Norland 2005).

In addition, growing urban populations have inspired the efforts of urban planners towards strategies associated with urban infill, with the main aim to raise population density and concentrate people in proximity to urban services and amenities (Lin, Meyer & Barnett 2015). Considering these trends, the critical and growing importance of urban planning needs to be viewed against the backdrop that Breheny (1992) sketches, in that the world's cities can be seen as both the biggest source of pollution and waste as well as the largest consumers of natural resources.

Urban densification is a buzzword closely linked to the ideologies of new planning paradigms such as Smart Growth, New Urbanism and Compact Cities, which have been developed by scholars of planning and architecture who criticise the out-of-control suburban sprawl that is occurring in contemporary society (Jenks, Burton & Williams 1996; New Urbanism 2005; Sivam, Karuppanan & Davis 2012). It is believed that low-rise, high-density development is suited to and able to complement single dwelling residential development, as long as clever designs are implemented that suits the scale and height of a specific area (Williams 2000).

In Stellenbosch, South Africa, a once largely single residential area, the process of densification through the development of low-rise, high-density accommodation has become rampant in an attempt to accommodate an ever-growing student population. With both optimistic and pessimistic international attention being paid to the subject, densification in Stellenbosch demands in-depth research. It is necessary to shed light on the nature and extent of densification projects in the town in order to understand this planning strategy and analyse its effect on the town.

1.2 RESEARCH PROBLEM

There is a perpetual burden to supply accommodation to increasing population numbers in Stellenbosch. The most ideal way in which the property market is able to cater for this demand is through the development of low-rise, high-density accommodation (Donaldson & Morkel 2012). Densification is a national spatial strategy aimed at integrating cities socially and spatially (Stellenbosch Municipality 2012a). However, there is a notion that densification in Stellenbosch is implemented in an ad hoc manner due to the lack of adequate policies regulating development in the town and, where policies exist, that they are not enforced effectively (Donaldson & Morkel 2012). What the impact may be on urban space is not known yet. Thus, it was seen as valuable to determine the extent of urban densification in order to minimise undesired spatial consequences for future generations.

1.3 RESEARCH AIM AND OBJECTIVES

The study aimed to determine where, to what extent and why densification has taken place in selected areas of Stellenbosch from 2000 to 2016.

To achieve the research aim, the following objectives were set:

1. Identify properties, through municipal valuations, on which densification took place in the selected study areas between 2000 and 2016.
2. Identify the most prominent methods of densification in the selected study areas.
3. Map the change in residential density from 2000 to 2016 for each specific property in each of the different study areas.
4. Review the relevant policy documents and planning strategies for the area.

5. Make recommendations on the densification and future growth of Stellenbosch.

1.4 METHODOLOGY

As the study was primarily a desktop study, the first phase of the research process was to conduct a thorough review of the literature on the concept of urban densification. Quantitative data was obtained from the Stellenbosch Municipality and is discussed under the subheadings below.

1.4.1 Literature Review

The review of literature firstly entailed a comprehensive review of sustainable development and of design concepts that promote the principles of sustainable development. The vast extent of the available literature in this regard led to the identification of widely agreed upon sustainable urban forms and the positioning of urban densification within the planning realm. Furthermore, due to urban densification being rooted in a strong theoretical base, Chapter 3 focuses on the theory of urban densification from a design point of view, allowing for a more detailed understanding of urban densification in the built environment. A review of overarching policy documents related to urban densification in Stellenbosch was also undertaken.

1.4.2 Data

The study is based primarily on quantitative data, for which the extent of densification is calculated by dividing the number of dwelling units by the hectares of land (du/ha = density). To calculate real residential density, only the land pertaining to residential use was included, while the net residential density included the real residential area as well as half of the width of the internal access roads and public open spaces. Moreover, the gross residential density calculations included the entire area directly and indirectly serving the residential area under study. Commercial and industrial units were excluded from the study overall. Sites that were under construction were included based on the planned number of units. The subsections below describe the process of data collection and data analysis.

1.4.3 Data Collection

Initially, the researcher planned to investigate the building plan pertaining to each property in the study area. These documents usually provide all the information concerning the development of a property. However, in order to follow such a methodology, a personal approval letter from as well as a copy of the identity document of each of the property owners is required by law. Due to the practical implications relating to landowner privacy and time constraints, property valuation rolls were used as primary source of information, as these are more accessible to the public.

Data collection was a manual process of obtaining maps from various sources to identify the correct property numbers in the study area. The property numbers were used to extract quantitative data from the municipal valuation rolls relating to each of the properties. The quantitative data included property numbers, property sizes, building sizes and number of units. Municipal property valuations occur on a four-year basis with the latest valuation in 2013. Therefore, to obtain data for 2016, a process of ground-truthing was performed. Where there were discrepancies between the valuation rolls and the ground-truthing process, properties where analysed against diagrams provided by the Surveyor General at the Stellenbosch Municipality.

Data tables were constructed based on the information gathered, with density values added to each of the properties in the study area (Appendix D). These tables were used for the next phase, which was to map the data obtained from the various sources in order to provide a visual demonstration of how the study area has been influenced by urban densification since 2000. Based on the findings that emerged from the data, the study area was finally analysed in relation to the relevant literature that was reviewed during the first phase of the methodology.

Nominal data in the form of aerial photographs and shapefiles pertaining to the study area was gathered from the Centre of Geographical Analysis (CGA) at Stellenbosch University (SU). In addition, the PlanetGIS Explorer 5.0 Western Cape cadastral database was used to fill gaps in the database. Autodesk AutoCAD 2015 drawing software was used to consolidate all the various data sources in order to make a singular scaled map of the study area. Adobe Photoshop CC 2015 was used to add all the various data elements to the final maps and to demonstrate visually how the study area had been influenced by urban densification.

1.4.4 Data Analysis

The study primarily focused on changes in residential densities, e.g. where there was a single dwelling unit in the past there now are multiple dwelling units on the same plot. Therefore, the study disregarded any changes in density that was not related to residential land use, such as commercial uses or industrial uses.

In order to calculate real residential density, only the land pertaining to residential use was included, while the net residential density included the real residential area as well as half of the width of the internal access roads and public open spaces. Moreover, the gross residential density calculations included the entire area directly and indirectly serving the residential area under study.

The researcher disregarded any alterations to properties below 40 m^2. The reason for this is that changes of less than 40 m^2 to a property may be additions such as a swimming pool, a garage or a shed. This means that, although the properties experienced changes in floor area ratio, they were excluded from the study overall if these changes were smaller than 40 m^2. There were developments on properties that were mixed-use and therefore consisted of both residential and business units. In these cases, the business units were omitted from the study.

1.5 LIMITATIONS

There is much confusion in the literature concerning the definition and application of density measures and this may provide difficulty comparing the data provided in this study to that of other towns around the world. In addition, there are developments on properties that are of mixed-use and therefore consist of both residential and business units. This could influence the results, as the researcher excluded the business units from the calculation of density in such instances.

Concerning mapping and property number associations, neither the Municipality nor online sources provided updated and consistent maps containing the latest property numbers for each property. This meant that the researcher had to visit Surveyor General diagrams numerous times in order to make a map that contained the correct property number for each property. Furthermore, numerous people collect municipal valuation data, which presents a relatively high possibility of human error. To address this issue, the research adapted the data in accordance with the observed reality (ground-truthing) and the investigation of the Surveyor General diagrams, where necessary.

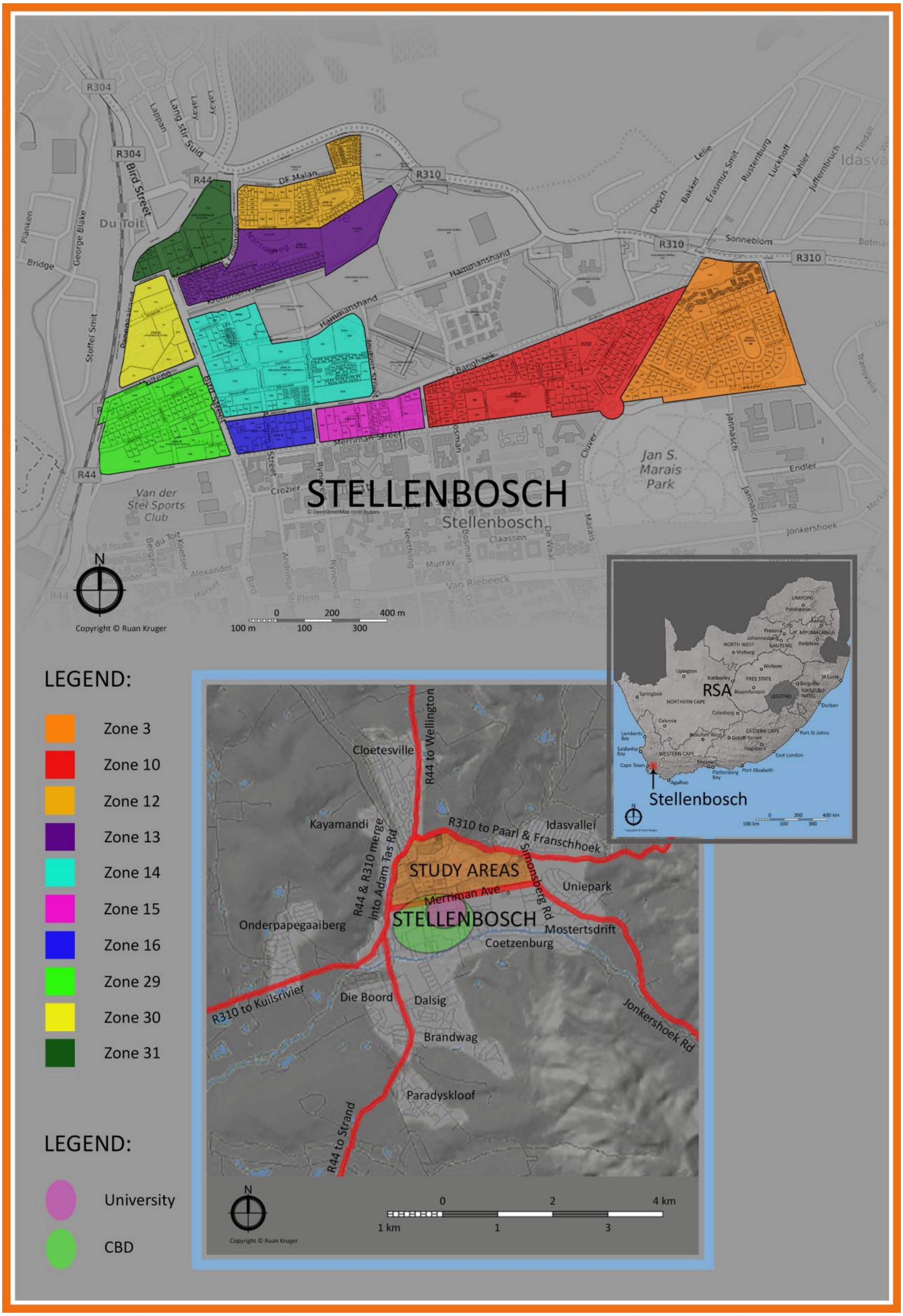
1.6 DESCRIPTION OF STUDY AREA

Founded in 1679, Stellenbosch is the oldest town in South Africa and is located in the Cape Winelands district, situated roughly 50 km from the City of Cape Town in the Western Cape province (Adendorff 2009). The urban fabric of the town is characterised by high-quality viniculture, street cafés, historical buildings and educational institutions. The economy of the town is moderately diverse and propelled by a flourishing tourism and agricultural industry, the university, global businesses and technological firms (Stellenbosch Municipality 2013).

In 2013, Stellenbosch had a population of 163 043 people, of whom more than 15 000 were students. This population figure is estimated to increase to 170 587 in 2017 (Western Cape Government 2014). Due to the strong institutional dominance in Stellenbosch, the town experiences great influxes of students to the town which, in addition to the general population growth, further increases the demand for accommodation. Therefore, the town is a trendy place for property development and attracts widespread investment (Stellenbosch Municipality 2013).

As the university is unable to cater for the total accommodation demand, the area is targeted by the private sector for densification through the redevelopment of single residential dwellings to dwelling types that serve higher densities (Benn 2010). However, Benn (2010) notes that the current state fosters social instability and a lack of community cohesion between students and permanent residents. Similarly, Donaldson and Morkel (2012: 64) note that modern consumer tendencies, the need for convenience, property rights and development pressures lead to unfitting and standardised building and space making and fear the loss of this unique sense of place due to “ad hoc” forms of densification occurring around the university’s campus.

The area under study is demarcated by Merriman Avenue to the south, the R44 (also known as Adam Tas) to the west, the R310 (also known as the Helshoogte Pass) to the north and Simonsberg Road to the east (Figure 1.1). According to the valuations department of the Stellenbosch Municipality, the area is demarcated into different valuation zones. It is important to note that this is merely a description of a specific area and is not related to the zones prescribed in the Stellenbosch Integrated Zoning Scheme (IZS). The municipal valuation zones were used due to the study focusing primarily on municipal valuation data. In addition, the proximity of the area under study to the university campus, the central business district (CBD) and major transit routes can be regarded as factors strongly encouraging densification and is therefore valuable for research purposes.



Source: Author (2016)

Figure 1.1 Study areas

With reference to Figure 1.1, Zones 12, 13 and 31 are also known as La Colline and Krommerivier. Zone 3 is also known as Simonswyk, Zones 29 and 30 are also known as Dennesig, Zone 10 is also known as Universiteitsoord or De Weides (referred to as Universiteitsoord in this study), and Zones 14, 15 and 16 are commonly referred to as Stellenbosch Central.

Zones 12, 13 and 31 (La Colline and Krommerivier) are roughly 1,5 km from the university and, being situated on a hill, overlook the town and the university campus (Property24 2015). The zone is characterised by a few gated complexes and some sectional title blocks, as well as full-title semi-detached dwellings constructed in the 1940s (Property24 2015). According to the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c), this area comprises educational, residential, general residential, general business and public open space zones.

Zone 3 (Simonswyk) is historically a middle-class former whites-only neighbourhood and, according to the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c), the area is currently zoned as residential, with a small portion of general business zoning and some public open space. The area consists of student housing, permanent residences, high-density housing, guesthouses, university-owned property and green space, among others (Benn 2010).

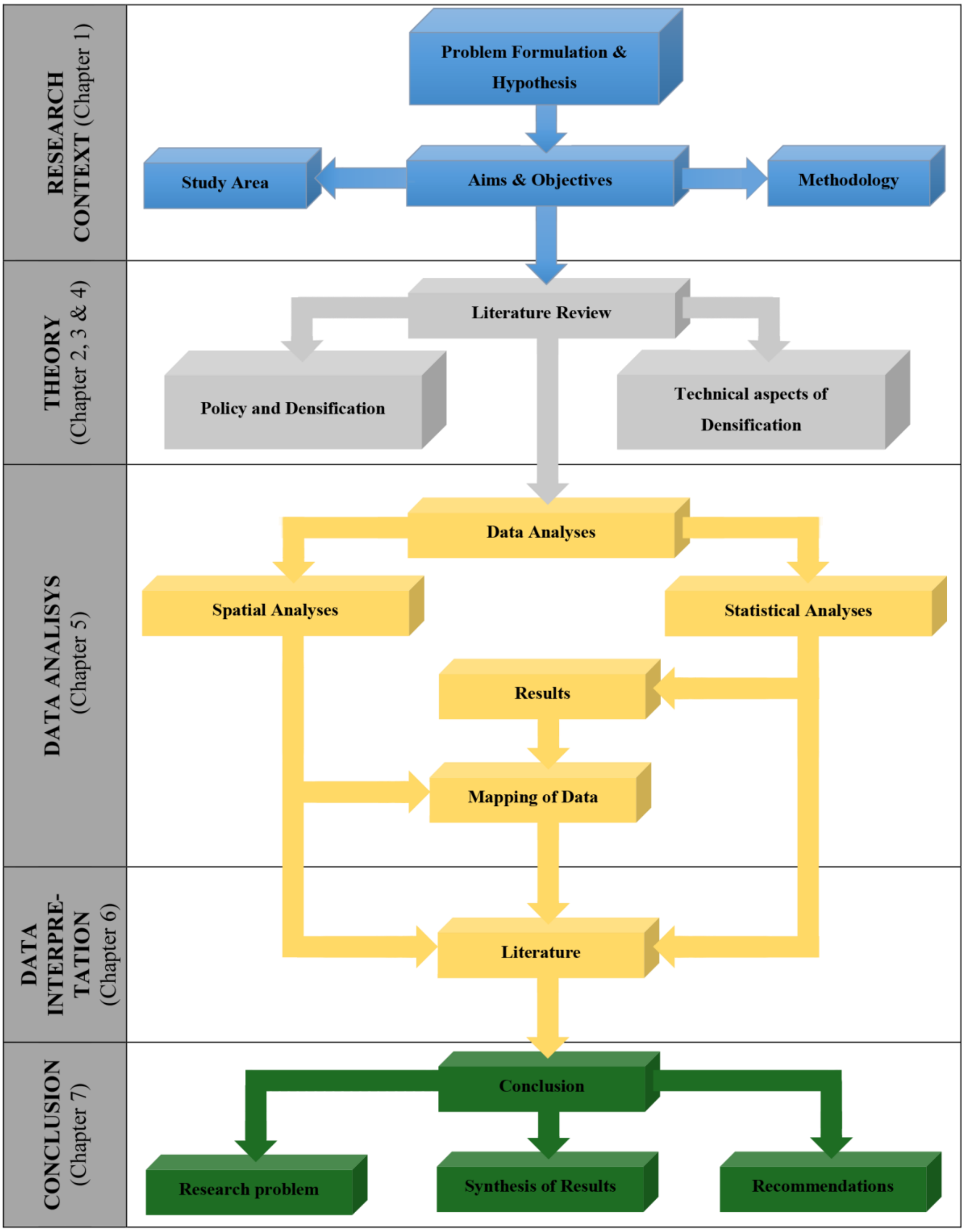
Zones 29 and 30 (Dennesig) are situated on the southern side of Bird Street and consist of single residential units as well as low-rise, high-density apartment blocks, mixed-use developments (MXDs), open space and some business areas. According to the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c), this area comprises residential, general residential, general business, light industry, utility services, a community zone and public open space zones.

Zone 10 (Universiteitsoord) has been greatly altered over the last decade because of escalating property values that invigorated property sales. In addition, densification was encouraged by the constant influx of student populations seeking accommodation close to campus and the area's centrality in relation to the CBD, the main campus and major transit corridors, such as the Cluver/Merriman link (Stellenbosch Municipality 2009). Consequently, the area was identified as a densification zone by the Municipality, which has been an influential feature in the rezoning and change of land use in the area (FishTank Consultants 2012). Zone 10 was rezoned from residential to general residential, which promotes densification through the construction of multiple flat developments and boarding houses (Benn 2010). The area also consists of general business zoning, community zoning and public open space (Stellenbosch Municipality 2012c).

Concerning Zones 14, 15 and 16 (Stellenbosch Central), mixed zoning regulations pertain to the areas. The area can be regarded as a hub of activity because of its proximity to the university campus and its situation in the middle of the surrounding residential neighbourhoods. According to the Stellenbosch Municipality (2012c), a small portion of the area is zoned for residential and general residential use. The remaining zones in the area are general business, educational, utility services and public open space.

1.7 RESEARCH DESIGN

Figure 1.2 provides a breakdown of the research phases, each consisting of several components, which together form the research design.



Source: Author (2016)

Figure 1.2 Research design

CHAPTER 2: REVIEW OF LITERATURE

2.1 INTRODUCTION

The chapter focuses on the literature regarding urban densification and related concepts in an attempt to provide clarity in terms of densification and how it is experienced across the globe. The chapter starts by seeking to explain the shift from uncoordinated growth patterns to a more organised arrangement of urban development. Therefore, attention is focused on the phenomenon known as urban sprawl, which can be regarded as an initiator of sustainable development thinking and design and consequently the introduction of unban densification into planning policy and practice.

2.2 TOWARDS AN ORGANISED ARRANGEMENT OF DEVELOPMENT

The following section aims to provide a juxtaposition between developed and developing countries and their efforts towards a more organised arrangement of development.

2.2.1 Cities in the Developed World

Efforts in the United States of America (USA) to achieve a more organised arrangement of urbanisation rest on the belief that growth has gone amiss, although in many developing cities, uncoordinated and unplanned growth is a reality and has resulted in many unwanted urban features, such as a lack of basic services, overcrowding and congestion (Arku 2009; Brueckner 2000). Similarly, European planning policies of the 1990s, such as the "Green Paper on the Urban Environment (1990)" and the "Strategy for Sustainable Development (2001)", reflect the debate on unmanaged growth, regarding it as both detrimental to quality of life and economic sustainability (Arku 2009: 257).

Moreover, cities in North America have experienced dramatic changes over the last century. According to Behan, Maoh and Kanoroglou (2008), extensive transit networks have made once inaccessible places accessible, creating a decentralised population structure and changing the urban fabric from the traditional urban centres to present suburbia. These authors argue that decentralised population patterns create polycentric sprawls as opposed to monocentric communities (also see Jabareen 2006; 2013). Hamilton, Ontario is an example of a city in which sprawling development is largely attributed to the decentralisation and urban decline of the city, which in turn create massive challenges for transportation planners (Behan, Maoh & Kanoroglou 2008).

The idea of concentrated urban development has been evident throughout the history of Dutch spatial planning (Van der Waals 2000). The idea rested mainly in the social and economic situation in cities and the conservation of open space (Van der Waals 2000). By the end of the 1980s, environmental consciousness had grown, particularly in the reduction of automobile dependency, and it formed part of policy soon after (Van der Waals 2000). In the 1980s the government shifted from concentrated urban development to the compact city policy (Van der Waals 2000).

A prominent feature in the Dutch planning system is national government's involvement in the planning process. The Environmental Act that was passed in 2014, for example, introduced a trickle-down planning structure, with fewer rules, better legislation and more space for development. The intent was to simplify decision making across government sectors, following the motto "decentralise if possible, centralise if necessary", which allows for better progression of development opportunities and greater stakeholder participation in spatial development (Vink & Van der Burg 2012: 41). Unlike many developing countries, the Dutch government takes responsibility for designating locations for new developments and the provision of subsidies encouraging spatial and infrastructure development (IES s.a.; Needham 2005).

North America and Europe reflect similar patterns, even though there are differences within their geographical, institutional and policy approaches. North American cities have lower population densities and are more spread out than European cities. Car ownership is higher in North America than in Europe. Mileage per vehicle is also higher, and the use of energy per capita is double that of the Europeans. Intercity passenger rail is very important in Europe and almost non-existent in North America. This is in contrast with air transport, which is more important in North America than in Europe. With the exception of the largest Canadian and US cities, urban public transport in Europe is superior to that of North America. In terms of clean air legislation, North American cities are more advanced than most European cities (Greene & Wegener 1997).

2.2.2 Cities in the Developing World

With regard to developing countries it is evident that cities are expanding rapidly as a result of their high economic and rural-urban migration growth rates (UN-Habitat 2004). Thus, cities in developing countries are facing enormous challenges concerning housing, infrastructure and poverty (Dave 2011). Due to a dominant Western and Anglo-American influence, developing countries strive to compete with the criteria of global, which are often criticised for their emphasis on economic measurements (Lemanski 2007). Dave (2011) notes that the economic growth rates in many developing cities can be detrimental, as they stretch the divide between rich and poor. He therefore states that social sustainability should enjoy the same attention as economic and environmental sustainability in the context of developing countries in particular.

Although some non-Western global cities, like Mexico City, Sao Paulo, Singapore and Hong Kong, have reached global city status in some way or another, this success is based predominantly on economies of integrated networks and capital flows derived from Western and Anglo-American values (Lemanski 2007). Lemanski (2007) blames the ethnocentrism of the global city criteria for misleading many developing countries' expenditure in terms of resources in the global economy to achieve externally determined standards, often to the detriment of greater domestic concerns. Therefore, a more south-centric understanding of urban success is necessary, as many poorer cities are vital to the global economy in some way or another (Lemanski 2007).

Throughout the literature there is a great deal of concern about whether or not urban form can influence the sustainability of cities. The core topic of this debate revolves around energy consumption and urban form, with a specific focus on transport and transit use (Anderson, Kanaroglou & Miller 1996; Bannister 1992; Breheny 1996; Himanen, Lee-Gosselin & Perrels 2005; Holden & Norland 2005; Hong & Shen 2013; Jenks, Burton & Williams 1996; Newman & Kenworthy 1996). Apart from disagreements by authors such as Thomas and Cousins (1996), Simmonds and Coombe (2000), Boarnet and Crane (2001) and Neuman (2005), there is ample literature in support of the opinion that urban form is crucial in promoting sustainable development (Dantzig & Saaty 1973; Jenks, Burton & Williams 1996; Williams, Burton & Jenks 2000a).

According to Broitman and Koomen (2015), two prominent types of development occur because of increasing population densities and urbanisation, comprising firstly, the development of new buildings within the existing built-up areas, and secondly, the building of new developments in vacant areas or on vacant land (also see Arrigone 1995; De Klerk 1998). In the urban context, the former is usually referred to as the compact city (densification), while the latter takes the form of urban sprawl or the green/dispersed city (Broitman & Koomen 2015; Holden & Norland 2005).

Holden and Norland (2005) mention two prevailing issues regarding the discourse on the compact city and the dispersed city: firstly, which urban form is the most energy efficient form and secondly, which feature of sustainable development is the most valued? According to Williams, Burton and Jenks (2000b), Van der Waals (2000) and Neuman (2005), there is a gap in the knowledge regarding the complexities of different urban forms and the impact each of them may have. Nevertheless, the rationalisation for the compact city rests mainly on the fact that it promotes the least energy-intensive activity patterns as opposed to the green/dispersed city, and therefore the assumption holds that it is more sustainable than the dispersed city (Holden & Norland 2005).

2.3 URBAN SPRAWL AND DENSITY

Urban sprawl or expansion is a phenomenon that has grown in awareness and concern in cities and states across both northern America and Europe since early in the 20th century. Those in favour of the dispersed city suggest a more open type of urban structure, also referred to as the green city (Holden & Norland 2005). Earle Draper, a town planner in the south-eastern United States, first used the concept ‘sprawl’ in 1937, and discussions on the relationship of sprawl with income and transport were ignited not long after (Nechyba & Walsh 2004).

The perception among economists is that spatial growth is driven by three underlying forces, namely increasing household income levels, increasing populations and transportation developments (Mieszkowski & Mills 1993). Dieleman and Wegener (2004) affirm that urban sprawl is the result of a combination of increasing prosperity, a rapid increase in personal mobility due to the automobile, and changing livelihood patterns. Gordon and Richardson (1997) blame advances in telecommunications and information processing for the diffusion of populations and economic activities. Behan, Maoh and Kanoroglou (2008) mention the term job suburbanisation, which entails the transfer of employment to the suburbs. They argue that this is caused partly by changes in transport modes in past years, from shipping and rail to more cost-effective modes such as trucks.

Broadly defined, urban sprawl is development planning that results in undesirable urban features. Some of these features include leapfrog expansion of new, low-density developments and the spatial expansion of cities, often in an outward sprawling fashion. This consumes valuable land of agricultural importance and for open space, increases transit distances, and the latter is accompanied by increases in air and noise pollution and increases in service costs, none of which encourage a good quality of life (Arku 2009; Camagni, Gibelli & Rigamonti 2002; Coppola 2012; De Klerk 1998; Dieleman & Wegener 2004; Loibl & Toetzer 2003; Neuman 2005; Zhu 2012). In addition, Brueckner (2000) claims that urban sprawl can be seen as the extreme spatial growth of cities, with the emphasis on extreme. Carlow (2014) notes that sprawling developments result in an exponential increase in the resource consumption of fossil fuels for motorised transport, heating and cooling of non-compact developments, the social and economic issues that result from a lack of connectivity and isolation, and the deterioration of land. Turok (2011) mentions the negative impact on financial resources related to the delivery of bulk infrastructure and long-distance commuting as a consequence of sprawl, which affects overall productivity.

In contrast to scholars who oppose urban sprawl, such as Dantzig and Saaty (1973), Thomas and Cousins (1996) support a more dispersed form of development within cities. According to them, not only does such development have the potential to foster settlement patterns in line with popular aspirations and environmental sustainability objectives, but it also holds the potential to satisfy the demands of the economic market, which in turn may encourage greater political buy in (Thomas & Cousins 1996). Therefore, they argue that the characteristics of a compact city should be linked to accessibility for all, compactness in relation to scale and an increased consciousness of wildlife (Thomas & Cousins 1996).

Cities have the potential to be extremely efficient when residents are living close to one another. The delivery of services such as water, transportation, sanitation, education, healthcare and other social and cultural services becomes easier to provide and maintain (Anderson, Hooper & Tuvshinbat 2016; Arku 2009; Jabareen 2006; World Bank 2016). However, with the inevitable growth of cities, the expense of meeting basic needs increases and so does the impact and dependence on natural resources and the environment (World Bank 2016).

As a result of this ongoing urban sprawl phenomenon, cities and their planners have been forced to adapt their strategies and identify design types, e.g. urban densification, that are able to facilitate rapid influxes of people seeking livelihood opportunities within and around city centres (Neuman 2005; Sivam, Karuppanan & Davis 2012). Urban densification is a catchword closely linked to the ideologies of planning paradigms such as the compact city policy developed in Europe, and new urbanism and smart growth developed in northern America (Dieleman & Wegener 2004). These paradigms, developed by planners and architects, criticise the out-of-control suburban sprawl that is occurring in contemporary society and promote government regulation of urban land (Dieleman & Wegener 2004; Jenks, Burton & Williams 1996; New Urbanism 2005; Sivam, Karuppanan & Davis 2012).

Authors in defence of the phenomenon of urban sprawl believe that low-density, sprawling developments hold benefits for stakeholders, such as cheaper land and housing options because of being outside of the city centre (Gordon & Richardson 1997; Kahn 2001). Nevertheless, rapid expansion and urban growth that consume natural resources increase the constraints on and challenges of sustainable development.

2.4 DESIGN CONCEPTS OF SUSTAINABLE URBAN FORMS

With the rise of sustainable development as an issue in the 1980s, scholars quickly ventured into discussions about the form of cities and began investigating new settlement forms and configurations that allow the built environment to function in a more constructive fashion, thereby being less consumptive and less polluting (Jabareen 2004; 2006). According to Yeh and Li (2000), there is ample evidence of a solid yet multifaceted relationship between urban form and sustainable development. They note a strong connection between the physical characteristics of cities, such as size, density and quantity of open space and energy use in transport. Since the recognition of sustainable development, the debate in the urban context has revolved mainly around the concentration or dispersal of urban development (Zhang 2000).

2.4.1 Sustainable development

The most popular definition of sustainable development was first documented by the World Commission on Sustainable Development in the 1987 Brundtland Report. The Commission defined sustainable development as development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCSD 1987: 8). According to Odeh (2010: 344), sustainable development “is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations”. The concept provides basis for the reconciliation and expansion of the general goals of economic development, social development, safety and security and environmental protection (Dernbach 2005).

Carlow (2014) has an interesting way of explaining the relationship between urban form and sustainability. She argues that space should be seen as a natural, non-renewable resource in the same light as one would look at gas or oil. In this sense, the output and use of space should be managed and preserved and not exploited. Thus, restricting the expansion of the built environments’ footprint in urban areas compels this resource to be used more efficiently, and in more productive and creative ways. Furthermore, she notes that spatial constraints in urban areas result in various forms of densification within the existing urban area and encourage innovative uses and arrangements of urban development while acknowledging the hazards of dense urban environments.

Carlow (2014) furthermore notes that poverty contributes to environmental degradation and that environmental protection is more likely to be accomplished when it is combined with economic development where financial resources are scarce. She argues that the greater efficiency and conservation that are required for sustainable development will be more likely when they are more economically attractive than the existing high levels of materials and energy consumption.

While the application of sustainability varies, it is widely agreed amongst disciplines that sustainability aims to decrease greenhouse gas emissions, enable people to live harmoniously within natural ecosystems and encourage a shift towards becoming self-sufficient in terms of the production of energy, food and a good quality of life (Beatley & Newman 2009).

Jabareen (2006) developed a thematic analysis instrument that draws data across various specified fields throughout literature identifying similarities and relationship patterns. Using this instrument, it is possible to identify recurring concepts and themes of significance such as compactness, sustainable transport, density, mixed land uses, diversity, passive solar design and greening (Jabareen 2006). Based on the findings, the author will discuss the design concepts that draw most attention in the literature, followed by a discussion on widely accepted sustainable urban forms.

2.4.1.1 Compactness

Compactness of the built environment is a commonly trusted method that is widely believed to achieve more sustainable urban forms. According to the World Bank (2016), cities have the potential to be extremely efficient when residents are living close to one another. In this regard, Elkin, McLaren and Mayer (1991) argue that the compactness of urban space reduces the cost, time and energy consumed in the transportation of goods, services and people. According to Wheeler (2002), compactness also refers to connectivity, which implies that forthcoming development should be focused around the existing built environment. Duany and Plater-Zyberk (1992), Jenks, Burton and Williams (1996) and Zhu (2012) argue that a sustainable city should be compact, dense, diverse and highly integrated. They suggest an urban form that is large enough to provide a rich urban life in terms of opportunities and services, but small enough to be walkable without having the desire for a private vehicle.

Jenks (2000) discusses the intensification of land as a general tool used for compactness, including the revitalisation of existing infrastructure, the development of urban land that was previously undeveloped, and additions and extensions as well as subdivisions and conversions. According to Jabareen (2006), the logic on which intensification rests is that it consumes land in a more efficient manner by raising the concentration of development and activity.

Williams, Burton and Jenks (2000a) note four recurring themes in the debate on compactness as a method for achieving sustainable urban forms. Firstly, a compact city goes hand in hand with rural conservation. Secondly, a compact city is associated with the promotion of quality of life, which is related to the degree of social interface and access to facilities and services. The third theme relates to the reduction of energy consumption because of building density, and the fourth to the reduction of CO_2 emissions through advancements in modes of transport.

Compactness has a strong relationship with liveability and aims to reduce traveling, which, according to Sherlock (1990), is one of the most inefficient and challenging features of contemporary urban living. According to Elkin, McLaren and Mayer (1991), a sustainable urban form entails a form and scale that encourage non-automotive means of transport, such as walking, cycling and efficient public transport, along with densities that encourage social interaction. Therefore, compactness is arguably one of the more superior methods to achieve sustainable urban forms.

2.4.1.2 Sustainable transport

According to Barrett (1996), the structure of contemporary cities resembles the dominant transport technologies that were present during their development. Transportation is a massive inspiration for growth and, without it, neither trade nor cities would exist, as global economies rely on trucks, railway, freight and cars for the transfer of goods and services and people (Greene & Wegener 1997: 177).

Jordan and Horan (1997: 72) define sustainable transport as “transportation services that reflect the full social and environmental costs of their provision; that respect carrying capacity; and that balance the needs for mobility and safety with the needs for access, environmental quality, and neighbourhood liveability". Himanen, Lee-Gosselin and Perrels (2005: 23) say sustainable transport "can be understood as a transport system that in itself is structurally viable in an economic, environmental and social sense, and does not impede the achievement of overall sustainability of a society". According to Steg and Gifford (2005), sustainable transport involves seeking a balance between its social, economic and environmental functions. They further note vagueness with regard to which social, economic and environmental functions should be balanced or emphasised. Although there is a lack of agreement on the definition of 'sustainable transport', the notion is that the current tendency in world transport is unsustainable (Greene & Wegener 1997; Steg & Gifford 2005).

Transport is at the core of the environmental debate and continues to be challenging for advancements in sustainable development (Goldman & Gorham 2006; Jenks, Burton & Williams 1996). Goldman and Gorham (2006: 262) note that "travel is increasing in virtually all regions of the world, usually at or faster than the rate of economic growth, and generally faster in the long run than the rate of reduction of energy and pollution intensity".

In addition, Bannister (1992) affirms the growth of the transport sector and notes specific increases in energy consumption for road and air transportation, not to mention the subsequent economic and environmental challenges. Newman and Kenworthy (1999) similarly blame the car for the decentralised nature of the modern metropolis. Hillman (2003) adds that increased car ownership and the planning alterations that accompany this reflect the current geographical dispersion of patterns and activity. Bannister (1992) has mentioned that motorised transport contributes significantly to emissions of carbon monoxide, hydrocarbons, nitrogen oxides and carbon dioxide in the UK and is generally associated with trends in energy depletion and environmental pollution.

Many policies have been proposed to potentially achieve a more sustainable transport system. For example, Mexico City, a notoriously smoggy capital, recently declared the worst air quality crisis in more than a decade. Interestingly, the government's response was to order all cars to remain idle for at least one day of the week. They also limited the amount of waste coming into the city from bordering states. However, car restrictions are their dominant focus to solve the air quality problem (Phys.org 2016).

Steg and Gifford (2005) distinguish between behavioural and technological changes aimed at more sustainable transport. They mention that behavioural changes target the level of car use, while technological solutions target the negative impact per car and per kilometre. Behavioural changes include changing destination choices, shifting to more environmentally friendly modes of transport, combining trips, including more people in one car or reducing travel. Technological solutions include advancements in technology, for example in the type of road surface used to reduce noise pollution or more energy efficient models.

In addition, transit-orientated development (TOD) is a popular strategy aimed at curbing sprawl and the subsequent automobile dependency it creates (Cervero & Sullivan 2011). TOD is typically a display of mixed land uses including retail, office and residential apartments and generally comprises medium- to high-density areas aimed at maximising access to public transportation (Holmes & Van Hemert 2008).

As mentioned above, regardless of efforts towards sustainable transport, it is widely argued that current trends in transport are not sustainable (Greene & Wegener 1997; Steg & Gifford 2005). The preferential use of the car continues to overshadow technological solutions, therefore it is important to educate and inform the masses in order to influence behavioural changes and strive to achieve less automobile-dependent modes of travel (Steg & Gifford 2005).

2.4.1.3 Density

Density can be defined as the ratio of dwelling units or people to a given land parcel and is a crucial aspect in the debate on sustainable urban form (Davis 1977). Density is based on the idea of viable thresholds, which means that urban functions and activities become viable at a certain density threshold due to the generation of interactions (Jabareen 2006). Where density measures are applied, they aim to generate, alternate or otherwise influence the form of the built environment (Alexander, Reed & Murphy 1988).

With the inevitable growth of cities, the expense of meeting basic needs increases, and so do the impact of and dependence on natural resources and the environment (World Bank 2016). According to the World Bank (2016), cities have the potential to be extremely efficient when residents are living close to one another. The delivery of services such as water, transportation, sanitation, education, healthcare and other social and cultural services becomes easier to provide and maintain (Arku 2009; Jabareen 2006; World Bank 2016). In addition, Younger *et al*. (2008) note that interventions aimed at increasing public transit, green space and density hold substantial co-benefits through encouraging physical activity and cutting air pollution.

Quastel, Moos and Lynch (2012) note that North American planning policies have been dominated by the notion of 'sustainability-as-density'. The concept was formed on principles of mixed, walkable, all-inclusive communities, employment close to housing and the conservation of green space. According to Carlow (2014), densification tactics can be seen as using space to its full potential. Yeh and Li (2000) argue that compact forms of development have the potential to preserve prime agricultural land, conserve energy, lower development costs and stimulate greater sustainable development. Scholars such as Duany and Plater-Zyberk (1992), Jenks, Burton and Williams (1996) and Zhu (2012) argue that compaction and higher densities encourage community-orientated social patterns and that these are an effective means of making cities sustainable. Carl (2000) proves the importance of density, arguing that sustainable cities are a matter of density.

According to Davis (1977), the negative effects of high density, such as overcrowding and crime, are proved to be merely a matter of perception, as there is no evidence connecting such issues to density. He notes that the way the urban fabric of an area is structured has an influence on the perception of density, as some areas may appear relatively uncrowded, yet reveal very high densities and vice versa (Davis 1977). Furthermore, density is commonly related to slums, although some of the most elegant neighbourhoods in the United States display very dense living conditions, e.g. Brooklyn Heights, New York (Davis 1977; Zhu 2012). In contrast to the American metropolis, European countries are denser and are often lauded for their ability to balance urbanity and density by managing to make the urban texture appear less intense (Davis 1977).

Jabareen (2006) notes that density is the core feature accompanying transit use. In addition, as density escalates, car ownership decreases and therefore car travel (measured by per capita vehicle miles of travel (VMT)) also decreases (Jabareen 2006). Holden and Norland (2005) support this by arguing that the degree of daily travel reduces in densely occupied areas.

However, the OECD (2012) questions whether the compact city policy actually translates into concrete, beneficial outcomes for urban sustainability. For example, interventions that promote the intensified use of the built-up area often result in increased air pollution, traffic congestion and associated noise, insufficient affordable housing, neglect of green space and little or no vegetation in cities (Greene & Wegener 1997; OECD 2012). Similarly, Holden and Norland (2005) note that decentralised patterns of development could potentially decrease energy consumption in households. They argue that private gardens as opposed to high-density living reduce the urge for leisure travel by plane, which is usually the highest in central urban areas because of high densities.

2.4.1.4 Mixed land uses

There is much agreement among planners and scholars that mixed land use play a vital role in promoting sustainable urban form (Jabareen 2006, Musakwa & Van Niekerk 2013). For centuries, the integration of business facilities, multi-family and single-family housing has allowed people to walk to a variety of close-to-home destinations (Brown *et al.* 2009). However, with the dawn of Euclidian zoning in the United States, this practice has been prevented through the separation of land use opportunities and has given rise to modern health and environmental problems, such as a less active population and vehicle pollution (Brown *et al.* 2009).

It can be argued that mixed-use development has experienced a renaissance to some extent. Buildings were traditionally constructed on the basis that people lived atop shops and businesses; however, over time, mixed-use development (MXD) faded and the residential monofunctional sector flourished. However, MXD has become popular once again and there is a growing debate on residential over retail in the mixed-use arena (Garris 2006).

In addition, Garris (2006) mentions that the mixed-use method is increasing in popularity in U.S. downtowns and notes mixed-use trends in hospitality facilities, shopping malls, office parks and university campuses. Cervero (1988) mentions that MXD has the potential to decrease automobile trips and crowding levels. For example, if one area was devoted to several activities there would be less travel than if that area was devoted to a single activity. Jabareen (2006) confirms this, arguing that heterogeneous or mixed-use zoning permits harmonious land use to form agglomerations of activities in close proximity to one another and subsequently reduce travel distances. Furthermore, with the mixing of retail, office and other land uses, travel excursions are usually more dispersed throughout the day, in contrast to single function land uses and the associated peak hours (Cervero 1988). Apart from the numerous transport advantages, MXDs have the potential to refresh suburban work environments that have become somewhat sterile and undistinguishable by adding activities and attracting feet (Cervero 1988).

Sean Davis (in Piell 2009: 57) believes that MXDs are much more attractive to the market place and claims:

> it's got that 24/7 feel, where you can walk from your residence and get on the street, and you can go shopping and go to the bar or the restaurant, and you don't have to get in your car. It's got a lot more curb appeal.

Furthermore, the diversification of uses contributes greatly to efficiency. For example, land consumption levels are much more significant with traditional horizontal mixed-use communities opposed to vertically layering the uses and generating higher residential and commercial densities (Piell 2009). The study of Cassidy (2007) emphasises MXDs as the most appealing retail property option for new and redevelopment programmes between the retail developers included in the study.

2.4.1.5 Diversity

It is widely agreed that diversity of activity is a crucial aspect for achieving the sustainability of cities and promoting additional, desirable urban features (Jabareen 2006; Jacobs 1961). According to Jabareen (2006), diverse development entails a variety of building, housing options, land use, rents and architectural designs. Jane Jacobs (1961) highlighted the concept of diversity in her book, *The Death and Life of Great American Cities.* She wrote:

> In dense, diversified city areas, people still walk, an activity that is impractical in the suburbs and in most grey areas. The more intensely various and close-grained the diversity of an area, the more walking will occur. Even people, who come into a lively, diverse area from outside, whether by car or by public transportation, walk when they get there. (Jacobs 1961: 230).

Another prominent study relating to diversity is Richard Florida's development of creative class theory. The theory argues that certain groups of people, the so-called creative class, are attracted to urban economies because they are tolerant, diverse and open to creativity. This enables the growth of the urban economy (Hackler & Meyer 2008). According to Jacobs (1961), tolerance is only possible when the streets of great cities allow strangers to dwell in peace together. Wessel (2009) furthers this notion by arguing that cities that do not have a diversified street life would drive social and ethnic groups apart, people would easily fall prey to prejudice and little or no intergroup contact will exist. In addition, Wheeler (2002) mentions that uniformity of the built environment results in unattractive, uninteresting urban settings, segregation of class and ethnic groups, limited housing options for different income groups and job-housing inequalities that result in higher levels of congestion, car dependency and pollution.

2.1.4.6 Passive solar design

Passive solar design entails innovative ways to enhance the suitability and comfortability of a specific environment through quality design layout and fabric choices (Patino 2014). According to the U.S. Department of Energy (DOE 2001), buildings can be designed so that windows, walls and floors can collect, store and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is referred to as passive solar design or climatic design because, unlike active solar heating systems, it does not involve the use of mechanical and electrical devices such as pumps, fans or electrical controls to move the solar heat (DOE 2001).

Passive solar architecture makes use of building elements to capture and store energy, as windows are designed for solar gain, daytime lighting and ventilation, while overhangs, fins and shading are designed for solar cooling (Bainbridge & Haggard 2011). A good example of contemporary passive and active solar design is Rolf Disch's Das Sonnenschiff (the sun ship) neighbourhood in Freiburg, Germany. The 53-unit mixed-use development built in 2004 uses large solar photovoltaic panel overhangs to provide shade and collect sunlight during the summer, while allowing light to enter and heat to be collected during the winter (Patino 2014).

Anderson and Michal (1978) note that the debate on energy conservation in buildings is often limited to the reduction of energy consumption, regardless of whether it is renewable or non-renewable. They argue that, although solar energy influences the reduction of fossil fuels, it is not considered a feature of energy conservation (Anderson & Michal 1978). Nevertheless, Bainbridge and Haggard (2011) state that energy consumption in buildings can be reduced by 80 to 90% with no additional cost merely by utilising integrated design principles. In addition, Ritzen *et al*. (2016) believe that the operational energy demand in existing buildings can be reduced by simply adding energy-generation mechanisms and insulation packages.

2.1.4.7 Greening

Greening is also referred to as green urbanism and has presented itself as a vital design concept for sustainable urban form since the 1990s (Jabareen 2006; Lehmann 2010). According to Lehmann (2010), green urbanism is a theoretical urban design model that encourages compact energy-efficient urban development with zero waste and zero emissions.

Newman (2010) refers to green urbanism as settlements that are smart, secure and sustainable. He cites seven different types of cities to describe features of green urbanism. They are the renewable city, the carbon-neutral city, the distributed city, the biophilic city, the eco-efficient city, the place-based city and the sustainable transport city. According to Newman (2010), there is no city that portrays all seven features; however, there are cities that are progressing in one or two of these aspects.

Cervero and Sullivan (2011) discuss the sustainability potential of combining green urbanism and TODs. In Sweden, Germany and Australia, this combination has resulted in a decline in car-orientated suburban development and a decrease of up to 30% in carbon emissions and energy consumption (Cervero & Sullivan 2011).

2.5 SUSTAINABLE URBAN FORMS

Countries across the globe have reacted to the complications associated with rapid urban growth and land-consumptive development patterns by developing a wide range of policy instruments designed to manage urban growth. The following urban growth management theories have been developed in an attempt to guide urban development towards achieving the most desirable sustainable urban form possible. These forms offer variations in their principles, and simultaneously reflect a culmination of experiences gained from past generations and theories.

2.5.1 Neo-traditional development

Neo-traditional development is a North American response to traditional auto-dependent suburbs aimed at encouraging pedestrian-based developments that are of mixed use and in which a sense of community can be fostered (Bohl 2000; Duany & Plater-Zyberk 1992; Goffman 2011; New Urbanism 2005). New urbanism and TODs are the most influential among neo-traditional approaches to planning and development (Jabareen 2006).

New urbanism is patterned on American small-town planning from past generations to produce neighbourhood forms that consist of diversity in terms of housing options, instead of creating superblocks or suburbs (Bohl 2000; Goffman 2011). As Wheeler (2002) points out, the most attractive and vibrant districts are usually based on 19^{th}-century neighbourhoods with a variety of building types and diverse land uses.

New urbanism criticises current sprawling development patterns and emphasises citizen participation in the planning process. New urbanism encourages the integration of public and private space and emphasises the importance of the neighbourhood (New Urbanism 2005). The neighbourhood should be designed to be attractive, compact and to encourage diversity of housing types, with the mixing of business and public open spaces to create a central public hub that promotes walkability and the interaction of residents. This type of urban form reduces the use of private transport and the incidence of sprawl and encourages the use of public open spaces (Audirac & Shermyen 1994; Duany & Plater-Zyberk 1992; Fulton 1992; Goffman 2011; New Urbanism 2005).

However, it is argued that there is a gap between the aspirations of new urbanism and its reality in practice. Beatley (2000) criticises new urbanism for displaying little interest in the constriction of its ecological footprint or encouraging ecologically sustainable lifestyles. In addition, Nasar (2003) found a positive correlation in that higher densities and MXD result in decreasing automobile use although the scenario did not necessarily translate into a stronger sense of community as emphasised in neo-traditional objectives.

TOD is another prevailing concept in neo-traditional development. TOD is a pattern according to which developments are planned, with the emphasis on proximity and reliance on high–frequency transit (Holmes & Van Hemert 2008). TOD is typically a display of mixed land uses, including retail, office and residential apartments and usually comprises medium- to high-density areas aimed at maximising access to public transportation (Holmes & Van Hemert 2008). Over the years, numerous ideas, such as transit villages, transit-supportive development and transit-friendly design, have emerged around the concept (Bernick & Cervero 1997). All these ideas have mutual features, such as development that is in close proximity to and that inspires the use of transit facilities, as well as being MXD.

In terms of sustainable urban form, neo-traditional development highlights certain features of sustainability. Neo-traditional development encourages higher residential densities than the typical suburb. Concerning sustainable transportation, it promotes TOD, which goes hand in hand with walkability and pedestrian-orientated development. Furthermore, the promotion of mixed land uses also lends substance to the sustainability prospects of neo-traditional development.

2.5.2 Urban containment

Urban containment is an example of an urban growth management strategy that is widely used in planning and is aimed at combating urban sprawl and promoting the conservation of agricultural land and open space (Bengston & Youn 2006; Cohen 1994). The traditional methods of land-use control, which aimed at eliminating unwanted uses of land from residential communities, has weakened the capability of low-income households or people of colour to acquire suitable housing in good neighbourhoods (Nelson, Dawkins & Sanchez 2004).

The ideal on which urban containment rests is to impose geographical restrictions on urban growth in an attempt to limit sprawl and contain urban growth (Nelson, Dawkins & Sanchez 2004). Urban containment policies use a variety of policy instruments to direct “push” and “pull” factors that prevent outward growth and force the market for development inwards in order to facilitate public infrastructure investment to construct desirable urban forms (Jabareen 2006: 44; Nelson, Dawkins & Sanchez 2004). Amongst others, there are three main types of urban containment policies that are employed to influence both “push” and “pull” factors in restructuring urban growth. Greenbelts and urban growth boundaries (UGBs), or urban edges as they are referred to in South Africa, are policies devoted to inspire “push” factors, and urban service areas are employed to manipulate the “pull” factors (Bengston & Youn 2006; Jabareen 2006: 44; Pendall, Martin & Fulton 2002).

A greenbelt refers to an area of open space that spans the entire metropolitan or non-metropolitan area, e.g. forests, farmland or green trails, and serves as a buffer to protect land or water resources from development (Jabareen 2006; Pendall, Martin & Fulton 2002). Greenbelt efforts are directed at keeping undeveloped spaces vacant, thereby restricting land consumptive development such as sprawling (OECD 2012; Siedentop, Fina & Krehl 2016). According to Thomas (1970), the origin of the greenbelt concept dates back further than the initial use of the term. The ‘garden city’ imagined by Ebenezer Howard at the end of the nineteenth century is a concept that draws on the work of others and portrays the idea of a belt of gardens that surrounds the city. London was first in the UK and Europe to experiment with this growth management method, and today many countries, including Germany, regard greenbelts as the best growth management policy (Cohen 1994; Siedentop, Fina & Krehl 2016).

In contrast to greenbelts, UGBs are not a physical space but rather an imaginary line that spans around urban areas and separates them from adjacent rural areas (Bengston & Youn 2006). They serve as restrictions to development beyond their boundaries thereby curbing sprawling development and conserving land and water resources or encouraging inner-city neighbourhood renewal (Jabareen 2006). Regulatory tools such as zoning are used to define UGBs for areas of urban use as well as rural use. A prominent distinction between these two growth management policies is that UGBs are more flexible in that they are designed against expected growth and therefore can be amended, while greenbelts are designed to be permanent (Bengston & Youn 2006).

The third prominent type of urban containment policy is the urban service area or boundary. Urban service boundaries are commonly associated with public facility ordinances, and they act as a buffer beyond which no public service infrastructure, such as sewerage and water, will be provided, consequently prohibiting development (Bengston & Youn 2006).

In addition, growth management strategies that aim to synchronise economic, environmental and social needs are referred to as smart growth strategies (Jabareen 2006). The term originated in the USA, due to increased environmental consciousness, and has been a heated topic in planning spheres since the 1990s, although some of the ideas behind the concept date further back (Arku 2009; O'Connell 2008). Broadly speaking, smart growth is a response to contemporary patterns of urbanisation that are characterised by the outward and leapfrogging expansion of new developments, low overall densities, a rigid specialisation of land uses, large-scale alteration of open space and the conversion of environmentally sensitive lands to urban uses (Arku 2009; Filion & McSpurren 2007). Proponents of smart growth claim that contained and managed growth may be more cost effective in the long run as opposed to sprawling developments (Ciscel 2001).

Andres Duany, Mike Lydon and Jeff Speck (2004) wrote *The Smart Growth Manual*, which starts with an argument for thinking in the global contexts, acting at a local level and planning at the regional level. The manual provides far-reaching practical advice and recommends a range of planning possibilities and options for smart growth. To mention a few, they suggest pedestrian- and bicycle-friendly designs; allowing supplementary dwellings to raise density; designing wide sidewalks decorated with trees in retail areas; repairing and reclaiming old buildings; using plants that complement an area's features, depending on water availability; creating healthy, natural indoor environments; designing grid-like transit networks as opposed to dead-ends; and making use of passive cooling and heating.

Other suggestions that are more shaped to our present situation include using advanced conservation practices; protecting swamplands and encouraging parks around them; reducing run-off by absorbent surface designs; on-site energy generation; reducing traffic in residential areas; and lowering the amount of parking where public transport options are available (Duany, Lydon & Speck 2004).

O'Connell (2008: 1356) mentions that smart growth is "a form of growth regulation that seeks to direct rather than stop growth by encouraging more compact development and more protection of land for development". Arku (2009) affirms this statement by arguing that smart growth does not imply limited or no growth; rather, it underscores the revitalisation of the existing built-up areas and, ultimately, compact development where needed. Furthermore, smart growth places emphasis on an efficient, eco-friendly compact display of urban development. Ideally, smart growth developments encourage walkable living patterns and mixed-use communities, and provide a range of transport systems with numerous housing and employment options (Arku 2009).

Smart growth has a different meaning to different parties. While certain people advocate the redevelopment and rehabilitation of existing areas and infrastructure, others emphasise public transit developments to reduce travel distances and vehicle dependence (Arku 2009; Neuman 2005; Zhu 2012). Nevertheless, smart growth strategies have one predominant goal, which is to encourage urban development efforts towards compactness and the optimal use of pre-existing urban areas (Arku 2009; Goffman 2011).

2.5.3 Compact City

The first reference to the compact city in the literature was by Dantzig and Saaty (1973), in their book *Compact City: A Plan for A Liveable Urban Environment*, in which they suggest the idea of a circular city. This city would ideally comprise of eight levels, of which the central core consists of commercial, industrial, amusement and services, while the highest level acts as a large recreational playground (Dantzig & Saaty 1973). Around the core of the city would be the residential area, characterised by apartments and houses. A circular ring, referred to as the mid-plaza, would run through the residential area and support local facilities like hospitals, schools, neighbourhood stores and recreational zones. This proposed city houses 250 000 inhabitants and, merely by multiplying its height and diameter, has the potential of accommodating two million residents. At full capacity, the city has 256 elevation systems, complemented by a mass-transit system operating along the circular lines and the mid-plaza. The transport system also relies on publicly owned electronic vehicles (Dantzig & Saaty 1973). According to Dantzig and Saaty (1973), the characteristics of compact cities are high, dense settlements with well-defined edges, mixed uses of land, clear identity and diversity, decreased dependence on the automobile, self-sufficiency of everyday life, social fairness and an independent government.

The concept is somewhat controversial and difficult to define, as there is no common use or concrete definition as to what a compact city encompasses (Neuman 2005; OECD 2012). It therefore is imperative to understand the difference between 'compact city' and 'compact urban development'. According to the OECD (2012), a compact city is a policy mechanism at the metropolitan level aimed at guiding urban development and urban form, while compact urban development commonly refers to developments on a neighbourhood level.

The compact city phenomenon has been embraced across many Western countries as a guiding mechanism for urban development (Van der Waals 2000). Similarly, compact cities have also been successful in providing alternatives for dissatisfactory building in American communities in recent years (Neuman 2005). As a result, compact cities are widely accepted to be the most sustainable model aimed at addressing the undesired consequences of urbanisation and urban sprawl (Dantzig & Saaty 1973; Dewar 2000; Duany & Plater-Zyberk 1992; Van der Waals 2000). The above-mentioned notion has been discussed throughout the literature, with the core of this debate resting mainly on the relationship between urban form and energy consumption affected by traffic (Anderson, Kanaroglou & Miller 1996; Jenks, Burton & Williams 1996; Newman & Kenworthy 1996).

Van der Waals (2000) claims that the confidence in the compact city model with regard to sustainability rests mainly on the anticipated decline in vehicle traffic and the preservation of rural areas. He further notes that 'sustainability' in the compact city debate often neglects environmental factors such as the disintegration of natural areas, energy use in buildings and local air pollution, as it is limited merely to energy use in traffic (Van der Waals 2000). Similarly, Neuman (2005: 12) note "that the relation between compactness and sustainability can be negatively correlated, weakly related, or correlated in limited ways". Although the transport sector is important, other sectors, like air travel and buildings, tend to consume more energy and receive less attention with regard to the sustainability of the compact city policy (Neuman 2005; Van der Waals 2000).

The aim of compact city policies is to address integrated urban policy goals and urban sustainability goals (economic viability, environmental quality, social equity, etc.). Compact city policies are expected to play a role in meeting these goals because, by influencing the use of space in cities, they can substantially improve cities' environmental, social and economic performance (OECD 2012).

2.5.4 Eco-City

Within the sustainability debate, contradictions exist between the responsibility of environmental consciousness and the quality of life within urban settings on the one hand, and the actual conditions in cities that foster high energy and land consumption patterns, as well as pollution, on the other (Joss & Molella 2013). Roseland (1997) argues that several disconnected concepts or ideas relating to planning, housing, transport, energy, health and development all form part of the single framework termed the 'eco-city'. The term was first used in 1975 by a non-profit organisation called Urban Ecology that was formed with the goal of building cities in balance with nature (Roseland 1997).

According to Roseland (1997), an eco-city includes all the interrelated concepts of sustainable urban development, sustainable communities, sustainable cities, bioregionalism, community, economic development, appropriate technology, social ecology and the movement towards green cities and communities. Jabareen (2006) agrees that the term eco-city should be viewed as an overarching concept that entails a wide and comprehensive range of proposals that seek to promote urban sustainability. He further notes that greening and passive-solar designs are distinctive concepts of the eco-city, while concepts such as density seem "formless" (Jabareen 2006: 47).

Song (2011) mentions some of the basic principles of constructing an eco-city that includes the principle of sustainable development. These principles include people orientation, the co-ordination of social, economic and ecological benefits, and protection of the environment, innovation, overall planning and considering local conditions.

2.6 DENSIFICATION AS A STRATEGY TOWARDS SUSTAINABLE URBAN FORMS

The following section aims to define and explain urban densification as a strategy towards sustainable urban forms within the international context and in the shift to South Africa to provide an understanding from the perspective of a developing country.

2.6.1 International context

Urban densification is a catchword closely related to the ideologies of planning paradigms, such as the compact city policy developed in Europe, and new urbanism and smart growth developed in North America (Boyko & Cooper 2011; Dieleman & Wegener 2004). These paradigms, developed by planners and architects, criticise the out-of-control suburban sprawl that is occurring in contemporary society and promote government regulation of urban land (Dieleman & Wegener 2004; Jenks, Burton & Williams 1996; New Urbanism 2005; Sivam, Karuppanan & Davis 2012). The compact city model, in particular, suggests the opposite of urban sprawl and encourages densification and, as a result, the concept of urban densification is largely linked to the compact city debate (Chen, Jia & Lau 2008; Neuman 2005; Zhu 2012).

Urban densification is enjoying critical attention in the arena of planning and research on urban structures (Kyttä *et al.* 2013). It is important to note the difference between the compact city, compact urban development and urban densification. Arrigone (1995) distinguishes between compaction and urban densification by arguing that compaction suggests advancement in building density (total built residential floor area per hectare), while urban densification implies a progression in residential density (number of dwelling units per hectare). According to the OECD (2012), the compact city is a policy mechanism at the metropolitan level aimed at guiding urban development and urban form, while compact urban development commonly refers to developments on a neighbourhood level (OECD 2012).

According to Broitman and Koomen (2015), two prominent types of development occur because of increasing population densities and urbanisation. These are, firstly, the development of new buildings within the existing built-up areas and, secondly, the building of new developments in vacant areas or on vacant land (also see Arrigone 1995; De Klerk 1998). In the urban context, the first mentioned is usually referred to as the compact city (densification), while the latter takes the form of urban sprawl or the green/dispersed city (Broitman & Koomen 2015; Holden & Norland 2005). According to De Klerk (1998), it is far less problematic to attain greater densities in unoccupied areas than in existing, built-up areas, although densification is more essential in the latter.

The principles of urban densification and compaction were born in Europe, where traditional planning succeeded in limiting commuting distances between home, work and other activities (Camagni, Gibelli & Rigamonti 2002; Dempsey, Brown & Bramley 2012; Neuman 2005). The assumption holds that European planning policies and strategies often affected planning in other parts of the world, especially in developing countries (Dempsey, Brown & Bramley 2012). Due to the consequences of rapid urbanisation, as is the case in many developing countries, Zhu (2012) mentions that the compact city is a necessary solution, rather than a choice, in order to accommodate such growing population densities. In the developing world, densification prospects generally include a shift from moderately low-density, informal settlements on the periphery to more compact, high-rise residential development (Anderson, Hooper & Tuvshinbat 2016). Sivam, Karuppanan and Davis (2012) argue that the goal of building a high-rise development has changed over time – from the original aim of community living and public spaces for social activities and interaction during the 1960s and 1970s, to a new goal to attain higher densities.

Around the world, many cities advocate the implementation of densification strategies as a means of managing a wide range of social, economic and environmental challenges (Dave 2010). However, Dempsey, Brown and Bramley (2012) and Kyttä *et al.* (2013) point out that urban densification and consolidation strategies in support of a sustainable urban form comprise one of the most contentious topics in urban planning. They note that, regardless of the rationalisation of urban densification as a reaction to urban swelling and a strategy addressing the concerns of climate change, there are growing concerns regarding the potential undesired social consequences of compact urban settings (Kyttä *et al.* 2013). In addition, many authors (Arnberger 2012; Camagni, Gibelli & Rigamonti 2002; Kyttä *et al.* 2013; Lin, Meyer & Barnett 2015; Neuman 2005; Schmidt-Thomé *et al.* 2013a; Smith 2013; Zhu 2012) seem to extensively explore the urban densification phenomenon and the relationship between environmental or social cost related to different forms of urban expansion.

Proponents of urban densification, such as Jacobs (1961), Duany and Plater-Zyberk (1992), Jenks, Burton and Williams (1996), Dewar (2000); OECD (2012) and Zhu (2012), amongst others, argue that urban densification as a compact city strategy is a more energy-efficient and a less polluting urban planning approach. This is due to decreasing proximities, which go hand in hand with decreased reliance on automobile transportation, as people can participate in business and consumption activities closer to where they reside. In addition, these authors argue that community-orientated social patterns are better constructed in highly dense and compact areas and that this is an effective method of making cities sustainable.

However, Neuman (2005) challenges this argument, as he argues that the sustainability of a city is influenced not merely by the built environment, but rather through the broader process of city building. This argument is supported by Zhu (2012), who claims that increased densities can breed crime, social negligence and vandalism when associated with certain socio-economic conditions. Similarly, Kyttä *et al.* (2013) contest the notion of Duany and Plater-Zyberk (1992) and Jenks, Burton and Williams (1996) that densification holds ecological benefits such as a reduction in energy consumption through decreased automobile dependency, arguing that it can also negatively influence urban character, perceived environmental quality and local lifestyles.

Schmidt-Thomé *et al.* (2013b) conducted a study in Finland to assess what types of development and services would interest people to reside in a specific area. Their findings challenge the assumption that the majority of people favour more space and subsequently oppose higher density living. The results indicated that people were attracted more to locations that offered increased access to transit corridors, green space and urban services. In the light of their study, densification procedures were viewed as being less problematic than what was predicted, and the major density infill developments were highly supported. Similarly, the results of a study by Anderson, Hooper and Tuvshinbat (2016) in Mongolia rendered moderately high support for rising unit-level density and apartment living amongst residents in their study sample. These authors suggest that well-planned urban densification projects can be a feasible solution when the interests of residents are taken into consideration and correspond with those of policymakers (Anderson, Hooper & Tuvshinbat 2016; Schmidt-Thomé *et al.* 2013b).

As with many other urban centres, Sydney, Australia experienced rapid growth, which sparked emphasis on more compact forms of development in an attempt to restrict potential urban sprawl and revive the city’s existing suburbs (Lin, Meyer & Barnett 2015). Lin, Meyer and Barnett (2015) found that the extent of tree cover in their study area decreased when the dwelling density of that area was raised. They note that densification methods, such as consolidation, bigger houses on smaller plots and higher density housing, limit the space for tree cover in residential areas and ultimately affect certain socio-economic communities that rely on tree cover as a symbol of green space.

Furthermore, the Australian stakeholder’s perception of density in Adelaide was studied by Sivam, Karuppanan and Davis (2012) and the finding showed that the perception of density had little consistency or consent of development and planning with relation to the application of density, the definition of density and whether or not density is a positive trait. They discovered that the built form of residential areas had a greater effect on the stakeholder’s perception of density as opposed to the actual measurement thereof. This supports the argument of Boyko and

Cooper (2011) that complexities with regard to the definition, calculation, correlation and concepts create confusion worldwide amongst people and planners with regard to interpretation and application. Thus, Sivam, Karuppanan and Davis (2012: 19) argue that “residential density policy should not be established without clear policies governing the built form”.

In addition, Arnberger (2012) analysed the implications of urban densification on the recreational value of public urban green space in Austria. The study’s findings revealed that urban densification close to public green space had transpired into perceptions of overcrowding and subsequently reduced the recreational value thereof. Urban green space is a key feature in the sustainable cities debate, and the overconsumption thereof easily generates perceptions of crowding, which results in a degraded experience. Subsequently, people turn to coping strategies, such as inter-area displacement, as they feel vulnerable in the sense that they are deprived of the desired recreational value of public green space in their area. This scenario produces further repercussions for other green spaces, sustainable city management and the urban planning policies of cities (Arnberger 2012).

Smith (2013) emphasised the consumptive nature of real estate in California and calculated the potential benefits of urban densification as opposed to edge developments. The findings show that densification projects could potentially save farmland at a 1:5 ratio. This means that every square kilometre of densified project space can save five square kilometres of farmland or land that could be assigned to other uses (Smith 2013). In the case of many developing countries, scarce land resources and increasing urbanites highlight the essential need for compact development (Zhu 2012: 77).

2.6.2 South African context

Similar to the situation in many other developing countries, South African cities and towns face rapid spatial expansion coupled with increased population densities, which create enormous challenges for city and town planning and sustainable development. With regard to urban densification in South Africa, the apartheid legacy contributed many additional levels of complexity, such as cultural differences and segregation of racial groups (Ballard 2004; Chobokoane & Horn 2014; Lemanski 2007). The complexity is further exacerbated by poor economic performance and a lack of legal framework for densification policies and guidelines, as well as implementation discrepancies between authorities (Arrigone 1995; De Klerk 1998; Lemanski 2007). Therefore, the spatial form of South Africa is one that displays a structure based on races, severely disjointed, sprawling with weak functional integration (Todes, Dominik & Hindson 2000).

The present structure and form of South African cities and towns has mainly been influenced between the 1940's and early 1970's, a period Harrison, Todes & Watson (2008) refers to as 'high apartheid'. During this period, influential planning policy instruments such as the 1950 Group Areas Act was developed and implemented under the apartheid government (Mabin 1992). The Act was created with the intention to racially separate groups of people based on ethnicity through forced removals, influx-controls and the development of new large-scale semi-formal townships on the periphery of the urban edge, for example Khayelitsha in Cape Town (Mabin 1992; Todes, Dominik & Hindson 2000; Ballard 2004; Geyer et al 2012).

Under the Group Areas Act, white privileged groups generally occupied the core economic hub of cities while Indian and coloured groups were relocated to intermediate spaces beyond the urban core and black groups were positioned on the periphery in largely under-serviced areas (Todes, Dominik & Hindson 2000). It is interesting to note how this racially and structurally dividing policy created under the apartheid regime continues to dominate the form of many cities in South Africa. According to Hindson (1999), planning regulations during this period had vast restrictions on mixed land-uses and, contradictory to current compact city planning approaches, promoted low-density suburban car-orientated development. As a result of these restrictions, development in the white urban core transpired into additional fragmentation and urban sprawl within cities in South Africa (Hindson 1999).

The late 1970's, however, witnessed declining controls which resulted in the rapid urbanisation of black racial groups into townships, consequently leading to overcrowded living conditions and the flourishing of informal settlements in and around them (Hindson, Byerley & Morris 1994). According to Geyer *et al.* (2012), pressure from black population groups to urbanise remained high, despite influx-control legislation. With the abolition of influx control in 1991, South African cities experienced an extremely high rate of black and coloured urbanisation in which the majority of the black population inhabited newly formed informal and formal settlements in and around the edges of black townships (Geyer *et al.* 2012). This had a profound impact on the capacity of resources and service delivery and consequently deteriorating living conditions and poverty in townships around city centres (Todes, Dominik & Hindson 2000).

In the case of South Africa, informal settlements are generally characterised by extremely high densities and, in most cases, lack the essential basic services, which highlight for many scholars the need for densification (e.g. Arrigone 1995; De Klerk 1998). Although the South African state-funded low-cost housing scheme, the Breaking New Ground initiative, had a large roll-out of government sponsored low-cost housing, the rapid migration of poor population groups continue to exceed the governments coping capacity (Govender, Barnes & Pieper 2011). The housing and service delivery backlog is further exacerbated by the owners of subsidized houses erecting informal or backyard dwellings from scanty building materials to rent out to informal dwellers as a means of supplementary or, in most cases, primary income. In addition, land restitution and previously disadvantaged cultural groups occupying undeveloped land threaten land resources in South Africa (Ballard 2004).

According to Arrigone (1995), Lemanski (2007) and Horn (2010), South African cities exhibit a huge contrast between primarily white conurbations and wealth on the one hand, and black informal settlements associated with poverty on the other. Therefore, Arrigone (1995: 1), states that South African spatial policies reflect “the most extreme form of spatial distortion which, one could arguably say, has not been observed in any other place in modern history”.

The urban fabric of South Africa has been altered due to the removal of apartheid controls, which allowed businesses and individuals the right to make un-prescribed personal decisions in terms of housing and employment options (Harrison & Todes 2015). Apart from migrant influxes into cities during the initial loosening of controls, white population groups began to decentralise through urban flight and the continued growth of the black and coloured townships on the periphery created a process of large-scale settlement development on the periphery of cities (Geyer *et al.* 2012). Geyer *et al.* (2012) notes how economic decentralisation has become a prominent feature that is evident in the growth of industrial and commercial development in sub-centres and the decline of economic functions in the historic city centres, which somewhat contradicts the compact city policy in terms of combatting sprawling development.

Since the 1990’s, the compact city policy has been a prominent feature in SDF’s in South Africa and has had to be reformed in ways that address the racially and spatially fragmented cities and respond to evolving political, economic and social forces (Todes, Dominik & Hindson 2000). Thus, the transition to democracy inspired planners to pursue sustainable city planning that promotes compaction, integration and social equity in an attempt to rectify the spatial fragmentation created under apartheid (Chobokoane & Horn 2014; Harrison, Todes & Watson 2008).

Densification is a national spatial strategy aimed at integrating cities socially and spatially (Stellenbosch Municipality 2012a). The importance of land conservation and increased urban densities through compaction has increasingly been recognised in policy frameworks since 1995. The publication of the Development Facilitation Act (DFA) (Act No. 67 of 1995) provided a foundation for the South African government's commitment to compaction policies and the fight against urban sprawl (South Africa 1995).

Chobokoane and Horn (2014: 80) summarised other policy frameworks and guidelines that have supported urban compaction in South Africa since 1995. These include:

> Reconstruction and Development Program (RSA 1994); Growth Employment and Redistribution (RSA 1996); Accelerated and Shared Growth Initiative for South Africa (RSA 2007); the New Growth Path (RSA 2010); the National Growth and Development Strategy; the draft National Spatial Development Perspective; the Integrated Rural Development Strategy, the National Physical Development Framework, the Spatial Guidelines for Infrastructure Investment and Development; the Planning Framework for the Republic of South Africa; the Green Paper on Spatial Planning which served as the foundation for the production of a White Paper on Spatial Planning and Land-use Management; the Urban Development Strategy and the Urban Development Framework.

According to Chobokoane and Horn (2014), the White Paper on Local Government was an important stepping stone in South Africa, as it led to the introduction of the Municipal Systems Act (32 of 2000) (South Africa 2000), and consequently Integrated Development Plans (IDPs), and Spatial Development Frameworks (SDFs) within municipalities. In other words, municipalities in South Africa hold full responsibility over land-use planning as far as their jurisdiction stretches and have the authority to introduce administrative and integrated zoning by-laws (Stellenbosch Municipality 2015/16).

However, there is still a lack of a legal framework that prescribes and enforces the concept and principles of urban densification in South Africa. As Harrison and Todes (2015) point out, policies exist to restructure cities and towns, but urban policies do not solve the issues of racial segregation and neither do they directly influence urbanisation. This emphasises the need for planners in South Africa to be context and culturally sensitive concerning densification and compact strategies in order to reduce potential land losses and address the economic and social needs of the entire population.

2.7 CONCLUSION

The literature review focused on urban densification and related concepts. Across the world there has been a shift away from urban sprawl and dispersed development patterns toward achieving a more organised arrangement of urbanisation and development. This is based on the belief that growth has gone amiss and that current patterns of urbanisation are unsustainable. Developing countries are particularly vulnerable in this regard due to the enormous pre-existing challenges in terms of housing, infrastructure and poverty, which are further exacerbated by uncoordinated urbanisation. In addition, Lemanski (2007) blames the ethnocentrism of the global city criteria for misleading many developing countries' expenditure in terms of resources in the global economy to achieve externally determined standards, often to the detriment of greater domestic concerns. Therefore, a more south-centric understanding of urban success is necessary, as many poorer cities are vital to the global economy (Lemanski 2007).

A prominent concern in the literature is the debate on whether or not urban form and planning can influence the sustainability of cities. The core topic of this debate revolves around energy consumption and urban form, with a specific focus on transport and transit use. There is ample evidence in support of the opinion that urban form is crucial in promoting sustainable development. However, there are conflicting views regarding this opinion, which argue that the sustainability of a city is dependent on more variables than merely the built form. This has led to the identification of various design concepts that should form part of sustainable city building. These include compactness, density, diversity, sustainable transport, mixed land uses, passive solar design and greening.

Sustainable urban forms or growth management policies, such as neo-traditional development, urban containment, the compact city and the eco-city, are all a response to the consequences of sprawling development and encourage high densities, mixed land use, walkability, reduced transport dependency, community interaction and social validity. Urban densification is widely viewed as a compact city strategy that aims to increase residential densities. This can only be achieved in a meaningful way if the design concepts of environmental, economic and social sustainability are incorporated. However, sustainable urban forms can only be achieved through government intervention to develop policies that regulate aspects such as density in cities. If this does not happen, such aspects can quickly result in negative consequences, such as congestion and crowding.

Densification should not be regarded as an outcome in itself, but rather as a mechanism towards achieving a range of beneficial outcomes related to connectivity, convenience and social vitality (Turok 2011; Wheeler 2002). It therefore is evident that a singular model for cities cannot be applied to all socio-economic and environmental challenges experienced by cities across the world. According to Jenks, Burton and Williams (1996), the quest for one superior sustainable urban form needs to be replaced by the understanding that a number of sustainable urban forms may exist. Therefore, although urban densification is rooted as a compact city strategy, it is clear that this planning strategy is an amalgamation of various related schools of thought that draw on various aspects of sustainable design and sustainable city building, and should be applied in ways that are appropriate to the given context of an area.

CHAPTER 3: SOCIO-TECHNICAL ASPECTS OF URBAN DENSIFICATION

3.1 INTRODUCTION

Density is a multifaceted and complex concept because of the "multitude of definitions" of the concept across various disciplines and within different contexts (Anderson, Hooper & Tuvshinbat 2016; Boyko & Cooper 2011; Broitman & Koomen 2015; Burton 2002; Cheng 2010: 3; Churchman 1999; Dempsey, Brown & Bramley 2012; Density Atlas 2011; Turok 2011). For the purpose of the study, this chapter will focus on the socio-technical aspects of urban densification, with an emphasis on aspects of physical density. I will start by defining urban densification, physical density and the housing component with a review of different dwelling types. Furthermore, the chapter will investigate factors influencing residential density and look at methods of densification and where it needs to occur. Finally, this chapter will explore the advantages and disadvantages of urban densification from an economic, social, spatial and environmental point of view.

3.2 URBAN DENSIFICATION

Public authorities in many parts of the globe are focusing their energies on increasing urban population densities (Lin, Meyer & Barnett 2015; Newman 2010; Turok 2011). This tendency is based on the belief that compact urban development promotes more intensive and efficient use of infrastructure and minimises the carbon consequence of automobile travel (Holden & Norland 2005; Jenks, Burton & Williams 1996). In addition, it is also argued that higher urban densities have the potential to assist economies that are more productive and encourage lively and inclusive community patterns, as residents and businesses are located in interactive proximities to one another, thereby enhancing social interfaces and the exchange of ideas (Zhu 2012). According to Attia (2015: 3), "urban densification is a sustainable urban strategy that many European countries advocate for the compact city to limit mobility, share resources and infrastructure and reach maximum efficiency".

In contrast, densification processes often produce negative responses amongst residents due to the association of density with overcrowded tower blocks and noisy residents (Arnberger 2012). According to Zhu (2012), communities oppose high-rise buildings and the influx of new residents in defence of their neighbourhood character and the additional strain on public facilities and services. However, density does not necessarily entail high-rise structures and congested roads (OECD 2012). Density should not be regarded as an outcome in itself, but rather as a mechanism towards achieving a range of beneficial outcomes related to connectivity, convenience and social vitality (Turok 2011; Wheeler 2002). Nonetheless, there is growing evidence that density can improve housing options, employment, public services and amenities with sensitive and context-specific urban planning and management (Neuman 2005; Newman 2010; Turok 2011).

3.3 DEFINING DENSITY

Density can be defined and expressed through a variety of relationships between entities (Boyko & Cooper 2011; Churchman 1999; Dempsey, Brown & Bramley 2012; Smit 2008). It is these complexities with regard to the definition, calculations, correlations and concepts across various disciplines that create confusion amongst people and, as a result, density is rarely understood beyond a meek ratio of units to an area (Boyko & Cooper 2011).

Density can be separated into two overarching categories, namely physical density and perceived density. While physical density refers to a quantitative measure of the concentration of physical structures or individuals, perceived density refers to an individual's perception regarding the number of people and available space in relation to the spatial characteristics of an area (Cheng 2010). Although people's perception of density has a huge influence on their choice of residence, housing options and degree of social interaction (Sivam, Karuppanan & Davis 2012), physical density enjoys much more attention amongst urban planners (Turok 2011). Nevertheless, the objective of urban geographers, planners and architects is to weave physical density with innovative planning and design in order to manipulate people's perceptions of density (Alexander, Reed & Murphy 1988). Table 3.1 summarises a wide variety of definitions of density based on the work of Senior, Wood and Walker (1988) for interpretation purposes.

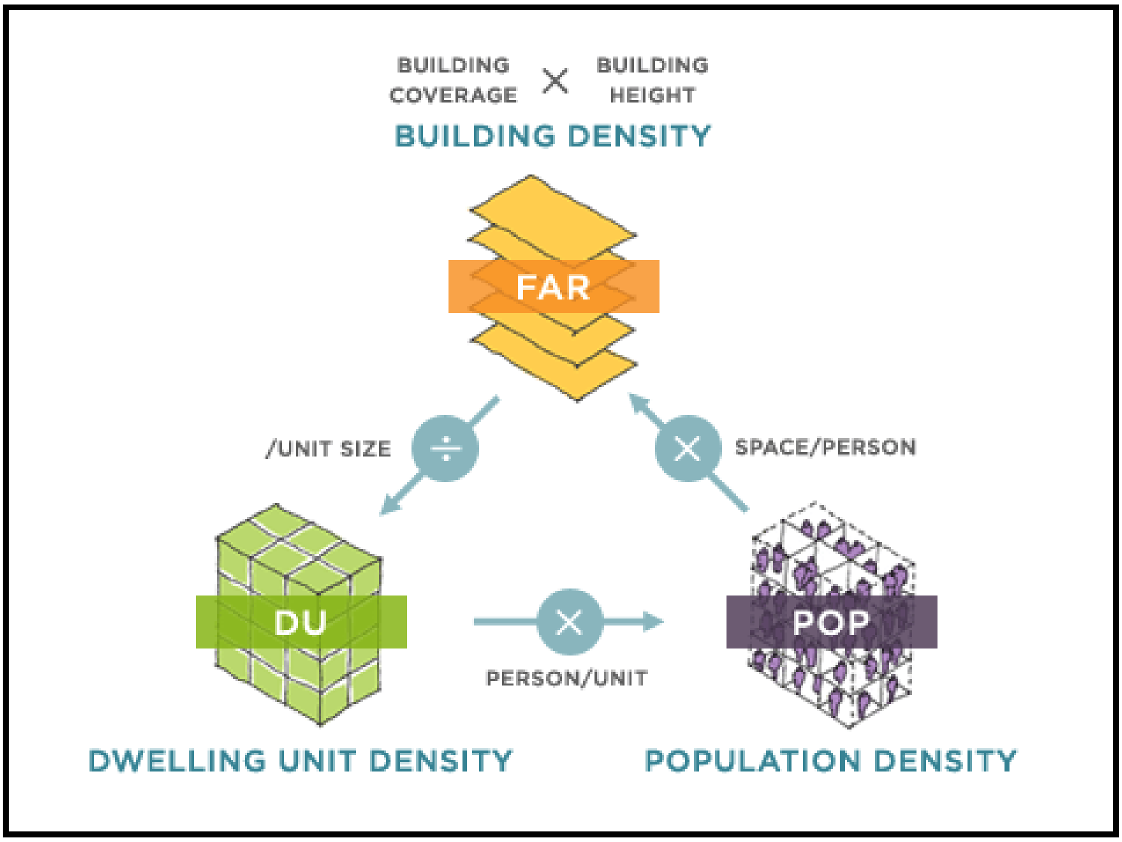
According to Cheng (2010), physical density generates validity once it relates to a specific geographical scale of reference. For example, population density calculations over land will vary significantly if a whole country's landscape is the scale of reference, opposed to a city or a suburb being the scale of reference. Similarly, the Density Atlas (2011) stresses the need for a defined scale when comparing areas, as larger land parcels will include other non-residential spaces such as retail, services, parks etc., subsequently lowering the dwelling units, floor area ratio (FAR), population density and overall density of a given area. Thus, it is important to clarify the scale of geographical reference in density calculations to avoid skewed results and comparisons (Cheng 2010; Density Atlas 2011).

Table 3.1 Definitions of density

DEFINITIONS OF DENSITY	
Net residential density	The population (or accommodation) divided by the site area, which includes all land covered by dwellings, gardens, local roads and half the width of surrounding roads and any adjacent public open space.
Gross residential density	The population (or accommodation) divided by the site area, which includes all land covered by dwellings and gardens, roads, local shops, primary schools and most open spaces, but excluding other urban uses such as industrial land, secondary schools, town parks and town centre.
Town density	Applied to the town as a whole. It is the total residential population (or accommodation) divided by the area of the town, excluding undeveloped or agricultural land but including industrial land, all public open spaces, all schools and all types of development.
Building density	The intensity with which a site is developed; it is best measured as a ratio of the floor area developed relative to the overall site area (FAR).
Floor area ratio	FAR is the total floor area of buildings accommodated on the site (on all floors) divided by total site area.
Occupancy density	The rate at which floor area is occupied; it expresses the amount of floor area per person in a household (floor space rate).
Floor space rate (FSR)	The total amount of floor space on a site divided by the total population. It is measured in square metres per person.
Population density	The number of people living in a given unit of area and usually expressed as persons per hectare.
Persons per hectare (PPH)	The total number of people divided by the site area in hectares.
Dwellings per hectare (DPH)	The total number of dwellings divided by the site area in hectares.
Open space ratio (OSR)	The square metres of open space on a site for every square metre of floor area.
Living space rate	The square metres of non-vehicular outdoor space on a site for every square metre of floor space.

Source: Senior, Wood and Walker (1988)

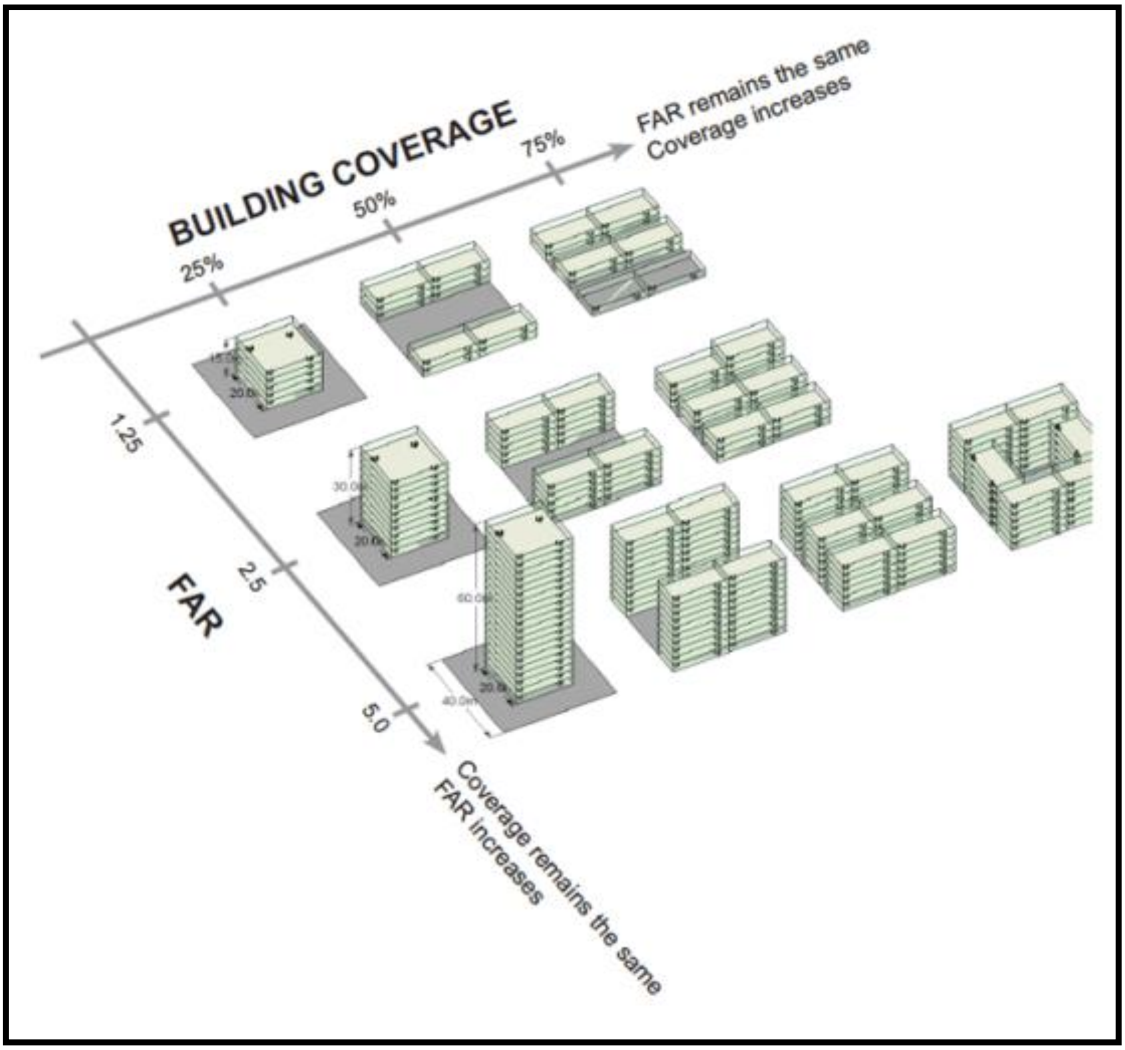
In the planning realm, physical density can be subdivided into three components, namely building density, dwelling unit density and population density (Cheng 2010; Density Atlas 2011; Turok 2011). With reference to Figure 3.1, the Density Atlas (2011) developed a diagram to highlight the most common quantitative measures of density, each describing it from a distinctive angle. They argue that these measures are often viewed in isolation without compensation for the other. For interpretation purposes, it is crucial that all three components of density are investigated, and compared, in order to generate the most substantial picture of density (Density Atlas (2011).



Source: Density Atlas (2011: n.p.n.)

Figure 3.1 Quantitative measurements of density

Figure 3.2 illustrates the relationship between coverage and FAR. FAR is the ratio of floor area of a structure(s) to the area of the lot (Joshi & Kono 2009; Noble, Noble & Costa 1993). FAR is a measuring instrument used by developers, architects and planners to determine the intensity of developments and control building sizes containing numerous households, e.g. condominiums and apartment blocks (Boyko & Cooper 2011). In addition, many cities enforce maximum and minimum FAR regulations in an attempt to relieve undesired population externalities such as congestion (Joshi & Kono 2009).



Source: Density Atlas (2011: n.p.n.)

Figure 3.2 Relationship between FAR and coverage

However, the Density Atlas (2011) notes that FAR alone is inadequate to define density and that a better depiction of density is generated by analysing building coverage concurrently. Coverage is the ratio between the total floor area of buildings and the area of the lot (Senior, Wood & Walker 1988). Figure 3.2 shows how different development settings with identical FAR but different coverage will fabricate different types of development, e.g. low-rise or high-rise.

3.4 MEASURING DENSITY

When applied to human settlements, density measures include indicators such as the number of people, units or rooms per surface area, as well as related land-use intensity measures like coverage and FAR (Alexander, Reed & Murphy 1988; Cheng 2010; Dempsey, Brown & Bramley 2012; Smit 2008; Turok 2011). With reference to Table 3.2, it is evident that spans of measures are used to calculate and observe both population and building densities. According to the City of Cape Town (2012a), where policies are considered at the city level, gross base density is the applicable measure of densification, while net dwelling unit density figures become applicable when specific locations within the city are being considered. In addition, population density is the most appropriate measure of densification when it comes to the provision for public open spaces and other social facilities (Boyko & Cooper 2011; City of Cape Town 2012a).

Table 3.2 Measures of densification

MEASURE	DEFINITION
Dwelling unit density	Number of dwelling units per hectare (du/ha).
Population density	Number of people per hectare (calculated by multiplying the number of units by an appropriate average household size).
Building density	Ratio of total building floor area to the corresponding site area.
Gross du/ha	The number of dwelling units per hectare of land calculated in a designated area on the basis of land used for residential purposes and other land uses, such as industry, commercial, education, transport and parks. Excluded are land-extensive uses, such as agricultural land and natural areas/nature reserves/parks.
Net du/ha	Number of dwelling units per hectare of land calculated on the basis of land used for residential purposes, including the garden and off-street parking, if any.
Gross base density	The average number of dwelling units per hectare across the city as a whole, or a smaller unit, excluding land-extensive uses, such as large natural areas/nature reserves.

Source: CTDP (2012: 7)

Apart from various interpretations across disciplines, there are also variations on what needs to be included or excluded in the calculations of different measures of density (Boyko & Cooper 2011). For example, there is much confusion in the literature as to a precise definition of what net and gross residential area encompasses (Boyko & Cooper 2011). Authors such as Alexander, Reed & Murphy (1988), Senior, Wood and Walker (1988), Arrigone (1995), Churchman (1999) and Boyko and Cooper (2011) have explored these areas extensively and lack common ground on which functions need to be attributed to which area.

In addition, Cheng (2010) affirms disparities in the definition of these areas across different countries and cities. He notes that net residential density in the UK indicates only such land covered by residential development, including gardens, as well as additional spaces physically included in the development. Half the width of adjacent roads is usually also included here (Cheng 2010). However, in some states of the US and in Hong Kong, net residential density excludes parks, internal roads and other public places. They place emphasis purely on the area allocated for residence (Churchman 1999). This raises concerns over the utilisation of net residential density as the only measurement when studying a given area. According to Rudlin and Falk (1999), net residential density does not incorporate broader concerns related to mixed uses or land capacity, nor does it provide guidance for assessing issues such as walkability and the sustainability of public transport in an area. Nevertheless, net residential density can be derived by dividing the number of dwellings on a site by the sum total of residential plots and half of the access roads within the area (Arrigone 1995) (see equation 3.1). Interestingly, Senior, Wood and Walker (1988) include public open spaces in this equation.

Equation 3.1 Net residential density formula

$$Net\ residential\ density = \frac{Total\ residential\ units}{Total\ residential\ land\ area}$$

Source: New Designs for Growth (2008)

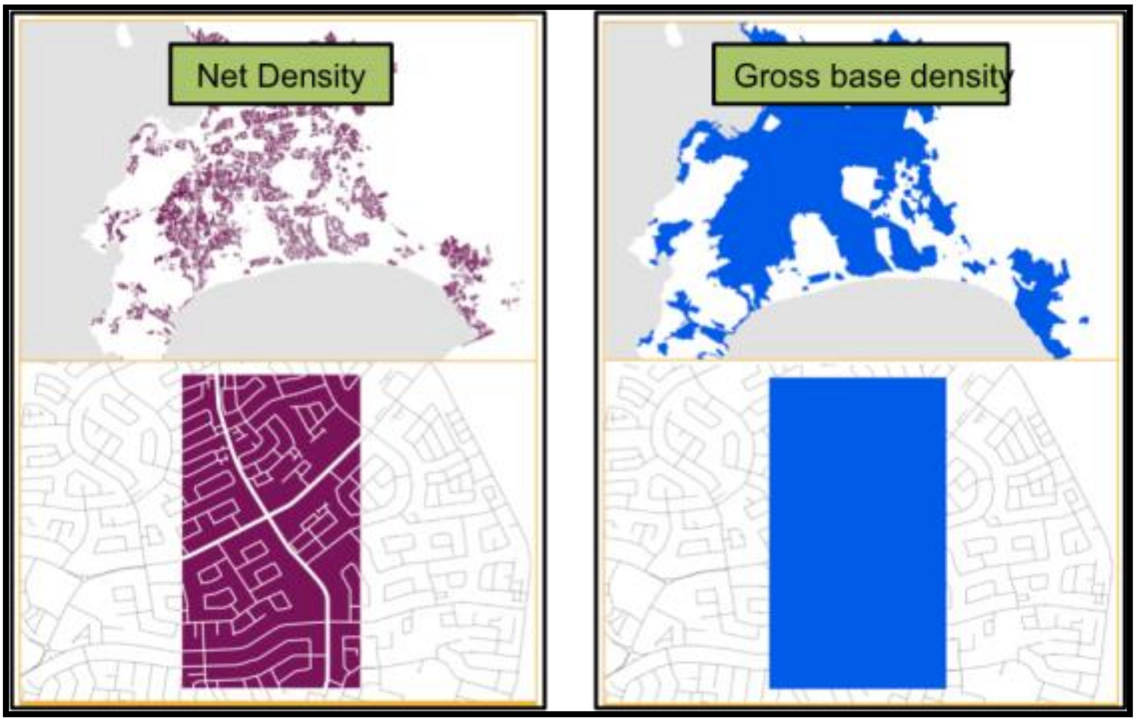
In addition, real or site residential density is a type of net residential density and can be determined by dividing the number of dwelling units with the sum total of all the residential properties in a given area, excluding roads and other infrastructure (Arrigone 1995) (see equation 3.2).

Equation 3.2 Real residential density formula

$$Real\ residential\ density = \frac{number\ of\ dwelling\ units\ on\ a\ site}{sum\ of\ residential\ plots}$$

Source: Arrigone (1995)

Moreover, there is general consensus that the gross residential area consists of the net residential area and includes both leisure activities and commercial activities, internal roads, parks, community centres, etc. that are utilised to serve the immediate community (Arrigone 1995; Cheng 2010; Senior, Wood & Walker 1988). Figure 3.3 is an attempt to visually clarify these disparities related to variables that are included or not included in the calculation of both the net and gross residential density of an area in South Africa.



Source: City of Cape Town (2012a: 7)

Figure 3.3 Net density and gross base density at citywide and at local scale

Gross residential density can be derived by dividing the number of dwelling units in an area by the total site area, inclusive of all land covered by dwellings and gardens, local shops, roads, primary schools and most open spaces. This calculation, however, excludes other urban uses, such as industrial land, secondary schools, town parks and town centre (New Designs for Growth 2008; Senior, Wood & Walker 1988) (see equation 3.3).

Equation 3.3 Gross residential density formula

$$Gross\ residential\ density = \frac{number\ of\ dwelling\ units}{total\ development\ land\ area}$$

Source: New Designs for Growth (2008)

When city density or town density (number of dwelling units in the urban area as a whole) is used as the measure, then everything except for agricultural land and undeveloped areas is included (Senior, Wood & Walker 1988). Furthermore, De Klerk (1998) notes that the gross residential area will always be greater or equal to that of the net residential area, and therefore the gross residential density will never be greater than the net residential density of that area.

Moreover, the number of people per hectare generally measures the actual residential population (Turok 2011). The number of people per hectare refers to either the number of people utilising public transport, rendering it viable or not, or the number of people that increase the level of economic opportunity in a given area and the number of people that occupy public spaces that generate popular spaces or not (Smit 2008). Using population as a measure of density is inadequate considering the urban flow phenomenon, where people are not stationary and are constantly moving during the day (Smit 2008).

Dwelling unit density is a commonly used measurement of density amongst developers and realtors who are concerned with the number of marketable units in a specific area (Boyko & Cooper 2011; Density Atlas 2011). According to section 8 of the Stellenbosch Municipality Zoning Scheme Regulations (ZSR) (Stellenbosch Municipality 1996), a dwelling units refers to "a self-contained inter-leading group of rooms with not more than one kitchen". Turok (2011) notes that building density is generally measured by the number of dwellings per hectare and mentions limitations to this measure, as it disregards the size of the dwellings and the number of liveable rooms, which ultimately also influence density. Senior, Wood and Walker (1988) similarly criticise this measurement, stating that physical density is dependent on more variables, such as height, as well as the number of inhabitants per dwelling. However, De Klerk (1998) argues that the number of rooms per surface area is inadequate as a global measurement of density, as different income groups and diverse cultures utilise rooms differently. For example, in many African cultures it is not unusual for twelve or more people to live in one room, thereby using space optimally. Thus, it is difficult to make intercultural comparisons, and therefore using rooms per surface area will not provide a realistic reflection of density (De Klerk 1998).

Nevertheless, dwelling units per hectare is widely regarded as the most accurate and permanent indicator of density at ‘block’ scale, considering that residential density can only be achieved through an increase in the number of dwelling units per area (Boyko & Cooper 2011; De Klerk 1998; Senior, Wood & Walker 1988; Smit 2008).

3.5 DEFINING THE HOUSING COMPONENT

Although many factors have an influence on urban densification when housing projects are planned, Arrigone (1995) states that residential density depends primarily on factors related to the physical planning and house design (residential plot size, site layout, topography and site conditions, appropriateness of dwelling types used), user acceptability and statutory planning and building regulations. Similarly, Boyko and Cooper (2011) note that the configuration and layout, housing form and design qualities, connectivity, mixed land uses together with density are all elements of a sustainable urban form.

Arrigone (1995) considers the size of the residential plot to be the most influential factor determining residential densities. He argues that, in order to increase the residential density, the most logical approach would be to reduce plot sizes and provide more plots on the same amount of land. The type of site layout implemented will also affect the residential density, and therefore Arrigone (1995) suggests the prevention of vehicle through-traffic while maintaining vehicular access to different plots. It is widely argued that high-density urban development promotes sustainable transport systems and an urban layout that minimises dependency on private transport (Williams 2000). Thus, by decreasing public areas and roads, higher residential densities can be achieved (Arrigone 1995, Van Heerden 1998).

Topography and site conditions are regarded as significant determinants of the way in which sites are laid out for development (Arrigone 1995, Van Heerden 1998). It is often the case where environmental influences, such as steep slopes, swamps or unstable site conditions, restrict the development of a portion of the site, and therefore residential density may be influenced in response to topography and site conditions (Arrigone 1995, Van Heerden 1998). Additionally, the appropriateness of the dwelling types and their location with respect to plot boundaries are two important determinates that will influence residential density (Arrigone 1995).

Similarly, Senior, Wood and Walker (1988) mention that height, the degree of attachment and dwelling size are considered generative factors when defining a range of housing options. They mention height as a factor due to its influence on the overall cost, type of access, its relationship to the surface, type of open space, the type of household, site utilisation, the delivery system and the intensity of development. Height is categorised as low-rise (single storey and two to four storeys), medium-rise (five to ten storeys) and high-rise (eleven or more storeys).

Degree of attachment refers to the degree of attachment of one dwelling to another and their association with one another, since this affects site utilisation, building configuration, cost, intensity of development and the type of delivery system (Senior, Wood & Walker 1988). Attachment is categorised as detached dwellings, dwellings attached horizontally, dwellings attached vertically and dwellings attached horizontally and vertically. Dwelling size is categorised as micro (30 m^2 and less), very small (30 to 50 m^2), small (50 to 70 m^2), medium (70 to 100 m^2), large (100 to 200 m^2), and very large (200 m^2 or more) (Senior, Wood & Walker 1988; Van der Linde 2000).

Furthermore, Senior, Wood and Walker (1988) introduced a sub-category for height and attachment, as they argue that they are primary determinants of building form. According to Senior, Wood and Walker (1988), when these two categories are combined in their various combinations, they describe sub-categories of the housing range. For example, single-storey detached dwellings, single-storey dwellings attached horizontally, low-rise detached dwellings, low-rise dwellings attached either horizontally, vertically or both, medium-rise dwellings attached both horizontally and vertically, and high-rise dwellings attached both horizontally and vertically.

In *The Form of Housing*, Davis (1977) states that, in the United States, great importance has been attached to ownership of single-family homes, based on the belief that this type of living arrangement corresponds to traditional American values. This, in conjunction with assistance from government and financing institutions, helped home ownership to become the dominant housing style in American life. In turn, this leads to a set of requirements that emerged as predominantly important in family housing (Davis 1977).

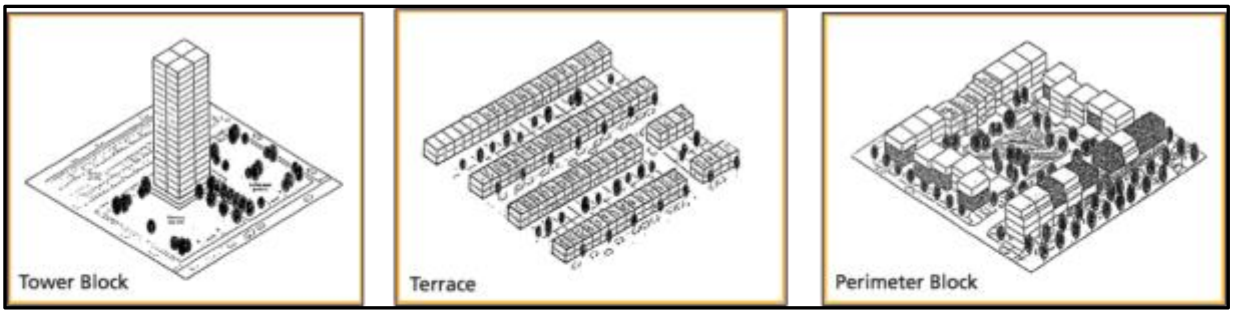
The Institute for Architecture and Urban Studies in New York developed a list of statements that reflect the requirement criteria. The list includes community, child supervision, security, maintenance, liveability and responsiveness to context (Davis 1977). In a single-family detached home, the majority of these elements are taken care of. However, because of past perceptions regarding single detached family houses and contemporary land shortages, a conflict has emerged between high-rise vs. low-rise developments or, as Davis (1977) describes it, the house vs. housing conflict.

With patterns of rapid urbanisation and population increases, it has become vital to create ways in which land is used more efficiently whilst identifying and creating lower cost housing options. Although developers are moving away from the single-family detached dwelling, it is important that new design types retain the elements found in the traditional family house, which allow high user satisfaction (Davis 1977). According to Donaldson and Morkel (2012), modern consumer tendencies, the need for convenience, property rights and development pressures lead to unfitting and standardised building and space making. Similarly, Neuman (2005) argues that the use of generic planning procedures has little concern for the context-specific nature of settlements, while they should be concentrated around the specific culture within a given area. Therefore, it is of critical importance that the beneficiaries of housing projects agree with the densification proposals, as their consent plays a major role and will ultimately lead to a high level of satisfaction (Arrigone 1995).

Finally, it boils down to how willing or how able public authorities are to develop and enforce statutory planning and building regulations, as well as to allow flexibility in order to promote beneficial densification projects (Arrigone 1995). Due to the complexity of this conflict, no specific solutions exist. However, several means of achieving higher residential density through diverse housing options can be considered.

3.5.1 Dwelling types

There are numerous types of accommodation that all produce different densities. However, different building forms can also produce the same density, as shown in Figure 3.4. It is essential to take note of the type of accommodation specific to each land parcel and the methods in which they can be developed to increase their density.



Source: City of Cape Town (2012a: 4)

Figure 3.4 The same density depicted in different building forms

3.5.1.1 Single family detached dwellings

Single detached dwellings are lone-standing units each on its own individual property (De Klerk 1998; Van der Linde 2000). The size of the property usually varies between 300 and 2 000 square metres and is usually in relation to the different socio-economic classes. For example, low-income housing is usually provided on areas of roughly 300 square metres or sometimes smaller, while middle-income groups are accommodated on properties that are 300 to 600 square metres, and high-income accommodation is provided on larger properties (De Klerk 1998). Single detached dwellings have more walls that are exterior as opposed to apartments and, as a result, they consume far more energy per capita dwelling than apartments (Jermyn & Richman 2016).

3.5.1.2 Semi-detached dwelling

Semi-detached dwellings refer to various housing types in which one or more walls of two adjacent dwellings are shared, for example where two single-storey dwellings share a wall but each dwelling has its own entrance. Row housing is a form of semi-detached dwellings where more than two single- or double-storey dwellings share walls with each other and have their own entrances (De Klerk 1998).

A different form of a semi-detached dwelling is terraced housing. Terraced housing differs from row housing in that row housing has a yard in the front and back of the dwelling, whilst in terraced housing the yard claims the space adjacent to the unit and the roof of the lower unit (Davis 1977). An additional option is cluster housing, which refers to dwellings that can be clustered into high-density units (approximately 45 to 50 per hectare). Cost savings are considerable due to fewer roads and utilities (Davis 1977).

3.5.1.3 Courtyard dwelling

Courtyard dwellings are arranged in L- or U-shaped units to create communal courtyard areas within the development. This accommodation type generates a sense of community through these inclusive communal areas (De Klerk 1998).

3.5.1.4 Walk-ups

Walk-ups are apartment blocks that usually consist of three or fewer storeys and where the dwelling units are accessed without the aid of a mechanical elevation system (De Klerk 1998). Stacked town houses or garden apartments are two different forms of walk-ups (Davis 1977). Although these units mostly do not have any private outer space on the ground, they share stairs and hallways for access (Davis 1977).

3.5.1.5 Elevator-supported land-in-the-air

Land-in-the-air dwelling units share a communal entrance through a hallway or a foyer. The dwelling units are usually small and, because this accommodation type usually consists of a number of levels on a small surface area, they are regarded as relatively high-density accommodation (De Klerk 1998; Van der Linde 2000).

Land-in-the-air schemes use a 'skip stop' elevator that skips floors, as it is not necessary to duplicate the access on every level (Davis 1977). This allows for various other configurations, including the potential for double-aspect open-ended plans to increase light and air into spaces (Davis 1977).

3.5.1.6 Mixed use

Mixed-use blocks are usually multi-storey developments in which retail and office spaces are present with a number of dwelling units in which people live. This type of accommodation integrates the idea of working, living and shopping in the same floor area and it fosters relatively high densities (De Klerk 1998).

3.6 GENERIC METHODS OF DENSIFICATION

There are a wide variety of methods that can be applied to achieve higher densities. However, it is important to bear in mind the different characteristics of diverse environments in order to identify the most suited method of densification for a specific area (Schmidt-Thomé *et al.*

2013a). It is also necessary to differentiate between densification of existing areas and densification of new developments.

According to De Klerk (1998), the densification of existing areas proposes more challenges, as new designs should incorporate and improve the existing infrastructure. It is much easier to achieve higher densities in uninhabited areas than in existing areas, although densification is mostly needed in the latter (De Klerk 1998).

According to Neuman (2005), the standardisation of practice provides many obstacles to compact and dense development, as architects and planners make use of generic planning procedures with little concern for the specific context in which their design will be implemented. He argues that design principles across the globe are based on standardised technologies while they should rather be focused on the local culture within a given area (Neuman 2005).

3.6.1 Subdivision of property

Existing properties can be subdivided in order to make provision for additional housing. This method usually goes hand in hand with re-zoning, as it often requires lowered standards for property sizes through zoning (Arrigone 1995). This method is very useful where existing dwellings are built on large properties, due to the high maintenance costs related to such large premises (De Klerk 1998).

The placement of dwellings plays an important role in the application of this method, as it becomes difficult to subdivide properties when the existing dwelling is placed in the centre of the premises. It is usually the case that the additional dwelling(s) do not have direct access from the road; however, this problem can be address through the application of panhandle layouts (Arrigone 1995; Verreynne & Steÿn 1997).

3.6.2 Increase of bulk rights

Bulk and massing are used internationally to control the amount of construction in a particular area (Holden & September 2007). Based on zoning scheme regulations, different areas have different bulk restrictions. Although it is a lengthy legal process, developers and landowners can apply for an increase in bulk rights pertaining to a specific property in order to achieve higher densities on a specific property (Holden & September 2007).

3.6.3 Attached/detached second dwelling

In cases where there is sufficient space on a property, it can be viable to build another structure on the premises to increase the number of units on the same property (Arrigone 1995; Verreynne & Steÿn 1997). Often owners renovate their garage into a dwelling unit and change the use from non-residential into residential, and therefore they manage to increase the density of the given property. When an addition is made, it can be attached to the existing structure, or it can be constructed in the backyard of the property, as long as there is an increase in the number of dwelling units (Arrigone 1995; Verreynne & Steÿn 1997).

3.6.4 Consolidation

The consolidation of property is where two or more properties are consolidated under the same property number. This is a highly useful method of densification, as developers can achieve very high densities. Property that is used for single dwelling can now be used for high-density accommodation types like apartment blocks (Verreynne & Steÿn 1997). Consolidation can either be used to increase densities by linking two houses and developing them to increase the number of units, or properties are consolidated and their structures demolished in order to be redeveloped with large apartment blocks (Arrigone 1995).

3.6.5 Infill development

The greatest opportunity for the densification of urban areas lies in segments of undeveloped and underutilised open spaces (Arrigone 1995). It is important that undeveloped and underutilised land is identified and utilised for the development of new residential areas (De Klerk 1998). Thus, infill development is the way in which underutilised land that is appropriate for development is identified and developed in a way that will maximise the unit density to accommodate high population densities.

3.6.6 Zoning

Zoning is a very useful instrument in densification. Through zoning, it is possible to reduce restrictions, for example on the subdivision of property, in order to generate higher densities (Spreiregen 1981). Zoning is also used to legally change the use of a non-residential building to general residential, and therefore is a useful instrument in cases where a building is not utilised but not zoned residential either. Through the alteration of the zoning ordinances, developers can generate residential densities in buildings that had no residential density (Arrigone 1995; Verreynne & Steÿn 1997).

In addition, Randal O'Toole (s.a.) mentions the idea of land swops/zoning swops or tradable development rights, which entails the transfer of ownership of developmental rights of a segment of land that is in public ownership, where new development is desired, to a private developer that seeks to develop land in an undesired developmental area. In this way it is possible to achieve higher densities than the provisions made by zoning schemes.

According to De Klerk (1998), this is a fair system, seeing that the benefits of densification are equally shared amongst those who are willing to pay the price thereof. However, De Klerk (1998) states further that if zoning schemes are not made more flexible to encourage mixed land uses, fragmented zones will arise, which is in contrast with the aim of densification. Musakwa and Van Niekerk (2013) point out that studies pertaining to the changes in planning policies, particularly relating to zoning changes to promote MXD, encourages the social, economic and environmental aspects of sustainable development.

3.7 WHERE DENSIFICATION NEEDS TO OCCUR

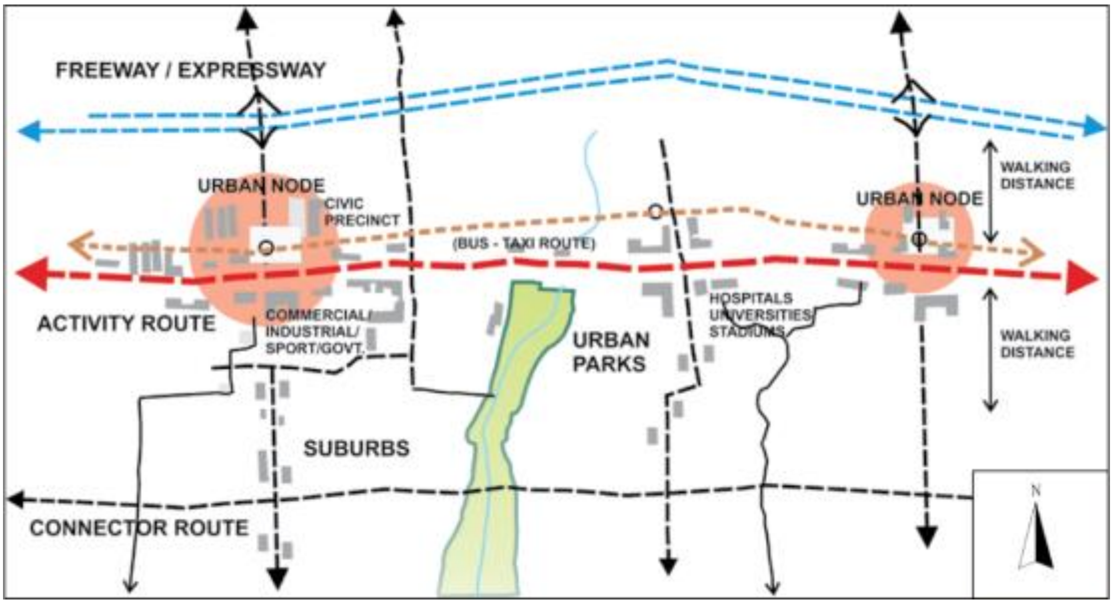
There are two prominent ways in which densification occurs; firstly, through the densification of existing areas and, secondly, through the densification of new developments. According to De Klerk (1998), the densification of existing areas poses more challenges, as new designs should incorporate and improve the existing infrastructure. It is much easier to achieve higher densities in uninhabited areas than in existing areas, although densification is mostly needed in the latter (De Klerk 1998). Furthermore, Van der Linde (2000) argues that densification needs to occur next to activity corridors, in existing built-up areas and in open spaces within the urban edge.

3.7.1 Development corridors

Areas where high-intensity urban development is centred on activity and development routes are referred to as development corridors (City of Cape Town 2012b). They are characterised by a dynamic relationship between land use and the movement system, which is supported by public and private transport services to facilitate ease of movement (City of Cape Town 2012b).

A corridor is a linear form of urban development and is based on the concept that all major activities can be concentrated along a single linear configuration, which relies on transportation for access (Jordaan 2003). A development corridor is graphically illustrated in Figure 3.5. The basic elements include activity routes, passenger rail stations, modal interchanges and freeways.

Densification firstly needs to be implemented at demarcated nodes (see Figure 3.5), after which it needs to be encouraged along activity corridors to ultimately link the different nodes (Van der Linde 2000). All the streets and avenues within the activity corridor are referred to as the activity spines, and for these spines to have a positive influence on the entire corridor a minimum level of support needs to be provided. This minimum level of support is referred to as the threshold value of the activity streets. This threshold value depends on the number of feet that moves around it. Therefore, it can be assumed that high population densities will contribute to the success of the activity spines and its linking of nodes (Green 1990).



Source: City of Cape Town (2012b: 33)

Figure 3.5 Concept of a development corridor

An important aspect of the activity spine is the means of transport that it entails. It is argued that the predominance of car movement negatively affects the sustainability of corridors because it is reliant on a single mode of transport (Jordaan 2003). Walking distance is a critical aspect in the development of effective public transport. Research shows accepted walking distances in low-income areas to be estimated at 700 m to 1 km (Jordaan 2003). Green (1990) points out that the socio-economic status of the immediate population in close proximity to the activity street should be taken into account. For example, lower income groups will on average spend less money on products and services provided by the activity spine (Van der Linde 2000). To ensure the viability of the activity spine, the population density of this lower income group needs to be increased in order to meet the threshold value requirements of the activity spine (Van der Linde 2000). To be successful in the implementation of this concept, it is important to understand all the variables, such as user requirements, movement patterns, transport systems, income levels and possible density.

3.7.2 Existing built-up areas

Behrens (1993) and Arrigone (1995) identified various methods that can be followed to intensify the density in existing built-up urban areas. The first is the provision of multiple dwelling units, which implies that development regulations make provision for two dwelling units per property without the subdivision of that property (Arrigone 1995; Behrens 1993). Multiple dwellings usually take the form of a second detached dwelling unit on one property (e.g. granny flat) or a single dwelling unit that is divided into two (Arrigone 1995; Behrens 1993). In this regard, it is possible to establish a third dwelling unit on the property, as long as the infrastructure of the given property is sufficient (Arrigone 1995; Behrens 1993). Secondly, the subdivision of property is another method towards intensifying the density in existing built-up urban areas. Subdivision implies that development regulations should decrease the minimum property size in order to make the subdivision of large properties possible (Arrigone 1995; Behrens 1993).

Furthermore, Arrigone (1995) says that buildings that are not utilised for the residential function can be legally altered to accommodate additional housing. In addition, brownfield developments, which are parcels of land once used for industrial and commercial activities but that have become unused, deserted and dilapidated areas, stand out as prime areas for densification (Van der Linde 2000). Both urban renewal and urban regeneration can contribute greatly to the process of urban densification in existing built-up urban areas (Couch 1990).

3.7.3 Open areas within the urban edge

The development of underdeveloped land in developed areas holds the most potential for densification in existing urban areas (Arrigone 1995). This process is referred to as infill development. Infill development can occur through the development of excessively wide road reserves, in land reserves due to ineffective layout, in public spaces that are not being utilised effectively, and in land parcels controlled by institutions that cannot afford them anymore (Dewar 1991).

Land swops/zoning swops or tradable development rights entails the swapping of ownership of developmental rights of a segment of land that is in public ownership, where new development is desired, with the rights of a private developer that seeks to develop land in an undesired developmental area (O'Toole s.a.). This process involves financial compensation, would there be any variations in the market value of the transferred land. In order to apply this method of infill development, local authorities need to have ownership of unused and vacant land in desired developmental areas and the owner of developmental rights need to be willing to comply with the transfer. In this manner, the authorities can stimulate development in desired developmental areas (Van der Linde 2000).

Land consolidation is a process in which ineffective land parcels are redistributed on a negotiated basis (Behrens 1993). The process of land consolidation can be initiated through authorities or private institutions and is dependent on the approval of participating landowners (Behrens 1993). It can be used for redevelopment with higher densities, especially with low-cost housing. However, Arrigone's (1995) definition of land consolidation differs slightly from that of Behrens (1993), as he defines it as the progressive upgrading and densification of communities. According to him, it entails the upgrading of informal settlements to formal settlements through the improvement of infrastructure and provision of services and opportunities.

An additional way in which unutilised and vacant land in public possession can be developed is through public housing programmes, where local authorities can actively engage in high-density infill development while setting an example of the desired development to private developers (Van der Linde 2000).

Property tax can also play a crucial role in encouraging landowners of underutilised land to develop if there is deterring tax regulation on underutilised land (Behrens 1993). This kind of tax can be uniform according to market value, or it can be measured against a rate relative to the duration for which the land is underutilized (Behrens 1993).

3.8 ADVANTAGES AND DISADVANTAGES OF DENSIFICATION

Throughout the literature is it evident that many authors hold different perceptions of the benefits and disadvantages of urban densification and whether or not this planning strategy is a positive or negative trait. Churchman (1999) notes that diverse groups of people and various urban settings experience the impact of density dissimilarly. In addition, a particular advantage of higher urban densities cannot be viewed in isolation to that advantage, as there are many associated adverse impacts that may be overshadowed by only focusing on the advantages. Therefore it becomes critical to understand density and the consequent impacts beyond its intention and incorporate aspects such as liveability, quality of life, perceived equity and sustainability (Boyko & Cooper 2011). With this in mind, the following section will focus on the economic, social, spatial and environmental advantages and disadvantages of densification based on the relevant literature.

3.8.1 Advantages of densification

Throughout western cities, some states in North America and in many developing countries as in Asia and South Africa, there is growing concern regarding the uncontrolled and outward development of urban forms (Arku 2009; Brueckner 2000; Horn 2010). According to Dieleman and Wegener (2004: 308), such kind of development is accompanied by a span of 'unintentional' spatial consequences. Ewing, Pendall and Chen (2003) note the dependence on private cars and the associated congestion and air pollution, central city decline and uncoordinated investment in urban centres, and the demise of green space in urban areas, as the most remarkable consequences. In the light of this, the advantages of densification are set out in terms of economic, social, spatial and environmental advantages in order to demonstrate exactly in which sphere the benefits of densification can improve the sustainability of a city and the livelihood of its inhabitants.

3.8.1.1 Economic

The idea of concentrated urban development in the 1990s rested mainly on the social and economic situation in cities and the conservation of open space (Van der Waals 2000). It is widely argued that cities have the potential to be extremely efficient when residents are living close to one another (Anderson, Hooper & Tuvshinbat 2016; World Bank 2016). Elkin, McLaren and Mayer (1991) argue that compactness of urban space reduces the cost, time and energy consumed in the transportation of goods, services and people. The delivery of services such as water, transportation, sanitation, education, healthcare and other social and cultural services becomes easier to provide and (Anderson, Hooper & Tuvshinbat 2016; Arku 2009; Jabareen 2006; World Bank 2016). Therefore, densification encourages economic opportunities and facilitates service provision (City of Cape Town 2012a).

Higher urban density is consistently related to increased levels of public transit use and a decline in car ownership, which ultimately leads to lower overall costs of managing and operating commuter transportation systems (Newman & Kenworthy 1999). According to Jabareen (2006), density is related to a threshold value and, at a certain density, the degree of interaction is adequate to render urban functions feasible. Therefore, densification and the associated density results in transport systems that are more feasible, as more people make use of public transport systems in densely populated areas (Breheny 1996; Williams, Burton & Jenks 2000a). Interestingly, this relates to the principle of economies of scale, because due to the increased number of people who share facilities and services it becomes cheaper, as more people share the cost. There is also a greater possibility for such public services to be more economically sustainable due to more people supporting them (De Loor 1992).

Authors such as Sassen (2001) and Scott (2001), amongst others, note how higher densities relate to decreased proximities and hold far-reaching benefits, such as urban agglomeration of economies. Neuman (2005) states that high residential densities go hand in hand with strong economic interaction due to the agglomeration of economic and employment opportunities. According to Broberg and Kyttä (2010), densification allows for advancements in energy and transport technologies. Interestingly, Carlino, Chatterjee and Hunt (2007) found that cities with double the employment density as opposed to others display a product patent rate that is 20% higher than that of a city with half the employment density. Similarly, De Loor (1992) argues that densification is economically beneficial in that it promotes better use of public transport services and a reduction in transport costs. As a result of decreased travel distances and lower transport costs, employers have the opportunity to cut on wages, as less money has to be spent on travel costs (De Loor 1992). Moreover, densification proposes sustainable transportation initiatives which, according to Himanen, Lee-Gosselin and Perrels (2005: 23), entail "a transport system that in itself is structurally viable in an economic, environmental and social sense, and does not impede the achievement of overall sustainability of a society".

In addition, through densification expensive land can be used to achieve higher densities coupled with higher returns, as it serves more people and therefore the land is used more effectively (Himanen, Lee-Gosselin & Perrels 2005). Furthermore, higher density housing holds an economic advantage for a large portion of the population (e.g. single parents, students, unmarried youth and the elderly), as their needs and financial capacity often restrict them to small places (Himanen, Lee-Gosselin and Perrels 2005). In addition, Haughey (2005) notes that densification positively affects the value of surrounding detached dwellings.

3.8.1.2 Social

A sustainable urban form entails a form and scale that encourage non-automotive means of transport, such as walking and cycling, and efficient public transport with densities that encourage social interaction (Elkin, McLaren & Mayer 1991). Burton (2000) points out four social equity benefits of higher densities, which relate to the use of public transport, a lower death rate associated with mental disorder, improved access to supermarkets and less social segregation.

Densification is a national spatial strategy aimed at integrating cities socially and spatially (Stellenbosch Municipality 2012a). De Chiara, Panero and Zelnik (1995) mentions that it is easier to create a sense of community and a community identity in dense areas where people live close to each other. In addition, high-density areas are usually associated with greater variety of accommodation types and therefore the user has a greater range of options to choose from (Alexander & Tomalty 2002; City of Cape Town 2012a).

Densification enhances the opportunity for walking and cycling and therefore it has potential health benefits for residents (Alexander & Tomalty 2002; Bannister 1992). In addition, Haughey (2005) argues that densification increases pedestrian movement and therefore creates a 24-hour community, which results in less crime and, ultimately, safer communities. According to Thomas and Cousins (1996), higher density living improves accessibility for all through public transport or by bicycle or on foot. Arrigone (1995) and Masnavi (2000) support this claim, arguing that densification is associated with increased access to a city's amenities for residents. Similarly, Dave (2010) found support that increased dwelling densities at the neighbourhood level have a positive correlation with increased access to urban facilities and services.

In addition, densification encourages the promotion of quality of life, which is related to the degree of social interfaces and access to facilities and services (Williams, Burton & Jenks 2000a). According to Jabareen (2006), the mixing of land use, coupled with high residential densities, results in compactness, which ultimately promotes social interaction.

3.8.1.3 Spatial

According to Jabareen (2006), diverse development, which is promoted through urban densification, entails a variety of building, housing option, land use, rents and architectural designs. Similarly, Alexander and Tomalty (2002) mention that high-density areas are usually associated with a greater variety of accommodation types. In addition, Cheng (2010) notes the diverse spatial benefits associated with different site layouts. For example, high-rise layouts hold the benefit of available space for additional shared facilities, such as gymnasiums and community midpoints, courtyard developments allow for increased communal semi-private open space, and single-family detached layouts allow for smaller but private spaces. Meyer (1972) argues that the densification of urban areas restricts urban sprawl that encroaches on valuable agricultural land and other natural resources. This is achieved by encouraging vertical development rather than horizontal development (City of Cape Town 2012a).

According to Green (1990), densification has the ability to enhance the implementation of activity spines and corridors, which can assist the stimulation of low-income areas. The densification of nodes and activity corridors is a way of improving the status of an area, and therefore it can uplift the entire livelihood status of a community (Green 1990). Dewar (1991) argues that, through the integration of urban services and the provision of greater accessibility, the user spends less time on service to and from work. In addition, Haughey (2005) notes the benefits of shared parking in mixed-use developments that are promoted through densification. According to Van der Linde (2000), well-planned densification can reduce current usage of space concerning roads, as it encourages higher levels of pedestrian travel.

3.8.1.4 Environmental

The rationalisation for the compact city rests mainly on the fact that it promotes the least energy-intensive activity patterns as opposed to the green/dispersed city, and therefore the assumption holds that it is more sustainable than the dispersed city (Holden & Norland 2005). Williams, Burton and Jenks (2000a) note four recurring themes in the debate on compactness as a method for achieving sustainable urban forms. Interestingly, three of the four themes mentioned relate to the environmental aspects of densification. The first theme is that a compact city goes hand in hand with rural conservation. The second theme relates to the reduction of energy consumption through building densities, and the third to the reduction in CO_2 emissions through advancements in modes of transport. Norman, MacLean and Kennedy (2006) conclude that low-density peripheral developments are more intensive on a per capita basis in both greenhouse gas and energy consumption.

Densification reduces the consumption of scarce resources such as land, minerals and biodiversity areas (City of Cape Town 2012a). In addition, authors such as Alexander and

Tomalty (2002), Haughey (2005) and Kamal-Chaoui and Robert (2009) all support the argument that higher urban densities relate to better use of natural resources and the existing urban infrastructure. Likewise, Van der Waals (2000) mentions that policymakers are advocating the compact city and its association with higher urban densities, as it promotes the protection of land in rural areas.

Furthermore, higher densities facilitate the conservation of land resources for leisure activities and other public uses (De Chiara, Panero & Zelnik 1995). Additionally, where a number of people can be accommodated on a smaller area, the impact of residential development on the environment will be less (Behrens 1993). According to Jabareen (2006), higher densities result in the intensified use of urban areas and the logic on which intensification rests is that it consumes land in a more efficient manner by raising the concentration of development and activity. This reduces the development strain on both industrial and agricultural land, as well as on existing green space (Alexander & Tomalty 2002; Churchman 1999).

It is believed that car travel and ownership decreases with the increase in densities (Holden & Norland 2005; Jabareen 2006). Therefore, higher urban densities result in the reduction of CO_2 emissions from fossil fuels, and consequently a less harmful carbon footprint (Burton 2000; Churchman 1999; Holden & Norland 2005).

3.8.2 Disadvantages of densification

The alleged benefits of densification and the compact city are widely documented in the work of Jenks, Burton and Williams (1996), Williams, Burton and Jenks (2000a) and Boyko and Cooper (2011), amongst others. However, Burton (2002) and Neuman (2005) note that there is vagueness in or a lack of empirical support for densification. Although Zhu (2012) regards densification as a necessary solution as opposed to a choice, a number of disadvantages can occur when initiatives are poorly planned and if regulatory policies are not providing proper guidance. In this light, the disadvantages of densification will be explored from the economic, social, spatial and environmental perspectives.

3.8.2.1 Economic

In cases where densification occurs without proper planning it can foster undesired economic issues, including inadequate refuse disposal, poor water quality, and general congestion (Lemon 1995). Where densification is implemented in city centres without adequate public transport systems in place, it will increase the dependence on private motor vehicles and therefore lead to the congestion of existing transport systems (Lemon 1995). In addition, when existing road networks become over-utilised, new networks have to be constructed which are associated with high costs (Green 1990).

The compact city debate repeatedly mentions the conservation of agricultural land. However, Gordon and Richardson (1997) note the application of bit-rent curves in compact city policy, and how they transpire into land uses that have less value. According to Gordon and Richardson (1997), developers face relatively risky circumstances in terms of residential rejection upon new developments, which is related to the preference for a single-family detached dwelling, and such rejection may be costly.

In addition, Alexander and Tomalty (2002) found that higher density has a negative effect on the affordability of housing in urban centres. Holcombe and Williams (2008) revealed that government expenditure on facilities and services in large cities tends to increase with higher population densities.

3.8.2.2 Social

According to Verreynne and Steÿn (1997), high population densities create crowding, which leads to social disorganisation that goes hand in hand with poverty and other sociological problems, such as theft, rape and drug abuse. Similarly, De Roo and Miller (2000) and Zhu (2012) argue that, under certain socio-economic conditions, higher densities can foster crime, social irresponsibility and vandalism. Additionally, high-rise buildings lessen public space and increase the likelihood of criminal activity in elevators and other communal spaces (Sazanami 1972). Similarly, Alexander and Tomalty (2002) found that higher density has a negative relationship with access to green space.

Densification is criticised for its association with gentrification and increased costs of local housing. According to Quastel, Moos and Lynch (2013), densification has characteristics of gentrification as it influences cultures and lifestyles through the socio-economic configuration of settlements. Moreover, the quality of life can be compromised in high-density urban centres due to congestion and the loss of identity (Breheny 1992). In addition, it goes without saying that contagious diseases will be more common and have a greater impact on general health in higher residential densities. Graham and Glaister (2003) found that the pedestrian casualty rate increases gradually as a result of higher urban densities.

Neuman (2005) notes that the urban concentration of people and activities holds benefits, although people generally still position themselves on the sprawling periphery as opposed to the denser core of urban areas when given the choice. Burton (2002) points out that urban compactness has a limited affiliation with social equity and that, more often than not, it is experienced in a negative way. Neuman (2005) argues that the use of generic planning procedures has little concern for the context-specific nature of settlements, while they should be concentrated around the specific culture within a given area.

3.8.2.3 Spatial

According to Donaldson and Morkel (2012), modern consumer tendencies, the need for convenience, property rights and development pressures lead to unfitting and standardised building and space making. In addition, Wheeler (2002) mentions that uniformity of the built environment results in unattractive, uninteresting urban settings, the segregation of class and ethnic groups, limited housing options available for different income groups, and job-housing inequalities that result in higher levels of congestion, car dependency and pollution.

Kyttä *et al.* (2013) contest the notion of Duany and Plater-Zyberk (1992) and Jenks, Burton and Williams (1996) that densification holds ecological benefits, such as the reduction in energy consumption through decreased automobile dependency, arguing that it can also negatively influence urban character, perceived environmental quality and local lifestyles. Moreover, Van der Waals (2000) notes that poorly planned compact cities can lead to the over-utilisation and overloading of existing facilities and infrastructure and, according to Sazanami (1972), high-rise buildings potentially lessen public space

3.8.2.4 Environmental

According to Neuman (2005), the empirical study by Williams, Burton and Jenks (2000a) poses a weak relationship between the reduction of automobile dependency and higher densities. Neuman (2005) argues that traveling based on the desire for exclusive shopping or specific employment opportunities is self-determining and cannot be correlated with higher densities. According to Holden and Norland (2005), energy consumption related to traveling by airplane is more consumptive in high-density areas as opposed to less dense areas.

Tratalos *et al*. (2007) note the poor environmental performance concerning green space in high-density urban areas. According to Sazanami (1972), achieving high densities through high-rise buildings can lead to increased noise pollution and a reduction in natural sunlight. Hatt *et al*. (2004) reveal that urbanisation that is associated with higher urban densities has a strong relationship with the degradation of stream water quality in urban areas. Densification is associated with high levels of impervious surface coverage and therefore can influence run-off capabilities in urban areas (Neuman 2005). Van der Waals (2000) notes that the compact city debate often neglects environmental factors related to the fragmentation of natural areas, energy use in buildings and local air pollution.

3.9 CONCLUSION

It is evident that, as a result of the variety of interpretations across various disciplines and its application within various settings, density is a complex and multifaceted concept. In the light of this there is a need to simplify density as a concept in order to make its interpretation more valuable in the urban environment. Density can be separated into two overarching categories, namely physical density and perceived density. While physical density refers to a quantitative measure of the concentration of physical structures or individuals, perceived density refers to an individual's perception regarding the number of people and available space in relation to the spatial characteristics of an area.

In the planning realm, physical density can be subdivided into three components, namely building density, dwelling unit density and population density. For interpretation purposes, it is crucial that all three components are investigated and compared in order to generate the most comprehensive picture of density. Residential density depends primarily on factors related to the physical planning and house design, user acceptability and statutory planning and building regulations. It is important, however, to identify the most suited locations for densification, while understanding the factors that influence residential density and being aware of various housing options that can be utilised to achieve higher densities and simultaneously maintain a high level of user satisfaction. Table 3.3 summarises the advantages and disadvantages of densification from an economic, social, spatial and environmental point of view.

Table 3.3 Summary of the advantages and disadvantages of densification

ADVANTAGES AND DISADVANTAGES OF DENSIFICATION		
	Advantages	**Disadvantages**
Economic	• Economic efficiency • Reduced cost of service provision • Reduced transport costs • Cost-effective maintenance of facilities • Viable functions and economically sustainable services • Urban agglomeration of activities • Advancements in energy and transport technologies • Increased product patent rate • Efficient use of expensive land • Greater housing options for lower income groups • Increased value of surrounding environment	• Potentially inadequate service delivery (i.e. refuse disposal, water quality) • Cost related to overcrowded and congested facilities • Residential rejection of new developments • Increased rental and property values • Increased governmental expenditure on services and facilities
Social	• Walking, cycling and related health benefits • Social interaction • Social integration • Sense of community • Improved accessibility of urban facilities • Higher user satisfaction due to variety of options • Safer communities • Good quality of life	• Social disorganisation • Crowding (perception?) • Increased sociological problems • Diminishing public spaces • Association with gentrification • Loss of community identity or town character • Contagious diseases • Increased pedestrian casualty rate
Spatial	• Variety of land uses • Variety of housing options and designs • Site configuration benefits (shared facilities, shared semi-private space, private space) • Restricts urban sprawl • Defined urban edge • Vertical development • Activity spines and corridors • Finely grained urban fabric • Greater service provision configurations • Shared parking facilities • Reduced usage of space	• Standardised building and space making • Unattractive , uninteresting urban settings • Class and ethnic segregation • Job-housing inequalities • Congested streetscapes • Loss of town identity and character • Over-utilisation of existing infrastructure • Excessive building and construction

ADVANTAGES AND DISADVANTAGES OF DENSIFICATION		
	Advantages	**Disadvantages**
Environmental	• Less energy intensive • Rural conservation • Conservation of agricultural land • Conservation of land for recreational purposes • Land use efficiency • Reduction in CO_2 emissions • Better use of natural resources • Better use of infrastructure • Less harmful carbon footprint	• Increased air travel • Increased travel for exclusive shopping • Increased travel based on job-suburbanisation • Green space degradation • Increased noise and air pollution • Reduction in natural sunlight • Degraded stream water quality • Increased impervious stream water quality • Increased energy use in buildings

Source: Author (2016)

It can be concluded that a wide range of housing options and their combinations exist. It is imperative that developers pay special attention to the specific setting in order to choose the most suited combinations for a given user and within a specific context. Moreover, densification holds many environmental, social, spatial and economic advantages and disadvantages that need to be identified, analysed and compared to establish the most suited approach when developers plan projects based on densification principles.

CHAPTER 4: URBAN DENSIFICATION AND POLICY IN STELLENBOSCH

4.1 INTRODUCTION

This chapter focuses on the fourth objective set out in the research structure, which was to identify the relevant policy documents and planning strategies in Stellenbosch. The chapter starts by looking into the background of the policy playing field, followed by a discussion of the IDP, the SDF and the IZS of Stellenbosch Municipality.

The Constitution of the Republic of South Africa (Act 108 of 1996) (South Africa 1996), the White Paper on Local Government that paved the way for the Municipal Systems Act (32 of 2000) (South Africa 2000), the National Environmental Act (107 of 1998, NEMA) (South Africa 1998), and various provincial ordinances (e.g. integrated development plans (IDP)) direct spatial planning in South Africa. These policies aim to improve the economic and developmental growth and decision-making of communities while promoting the social welfare of all citizens (Chobokoane & Horn 2014; Ngxiza 2011; Stellenbosch Municipality 2012b). Sectorial planning ordinances can be separated into two categories. Firstly, spatial development frameworks (SDFs) are used to guide and inform spatial development in relation to the desired urban form and define the policies and strategies to accomplish this. Secondly, land use management systems (LUMS) are directed by the SDF and relate to zoning schemes and regulations that affect the developmental rights of an area.

The dawn of the new millennium marked the end of the ‘transitional’ period in spatial politics influencing the urban space of Stellenbosch and witnessed the rise of the new Stellenbosch Municipality (WC024) (Nicks 2012:37). In addition, Donaldson and Morkel (2012: 60) note that Stellenbosch had experienced significant political fluctuation between the ruling parties of the African National Congress (ANC) and the Democratic Alliance (DA), which, according to Nicks (2012), resulted in discrepancies with regard to the coordination and exchange of institutional knowledge. Consequently, the success of new representatives and their potential for advancements in policy and municipal capacity building were greatly hampered (Donaldson & Morkel 2012). Similarly, Eggenberger and Partidário (2012) points out that a major challenge in spatial planning policy stems from the coordination deficit between different sectors of government.

4.2 STELLENBOSCH INTEGRATED DEVELOPMENT PLAN (IDP)

The Municipal Systems Act of 2000 (South Africa 2000) mandates the production of IDPs in all municipalities in South Africa (Chobokoane & Horn 2014). The mandate is based on the assumption that the IDP would contribute to the land development objectives (LDOs) required in the Development Facilitation Act (DFA) and additionally facilitate the repeal process of the LDOs (Berrisford 2011). Therefore, the IDP is the primary management instrument of local government that aims to guide the present and future activities and resource distribution of the entire municipality.

To date, Stellenbosch Municipality has developed three generations of IDPs, each of which sets out the desired accomplishments of the Municipality over five years, with annual reviewing. The 1st generation IDP (2002 to 2006) can be regarded as a learning curve, as it was the first of its kind and led to new directives in respect of credible IDPs (Stellenbosch Municipality 2007).

The 2nd generation IDP (2007 to 2011) was centred more around implementation, with an emphasis on sustainable and integrated human settlements and local economic development (LED). In addition, this IDP indicated awareness of the priority of preserving the residential character of residential areas from the infringement of densification and ineffective ZSR (Stellenbosch Municipality 2007). One of the strategic planning objectives was to finalise the SDF, including overlays on densification, heritage, environment, built form and special areas (Stellenbosch Municipality 2007). However, the 2007 IDP of Stellenbosch Municipality can be criticised for not providing an official SDF and, to date, only the heritage overlay has become a reality.

The 3rd generation IDP (2012) aims to address the shortcomings of previous IDPs concerning development and planning. This is evident in the approval of the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b). Similar to previous concerns, the priority issue of densification changing the existing character of residential areas is consistently highlighted. However, the Stellenbosch Municipality IDP (Stellenbosch Municipality 2012a), together with the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b), aims to address the Municipality’s housing needs and integration aspirations by encouraging social and GAP housing, increasing the viability of public transport with redevelopment, infill and new development, encouraging the development of additional dwellings and the subdivision of properties to minimum property sizes, and multiplying densities along major transit links and around public open spaces.

4.3 STELLENBOSCH MUNICIPALITY SPATIAL DEVELOPMENT FRAMEWORK (SDF)

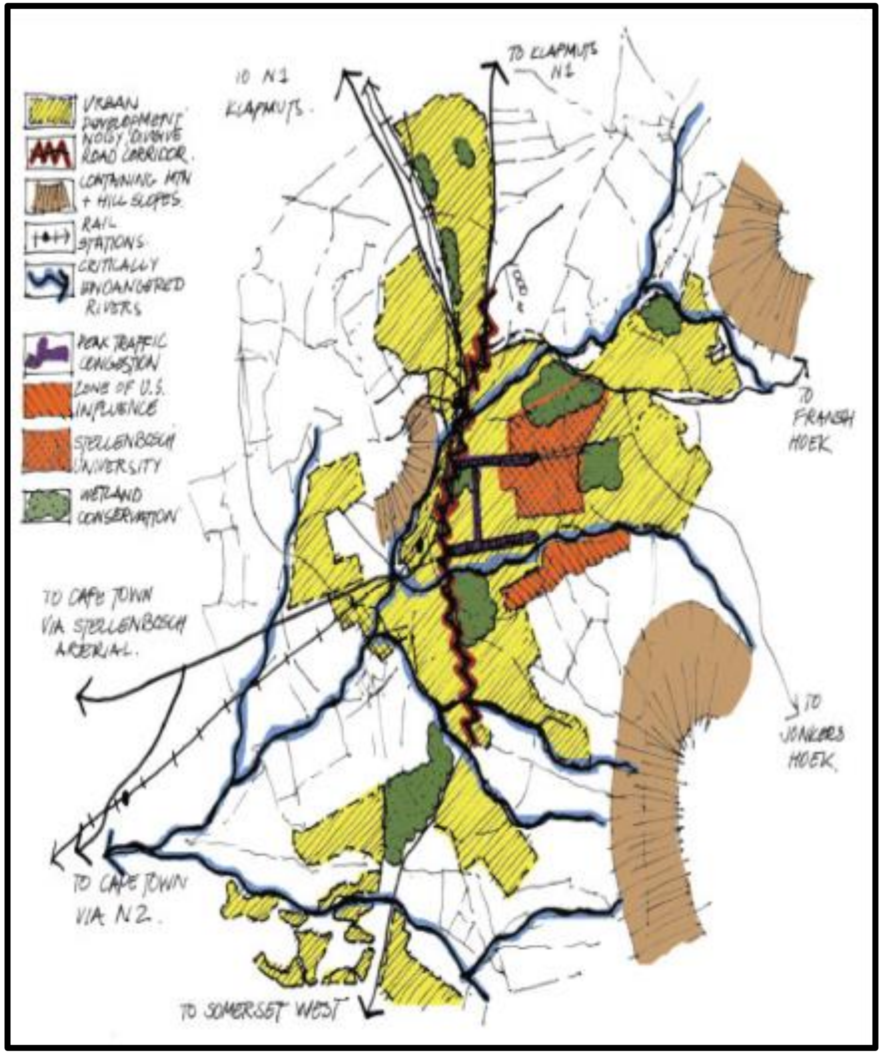
In contribution to the IDP, Stellenbosch Municipality drafted a SDF in2005 that placed great emphasis on public participation. However, most of the interest was from retired, white middle-class participants (Nicks 2012). In 2006, another Stellenbosch Municipality SDF (2006) was prepared, and this time emphasis was placed on organising and planning a town that was able to handle rapid growth while avoiding outward expansion and preserving the unique character of the town (Nicks 2012).

The latest Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) was developed in 2011 by CNdV and was only officially approved in February 2013, according to the Stellenbosch Infrastructure Plan (Stellenbosch Municipality 2013). Hence, the unofficial status of the SDF (for two years) presented undesired effects on future planning to date (Stellenbosch Municipality 2013). In addition, the lack of a distinct urban edge coupled with the application of containment policies within these vague edges was not in line with the principles of a sustainable urban form (Stellenbosch Municipality 2013). The Stellenbosch Municipality's IP (2013) further highlights concerns in the SDF (Stellenbosch Municipality 2012b) about the capacity of bulk infrastructure in particular. This is based on the lack of coordination between the growth strategy of the university and the extensive process of densification occurring adjacent to the university.

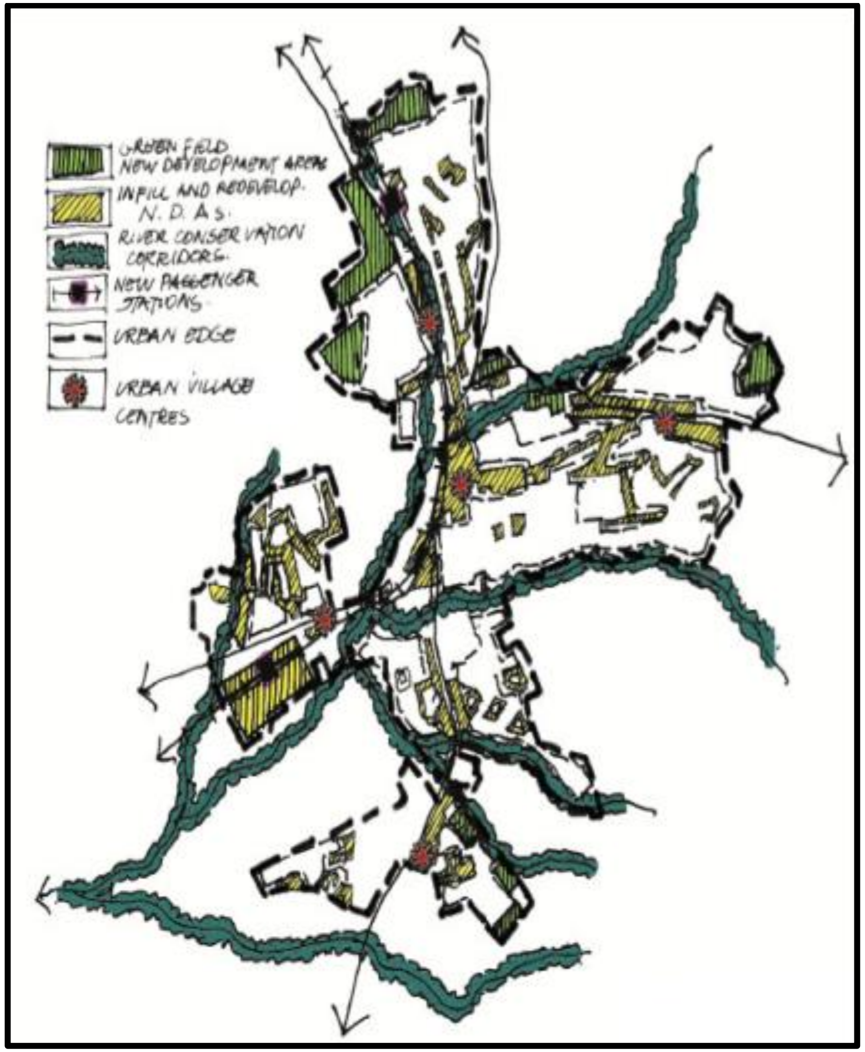
Nevertheless, on a microlevel, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) recognises the incapacity of the town's infrastructure to meet development needs between 2012 and 2017, with the exception of solid waste disposal, and stipulates a number of strategies, accompanied by a set of principles for each strategy, aimed at guiding spatial development in the future. These include interconnected nodes, car-free transport, inclusive economic growth, optimal land use, resource custodianship, food and agriculture, as well as heritage.

With regard to the principles set out, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) encourages higher density development in the town, provided that it adheres to restrictions stipulated in the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c). The Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b: 16) states that "the principles of walking distance, functional integration, socio-economic integration, appropriate densification and the urban edge should inform settlement design".

Figure 4.1 provides a visual interpretation of Stellenbosch as analysed by the Stellenbosch Municipality SDF, and Figure 4.2 is a proposal to guide development and the future form of the town provided by the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b). In Figure 4.2 it is evident that a clearer urban edge is proposed, and that infill as well as redevelopment is strongly promoted. It can also be seen that a stronger emphasis is placed on the conservation of currently endangered river corridors. A contradicting factor, however, is the number of greenfield development areas proposed by the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b). Although the Stellenbosch Municipality SDF discourages the development of greenfields under the promotion of interconnected nodes, Figure 4.2 suggest otherwise, as these greenfields are on the periphery of the town, thus leading to a more sprawling form of development.



Source: Stellenbosch SDF (Stellenbosch Municipality 2012b: 33)



Source: Stellenbosch SDF (Stellenbosch Municipality 2013b: 33)

Figure 4.1 Stellenbosch town analyses

Figure 4.2 Stellenbosch town proposals

In order to promote walking, which goes hand in hand with accessibility, the Stellenbosch Comprehensive Integrated Transport Plan (Stellenbosch Municipality 2011) suggests that 20 minutes or 1 to 2 km proximities be the norm with respect to densification projects. In addition, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b: 17) states that half of the "activities found in urban areas (e.g. employment, shopping, public transport, social and recreational) should be within 1 km of where people live". It is interesting to note that transit-orientated developments (TODs), as contained in the SDF, are supported in the IDP. This form of development facilitates an increase in density and integration (Holmes & Van Hemert 2008). Similar to the argument of Jabareen (2006) regarding the viability of public infrastructure at certain densities, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b: 17) aims "to achieve the settlement densities needed to make the public transport system financially and operationally viable". According to the Stellenbosch Municipality CITP (Stellenbosch Municipality 2011) and Donaldson and Morkel (2012), current densities do not provide sufficient viability to sustain public facilities, small businesses and transport infrastructure, and this can be tackled with appropriate densification and the enforcement of the urban edge.

The Municipality aims to address its housing backlog through the densification of existing suburbs instead of encroaching on greenfields, or through extensions if they are not isolated but form part of the existing suburb (Stellenbosch Municipality 2012b). Therefore, the promotion of second dwellings, subdivisions, sectional titles, redevelopment of current low-density areas, brownfield development and infill development is evident in the SDF (Stellenbosch Municipality 2012b). The SDF recognises the distinctive nature of each suburb, which consequently requires suitable context-specific combinations of densification (Stellenbosch Municipality 2012b).

The SDF (Stellenbosch Municipality 2012b) stipulates the goal of integrating low-, middle- and high-income accommodation, with approximately 25 dwelling units per hectare in larger settlements, as opposed to isolated settlements or gated communities. In terms of the actual implementation of this principle within the municipal space, there are examples where the municipality is not faring too well. This is evident in the numerous gated communities along the R304 between Stellenbosch and the intersection with the M23 that have been developed since the approval of the SDF in 2013. In addition, the Stellenbosch Municipality CITP (Stellenbosch Municipality 2011) raises concerns regarding the achievement of this principle based on the high land values within the Stellenbosch Municipal area, stating that it restricts the development of low-income and GAP housing.

The CITP (Stellenbosch Municipality 2011: 21) states “the relationship between economic efficiency, social justice and ecological integrity is not one of equal and overlapping spheres”. Bearing this in mind, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b), in addition to the above, aims to conserve and manage resources in a sustainable manner. With regard to energy consumption, the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) demands that energy efficiency standards are incorporated in all new development applications, and it enforces the installation of solar water heating devices for all new housing projects, including low-income housing. Furthermore, the SDF (Stellenbosch Municipality 2012b) promotes the use of low-carbon building materials and the adoption of local material providers in order to reduce the energy consumed in the transport of fabrics sourced elsewhere.

Agricultural land that surrounds the town of Stellenbosch is under enormous development pressure. According to the Stellenbosch Municipality IP (Stellenbosch Municipality 2013), the Municipality requires approximately 750 to 1 000 hectares in order to meet the housing shortage. The IP (Stellenbosch Municipality 2011) notes that, without adequate redevelopment and infill strategies, the Municipality will need to acquire roughly 15 to 20 farms, which will have severe consequences for the Municipality’s economy, including the loss of gross domestic product (GDP) contributions from agriculture, the loss of low-skilled jobs as well as export losses. The Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) does, however, aim to preserve a minimum of 10 000 hectares of agricultural land for local food production and maintain the productivity potential of agricultural land in the surrounding area.

Food miles are a sustainability concept that has emerged and gained heightened consumer awareness throughout Europe and North America (Ballingall & Winchester 2010). The concept addresses the environmental damage associated with the transport of products to consumers (Ballingall & Winchester 2010; Stellenbosch Municipality 2011). It is interesting to note that the Stellenbosch Municipality CITP (Stellenbosch Municipality 2011) makes mention of this concept in an attempt to reduce the distance between production and consumption, while the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) completely fails to mention this concept. Although the Stellenbosch Municipality SDF discourages the development of superstores, which are associated with car travel, the Municipality promotes the potential of neighbourhood-level business, thereby encouraging LED. The Stellenbosch Municipality CITP (Stellenbosch Municipality 2013) recognises that municipal by-laws exclude informal traders from acquiring retail space due to high rentals. Nevertheless, the SDF (Stellenbosch Municipality 2012b) seeks to identify locations in major centres where informal traders can sell farming produce along with arts and crafts.

Stellenbosch has a unique sense of place that is largely attributed to the agricultural and scenic landscapes, historic architecture, museums, tourism and fine-grained historic urban street character (Stellenbosch Municipality 2012b). The Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) recognises the threat of uncontrolled growth upon the unique urban fabric of the area and proposes restrictions to control building styles and height, adequate zoning scheme regulations and parameters for sensitive biodiversity. However, authors such as Donaldson and Morkel (2012: 64) fear the loss of this unique sense of place due to “ad hoc” forms of densification occurring around the university campus.

4.4 STELLENBOSCH INTEGRATED ZONING SCHEME (IZS)

According to the Stellenbosch Municipality’s IDP (Stellenbosch Municipality 2012b) and the City of Cape Town’s Zoning Scheme Regulations (City of Cape Town 2012c), the main objective of zoning schemes are to conserve, protect and uplift the common wellbeing of the entire population in a given area. Land use planning in the Western Cape, including zoning schemes, is governed nationally by the Spatial Planning and Land Use Management Act (SPLUMA) (Act 16 of 2013) and provincially by the Western Cape Department of Environmental Affairs and Development Planning (DEADP) and Western Cape Land Use Planning Act (LUPA) (Act 3 of 2014) (Stellenbosch Municipality 2015/16). Consequently, municipalities in South Africa hold full responsibility over land use planning as far as their jurisdiction stretches and have the authority to introduce administrative and integrated zone by-laws (Stellenbosch Municipality 2012a).

Zoning is an internationally recognised LUMS that legally governs the rights to a property with regard to the use, for example commercial, residential, business, industrial, recreation, mixed-use and open space, as well as determining the bounds within which land may be developed, e.g. height, parking, coverage, etc. (Munneke 2005; Stellenbosch Municipality 2012a; 2012c) (Appendix B). It is of critical importance that development applications adhere to the provisions and intent of the specific zoning scheme applicable to the site.

Land parcels in Stellenbosch are currently regulated under the Stellenbosch Municipality’s Zoning Scheme Regulations (ZSR) approved in 1996 and consist of regulatory documents, zoning maps (Appendix A) as well as a zoning record of all decisions taken on each property (Stellenbosch Municipality 1996; 2012c). However, due to the large number of heritage sites in

Stellenbosch, the Municipality produced a heritage overlay zoning scheme (Stellenbosch Municipality 2012c), which is an amendment of the main zoning scheme and prescribes more or less restrictive development parameters than the Stellenbosch Municipality ZRS of 1996. In other words, overlay zoning acknowledges local differences and is used to provide flexibility as well as greater control in terms of the original Stellenbosch Municipality ZRS in order to meet the present demands of the town, such as the preservation of local character or to encourage development in specific areas (City of Cape Town 2012c; Stellenbosch Municipality 2012c). Table B.1 in Appendix B shows how the original land use zoning scheme, as per the Stellenbosch Municipality ZSR (Stellenbosch Municipality 1996), was transformed to the new Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c). It is important, however, to use the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c) together with the principal regulations stipulated in the ZSR (Stellenbosch Municipality 1996).

With reference to Table C.1 in Appendix C, the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c) categorises the use of land into primary, additional or consent uses, and proposals are only approved once they are in line the with these land use categories. Primary uses are those uses that are permitted by the IZS (Stellenbosch Municipality 2012c) on the specific property and require no further authorisation from Council. Additional uses take place in addition to the primary use and are limited by a number of conditions to eliminate undesired effects on the surrounding residents (Stellenbosch Municipality 2012c). The IZS (Stellenbosch Municipality 2012c) permits only one additional use per property in all residential areas. Consent for uses is assessed in accordance with the criteria prescribed in the planning law and can only be permitted with the consent of Council, which is generally largely dependent on public participation (Stellenbosch Municipality 2012c). In addition, there is a set of development rules pertaining to each specific zone to which developments have to adhere (Appendix C; also see Stellenbosch Municipality 1996). However, in cases where the land use category of a specific zone is unclear, the final decision rests with the Council.

In addition, the zoning scheme stipulates a two-year lapse period, which means that property owners or developers only have this period to start developments, or else an entirely new application needs to undergo approval (Stellenbosch Municipality 2012c). Consequently, this provision has the potential to result in the abandonment of incomplete developments or an increase in the pace of development.

4.5 DRAFT DENSIFICATION STRATEGY FOR UNIVERSITEITSOORD STELLENBOSCH (DDS)

Universiteitsoord was recognised as a densification zone due to its centrality with regard to the CBD, the university campus and the Cluver/Merriman transit corridor (Benn 2010; Stellenbosch Municipality 2009). The Stellenbosch Municipality DDS (Stellenbosch Municipality 2009) for Universiteitsoord was designed because of immense development pressure in the area and aims to provide regulatory guidelines based on the zoning regulations of the area. The DDS (Stellenbosch Municipality 2009) provides the following measurement parameters for densification in an attempt to manage the extent of densification in the area (Table 4.1).

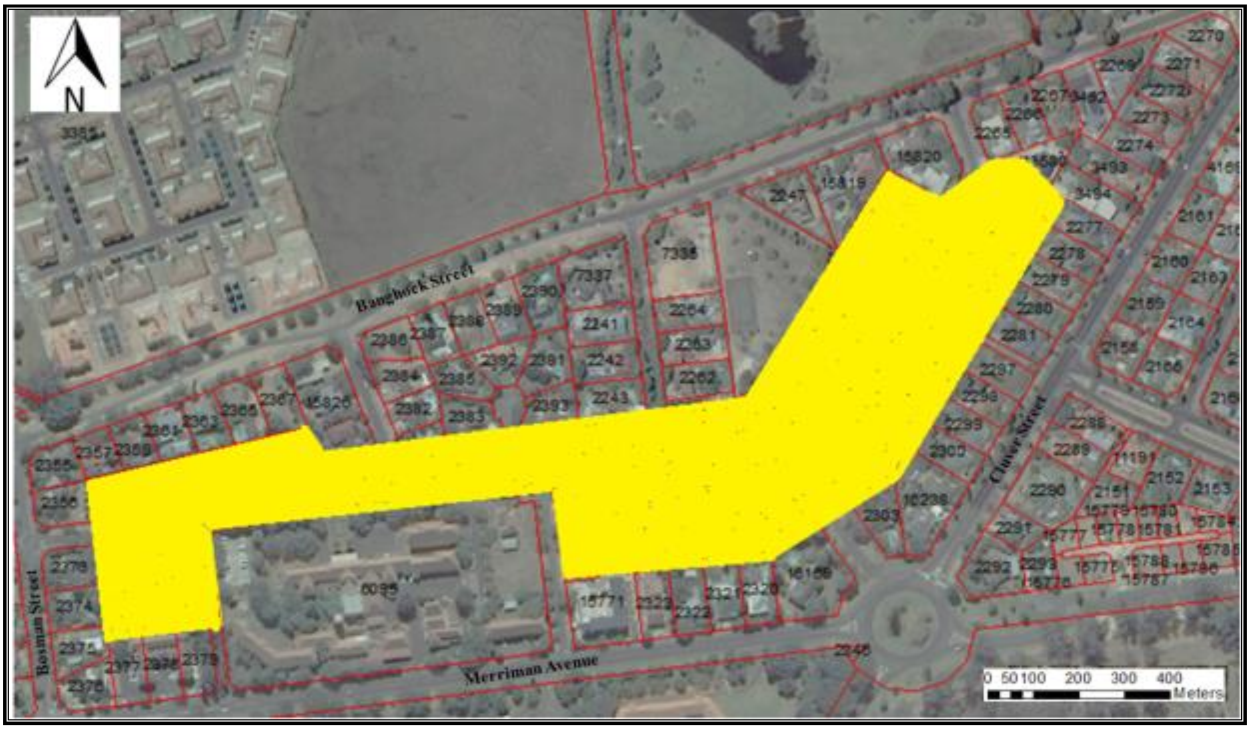
Table 4.1 Measurement parameters for densification

DENSIFICATION PARAMETERS IN UNIVERSITEITSOORD	
A minimum property size	Determines features such as depth of housing, street frontage and area applicable for landscaping, thus adding to a specific character. This parameter is easy to apply but inflexible upon diverse development possibilities.
Gross density of an area (du/ha)	Refers to the impact of the number of dwelling units on residential precincts with respect to traffic, services, social needs and open space.
Floor area ratio	Relates to all subsystems in the urban environment and is appropriate for the control of density gradients.

Source: Stellenbosch Municipality (2009: 1)

In addition, the Stellenbosch Municipality DDS (Stellenbosch Municipality 2009) formulated four policy guidelines for densification in Universiteitsoord. The guidelines are retaining the single-residential character of the inner block, encouraging densification within the demarcated outer edges, minimising through traffic and congestion through Roux and Hospital Streets, as well as minimising on-street parking in the densification process.

With regard to retaining the single-residential character of the inner block (Figure 4.3), the DDS (Stellenbosch Municipality 2009) aims to restrict densification to the subdivision of existing properties and the addition of a second dwelling unit, without subdividing the plot. However, the positioning and utilisation of the second dwelling unit is critical, as it may influence the appeal of the area and potentially contribute to the density of the area, although, in some cases, it represents basic extensions such as shading. All single-residential zoning considerations apply to this section of the area. The building heights may not exceed two storeys above ground level (Appendix C). The DDS (Stellenbosch Municipality 2009) mentions the necessity to upgrade the zoning restrictions pertaining to the inner block in order to enforce consent approval for the establishment of student accommodation in this part of the area (Stellenbosch Municipality 2009).



Source: Created on the basis of the DDS (Stellenbosch Municipality 2009: 4)

Figure 4.3 Residential inner block of Universiteitsoord in yellow

With regard to promoting densification on the outskirts of the area, the DDS (Stellenbosch Municipality 2009) stipulates that developments adhere to the proportions of the surrounding buildings, such as height and form (Figure 4.4). In this section of the area, the consolidation of properties is an essential mechanism for redevelopment and developers need to ensure that projects are directed outwards to link with the surrounding public transit network (Stellenbosch Municipality). The DDS (Stellenbosch Municipality 2009) further specifies that the policy guidelines should be applied appropriately to the context-specific nature of the area, as the outer and inner sections have different relationships with the surrounding space. To provide clarity, the DDS (Stellenbosch Municipality 2009) differentiates between various sections of the outer edge (Block A to B in Figure 4.4) and provides specifications for densification in each block (Table 4.2).

Source: Created on the basis of the DDS (Stellenbosch Municipality 2009: 7)

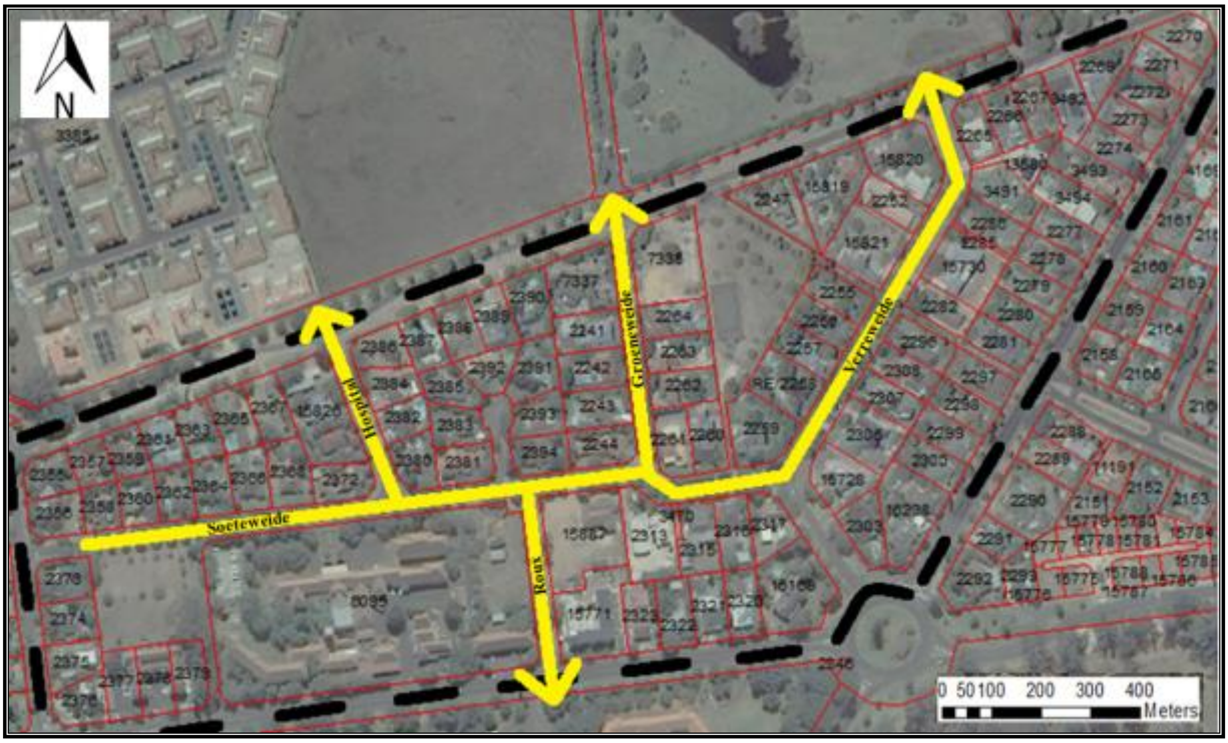
Figure 4.4 Outer edges of Universiteitsoord marked for densification

Table 4.2 Development specifications pertaining to the outer edge

OUTER EDGES	DEVELOPMENT SPECIFICATIONS
Block A	Site consolidation and redevelopment of existing sites are promoted in this block to achieve higher densities. Development in this block should enhance the interface between buildings and public space through aspects such as public planting, paving of surfaces, street furniture and street lighting, as well as by stressing the central point of the Cluver Banghoek link. Buildings must be positioned onto the street with a height restriction of 12 m from the highest point.
Block B	Shares the same principles of densification formulated for Block A. In addition, within both these blocks, a detailed landscaping plan is required prior to development.
Block C	Similarly stipulates the principles set out for Blocks A/B and promotes consolidation of sites to enhance redevelopment while attempting to conserve existing trees to the full. Densification in this block must pay careful attention to the edges of Hospital and Groeneweide Streets.
Block D	Shares the same principles set out in the previous blocks. However, the building height restriction for this block has increased to 15 m above the site.
Block E	Densification in this block should be sympathetic and sensitive with respect to the context of Cluver Street.

Source: Created on the basis of the DDS (Stellenbosch Municipality 2009)

With regard to minimising through traffic, Figure 4.5 demonstrates the traffic suggestion set out in the DDS (Stellenbosch Municipality 2009). This proposal aims to improve the peak-hour logistics of vehicle movement in the area and promotes beneficial alterations of the intersections linking both Banghoek Road and Merriman Avenue with Bosman Street. Moreover, the DDS (Stellenbosch Municipality 2009) proposes the introduction of a one-way street configuration in Roux, Groeneweide and Hospital Streets.



Source: Created on the basis of the DDS (Stellenbosch Municipality 2009: 18)

Figure 4.5 Proposed traffic schemes for Universiteitsoord

Finally, the Stellenbosch Municipality DDS (Stellenbosch Municipality 2009) stresses the parking predicament in the area and formulates the goals to reduce on-street parking and produce adequate parking space in the densification process. With reference to the outer edge of the area (Figure 4.4), the DDS (Stellenbosch Municipality 2009) instructs that parking should be out of sight in order to preserve the residential character and reduce the impact on the surrounding environment. Furthermore, densification in this area should enhance the benefits of being located in close proximity to public transit corridors and comply with the Municipality IZS's parking parameter.

4.6 CONCLUSION

In light of the above, it is evident that spatial planning in Stellenbosch, like many other towns in South Africa, is hampered by the legacy of the apartheid era, current inefficient coordination between different spheres of government, and the lack of comprehensive legal frameworks that prescribe and regulate spatial planning and development. With the introduction of the Municipal Systems Act (Act 32 of 2000) in 2000 (South Africa 2000), municipalities obtained a foundation for spatial planning policies to be implemented that would guide development and decision-making in terms of resource allocation and development priorities. Although this foundation presented a starting point away from the apartheid legacy, success rests mainly on the Municipality's ability to formulate and implement spatial policy directives and prioritise development initiatives and resource distribution. This process has taken some time, considering the unofficial status of the Stellenbosch Municipality SDF, which was only approved in 2013 regardless of three generations of IDPs.

It is evident that densification is a high priority in spatial planning in Stellenbosch. Through the development of policy since the introduction of IDPs and SDFs on a national level, the increased importance of spatial and social integration and the context-specific application of densification is recognised. However, the overarching Stellenbosch Municipality ZSR (Stellenbosch Municipality 1996), which aims to regulate land use and the development of land under these specific uses, is relatively outdated, rendering it ineffective. It can also be regarded as restrictive to current development needs and priorities. Therefore, the overlay zoning becomes critical and, despite the Stellenbosch Municipality IDP (Stellenbosch Municipality 2012a) formulating the spatial development objectives to design heritage, densification, environment and built form overlays, only the heritage overlay zoning scheme currently shows progress.

The lack of legal framework for densification is evident, considering that Universiteitsoord is the only suburb in Stellenbosch that has a draft densification framework. This highlights concerns for land use and development in the town, as densification is not a unique feature only in this area, but can be witnessed throughout most of the town. As a result, authors such as Donaldson and Morkel (2012: 64) fear the loss of the town's character and its unique sense of place due to "ad hoc" forms of densification occurring around the university campus. Although the DDS (Stellenbosch Municipality 2009) for Universiteitsoord aims to conserve the historic character of its inner core, closer inspection of this area suggests otherwise.

It can be concluded that the Municipality needs to reconsider its approach to attaining and implementing its strategic policy objectives and move away from business as usual to ensure that decision making, resource allocation and development priorities are in line with sustainable development, especially considering the unique heritage and character of the town of Stellenbosch.

CHAPTER 5: DATA ANALYSIS: EXTENT OF DENSIFICATION IN THE STELLENBOSCH CASE STUDY AREAS

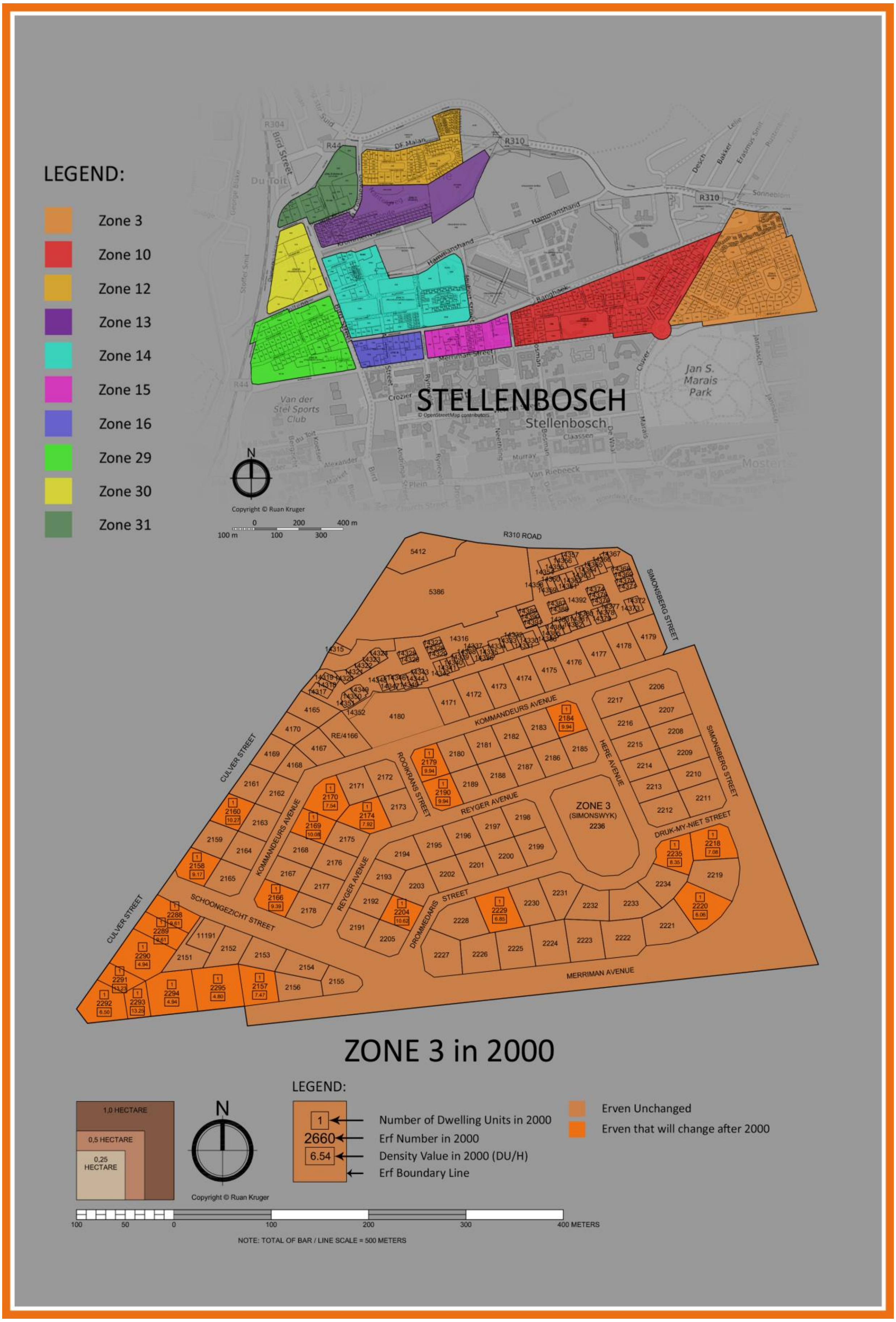
5.1 INTRODUCTION

Using municipal valuations, this chapter identifies properties on which densification has taken place between 2000 and 2016. The chapter highlights the methods of densification used in each of the study zones and maps all of the changes in residential density from 2000 to 2016. The author will provide the findings for each of the study zones individually, after which the next chapter will focus on a discussion of these findings based on the relevant literature. It is important to note that this is merely a description of a specific area and is not related to the zones prescribed in the Stellenbosch Municipality IZS (Stellenbosch Municipality 2012c). The municipal valuation zones were used due to the study focusing primarily on municipal valuation data.

Concerning data interpretation, the author created maps of the area for 2000 and 2016, as well as tables with detailed information regarding the properties that have undergone densification since 2000. For each of the study zones, the real, net and gross residential density was calculated in order to provide a scale of reference. Additionally, Appendix D provides detailed information regarding all the properties in the study area. Moreover, it is important to note that this study focuses purely on changes in residential density, and therefore only residential units were taken into consideration. The study further disregards any alterations smaller than 40 m^2, as these may be additions such as a swimming pool or a shade roof. Sites that were under construction at the time of the study were included based on the planned number of units.

5.2 ZONE 3

Zone 3 (Simonswyk) is demarcated by Cluver Street to the west, the R310 to the north, Simonsberg Street to the east and Merriman Avenue to the south (Figure 5.1). Zone 3 is historically a middle-class neighbourhood and, according to the IZS (Stellenbosch Municipality 2012c), the area is zoned residential, with a small portion of general business zoning and some public open space (Appendix A). The area consists of student housing, permanent residents, high-density housing, guesthouses, university-owned property and green space, amongst others (Benn 2010). Figure 5.1 shows all the properties in Zone 3 that changed after 2000, and for each of these properties the number of dwelling units, as well as the density in the year 2000, is indicated in orange.



Source: Author (2016)

Figure 5.1 Zone 3 in 2000

Table 5.1 should be used in conjunction with Figure 5.1, as it provides more detailed data for each of the properties that has experienced change after 2000. Table 5.1 also shows the new erf number for 2016 where applicable, and includes the number of dwelling units as well as the density for each of the properties that changed during the study period. For data on all the properties in Zone 3, Appendix D contains a table covering all the data for the area.

In 2000 there were 189 properties, of which four were zoned for business uses and three were open spaces (Appendix D). Of these 189 properties, 23 have experienced changes greater than 40 m² since 2000. This means that 12.16% of all the properties in Zone 3 have undergone significant alterations in the last 16 years. However, when only the properties zoned for residential use are examined, it is evident that Zone 3 had 182 residential properties in 2000, and therefore 12.64% of the residential properties have experienced densification since 2000.

Table 5.1 Densification data for Zone 3

DATA FOR ZONE 3									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/H)	
2000	2016	2000	2016	2000/ha	2016/ha	2000	2016	2000	2016
2158	2158	RESIDENTIAL	RESIDENTIAL	0.1091	0.1091	1	2	9.17	18.33
2160	2160	RESIDENTIAL	RESIDENTIAL	0.0974	0.0974	1	2	10.27	20.53
2166	2166	RESIDENTIAL	RESIDENTIAL	0.1065	0.1065	1	2	9.39	18.78
2169	2169	RESIDENTIAL	RESIDENTIAL	0.0992	0.0992	1	2	10.08	20.16
2170	RE/2170	RESIDENTIAL	RESIDENTIAL	0.1327	0.0748	1	1	7.54	13.37
	15720		RESIDENTIAL		0.0579		1		17.27
2174	2174	RESIDENTIAL	RESIDENTIAL	0.1263	0.1263	1	2	7.92	15.84
2179	2179	RESIDENTIAL	RESIDENTIAL	0.1006	0.1006	1	2	9.94	19.88
2184	2184	RESIDENTIAL	RESIDENTIAL	0.1006	0.1006	1	2	9.94	19.88
2190	2190	RESIDENTIAL	RESIDENTIAL	0.1006	0.1006	1	2	9.94	19.88
2204	2204	RESIDENTIAL	RESIDENTIAL	0.0942	0.0942	1	2	10.62	21.23
2218	2218	RESIDENTIAL	RESIDENTIAL	0.1412	0.1412	1	2	7.08	14.16
2220	2220	RESIDENTIAL	RESIDENTIAL	0.165	0.165	1	2	6.06	12.12
2229	2229	RESIDENTIAL	RESIDENTIAL	0.1459	0.1459	1	2	6.85	13.71
2235	2235	RESIDENTIAL	RESIDENTIAL	0.1198	0.1198	1	2	8.35	16.69
2288	2288	RESIDENTIAL	RESIDENTIAL	0.1041	0.1041	1	12	9.61	115.27
2289	16361	RESIDENTIAL	RESIDENTIAL	0.1041	0.3064	1	33	9.61	107.70
2290		RESIDENTIAL		0.2023		1		4.94	
2291	15842	RESIDENTIAL	RESIDENTIAL	0.0756	0.3049	1	43	13.23	141.03
2292		RESIDENTIAL		0.1538		1		6.50	

<table>
<tr><th colspan="10">DATA FOR ZONE 3</th></tr>
<tr><th colspan="2">ERF NUMBER (SB)</th><th colspan="2">LAND USE</th><th colspan="2">ERF SIZE/HA</th><th colspan="2">DWELLING UNITS</th><th colspan="2">DENSITY (DU/H)</th></tr>
<tr><th>2000</th><th>2016</th><th>2000</th><th>2016</th><th>2000/ha</th><th>2016/ha</th><th>2000</th><th>2016</th><th>2000</th><th>2016</th></tr>
<tr><td>2293</td><td rowspan="4">15775-15787</td><td>RESIDENTIAL</td><td rowspan="4">RESIDENTIAL</td><td>0.0755</td><td rowspan="4">0.5443</td><td>1</td><td rowspan="4">14</td><td>13.25</td><td rowspan="4">25.72</td></tr>
<tr><td>2294</td><td>RESIDENTIAL</td><td>0.2023</td><td>1</td><td>4.94</td></tr>
<tr><td>2295</td><td>RESIDENTIAL</td><td>0.2082</td><td>1</td><td>4.80</td></tr>
<tr><td>2157</td><td>RESIDENTIAL</td><td>0.1338</td><td>1</td><td>7.47</td></tr>
</table>

Source: Author (2016)

In 2016 there are a total of 195 properties, of which four were zoned for business and three were open space properties, meaning that there are 188 residential properties (Appendix D). With reference to Figure 5.2 and Table 5.1, it is interesting to note that there were more properties in 2016 than in 2000, due to different methods of densification applied in Zone 3. For example, erven 2293, 2294, 2295 and 2157 were consolidated and then subdivided into 13 different properties that currently hold 14 dwelling units, in contrast to four dwelling units in 2000. In addition, erf 2170 was subdivided into two different properties and, where it had one dwelling unit in 2000, there were two dwelling units in 2016. Furthermore, erven 2289 and 2290 were consolidated to form erf number 16361, which currently has 31 dwelling units more than in 2000. Similarly, erven 2291 and 2292 were consolidated to form erf number 15842, which currently has 41 dwelling units more than in 2000.

Figure 5.2 and Table 5.1 show that 13 of the properties in Zone 3 experienced densification through the addition of an additional dwelling unit, while one property added multiple dwelling units (erf 2288). This means that the higher residential density in Zone 3 was achieved through 2.20% of the properties showing consolidation, 2.75% being subdivided, 7.14% of properties constructing an additional dwelling unit, and 0.55% adding multiple attached dwelling units.

5.2.1 Measuring density of Zone 3

With reference to Table 5.2, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (194 in 2000 and 301 in 2016) by the sum total area of all the residential plots (13.353 ha in both 2000 and 2016). This measure excludes all properties devoted to non-residential uses and does not consider any internal or external roads.

Equation 5.1 Real residential density of Zone 3

$$Real\ residential\ density\ 2000 = \frac{194}{13.353} = 14.53$$

$$Real\ residential\ density\ 2016 = \frac{301}{13.353} = 22.54$$

Table 5.2 Density of Zone 3

DENSITY OF ZONE 3			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	14.53	22.54	55%
Net du/ha	12.13	18.83	55%
Gross du/ha	9.46	14.68	55%

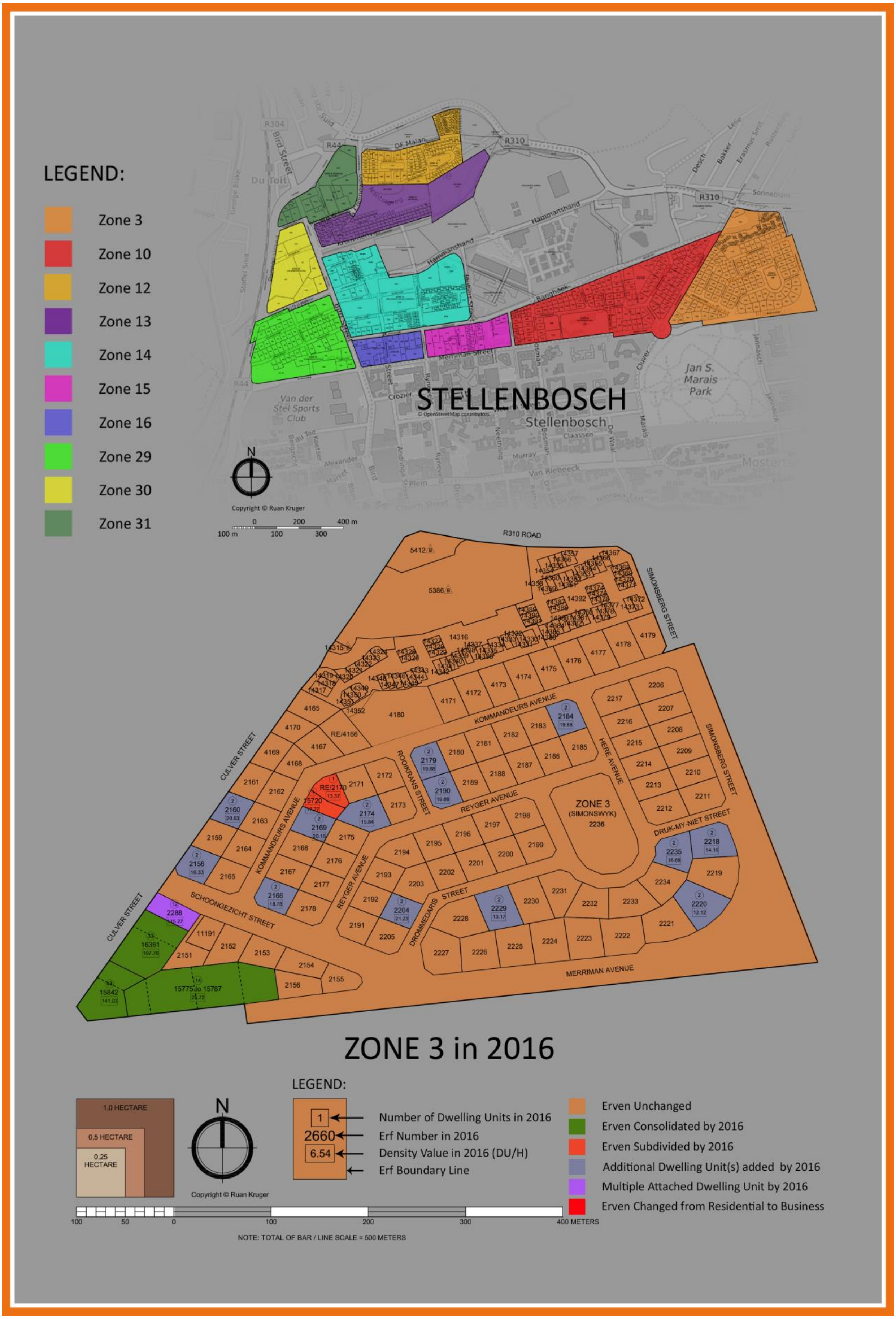
Source: Author (2016)

The net residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (194 in 2000 and 301 in 2016) by the sum total area of all the residential plots (13.353 ha in both 2000 and 2016), open spaces (1.0143 ha in 2000 and 2016), as well as half of the width of the internal access roads (1.622 ha) in Zone 3. The internal access roads used in the calculation were Schoongezicht Street, Kommandeurs Avenue, Reyger Avenue, Drommedaris Street, Rooikrans Street, Here Avenue and Druk-My-Niet Street.

Equation 5.2 Net residential density of Zone 3

$$Net\ residential\ density\ 2000 = \frac{194}{15.9893} = 12.13$$

$$Net\ residential\ density\ 2016 = \frac{301}{15.9893} = 18.83$$



Source: Author (2016)

Figure 5.2 Densification in Zone 3 in 2016

The gross residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (194 in 2000 and 301 in 2016) by the sum total of the entire area (20.505 ha). This included land that is used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.3 Gross residential density of Zone 3

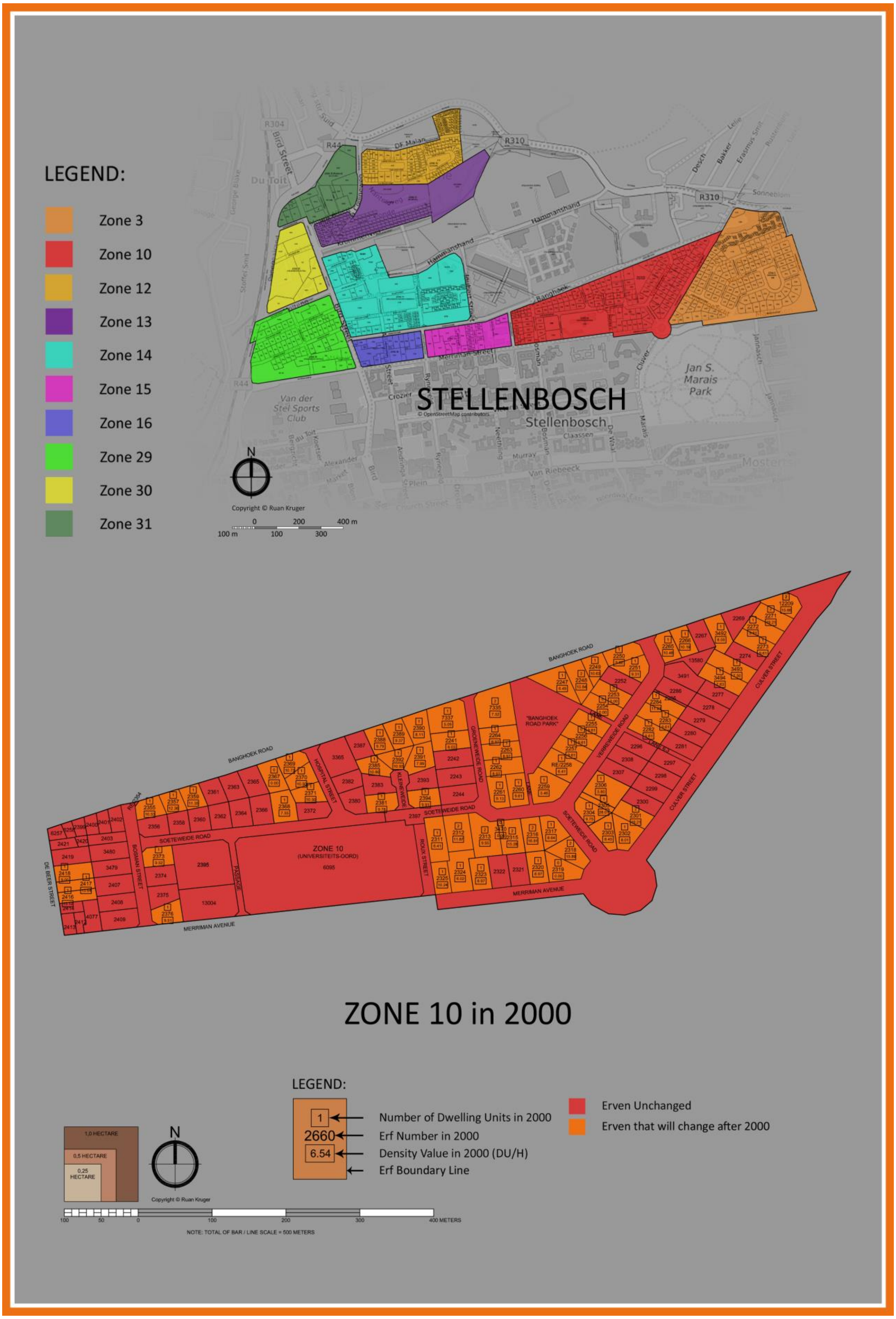
$$Gross\ residential\ density\ 2000 = \frac{194}{20.505} = 9.46$$

$$Gross\ residential\ density\ 2016 = \frac{301}{20.505} = 14.68$$

5.3 ZONE 10

Zone 10 (Universiteitsoord) is demarcated by De Beer Street to the west, Banghoek Road to the north, Cluver Street to the east and Merriman Avenue to the south. Zone 10 was greatly altered over the decade because of escalating property values, which invigorated property sales. In addition, densification was encouraged by the constant influx of students seeking accommodation close to campus and the area's centrality in relation to the CBD, the main campus and major transit corridors, such as the Cluver/Merriman link (Stellenbosch Municipality 2009). Consequently, the area was tagged as a densification zone by the Municipality, and this has been an influential feature in the rezoning and change of land use in the area (FishTank Consultants 2012). Zone 10 was rezoned from residential to general residential, which promoted densification through the construction of multiple flat developments and boarding houses (Benn 2010). The area also consists of general business zoning, community zoning and public open space (Stellenbosch Municipality 2012c).

Figure 5.3 shows all the properties in Zone 10 that changed after 2000 and, for each of these properties, the number of dwelling units as well as the density in 2000 is indicated in orange. Table 5.3 should be read in conjunction with Figure 5.3, as it provides more detailed data on each of the properties that has experienced change after 2000. Table 5.3 also shows the new erf number for 2016, where applicable, and includes the number of dwelling units as well as the density of each of the properties that has changed during the study period. For data on all the properties in Zone 10, Appendix D has a table covering all the data for the area.



Source: Author (2016)

Figure 5.3 Zone 10 in 2000

In 2000 there were 137 properties, of which four were zoned for business use, one for community use, one for institutional use and two were open spaces (Appendix D). Of these 137 properties, 73 have experienced changes greater than 40 m^2 since 2000. This means that 53.3% of all the properties in Zone 10 have undergone significant alterations in the last 16 years. However, when only the properties pertaining to residential use are examined, it is evident that Zone 10 had 129 residential properties in 2000, therefore 56.6% of the residential properties have experienced densification after 2000.

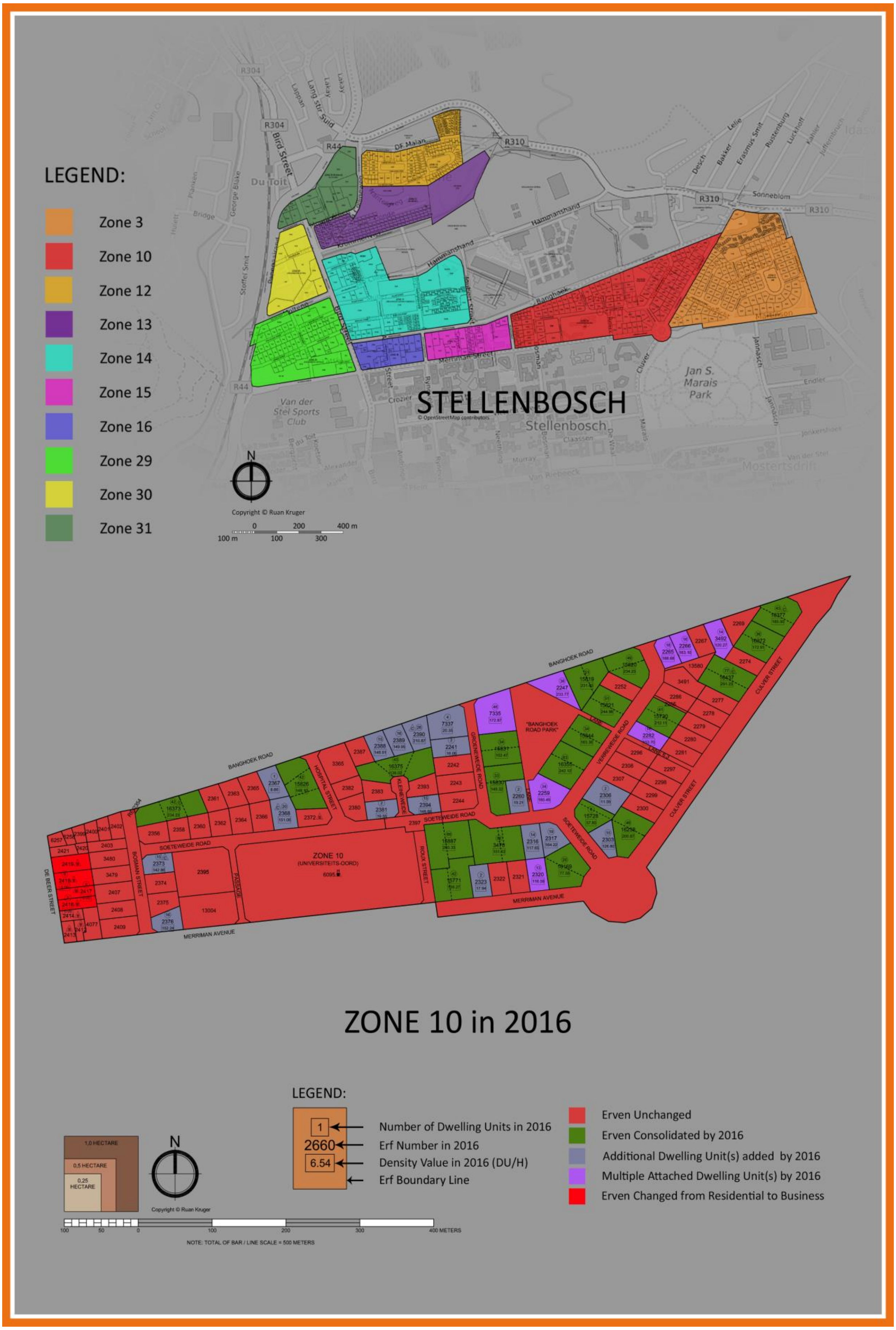
Table 5.3 Densification data for Zone 10

DATA FOR ZONE 10									
ERF NUMBER (SB)		**LAND USE**		**ERF SIZE/HA**		**DWELLING UNITS**		**DENSITY (DU/HA)**	
2000	**2016**	**2000**	**2016**	**2000/HA**	**2016/HA**	**2000**	**2016**	**2000**	**2016**
2241	2241	RESIDENTIAL	RESIDENTIAL	0.1245	0.1245	1	2	8.03	16.06
2247	2247	RESIDENTIAL	RESIDENTIAL	0.154	0.154	1	36	6.49	233.77
2248	15819	RESIDENTIAL	RESIDENTIAL	0.1263	0.2204	2	51	15.84	231.40
2249		RESIDENTIAL		0.0941		1		10.63	
2250	15820	RESIDENTIAL	RESIDENTIAL	0.1018	0.2092	1	49	9.82	234.23
2251		RESIDENTIAL		0.1074		1		9.31	
2253	15821	VACANT	RESIDENTIAL	0.1041	0.2082	0	51	0.00	244.96
2254		VACANT		0.1041		0		0.00	
2255	15844	RESIDENTIAL	RESIDENTIAL	0.1041	0.2082	1	34	9.61	163.30
2256		RESIDENTIAL		0.1041		1		9.61	
2257	16355	RESIDENTIAL	RESIDENTIAL	0.1041	0.2602	1	63	9.61	242.12
2258		RESIDENTIAL		0.1561		1		6.41	
2259	2259	RESIDENTIAL	RESIDENTIAL	0.1833	0.1833	1	34	5.46	185.49
2260	2260	RESIDENTIAL	RESIDENTIAL	0.1041	0.1041	1	2	9.61	19.21
2261	15830	RESIDENTIAL	RESIDENTIAL	0.1095	0.221	1	33	9.13	149.32
2262		RESIDENTIAL		0.1115		1		8.97	
2263	15831	RESIDENTIAL	RESIDENTIAL	0.1115	0.223	1	34	8.97	152.47
2264		RESIDENTIAL		0.1115		1		8.97	
2265	2265	RESIDENTIAL	RESIDENTIAL	0.0954	0.0954	1	18	10.48	188.68
2266	2266	RESIDENTIAL	RESIDENTIAL	0.0981	0.0981	1	16	10.19	163.10
12209	16377	RESIDENTIAL	RESIDENTIAL	0.1277	0.2318	2	43	15.66	185.50
2271		RESIDENTIAL		0.1041		2		19.21	
2272	16372	RESIDENTIAL	RESIDENTIAL	0.1041	0.2082	1	36	9.61	172.91
2273		RESIDENTIAL		0.1041		1		9.61	
2282	2282	RESIDENTIAL	RESIDENTIAL	0.1041	0.1041	1	16	9.61	153.70
2283	15730	RESIDENTIAL	RESIDENTIAL	0.1041	0.1933	1	41	9.61	212.11
2284		RESIDENTIAL		0.0892		1		11.21	
2301	16238	RESIDENTIAL	RESIDENTIAL	0.1041	0.229	2	46	19.21	200.87
2302		RESIDENTIAL		0.1249		1		8.01	
2303	2303	RESIDENTIAL	RESIDENTIAL	0.1183	0.1183	1	15	8.45	126.80
2304	15728	RESIDENTIAL	RESIDENTIAL	0.1026	0.1383	1	8	9.75	57.85
2305		RESIDENTIAL		0.0357		1		28.01	
2306	2306	RESIDENTIAL	RESIDENTIAL	0.1725	0.1725	1	2	5.80	11.59
2311	15887	RESIDENTIAL	RESIDENTIAL	0.1561	0.3246	1	66	6.41	203.33
2312		RESIDENTIAL		0.1685		2		11.87	
2313	3470	RESIDENTIAL	RESIDENTIAL	0.201	0.3441	2	52	9.95	151.12
3470		REMAINDER		0.0122		0		0.00	
2315		RESIDENTIAL		0.1309		2		15.28	
2316	2316	RESIDENTIAL	RESIDENTIAL	0.119	0.119	2	14	16.81	117.65
2317	2317	RESIDENTIAL	RESIDENTIAL	0.1157	0.1157	1	19	8.64	164.22

DATA FOR ZONE 10									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
2318	16169	RESIDENTIAL	RESIDENTIAL	0.1259	0.2579	2	20	15.89	77.55
2319		VACANT		0.132		0		0.00	
2320	2320	RESIDENTIAL	RESIDENTIAL	0.1115	0.1115	1	13	8.97	116.59
2323	2323	RESIDENTIAL	RESIDENTIAL	0.1115	0.1115	1	2	8.97	17.94
2324	15771	RESIDENTIAL	RESIDENTIAL	0.166	0.2637	1	42	6.02	159.27
2325		RESIDENTIAL		0.0977		1		10.24	
2355	16373	RESIDENTIAL	RESIDENTIAL	0.095	0.264	1	42	10.53	234.23
2357		RESIDENTIAL		0.0809		1		12.36	
2359		RESIDENTIAL		0.0881		1		11.35	
2367	2367	VACANT	RESIDENTIAL	0.1155	0.1155	0	1	0.00	8.66
2368	2368	RESIDENTIAL	RESIDENTIAL	0.1324	0.1324	1	20	7.55	151.06
2369	15826	RESIDENTIAL	RESIDENTIAL	0.0932	0.2836	1	42	10.73	148.10
2370		RESIDENTIAL		0.0952		1		10.50	
2371		RESIDENTIAL		0.0952		1		10.50	
2373	2373	RESIDENTIAL	RESIDENTIAL	0.105	0.105	1	15	9.52	142.86
2376	2376	RESIDENTIAL	RESIDENTIAL	0.1051	0.1051	1	16	9.51	152.24
2381	2381	RESIDENTIAL	RESIDENTIAL	0.1023	0.1023	1	2	9.78	19.55
2385	16375	RESIDENTIAL	RESIDENTIAL	0.0926	0.3093	1	43	10.80	139.02
2392		RESIDENTIAL		0.0915		1		10.93	
2391		RESIDENTIAL		0.1252		1		7.99	
2388	2388	RESIDENTIAL	RESIDENTIAL	0.1021	0.1021	1	15	9.79	146.91
2389	2389	RESIDENTIAL	RESIDENTIAL	0.1067	0.1067	1	16	9.37	149.95
2390	2390	RESIDENTIAL	RESIDENTIAL	0.1233	0.1233	1	26	8.11	210.87
2394	2394	RESIDENTIAL	RESIDENTIAL	0.1009	0.1009	1	15	9.91	148.66
7335	7335	RESIDENTIAL	RESIDENTIAL	0.2661	0.2661	2	46	7.52	172.87
3492	3492	RESIDENTIAL	RESIDENTIAL	0.1164	0.1164	1	14	8.59	120.27
3493	16437	RESIDENTIAL	RESIDENTIAL	0.1333	0.2644	1	77	7.50	291.23
3494		RESIDENTIAL		0.1311		1		7.63	
7337	7337	RESIDENTIAL	RESIDENTIAL	0.1966	0.1966	1	4	5.09	20.35
2416	2416	RESIDENTIAL	BUSINESS	0.0762	0.0762	1	0	13.12	0.00
2417	2417	RESIDENTIAL	BUSINESS	0.0733	0.0733	1	0	13.64	0.00
2418	2418	RESIDENTIAL	BUSINESS	0.1111	0.1111	1	0	9.00	0.00
2419	2419	RESIDENTIAL	BUSINESS	0.1115	0.1115	1	0	8.97	0.00

Source: Author (2016)

In 2016 there were 113 properties, of which four were zoned for business use, five for institutional use, one was a community zone and two were open spaces. This means that there were 101 residential properties in Zone 10 in 2016 (Appendix D). With reference to Figure 5.4 and Table 5.3, it is interesting to note that there were 28 fewer residential properties in 2016 than in 2000, due to the dominance of consolidation (44 properties and 34.1%) for densification in this area.



Source: Author (2016)

Figure 5.4 Densification in Zone 10 in 2016

In addition, 13.2% (17 erven) of the properties in 2000 added an additional dwelling unit during the study period. It can be observed that 6.2% (eight erven) of the properties in 2000 added multiple attached dwelling units during the study period. There were also four properties (3.1%) (2416, 2417, 2418 and 2419) that were used for residential purposes in 2000 and currently are used for institutional purposes, which caused a decline in the overall residential density of the area.

5.3.1 Measuring density of Zone 10

With reference to Table 5.4, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (203 in 2000 and 1 377 in 2016) by the sum total area of all the residential plots (14.163 ha in 2000 and 13.791 ha in 2016). This measure excludes all properties devoted to non-residential uses and does not consider any internal or external roads.

Equation 5.4 Real residential density of Zone 10

$$Real\ residential\ density\ 2000 = \frac{203}{14.163} = 14.33$$

$$Real\ residential\ density\ 2016 = \frac{1377}{13.791} = 99.85$$

Table 5.4 Density of Zone 10

DENSITY OF ZONE 10			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	14.33	99.85	597%
Net du/ha	12.23	84.90	594%
Gross du/ha	9.70	65.81	579%

Source: Author (2016)

The net residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (203 in 2000 and 1 377 in 2016) by the sum total area of all the residential plots (14.163 ha in 2000 and 13.791 ha in 2016), open spaces (1.0354 ha), as well as half of the width of the internal access roads (1.394 ha) in Zone 10. The roads used in the calculation were Bosman Street, Soeteweide Road, Hospital Street, Roux Street, Groeneweide Road and Verreweide Road.

Equation 5.5 Net residential density of Zone 10

$$Net\ residential\ density\ 2000 = \frac{203}{16.592} = 12.23$$

$$Net\ residential\ density\ 2016 = \frac{1377}{16.220} = 84.90$$

The gross residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (203 in 2000 and 1 377 in 2016) by the sum total of the area (20.925 ha). This includes land that is used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.6 Gross residential density of Zone 10

$$Gross\ residential\ density\ 2000 = \frac{203}{20.925} = 9.70$$

$$Gross\ residential\ density\ 2016 = \frac{1377}{20.925} = 65.81$$

5.4 ZONES 14, 15 AND 16

Zones 14, 15 and 16 (Stellenbosch Central) are demarcated by Bird Street to the west, Krommerivier Street and Hammanshand to the north, Joubert Street and De Beer Street to the east and Merriman Avenue to the south. These zones have a variety of zoning regulations pertaining to the,. According to the IZS (Stellenbosch Municipality 2012c), a small portion of the area is zoned for residential and general residential. The remaining zones for the area are general business, educational, utility services and public open space. The area can be regarded as a hub of activity as a result of its close proximity to the university campus and being situated in the middle of the surrounding residential neighbourhoods.

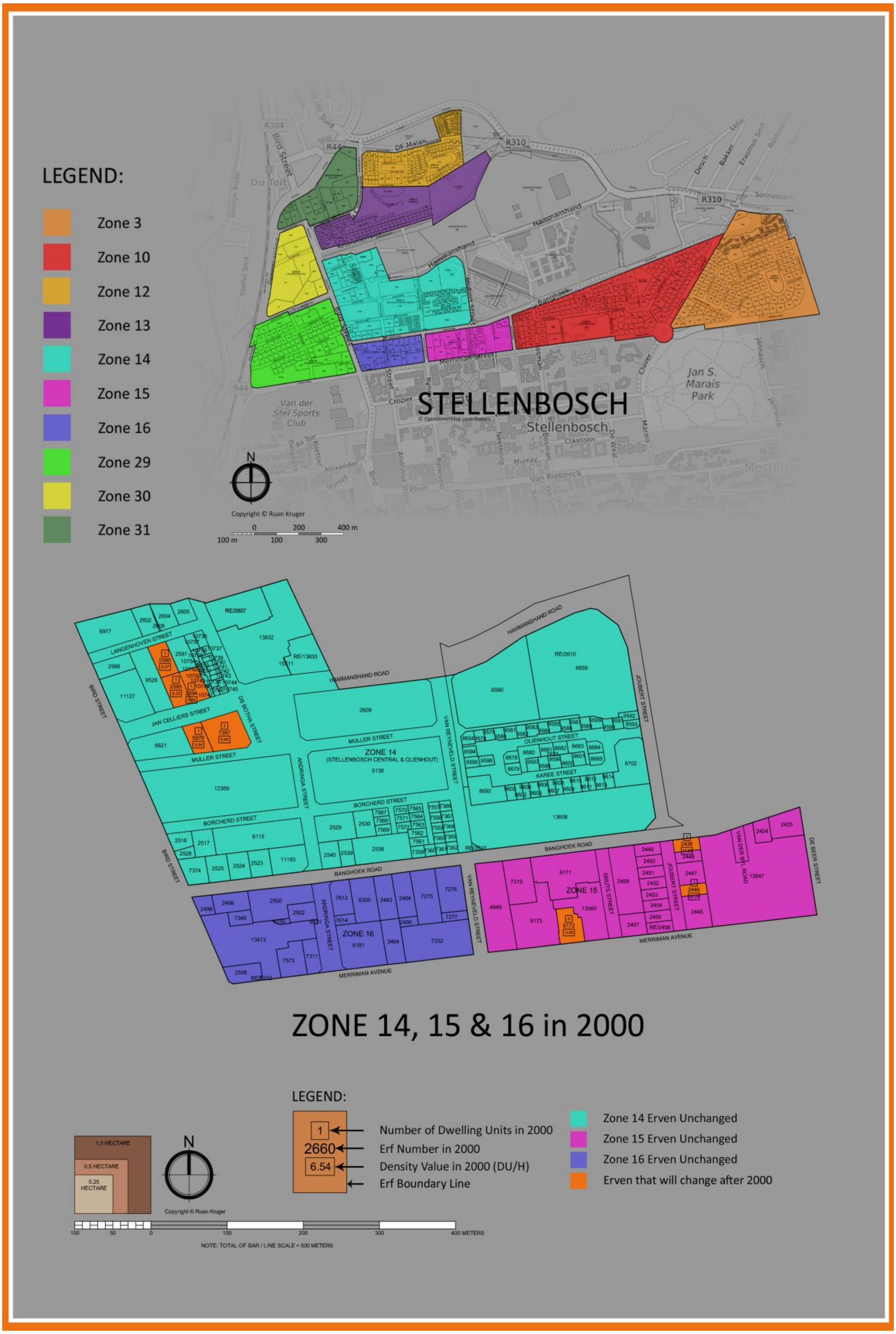
Figure 5.5 shows all the properties in Zones 14, 15 and 16 that changed after 2000 and for each of these properties, the number of units as well as the density in 2000 is indicated in orange. Tables 5.5 and 5.7 should be read in conjunction with Figure 5.5, as it provides more detailed data on each of the properties that has experienced change after 2000. Tables 5.5 and 5.7 also show the new erf numbers for 2016, where applicable, and include the number of dwelling units as well as the density of each of the properties that has changed during the study period. Data on all the properties in these zones can be found in the table in Appendix D.

Table 5.5 Densification data for Zone 14

DATA FOR ZONE 14									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
7597	7597	RESIDENTIAL	RESIDENTIAL	0.231	0.231	2	32	8.66	138.53
5978	5978	RESIDENTIAL	RESIDENTIAL	0.1006	0.1006	1	16	9.94	159.05
2594	14604	RESIDENTIAL	RESIDENTIAL	0.108	0.2161	1	27	9.26	124.94
2595		RESIDENTIAL		0.1081		1			
2590	2590	RESIDENTIAL	RESIDENTIAL	0.1079	0.1079	1	14	9.27	129.75

Source: Author (2016)

In 2000, Zone 14 had a total of 127 properties, of which two were open spaces, one was a remainder, six were used for business purposes, two were used for municipal uses, of which one was used for residential purposes and one for institutional use, six were parking areas, four were used by religious institutions, one held a jail and one an old age home (also a residential use dwelling) (Appendix D). This means that there are 105 residential properties in Zone 14 in 2000. Of these 105 residential properties, 4.76% (five erven) have experienced densification in the last 16 years.



Source: Author (2016)

Figure 5.5 Zones 14, 15 and 16 in 2000

In 2016, Zone 14 had 104 residential properties and there had been no changes in land use between 2000 and 2016. With reference to Figure 5.6 and Table 5.5, it is evident that the decrease in the number of residential properties in Zone 14 is due to erf 2594 and 2595 being consolidated (1.90%) in erf number 14604 after 2000. In addition, Figure 5.6 and Table 5.5 show that 2.86% (three erven) experienced densification by adding multiple attached dwelling units to the same property.

5.4.1 Measuring density of Zone 14

With reference to Table 5.6, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (715 in 2000 and 798 in 2016) by the sum total area of all the residential plots (11.540 ha in both 2000 and 2016). This measure excludes all properties devoted to non-residential uses and does not consider any internal or external roads.

Equation 5.7 Real residential density of Zone 14

$$Real\ residential\ density\ 2000 = \frac{715}{11.540} = 61.96$$

$$Real\ residential\ density\ 2016 = \frac{798}{11.540} = 69.15$$

Table 5.6 Density of Zone 14

DENSITY OF ZONE 14			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	61.96	69.15	11.6%
Net du/ha	51.58	57.57	11.6%
Gross du/ha	36.36	40.58	11.6%

Source: Author (2016)

The net residential dwelling unit density of Zone 14 was derived by dividing the number of residential dwelling units (715 in 2000 and 798 in 2016) by the sum total area of all the residential plots (11.540 ha in both 2000 and 2016), open spaces (0.1118 ha) as well as half of the width of the internal access roads (2.209 ha). The roads used in the calculation were Langenhoven Street, Jan Celliers Street, DS Botha Street, Muller Street, Andringa Street, Borcherd Street, Van Reyneveld Street, Karee Street, Olienhout Street and two access lanes.

Equation 5.8 Net residential density of Zone 14

$$Net\ residential\ density\ 2000 = \frac{715}{13.861} = 51.58$$

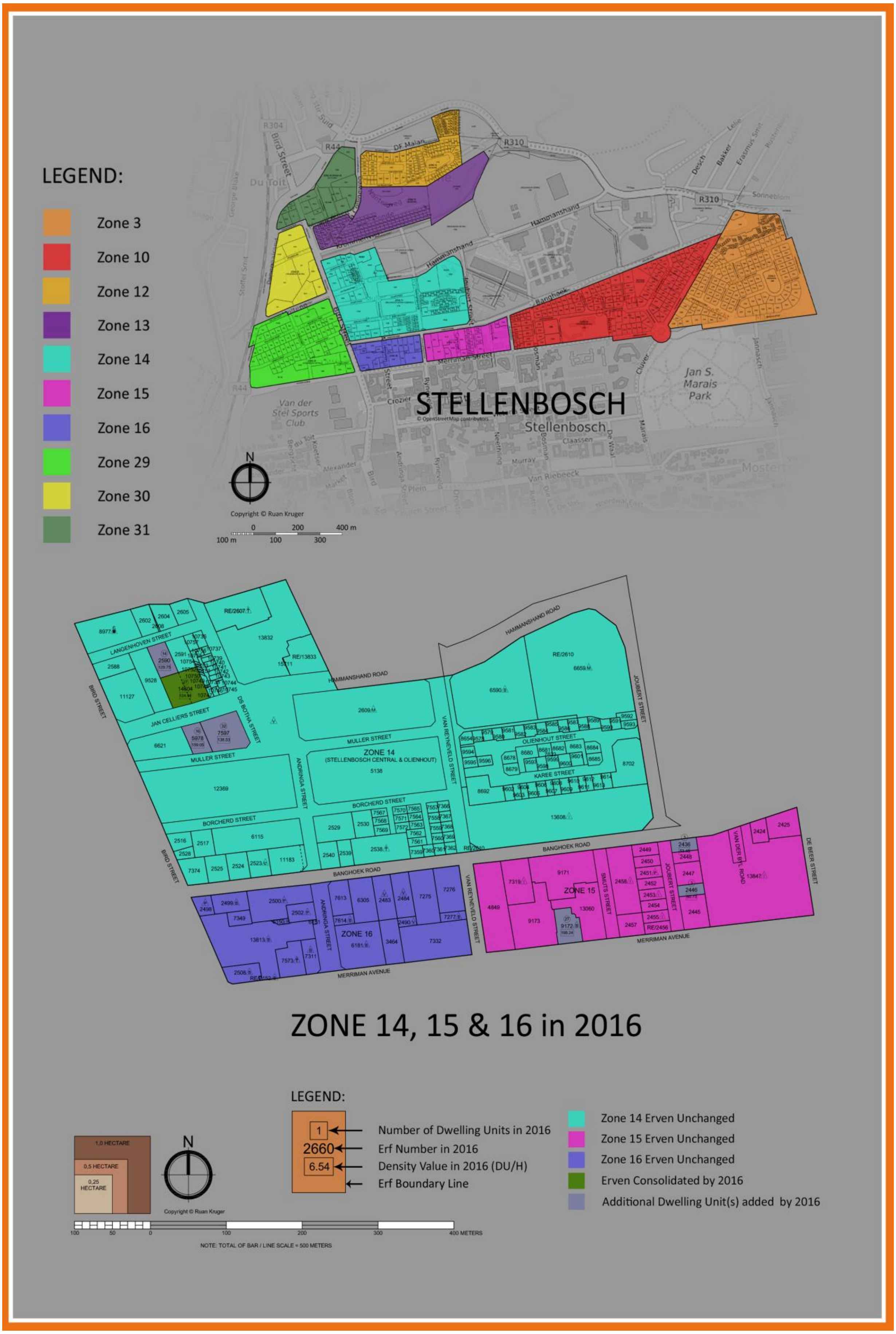
$$Net\ residential\ density\ 2016 = \frac{798}{13.861} = 57.57$$

The gross residential dwelling unit density of Zone 14 was derived by dividing the number of residential dwelling units (715 in 2000 and 798 in 2016) by the sum total of the area (19.664 ha). This includes land that is used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.9 Net residential density for Zone 14

$$Gross\ residential\ density\ 2000 = \frac{715}{19.664} = 36.36$$

$$Gross\ residential\ density\ 2016 = \frac{798}{19.664} = 40.58$$



Source: Author (2016)

Figure 5.6 Densification in Zones 14, 15 and 16 in 2016

Concerning Zone 15, there were 24 properties in both 2000 and 2016. In 2000, one was zoned for business use, three for institutional use and three properties were used for parking. This means that, in 2000, Zone 15 had 17 residential properties. However, in 2016, one (4.16%) of the properties (erf 9172) that had been used for business purposes in 2000 had changed to mixed use. Therefore, in 2016 there were 18 residential properties in Zone 15.

With reference to Figure 5.6 and Table 5.7, it is evident that 17.65% of the area (three erven) had experienced densification through the addition of multiple dwelling units after 2000. Other than these additions, there were no other methods of densification in this area between 2000 and 2016.

Table 5.7 Densification data for Zone 15

DATA FOR ZONE 15									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
2436	2436	RESIDENTIAL	RESIDENTIAL	0.0561	0.0561	1	3	17.83	53.48
2446	2446	RESIDENTIAL	RESIDENTIAL	0.0494	0.0494	1	3	20.24	60.73
9172	9172	BUSINESS	MXD	0.1362	0.1362	0	27	0.00	198.24

Source: Author (2016)

5.4.2 Measuring density of Zone 15

With reference to Table 5.8, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (207 in 2000 and 238 in 2016) by the total area of all the residential plots (2.407 ha in 2000 and 2.542 ha 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.10 Real residential density of Zone 15

$$Real\ residential\ density\ 2000 = \frac{207}{2.407} = 86.00$$

$$Real\ residential\ density\ 2016 = \frac{238}{2.542} = 93.63$$

Table 5.8 Density of Zone 15

DENSITY OF ZONE 15			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	86.00	93.63	8.87%
Net du/ha	78.20	85.55	9.40%
Gross du/ha	38.13	43.84	14.98%

Source: Author (2016)

The net residential dwelling unit density of Zone 15 was derived by dividing the number of residential dwelling units (207 in 2000 and 238 in 2016) by the sum total area of all the residential plots (2.407 ha in 2000 and 2.542 ha in 2016), open space (0) as well as half of the width of the internal access roads (0.240 ha). The internal access roads used in the calculation were Smuts Street, Joubert Street and Van der Byl Road.

Equation 5.11 Net residential density of Zone 15

$$Net\ residential\ density\ 2000 = \frac{207}{2.647} = 78.20$$

$$Net\ residential\ density\ 2016 = \frac{238}{2.782} = 85.55$$

The gross residential dwelling unit density of Zone 15 was derived by dividing the number of residential dwelling units (207 in 2000 and 238 in 2016) by the sum total of the area (5.429 ha). This included land that is used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.12 Gross residential density of Zone 15

$$Gross\ residential\ density\ 2000 = \frac{207}{5.429} = 38.13$$

$$Gross\ residential\ density\ 2016 = \frac{238}{5.429} = 43.84$$

With regard to Zone 16 (Figure 5.5 and 5.6), there were 24 properties, of which only five were used for residential purposes, in both 2000 and 2016. The other properties were three vacant plots that are used as open space but are not officially zoned as open space according to the IZS (Stellenbosch Municipality 2012c), six properties used for parking, nine properties used for business and one religious institution. There were no incidences of densification evident in the data for Zone 16 within the study period. Nevertheless, Table 5.9 provides the residential density figures for Zone 16.

5.4.3 Measuring density of Zone 16

Concerning Table 5.9, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (85 in both 2000 and 2016) by the total area of all the residential plots (1.146 ha in 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.13 Real residential density of Zone 16

$$Real\ residential\ density\ 2000 = \frac{85}{1.146} = 74.20$$

$$Real\ residential\ density\ 2016 = \frac{85}{1.146} = 74.20$$

Table 5.9 Density of Zone 16

DENSITY OF ZONE 16			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	74.20	74.20	0.00%
Net du/ha	65.74	65.74	0.00%
Gross du/ha	21.58	21.58	0.00%

Source: Author (2016)

The net residential dwelling unit density of Zone 16 was derived by dividing the number of residential dwelling units (85 in both 2000 and 2016) with the total area of all the residential plots (1.146 ha in both 2000 and 2016), open space (0) as well as half of the width of the internal access roads (0.147 ha). The internal access road used in the calculation includes only Andringa Street.

Equation 5.14 Net residential density for Zone 16

$$Net\ residential\ density\ 2000 = \frac{85}{1.293} = 65.74$$

$$Net\ residential\ density\ 2016 = \frac{85}{1.293} = 65.74$$

The gross residential dwelling unit density of Zone 16 was derived by dividing the number of residential dwelling units (85 in both 2000 and 2016) by the sum total of the entire area (3.938 ha). This included land used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

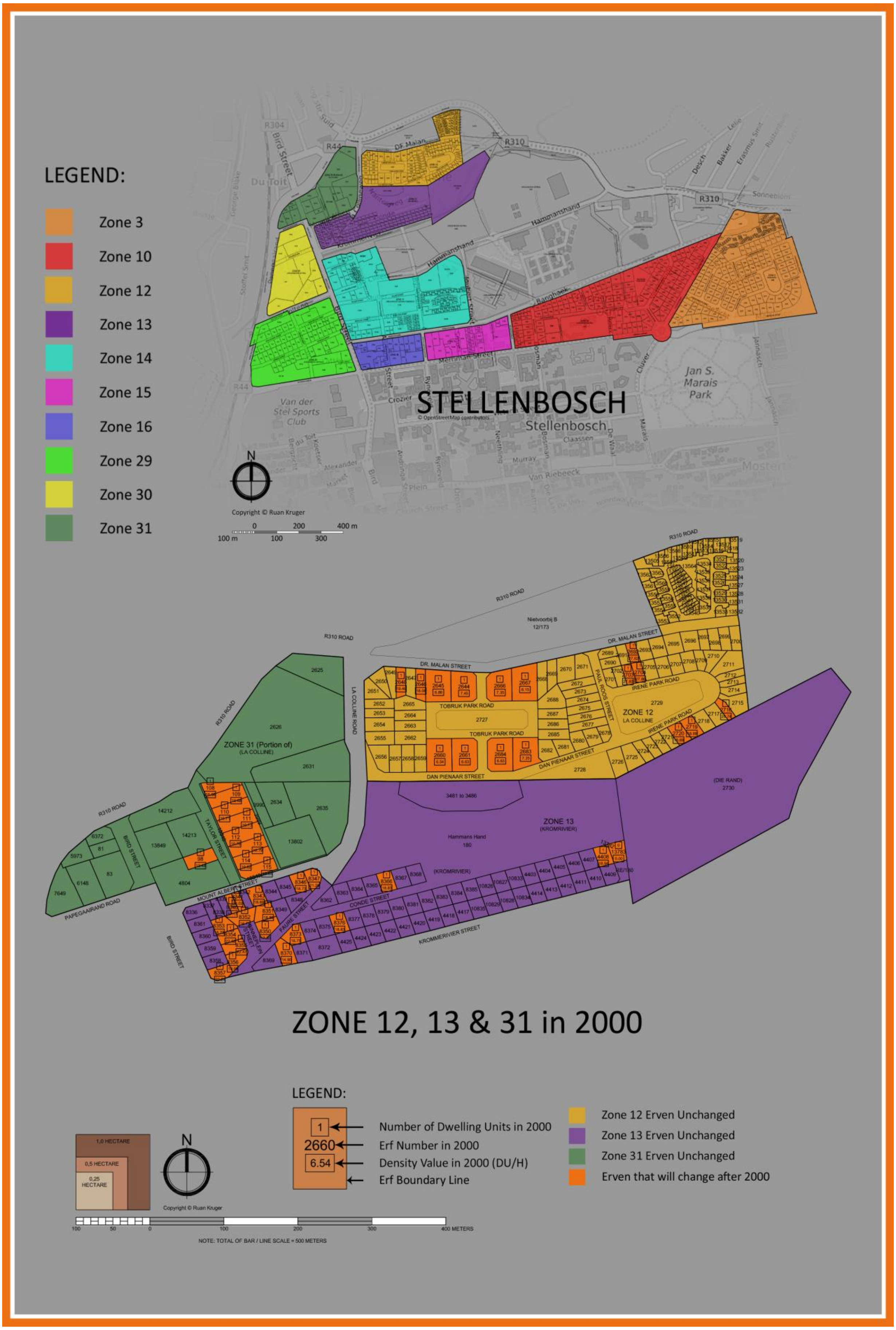
Equation 5.15 Gross residential density of Zone 16

$$Gross\ residential\ density\ 2000 = \frac{85}{3.938} = 21.58$$

$$Gross\ residential\ density\ 2016 = \frac{85}{3.938} = 21.58$$

5.5 ZONES 12, 13 AND 31

Zones 12, 13 and 31 (La Colline and Krommerivier) are demarcated by Bird Street to the west, the R310 to the north and Krommerivier Street to the south. The zone is characterised by a few gated complexes and some sectional title blocks, as well as full-title semi-detached dwellings constructed in the 1940s (Property24 2015). According to the IZS (Stellenbosch Municipality 2012c), this area comprises educational, residential, general residential, general business and public open space zones. Figure 5.7 shows all the properties in Zones 12, 13 and 31 that changed after 2000 and, for each of these properties, the number of units as well as the density in 2000 are indicated in orange.



Source: Author (2016)

Figure 5.7 Zones 12, 13 and 31 in 2000

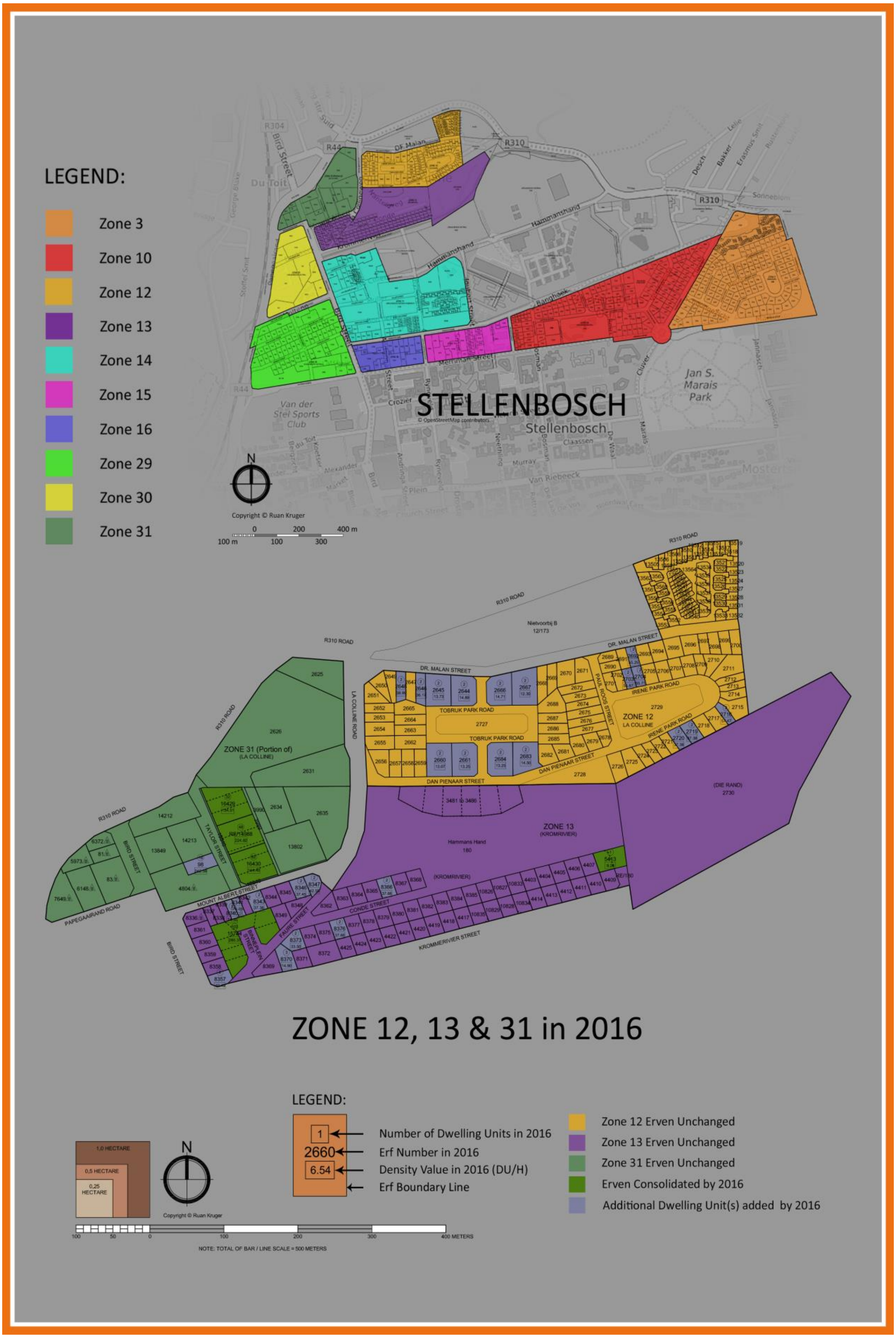
Tables 5.10, 5.12 and 5.14 should be read in conjunction with Figure 5.7, as it provides more detailed data on each of the properties that have experienced change after 2000. Tables 5.10, 5.12 and 5.14 also show the new erf numbers for 2016, where applicable, and include the number of dwelling units as well as the density of each of the properties that has changed during the study period. Data on all the properties in these zones can be found in the table in Appendix D.

Table 5.10 Densification data for Zone 12

DATA FOR ZONE 12									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
2644	2644	RESIDENTIAL	RESIDENTIAL	0.1343	0.1343	1	2	7.45	14.89
2645	2645	RESIDENTIAL	RESIDENTIAL	0.1457	0.1457	1	2	6.86	13.73
2646	2646	RESIDENTIAL	RESIDENTIAL	0.0553	0.0553	1	2	18.08	36.17
2647	2647	RESIDENTIAL	RESIDENTIAL	0.0513	0.0513	1	2	19.49	38.99
2660	2660	RESIDENTIAL	RESIDENTIAL	0.153	0.153	1	2	6.54	13.07
2661	2661	RESIDENTIAL	RESIDENTIAL	0.1509	0.1509	1	2	6.63	13.25
2666	2666	RESIDENTIAL	RESIDENTIAL	0.136	0.136	1	2	7.35	14.71
2667	2667	RESIDENTIAL	RESIDENTIAL	0.1626	0.1626	1	2	6.15	12.30
2683	2683	RESIDENTIAL	RESIDENTIAL	0.1379	0.1379	1	2	7.25	14.50
2684	2684	RESIDENTIAL	RESIDENTIAL	0.1509	0.1509	1	2	6.63	13.25
2692	2692	RESIDENTIAL	RESIDENTIAL	0.0362	0.0362	1	2	27.62	55.25
2703	2703	RESIDENTIAL	RESIDENTIAL	0.0358	0.0358	1	2	27.93	55.87
2704	2704	RESIDENTIAL	RESIDENTIAL	0.0359	0.0359	1	2	27.86	55.71
2716	2716	RESIDENTIAL	RESIDENTIAL	0.0348	0.0348	1	2	28.74	57.47
2719	2719	RESIDENTIAL	RESIDENTIAL	0.0535	0.0535	1	2	18.69	37.38
2720	2720	RESIDENTIAL	RESIDENTIAL	0.0535	0.0535	1	2	18.69	37.38

Source: Author (2016)

In both 2000 and 2016, Zone 12 had 146 properties, of which three were used as open spaces (Appendix D). This means that there are 143 residential properties in Zone 12. Of these 143 residential properties, 11.18% (16 erven) have experienced densification in the last 16 years. With reference to Figure 5.8 and Table 5.10 it is evident that densification has occurred only through the construction of additional dwelling units. This method of densification can be observed in all 11.18% of the properties that have experienced densification since 2000.



Source: Author (2016)

Figure 5.8 Densification in Zones 12, 13 and 31 in 2016

5.5.1 Measuring density of Zone 12

With reference to Table 5.11, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (274 in 2000 and 290 in 2016) by the sum total area of all the residential plots (7.470 ha in both 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.16 Real residential density of Zone 12

$$Real\ residential\ density\ 2000 = \frac{274}{7.470} = 36.68$$

$$Real\ residential\ density\ 2016 = \frac{290}{7.470} = 38.82$$

Table 5.11 Density of Zone 12

DENSITY OF ZONE 12			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	36.68	38.82	5.8%
Net du/ha	29.85	31.60	5.8%
Gross du/ha	27.90	29.53	5.8%

Source: Author (2016)

The net residential dwelling unit density of Zone 12 was derived by dividing the number of residential dwelling units (274 in 2000 and 290 in 2016) by the total area of all the residential plots (7.470 ha in both 2000 and 2016), open spaces (1.064 ha) as well as half of the width of the internal access roads (0.644 ha). The internal access roads used in the calculation were Tobruk Park Road, Dan Pienaar Street, Paul Roos Street and Irene Park Road.

Equation 5.17 Net residential density of Zone 12

$$Net\ residential\ density\ 2000 = \frac{274}{9.178} = 29.85$$

$$Net\ residential\ density\ 2016 = \frac{290}{9.178} = 31.60$$

The gross residential dwelling unit density of Zone 12 was derived by dividing the number of residential dwelling units (274 in 2000 and 290 in 2016) by the total area (9.822 ha). This includes land that is used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.18 Gross residential density of Zone 12

$$Gross\ residential\ density\ 2000 = \frac{274}{9.822} = 27.90$$

$$Gross\ residential\ density\ 2016 = \frac{290}{9.822} = 29.53$$

Concerning Zone 13, there were 85 properties in 2000, all were of which used for residential purposes. With reference to Figures 5.7 and 5.8 and Table 5.12 it is evident that 22.35% (19 erven) of the area experienced densification after 2000. In 2016 there were 78 residential properties, due to the consolidation of erven 8350, 8351, 8352, 8353, 8354, 8355 and 8356 to form erf 15704, as well as the consolidation of erven 4408 and 13789 to form erf 5413.

Table 5.12 Densification data for Zone 13

DATA FOR ZONE 13									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
4408	5413	RESIDENTIAL	RESIDENTIAL	0.0528	0.108	1	1	18.94	9.26
13783		RESIDENTIAL		0.0552		0		0.00	
8340	8340	RESIDENTIAL	RESIDENTIAL	0.0269	0.0269	1	2	37.17	74.35
8341	8341	RESIDENTIAL	RESIDENTIAL	0.0263	0.0263	1	2	38.02	76.05
8343	8343	RESIDENTIAL	RESIDENTIAL	0.0535	0.0535	1	2	18.69	37.38
8346	8346	RESIDENTIAL	RESIDENTIAL	0.0534	0.0534	1	2	18.73	37.45
8347	8347	RESIDENTIAL	RESIDENTIAL	0.047	0.047	1	2	21.28	42.55
8348	15704	RESIDENTIAL	RESIDENTIAL	0.0578	0.3638	1	102	17.30	280.37
8349		RESIDENTIAL		0.0532		1		18.80	
8350		RESIDENTIAL		0.0597		1		16.75	
8351		RESIDENTIAL		0.0534		1		18.73	
8352		RESIDENTIAL		0.0444		1		22.52	

DATA FOR ZONE 13									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
8353		RESIDENTIAL		0.0445		1		22.47	
8354		RESIDENTIAL		0.0508		1		19.69	
8357	8357	RESIDENTIAL	RESIDENTIAL	0.0494	0.0494	1	2	20.24	40.49
8366	8366	RESIDENTIAL	RESIDENTIAL	0.0531	0.0531	1	2	18.83	37.66
8370	8370	RESIDENTIAL	RESIDENTIAL	0.0671	0.0671	1	3	14.90	44.71
8373	8373	RESIDENTIAL	RESIDENTIAL	0.0597	0.0597	1	2	16.75	33.50
8376	8376	RESIDENTIAL	RESIDENTIAL	0.0531	0.0531	1	2	18.83	37.66

Source: Author (2016)

In addition, the results for Zone 13 indicate that 11.74% (10 erven) of all the residential properties experienced densification through the construction of additional dwelling units, while 10.59% (nine erven) experienced densification through the process of consolidation.

5.5.2 Measuring density of Zone 13

With reference to Table 5.13, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (267 in 2000 and 373 in 2016) by the total area of all the residential plots (9.339 ha in both 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.19 Real residential density of Zone 13

$$Real\ residential\ density\ 2000 = \frac{267}{9.339} = 28.59$$

$$Real\ residential\ density\ 2016 = \frac{373}{9.339} = 39.94$$

Table 5.13 Density of Zone 13

DENSITY OF ZONE 13			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	28.59	39.94	39.7%
Net du/ha	27.34	38.19	39.7%
Gross du/ha	19.81	27.68	39.7%

Source: Author (2016)

The net residential dwelling unit density of Zone 13 was derived by dividing the number of residential dwelling units (267 in 2000 and 373 in 2016) by the total area of all the residential plots (9.339 ha in both 2000 and 2016), open spaces (0) as well as half of the width of the internal access roads (0.427 ha). The internal access roads used in the calculation were Faure Street and Conde Street.

Equation 5.20 Net residential density of Zone 13

$$Net\ residential\ density\ 2000 = \frac{267}{9.766} = 27.34$$

$$Net\ residential\ density\ 2016 = \frac{373}{9.766} = 38.19$$

The gross residential dwelling unit density of Zone 13 was derived by dividing the number of residential dwelling units (267 in 2000 and 373 in 2016) by the sum total of the area (13.475 ha). This included land used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.21 Gross residential density of Zone 13

$$Gross\ residential\ density\ 2000 = \frac{267}{13.475} = 19.81$$

$$Gross\ residential\ density\ 2016 = \frac{373}{13.475} = 27.68$$

With regard to Zone 31, there were 28 properties in 2000, of which eight were used for business purposes, six were devoted to a school and one property was a remainder. This means that there were 13 residential properties in Zone 31 in 2000. With reference to Figures 5.7 and 5.8 and Table 5.14 is evident that 69.2% (nine erven) of the residential properties experienced densification after 2000. In 2016 there were eight residential properties compared to 13, and this was due to 61.54% of the properties being consolidated after 2000. In addition, one property (erf 98) experienced densification through the construction of multiple dwelling units (7.69%) after 2000.

Table 5.14 Densification data for Zone 31

DATA FOR ZONE 31									
ERF NUMBER (SB)		LAND USE		ERF SIZE/HA		DWELLING UNITS		DENSITY (DU/HA)	
2000	2016	2000	2016	2000/HA	2016/HA	2000	2016	2000	2016
111	14988	RESIDENTIAL	RESIDENTIAL	0.0932	0.2135	1	48	10.73	224.82
112				0.0929		1		10.76	
108	16429	RESIDENTIAL	RESIDENTIAL	0.0603	0.2379	1	32	16.58	134.51
109				0.0936		1		10.68	
110				0.0934		1		10.71	
113	16430	RESIDENTIAL	RESIDENTIAL	0.0927	0.2216	1	32	10.79	144.40
114				0.0924		1		10.82	
115				0.0922		1		10.85	
98	98	RESIDENTIAL	RESIDENTIAL	0.0742	0.0742	1	18	13.48	242.59

Source: Author (2016)

5.5.3 Measuring density of Zone 31

With reference to Table 5.15, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (486 in 2000 and 607 in 2016) by the total area of all the residential plots (1.880 ha in both 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.22 Real residential density of Zone 31

$$Real\ residential\ density\ 2000 = \frac{486}{1.880} = 258.51$$

$$Real\ residential\ density\ 2016 = \frac{607}{1.880} = 322.87$$

Table 5.15 Density of Zone 31

DENSITY OF ZONE 31			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	258.51	322.87	24.9%
Net du/ha	226.68	283.12	24.9%
Gross du/ha	69.15	86.37	24.9%

Source: Author (2016)

The net residential dwelling unit density of Zone 31 was derived by dividing the number of residential dwelling units (486 in 2000 and 607 in 2016) by the total area of all the residential plots (1.880 ha in both 2000 and 2016), open spaces (0) as well as half of the width of the internal access roads (0.264 ha). The internal access roads used in the calculation were Taylor Street and a section of Bird Street.

Equation 5.23 Net residential density of Zone 31

$$Net\ residential\ density\ 2000 = \frac{486}{2.144} = 226.68$$

$$Net\ residential\ density\ 2016 = \frac{607}{2.144} = 283.12$$

The gross residential dwelling unit density of Zone 31 was derived by dividing the number of residential dwelling units (486 in 2000 and 607 in 2016) by the sum total of the entire area (7.028 ha). This included land used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.24 Gross residential density of Zone 31

$$Gross\ residential\ density\ 2000 = \frac{486}{7.028} = 69.15$$

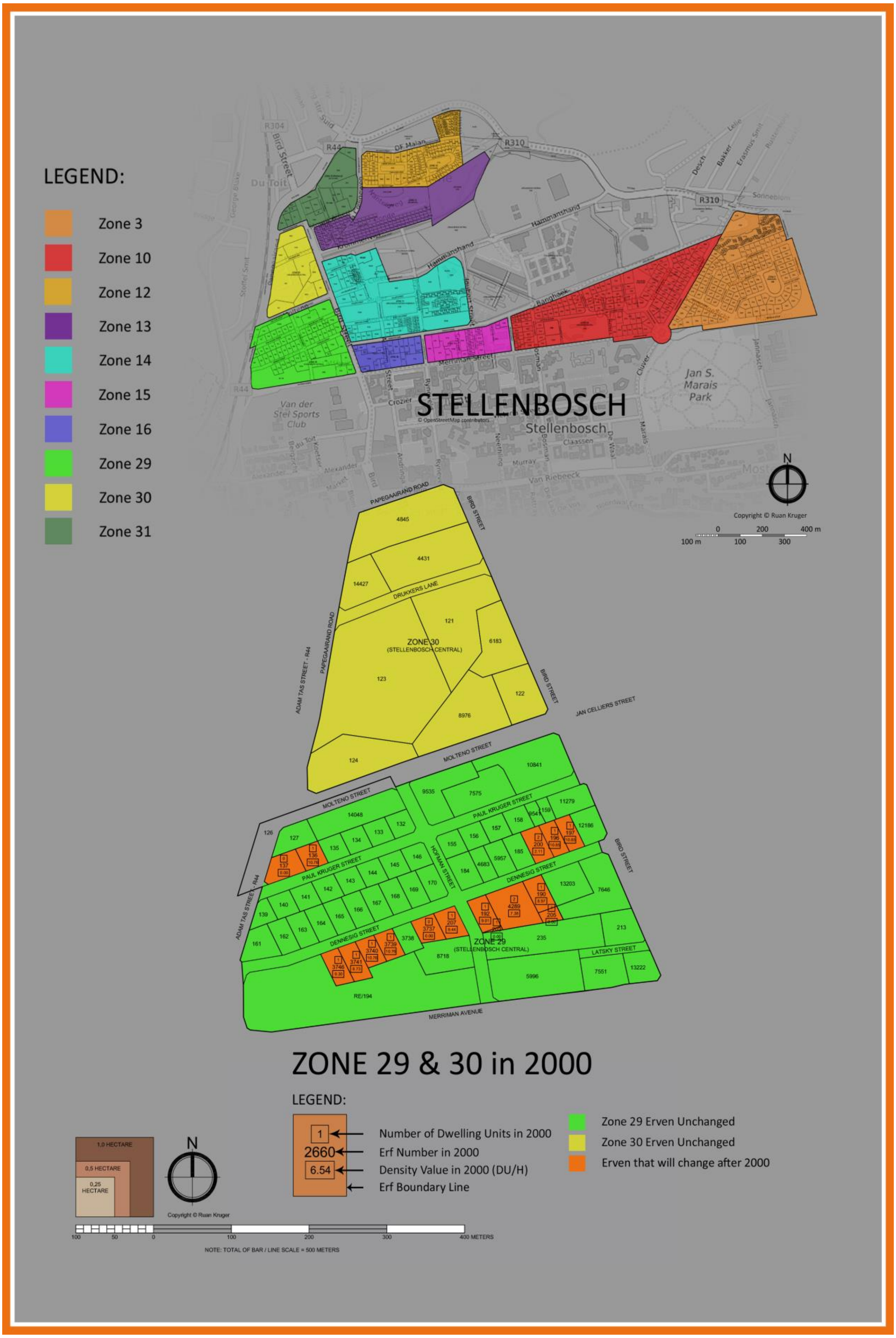
$$Gross\ residential\ density\ 2016 = \frac{607}{7.028} = 86.37$$

5.6 ZONES 29 AND 30

Zones 29 and 30 (Dennesig) are demarcated by the R44 to the west, Papegaairand Road to the north, Bird Street to the east and Merriman Avenue to the south. The zone consists of single residential units as well as low-rise, high-density apartment blocks, mixed-use developments, open space and some business areas. According to the IZS (Stellenbosch Municipality 2012c), this area comprises residential, general residential, general business, light industry, utility services, a community zone and public open space zones.

Figure 5.9 shows all the properties in Zone 29 and 30 that changed after 2000 and, for each of these properties, the number of units as well as the density in 2000 are indicated in orange. Table 5.16 should be read in conjunction with Figure 5.9, as it provides more detailed data on each of the properties that experienced change after 2000. Table 5.16 also shows the new erf numbers for 2016, where applicable, and includes the number of dwelling units as well as the density of each of the properties that changed during the study period. Data on all the properties in these zones appears in the table in Appendix D.

In 2000, Zone 29 had a total of 65 properties, of which one was used for parking, one for a school, one as open space, one for a religious institution and four for business uses (Appendix D). This means that there were 57 residential properties in Zone 29 in 2000. Moreover, 7% (4 erven) of these residential properties were MXDs in 2000. With reference to Figure 5.9 and Table 5.16, it is evident that 28.1% (16 erven) of the residential properties in Zone 29 experienced densification after 2000.



Source: Author (2016)

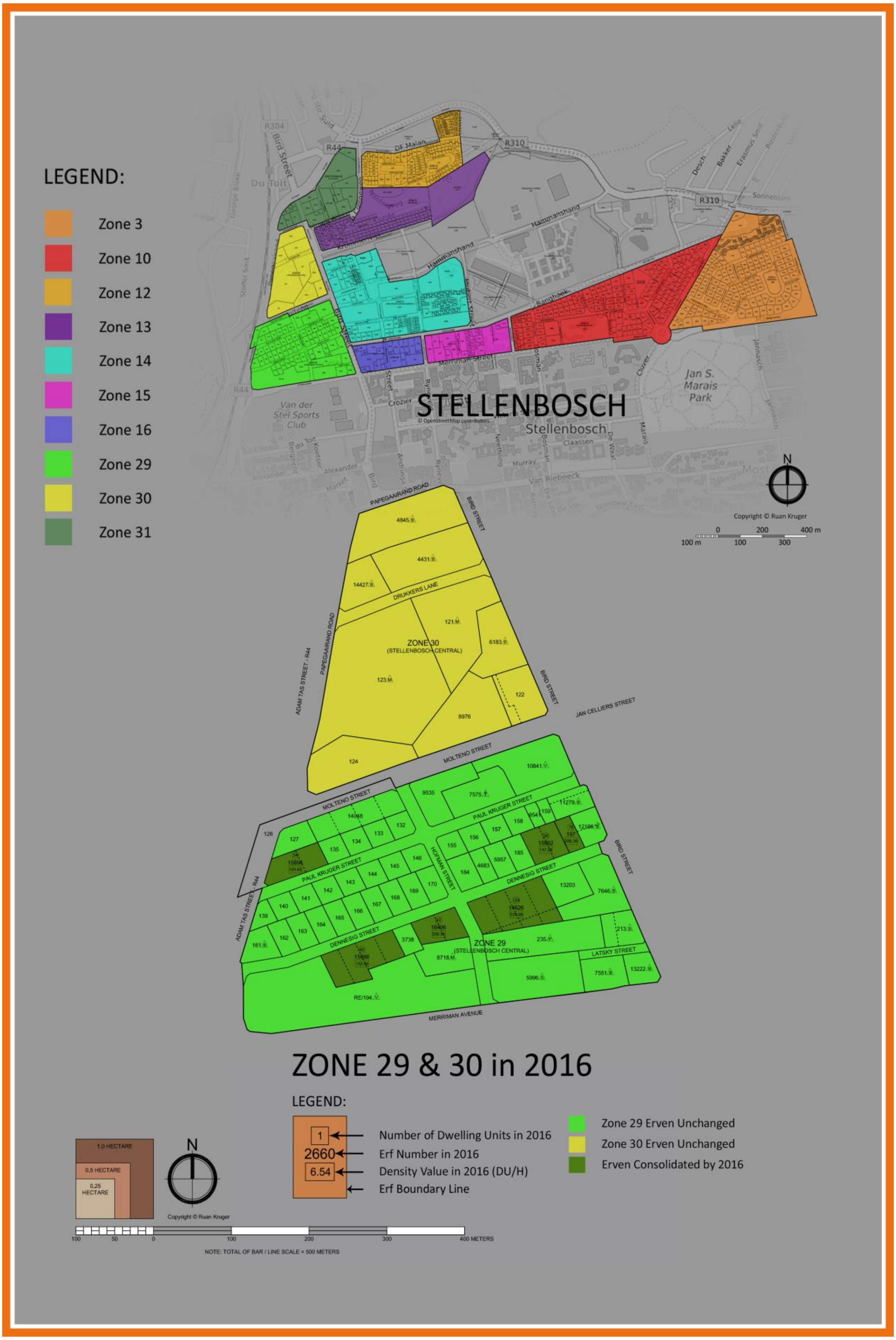
Figure 5.9 Zones 29 and 30 in 2000

In 2016, Zone 29 has 27 residential properties, of which four were MXDs (Appendix D). With reference to Figure 5.10 and Table 5.16, it is evident that the reduction in the number of properties was mostly due to the consolidation (26.3%) of properties. There also was one incident where densification occurred through the construction of multiple dwelling units (1.9%).

Table 5.16 Densification data for Zone 29

DATA FOR ZONE 29									
ERF NUMBER (SB)		**LAND USE**		**ERF SIZE/HA**		**DWELLING UNITS**		**DENSITY (DU/HA)**	
2000	**2016**	**2000**	**2016**	**2000/ha**	**2016/ha**	**2000**	**2016**	**2000**	**2016**
136	15894	RESIDENTIAL	RESIDENTIAL	0.0928	0.2316	1	24	10.78	103.63
137				0.1388		0		0.00	
196	15862	RESIDENTIAL	RESIDENTIAL	0.0922	0.2037	1	30	10.85	147.28
200				0.1115		2		2.11	
197	197	RESIDENTIAL	RESIDENTIAL	0.0921	0.0921	1	19	1.09	206.30
3746	15886	RESIDENTIAL	RESIDENTIAL	0.1075	0.4078	1	62	9.30	152.04
3741		RESIDENTIAL		0.1145		1		8.73	
3740		RESIDENTIAL		0.0929		1		10.76	
3739		RESIDENTIAL		0.0929		1		10.76	
3737	16406	RESIDENTIAL	RESIDENTIAL	0.1031	0.209	0	42	0.00	200.96
207				0.1059		1		9.44	
190	14626	RESIDENTIAL	RESIDENTIAL	0.1115	0.5415	1	124	8.97	228.99
192		RESIDENTIAL	RESIDENTIAL	0.111		1		9.01	
203		RESIDENTIAL	RESIDENTIAL	0.0066		0		0.00	
205		RESIDENTIAL	RESIDENTIAL	0.0414		0		0.00	
4289		RESIDENTIAL	RESIDENTIAL	0.271		2		7.38	

Source: Author (2016)



Source: Author (2016)

Figure 5.10 Densification in Zones 29 and 30 in 2016

5.6.1 Measuring density of Zone 29

With reference to Table 5.17, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (342 in 2000 and 629 in 2016) by the total area of all the residential plots (7.369 ha in both 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.25 Real residential density of Zone 29

$$Real\ residential\ density\ 2000 = \frac{342}{7.369} = 46.41$$

$$Real\ residential\ density\ 2016 = \frac{629}{7.369} = 85.36$$

Table 5.17 Density of Zone 29

DENSITY OF ZONE 29			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	46.41	85.36	83.9%
Net du/ha	33.30	61.25	83.9%
Gross du/ha	24.41	44.89	83.9%

Source: Author (2016)

The net residential dwelling unit density of Zone 29 was derived by dividing the number of residential dwelling units (342 in 2000 and 629 in 2016) by the total area of all the residential plots (7.369 ha in both 2000 and 2016), open spaces (1.9368 ha) as well as half of the width of the internal access roads (0.963 ha). The internal access roads used in the calculation are Paul Kruger Street, Hoffman Street, Dennesig Street and Latsky Street.

Equation 5.26 Net residential density of Zone 29

$$Net\ residential\ density\ 2000 = \frac{342}{10.2688} = 33.30$$

$$Net\ residential\ density\ 2016 = \frac{629}{10.2688} = 61.25$$

The gross residential dwelling unit density of Zone 29 was derived by dividing the number of residential dwelling units (342 in 2000 and 629 in 2016) by the sum total of the entire area (14.011 ha). This included land used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.27 Gross residential density of Zone 29

$$Gross\ residential\ density\ 2000 = \frac{342}{14.011} = 24.41$$

$$Gross\ residential\ density\ 2016 = \frac{629}{14.011} = 44.89$$

Concerning Zone 30, the results indicate that there are nine properties in both 2000 and 2016 (see Figures 5.9 and 5.10). Of the nine properties in Zone 30, only three were in residential use, while four were zoned for business use and two for municipal use. There were no changes in land use during the period of study and no densification occurred in this zone during the study period. Nevertheless, Table 5.18 provides the density figures for Zone 30.

5.6.2 Measuring density of Zone 30

With reference to Table 5.18, the real residential dwelling unit density of the area was derived by dividing the number of residential dwelling units (162 in 2000 and 2016) by the total area of all the residential plots (1.665 ha in both 2000 and 2016). This measure excluded all properties devoted to non-residential uses and did not consider any internal or external roads.

Equation 5.28 Real residential density of Zone 30

$$Real\ residential\ density\ 2000 = \frac{162}{1.665} = 97.30$$

$$Real\ residential\ density\ 2016 = \frac{162}{1.665} = 97.30$$

Table 5.18 Density of Zone 30

DENSITY OF ZONE 30			
Measures of density	**2000**	**2016**	**Percentage increase in du/ha**
Real du/ha	97.30	97.30	0.0%
Net du/ha	88.96	88.96	0.0%
Gross du/ha	22.37	22.37	0.0%

Source: Author (2016)

The net residential dwelling unit density of Zone 30 was derived by dividing the number of residential dwelling units (162 in 2000 and 2016) by the total area of all the residential plots (1.665 ha in both 2000 and 2016), open spaces (0) as well as half of the width of the internal access roads (0.156 ha). The internal access road used in the calculation was Drukkers Lane.

Equation 5.29 Net residential density if Zone 30

$$Net\ residential\ density\ 2000 = \frac{162}{1.821} = 88.96$$

$$Net\ residential\ density\ 2016 = \frac{162}{1.821} = 88.96$$

The gross residential dwelling unit density of Zone 30 was derived by dividing the number of residential dwelling units (162 in 2000 and 2016) by the sum total of the entire area (7.241 ha). This included land used for non-residential purposes as well as all the internal access roads. However, the units pertaining to non-residential land were excluded completely.

Equation 5.30 Gross residential density of Zone 30

$$Gross\ residential\ density\ 2000 = \frac{162}{7.241} = 22.37$$

$$Gross\ residential\ density\ 2016 = \frac{162}{7.241} = 22.37$$

5.7 CONCLUSION

Based on the findings it is evident that densification has been a prominent feature in the study area since 2000. The chapter analysed the changes in residential density from 2000 to 2016 for each specific property and in each of the different study zones. In addition, the research methodology followed in this study was successful in providing the necessary data in order to create maps and tables that reflect where and to what extent densification has taken place in the study areas since 2000.

CHAPTER 6: DATA INTERPRETATION

6.1 INTRODUCTION

In Stellenbosch, South Africa, a once largely single residential area, the process of urban densification through the development of low-rise, high-density accommodation has become rampant in an attempt to accommodate an ever-growing population. It is thus valuable to determine the extent of densification in Stellenbosch in line with sustainability aspirations in order to minimise undesired spatial consequences for future generations. This chapter provides an interpretation of the data analysed in Chapter 5. The following chapter revisits the research problem with a focus on the empirical findings, and aims to make correlations based on the relevant literature discussed throughout this work.

6.2 OUTCOME SYNTHESIS OF DENSIFICATION

Table 6.1 summarises all the findings of this study in order to provide clarity in terms of the changes in residential density that occurred in the various study zones since 2000. To view the density of each property included in this study Appendix D, Table D.1 to Table D.7 can be refered to. The findings of the data analysis revealed a zero change in residential density for Zone 16 and Zone 30. All the other zones reflected gross increases in dwelling unit density, with the lowest increase of 5.8% in Zone 12 and the highest of 579% in Zone 10.

Table 6.1 Summary of results on density of each study zone

SUMMARY OF DENSIFICATION DATA				
Zones	**Measures of density**	**2000**	**2016**	**Percentage increase in du/ha**
3	Real du/ha	14.53	22.54	55%
	Net du/ha	12.13	18.83	55%
	Gross du/ha	9.46	14.68	55%
10	Real du/ha	14.33	99.85	597%
	Net du/ha	12.23	84.90	594%
	Gross du/ha	9.70	65.81	579%
12	Real du/ha	36.68	38.82	5.8%
	Net du/ha	29.85	31.60	5.8%
	Gross du/ha	27.90	29.53	5.8%
13	Real du/ha	28.59	39.94	39.7%
	Net du/ha	27.34	38.19	39.7%
	Gross du/ha	19.81	27.68	39.7%
14	Real du/ha	61.96	69.15	11.6%
	Net du/ha	51.58	57.57	11.6%
	Gross du/ha	36.36	40.58	11.6%
15	Real du/ha	86.01	93.63	8.9%
	Net du/ha	78.20	85.55	9.4%
	Gross du/ha	39.82	45.78	14.9%

SUMMARY OF DENSIFICATION DATA				
Zones	**Measures of density**	**2000**	**2016**	**Percentage increase in du/ha**
16	Real du/ha	74.20	74.20	0.00%
	Net du/ha	65.74	65.74	0.00%
	Gross du/ha	21.58	21.58	0.00%
29	Real du/ha	46.41	85.36	83.9%
	Net du/ha	33.30	61.25	83.9%
	Gross du/ha	24.41	44.89	83.9%
30	Real du/ha	97.30	97.30	0.0%
	Net du/ha	88.96	88.96	0.0%
	Gross du/ha	22.37	22.37	0.0%
31	Real du/ha	258.51	322.87	24.9%
	Net du/ha	226.68	283.12	24.9%
	Gross du/ha	69.15	86.37	24.9%

Source: Author (2016)

A part of the study aimed to determine the extent of densification in the area under study, while one of the objectives was to identify the most prominent methods of densification between 2000 and 2016. Therefore, Table 6.2 provides a concluding summary of the extent of densification and the methods used for densification in all of the study zones. It is important to note that the change in land use observed in Table 6.2 does not form part of the total densification calculation. For example, Zone 10 had a 3.10% change in land use, but this had no impact on the density as the change during the study period was merely from residential use to institutional use.

Table 6.2 Methods of densification in each study zone

METHODS OF DENSIFICATION						
Zones	**Consolidation**	**Subdivision of property**	**Additional dwelling units**	**Multiple attached dwelling units**	**Change in land use**	**Densification**
3	2.20%	2.75%	7.14%	0.55%	0.00%	12.64%
10	34.10%	0.00%	13.20%	6.20%	3.10%	56.60%
12	0.00%	0.00%	11.18%	0.00%	0.00%	11.18%
13	10.59%	0.00%	11.74%	0.00%	0.00%	22.35%
14	1.90%	0.00%	0.00%	2.86%	0.00%	4.76%
15	0.00%	0.00%	0.00%	17.65%	4.16%	17.65%
16	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
29	26.20%	0.00%	0.00%	1.90%	0.00%	28.10%
30	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
31	61.54%	0.00%	0.00%	7.69%	0.00%	69.20%

Source: Author (2016)

From Table 6.2 it is evident that, although there are areas where no consolidation occurred, the consolidation of properties was the most prominent method of densification since 2000. This is followed by the construction of additional dwelling units and the construction of multiple attached dwelling units respectively.

The results indicate that 12.64% of the residential properties in Zone 3 in 2000 experienced densification. Densification in this zone can be attributed to 2.20% of the residential properties being consolidated, 2.75% being subdivided, 7.14% constructing an additional dwelling unit and 0.55% adding multiple attached dwelling units. There were 107 dwelling units more in 2016 than in 2000, and all the measures of density revealed a 55% increase over the study period. Concerning Zone 10, 56.60% of the residential properties in this zone experienced densification since 2000. This trend can be attributed to 34.10% of the residential properties being consolidated, 13.20% building an additional dwelling unit and 6.20% adding multiple attached dwelling units. The number of dwelling units in this zone increased significantly – by 1 174 dwelling units – since 2000. In addition, the results reveal that 3.10% of the residential properties had undergone changes in land use from residential to institutional since 2000. This change in land use is accompanied by a decrease in the residential area used in the density calculations and supports the variations in percentage density increase witnessed in Table 5.4 (Chapter 5).

Data for Zone 12 reveal that 11.18% of the residential properties underwent densification during the period of study, and this was entirely due to the construction of an additional dwelling unit. Additionally, the data for 2016 show that there were 16 more dwelling units and the measures of density in this zone all increased by 5.8%. The data for Zone 13 show that 22.35% of the residential properties experienced had densification since 2000. This is the result of 10.59% consolidation and 11.74% constructing an additional dwelling unit. In 2016 there were 373 dwelling units compared to 267 in 2000, and the density measure in this zone increased by 39.7% in this period.

Regarding Zone 14, the data reveals that 4.76% of the residential properties have experienced densification since 2000. The results reveal no changes in land use, although there was one less property in 2016. This is due to 1.90% of the residential properties being consolidated. In addition, 2.86% of the residential properties added multiple attached dwelling units and the number of dwelling units overall increased by 83 during the study period. All the measures of density consistently increased by 11.6% since 2000. The findings related to Zone 15 show that 17.65% of the residential properties have undergone densification since 2000. This trend can be accredited entirely to the construction of multiple attached dwelling units. In addition, there were 31 more dwelling units in 2016 than in 2000, and 4.16% of the properties changed from business use to MXDs after 2000. Once again, this supports the variation in the real, net and gross residential dwelling unit density observed in Table 5.8.

Data for Zone 29 show that 28.10% of the residential properties in Zone 29 have undergone densification since 2000. This trend can be attributed to a significant 26.20% of residential properties being consolidated and 1.90% building multiple attached dwelling units. In addition, there were 287 more dwelling units in 2016 than in 2000, and the different density calculations all reveal an 83.9% increase. Finally, the results for Zone 31 indicate that 69.20% of the residential properties in this area experienced densification. Consolidation contributed 61.54%, while 7.69% of the residential properties constructed multiple attached dwelling units. The density measures in this zone consistently increased by 24.9% across all fields; however, the number of dwelling units increased by 121 compared to 2000.

6.3 IMPACT OF DENSIFICATION ON URBAN SPACE IN STELLENBOSCH

It is widely argued that cities and towns have the potential to be extremely efficient when residents are living close to one another (Anderson, Hooper & Tuvshinbat 2016; World Bank 2016). Elkin, McLaren and Mayer (1991) argue that the compactness of urban space reduces the cost, time and energy consumed in the transportation of goods, services and people. The delivery of services such as water, transportation, sanitation, education, healthcare and other social and cultural services becomes easier to provide and maintain (Anderson, Hooper & Tuvshinbat 2016; Arku 2009; Jabareen 2006; World Bank 2016). According to proponents of the compact city, of which densification is a strategy, a sustainable city should be compact, dense, diverse and highly integrated (Duany & Plater-Zyberk 1992; Jenks, Burton & Williams 1996; Zhu 2012).

In Stellenbosch, these principles of densification are encouraged in the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b: 16), which states that “the principles of walking distance, functional integration, socio-economic integration, appropriate densification and the urban edge should inform settlement design”. Higher-density development in the town is encouraged, provided that it adheres to restrictions stipulated in the IZS (Stellenbosch Municipality 2012b; 2012c). However, the study results reveal that densification takes place in an ad hoc, unstructured and unplanned manner. This is largely as a result of the natural consumer demand for housing in areas that are in close proximity to the CBD and the university campus. The findings support this argument, as it is evident that densification has occurred unplanned in all the areas, other than in Zone 16 and 30, as only Zone 10 was earmarked for densification (Benn 2010). This is further supported by Donaldson and Morkel (2012), who note that modern consumer tendencies, the need for convenience, property rights and development pressures lead to unfitting and standardised building and space making and fear the loss of this unique sense of place due to “ad hoc” forms of densification around the university campus.

Proponents of compactness suggest an urban form that is large enough to provide a rich urban life in terms of opportunities and services, but small enough to be walkable without having the desire for a private vehicle (Duany & Plater-Zyberk 1992; Jenks, Burton & Williams 1996; Zhu 2012). It can be argued that densification in the area under study has reached a level of compactness in terms of promoting walkability and cycling for local residents, as these locations are all in relative proximity to the CBD, transit links and the university campus. According to the Stellenbosch CITP (Stellenbosch Municipality 2011) and Jordaan (2003), appropriate walking distances with respect to densification projects should be approximately 20 minutes or 1 to 2 km, and all of the areas in this study comply with this provision. However, the lack of a viable transport system, coupled with the housing shortage mentioned in the SDF (Stellenbosch Municipality 2012b), results in a daily influx of visitors using their own private vehicles. This, in combination with the lack of parking facilities provided by the university and the Municipality, creates the problem of overcrowded on-street parking in residential areas and the perception that the town is congested. The findings prove that parking facilities are inadequate, considering that only Zones 14, 15 and 16 have allocated public parking facilities (Appendix D).

The study areas’ proximity to the CBD and the university justifies the application of densification. It can be argued that the socio-economic classes that are able to acquire accommodation in these areas may reap the benefits of walking and decreased commuting distances, increased social integration and increased safety as the area experiences increased movement and security improvements as a consequence of densification. This supports the argument of Haughey (2005), namely that densification increases pedestrian movement and therefore creates a 24-hour community, which results in less crime and, ultimately, in safer communities. In contrast, De Roo and Miller (2000) and Zhu (2012) argue that, in certain socio-economic conditions, higher densities can foster crime, social irresponsibility and vandalism. This is particularly evident in the numerous informal settlements, e.g. Khayamandi amongst others, that span almost around the entire Stellenbosch and fall victim to such undesired spatial features. In addition, these informal settlements and their related socio-economic conditions have a spill-over effect into the town, which can explain the increase in drug-related crime in Stellenbosch over the past years as mentioned in the town’s IDP (Stellenbosch Municipality 2012a: 33).

Alexander and Tomalty (2002) found that higher density has a negative effect on the affordability of housing in urban centres. As a result, lower income groups are deprived of the opportunity to reside in these areas, which broadens the gap between rich and poor and creates a sense of inferiority that may lead to increased criminal activity in these areas. As a guideline, the SDF (Stellenbosch Municipality 2012b) stipulates the principle of integrating low-, middle- and high-income accommodation, with approximately 25 dwelling units per hectare in larger settlements as opposed to isolated settlements or gated communities. This is aimed particularly at areas where traffic congestion is prevalent. However, discrepancies exist regarding the implementation of this principle. Although the zones in the study area are not necessarily highly congested in terms of traffic flow, on-street parking creates the perception of congestion. In addition, the findings of the study on density and the current reality are that, with the exclusion of Zones 16 and 30, all the other zones have a higher density figure than the desired average of 25 dwelling units per hectare proposed in the SDF (Stellenbosch Municipality 2012b). The results indicate that the real, net and gross residential dwelling unit densities of all the other zones are currently well above 25 dwelling units per hectare, with the highest gross residential dwelling unit density observed in Zones 10 and 31, at 65.81 and 86.37 dwelling units per hectare respectively.

Concerning the vision of the Stellenbosch SDF (Stellenbosch Municipality 2012b), namely to integrate low-, middle- and high-income accommodation and steer away from isolated settlements and gated communities through densification, it can be argued that integration has been neglected considering the luxurious apartments that have been erected since 2000. These apartments are essentially associated with high bonds and rental values, which can only be acquired by high middle- and high-income earners, and thus it excludes low- and middle-income occupants from the opportunity to affordable accommodation close to the CBD and the university campus. The numerous gated communities along the R304 between Stellenbosch and the intersection with the M23, which have been developed since the approval of the Stellenbosch Municipality SDF in 2013, suggest that isolated settlements and gated communities have become more popular, regardless of the goal to steer away from such kinds of development.

The perception amongst economists is that three underlying forces, namely increasing household income levels, increasing populations and transportation developments, drive spatial growth (Mieszkowski & Mills 1993). In Stellenbosch, similar circumstances drive spatial growth and the urban sprawl phenomenon, and their impediment to agricultural land can be witnessed in the numerous higher income gated developments along the R44, including De Zalze and Jamestown.

These new developments have little or no public transport systems connecting the nodes to the town, and consequently increase the dependence on private transport, which contributes greatly to traffic congestion and CO_2 emissions. Where there is a lack of a viable transport system, coupled with increasing criminal activity as is the case with drug-related crime in Stellenbosch (Stellenbosch Municipality (2012a), most people prefer to use their private vehicles, which correlates with the findings of Steg and Gifford (2005) regarding the car as a preferred mode of transport.

Dave (2011) mentions that economic growth rates increase the gap between the poor and the affluent. The economic divide is a prominent feature in Stellenbosch. Although the Stellenbosch Municipality IDP (Stellenbosch Municipality 2012a) and the Stellenbosch Municipality SDF (Stellenbosch Municipality 2012b) strongly promote LEDs and provide informal trading space, e.g.. in the CBD on the corner of Bird Street and Merriman Avenue, high rentals attached to retail space in Stellenbosch still exclude lower income traders from the market space to some extent. Densification in the area under study is associated predominantly with the development of luxurious walk-ups and low-rise high-density apartment blocks, which broaden the gap between rich and poor, as only the middle high- and high-income groups are able to occupy these spaces.

According to Quastel, Moos and Lynch (2013), densification has characteristics of gentrification, as it influences cultures and lifestyles through the socio-economic configuration of settlements. Thus, with development focusing predominantly on the accommodation demand of a single socio-economic class, the needs of other residents who have the desire to occupy these spaces are neglected. For example, in Zone 10, the process of densification causes spatial dysfunctionality between permanent residents and the students and, as a result, a "sterile and disjointed student urban landscape" is created that lies desolate for more than a third of the year and progressively degrades the historical nature of the urban space in Stellenbosch (Donaldson & Morkel 2012: 64).

However, Zones 10, 15 and 16, located between Merriman Avenue and Banghoek Road, both border university land. As a result of the strong institutional influence, it can be argued that the area is engrained with an inevitable affiliation to the university and therefore it will not be able to avoid the influx of students into these areas. Benn (2010) notes that the current state in Zone 10 fosters social instability and a lack of community cohesion between students and permanent residents. However, it can be argued that homeowners in these areas obtained their properties as a result of several probable reasons. These potentially include the need for convenience, the close proximity to the university as a result of either employment at the university or in the CBD, having family members enrolled at the university or future investment opportunities stemming from rental opportunities and rising property values. This means that they are willingly affiliated themselves with the university to some extent. In addition, the absence of a clear buffer zone between the university and these residential areas further suggests the awareness of buyers that they will be associating with the university and the conditions that accompany studentified suburbs, such as noise pollution and the lack of community cohesion between students and permanent residents.

According to Wheeler (2002), compactness also refers to connectivity, which implies that forthcoming developments should be focused on the existing built environment. The findings of this study reveal that development is connected, in the sense that new developments are occurring within the existing built-up areas. However, concerns arise regarding the scattered nature of new developments within these existing areas, and the small number of MXDs that can be found in the study area, although there are far-reaching agreements among planners and scholars that mixed land use play a vital role in promoting sustainable urban form (Jabareen 2006; Musakwa & Van Niekerk 2013).

Density is based on the idea of viable thresholds, meaning that urban functions and activities become viable at a certain density (threshold) due the generation of interactions (Jabareen 2006). It can be argued that a greater threshold has been created since 2000, although the systems that should support and benefit from this threshold have only been mentioned in policy and have not yet become a reality in terms of implementation. Interestingly, Donaldson and Morkel (2012) mention that current densities in the town do not provide sufficient viability to sustain public facilities, small businesses and transport infrastructure, and the these can addressed with appropriate densification and the enforcement of an urban edge. Therefore, appropriate densification should be promoted to address the viability issue and, in the process, authorities and developers should integrate housing options in such a way that a sufficient threshold is created for the periods when the students are not in town for a third of the year.

According to Carlow (2014), densification tactics can be seen as using space to its full potential. The findings suggest that developers are achieving relatively high residential densities on small properties, which means that they are working toward maximising the potential of the existing built environment. However, the findings reveal that there are parcels of land, e.g. the parcel of land behind the Stellenbosch Correctional Services on Ds Botha Road in Zone 14 and erf 2484 in Zone 16, which provide typical examples of underutilised land in a built-up environment. This underutilised land is currently used by vagrants and poses security hazards to pedestrians and cyclists alike. According to Arrigone (1995) and De Klerk (1998), the greatest opportunity for the densification of urban areas lies in segments of undeveloped and underutilised open spaces. In addition, according to Alexander and Tomalty (2002) and the City of Cape Town (2012a), high-density areas are usually associated with a greater variety of accommodation types and therefore the user has a greater range of housing options. This is true considering the variety of accommodation types found in the study area, from single residential dwelling units to low-rise high-density apartments that generally consist of a mix of studio units, bachelor units and two- to three-bedroom units.

6.4 CONCLUSION

Most of the residential areas included in the study revealed a significant increase in density since 2000. This can be seen as the product of increasing population densities in the town and a stronger focus on municipal efforts since the adoption of IDPs and SDFs emphasising densification as a strategy to cater for these influxes.

Although the kind of densification occurring in Stellenbosch seems to exclude the low- and low-middle-income social groups from owning property in the town, the increase in the real, net and gross residential dwelling unit density observed in the findings suggest that more people can be housed closer to the amenities and facilities offered in the town. Irrespective of the vision of urban densification, there are many negative impacts associated with higher density urban forms. In Stellenbosch, the process of densification is changing the residential texture of the town, from traditional single residential dwellings to low-rise, high-density dwelling types, without incorporating aspects of socio-economic integration, appropriate density, mixed use, sustainable transport initiatives and environmental and historic conservation in an attempt to accommodate an ever-growing population. This is due to the inability of the Municipality and the university to provide a feasible solution to their accommodation shortfalls and, as a result, the private sector enjoys the opportunity to flood the market with high-density accommodation with vague restrictions by the governing authorities. The result is a kind of development that is biased towards profit motivation as opposed to development that incorporates a holistic approach to densification.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter combines all the previous chapters and draws on the findings of the work to draw conclusions and make recommendations for the future growth of Stellenbosch and possible future research.

7.2 REVISITING THE RESEARCH PROBLEM

There is a perpetual burden to supply accommodation to increasing population numbers in Stellenbosch. The most ideal way in which the property market is able to cater for this demand is through the development of low-rise, high-density accommodation (Donaldson & Morkel 2012). Densification is a national spatial strategy aimed at integrating cities socially and spatially (Stellenbosch Municipality 2012a). However, there is a notion that densification in Stellenbosch is implemented in an ad hoc manner due to the lack of adequate policies regulating development in the town and, where policies exist, they are not enforced effectively (Donaldson & Morkel 2012). What the impact may be on urban space is not known yet. Thus, it is valuable to determine the extent of urban densification in order to minimise undesired spatial consequences for future generations.

In this study, the aim was to determine where, to what extent and why densification has taken place in Stellenbosch in the area demarcated by Merriman Avenue, the R44, the R310 and Simonsberg Road from 2000 to 2016. To achieve the research aim, the first objective was to identify properties, through municipal valuations, on which densification had taken place in all of the study areas between 2000 and 2016. Data was collected from the Stellenbosch Municipality and, in cases where disparities existed, additional information was obtained from the Surveyor General diagrams. Municipal valuations are done on a four-year basis, with the latest valuation taking place in 2013. Therefore, a process of ground-truthing was performed to obtain data up to 2016. The findings that reflect where and to what extent densification has taken place since 2000 are recorded in Chapter 5.

The second objective was to identify the most prominent methods of densification in the study area. Table 5.20 in Chapter 5 summarises the results obtained in this regard. It can be concluded from these results that, although there are areas where no consolidation has occurred, the consolidation of properties remains the most prominent method of densification since 2000. This is followed by the construction of additional dwelling units and the construction of multiple attached dwelling units respectively.

A major limitation to achieving the third objective, to map the changes in residential density, was that neither the Municipality nor online sources possessed updated and consistent maps and data containing the latest property numbers for each property. This meant that the researcher had to use all available sources, such as Stellenbosch Municipality, Surveyor General diagrams and the PlanetGIS Explorer 5.0 Western Cape cadastral database to create maps.

The newly created maps show:

- the location of the study area;
- the different zones with a reference to scale;
- the latest erf numbers in 2016;
- properties where densification has and has not occurred;
- the number of dwelling units in 2000 and 2016;
- the density values per hectare for each of these properties;
- the relationship of a property to the size of a hectare to convey a sense of scale to the density values indicated;
- the methods of densification;
- the new boundary lines as effected by densification.

Chapter 4 addressed the fourth objective, which was to identify the relevant policy documents and planning strategies pertaining to the study area. The research problem suggested that densification is implemented in an ad hoc manner due to the lack of adequate policies regulating development in the town and, where policies exist, they are not enforced effectively. The findings suggest that policy documentation that provides guidelines, such as the Stellenbosch Municipality IDPs, SDFs and IZSs, have been in development since 2000. However, sixteen years later, there still are areas where unplanned and ad hoc densification is taking place, as is evident from the results of this study. This suggests that, although spatial planning policies do exist, they may not be enforced adequately and/or sufficiently. The final objective was to make recommendations on densification and the future growth of Stellenbosch. The recommendations will be made at the end of this chapter, following a short discussion of the main conclusions supported by the evidence provided throughout the previous chapters of this study.

Based on the findings, the author concludes that densification has been a prominent feature in all the zones under study since 2000, excluding Zone 16 and 30. Due to several factors, the zones in the study area provide an obvious choice for densification in Stellenbosch. These factors relate to proximity and the need for convenience, the existing infrastructure, housing demand and supply, as well as the availability of land and subsequent development opportunities.

One of the major factors that encourage densification in the study area is the close proximity of the university and the CBD of Stellenbosch. It is widely agreed that appropriate walking distances with respect to densification projects should be approximately 20 minutes or within a radius of 1 to 2 km. The entire study area is conveniently situated within this range with respect to retail, business, institutional and recreational functions. Another factor that promotes densification is the existing transport infrastructure with reference to the main arteries or transit links surrounding the study area. The area is demarcated by Merriman Avenue, which provides links to the R44, Bird Street (leading the CBD to the N1), and Cluver and Simonsberg Roads, extending to the R310. The R44 borders the study area on the western side and provides a link from Somerset West all the way to Paarl. The R310 provides a link to Paarl as well as to Franschhoek. Simonsberg Road links to the R310 and extends all the way from Stellenbosch to Jonkershoek.

With reference to land availability and development opportunities, the findings reveal that there are parcels of land that are currently underutilised and undeveloped. Examples of such land can be found in the parcel of land behind the Stellenbosch Correctional Services on Ds Botha Road in Zone 14, and erf 2484 in Zone 16, which provides a typical example of underutilised land in a built-up environment. This underutilised land currently is used by vagrants and poses security hazards for pedestrians and cyclists alike. Therefore, these spaces offer development opportunities and can be used to add value to the housing component and the housing shortage, while creating meaningful spaces and enhancing the neighbourhood.

Another critical factor influencing densification in the study area is the demand for housing in Stellenbosch. Neither the university nor the Municipality is able to adequately meet the demand for accommodation in the town. This is partly due to the university not capping its enrolment numbers based on their capacity to supply accommodation, and the Municipality not accepting the responsibility of designating suitable locations for development and parking in the town. This indicates that development is not adequately guided or regulated by the governing authorities, which allows developers an degree of autonomy concerning development choices, which supports the current ad hoc nature of densification evident in the results. Therefore, it can be argued that a method of accountability needs to be implemented to ensure that the Municipality and its policies enforce restrictions on the university on the grounds that they are not able to meet their housing demands. In addition, the Municipality should dedicate densification zones and provide incentives to developers if they adhere to properly planned prescriptions and sustainability aspirations, such as integration, economic opportunity, walkability, appropriate densities, sense of community, mixed use and functional viability, all of which create a good quality of life for the residents of Stellenbosch.

7.3 RECOMMENDATIONS FOR FUTURE GROWTH

The town of Stellenbosch is characterised by high-quality viniculture, street cafés, historical buildings and educational institutions. The economy of the town is moderately diverse and driven by a flourishing tourism and agricultural industry, the university, global businesses and technological firms. This creates conflicting goals in terms of where to prioritise development and resource allocation. It is recommended that the Municipality and stakeholders accept the diverse character of the town and that diverse planning strategies and policies should be designed in a context- and area-specific nature in order to maximise the potential of the town without diminishing the unique sense of place for which Stellenbosch is known worldwide.

Based on the focus of the literature used for this study, it is evident that a large portion of work is dedicated to the social impact of densification. Therefore, it may be valuable for future research to focus on the social impact and implications of densification in Stellenbosch through the application of questionnaires to determine the understanding and perception of density amongst residents of the town. In addition, it may be valuable to determine the effect that densification has on the affordability of housing stock and whether or not densification in Stellenbosch manages to integrate or exclude different socio-economic classes based on the affordability of housing. This kind of research, in turn, can be used to ensure that all the impacts of densification, both positive and negative, as well as the concerns of local residents, are taken into account in order to inform spatial planning policy directives.

In addition, the Municipality should identify suitable locations for densification and identify Council-owned land that is available for the development or redevelopment of new and existing buildings. Available land should be re-zoned, where necessary, in line with the specific planning strategies for a given area. Incentives can be used as a tool to encourage developers to develop land, provided that it meets the developmental guidelines determined by the context-specific planning strategies. Guidelines should ideally incorporate the holistic principles of densification, such as socio-economic integration, mixed use, sustainable transport, appropriate densities, and sense of community, environmental consciousness and functional viability.

An example of a well-planned and executed densification project in the Western Cape province can be found in the Melkbosch Village development in Melkbosstrand. The 468-unit development consists of free-standing and sectional title homes. Interestingly, this development manages to incorporate 100 social housing units, which was cross-subsidised by the developer and the Western Cape Government. The same look and feel was used for both the subsidised houses and the more expensive free enterprise units. While the development manages to include members of the disadvantaged community, it is expected of these members to conform to the management rules of the development (Frost 2010). Although this project was developed on a relatively large piece of land, the same principles can be applied on a smaller scale on any available land in Stellenbosch.

This is one the few good examples where true socio-economic integration of low- and high-income residents takes place in a managed way. Although it will certainly be challenging, Stellenbosch has the opportunity to apply similar principles to future growth strategies. In addition, as a result of the shortage of available land within the urban edge, this example of densification can answer the need for densification projects that integrate different socio-economic groups and provide diverse types of housing with a potentially high level of user satisfaction.

Finally, the Density Atlas (2011) argues that density measures are often viewed in isolation, without consideration of the other. Therefore, it can be argued that dwelling unit density alone, as is the case in this study, is not a comprehensive measure of density in its entirety, and that it is crucial that all three components (dwelling unit density, building density and population density) are investigated and compared in order to generate the most substantial picture of density in Stellenbosch.

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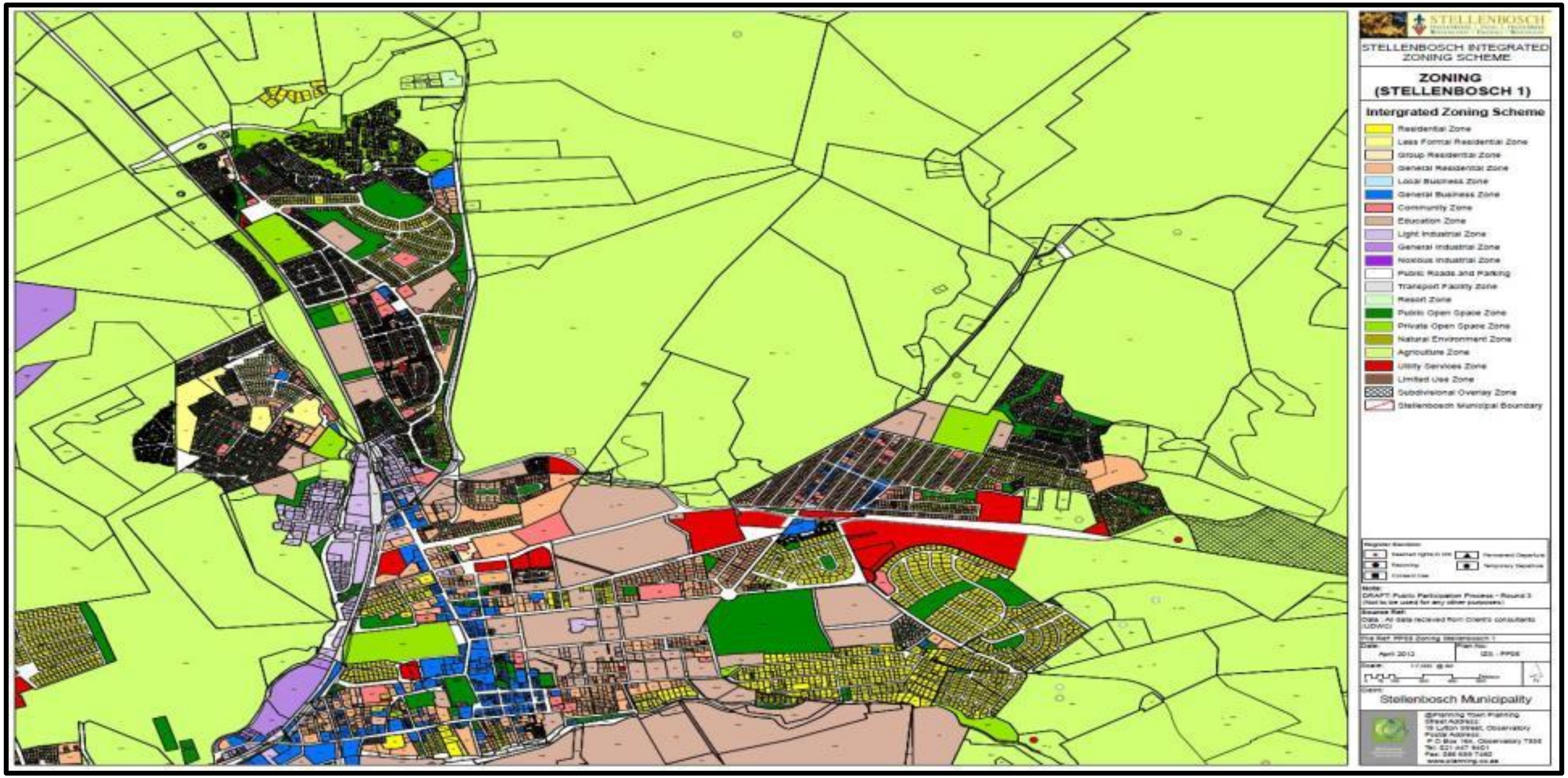
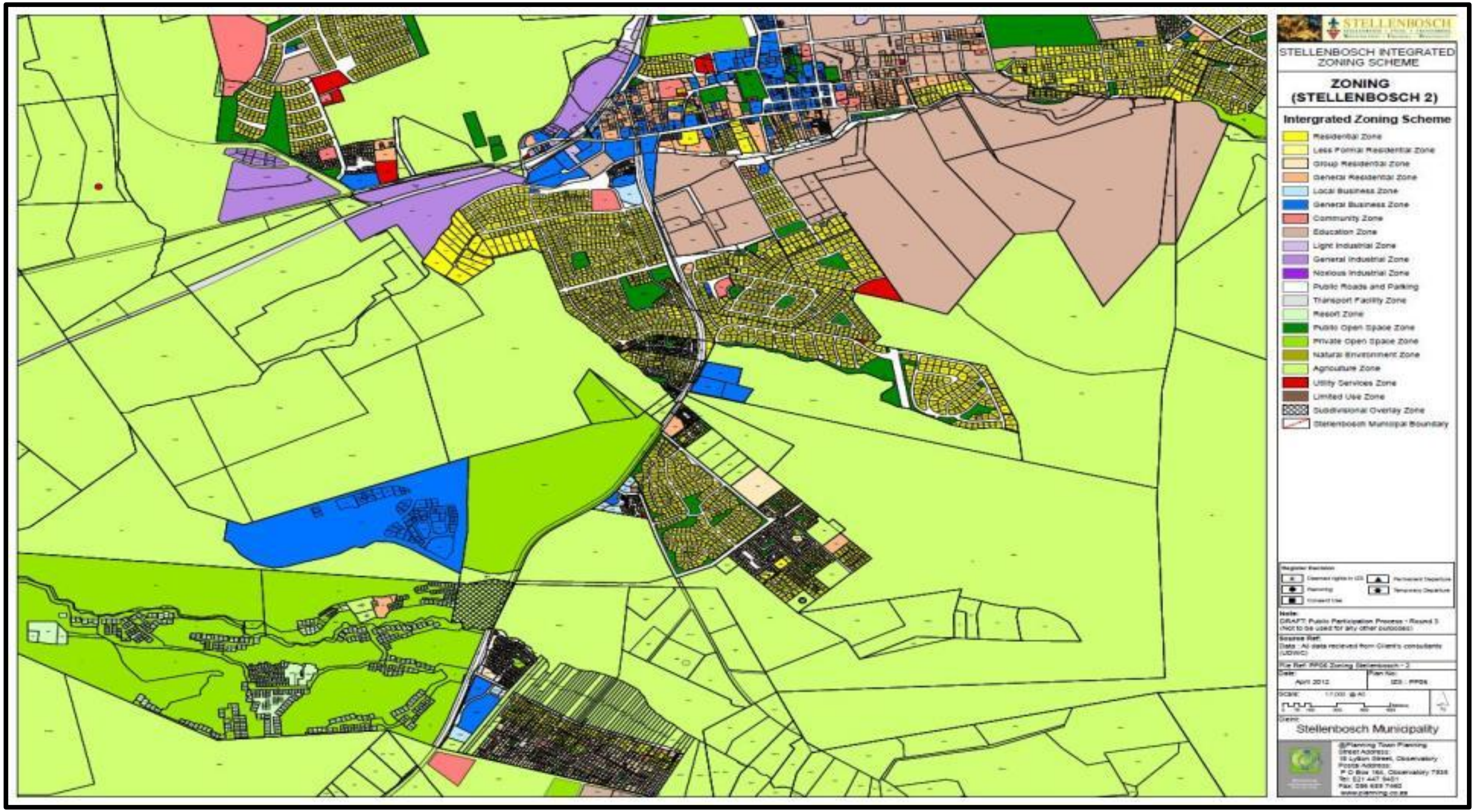
APPENDIX A: STELLENBOSCH IZS (2012) MAPS



Source: Stellenbosch Municipality (2012c: n.p.n.)

Figure A.1 Stellenbosch Zoning Map 1



Source: Stellenbosch Municipality (2012c: n.p.n.)

Figure B.2 Stellenbosch Zoning Map 2

APPENDIX B: STELLENBOSCH IZS (2012) USE CHANGES

Table B.1 Conversion from existing zoning to integrated zoning

STELLENBOSCH SCHEME	
Existing Use Zone	**IZS Use Zone**
Single Residential	Residential Zone
Less Formal Residential	Less Formal Residential Zone
Group Housing	Group Residential Zone
General Residential	General Residential Zone
General Business	General Business Zone
Specific Business	General Business Zone
Restricted Business	Local Business Zone
University	Education Zone
Institution	Community Zone
Educational Institution	Education Zone
Place of Worship	Community Zone
Agriculture	Agriculture Zone
Local Authority Government	Council to allocate: Utility Zone if no other zoning is allocated
Public Open Space	Public Open Space Zone
Private Open Space	Private Open Space Zone
Special Business	Light Industrial Zone
Light Industrial	Light Industrial Zone
General Industrial	General Industrial Zone
Noxious Industrial	Noxious Industrial Zone
Undetermined	Limited Use Zone
Special Zone	General Business Zone
Wine Industry	Within Urban Edge: Light or General Industrial depending on context Outside Urban Edge: Agriculture Zone consent for 'Agricultural industry' (Wine industry)

Source: Stellenbosch Municipality (2012c: 15)

APPENDIX C: STELLENBOSCH IZS (2012) REGULATIONS

Table C.1 Residential Zoning

RESIDENTIAL	Erf Area	COVERAGE (% of site area)	HEIGHT	BUILDING LINES		OTHER PROVISIONS
				Street Boundary	Common Boundary	
RESIDENTIAL ZONE **PRIMARY USES** Dwelling house, Second dwelling **ADDITIONAL USES** Bed and breakfast establishment, Lodging establishment, Home daycare centre, Home occupation practice **CONSENT USES** Additional uses exceeding development rules, Guest house, Boarding house, House shop, House tavern, Extramural facility, Renewable energy structure	Less than 250m²	60%	2 storeys	2m	1m	Additional Use parameters: • Bed and Breakfast: 3 bedrooms and 6 people • Lodging establishment: 3 bedrooms, 3 people • Home occupation: smallest of 50m² or 30% of dwelling floor area • Home daycare: maximum 6 children Only one additional use permitted per property; Operator to reside on site; Building to remain dwelling house Refer to Parking in Table B
	251-500m²	50%		3m	1.5	
	501-700m²	50%		4m	2m	
	701-1500m²	40%		4m	2m	
	More than 1500m²	30%		4m	2m	
LESS FORMAL RESIDENTIAL ZONE **PRIMARY USES** Dwelling house, Second dwelling, Shelter **ADDITIONAL USES** Bed and breakfast establishment, Lodging establishment, Home daycare centre, Home occupation practice, House shop **CONSENT USES** Additional uses exceeding development rules, House tavern, Guesthouse , Boarding house, Welfare institution, Community residential, Extramural facility, Place of education, Place of worship, Renewable energy structure	N/A	80%	2 storeys	1m	0m on one boundary; 1m on all other boundaries	Additional Use parameters: • Bed and Breakfast: 3 bedrooms and 6 people • Lodging establishment: 3 bedrooms, 3 people • Home occupation: smallest of 50m² or 30% of dwelling floor area • Home daycare: maximum 6 children • House shop: smallest of 50m² or 30% of dwelling floor area Only one additional use permitted per property; Operator to reside on site; Building to remain dwelling house Refer to Parking in Table B
GROUP RESIDENTIAL ZONE **PRIMARY USES** Group houses **ADDITIONAL USES** Home daycare centre, Bed and breakfast establishment; Lodging establishment, Home occupation practice, Open space, Place of sport and recreation, Flats **CONSENT USES** Additional uses exceeding development rules, Retirement village, Renewable energy structure	N/A	To be determined by SDP; if no limit then no more than 50%	2 storeys	External boundaries: 3m Internal boundaries: 0m	External boundaries: 3m Internal boundaries: 0m	Max 50 du/ha Additional Use parameters: • Bed and Breakfast: 3 bedrooms and 6 people • Lodging establishment: 2 bedrooms, 2 people • Home occupation: smallest of 50m² or 30% of dwelling floor area • Home daycare: maximum 6 children Only one additional use permitted per property; Operator to reside on site; Building to remain dwelling house Refer to Parking in table B

Source: Stellenbosch Municipality (2012c: 4)

Table D.1 Residential Zoning (continue)

RESIDENTIAL (CONT)	Erf Area	COVERAGE (% of site area)	HEIGHT	BUILDING LINES		OTHER PROVISIONS
				Street Boundary	Common Boundary	
GENERAL RESIDENTIAL ZONE **PRIMARY USES** Flats, Dwelling house, Second dwelling house, Boarding house; Guesthouse **ADDITIONAL USES** Bed and breakfast establishment, Lodging establishment, Home daycare centre; Home occupation practice **CONSENT USES** Additional uses exceeding development rules, Welfare institution; Community residential, Place of indoor recreation, Conference facilities (associated with a guesthouse), Rooftop base telecommunication station, Renewable energy structure	Min Erf size for General Residential use rights 1000m² Otherwise Residential Zone applies	50%	3 storeys	4.5m	Ground and first floor: 4.5m Second floor: 6m	Additional Use parameters in dwelling house: • Bed and Breakfast: 3 bedrooms and 6 people • Lodging establishment: 3 bedrooms, 3 people • Home occupation: smallest of 50m² or 30% of dwelling floor area • Home daycare: maximum 6 children Only one additional use permitted per property; Operator to reside on site; Building to remain dwelling house Refer to Parking in Table B

Source: Stellenbosch Municipality (2012c: 5)

APPENDIX D: RAW DATA

Table D. 1 Raw data for Zone 12, 13 and 31

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
10826	10826	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
10827	10827	RES	RES	538	0.0538	538	0.0538	1	1	18.59	18.59
10828	10828	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
10829	10829	RES	RES	536	0.0536	536	0.0536	1	1	18.66	18.66
10833	10833	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
10834	10834	RES	RES	537	0.0537	537	0.0537	1	1	18.62	18.62
10835	10835	RES	RES	533	0.0533	533	0.0533	1	1	18.76	18.76
13505	13505	RES	RES	261	0.0261	261	0.0261	1	1	38.31	38.31
13506	13506	RES	RES	161	0.0161	161	0.0161	1	1	62.11	62.11
13507	13507	RES	RES	192	0.0192	192	0.0192	1	1	52.08	52.08
13508	13508	RES	RES	148	0.0148	148	0.0148	1	1	67.57	67.57
13509	13509	RES	RES	142	0.0142	142	0.0142	1	1	70.42	70.42
13510	13510	RES	RES	141	0.0141	141	0.0141	1	1	70.92	70.92
13511	13511	RES	RES	141	0.0141	141	0.0141	1	1	70.92	70.92
13512	13512	RES	RES	129	0.0129	129	0.0129	1	1	77.52	77.52
13513	13513	RES	RES	142	0.0142	142	0.0142	1	1	70.42	70.42
13514	13514	RES	RES	147	0.0147	147	0.0147	1	1	68.03	68.03
13515	13515	RES	RES	136	0.0136	136	0.0136	1	1	73.53	73.53
13516	13516	RES	RES	175	0.0175	175	0.0175	1	1	57.14	57.14
13517	13517	RES	RES	132	0.0132	132	0.0132	1	1	75.76	75.76
13518	13518	RES	RES	135	0.0135	135	0.0135	1	1	74.07	74.07
13519	13519	RES	RES	217	0.0217	217	0.0217	1	1	46.08	46.08
13520	13520	RES	RES	167	0.0167	167	0.0167	1	1	59.88	59.88
13521	13521	RES	RES	140	0.014	140	0.014	1	1	71.43	71.43
13522	13522	RES	RES	145	0.0145	145	0.0145	1	1	68.97	68.97
13523	13523	RES	RES	158	0.0158	158	0.0158	1	1	63.29	63.29
13524	13524	RES	RES	174	0.0174	174	0.0174	1	1	57.47	57.47
13525	13525	RES	RES	149	0.0149	149	0.0149	1	1	67.11	67.11
13526	13526	RES	RES	150	0.015	150	0.015	1	1	66.67	66.67
13527	13527	RES	RES	166	0.0166	166	0.0166	1	1	60.24	60.24
13528	13528	RES	RES	165	0.0165	165	0.0165	1	1	60.61	60.61
13529	13529	RES	RES	140	0.014	140	0.014	1	1	71.43	71.43
13530	13530	RES	RES	126	0.0126	126	0.0126	1	1	79.37	79.37
13531	13531	RES	RES	162	0.0162	162	0.0162	1	1	61.73	61.73
13532	13532	RES	RES	218	0.0218	218	0.0218	1	1	45.87	45.87

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
13533	13533	RES	RES	186	0.0186	186	0.0186	1	1	53.76	53.76
13534	13534	RES	RES	207	0.0207	207	0.0207	1	1	48.31	48.31
13535	13535	RES	RES	205	0.0205	205	0.0205	1	1	48.78	48.78
13536	13536	RES	RES	205	0.0205	205	0.0205	1	1	48.78	48.78
13537	13537	RES	RES	214	0.0214	214	0.0214	1	1	46.73	46.73
13538	13538	RES	RES	212	0.0212	212	0.0212	1	1	47.17	47.17
13539	13539	RES	RES	195	0.0195	195	0.0195	1	1	51.28	51.28
13540	13540	RES	RES	131	0.0131	131	0.0131	1	1	76.34	76.34
13541	13541	RES	RES	125	0.0125	125	0.0125	1	1	80.00	80.00
13542	13542	RES	RES	119	0.0119	119	0.0119	1	1	84.03	84.03
13543	13543	RES	RES	150	0.015	150	0.015	1	1	66.67	66.67
13544	13544	RES	RES	171	0.0171	171	0.0171	1	1	58.48	58.48
13545	13545	RES	RES	125	0.0125	125	0.0125	1	1	80.00	80.00
13546	13546	RES	RES	132	0.0132	132	0.0132	1	1	75.76	75.76
13547	13547	RES	RES	128	0.0128	128	0.0128	1	1	78.13	78.13
13548	13548	RES	RES	120	0.012	120	0.012	1	1	83.33	83.33
13549	13549	RES	RES	126	0.0126	126	0.0126	1	1	79.37	79.37
13550	13550	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
13551	13551	RES	RES	131	0.0131	131	0.0131	1	1	76.34	76.34
13552	13552	RES	RES	176	0.0176	176	0.0176	1	1	56.82	56.82
13553	13553	RES	RES	212	0.0212	212	0.0212	1	1	47.17	47.17
13554	13554	RES	RES	161	0.0161	161	0.0161	1	1	62.11	62.11
13555	13555	RES	RES	140	0.014	140	0.014	1	1	71.43	71.43
13556	13556	RES	RES	149	0.0149	149	0.0149	1	1	67.11	67.11
13557	13557	RES	RES	166	0.0166	166	0.0166	1	1	60.24	60.24
13558	13558	RES	RES	158	0.0158	158	0.0158	1	1	63.29	63.29
13559	13559	RES	RES	131	0.0131	131	0.0131	1	1	76.34	76.34
13560	13560	RES	RES	147	0.0147	147	0.0147	1	1	68.03	68.03
13561	13561	RES	RES	206	0.0206	206	0.0206	1	1	48.54	48.54
13562	13562	RES	RES	264	0.0264	264	0.0264	1	1	37.88	37.88
13563	13563	RES	RES	194	0.0194	194	0.0194	1	1	51.55	51.55
2644	2644	RES	RES	1343	0.1343	1343	0.1343	1	2	7.45	14.89
2645	2645	RES	RES	1457	0.1457	1457	0.1457	1	2	6.86	13.73
2646	2646	RES	RES	553	0.0553	553	0.0553	1	2	18.08	36.17
2647	2647	RES	RES	511	0.0511	511	0.0511	1	1	19.57	19.57
2648	2648	RES	RES	513	0.0513	513	0.0513	1	2	19.49	38.99
2649	2649	RES	RES	491	0.0491	491	0.0491	1	1	20.37	20.37
2650	2650	RES	RES	541	0.0541	541	0.0541	1	1	18.48	18.48

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		**LAND USE**		**ERF SIZE**				**DU**		**(DU/Ha)**	
2000	**2016**	**2000**	**2016**	**2000**	**2000/ha**	**2016**	**2016/ha**	**2000**	**2016**	**2000**	**2016**
2651	2651	RES	RES	587	0.0587	587	0.0587	1	1	17.04	17.04
2652	2652	RES	RES	498	0.0498	498	0.0498	1	1	20.08	20.08
2653	2653	RES	RES	495	0.0495	495	0.0495	1	1	20.20	20.20
2654	2654	RES	RES	1448	0.1448	1448	0.1448	2	2	13.81	13.81
2655	2655	RES	RES	704	0.0704	704	0.0704	1	1	14.20	14.20
2656	2656	RES	RES	752	0.0752	752	0.0752	1	1	13.30	13.30
2657	2657	RES	RES	616	0.0616	616	0.0616	1	1	16.23	16.23
2658	2658	RES	RES	634	0.0634	634	0.0634	1	1	15.77	15.77
2659	2659	RES	RES	604	0.0604	604	0.0604	1	1	16.56	16.56
2660	2660	RES	RES	1530	0.153	1530	0.153	1	2	6.54	13.07
2661	2661	RES	RES	1509	0.1509	1509	0.1509	1	2	6.63	13.25
2662	2662	RES	RES	778	0.0778	778	0.0778	1	1	12.85	12.85
2663	2663	RES	RES	594	0.0594	594	0.0594	2	2	33.67	33.67
2664	2664	RES	RES	585	0.0585	585	0.0585	1	1	17.09	17.09
2665	2665	RES	RES	683	0.0683	683	0.0683	1	1	14.64	14.64
2666	2666	RES	RES	1360	0.136	1360	0.136	1	2	7.35	14.71
2667	2667	RES	RES	1626	0.1626	1626	0.1626	1	2	6.15	12.30
2668	2668	RES	RES	615	0.0615	615	0.0615	1	1	16.26	16.26
2669	2669	RES	RES	502	0.0502	502	0.0502	1	1	19.92	19.92
2670	2670	RES	RES	812	0.0812	812	0.0812	1	1	12.32	12.32
2671	2671	RES	RES	673	0.0673	673	0.0673	1	1	14.86	14.86
2672	2672	RES	RES	550	0.055	550	0.055	1	1	18.18	18.18
2673	2673	RES	RES	531	0.0531	531	0.0531	1	1	18.83	18.83
2674	2674	RES	RES	523	0.0523	523	0.0523	1	1	19.12	19.12
2675	2675	RES	RES	560	0.056	560	0.056	1	1	17.86	17.86
2676	2676	RES	RES	553	0.0553	553	0.0553	1	1	18.08	18.08
2677	2677	RES	RES	588	0.0588	588	0.0588	1	1	17.01	17.01
2678	2678	RES	RES	309	0.0309	309	0.0309	1	1	32.36	32.36
2679	2679	RES	RES	467	0.0467	467	0.0467	1	1	21.41	21.41
2680	2680	RES	RES	489	0.0489	489	0.0489	1	1	20.45	20.45
2681	2681	RES	RES	487	0.0487	487	0.0487	1	1	20.53	20.53
2682	2682	RES	RES	627	0.0627	627	0.0627	1	1	15.95	15.95
2683	2683	RES	RES	1379	0.1379	1379	0.1379	1	2	7.25	14.50
2684	2684	RES	RES	1509	0.1509	1509	0.1509	1	2	6.63	13.25
2685	2685	RES	RES	577	0.0577	577	0.0577	1	1	17.33	17.33
2686	2686	RES	RES	559	0.0559	559	0.0559	1	1	17.89	17.89
2687	2687	RES	RES	540	0.054	540	0.054	1	1	18.52	18.52
2688	2688	RES	RES	845	0.0845	845	0.0845	1	1	11.83	11.83

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
2689	2689	RES	RES	339	0.0339	339	0.0339	1	1	29.50	29.50
2690	2690	RES	RES	357	0.0357	357	0.0357	1	1	28.01	28.01
2691	2691	RES	RES	359	0.0359	359	0.0359	1	1	27.86	27.86
2692	2692	RES	RES	362	0.0362	362	0.0362	1	2	27.62	55.25
2693	2693	RES	RES	493	0.0493	493	0.0493	1	1	20.28	20.28
2694	2694	RES	RES	544	0.0544	544	0.0544	1	1	18.38	18.38
2695	2695	RES	RES	619	0.0619	619	0.0619	2	2	32.31	32.31
2696	2696	RES	RES	608	0.0608	608	0.0608	1	1	16.45	16.45
2697	2697	RES	RES	365	0.0365	365	0.0365	1	1	27.40	27.40
2698	2698	RES	RES	435	0.0435	435	0.0435	1	1	22.99	22.99
2699	2699	RES	RES	448	0.0448	448	0.0448	1	1	22.32	22.32
2700	2700	RES	RES	465	0.0465	465	0.0465	1	1	21.51	21.51
2701	2701	RES	RES	339	0.0339	339	0.0339	1	1	29.50	29.50
2702	2702	RES	RES	358	0.0358	358	0.0358	1	1	27.93	27.93
2703	2703	RES	RES	358	0.0358	358	0.0358	1	2	27.93	55.87
2704	2704	RES	RES	359	0.0359	359	0.0359	1	2	27.86	55.71
2705	2705	RES	RES	493	0.0493	493	0.0493	1	1	20.28	20.28
2706	2706	RES	RES	493	0.0493	493	0.0493	1	1	20.28	20.28
2707	2707	RES	RES	470	0.047	470	0.047	1	1	21.28	21.28
2708	2708	RES	RES	495	0.0495	495	0.0495	1	1	20.20	20.20
2709	2709	RES	RES	350	0.035	350	0.035	1	1	28.57	28.57
2710	2710	RES	RES	548	0.0548	548	0.0548	1	1	18.25	18.25
2711	2711	RES	RES	901	0.0901	901	0.0901	1	1	11.10	11.10
2712	2712	RES	RES	383	0.0383	383	0.0383	1	1	26.11	26.11
2713	2713	RES	RES	344	0.0344	344	0.0344	1	1	29.07	29.07
2714	2714	RES	RES	421	0.0421	421	0.0421	1	1	23.75	23.75
2715	2715	RES	RES	861	0.0861	861	0.0861	1	1	11.61	11.61
2716	2716	RES	RES	348	0.0348	348	0.0348	1	2	28.74	57.47
2717	2717	RES	RES	537	0.0537	537	0.0537	1	1	18.62	18.62
2718	2718	RES	RES	528	0.0528	528	0.0528	1	1	18.94	18.94
2719	2719	RES	RES	535	0.0535	535	0.0535	1	2	18.69	37.38
2720	2720	RES	RES	535	0.0535	535	0.0535	1	2	18.69	37.38
2721	2721	RES	RES	371	0.0371	371	0.0371	1	1	26.95	26.95
2722	2722	RES	RES	374	0.0374	374	0.0374	2	2	53.48	53.48
2723	2723	RES	RES	379	0.0379	379	0.0379	1	1	26.39	26.39
2724	2724	RES	RES	407	0.0407	407	0.0407	1	1	24.57	24.57
2725	2725	RES	RES	727	0.0727	727	0.0727	1	1	13.76	13.76
2726	2726	RES	RES	731	0.0731	731	0.0731	1	1	13.68	13.68

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		**LAND USE**		**ERF SIZE**				**DU**		**(DU/Ha)**	
2000	**2016**	**2000**	**2016**	**2000**	**2000/ha**	**2016**	**2016/ha**	**2000**	**2016**	**2000**	**2016**
2728	2728	O S	O S	2457	0.2457	2457	0.2457	0	0	0.00	0.00
3481-3486	3481-3486	RES	RES	5809	0.5809	5809	0.5809	37	37	63.69	63.69
4403	4403	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
4404	4404	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
4405	4405	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
4406	4406	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
4407	4407	RES	RES	541	0.0541	541	0.0541	1	1	18.48	18.48
4408	5413	RES	RES	528	0.0528	1080	0.108	1	1	18.94	9.26
13783		RES		552	0.0552			0		0.00	
4409	4409	RES	RES	522	0.0522	522	0.0522	1	1	19.16	19.16
4410	4410	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
4411	4411	RES	RES	535	0.0535	535	0.0535	2	2	37.38	37.38
4412	4412	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
4413	4413	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
4414	4414	RES	RES	536	0.0536	536	0.0536	1	1	18.66	18.66
4417	4417	RES	RES	534	0.0534	534	0.0534	1	1	18.73	18.73
4418	4418	RES	RES	537	0.0537	537	0.0537	1	1	18.62	18.62
4419	4419	RES	RES	537	0.0537	537	0.0537	1	1	18.62	18.62
4420	4420	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
4421	4421	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
4422	4422	RES	RES	537	0.0537	537	0.0537	1	1	18.62	18.62
4423	4423	RES	RES	541	0.0541	541	0.0541	2	2	36.97	36.97
4424	4424	RES	RES	540	0.054	540	0.054	1	1	18.52	18.52
4425	4425	RES	RES	539	0.0539	539	0.0539	1	1	18.55	18.55
8337	8337	RES	RES	267	0.0267	267	0.0267	1	1	37.45	37.45
8338	8338	RES	RES	267	0.0267	267	0.0267	1	1	37.45	37.45
8339	8339	RES	RES	266	0.0266	266	0.0266	1	1	37.59	37.59
8340	8340	RES	RES	269	0.0269	269	0.0269	1	2	37.17	74.35
8341	8341	RES	RES	263	0.0263	263	0.0263	1	2	38.02	76.05
8342	8342	RES	RES	270	0.027	270	0.027	1	1	37.04	37.04
8343	8343	RES	RES	535	0.0535	535	0.0535	1	2	18.69	37.38
8344	8344	RES	RES	534	0.0534	534	0.0534	1	1	18.73	18.73
8345	8345	RES	RES	534	0.0534	534	0.0534	1	1	18.73	18.73
8346	8346	RES	RES	534	0.0534	534	0.0534	1	2	18.73	37.45
8347	8347	RES	RES	470	0.047	470	0.047	1	2	21.28	42.55
8348	8348	RES	RES	483	0.0483	483	0.0483	1	1	20.70	20.70
8349	8349	RES	RES	555	0.0555	555	0.0555	1	1	18.02	18.02
8350	15704	RES	RES	578	0.0578	3638	0.3638	1	102	17.30	280.37

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
8351		RES		532	0.0532			1		18.80	
8352		RES		597	0.0597			1		16.75	
8353		RES		534	0.0534			1		18.73	
8354		RES		444	0.0444			1		22.52	
8355		RES		445	0.0445			1		22.47	
8356		RES		508	0.0508			1		19.69	
8357	8357	RES	RES	494	0.0494	494	0.0494	1	2	20.24	40.49
8358	8358	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8359	8359	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8360	8360	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8361	8361	RES	RES	533	0.0533	533	0.0533	1	1	18.76	18.76
8362	8362	RES	RES	574	0.0574	574	0.0574	1	1	17.42	17.42
8363	8363	RES	RES	531	0.0531	531	0.0531	1	1	18.83	18.83
8364	8364	RES	RES	532	0.0532	532	0.0532	1	1	18.80	18.80
8365	8365	RES	RES	534	0.0534	534	0.0534	2	2	37.45	37.45
8366	8366	RES	RES	531	0.0531	531	0.0531	1	2	18.83	37.66
8367	8367	RES	RES	533	0.0533	533	0.0533	1	1	18.76	18.76
8368	8368	RES	RES	533	0.0533	533	0.0533	1	1	18.76	18.76
8369	8369	RES	RES	754	0.0754	754	0.0754	1	1	13.26	13.26
8370	8370	RES	RES	671	0.0671	671	0.0671	1	3	14.90	44.71
8371	8371	RES	RES	522	0.0522	522	0.0522	1	1	19.16	19.16
8372	8372	RES	RES	1076	0.1076	1076	0.1076	1	1	9.29	9.29
8373	8373	RES	RES	597	0.0597	597	0.0597	1	2	16.75	33.50
8374	8374	RES	RES	531	0.0531	531	0.0531	1	1	18.83	18.83
8375	8375	RES	RES	532	0.0532	532	0.0532	1	1	18.80	18.80
8376	8376	RES	RES	531	0.0531	531	0.0531	1	2	18.83	37.66
8377	8377	RES	RES	532	0.0532	532	0.0532	1	1	18.80	18.80
8378	8378	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8379	8379	RES	RES	533	0.0533	533	0.0533	1	1	18.76	18.76
8380	8380	RES	RES	536	0.0536	536	0.0536	1	1	18.66	18.66
8381	8381	RES	RES	532	0.0532	532	0.0532	1	1	18.80	18.80
8382	8382	RES	RES	537	0.0537	537	0.0537	2	2	37.24	37.24
8383	8383	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8384	8384	RES	RES	535	0.0535	535	0.0535	1	1	18.69	18.69
8385	8385	RES	RES	536	0.0536	536	0.0536	1	1	18.66	18.66
13802	13802	RES	RES	3660	0.366	3660	0.366	73	73	199.45	199.45
RE/174	RE/174	RES	RES	12988	1.2988	12988	1.2988	128	128	98.55	98.55
2730	2730	RES	RES	46708	4.6708	46708	4.6708	149	149	31.90	31.90

DATA FOR ZONE 12, 13 & 31 (LA COLLINE & KROMRIVIER)											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
108	16429	RES	RES	603	0.0603	2379	0.2379	1	32	16.58	134.51
109				936	0.0936			1		10.68	
110				934	0.0934			1		10.71	
111	RE/14988	RES	RES	932	0.0932	2135	0.2135	1	48	10.73	224.82
112				929	0.0929			1		10.76	
113	16430	RES	RES	927	0.0927	2216	0.2216	1	32	10.79	144.40
114				924	0.0924			1		10.82	
115				922	0.0922			1		10.85	
98	98	RES	RES	742	0.0742	742	0.0742	1	18	13.48	242.59
14213	14213	RES	RES	2124	0.2124	2124	0.2124	173	173	814.50	814.50
14212	14212	RES	RES	2756	0.2756	2756	0.2756	116	116	420.90	420.90
13849	13849	RES	RES	2412	0.2412	2412	0.2412	115	115	476.78	476.78
8336	8336	BUS	BUS	512	0.0512	512	0.0512	0	0	0.00	0.00
4804	4804	BUS	BUS	4143	0.4143	4143	0.4143	0	0	0.00	0.00
81	81	BUS	BUS	648	0.0648	648	0.0648	0	0	0.00	0.00
83	83	BUS	BUS	2358	0.2358	2358	0.2358	0	0	0.00	0.00
6372	6372	BUS	BUS	615	0.0615	615	0.0615	0	0	0.00	0.00
5973	5973	BUS	BUS	840	0.084	840	0.084	0	0	0.00	0.00
6148	6148	BUS	BUS	1851	0.1851	1851	0.1851	0	0	0.00	0.00
7649	7649	BUS	BUS	2069	0.2069	2069	0.2069	0	0	0.00	0.00
2635	2635	SCHL	SCHL	5372	0.5372	5372	0.5372	0	0	0.00	0.00
2634	2634	SCHL	SCHL	1933	0.1933	1933	0.1933	0	0	0.00	0.00
3390	3390	SCHL	SCHL	860	0.086	860	0.086	0	0	0.00	0.00
2631	2631	SCHL	SCHL	5025	0.5025	5025	0.5025	0	0	0.00	0.00
2626	2626	SCHL	SCHL	17010	1.701	17010	1.701	0	0	0.00	0.00
2625	2625	SCHL	SCHL	3006	0.3006	3006	0.3006	0	0	0.00	0.00
15540	15540	NON-RES	NON-RES	392	0.0392	392	0.0392	0	0	0.00	0.00
2729	2729	O S	O S	5059	0.506	5059	0.506	0	0	0.00	0.00
2727	2727	O S	O S	3123	0.3123	3123	0.3123	0	0	0.00	0.00

Source: Stellenbosch Municipality (2015/16)

Table D.2 Raw data for Zone 3

DATA FOR ZONE 3											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
11191	11191	RES	RES	786	0.0786	786	0.0786	1	1	12.72	12.72
2151	2151	RES	RES	985	0.0985	985	0.0985	1	1	10.15	10.15
2152	2152	RES	RES	1220	0.122	1220	0.122	1	1	8.20	8.20
2153	2153	RES	RES	1068	0.1068	1068	0.1068	1	1	9.36	9.36
2154	2154	RES	RES	1028	0.1028	1028	0.1028	1	1	9.73	9.73
2155	2155	RES	RES	996	0.0996	996	0.0996	1	1	10.04	10.04
2156	2156	RES	RES	1119	0.1119	1119	0.1119	1	1	8.94	8.94
2158	2158	RES	RES	1091	0.1091	1091	0.1091	1	2	9.17	18.33
2159	2159	RES	RES	1007	0.1007	1007	0.1007	1	1	9.93	9.93
2160	2160	RES	RES	974	0.0974	974	0.0974	1	2	10.27	20.53
2161	2161	RES	RES	984	0.0984	984	0.0984	1	1	10.16	10.16
2162	2162	RES	RES	984	0.0984	984	0.0984	1	1	10.16	10.16
2163	2163	RES	RES	974	0.0974	974	0.0974	2	2	20.53	20.53
2164	2164	RES	RES	1042	0.1042	1042	0.1042	1	1	9.60	9.60
2165	2165	RES	RES	1091	0.1091	1091	0.1091	1	1	9.17	9.17
2166	2166	RES	RES	1065	0.1065	1065	0.1065	1	2	9.39	18.78
2167	2167	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2168	2168	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2169	2169	RES	RES	992	0.0992	992	0.0992	1	2	10.08	20.16
2170	RE/2170	RES	RES	1327	0.1327	748	0.0748	1	1	7.54	13.37
	15720		RES			579	0.0579		1		17.27
2171	2171	RES	RES	1026	0.1026	1026	0.1026	1	1	9.75	9.75
2172	2172	RES	RES	1006	0.1006	1006	0.1006	1	1	9.94	9.94
2173	2173	RES	RES	1006	0.1006	1006	0.1006	2	2	19.88	19.88
2174	2174	RES	RES	1263	0.1263	1263	0.1263	1	2	7.92	15.84
2175	2175	RES	RES	992	0.0992	992	0.0992	2	2	20.16	20.16
2176	2176	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2177	2177	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2178	2178	RES	RES	1064	0.1064	1064	0.1064	1	1	9.40	9.40
2179	2179	RES	RES	1006	0.1006	1006	0.1006	1	2	9.94	19.88
2180	2180	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2181	2181	RES	RES	992	0.0992	992	0.0992	2	2	20.16	20.16
2182	2182	RES	RES	992	0.0992	992	0.0992	2	2	20.16	20.16
2183	2183	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2184	2184	RES	RES	1006	0.1006	1006	0.1006	1	2	9.94	19.88
2185	2185	RES	RES	1006	0.1006	1006	0.1006	1	1	9.94	9.94
2186	2186	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08

DATA FOR ZONE 3											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
2187	2187	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2188	2188	RES	RES	992	0.0992	992	0.0992	2	2	20.16	20.16
2189	2189	RES	RES	992	0.0992	992	0.0992	1	1	10.08	10.08
2190	2190	RES	RES	1006	0.1006	1006	0.1006	1	2	9.94	19.88
2191	2191	RES	RES	1059	0.1059	1059	0.1059	1	1	9.44	9.44
2192	2192	RES	RES	942	0.0942	942	0.0942	2	2	21.23	21.23
2193	2193	RES	RES	942	0.0942	942	0.0942	1	1	10.62	10.62
2194	2194	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
2195	2195	RES	RES	1008	0.1008	1008	0.1008	1	1	9.92	9.92
2196	2196	RES	RES	1017	0.1017	1017	0.1017	1	1	9.83	9.83
2197	2197	RES	RES	1027	0.1027	1027	0.1027	1	1	9.74	9.74
2198	2198	RES	RES	1095	0.1095	1095	0.1095	1	1	9.13	9.13
2199	2199	RES	RES	1095	0.1095	1095	0.1095	1	1	9.13	9.13
2200	2200	RES	RES	1027	0.1027	1027	0.1027	1	1	9.74	9.74
2201	2201	RES	RES	1017	0.1017	1017	0.1017	1	1	9.83	9.83
2202	2202	RES	RES	1008	0.1008	1008	0.1008	1	1	9.92	9.92
2203	2203	RES	RES	1184	0.1184	1184	0.1184	1	1	8.45	8.45
2204	2204	RES	RES	942	0.0942	942	0.0942	1	2	10.62	21.23
2205	2205	RES	RES	1059	0.1059	1059	0.1059	1	1	9.44	9.44
2206	2206	RES	RES	1325	0.1325	1325	0.1325	2	2	15.09	15.09
2207	2207	RES	RES	1099	0.1099	1099	0.1099	1	1	9.10	9.10
2208	2208	RES	RES	1069	0.1069	1069	0.1069	1	1	9.35	9.35
2209	2209	RES	RES	1039	0.1039	1039	0.1039	1	1	9.62	9.62
2210	2210	RES	RES	1009	0.1009	1009	0.1009	1	1	9.91	9.91
2211	2211	RES	RES	1216	0.1216	1216	0.1216	1	1	8.22	8.22
2212	2212	RES	RES	1203	0.1203	1203	0.1203	1	1	8.31	8.31
2213	2213	RES	RES	991	0.0991	991	0.0991	1	1	10.09	10.09
2214	2214	RES	RES	991	0.0991	991	0.0991	1	1	10.09	10.09
2215	2215	RES	RES	991	0.0991	991	0.0991	1	1	10.09	10.09
2216	2216	RES	RES	991	0.0991	991	0.0991	1	1	10.09	10.09
2217	2217	RES	RES	1157	0.1157	1157	0.1157	1	1	8.64	8.64
2218	2218	RES	RES	1412	0.1412	1412	0.1412	1	2	7.08	14.16
2219	2219	RES	RES	1681	0.1681	1681	0.1681	2	2	11.90	11.90
2220	2220	RES	RES	1650	0.165	1650	0.165	1	2	6.06	12.12
2221	2221	RES	RES	1679	0.1679	1679	0.1679	2	2	11.91	11.91
2222	2222	RES	RES	1580	0.158	1580	0.158	1	1	6.33	6.33
2223	2223	RES	RES	1514	0.1514	1514	0.1514	1	1	6.61	6.61
2224	2224	RES	RES	1563	0.1563	1563	0.1563	2	2	12.80	12.80

DATA FOR ZONE 3

ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
2225	2225	RES	RES	1462	0.1462	1462	0.1462	1	1	6.84	6.84
2226	2226	RES	RES	1486	0.1486	1486	0.1486	1	1	6.73	6.73
2227	2227	RES	RES	1566	0.1566	1566	0.1566	1	1	6.39	6.39
2228	2228	RES	RES	1634	0.1634	1634	0.1634	1	1	6.12	6.12
2229	2229	RES	RES	1459	0.1459	1459	0.1459	1	2	6.85	13.71
2230	2230	RES	RES	1436	0.1436	1436	0.1436	1	1	6.96	6.96
2231	2231	RES	RES	1320	0.132	1320	0.132	1	1	7.58	7.58
2232	2232	RES	RES	1212	0.1212	1212	0.1212	1	1	8.25	8.25
2233	2233	RES	RES	1429	0.1429	1429	0.1429	1	1	7.00	7.00
2234	2234	RES	RES	1289	0.1289	1289	0.1289	2	2	15.52	15.52
2235	2235	RES	RES	1198	0.1198	1198	0.1198	1	2	8.35	16.69
2288	2288	RES	RES	1041	0.1041	1041	0.104	1	12	9.61	115.27
2289	16361	RES	RES	1041	0.1041	3064	0.3064	1	33	9.61	107.70
2290		RES		2023	0.2023			1		4.94	
2291	15842	RES	RES	756	0.0756	3049	0.3049	1	43	13.23	141.03
2292		RES		1538	0.1538			1		6.50	
2293	15775-15787	RES	RES	755	0.0755	5443	0.5443	1	14	13.25	25.72
2294		RES		2023	0.2023			1		4.94	
2295		RES		2082	0.2082			1		4.80	
2157		RES		1338	0.1338			1		7.47	
4165	4165	RES	RES	1057	0.1057	1057	0.1057	1	1	9.46	9.46
4166	4166	RES	RES	1251	0.1251	1251	0.1251	1	1	7.99	7.99
4167	4167	RES	RES	1017	0.1017	1017	0.1017	1	1	9.83	9.83
4168	4168	RES	RES	792	0.0792	792	0.0792	1	1	12.63	12.63
4169	4169	RES	RES	948	0.0948	948	0.0948	1	1	10.55	10.55
4170	4170	RES	RES	851	0.0851	851	0.0851	1	1	11.75	11.75
4171	4171	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
4172	4172	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
4173	4173	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
4174	4174	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
4175	4175	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
4176	4176	RES	RES	1094	0.1094	1094	0.1094	1	1	9.14	9.14
4177	4177	RES	RES	1127	0.1127	1127	0.1127	1	1	8.87	8.87
4178	4178	RES	RES	1139	0.1139	1139	0.1139	1	1	8.78	8.78
4179	4179	RES	RES	1131	0.1131	1131	0.1131	1	1	8.84	8.84
14317	14317	RES	RES	192	0.0192	192	0.0192	1	1	52.08	52.08
14318	14318	RES	RES	111	0.0111	111	0.0111	1	1	90.09	90.09
14319	14319	RES	RES	109	0.0109	109	0.0109	1	1	91.74	91.74

DATA FOR ZONE 3											
ERF NUM (SB)		**LAND USE**		**ERF SIZE**				**DU**		**(DU/Ha)**	
2000	**2016**	**2000**	**2016**	**2000**	**2000/ha**	**2016**	**2016/ha**	**2000**	**2016**	**2000**	**2016**
14320	14320	RES	RES	150	0.015	150	0.015	1	1	66.67	66.67
14321	14321	RES	RES	125	0.0125	125	0.0125	1	1	80.00	80.00
14322	14322	RES	RES	123	0.0123	123	0.0123	1	1	81.30	81.30
14323	14323	RES	RES	138	0.0138	138	0.0138	1	1	72.46	72.46
14324	14324	RES	RES	155	0.0155	155	0.0155	1	1	64.52	64.52
14325	14325	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14326	14326	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14327	14327	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14328	14328	RES	RES	108	0.0108	108	0.0108	1	1	92.59	92.59
14329	14329	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14330	14330	RES	RES	172	0.0172	172	0.0172	1	1	58.14	58.14
14331	14331	RES	RES	111	0.0111	111	0.0111	1	1	90.09	90.09
14332	14332	RES	RES	111	0.0111	111	0.0111	1	1	90.09	90.09
14333	14333	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14334	14334	RES	RES	171	0.0171	171	0.0171	1	1	58.48	58.48
14335	14335	RES	RES	96	0.0096	96	0.0096	1	1	104.17	104.17
14336	14336	RES	RES	96	0.0096	96	0.0096	1	1	104.17	104.17
14337	14337	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14338	14338	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14339	14339	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14340	14340	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14341	14341	RES	RES	110	0.011	110	0.011	1	1	90.91	90.91
14342	14342	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14343	14343	RES	RES	162	0.0162	162	0.0162	1	1	61.73	61.73
14344	14344	RES	RES	110	0.011	110	0.011	1	1	90.91	90.91
14345	14345	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14346	14346	RES	RES	110	0.011	110	0.011	1	1	90.91	90.91
14347	14347	RES	RES	110	0.011	110	0.011	1	1	90.91	90.91
14348	14348	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14349	14349	RES	RES	162	0.0162	162	0.0162	1	1	61.73	61.73
14350	14350	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14351	14351	RES	RES	120	0.012	120	0.012	1	1	83.33	83.33
14354	14354	RES	RES	174	0.0174	174	0.0174	1	1	57.47	57.47
14355	14355	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14356	14356	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14357	14357	RES	RES	169	0.0169	169	0.0169	1	1	59.17	59.17
14358	14358	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14359	14359	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29

DATA FOR ZONE 3											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/Ha)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
14360	14360	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14361	14361	RES	RES	113	0.0113	113	0.0113	1	1	88.50	88.50
14362	14362	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14363	14363	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14364	14364	RES	RES	113	0.0113	113	0.0113	1	1	88.50	88.50
14365	14365	RES	RES	113	0.0113	113	0.0113	1	1	88.50	88.50
14366	14366	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14367	14367	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14368	14368	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14369	14369	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14370	14370	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14371	14371	RES	RES	118	0.0118	118	0.0118	1	1	84.75	84.75
14372	14372	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14373	14373	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14374	14374	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14375	14375	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14376	14376	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14377	14377	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14378	14378	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14379	14379	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14380	14380	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14381	14381	RES	RES	114	0.0114	114	0.0114	1	1	87.72	87.72
14382	14382	RES	RES	113	0.0113	113	0.0113	1	1	88.50	88.50
14383	14383	RES	RES	111	0.0111	111	0.0111	1	1	90.09	90.09
14384	14384	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14385	14385	RES	RES	112	0.0112	112	0.0112	1	1	89.29	89.29
14386	14386	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14387	14387	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14388	14388	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
14389	14389	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14390	14390	RES	RES	115	0.0115	115	0.0115	1	1	86.96	86.96
14391	14391	RES	RES	116	0.0116	116	0.0116	1	1	86.21	86.21
2236	2236	O S	O S	6095	0.6095	6095	0.6095	0	0	0.00	0.00
4180	4180	O S	O S	3782	0.3782	3782	0.3782	0	0	0.00	0.00
14352	14352	O S	O S	266	0.0266	266	0.0266	0	0	0.00	0.00
5386	5386	BUS	BUS	12416	1.2416	12416	1.2416	0	0	0.00	0.00
5412	5412	BUS	BUS	1949	0.1949	1949	0.1949	0	0	0.00	0.00
14315	14315	BUS	BUS	182	0.0182	182	0.0182	0	0	0.00	0.00

Source: Stellenbosch Municipality (2015/16)

Table D.3 Raw data for Zone 29 and 30

DATA FOR ZONE 29 & 30											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
127	127	RES	RES	1505	0.1505	1505	0.1505	12	12	79.73	79.73
14048	14048	RES	RES	3701	0.3701	3701	0.3701	44	44	118.89	118.89
132	132	RES	RES	917	0.0917	917	0.0917	1	1	10.91	10.91
133	133	RES	RES	928	0.0928	928	0.0928	1	1	10.78	10.78
134	134	RES	RES	927	0.0927	927	0.0927	1	1	10.79	10.79
135	135	RES	RES	933	0.0933	933	0.0933	1	1	10.72	10.72
136	15894	RES	RES	928	0.0928	2316	0.2316	1	24	10.78	103.63
137				1388	0.1388			0		0.00	
139	139	RES	RES	787	0.0787	787	0.0787	1	1	12.71	12.71
140	140	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
141	141	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
142	142	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
143	143	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
144	144	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
145	145	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
146	146	RES	RES	932	0.0932	932	0.0932	1	1	10.73	10.73
155	155	RES	RES	932	0.0932	932	0.0932	1	1	10.73	10.73
156	156	RES	RES	937	0.0937	937	0.0937	2	2	21.34	21.34
157	157	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
158	158	RES	RES	937	0.0937	937	0.0937	1	1	10.67	10.67
159	159	RES	RES	474	0.0474	474	0.0474	1	1	21.10	21.10
162	162	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
163	163	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
164	164	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
165	165	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
166	166	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
167	167	RES	RES	1115	0.1115	1115	0.1115	2	2	17.94	17.94
168	168	RES	RES	1115	0.1115	1115	0.1115	2	2	17.94	17.94
169	169	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
170	170	RES	RES	1110	0.111	1110	0.111	1	1	9.01	9.01
184	184	RES	RES	1332	0.1332	1332	0.1332	1	1	7.51	7.51
4683	4683	RES	RES	898	0.0898	898	0.0898	2	2	22.27	22.27
9541	9541	RES	RES	463	0.0463	463	0.0463	1	1	21.60	21.60
185	185	RES	RES	1116	0.1116	1116	0.1116	1	1	8.96	8.96
196	15862	RES	RES	922	0.0922	2037	0.2037	1	30	10.85	147.28
200				1115	0.1115			2		2.11	
197	197	RES	RES	921	0.0921	921	0.0921	1	19	1.09	206.30
9535	9535	RES	RES	3239	0.3239	3239	0.3239	39	39	39.32	120.41
10841	10841	RES	RES	5281	0.5281	5281	0.5281	0	0	0.00	0.00

DATA FOR ZONE 29 & 30											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/ha	2016	2016/ha	2000	2016	2000	2016
3746	15886	RES	RES	1075	0.1075	4078	0.4078	1	62	9.30	152.04
3741		RES		1145	0.1145			1		8.73	
3740		RES		929	0.0929			1		10.76	
3739		RES		929	0.0929			1		10.76	
3738	3738	RES	RES	929	0.0929	929	0.0929	1	1	10.76	10.76
3737	16406	RES	RES	1031	0.1031	2090	0.209	0	42	0.00	200.96
207				1059	0.1059			1		9.44	
190	14626	RES	RES	1115	0.1115	5415	0.5415	1	124	8.97	228.99
192		RES	RES	1110	0.111			1		9.01	
203		RES	RES	66	0.0066			0		0.00	
205		RES	RES	414	0.0414			0		0.00	
4289		RES	RES	2710	0.271			2		7.38	
13203	13203	RES	RES	2230	0.223	2230	0.223	36	36	161.43	161.43
5957	5957	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
7646	7646	RES	RES	3789	0.3789	3789	0.3789	85	85	224.33	224.33
213	213	MXD	MXD	2003	0.2003	2003	0.2003	18	18	89.87	89.87
11279	11279	MXD	MXD	1639	0.1639	1639	0.1639	4	4	24.41	24.41
7551	7551	MXD	MXD	2298	0.2298	2298	0.2298	54	54	234.99	234.99
13222	13222	GAR	GAR	1514	0.1514	1514	0.1514	0	0	0.00	0.00
8718	8718	LAW	LAW	2701	0.2701	2701	0.2701	0	0	0.00	0.00
235	235	PARK	PARK	5816	0.5816	5816	0.5816	0	0	0.00	0.00
RE/194	RE/194	O S	O S	19368	1.9368	19368	1.9368	0	0	0.00	0.00
5996	5996	SCHL	SCHL	6258	0.6258	6258	0.6258	0	0	0.00	0.00
12186	12186	BUS	BUS	1488	0.1488	1488	0.1488	0	0	0.00	0.00
7575	7575	RELG	RELG	3358	0.3358	3358	0.3358	0	0	0.00	0.00
161	161	BUS	BUS	1590	0.159	1590	0.159	0	0	0.00	0.00
121	121	MUNI	MUNI	8662	0.8662	8662	0.8662	0	0	0.00	0.00
123	123	MUNI	MUNI	22253	2.2253	22253	2.2253	0	0	0.00	0.00
122	122	RES	RES	3370	0.337	3370	0.337	45	45	133.53	133.53
124	124	RES	RES	6219	0.6219	6219	0.6219	22	22	35.38	35.38
8976	8976	RES	RES	7056	0.7056	7056	0.7056	95	95	134.64	134.64
6183	6183	BUS	BUS	4251	0.4251	4251	0.4251	0	0	0.00	0.00
14427	14427	BUS	BUS	2860	0.286	2860	0.286	0	0	0.00	0.00
4431	4431	BUS	BUS	6985	0.6985	6985	0.6985	0	0	0.00	0.00
4845	4845	BUS	BUS	6758	0.6758	6758	0.6758	0	0	0.00	0.00

Source: Stellenbosch Municipality (2015/16)

Table D.4 Raw data for Zone 10

DATA FOR ZONE 10											
ERF NUM (SB)		**LAND USE**		**ERF SIZE**				**DU**		**(DU/HA)**	
2000	**2016**	**2000**	**2016**	**2000**	**2000/HA**	**2016**	**2016/HA**	**2000**	**2016**	**2000**	**2016**
2241	2241	RES	RES	1245	0.1245	1245	0.1245	1	2	8.03	16.06
2242	2242	RES	RES	1245	0.1245	1245	0.1245	2	2	16.06	16.06
2243	2243	RES	RES	1245	0.1245	1245	0.1245	1	1	8.03	8.03
2244	2244	RES	RES	1226	0.1226	1226	0.1226	2	2	16.31	16.31
2247	2247	RES	RES	1540	0.154	1540	0.154	1	36	6.49	233.77
2248	15819	RES	RES	1263	0.1263	2204	0.2204	2	51	15.84	231.40
2249		RES	RES	941	0.0941			1		10.63	
2250	15820	RES	RES	1018	0.1018	2092	0.2092	1	49	9.82	234.23
2251		RES	RES	1074	0.1074			1		9.31	
2252	2252	RES	RES	1042	0.1042	1042	0.1042	1	1	9.60	9.60
2253	15821	RES	RES	1041	0.1041	2082	0.2082	0	51	0.00	244.96
2254		RES	RES	1041	0.1041			0		0.00	
2255	15844	RES	RES	1041	0.1041	2082	0.2082	1	34	9.61	163.30
2256		RES	RES	1041	0.1041			1		9.61	
2257	16355	RES	RES	1041	0.1041	2602	0.2602	1	63	9.61	242.12
2258		RES	RES	1561	0.1561			1		6.41	
2259	2259	RES	RES	1833	0.1833	1833	0.1833	1	34	5.46	185.49
2260	2260	RES	RES	1041	0.1041	1041	0.1041	1	2	9.61	19.21
2261	15830	RES	RES	1095	0.1095	2210	0.221	1	33	9.13	149.32
2262		RES	RES	1115	0.1115			1		8.97	
2263	15831	RES	RES	1115	0.1115	2230	0.223	1	34	8.97	152.47
2264		RES	RES	1115	0.1115			1		8.97	
2265	2265	RES	RES	954	0.0954	954	0.0954	1	18	10.48	188.68
2266	2266	RES	RES	981	0.0981	981	0.0981	1	16	10.19	163.10
2267	2267	RES	RES	981	0.0981	981	0.0981	1	1	10.19	10.19
2269	2269	RES	RES	1206	0.1206	1206	0.1206	1	1	8.29	8.29
12209	16377	RES	RES	1277	0.1277	2318	0.2318	2	43	15.66	185.50
2271		RES	RES	1041	0.1041			2		19.21	
2272	16372	RES	RES	1041	0.1041	2082	0.2082	1	36	9.61	172.91
2273		RES	RES	1041	0.1041			1		9.61	
2274	2274	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2277	2277	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2278	2278	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2279	2279	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2280	2280	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2281	2281	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2282	2282	RES	RES	1041	0.1041	1041	0.1041	1	16	9.61	153.70

DATA FOR ZONE 10											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
2283	15730	RES	RES	1041	0.1041	1933	0.1933	1	41	9.61	212.11
2284		RES	RES	892	0.0892			1		11.21	
2286	2286	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2296	2296	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2297	2297	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2298	2298	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2299	2299	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2300	2300	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2301	16238	RES	RES	1041	0.1041	2290	0.229	2	46	19.21	200.87
2302		RES	RES	1249	0.1249			1		8.01	
2303	2303	RES	RES	1183	0.1183	1183	0.1183	1	15	8.45	126.80
2304	15728	RES	RES	1026	0.1026	1383	0.1383	1	8	9.75	57.85
2305		RES	RES	357	0.0357			1		28.01	
2306	2306	RES	RES	1725	0.1725	1725	0.1725	1	2	5.80	11.59
2307	2307	RES	RES	1041	0.1041	1041	0.1041	1	1	9.61	9.61
2308	2308	RES	RES	1041	0.1041	1041	0.1041	2	2	19.21	19.21
2311	15887	RES	RES	1561	0.1561	3246	0.3246	1	66	6.41	203.33
2312		RES	RES	1685	0.1685			2		11.87	
2313	3470	RES	RES	2010	0.201	3441	0.3441	2	52	9.95	151.12
3470		RES	RES	122	0.012			0		0.00	
2315		RES	RES	1309	0.1309			2		15.28	
2316	2316	RES	RES	1190	0.119	1190	0.119	2	14	16.81	117.65
2317	2317	RES	RES	1157	0.1157	1157	0.1157	1	19	8.64	164.22
2318	16169	RES	RES	1259	0.1259	2579	0.2579	2	20	15.89	77.55
2319		RES	RES	1320	0.132			0		0.00	
2320	2320	RES	RES	1115	0.1115	1115	0.1115	1	13	8.97	116.59
2321	2321	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
2322	2322	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
2323	2323	RES	RES	1115	0.1115	1115	0.1115	1	2	8.97	17.94
2324	15771	RES	RES	1660	0.166	2637	0.2637	1	42	6.02	159.27
2325		RES	RES	977	0.0977			1		10.24	
2355	16373	RES	RES	950	0.095	2640	0.264	1	42	10.53	234.23
2357		RES	RES	809	0.0809			1		12.36	
2359		RES	RES	881	0.0881			1		11.35	
2356	2356	RES	RES	1044	0.1044	1044	0.1044	2	2	19.16	19.16
2358	2358	RES	RES	825	0.0825	825	0.0825	1	1	12.12	12.12
2360	2360	RES	RES	897	0.0897	897	0.0897	1	1	11.15	11.15
2361	2361	RES	RES	954	0.0954	954	0.0954	1	1	10.48	10.48

DATA FOR ZONE 10											
ERF NUM (SB)		**LAND USE**		**ERF SIZE**				**DU**		**(DU/HA)**	
2000	**2016**	**2000**	**2016**	**2000**	**2000/HA**	**2016**	**2016/HA**	**2000**	**2016**	**2000**	**2016**
2362	2362	RES	RES	970	0.097	970	0.097	1	1	10.31	10.31
2363	2363	RES	RES	1006	0.1006	1006	0.1006	1	1	9.94	9.94
2364	2364	RES	RES	1043	0.1043	1043	0.1043	1	1	9.59	9.59
2365	2365	RES	RES	1115	0.1115	1115	0.1115	1	1	8.97	8.97
2366	2366	RES	RES	1115	0.1115	1115	0.1115	2	2	17.94	17.94
2367	2367	RES	RES	1155	0.116	1155	0.1155	0	1	0.00	8.66
2368	2368	RES	RES	1324	0.1324	1324	0.1324	1	20	7.55	151.06
2369		RES	RES	932	0.0932			1		10.73	
2370	15826	RES	RES	952	0.0952	2836	0.2836	1	42	10.50	148.10
2371		RES	RES	952	0.0952			1		10.50	
2373	2373	RES	RES	1050	0.105	1050	0.105	1	15	9.52	142.86
2374	2374	RES	RES	1070	0.107	1070	0.107	1	1	9.35	9.35
2375	2375	RES	RES	1070	0.107	1070	0.107	1	1	9.35	9.35
2376	2376	RES	RES	1051	0.1051	1051	0.1051	1	16	9.51	152.24
2380	2380	RES	RES	1015	0.1015	1015	0.1015	1	1	9.85	9.85
2381	2381	RES	RES	1023	0.1023	1023	0.1023	1	2	9.78	19.55
2382	2382	RES	RES	914	0.0914	914	0.0914	1	1	10.94	10.94
2383	2383	RES	RES	1021	0.1021	1021	0.1021	1	1	9.79	9.79
3365	3365	RES	RES	1914	0.1914	1914	0.1914	1	1	5.22	5.22
2385		RES	RES	926	0.0926			1		10.80	
2392	16375	RES	RES	915	0.0915	3093	0.3093	1	43	10.93	139.02
2391		RES	RES	1252	0.1252			1		7.99	
2387	2387	RES	RES	975	0.0975	975	0.0975	1	1	10.26	10.26
2388	2388	RES	RES	1021	0.1021	1021	0.1021	1	15	9.79	146.91
2389	2389	RES	RES	1067	0.1067	1067	0.1067	1	16	9.37	149.95
2390	2390	RES	RES	1233	0.1233	1233	0.1233	1	26	8.11	210.87
2393	2393	RES	RES	982	0.0982	982	0.0982	1	1	10.18	10.18
2394	2394	RES	RES	1009	0.1009	1009	0.1009	1	15	9.91	148.66
2399	2399	RES	RES	371	0.0371	371	0.0371	1	1	26.95	26.95
2400	2400	RES	RES	460	0.046	460	0.046	1	1	21.74	21.74
2401	2401	RES	RES	520	0.052	520	0.052	1	1	19.23	19.23
2402	2402	RES	RES	618	0.0618	618	0.0618	1	1	16.18	16.18
2403	2403	RES	RES	730	0.073	730	0.073	2	2	27.40	27.40
2407	2407	RES	RES	1307	0.1307	1307	0.1307	1	1	7.65	7.65
2408	2408	RES	RES	1131	0.1131	1131	0.1131	1	1	8.84	8.84
2409	2409	RES	RES	1303	0.1303	1303	0.1303	1	1	7.67	7.67
2420	2420	RES	RES	221	0.0221	221	0.0221	1	1	45.25	45.25
3480	3480	RES	RES	1158	0.1158	1158	0.1158	1	1	8.64	8.64

DATA FOR ZONE 10											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
3479	3479	RES	RES	1127	0.1127	1127	0.1127	2	2	17.75	17.75
4077	4077	RES	RES	922	0.0922	922	0.0922	1	1	10.85	10.85
6257	6257	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
6258	6258	RES	RES	288	0.0288	288	0.0288	1	1	34.72	34.72
13004	13004	RES	RES	3284	0.3284	3284	0.3284	53	53	161.39	161.39
7335	7335	RES	RES	2661	0.2661	2661	0.2661	2	46	7.52	172.87
3491	3491	RES	RES	1287	0.1287	1287	0.1287	1	1	7.77	7.77
3492	3492	RES	RES	1164	0.1164	1164	0.1164	1	14	8.59	120.27
3493	16437	RES	RES	1333	0.1333	2644	0.2644	1	77	7.50	291.23
3494		RES	RES	1311	0.1311			1		7.63	
13580	13580	RES	RES	832	0.0832	832	0.0832	6	6	72.12	72.12
7337	7337	RES	RES	1966	0.1966	1966	0.1966	1	4	5.09	20.35
2416	2416	RES	BUS	762	0.0762	762	0.0762	1	0	13.12	0.00
2417	2417	RES	BUS	733	0.0733	733	0.0733	1	0	13.64	0.00
2418	2418	RES	BUS	1111	0.1111	1111	0.1111	1	0	9.00	0.00
2419	2419	RES	BUS	1115	0.112	1115	0.1115	1	0	8.97	0.00
2421	2421	INST	INST	485	0.0485	485	0.0485	0	0	0	0.00
2372	2372	BUS	BUS	1014	0.1014	1014	0.1014	0	0	0	0.00
2395	2395	O S	O S	4612	0.4612	4612	0.4612	0	0	0	0.00
6095	6095	COMM	COMM	25133	2.5133	25133	2.5133	0	0	0	0.00
2412	2412	USBD	USBD	364	0.0364	364	0.0364	0	0	0	0.00
2413	2413	USBD	USBD	500	0.05	500	0.05	0	0	0	0.00
2414	2414	USBD	USBD	449	0.0449	449	0.0449	0	0	0	0.00
UNKN	UNKN	BANGHOEK ROAD PARK		5742	0.5742	5742	0.5742	0	0	0	0.00

Source: Stellenbosch Municipality (2015/16)

Table D.5 Raw data for Zone 14

DATA FOR ZONE 14											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
8702	8702	RES	RES	2428	0.2428	2428	0.2428	28	28	115.32	115.32
8692	8692	RES	RES	1470	0.147	1470	0.147	12	12	81.63	81.63
8678	8678	RES	RES	298	0.0298	298	0.0298	1	1	33.56	33.56
8679	8679	RES	RES	296	0.0296	296	0.0296	1	1	33.78	33.78
8681	8681	RES	RES	302	0.0302	302	0.0302	1	1	33.11	33.11

DATA FOR ZONE 14											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
8682	8682	RES	RES	307	0.0307	307	0.0307	1	1	32.57	32.57
8684	8684	RES	RES	296	0.0296	296	0.0296	1	1	33.78	33.78
8685	8685	RES	RES	297	0.0297	297	0.0297	1	1	33.67	33.67
8654	8654	RES	RES	276	0.0276	276	0.0276	1	1	36.23	36.23
9579	9579	RES	RES	196	0.0196	196	0.0196	1	1	51.02	51.02
9580	9580	RES	RES	208	0.0208	208	0.0208	1	1	48.08	48.08
9581	9581	RES	RES	266	0.0266	266	0.0266	1	1	37.59	37.59
9582	9582	RES	RES	216	0.0216	216	0.0216	1	1	46.30	46.30
9583	9583	RES	RES	261	0.0261	261	0.0261	1	1	38.31	38.31
9584	9584	RES	RES	194	0.0194	194	0.0194	1	1	51.55	51.55
9585	9585	RES	RES	204	0.0204	204	0.0204	1	1	49.02	49.02
9586	9586	RES	RES	209	0.0209	209	0.0209	1	1	47.85	47.85
9587	9587	RES	RES	222	0.0222	222	0.0222	1	1	45.05	45.05
9588	9588	RES	RES	212	0.0212	212	0.0212	1	1	47.17	47.17
9589	9589	RES	RES	242	0.0242	242	0.0242	1	1	41.32	41.32
9590	9590	RES	RES	201	0.0201	201	0.0201	1	1	49.75	49.75
9591	9591	RES	RES	198	0.0198	198	0.0198	1	1	50.51	50.51
9592	9592	RES	RES	263	0.0263	263	0.0263	1	1	38.02	38.02
9593	9593	RES	RES	219	0.0219	219	0.0219	1	1	45.66	45.66
9594	9594	RES	RES	248	0.0248	248	0.0248	1	1	40.32	40.32
9595	9595	RES	RES	264	0.0264	264	0.0264	1	1	37.88	37.88
9596	9596	RES	RES	250	0.025	250	0.025	1	1	40.00	40
9597	9597	RES	RES	281	0.0281	281	0.0281	1	1	35.59	35.59
9598	9598	RES	RES	226	0.0226	226	0.0226	1	1	44.25	44.25
9599	9599	RES	RES	276	0.0276	276	0.0276	1	1	36.23	36.23
9600	9600	RES	RES	274	0.0274	274	0.0274	1	1	36.50	36.50
9601	9601	RES	RES	280	0.028	280	0.028	1	1	35.71	35.71
9602	9602	RES	RES	253	0.0253	253	0.0253	1	1	39.53	39.53
9603	9603	RES	RES	189	0.0189	189	0.0189	1	1	52.91	52.91
9604	9604	RES	RES	185	0.0185	185	0.0185	1	1	54.05	54.05
9605	9605	RES	RES	248	0.0248	248	0.0248	1	1	40.32	40.32
9606	9606	RES	RES	252	0.0252	252	0.0252	1	1	39.68	39.68
9607	9607	RES	RES	187	0.0187	187	0.0187	1	1	53.48	53.48
9608	9608	RES	RES	186	0.0186	186	0.0186	1	1	53.76	53.76
9609	9609	RES	RES	251	0.0251	251	0.0251	1	1	39.84	39.84
9610	9610	RES	RES	251	0.0251	251	0.0251	1	1	39.84	39.84
9611	9611	RES	RES	186	0.0186	186	0.0186	1	1	53.76	53.76
9612	9612	RES	RES	184	0.0184	184	0.0184	1	1	54.35	54.35

DATA FOR ZONE 14											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
9613	9613	RES	RES	251	0.0251	251	0.0251	1	1	39.84	39.84
9614	9614	RES	RES	253	0.0253	253	0.0253	1	1	39.53	39.53
7359	7359	RES	RES	276	0.0276	276	0.0276	1	1	36.23	36.23
7360	7360	RES	RES	222	0.0222	222	0.0222	1	1	45.05	45.05
7361	7361	RES	RES	226	0.0226	226	0.0226	1	1	44.25	44.25
7362	7362	RES	RES	228	0.0228	228	0.0228	1	1	43.86	43.86
7366	7366	RES	RES	203	0.0203	203	0.0203	1	1	49.26	49.26
7367	7367	RES	RES	202	0.0202	202	0.0202	1	1	49.50	49.50
7368	7368	RES	RES	201	0.0201	201	0.0201	1	1	49.75	49.75
7369	7369	RES	RES	201	0.0201	201	0.0201	1	1	49.75	49.75
7557	7557	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
7558	7558	RES	RES	196	0.0196	196	0.0196	1	1	51.02	51.02
7559	7559	RES	RES	196	0.0196	196	0.0196	1	1	51.02	51.02
7560	7560	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
7561	7561	RES	RES	264	0.0264	264	0.0264	1	1	37.88	37.88
7562	7562	RES	RES	270	0.027	270	0.027	1	1	37.04	37.04
7563	7563	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
7564	7564	RES	RES	201	0.0201	201	0.0201	1	1	49.75	49.75
7565	7565	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
7567	7567	RES	RES	220	0.022	220	0.022	1	1	45.45	45.45
7568	7568	RES	RES	218	0.0218	218	0.0218	1	1	45.87	45.87
7569	7569	RES	RES	277	0.0277	277	0.0277	1	1	36.10	36.10
7570	7570	RES	RES	200	0.02	200	0.02	1	1	50.00	50.00
7571	7571	RES	RES	199	0.0199	199	0.0199	1	1	50.25	50.25
7572	7572	RES	RES	238	0.0238	238	0.0238	1	1	42.02	42.02
5138	5138	RES	RES	12088	1.2088	12088	1.2088	68	68	56.25	56.25
RE/13833	RE/13833	RES	RES	2086	0.2086	2086	0.2086	0	0	0.00	0.00
6115	6115	RES	RES	4048	0.4048	4048	0.4048	40	40	98.81	98.81
12369	12369	RES	RES	13122	1.3122	13122	1.3122	71	71	54.11	54.11
7597	7597	RES	RES	2310	0.231	2310	0.231	2	32	8.66	138.53
5978	5978	RES	RES	1006	0.1006	1006	0.1006	1	16	9.94	159.05
10736	10736	RES	RES	264	0.0264	264	0.0264	1	1	37.88	37.88
10737	10737	RES	RES	96	0.0096	96	0.0096	1	1	104.17	104.17
10739	10739	RES	RES	97	0.0097	97	0.0097	1	1	103.09	103.09
10740	10740	RES	RES	90	0.009	90	0.009	1	1	111.11	111.11
10741	10741	RES	RES	88	0.0088	88	0.0088	1	1	113.64	113.64
10742	10742	RES	RES	87	0.0087	87	0.0087	1	1	114.94	114.94
10743	10743	RES	RES	97	0.0097	97	0.0097	1	1	103.09	103.09

DATA FOR ZONE 14

ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
10744	10744	RES	RES	85	0.0085	85	0.0085	1	1	117.65	117.65
10745	10745	RES	RES	111	0.0111	111	0.0111	1	1	90.09	90.09
10746	10746	RES	RES	81	0.0081	81	0.0081	1	1	123.46	123.46
10747	10747	RES	RES	84	0.0084	84	0.0084	1	1	119.05	119.05
10748	10748	RES	RES	17	0.0017	17	0.0017	1	1	588.24	588.24
10749	10749	RES	RES	93	0.0093	93	0.0093	1	1	107.53	107.53
10750	10750	RES	RES	20	0.002	20	0.002	1	1	500.00	500.00
10751	10751	RES	RES	21	0.0021	21	0.0021	1	1	476.19	476.19
10752	10752	RES	RES	22	0.0022	22	0.0022	1	1	454.55	454.55
10753	10753	RES	RES	21	0.0021	21	0.0021	1	1	476.19	476.19
10754	10754	RES	RES	22	0.0022	22	0.0022	1	1	454.55	454.55
10755	10755	RES	RES	109	0.0109	109	0.0109	1	1	91.74	91.74
10756	10756	RES	RES	87	0.0087	87	0.0087	1	1	114.94	114.94
10757	10757	RES	RES	275	0.0275	275	0.0275	1	1	36.36	36.36
2594	14604	RES	RES	1080	0.108	2161	0.2161	1	27	9.26	#####
2595		RES		1081	0.1081			1			
9528	9528	RES	RES	2131	0.2131	2131	0.2131	14	14	65.70	65.70
11127	11127	RES	RES	3134	0.3134	3134	0.3134	66	66	210.59	210.59
2588	2588	RES	RES	1090	0.109	1090	0.109	13	13	119.27	119.27
2590	2590	RES	RES	1079	0.1079	1079	0.1079	1	14	9.27	129.75
2591	2591	RES	RES	1087	0.1087	1087	0.1087	12	12	110.40	110.40
11288	11288	RES	RES	2558	0.2558	2558	0.2558	36	36	140.73	140.73
RE/2149	RE/2149	MUNI	MUNI	37952	3.7952	37952	3.7952	216	216	56.91	56.91
13832	13832	OLD AGE	OLD AGE	8397	0.8397	8397	0.8397	46	46	54.78	54.78
15711	15711	RE	RE	11	0.0011	11	0.0011	0	0	0.00	0.00
8680	8680	O S	O S	611	0.0611	611	0.0611	0	0	0.00	0.00
8683	8683	O S	O S	507	0.0507	507	0.0507	0	0	0.00	0.00
6590	6590	BUS	BUS	9201	0.9201	9201	0.9201	0	0	0.00	0.00
6659	6659	MUNI	MUNI	16169	1.6169	16169	1.6169	0	0	0.00	0.00
13608	13608	INST	INST	14389	1.4389	14389	1.4389	0	0	0.00	0.00
2529	2529	PARK	PARK	1785	0.1785	1785	0.1785	0	0	0.00	0.00
2530	2530	PARK	PARK	893	0.0893	893	0.0893	0	0	0.00	0.00
2538	2538	CHURCH	CHURCH	2585	0.2585	2585	0.2585	0	0	0.00	0.00
2539	2539	PARK	PARK	634	0.0634	634	0.0634	0	0	0.00	0.00
2540	2540	PARK	PARK	889	0.0889	889	0.0889	0	0	0.00	0.00
2609	2609	JAIL	JAIL	10938	1.0938	10938	1.0938	0	0	0.00	0.00
RE/2607	RE/2607	CHURCH	CHURCH	3188	0.3188	3188	0.3188	0	0	0.00	0.00
11183	11183	BUS	BUS	1639	0.1639	1639	0.1639	0	0	0.00	0.00

DATA FOR ZONE 14											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
2523	2523	MOSQ	MOSQ	965	0.0965	965	0.0965	0	0	0.00	0.00
2524	2524	PARK	PARK	965	0.0965	965	0.0965	0	0	0.00	0.00
2525	2525	PARK	PARK	978	0.0978	978	0.0978	0	0	0.00	0.00
7374	7374	CHURCH	CHURCH	1110	0.111	1110	0.111	0	0	0.00	0.00
2528	2528	BUS	BUS	336	0.0336	336	0.0336	0	0	0.00	0.00
2516	2516	BUS	BUS	643	0.0643	643	0.0643	0	0	0.00	0.00
6621	6621	BUS	BUS	2501	0.2501	2501	0.2501	0	0	0.00	0.00
8977	8977	BUS	BUS	3075	0.3075	3075	0.3075	0	0	0.00	0.00

Source: Stellenbosch Municipality (2015/16)

Table D.6 Raw data for Zone 15

DATA FOR ZONE 15											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
2424	2424	RES	RES	629	0.0629	629	0.0629	1	1	15.90	15.90
2425	2425	RES	RES	1386	0.1386	1386	0.1386	1	1	7.22	7.22
2436	2436	RES	RES	561	0.0561	561	0.0561	1	3	17.83	53.48
2448	2448	RES	RES	499	0.0499	499	0.0499	1	1	20.04	20.04
2447	2447	RES	RES	994	0.0994	994	0.0994	2	2	20.12	20.12
2446	2446	RES	RES	494	0.0494	494	0.0494	1	3	20.24	60.73
2445	2445	RES	RES	1492	0.1492	1492	0.1492	1	1	6.70	6.70
RE/2456	RE/2456	RES	RES	499	0.0499	499	0.0499	1	1	20.04	20.04
2455	2455	RES	RES	495	0.0495	495	0.0495	0	0	0.00	0.00
2454	2454	RES	RES	499	0.0499	499	0.0499	1	1	20.04	20.04
2452	2452	RES	RES	494	0.0494	494	0.0494	1	1	20.24	20.24
2450	2450	RES	RES	494	0.0494	494	0.0494	1	1	20.24	20.24
2449	2449	RES	RES	552	0.0552	552	0.0552	1	1	18.12	18.12
13060	13060	RES	RES	2877	0.2877	2877	0.2877	39	39	135.56	135.56
9172	9172	BUS	MXD	1362	0.1362	1362	0.1362	0	27	0.00	198.24
9173	9173	RES	RES	3780	0.378	3780	0.378	51	51	134.92	134.92
4849	4849	RES	RES	4303	0.4303	4303	0.4303	46	46	106.90	106.90
9171	9171	RES	RES	4018	0.4018	4018	0.4018	58	58	144.35	144.35
13847	13847	INST	INST	15524	1.5524	15524	1.5524	0	0	0	0
2453	2453	INST	INST	495	0.0495	495	0.0495	0	0	0	0
2451	2451	PARK	PARK	503	0.0503	503	0.0503	0	0	0	0

DATA FOR ZONE 15											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
2458	2458	PARK	PARK	2976	0.2976	2976	0.2976	0	0	0	0
2457	2457	PARK	PARK	971	0.0971	971	0.0971	0	0	0	0
7319	7319	INST	INST	2112	0.2112	2112	0.2112	0	0	0	0

Source: Stellenbosch Municipality (2015/16)

Table D.7 Raw data for Zone 16

DATA FOR ZONE 16											
ERF NUM (SB)		LAND USE		ERF SIZE				DU		(DU/HA)	
2000	2016	2000	2016	2000	2000/HA	2016	2016/HA	2000	2016	2000	2016
7275	7275	RES	RES	2250	0.225	2250	0.225	12	12	53.33	53.33
7276	7276	RES	RES	2023	0.2023	2023	0.2023	11	11	54.37	54.37
7332	7332	RES	RES	4147	0.4147	4147	0.4147	20	20	48.23	48.23
7613	7613	RES	RES	1205	0.1205	1205	0.1205	32	32	265.56	265.56
6305	6305	RES	RES	1832	0.1832	1832	0.1832	10	10	54.59	54.59
2483	2483	VAC	VAC	1411	0.1411	1411	0.1411	0	0	0.00	0.00
2484	2484	VAC	VAC	1424	0.1424	1424	0.1424	0	0	0.00	0.00
2490	2490	VAC	VAC	285	0.0285	285	0.0285	0	0	0.00	0.00
2500	2500	PARK	PARK	2839	0.2839	2839	0.2839	0	0	0.00	0.00
2502	2502	PARK	PARK	838	0.0838	838	0.0838	0	0	0.00	0.00
6150	6150	PARK	PARK	123	0.0123	123	0.0123	0	0	0.00	0.00
6151	6151	PARK	PARK	32	0.0032	32	0.0032	0	0	0.00	0.00
7311	7311	BUS	BUS	874	0.0874	874	0.0874	0	0	0.00	0.00
7573	7573	CHURCH	CHURCH	1453	0.1453	1453	0.1453	0	0	0.00	0.00
13818	13818	BUS	BUS	6743	0.6743	6743	0.6743	0	0	0.00	0.00
RE/7152	RE/7152	BUS	BUS	18	0.0018	18	0.0018	0	0	0.00	0.00
2499	2499	BUS	BUS	1164	0.1164	1164	0.1164	0	0	0.00	0.00
2498	2498	PARK	PARK	586	0.0586	586	0.0586	0	0	0.00	0.00
7349	7349	PARK	PARK	559	0.0559	559	0.0559	0	0	0.00	0.00
2508	2508	BUS	BUS	1052	0.1052	1052	0.1052	0	0	0.00	0.00
7277	7277	BUS	BUS	395	0.0395	395	0.0395	0	0	0.00	0.00
3464	3464	BUS	BUS	1422	0.1422	1422	0.1422	0	0	0.00	0.00
6181	6181	BUS	BUS	3383	0.3383	3383	0.3383	0	0	0.00	0.00
7614	7614	BUS	BUS	344	0.0344	344	0.0344	0	0	0.00	0.00

Source: Stellenbosch Municipality (2015/16)