

Urban and Rural Growth Modelling: From theory to practice

W Mostert



orcid.org/0000-0002-4681-5104

Dissertation submitted in *partial* fulfilment of the requirements
for the degree *Magister Artium et Scientiae* in *Urban and
Regional Planning* at the North-West University

Supervisor: Prof EJ Cilliers

Graduation May 2018

21251592



ACKNOWLEDGEMENTS

This research (or parts thereof) was made possible by the financial contribution of the NRF (National Research Foundation) South Africa. Any opinion, findings and conclusions or recommendations expressed in this material are those of the author(s) and therefore the NRF does not accept any liability in regard thereto. First and foremost I would like to thank God Almighty for the completion of this master's dissertation. Only due to His blessings could I finish this research. The sincerest gratitude to my supervisor, Prof Juanee Cilliers, who has supported me throughout this dissertation with her patience and knowledge. Also special thanks to I@Consulting for the support throughout this dissertation. Finally, I must express my very profound gratitude to my parent's and partner for providing me with unfailing support and continuous encouragement throughout my two years of study and through the process of researching and writing this dissertation. This accomplishment would not have been possible without them. Thank you.

ABSTRACT

Cities are considered complex systems (Batty, 2008). It consists of numerous interactive sub-systems and is affected by diverse factors including government land policies, population growth, transportation infrastructure, and market behaviour. According to Rui (2013), land use and transportation systems are considered as the two most important subsystems determining urban form and structure in the long term. Urbanisation is causing many spatial challenges for Planners. City growth and changes in land-use patterns cause various important social and environmental impacts (Lambin & Geist, 2007).

To understand the spatial and temporal dynamics of these processes, the factors that drive urban and rural development should be identified and analysed, especially those factors that can be used to predict future changes and their potential environmental effects. To plan for these changes, it is necessary to prognosticate the spatial pattern of urban and rural growth. This research considered the theory and practice of urban and rural growth modelling, in an attempt to develop a methodology to predict spatial patterns. The method applied to the area of study were based theoretical mathematic calculations and extensive experience in the field of urban and rural planning. The study also concluded on the importance and necessity of future growth predictions in order to address the challenges of the past and provide for needs of the future. The planning recommendations captured in the study were based on the findings from the theoretical and empirical investigation.

Key terms: Urbanisation, Urban, Rural, Growth, infrastructure, modelling

OPSOMMING

Stede word beskou as kompleks sisteme (Batty, 2008). Dit bestaan uit verskeie interaktiewe sub-stelsels en word geaffekteer deur diverse faktore insluitend, regeringsgrondbeleide, populasie groei, vervoer infrastruktuur en markgedrag. Grondgebruik en vervoer netwerke kan volgens Rui (2013), aanskou word as twee van die belangrikste sub-stelsels wat stedelike vorm en struktuur bepaal in die langtermyn. Verstedeliking veroorsaak verskeie ruimtelike uitdagings vir beplanners. Stedelike groei en verandering in grondgebruiks patrone veroorsaak verskeie sosiale en omgewingsimpakte (Lambin & Geist, 2007).

Om die ruimtelike en temporale dinamika van hierdie prosesse te verstaan, moet die faktore wat stedelike en landelike ontwikkeling dryf eers gebestudeer word, veral daardie faktore wat gebruik kan word om toekomstige veranderinge en omgewingsimpakte te bepaal. Om voorsiening te maak vir hierdie probleme, is dit noodsaaklik om die ruimtelike patroon van stedelike en landelike groei te ondersoek. Die navorsing neem die teorie en praktyk van stedelike en landelike groei inag, in 'n poging om 'n metodologie te ontwikkel vir stedelike en landelike groei. Die metode wat toegepas is op die studie area, was gebasseer op teoretiese wiskundige berekeninge asook breë kennis in die veld van stedelike en landelike beplanning. Die studie het ook die belangrikheid en noodsaaklikheid van toekomstige aannames aangespreek wat die uitdagings van die verlede aanspreek. Die beplanning aanbevelings in die studie is gebasseer op die bevindings van die teoretiese en empiriese navorsing.

Sleuteltermes: Verstedeliking, Stedelik, Landelik, Groei, Infrastruktuur, Modellering

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ACRONYMS

AH – Agri-Hub

AHP - Analytic Hierarchy Process

ARC-ISCW – Agricultural Research - Institute for Soil, Climate and Water

AURIN - Australian Urban Research Infrastructure Network

BGIS – Biodiversity Geographic Information System

CALLM – Chief Albert Luthuli Local Municipality

CBA – Critical Biodiversity Area

CBR – Crude Birth Rate

CDR – Crude Death Rate

CI – Consistency Index

CIDMS - City Infrastructure Delivery and Management System

CUF - California Urban Futures

CURBA - California Urban and Biodiversity Analysis

CRDP - Comprehensive Rural Development Programme

CSIR - Council for Scientific and Industrial Research

CTPC - Cape Town Project Centre

DAFF - Department of Agriculture, Forestry and Fisheries

DEA - Department of Environmental Affairs

DFA - Development Facilitation Act

DRAM - Disaggregated Residential Allocation Model

DRDLR - Department of Rural Development and Land Reform

EA – Enumeration Area

EDMRDP – Ehlanzeni District Rural Development Plan

EMM – Ekurhuleni Metropolitan Municipality

EMPAL - Employment Allocation Model

EMZ - Environmental Management Zone

EPA – Environmental Protection Agency

FPSU - Farmer Production Support Unit

GCRO - Gauteng City-Region Observatory

GDARD – Gauteng Department of Agricultural and Rural Development

GDP – Gross Domestic Product

GHG – Green House Gas

GIS – Geographic Information System

GSM - Growth Simulation Model

GVA - Gross Value added

HIV/AIDS - Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome

IDP - Integrated Development Plan

INTOSAI WGEA- International Organisation of Supreme Audit Institutions Working Group on Environmental Auditing

IPAP – Industrial Policy Action Plan

IUDF - Integrated Urban Development Framework

LM – Local Municipality

LTM - Land Transformation Model

LUCAS - Land-Use Change Analysis System

LUS – Land Use Scheme

LUT – Land Use Transport

LUTM – Land Use Transport Model

MCMD – My Choice My Decision

MDB – Municipal Demarcation Board

NDP - National Development Plan

NOAA – National Oceanic and Atmospheric Administration

NP - National Party

NPC – National Planning Commission

NRI – Rate of Natural Increase

OECD – Organisation for Economic Co-operation and Development

OWI – Online WhatIF

UK – United Kingdom

UN – United Nations

UNDESA - United Nations Department of Economic and Social Affairs

USA – United States of America

US – United States

SACAD - South African Conservation Areas Database

SACN – South African Cities Network

SAHITA - South African Home inspection Training Academy

SDI – Shack Dwellers International

SDF - Spatial Development Framework

SMME - Small, Medium and Micro-sized Enterprises

SPLUMA - Spatial Planning and Land Use Management Act

StatsSA - Statistics South African

RDP – Reconstruction and Development Programme

RUMC – Rural-Urban Market Centre

RS – Rating Score

CHAPTER 1: INTRODUCTION

1. Introduction

Our urban and rural landscapes have changed dramatically over the years. Predicting future urban and rural growth direction and expansion can ensure that the necessary planning is in place which includes infrastructure planning. This is a vital part of the planning process. It is important to be conversant on how many citizens must be served, where they are located and what their needs, preferences and abilities are.

Spatial planners tend to make assumptions on growth direction and future expansion without considering all the driving forces of urban and rural growth. The Lephalale Local Municipality in the Limpopo Province of South Africa was considered as case study to illustrate such. With the commencement of the construction of the Medupi power station in May 2007, immense growth was expected for the town of Lephalale. Although growth did take place, the number of general plans approved outweighed the projection made and now the Municipality is left with thousands of vacant stands.

This research argues that by employing urban and rural growth modelling tools, similar situations as in the case of Lephalale could be avoided in future. The enactment of the Spatial Planning and Land Use Management Act (SPLUMA), Act 16 of 2013, brought a new dimension to spatial planning whereby scenario building for future urban and rural expansion is now considered a necessity for all municipalities in South Africa. This research therefore, considered the theory and practice of urban and rural growth modelling, in an attempt to identify and predict spatial patterns and guide future spatial planning toward more sustainable practices.

1.1 Problem Statement

The South African demarcation of 2000 called for “wall-to-wall” municipalities. This meant municipalities had to extend their planning well beyond that of the former towns. “New land uses” and geographic areas now needed to be accommodated within the formal planning schemes, such as land under traditional leadership, informal settlements, mining areas, agricultural land and conservation areas. SPLUMA was passed by Parliament in 2013 and came into force on the first of July 2015, enforcing the “wall to wall” planning approach and requiring Planners to consider future growth of areas within a 5-year, 10-year and 20-year timeframe. Such scenario prediction was a new dimension to traditional planning approaches. The problem now lies in obtaining adequate data, especially within the informal and traditional land use areas, and to model future growth of these areas in order to ensure better integration of such into formal systems of spatial planning and land use management. This research considered the theory and practice of urban

and rural growth modelling, in an attempt to develop a methodology to predict spatial patterns, especially for the South African context.

1.2 Primary research aim and research questions

This research primarily aimed to consider the theory and practice of urban and rural growth modelling, in an attempt to develop a methodology to predict spatial patterns. As such, the specific research questions include:

- Which planning theories inform the spatial form?
- What informs and drives urban and rural growth?
- How is urban and rural growth modelling employed in practice?
- Why is it important to predict urban and rural spatial patterns in South Africa?
- What impact has legislation had on urban and rural growth in South Africa?
- What methodology can be developed to predict urban and rural spatial form?
- Can this methodology be applied to South African context?

Based on this research questions, the study concluded on the importance and necessity of future growth predictions in order to address the challenges of the past and provide for needs of the future.

1.3 Research Methodology

The literature study provided a comprehensive discussion on selected planning theories and the incremental role these theories has had on the current shape and layout of the built environment, especially referring to South Africa and understanding the current urban and rural form in South Africa. It is followed by a study on the current legislation applicable to planning within South Africa, in order to understand the drivers of development and role of legislation. Driving factors of urban and rural growth were identified and explained accordingly followed by the identification of land use models and software to assist with the process of predicting spatial patterns.

The empirical study considered various selected methods and processes which are currently applied globally with regard to urban and rural growth patterns. Specific case studies were included to identify the method and best practices, with the aim to develop an appropriate methodology to assist spatial planners with the process of determining future urban and rural growth direction which in turn, can be used within key policies and frameworks in South Africa. The town of Lephalale in the Limpopo Province were included as a primary case study to identify opportunities for urban and rural growth modelling in local context. The details of the empirical methodology are captured in the appropriate chapters. Based on the literature and empirical

investigation, the study concluded on the importance and necessity of future growth predictions in order to address the challenges of the past and provide for needs of the future. The research methodology is schematically presented in Figure 1-1.

The figure below illustrates the research method applied to the research study.

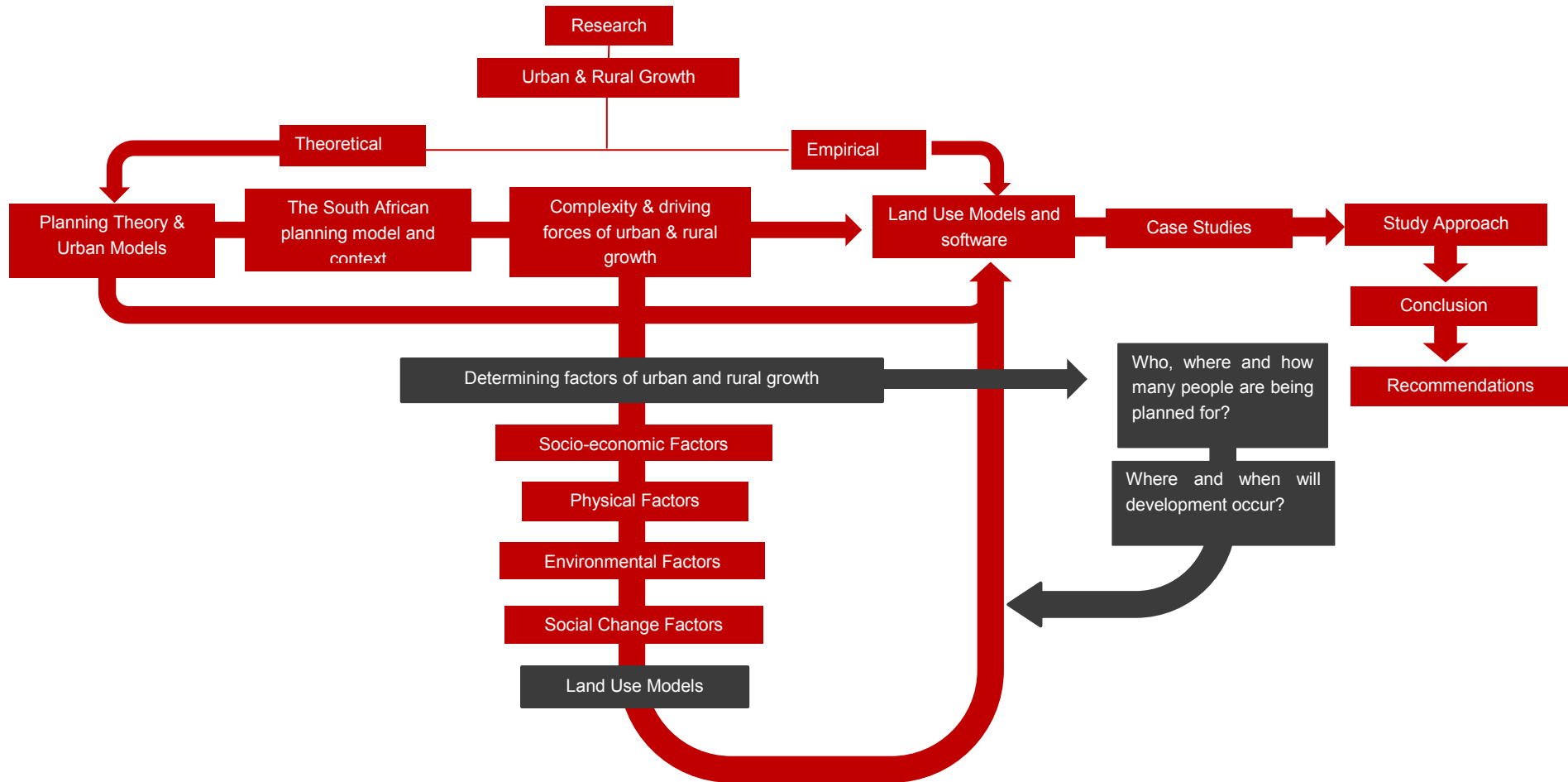
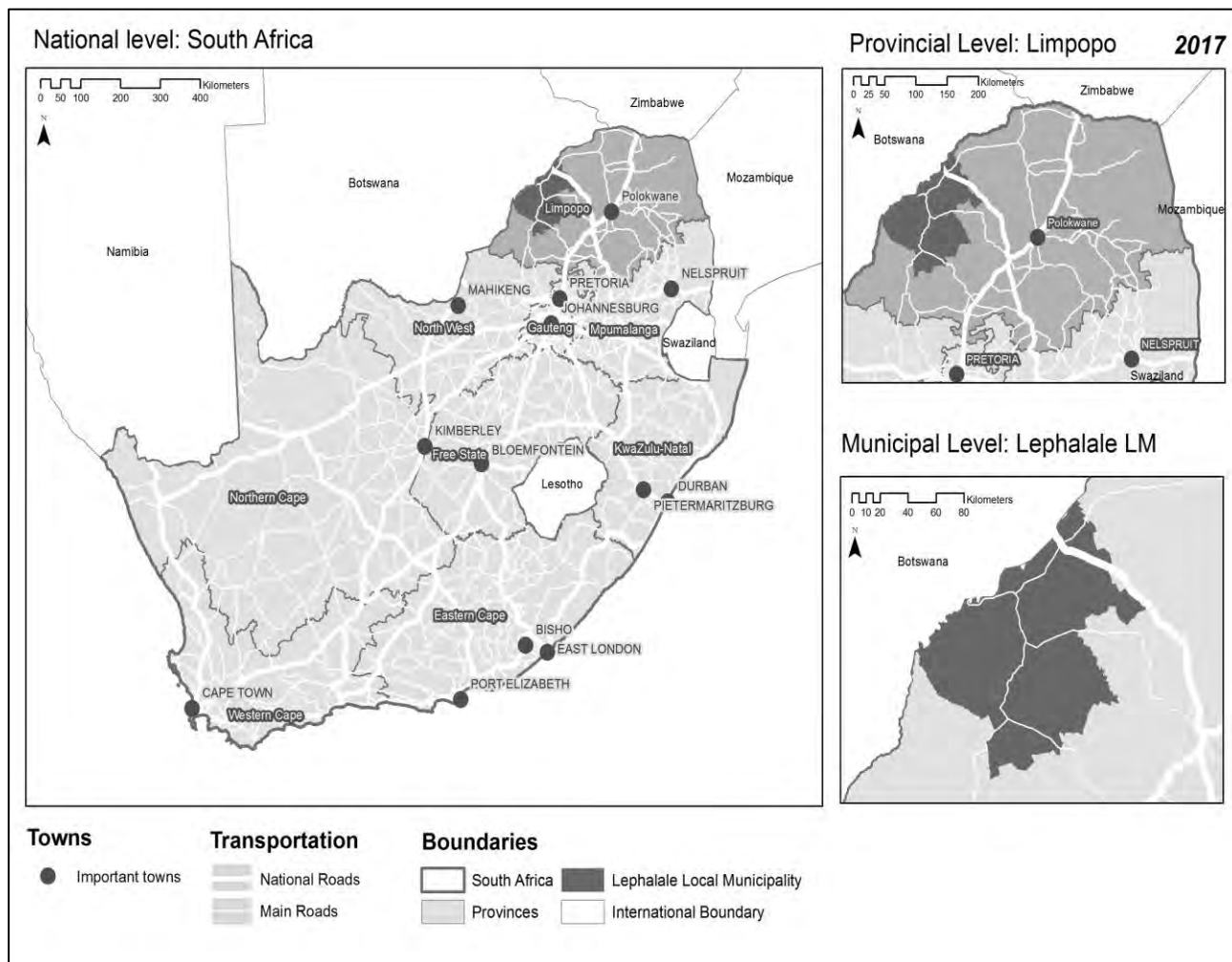


FIGURE 1-1: CONCEPTUAL MODEL OF THE RESEARCH PROCESS

Source: Own Construction (2016)

1.4 Delineation of the study area

This research considered the town of Lephalale in the Limpopo Province as a primary case study. The map below illustrates the delineation of the study area. This case study was selected to illustrate the opportunities for urban and rural growth modelling in local context, but the findings of this research are, however, applicable to other areas and municipalities in South Africa, as this research aimed to develop a broad methodology for urban and rural growth modelling.



Map 1-1: Delineation of the study area

Source: Adapted from I@Consulting (2017)

1.5 Limitations of the research

There is limited information available on rural growth modelling and appropriate tools, mainly because rural areas often lack detailed Geographical Information Systems (GIS) datasets and statistical information due to the previous exclusion from formal planning processes. This research employed available spatial datasets and statistical information in an attempt to illustrate an approach to spatial modelling for urban and rural growth. The case study is limited to the

Lephalale area, but could be applied to other municipalities in South Africa. This research is limited to a spatial planning approach to predict urban and rural growth.

1.6 **Structure of the dissertation**

The following is a summary of the structure and content of the remainder of the dissertation:

Chapter 2: Planning Theory and Urban Models

Chapter 2 considers the Central Place Theory and various selected urban models, as a point of departure to understand the spatial form and growth of urban and rural areas.

Chapter 3: The South African planning model and context

This chapter deals with the applicable legislation which led to the current urban and rural spatial form. The chapter also discusses the relevant legislation in South Africa which guides urban and rural growth.

Chapter 4: The complexity and driving forces of Urban and Rural Growth in South Africa

In order to determine what informs urban and rural growth, it is important to first identify the drivers of urban and rural growth. This chapter commences with identifying the various drivers of urban and rural growth and the importance thereof in terms of urban and rural growth modelling.

Chapter 5: Land Use Models and software

Chapter 5 identifies land use models and software broadly used in an attempt to obtain knowledge of the capabilities of land use models.

Chapter 6: Case Studies

The objective of this chapter is to illustrate how urban and rural growth modelling is employed in practice. Appropriate feature applicable to the relevant study area “Lephalale”, will then be selected with the aim of developing an appropriate methodology for urban and rural growth modelling.

Chapter 7: A South African urban and rural growth modelling approach

This chapter depicts a methodology which can be used within Spatial Development Frameworks, with the aim of predicting spatial patterns of urban and rural areas in South Africa.

Chapter 8: Conclusion

This chapter concludes the research which considered the theory and practice of urban and rural growth modelling.

Chapter 9: Recommendations: The systematic process of urban and rural growth

Chapter 9 commence with some recommendations in terms of future spatial planning as well as the limitations of the research study.

1.7 Definitions

The following are important definitions of applicable terminology that were used in this study.

TABLE 1-1: GLOSSARY

Category	Definition	Source
Demarcation	“The process of dividing the land into enumeration areas, with clear boundaries and of a defined enumeration area type.”	(StatsSA, 2011a)
Enumerator area type (EA type)	“The classification of enumerator areas according to set criteria profiling land use and human settlement within the area. Not to be confused with geography type, a broader classification.”	(StatsSA, 2011a)
Environmental Management Zone (EMZ)	Environmental Management Zones are based on the spatial section of the desired state of the environment and the biophysical constraints and opportunities. The zones do not only apply to sensitive areas but are classified according to different land use desires.	(LEDET , 2016)
Farms	“Farms cover an extensive area. The land is cultivated and the field size is usually quite large. Farm boundaries can be easily distinguished on the aerial photos; they are normally fence lines, edges of the fields, roads or rivers. The fields are cultivated with a variety of crops and the crops	(StatsSA, 2011a)

	differ from season to season and from area to area.”	
Geographical Information System (GIS)	A system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data.	(StatsSA, 2011a)
General Pan	Means a general plan approved by the surveyor-general in terms of the Land Survey Act, 1997 (Act No. 8 of 1997)	Land Survey Act, 1997 (Act No. 8 of 1997)
Green Infrastructure	Means a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings”.	European Commission (2013:7)
Household	A household is a group of persons who live together and provide themselves jointly with food or other essentials for living, or a single person who lives alone.	(StatsSA, 2011a)
Informal settlement	An unplanned settlement on land that has not been surveyed or proclaimed as residential, consisting mainly of informal dwellings.	(StatsSA, 2011a)
Land Use	Means the purpose for which land is or may be used lawfully in terms of the change of use of land use scheme, existing scheme or in terms of any other authorisation, permit or consent issued by a competent authority, and includes any conditions related to such land use purposes.	Spatial Planning and Land Use Management Act, Act 16 of 2013
Municipality	The area of jurisdiction of the third sphere of government, after national and provincial. There are now four types of municipalities encompassing the whole country including rural areas and tribal	(StatsSA, 2011a)

	<p>areas: metropolitan areas (Category A); local councils (Category B); district councils (Category C); and district management areas (DMAs). Metropolitan areas (Cat A) stand alone. District councils (Cat C) are subdivided into local councils (Cat B) and DMAs.</p>	
Population change	Percentage change in population size of an area between two defined periods.	(StatsSA, 2011a)
Population growth	This is a change in the size of the population (increase or decrease) of a particular place at the defined time as a function of births, deaths and net migration.	(StatsSA, 2011a)
Rural area	Any area that is not classified urban. Rural areas may comprise one or more of the following: tribal areas, commercial farms and informal settlements. (See settlement type.)	(StatsSA, 2011a)
Settlement types	<p>Classification according to the characteristics of a residential population in terms of urban and rural, the degree of planned and unplanned (in the case of urban) and jurisdiction (in the case of rural). The four broad settlement types found in South Africa are:</p> <ul style="list-style-type: none"> a) formal urban areas b) informal urban areas c) commercial farms d) tribal areas and rural informal settlements 	(StatsSA, 2011a)
Smallholdings	These are usually on the outskirts of towns. The activity that takes place is usually small-scale intensive farming, for example, pig and chicken	(StatsSA, 2011a)

	farming, vegetable farming, flower farms, kennels, stables and riding schools.	
Sub place	Second (lowest) level of the place name category, namely a suburb, section or zone of an (apartheid) township, smallholdings, village, sub-village, ward or informal settlement.	(StatsSA, 2011a)
Traditional area	Communally owned land under the jurisdiction of a traditional leader	(StatsSA, 2011a)
Township	Usually a town or part of a town. Historically, 'township' in South Africa referred to an urban residential area created for black migrant labour, usually beyond the town or city limits. Reference is sometimes made to 'black township', 'coloured township' and 'Indian township', meaning that these settlements were created for these population groups	(StatsSA, 2011a)
Tribal settlements	The appearance and organisation of villages in tribal areas vary in different parts of the country. Tribal settlements are found in areas that are legally proclaimed to be under tribal authorities.	(StatsSA, 2011a)
Urban area	A continuously built-up area with characteristics such as the type of economic activity and land use. Cities, towns, townships, suburbs, etc. are typical urban areas. An urban area is one which was proclaimed as such (i.e. in an urban municipality under the old demarcation) or classified as such during census demarcation by the Geography department of Stats SA	(StatsSA, 2011a)
Urban formal	Urban settlements (formal) occur on land that has been proclaimed as residential. A formal urban settlement is usually structured and organised.	(StatsSA, 2011a)

	Plots or erven make up a formal and permanent arrangement.	
Village	A settlement in a tribal area. A village has delimits (boundaries), which encompass not only populated areas, but also agricultural areas, e.g. grazing land, cropland or forested land. Villages are usually under the jurisdiction of tribal authorities, headed by chiefs, while sub-chiefs are direct principals of villages.	(StatsSA, 2011a)
Urban Growth boundaries	Urban growth boundaries are geographic areas defined in plans or regulations as desirable and appropriate for growth during a defined period of time	(Government, 2017)
Urban/Rural Edge	An Urban or Rural Edge is described as a line drawn around an urban or rural area to control and manage the growth thereof (CALLM, 2016).	(CALLM, 2016)
Remote Sensing	Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites.	(NOAA, 2017)

CHAPTER 2

Planning Theory and Urban Models

2. Introduction

The planning environment is ever changing. This chapter considers the Central Place Theory and various selected urban models, as a point of departure to understand urban and rural form and growth.

2.1 Central Place Theory

One of the most renowned theories is the central place theory that was developed by Walter Christaller (Eaton & Lipsey, 1982:56). According to Steyn & Barnard (1976), the essence of Christaller's theory stated that all settlements act as central places, providing one or more services to their surrounding areas. These settlements vary in importance, and according to the number and type of other settlements depended upon them, and the number and type of services or functions (Johnson, 1967:95). According to Shubham (2016), Walter Christaller made some assumptions to his theory with the objective to form a simplified basis for other theories. The assumptions took into account the growth and development of towns, human behaviour and fundamentals of economics (Shubham, 2016). The central place theory was based on the following assumptions (Shubham, 2016);

- An even (flat) terrain – A hilly and uneven terrain poses difficulty in development thus a flat area which promotes growth of town
- Evenly distributed population – residents are not concentrated at one particular place and no preference exists for a particular town
- Evenly distributed resources – no place has an advantage of resources, all places will compete under perfect market conditions
- Similar purchasing power – along with the population and resources, wealth is also fairly distributed. Because of this people have similar purchasing power
- Preference for nearest market – people will buy products from the nearest market and avoid longer commute. This keeps price constant as per other assumptions
- Equal transportation cost (proportional to distance) – the cost incurred in transporting of goods is equal for all and is proportional to distance
- Perfect competition – price is decided on basis of demand and supply. People will buy at lowest price which market has to offer, no seller has an advantage over another seller.

The two main concepts of Christaller's theory are threshold and range (Steyn and Barnard, 1976:230; Waugh, 2002:407). From these two concepts, the lower and upper limits of a central place's goods or services can be determined (Figure 2-1).

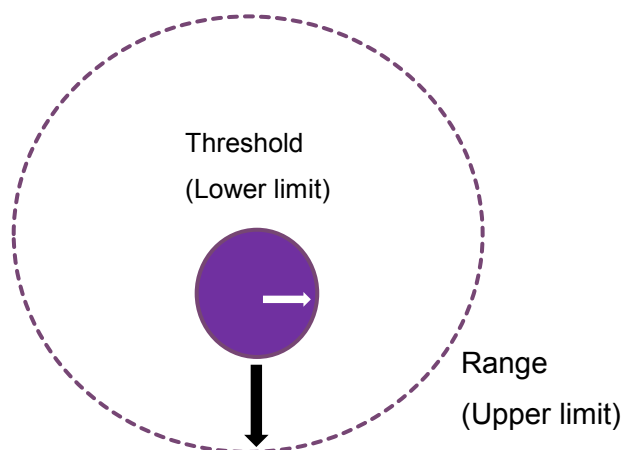


FIGURE 2-1: CENTRAL PLACE THEORY - RANGE AND THRESHOLD OF A COMMODITY

Source: Adapted from Beavon (1975:8)

According to Briney (2017), Christaller made two assumptions with regard to human behaviour:

1. Humans will always purchase goods from the closest place that offers the good;
2. Whenever demand for a certain good is high, it will be offered in close proximity to the population

These assumptions stated the importance of the “threshold” concept in Christaller's theory. The threshold referred to the minimum number of people needed for a central place business or activity to remain active and prosperous (Briney, 2017). In 1954, Losch modified Christaller’s central place theory because he believed it was too rigid (Briney, 2017). He argued that Christaller's model led to patterns where the distribution of goods and the accumulation of profits were based entirely on location. For this reason, he focused on maximising consumer welfare and creating an ideal consumer landscape where the need to travel for any good was minimised and profits were held level, not maximised to accrue extra (Briney, 2017).

According to Shubham (2016), Christaller gave three principles for the arrangement of central places namely, the marketing, transport and administration principle. Both Losch's and Christaller's theories are still relevant today when considering the location of retail in urban and rural areas and the patterns of possible growth. According to Herbert (1972:70), there are three models that have had a substantial impact upon the literature of urban studies. These models include Burgess concentric zone model, Hoyt’s sector model and Harris and Ullman’s multiple nuclei model. Other important models that will be discussed below include Mann’s model of urban structure, Vance’s urban realms model, Kearsley’s model, White’s model of the twenty-first-century, Davies apartheid model and the modernised apartheid model of Simon. All these models

include some important characteristics which should be taken into account when considering patterns of urban and rural growth, as explained accordingly.

2.2 Concentric Zone Model – Burgess (1923)

Burgess suggested a concentric zone model that was based on the outward expansion and the socio-economic groupings of inhabitants of the city of Chicago (Johnson, 1967:163; Waugh, 2002:420). In 1925, Burgess presented an urban land use model, which divided cities in a set of concentric circles expanding from the downtown to the suburbs (Rodrigue, 2017). According to Torrens (2000), Burgess classified the city into six broad zones:

- The central business district (CBD): the focus for urban activity and the confluence of the city's transportation infrastructures
- The zone of transition: generally a manufacturing district with some residential dwellings
- The zone of factories and working men's homes: this zone was characterised by a predominantly working-class population living in older houses and areas that were generally lacking in amenities
- The residential zone: this band comprised newer and more spacious housing for the middle classes
- The outer commuter zone: this land use ring was dominated by better quality housing for upper-class residents and boasted an environment of higher amenity.

The figure below illustrates the various zones of the concentric model.

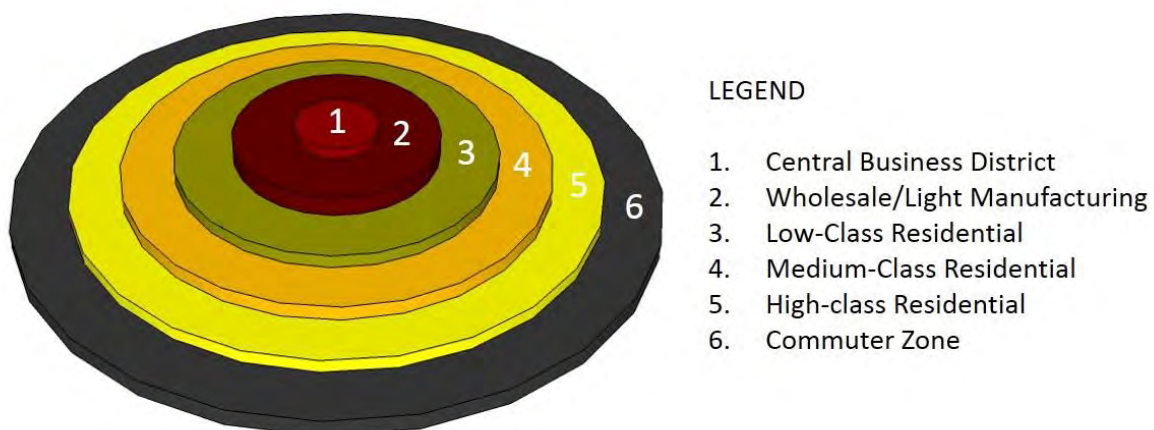


FIGURE 2-2: BURGESS - CONCENTRIC MODEL

Source: Adapted from Cilliers (2010); Beavon (1975)

Some of the characteristics of the concentric model are evident in the current spatial form of South Africa. Mixed land uses develop away from the CBD, while the majority of development is allocated in close proximity to major and main transport routes.

2.3 Sector Model – Hoyt (1939)

Hoyt presented a sector model which was based upon Burgess work (Cilliers, 2010:16). This sector model stated that mixed land-uses would develop away from the CBD and towards the periphery in the form of sectors (Herbert, 1972:72; Chapin & Kaiser, 1979:35; Pacione, 2005:141-142). It further stated that these developments would be directional Van der Merwe (1989:141-142) and focus along major transport routes, which is in direct contrast with the development of concentric zones as suggested by Burgess (Mayer, 1969:32; Johnson, 1967:166).

According to Chapin and Kaiser (1979), Hoyt made similar assumptions to Burgess however, he added three new factors:

- Wealthy people always choose the best sites, thus competition is based on the ability to pay;
- Wealthy residents can afford private cars or public transport, which means they live further from industries and nearer to main roads; and
- Similar land-uses attracted other similar land-uses, concentrating a function in a particular area and repelling others.

Figure 2-3 illustrates Hoyt's sector model.

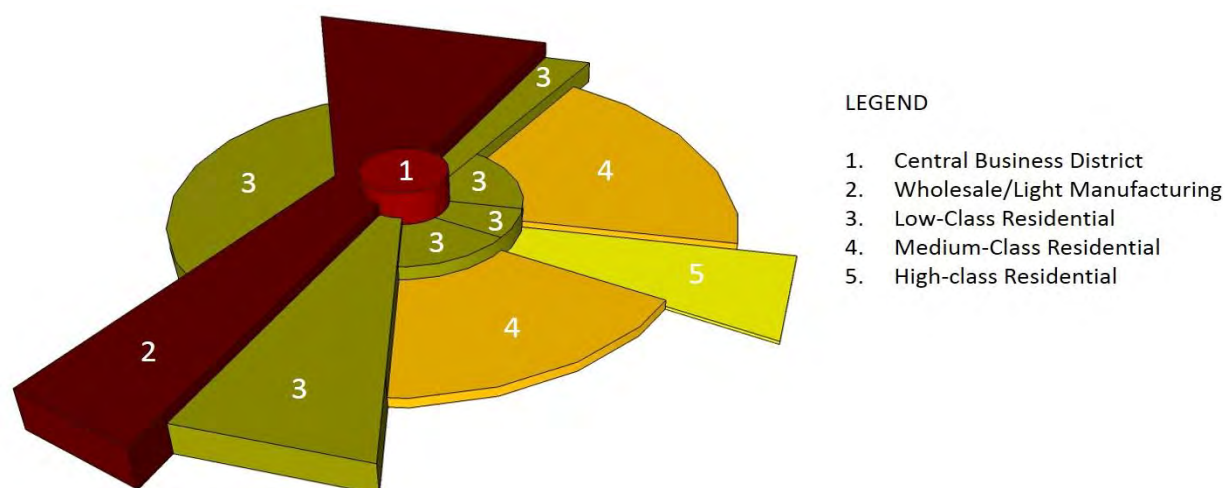


FIGURE 2-3: HOYT - SECTOR MODEL

Source: Adapted from Cilliers (2010); Waugh (2002:422)

Hoyt suggested that the areas of the highest rent tend to be along main transport routes (Waugh, 2002). He also claimed that once an area had developed a distinctive land use or function, it

tended to retain that land-use as the city extended outwards (Waugh, 2002). This should be considered when planning for urban and rural growth.

2.4 Multiple Nuclei Model-Harris and Ullman (1945)

Harris and Ullman developed an innovative multiple-nuclei theory of urban land use (Torrens, 2000). According to Torrens (2000), the model was based on the premise that large cities have a spatial structure that is predominantly cellular. This, they explain, is a consequence of cities' tendencies to develop as a myriad of nuclei that serve as the focal point for agglomerative tendencies (Torrens, 2000). The model also proposed that around these cellular nuclei, dominant land uses and specialised centres may develop over time. Figure 2-4 depicts Harris and Ullman's multiple nuclei model.

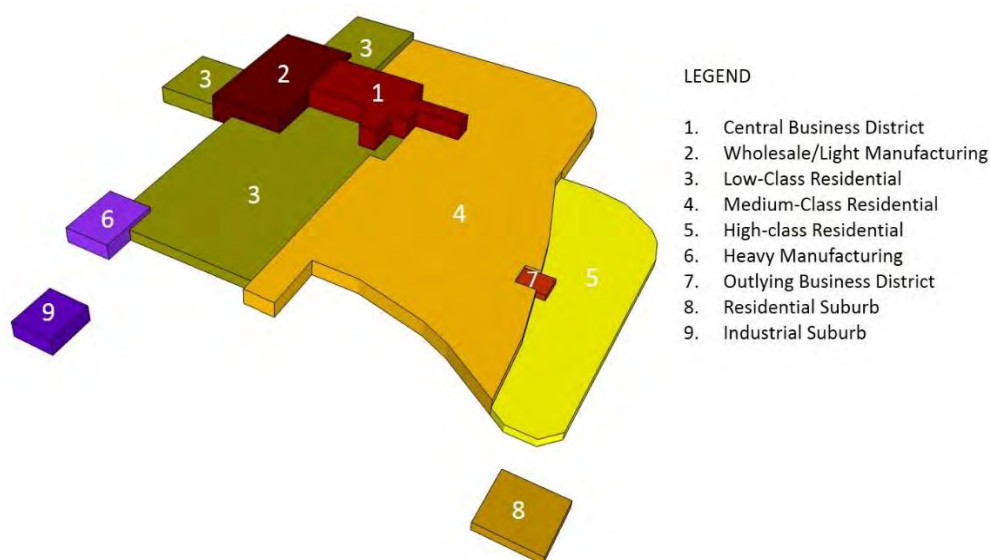


FIGURE 2-4: HARRIS AND ULLMAN - MULTIPLE-NUCLEI MODEL

Source: Adapted from Cilliers (2010); Waugh (2002:423)

According to Torrens (2000), the novelty in multiple-nuclei theory lied in its acknowledgement of several factors that strongly influence the spatial distribution of urban activity. Factors such as;

- Topography,
- Historical influences, and
- Special accessibility.

These are important factors to consider for future urban and rural planning.

2.5 Mann's Model of urban structure (1965)

Mann's model is based on studies of medium-sized cities in northern England which were not parts of conurbations, but which were large enough to show distinct functional zones (Rae, 2001). What makes Mann's model unique is its use of prevailing wind in determining industrial and residential locations. For example, the southwesterly wind is the predominantly wind in the UK. Thus the model suggested that the industrial area should be located in the eastern part of the city, where their pollution will most often blow away from the city, placing the most expensive residential sector west of centre in the cleanest location (Rae, 2001). Figure 2-5 represents Mann's model of the urban structure.

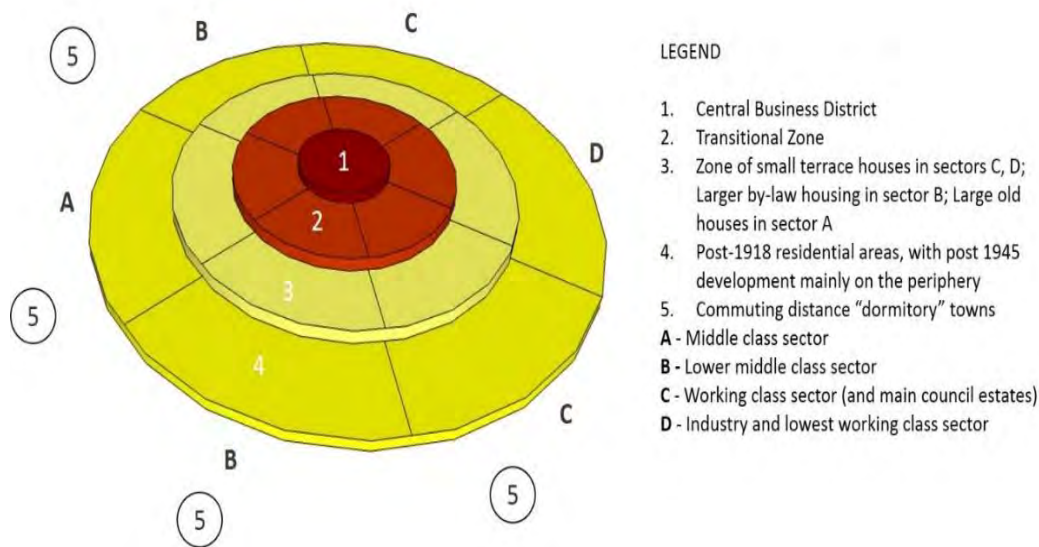


FIGURE 2-5: MANN'S MODEL OF THE STRUCTURE OF A HYPOTHETICAL BRITISH CITY

Source: Adapted from Daniel & Hopkinson (1990)

The model further stated that the industry will act as a magnet for the working class housing areas providing jobs appropriate to available skills (Rae, 2001). According to Rae (2001), Mann suggested that the working class population outnumbers the middle class by a factor of 3:1, thus more zones are demarcated as working-class than middle-class (two C sectors as opposed to one A sector). In addition, housing density would be greater in C than in A, thus catering for more people per unit area (Rae, 2001).

The concentric change relates to the age of housing and not the type of housing. The age of housing decreases with distance from the CBD. Logical, since all urban areas spread outwards as more land is needed, farmland being bought up a piece at a time to do this (Rae, 2001). For example, in Zone 4 there will be both new private and council houses, but each type will locate according to the sector. C4 is therefore likely to be council houses and A4 larger private housing

(Rae, 2001). The lower middle-class area of B4 is more likely to have a mix of council and private housing, though smaller private housing is likely to dominate (Rae, 2001). Although the model might not be widely applicable even within the United Kingdom (UK), the model does take into account some important local factors of urban development that should be considered when planning for urban and rural growth. For example, considering the importance of the environment and the effect thereof with regard to urban and rural growth.

2.6 Vance's urban-realms model (1964)

Vance (1964), extended the principles of the multiple nuclei model and proposed the Urban Realms Model (Choudhary, 2014). One of the key elements of Vance's model is the emergence of large self-sufficient urban areas, each focus on a downtown and central city. According to Vance (1964), the extent, character and internal structure of each 'urban realms' is shaped by five criteria:

- Terrain - especially topographical and water barriers;
- Overall size of the metropolis;
- Amount of economic activity within each realm;
- The internal accessibility of each realm in relation to its dominant economic core; and
- inter-accessibility among suburban realms.

According to Choudhary (2014), an important aspect here is the circumferential links and direct airport connections that are no longer required to interact with the central realm in order to reach other outlying realms and distant metropolises. The model has subsequently been applied to describe the general land use structure of U.S. cities (Choudhary, 2014). Figure 2-6 illustrates Vance's urban realms model

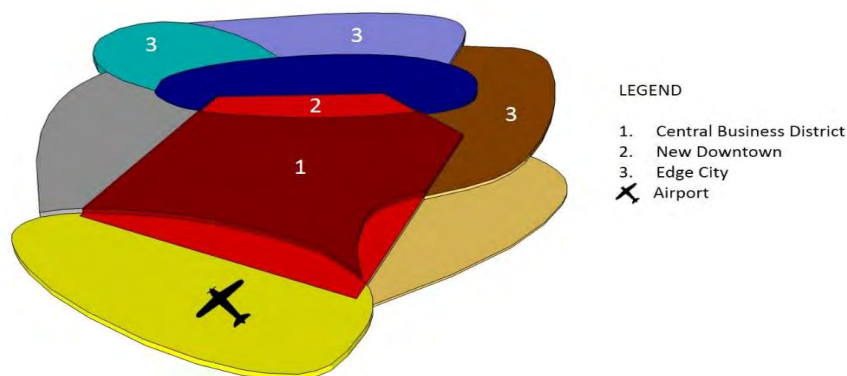


FIGURE 2-6: VANCE'S URBAN REALMS MODEL

Source: Adapted from Vance (1964)

A key characteristic of Vance’s model, which is evident in many urban areas in South Africa, is the emergence of large self-sufficient urban areas. This characteristic should be considered when planning for urban and rural growth.

2.7 Kearsley’s modified Burgess Model (1983)

According to Choudhary (2014), Kearsley’s model was an attempt to extend Mann’s model of the urban structure by taking into account contemporary dimensions of urbanisation such as the level of governmental involvement in urban development in Britain, slum clearance, suburbanization, decentralisation of economic activities, gentrification and ghettoisation. Because of the manipulation of the model’s various elements such as the extension of inner-city blight, minimisation of local and central government housing and expansion of recent low-density suburbs, the model offers a North American variant (Choudhary, 2014). Figure 2-7 illustrates Kearsley’s modified model of Burgess.

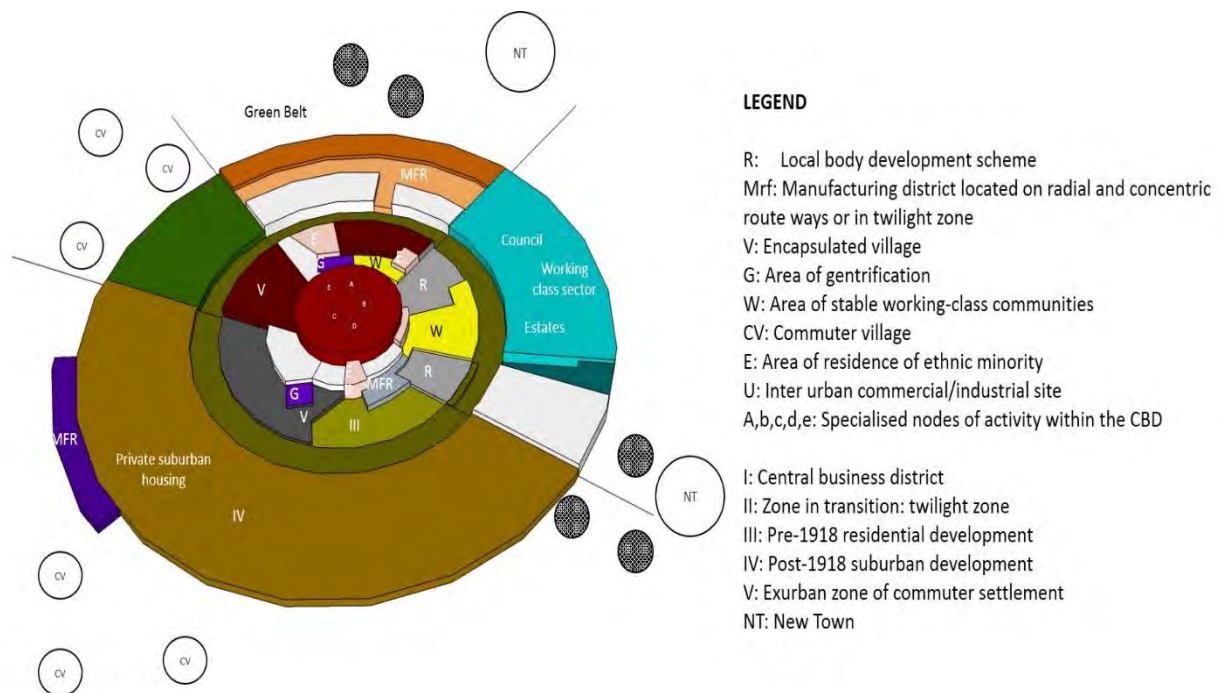


FIGURE 2-7: KEARSLEY'S - MODIFIED MODEL

Source: Adapted from Cilliers (2010); Pacione (2005:148)

Government involvement plays an incremental role with regard to urban and rural growth. There are many policies and plans in place which should be considered when planning for urban and rural growth. Some of which include the provision of housing through the reconstruction and development programme (RDP), densifications strategies, Integrated Development Plans (IDP), Spatial Development Frameworks (SDF's) and Land Use Schemes (LUS).

2.8 White's model of the twenty-first-century city (1987)

White proposed a revision of the Burgess model that aimed to better define the twenty-first-century city (White, 1987:236-242). According to Pacione (2005:148), he took new trends such as industrial development, social change, the automobile into consideration whilst revising the model.

White's model comprised of seven elements (Cilliers, 2010).

- Core: The CBD remains the focus of the metropolis
- Zone of stagnation: White stated that Burgess zone of transition would never realise as the CBD will grow vertically rather than spatially outwards.
- Pockets of poverty and minorities: These zones comprises of the underclass.
- Elite enclaves: Wealthy people have the best choice of where they would like to live
- The diffused middle class: These areas occupy the largest area of the metropolis and differ in appearance
- Industrial anchors and public sector control: The location of these entities affects zoning within and the form of the metropolis
- Epicentres and corridors: A distinguishing feature of the 21st-century city is the emerge of epicentres, located on major corridors

Figure 2-8 illustrates White's twenty-first-century model

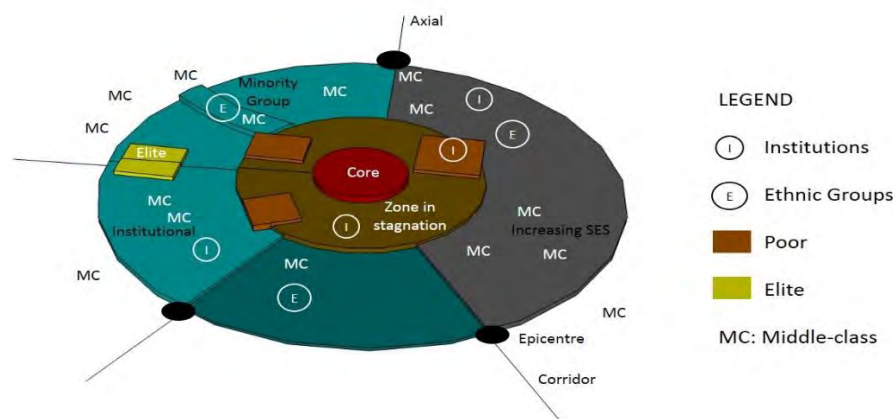


FIGURE 2-8: WHITE'S - TWENTY-FIRST-CENTURY MODEL

Source: Adapted from Cilliers (2010); Pacione (2005:149)

All seven elements of White’s model should be considered when planning for future urban and rural growth. The most important factor to consider is most definitely the difference in income levels.

2.9 Davies apartheid city model (1981)

The apartheid city model was developed by Davies in 1981. The model was preceded by his segregation model which concluded that race and ethnic groups have historically been the central character of the social, economic and spatial organisation in the South Africa (Cilliers, 2010:23; Davies, 1981:59-72). According to Pacione (2005:472), Davies model had strong resemblances to Hoyt’s sector model. The apartheid city was a result of the 1950 Group Areas Act, which sought to separate various racial groups in South Africa into distinct areas (Christopher, 1984:77). The model considered the following areas (Christopher, 1984:77).

- A white CBD, reserved for white business owners
- An Indian CBD, which was an exception and usually located closer to the Indian residential zone
- White residential areas of low, medium and high income situated around the CBD
- An industrial zone, which developed in the direction of non-whites residential areas
- An African residential area or township. These areas were usually separated from white residential areas by means of a physical barrier
- Indian and coloured residential areas, which was adjacent to African residential areas

Figure 2-9 illustrates the apartheid model of Davies.

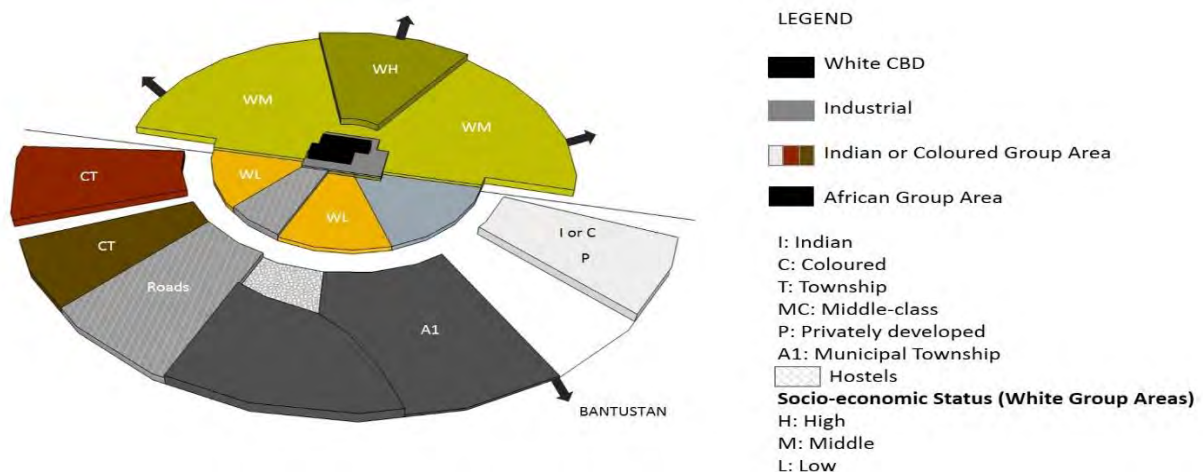


FIGURE 2-9: DAVIE'S - APARTHEID MODEL

Source: Adapted from Cilliers (2010); Simon (1989:192)

Apartheid has left a deep scar in South Africa's Spatial form. The separation of different race classes shaped South Africa's current spatial form. Before any future urban and rural planning can commence it is important to understand past spatial planning in order to rectify previous planning mistakes.

2.10 Simon modernised apartheid city model (1989)

Simon modified Davies apartheid city model by taking into account the various political environmental changes that were taking place within South Africa. The basis of Simon's model was to address the changes that were occurring due to the international pressure and sanctions (Simon, 1989:191).

According to Simon (1989:194-196) some of the changes that had a big effect on our towns and cities, were:

- The development of "Open" business districts. These business areas were open for the use of all racial groups and in some cases included in the CBD
- The establishment of free trade areas outside the CBD

These changes led to new shopping centre developing in white residential areas and initiating the decentralisation of business and commercial land-uses (Cilliers, 2010). The structure of our cities and towns are ever evolving and changing. One of the changes observed from the model includes the movement of development away from the CBD which has had a huge influence and spatial planning and land use management (Cilliers, 2010). Figure 2-10 illustrates Simon's modernised apartheid model.

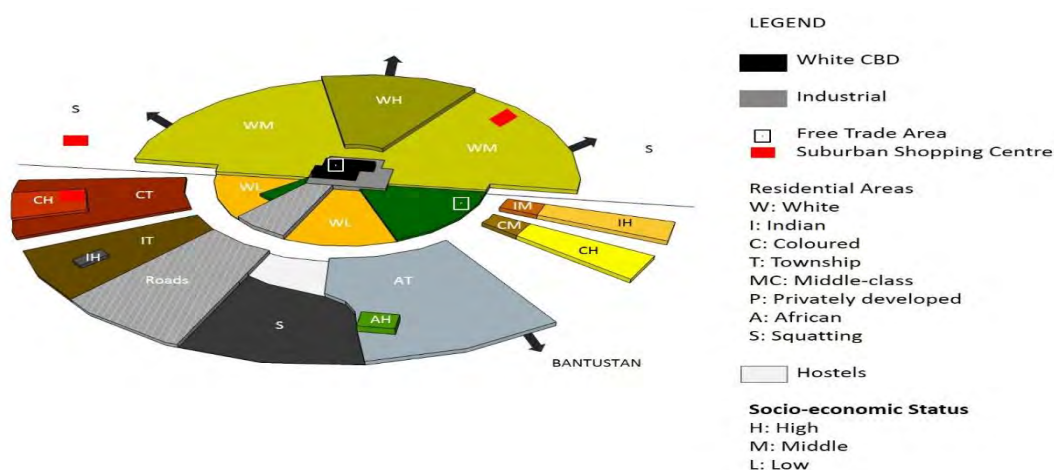


FIGURE 2-10: SIMON'S - MODERNISED APARTHEID CITY MODEL

Source: Adapted from Cilliers (2010); Simon (1989:193)

Apartheid has shaped the cities, towns and rural areas in South Africa. It is therefore, crucial to understand the current spatial form in South Africa in order to rectify the mistakes of the past and to plan for future urban and rural growth. An important characteristic from Simon's model was the establishment of free trade areas outside the CBD area. This led to the development of new business nodes and the degrading of the CBD area.

2.11 Conclusion

The Central Place Theory and urban models captured in this chapter provided a broad overview of growth patterns that should be understood when considering urban and rural growth modelling. Figure 2-11 illustrates the chronological “evolution” of the planning theory and models, along with the key aspects and contribution of each.

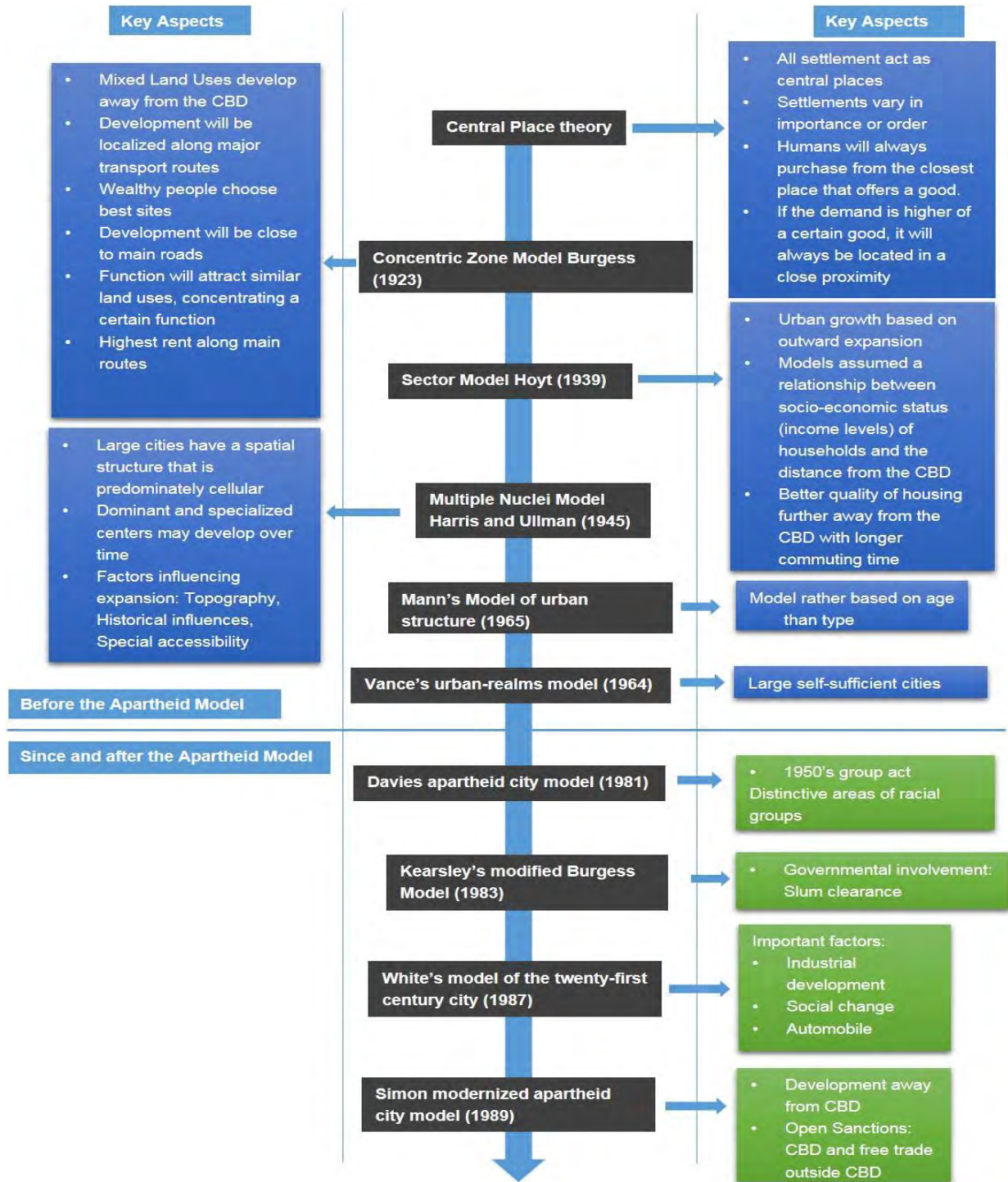


FIGURE 2-11: EVOLUTION OF PLANNING THEORIES

Source: Own Construction (2017)

The next chapter considers the South African planning model and context, based on the legislation which contributed to the current form of urban and rural areas in South Africa.

CHAPTER 3

The South African planning model and context

3. Introduction

It has been widely acknowledged that the apartheid spatial form of South Africa is not desired and that major redress is needed to make the country more inclusive, connected and efficient. The Spatial Planning and Land Use Management Act (SPLUMA) was enacted in 2013 and came into effect on the first of July in 2015. SPLUMA was developed to legislate for a single, integrated planning system for the entire country (South African Cities Network, 2015:18). This chapter considers the South African planning context by referring to post-apartheid planning legislation within South Africa as well as some new requirements in terms of SPLUMA with regard to Spatial Development Frameworks. This chapter captures the post-apartheid model and emphasises that it is crucial that all sector plans, strategies and policies are aligned in order to ensure harmonious planning and development. Figure 3-1 illustrates the contents discussed below.



FIGURE 3-1: THE SOUTH AFRICAN PLANNING MODEL AND CONTEXT

Source: Own Construction (2017)

3.1 The South African planning context

Before apartheid, South Africa had separate planning legislation for the then four provinces and black homelands (SACN, 2015). After 1994, in spite of reforms in government structures and high-level policy, existing land use planning laws and mechanisms remained largely unchanged (SACN, 2015). The most important single piece of legislation in South Africa is the Constitution Act, Act 108 of 1996. The Constitution was approved by the Constitutional Court on 4 December 1996 and took effect on 4 February 1997 (Constitution of the Republic of South Africa. 2017).

According to the SACN (2015:18), the Development Facilitation Act, Act 67 of 1995 (DFA), pre-dating the 2001 White Paper, which has since been repealed, was the only post-1994 piece of legislation that dealt with spatial development principles and provided a land use management mechanism. At a policy level, the White Paper on Local Government (1998), set the stage for a new paradigm in the form of developmental local government, with an emphasis on integrated development planning (SACN, 2015). The concepts introduced in the White Paper were legislated

in the Municipal Structures Act, Act 117 of 1998, and the Municipal Systems Act, Act 32 of 2000. In terms of the Municipal Systems Act, the municipal strategic spatial planning tool – the Spatial Development Framework (SDF) - formed part of the Integrated Development Plan (SACN, 2015).

The Government realised that there was a need to revive and assist the rural areas in South Africa. On 12 August 2009, the Cabinet approved the (CRDP) Comprehensive Rural Development Programme (Government, 2009). According to the Government (2009), the CRDP is premised on three phases:

- Phase One, which has meeting basic human needs as its driver
- Phase Two, which has large-scale infrastructure development as its driver
- Phase Three, with the emergence of rural industrial and credit financial sectors, which is driven by small, micro and medium enterprises and village markets.

In this context of the Municipal Systems Act, Act 32 of 2000, it was recognised in the National Development Plan (NDP) of 2013, that a reform of the planning system was required. One of the key visions of the Draft Integrated Urban Development Framework (IUDF) of 2014 was, “By 2030 South Africa should observe meaningful and measurable progress in reviving rural areas and in creating more functionally integrated, balanced and vibrant urban settlements.

With the finalisation of SPLUMA, some historical parallel planning related legislation was repealed. The planning legislation includes:

- Removal of Restrictions Act (84 of 1967)
- Physical Planning Act (88 of 1967)
- Less Formal Township Establishment Act (113 of 1991)
- Physical Planning Act (125 of 1991)
- Development Facilitation Act (67 of 1995) (DFA)

In addition to a lack of new planning legislation, various pieces of legislation governing issues with a direct impact on spatial planning remained in force or were formulated post-1994. Examples of these are the:

- Subdivision of Agricultural Land Act (70 of 1970)
- National Environmental Management Act (107 of 1998)
- Heritage Resources Act (25 of 1999)
- Mineral and Petroleum Resources Act (28 of 2002)

Currently, there is a Draft Preservation and Development of Agricultural Land Bill of 2015. The Bill will repeal the Subdivision of Agricultural Land Act, Act 70 Of 1970. But until then, the Subdivision of Agricultural Land Act, Act 70 of 1970 will remain enacted. One of the key requirements of Act 70 of 1970, is that all land outside the identified settlement boundaries must be zoned agricultural land. The new Bill will however, include different classes of agricultural land use zones together with many more salient points. Figure 3-2 illustrates the chronological post-apartheid planning evolution in South Africa.

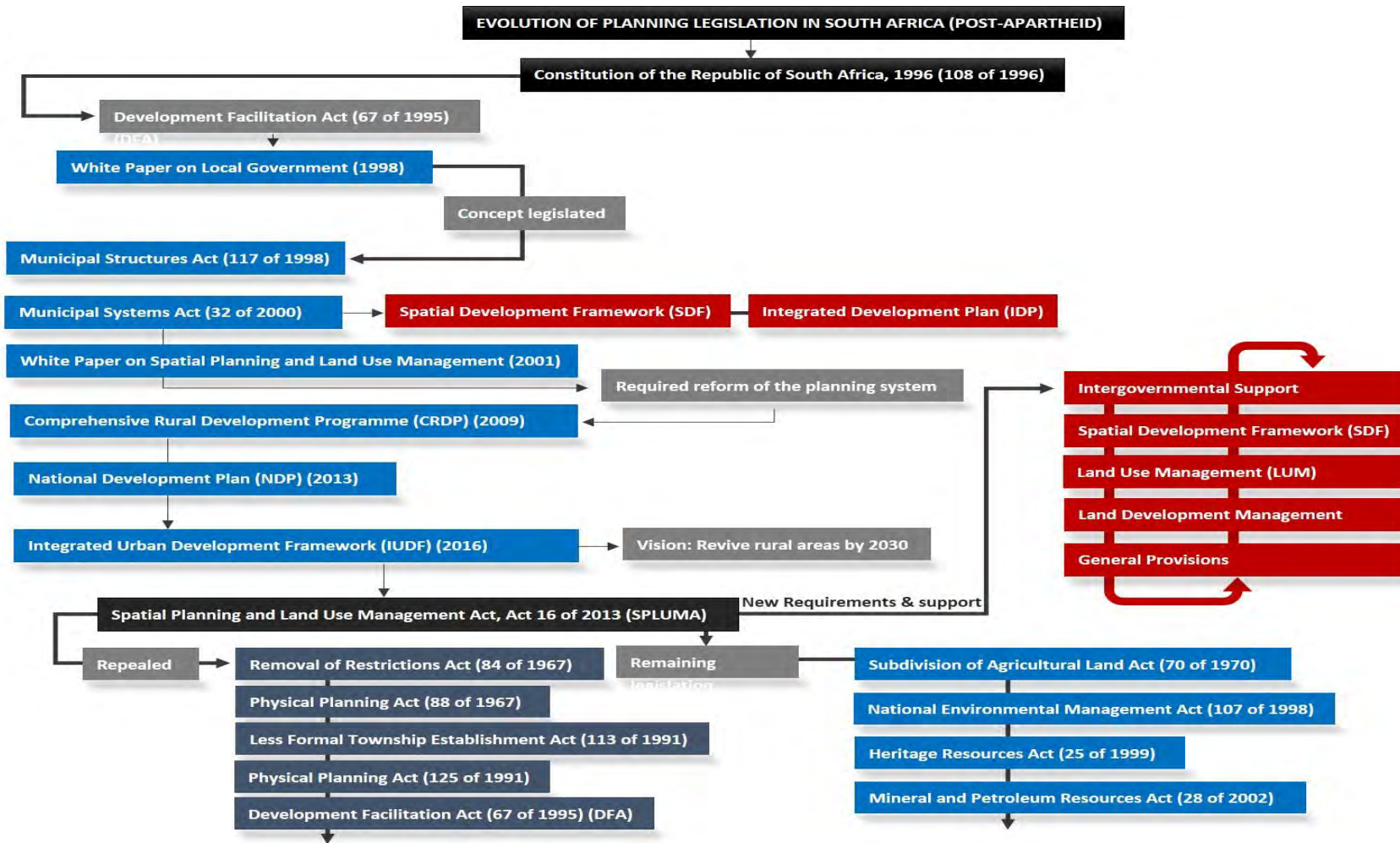


Figure 3-2: Post-Apartheid Planning Evolution in South Africa

Source: Own Construction (2017)

3.2 The South African planning model

It's been twenty-three years since the end of apartheid but various spatial challenges are still a reality of most South African environments. The enactment of SPLUMA introduced some new requirements to address the challenges from the past. Although many efforts are being made to address the imbalances of the past, many issues are still evident. Historic and economic antecedents of homelessness and unemployment have resulted in spaces of decadence and poverty which, in the postmodern urban structure, is being characterised by crime, a collapse of social morals and general urban decay (Donaldson, 2001). Many efforts are being made to revise the central business districts within South Africa through the implementation of Urban Regeneration Strategies and Plans, but it is not yet fully realised in practice.

The demarcation of 2000 implied that planning had to be extended well beyond the current boundaries of our cities, towns and rural areas. With the enactment of SPLUMA it further implied that more detailed planning was required with emphasis on rural incremental areas within South Africa. New planning requirements were now crucial in the compilation of both Spatial Development Frameworks and Land Use Schemes.

The effects of apartheid are however still evident today and unlikely to be fully rectified in the future. Figure 3-3 illustrates a modified model of Davies and Simon's apartheid models. One of the changes observed by Simon (1989:194-196), was the movement of development away from the CBD. This is still evident today, even though many efforts are being made in terms of urban regeneration strategies. Townships together with informal settlements are still located on the urban edges in close proximity to industrial areas. With distance from the CBD, the age of housing decreases. The neighbourhood nodes were established consisting of a mixture of middle to high-income groups. These neighbourhood nodes consist of some older houses and complexes. With more distance from the CBD, shopping centres and other business activities are located in close proximity to the middle and high-income groups, establishing new nodes. Figure 3-3 illustrates a model of the current shape of cities, towns and villages in South Africa.

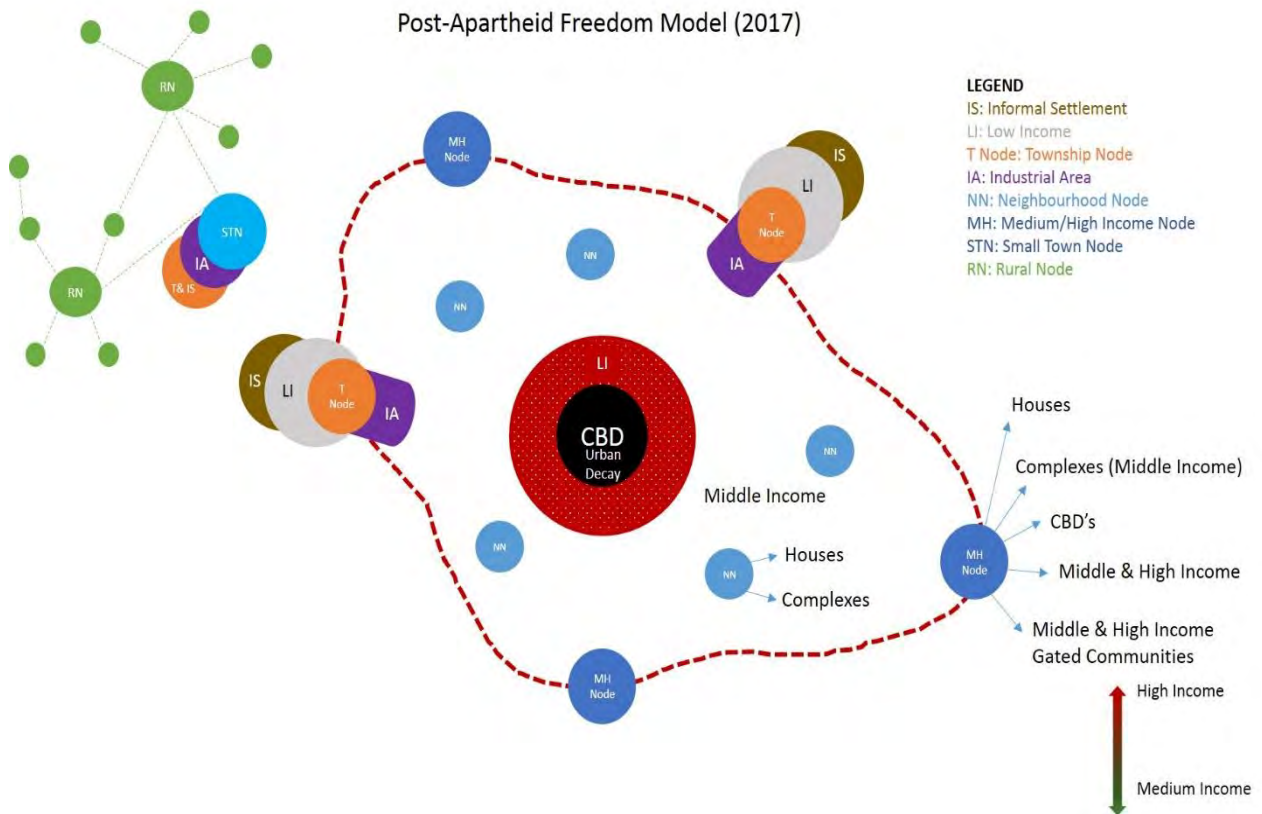


FIGURE 3-3: POST-APARTHEID FREEDOM MODEL

Source: Own Construction (2017)

The post-apartheid model has been widely reshaped by the introduction of gated communities in South Africa. Driven from a safety perspective, gated communities has various spatial impacts on urban and rural growth, some positive and others negative. According to Moneybags (2014), gated communities contributes to added safety (Gated communities also aid safety measures for the neighbourhood. The body corporate can erect speed bumps and enforce lower-than-typical speeds as measures for residents' safety), higher property values (The gates and fences of an estate provide the perception of security, safety and privacy – and in affluent neighbourhoods, privacy means exclusivity and thus higher property values), cost sharing (There are many items some property owners might be unable to afford individually, but in pooling resources and opting for a communal living they then become accessible to them), community cohesion (Estate living can foster a sense of togetherness, a feeling of unity and the unspoken understanding that neighbours will look out for each other), Enhanced status (Everyone wants to feel proud of their home and many use it as a status symbol. A gated community can offer prestige akin to a private club where access privileges are required), and modern touch (Gated communities may also offer buyers the opportunity to purchase a more modern home than those found in established areas,

simply because the homes found in those communities are newer than the freestanding ones in the neighbourhood).

Gated communities however, has become part of the problem and not the solution to spatial planning. It has tremendous implications with regard to spatial growth, some of which are; the transformation of open space to close space, which has an impact in terms of integration and accessibility (Landman & Badenhorst, 2012). According to Landman & Badenhorst (2012), as soon as an enclosed neighbourhood has been implemented or erected, visible fragmentation occurs in the form of road closures. Referring to Figure 3-3, enclosed neighbourhoods are located in the neighbourhood nodes (NN) and medium/high income nodes (MH). These road closures cause many problems in terms of access and traffic congestion on main arterials.

Gated estates are mostly located on the outskirts of the urban edges, with the majority of these estates catering for the higher income groups. In other cases, the rapid rate of development has impacted on service delivery (Landman & Badenhorst, 2012). If growth occurs at a rapid pace, the existing infrastructure cannot accommodate the growth. This has resulted in severe traffic congestion and lack of water and electricity supply (Landman & Badenhorst, 2012). According to Fabiyi (2006), enclosed neighbourhoods hamper social integration as gates are erected around an existing neighbourhood of homogeneous households to exclude “others” and maintain the “integrity” of the neighbourhood. This is a way of reinforcing apartheid or segregation, not so much in terms of race, but specifically in terms of economic class (Béni-Gbaffou, 2007).

The incremental rural areas are located away from towns. Some areas under traditional leadership have developed in such a manner, that it serves the same function of an urbanised area in terms of the establishment of activity nodes and the formalisation of stands. Many issues however, exist in incremental rural areas such as access to basic services and employment opportunities. Although Spatial Developments Frameworks are trying to rectify the gap between urban and rural areas, the footprint of the previous apartheid model is still evident and unlikely to disappear in the near future. The objective of integrated planning has to be supported with urban and rural growth strategies that could be supported with adequate modelling of spatial patterns. However, current planning challenges should be identified in an attempt to consider such as part of future planning solutions.

3.3 Current planning challenges

The relationship between strategic planning and the preparation of land-use schemes is central to integrative planning and ensuring effective decision-making regarding land use management and development control (Newcastle Local Municipality, 2016:26). The objective of aligning an IDP, SDF and LUS is to ensure that land use decisions do not contradict strategic and spatial planning goals (Newcastle Local Municipality, 2016:26). In practice however, there are inconsistencies with the alignment process, giving rise to the first challenge namely, alignment. SDF's are sometimes completed before the compilation of the Land Use Scheme. If the SDF is completed before the Land Use Scheme, it means the SDF will not be aligned with Land Use Scheme as the Scheme may identify newly approved layouts, land uses and zonings, which might affect any spatial proposals made within the SDF.

It is therefore crucial that the IDP, SDF and Land Use Scheme process are interlinked to ensure efficient planning. The second challenge at hand is to address the spatial imbalances of the past. The enactment of SPLUMA set new requirements where Planners are now required to analyse the existing spatial form of the city; apply structuring and restructuring elements and tools; and decide on the future spatial structure of the city. SPLUMA further introduced new requirements for municipal level planning, such as to clearly define who and what are being planned for; spatially identify "WHERE" and "WHEN" development will occur; link future development needs with infrastructure requirements; determine who will be responsible for implementing proposals; and spatially determine where investment should take place through a Capital Expenditure Framework.

Although SPLUMA clearly defines what is required in terms of spatial planning for the future, it is by no means an easy task at hand, as urban and rural growth systems are a complex phenomenon in South Africa. It is therefore, crucial to understand the complexities of urban and rural growth and the impact thereof. Chapter 4 deals with the complexities of urban and rural growth systems.

The complexity and driving forces of urban and rural growth in South Africa

4. Introduction

To fully understand the complexity of urban and rural growth in South Africa, it is necessary to consider the heterogeneous factors that drive growth. Urban and rural growth is influenced by many factors that fall into the broad realms of socioeconomic, social considerations, environmental, spatial and physical factors. It should be noted that not all urban and rural growth driving factors are applicable to all urban and rural areas. Planning is context-based and the wide disparities between urban and rural areas should be acknowledged when considering the factors that drive urban and rural growth. The figure depicted below summarises the broad contents of Chapter 4.

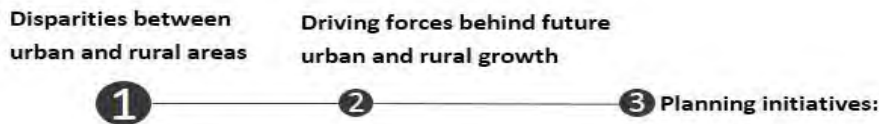


FIGURE 4-1: THE COMPLEXITY OF URBAN AND RURAL GROWTH

Source: Own Construction (2017)

4.1 The wide disparities between urban and rural areas

Urban and rural settlements are defined differently all over the world. Some categorise urban and rural settlements mainly in terms of population size, where the urban population is largely thought of more as non-agriculture than urban. The sole difference between urban and rural areas is usually a higher standard of living (UN, 2017). This distinction however, has become blurred in many industrialised countries and the sole difference between urban and rural areas are, in terms of the degree of the concentration of the population (UN, 2017). Figure 4-2 and Figure 4-3 illustrate some of the different types of settlements and areas within South Africa.

● Urban Area	<ul style="list-style-type: none"> • Urban formal • Informal Settlements
● Urban formal	<ul style="list-style-type: none"> • Formally proclaimed areas
● Informal Settlements	<ul style="list-style-type: none"> • Within urban areas • Not formally proclaimed areas (illegal occupation)
● Farms (Agricultural land)	<ul style="list-style-type: none"> • Agricultural Land – outskirts of urban area • Include agricultural holdings • Incremental role with regard to rural villages
● Rural Villages (Incremental areas)	<ul style="list-style-type: none"> • Traditional Authorities discourage informal settlements • Incremental role of agricultural Land

FIGURE 4-2: SETTLEMENT TYPES

Source: Own Construction (2017)






Type	Example	Definition
Urban Area		<p><i>"A continuously built-up area with characteristics such as the type of economic activity and land use. Cities, towns, townships, suburbs, etc. are typical urban areas".</i></p> <p>Source: (StatsSA, 2011)</p>
Urban Formal		<p><i>"Urban settlements (formal) occur on land that has been proclaimed as residential. A formal urban settlement is usually structured and organised. Plots or erven make up a formal and permanent arrangement. A local council or district council control development in these areas. Services such as water, sewage, electricity and refuse removal are provided; roads are formally planned and maintained by the council. This includes suburbs and townships".</i></p> <p>Source: (StatsSA, 2011)</p>
Informal Settlements		<p><i>"unplanned settlements and areas where housing is not in compliance with current planning and building regulations (unauthorized housing)".</i></p> <p>Source: (OECD, 1997)</p>
Farms (Agricultural land)		<p><i>"Farm: means a portion of land identified and described as such on a diagram in terms of the Land Survey Act, 1997, (Act No. 8 of 1997), and includes a portion of a farm similarly identified".</i></p> <p><i>"Agriculture: means the cultivation and/or utilisation of land for crops and plants, the keeping and breeding of animals, operation of a game farm, the utilisation of the natural veld or land on a limited or extensive basis and includes only such activities and buildings directly related to the main farming activities, but excludes abattoirs, intensive feed farming, agricultural industries and consent uses as defined".</i> Source: (CALLM, 2017)</p>
Rural Villages (Incremental Areas)		<p><i>"A settlement in a tribal area. A village has delimits (boundaries), which encompass not only populated areas, but also agricultural areas, e.g. grazing land, crop land or forested land. Villages are usually under the jurisdiction of tribal authorities, headed by chiefs, while sub-chiefs are direct principals of villages".</i></p> <p>Source: (StatsSA, 2001)</p>

FIGURE 4-3: CATEGORIES OF SETTLEMENTS

Source: Adapted from Du Toit (2008); Bradshaw (2017); Pinchuck & McCrea (2002); OECD (1997); CALLM (2017); HOFINET (2007); Zondo (2014); StatsSA (2001)

Urban development's trends with regard to the built environment, the urban and the provision of services can be scrutinised with the formal-informal continuum (UN-Habitat, 2009). Formal urban developments are those that go along with the purview of a state land administration system and complies with legal and regulatory requirements, while informal urban developments do not comply with one or another requirement (UN-Habitat, 2009).

In terms of future spatial modelling, it is important to distinguish between formal and informal, as well as urban and rural areas, because of disparities relating to commonage, income levels, the ability of citizens to pay for municipal services, etc. For statistical purposes, StatsSA classified urban and rural areas into the broad categories depicted in Table 4-1 (StatsSA, 2011a). Since the 2001 census, the categories have been reworked into new categories.

TABLE 4-1: STATSSA RECLASSIFICATION OF URBAN/RURAL CLASSIFICATIONS

Urban/ Rural	2001 Geography Type	2001: EA Type	1996 EA Type	2011 Type
Urban	Urban Formal	9 Hostel	13 Urban: hostels 23 Semi-urban: hostels	Urban Formal
		7 Industrial Area	14 Urban: institutions 24 Semi-urban: institutions	
		8 Institution	14 Urban: institutions 24 Semi-urban: institutions	
		6 Recreational	14 Urban: institutions 24 Semi-urban: institutions	
		3 Small Holding	31 Rural: formal	
		4 Urban Settlement	11: Urban: formal 21 Semi-urban: formal	
		0 Vacant	31 Rural: formal	

Urban/ Rural	2001 Geography Type	2001: EA Type	1996 EA Type	2011 Type
Rural	Urban Informal	5 Informal Settlement	12 Urban: informal 22 Semi-urban: informal 32 Rural: formal/semi-formal	Urban Informal
	Rural Formal	2 Farm 9 Hostel 7 Industrial Area 8 Institution 6 Recreational 3 Small Holding	37 Rural: farms 35 Rural: hostels 36 Rural: institutions 36 Rural: institutions 36 Rural: institutions	Commercial Farms
	Tribal Area	9 Hostel 7 Industrial Area 8 Institution 6 Recreational 1 Tribal Settlement 0 Vacant	36 Rural: institutions 36 Rural: institutions 36 Rural: institutions 36 Rural: institutions 33 Rural: tribal villages 34 Rural: informal 38 Rural: tribal exc. village	Tribal Area

Source: Adapted from StatsSA (2001); StatsSA (2011a)

There are some disparities between rural and urban areas in South Africa. Some municipalities hold the status of a more formal municipality while others are more rural. In some instances, a municipality can consist of a mixture of urban and rural areas. Some examples are listed in Table 4-2.

TABLE 4-2: EXAMPLES OF URBAN AND RURAL AREAS

Municipality	Location	Type of Municipality (Rural/Formal)
Moretele LM	North West Province	Rural
Kgetlengrivier LM	North West Province	Formal
Chief Albert Luthuli LM	Mpumalanga Province	Rural/Formal

Source: Own Construction (2017)

Table 4-3 and Figure 4-4 depict three different examples of rural areas in South Africa, either similarities or disparities.

TABLE 4-3: SIMILARITIES AND DISPARITIES BETWEEN RURAL AREAS IN SOUTH AFRICA

	Province	Municipality	Similarity or disparity
1	North West Province	Ratlou LM	Agricultural land inside settlement
2	Limpopo Province:	Lephalale LM	Agricultural Land outside settlements
3	Mpumalanga	Chief Albert Luthuli LM	Central Business Activities and formalised areas

Source: Own Construction (2017)

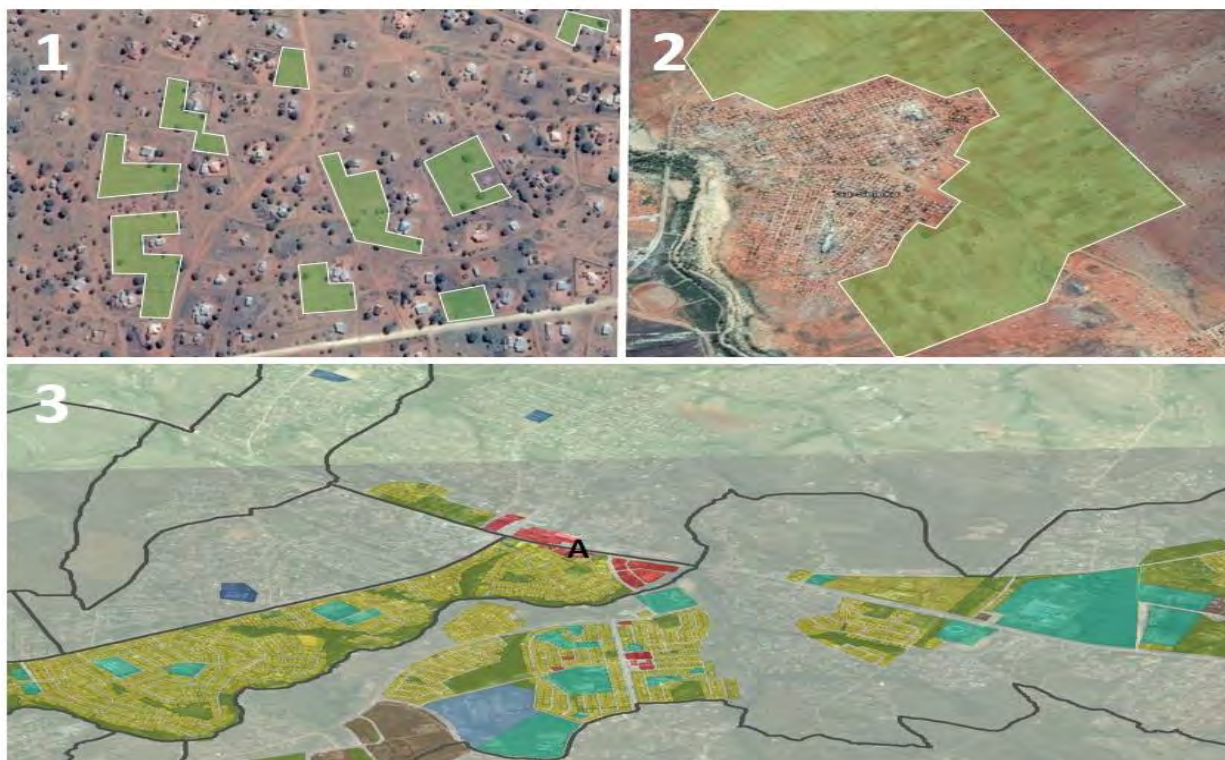


FIGURE 4-4: SIMILARITIES AND DISPARITIES BETWEEN RURAL AREAS IN SOUTH AFRICA

Source: Adapted from AfriGIS (2017); CALLM (2017)

From the figures above it is evident that settlements differ in terms of location and certain aspects. Example 1 and 2 from Figure 4-4, illustrate agricultural activities being practised either inside or outside the settlement. Some rural areas have formalised areas such as for example 3. The areas in colour illustrated in example 3, represent formalised areas, while the surrounding areas have not yet been formalised. The area depicted in red (A) illustrates the CBD area of the settlement Elukwatini. A similarity between all settlements regardless of size is that each settlement serves a certain function.

Employment opportunities are limited within rural communities, which means citizens seek employment opportunities in more urbanised areas. The movement from citizens away from rural settlements to more urbanised areas are putting a strain on the provision of housing. This causes informal settlements to establish on the urban edges of cities and towns. In rural communities, informal settlements are discouraged by traditional authorities. According to Fekade (2000), informal settlements may bear attributes like the illegal occupation of land, non-adherence to building codes and infrastructure standards, or both illegality of land and nonconformity to building standards and codes.

Fekade (2000), describes that informal settlements do not follow a linear development pattern but explode at a certain stage of their development lifetime. According to Fekade (2000), this leads to the three phases of informal settlement growth.

- Infancy/starting stage: At this stage land (e.g. agricultural land) is converted to residential use by low income households. The layout is depicted as scattered.
- Booming/consolidation stage: This stage comes into being by the urban critical mass after collective expansion. At this stage middle-income group is also attracted and housing construction would be heightened till no more vacant land is available.
- Saturation stage: This is the stage whereby additional construction is primarily entertained through vertical densification.

The spatial character of informal settlement growth consists of:

- Expansion: Conceptually informal settlement expansion can be achieved in three forms: inward, outwards or independent from a known boundary of an existing settlement.
- Densification: Densification refers to infilling of empty spaces by building structures built within the realm of an existing settlement (Timothy, 1995)
- Intensification: Intensification refers to the vertical increment of built-up structures

Figure 4-5 illustrates these spatial characters.

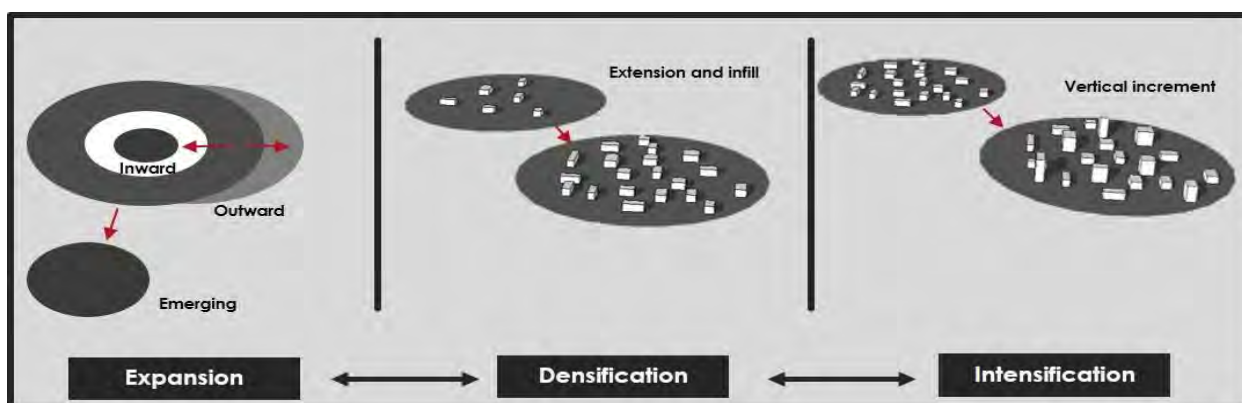


FIGURE 4-5: SPATIAL CHARACTERS OF INFORMAL SETTLEMENTS

Source: Own construction (2016)

Land allocation processes is another challenge when considering urban and rural growth modelling, as the majority of rural areas in South Africa fall within the jurisdiction of traditional leadership. Many kinds of literature exist with referral to the role of traditional authorities within South Africa. The role of traditional leaders however remains a controversial issue. According to

O'Malley (2007), the homelands system lay at the heart of the National Party (NP) government's policy of territorial and political separation based on race. Long before the NP's election victory in 1948, legislation had been enacted to lay the groundwork for the development of the homelands (O'Malley, 2007). This included the Natives Act, Act 27 of 1913 and the Land Act, Act 18 of 1936.

The enactment of the Black Land Act, Act 27 of 1913, set the wheels in motion for segregation policies pertaining to land ownership and occupation. The Native Affairs Act, Act 23 of 1920 was yet another piece of legislation by the South African Native Affairs Commission report of 1905. It paved the way for the creation of a countrywide system of tribally based occupation. According to O'Malley (2007), the Bantu Authorities Act, Act 68 of 1951 was passed in the early 1950s, increasing the powers of traditional authorities in preparation for self-governance, and in 1959, the Promotion of Bantu Self-Government Act, Act 46 of 1959, provided the legislative basis for the future homelands. In an attempt to further understand the disparities between urban and rural areas, the driving factors of urban and rural growth were considered.

4.2 Driving forces of urban and rural growth

Many factors influence future urban and rural growth. Before any decisions can be made with regard to future spatial planning it is important to understand all the drivers of urban and rural growth and the impact thereof. Figure 4-6 illustrates the driving forces of urban and rural growth, which will be discussed in the following section. The four main categories that drive growth in urban and rural areas have been identified namely, socio-economic, physical, environmental and social change factors.

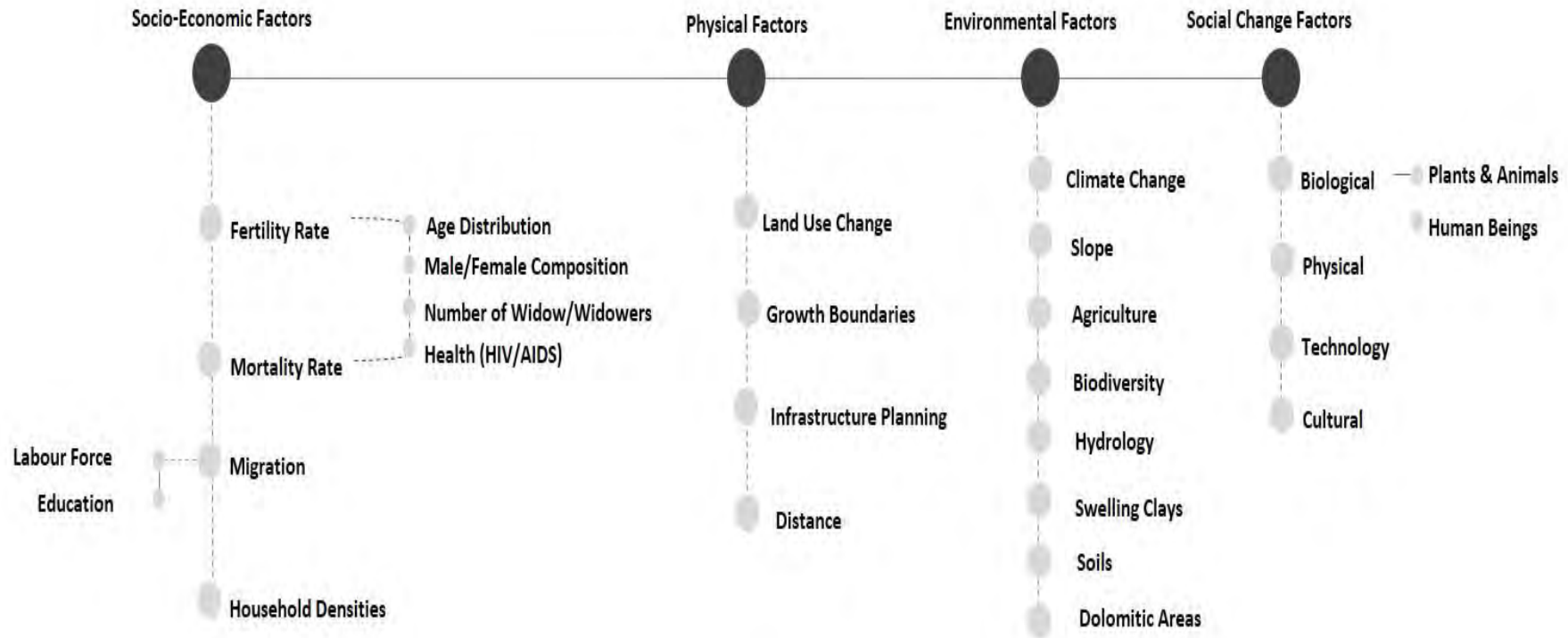


FIGURE 4-6: URBAN AND RURAL GROWTH FACTOR

Source: Own Construction (2017)

4.2.1 Socio-Economic Factors

The sole purpose of the economic factors discussed in this section is to identify the statistical information required to assist spatial planners to make more appropriate assumptions with regard to future population and household projections. The information is also a necessity for urban and rural growth modelling. Some methods to calculate future population and household sizes are also illustrated. To illustrate the availability of statistical information, the statistical information used in the study were sourced from StatsSa (2011), StatsSa community survey (2016) and Quantic Easy Data (Quantec, 2017). According to StatsSA (2016), the 2016 community survey was the second largest survey undertaken since the survey in 2007. The survey was one of the main data sources that provide indicators at National, Provincial and Municipal level for planning and monitoring the performance of specific development programmes (StatsSA., 2016). The last census from StatsSA occurred in 2011. Which means the gap in terms of statistical reliability could be questioned. Fortunately, Quantec updates statistical information on a quarterly basis. Quantec utilises StatsSA statistics and update the statistics based on quarterly surveys compiled. Although Statistics South Africa's data is available on seven levels (refer to Figure 4-7), not all the statistical information is available on a more detailed level such as sub place and small area level, which could pose as a limitation in terms of detailed planning.

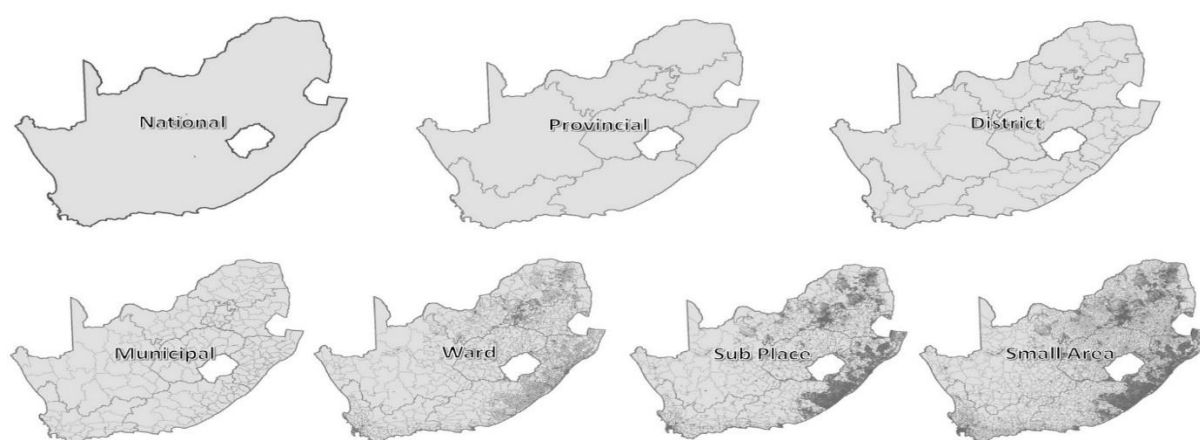


FIGURE 4-7: DIFFERENT LEVELS OF DATA AVAILABILITY

Source: MDB (2016)

As previously mentioned, in many aspects land use change and transportation systems can be regarded as two of the most important factors influencing urban and rural growth however, the main factors influencing population and household growth are fertility, mortality and the migration rates. In this section, the fundamental factors of growth will be discussed, relating to socio-economic factors, as illustrated in Figure 4-8.

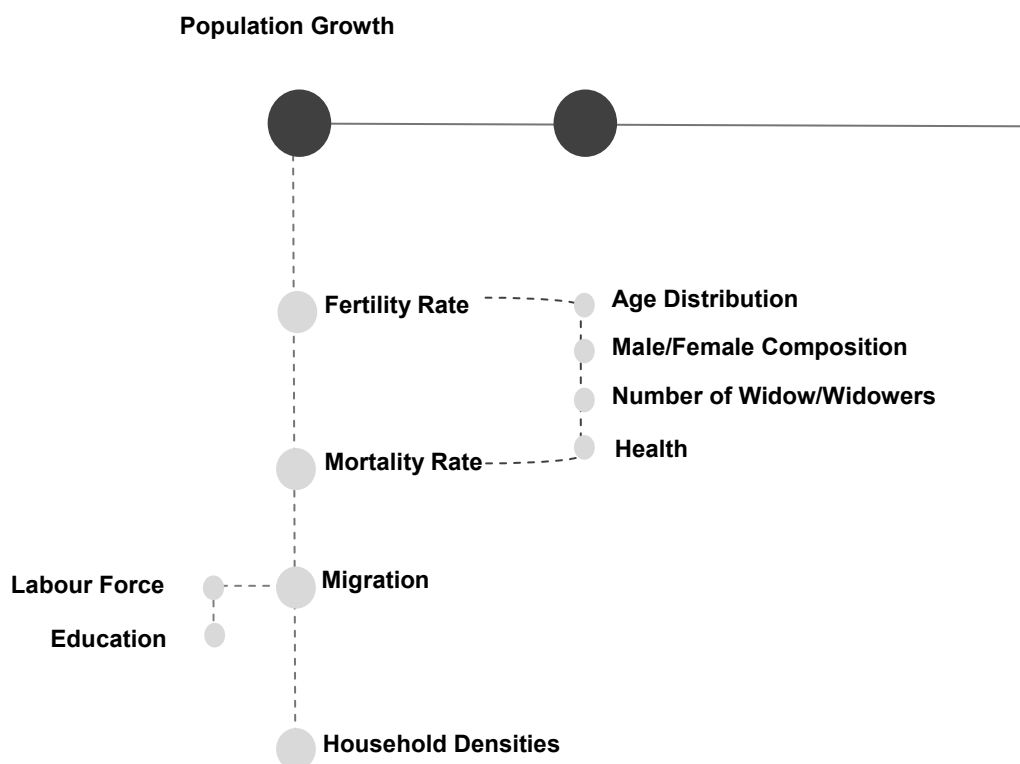


FIGURE 4-8: SOCIO-ECONOMIC FACTORS

Source: Own Construction (2017)

4.2.1.1 Population Growth

Urbanisation is causing considerable changes and opportunities for various income-levels in South Africa. According to Turok & Borel-Saladin (2014), attitudes towards urbanisation in South Africa are particularly complicated and equivocal due to the legacy of institutionalised racism, urban exclusion and rural deprivation. Pent-up migratory pressures were released when apartheid ended, but it left deep social inequalities and shortages of land and housing (NPC, 2012; Turok, 2014a). South Africa's population has accelerated since the removal of the apartheid regime. This is precipitating many negative impacts especially on housing delivery and the unemployment rate. The population figures for South Africa is depicted in Figure 4-9.

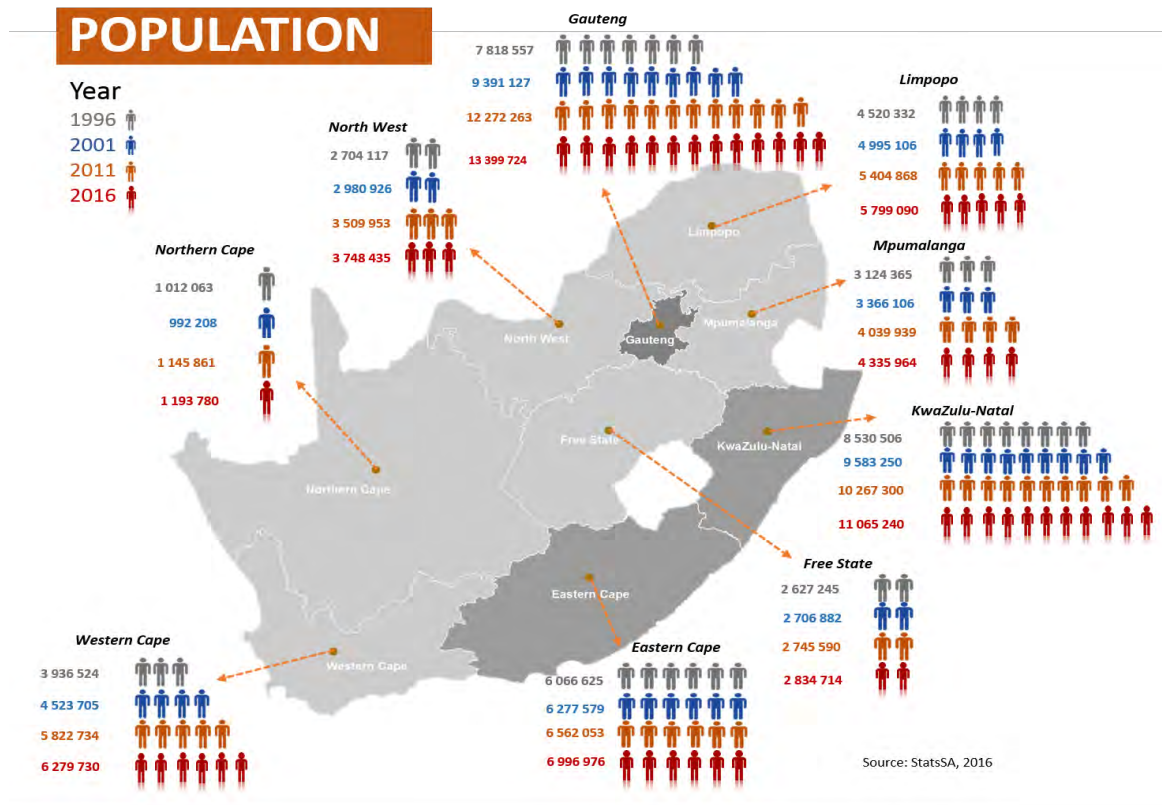


FIGURE 4-9: SOUTH AFRICAN POPULATION

Source: Adapted from Quantec (2013); StatsSA (2016)

The province with the highest population is the Gauteng Province, followed by KwaZulu-Natal, the Eastern Cape and the Western Cape. The Gauteng province covers the smallest land area of all the provinces within the Country. Gauteng was built on the wealth of gold found deep underground (Alexander, 2017). Although densely populated, the Gauteng province only covers a small percentage of rural areas under traditional leadership. What makes the province favourable is the employment opportunities it entails.

There are various mathematical calculations available to calculate future population change and growth. The accuracy however, will always be based on certain physical factors and assumptions. The following three excel based calculations can be used to predict future populations.

- Growth and Exponential Lines
- Forecast and Linear Lines
- Linest and Logarithmic Lines

Firstly a distinction has to be made between the difference of linear, exponential and logarithmic growth. According to Noujeim (2015), linear growth involves a quantity increasing with another

variable in a relation represented by a straight line on a graph. Exponential growth is common in physical processes such as population growth in the absence of predators or resource restrictions, where a slightly more general form is known as the law of growth (Noujeim, 2015). Logarithmic growth increases quickly in the beginning, but the gains decrease and become more difficult as time goes on (Clear, 2017). Figure 4-10 illustrates the difference between linear, exponential and logarithmic growth. Exponential growth is depicted in blue, linear growth in red and logarithmic growth in green.

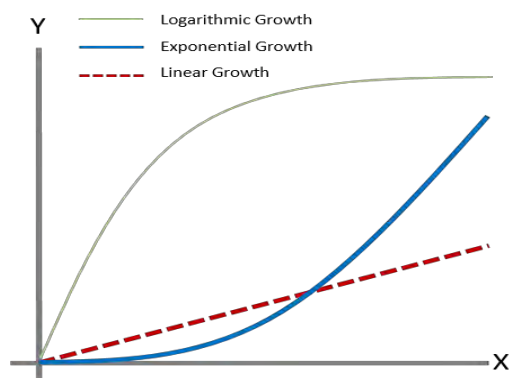


FIGURE 4-10: EXPONENTIAL AND LINEAR GROWTH

Source: Own Construction (2017)

The following calculations are examples of linear, exponential and logarithmic growth. The example illustrated below depicts a population of a given area over time. The objective was to calculate the population for the year 2018 using the three different mathematical approaches.

TABLE 4-4: POPULATION CALCULATIONS

Example			Formula's
	A	B	Growth and Exponential Lines
1	Year	Population	Formula: = GROWTH(known Y's, known x's, new x's)
2	2005	12 304	Where known Y's: B2:B14
3	2006	13 460	Known x's: A2:A14
4	2007	13 987	New x's: A15
5	2008	15 670	

6	2009	16 340	Forecast and Linear Lines	
7	2010	16 897	Formula: = FORECAST(x, known Y's, known x's)	
8	2011	17 580	Where x: A15	
9	2012	18 213	Known Y's: B2:B14 Known x's: A2:A14 new x's: A15 Linest and Logarithmic Lines Formula: $y=c*LN(x)+b$ Formula C = INDEX(LINEST(known y's, LN (known x's)), 1) Where known Y's: B2:B14 Known x's: A2:A14 Formula: $b = INDEX(LINEST(known y's, LN (known x's)),1, 2)$ Where known Y's: B2:B14 Known x's: A2:A14	
10	2013	19 679	Results:	
11	2014	21 003	Growth and Exponential Lines	25 355
12	2015	21 690	Forecast and Linear Lines	24 345
13	2016	22 318	Linest and Logarithmic Lines C	1 848 970
14	2017	23 678	Linest and Logarithmic Lines B	-14 046 073
15	2018	?	Linest and Logarithmic Lines	24 337

Source: Own Construction (2017)

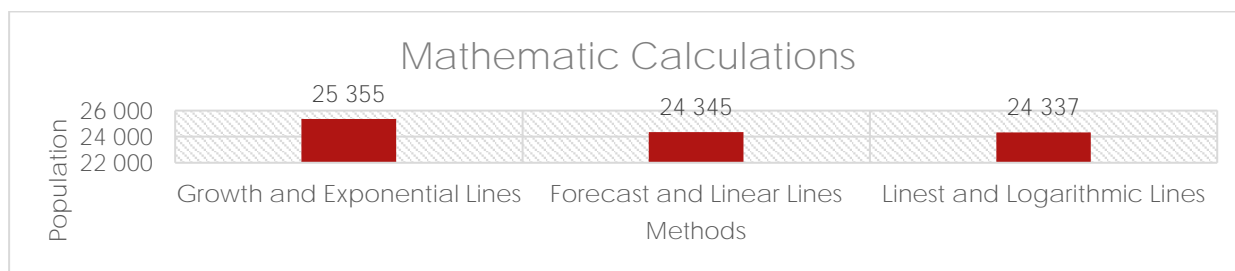


FIGURE 4-11: MATHEMATICAL CALCULATIONS

Source: Own Construction (2017)

From the results above it is evident that that linear and logarithmic lines calculated to similar results. Although the methods above can be used to calculate population growth, caution should be taken. The results of linear and exponential growth will always depict an increase in population growth, which in fact will not always be the case. Many factors can hamper population growth. Another method which can be used to determine future population and household figures is to use the growth rate from the municipality with regard to previous years (CALLM, 2016:115). This method is based on previous growth rates and will always rely on statistical availability. Table 4-5 illustrates the method used to calculate the additional year's population.

TABLE 4-5: POPULATION GROWTH CALCULATION

Year	Population	Formula	Calculation
2011	213 786	Growth rate = $((Ply - Ppy) / Ppy) / (Ly - Py)$	Growth rate =
2012	216 567	Where:	$((223\ 312 - 213\ 786) /$
2013	217 655	Ply: Population of latest year	$213\ 786) / (2017 -$
2014	218 899	Ppy: Population of previous year	$2011)) * 100$
2015	221 786	Ly: Latest year	= 0.9%
2016	223 312	Py: Previous year	Population = $223\ 312$
2017	?	Population = $Ply * (1 + \text{growth rate})$	$* (1 + 0.9\%)$
			= 225 302

Source: Own Construction (2017)

The methods and calculation above are examples of some calculations which can be used to predict future populations or household figures. The three main factors influencing population

growth however, are fertility, mortality, and migration factors (Population Reference Bureau, 2001). According to StatsSA (2016:46), demographic information constitutes the foundation of all socio-economic planning and as such national development priorities can only be realised with an understanding of demographic phenomena i.e. mortality, fertility and migration. The demographical phenomena's will now be discussed.

4.2.1.2 Fertility Rate and Mortality Rates

According to Norville et al. (2003), there has been a shift in behaviour in many societies due to many factors such as: postponement of marriage, increasing age of first birth, increasing divorce rates, lower marriage rates, more births outside marriage, an increasing number of women in the labour force, greater levels of education for women, a decreasing need for children to support elderly parents, a shift from rural to urban societies and government programs to encourage or discourage having children.

Mortality rate is one of the influential factors that have an impact on population and household growth. Mortality rates can be influenced by numerous factors or events. In some instances there has been considerable volatility in mortality trends, mainly because of war and natural disasters however, in the case of South Africa, war has not played a major role in mortality rates. In South Africa, mortality rates are mainly influenced by natural disasters, murder, health and vehicular deaths. Natural disasters, murder and vehicular deaths aside, the single most important factor that could shift the trajectory of life expectancy would appear to be medical progress (OECD, 2011). A factor contributing to the mortality rate in terms of health is, Human Immunodeficiency Virus (HIV). HIV has had a profound impact on population figures in South Africa.

The crude birth rate (CBR) and crude death rate (CDR) is important figures used to calculate future populations. CBR and CDR are usually expressed as the number of births or deaths per 1000 people in a given population, which allows geographers to compare population dynamics in countries with different population sizes (AAG, 2011). The number of births and deaths per annum can also be used to calculate the rate of natural increase (NRI), which describes the percentage annual growth of a population (AAG, 2011).

According to AAG (2011), the Rate of Natural Increase can be calculated using the following formula: *Birthrate/1000 population = Births per year/Total Population *1000*

$$\text{Death Rate/1000 population} = \text{Deaths per year/Total Population} * 1000$$

$$\text{RNI} = (\text{CBR} - \text{CDR}) * 10$$

The age and sex structure of a population are affected by the changes in the population (StatsSA, 2015). According to StatsSA (2015), these changes could be brought by migration, fertility or mortality. The aspect of age composition is briefly discussed below.

4.2.1.3 Age composition

The demographic transition associated with declining or inclining fertility and mortality levels is causing unprecedented changes in population age structures around the world (UNDESA, 2013:47). An inevitable consequence of the demographic transition resulting from fertility decline and increased longevity is population ageing, is the process by which older individuals become a proportionally larger share of the total population (UNDESA, 2013:47). According to UNDESA (2013:47), population ageing has a profound impact on various economic, political and social conditions through such factors as economic growth, savings and investment, labour supply and employment, pension schemes, health and long-term care, intergenerational transfers, family composition and living arrangements. Another influential factor that affects population and household figures are widow and widowers composition.

4.2.1.4 Widow and widower's composition

According to Servak et al. (2004), widowhood remains an important risk factor for the transition into poverty, especially households headed by elderly women. Servak et. al. (2004), states that faced with the loss of resources in widowhood, women have few options available to improve their economic status. According to the Government of India (2011:11), the classification of rural/urban, sex and marital status by age unveils the characteristics of population composition and provides disaggregated data for target-oriented projects. Male and female composition is also an important factor of population and household growth.

4.2.1.5 Male/Female composition

Male and female composition plays an integral role in urban and rural growth, especially within the economic sector. As mentioned in the marital status section it unveils the characteristics of population composition. According to the World Bank (2012:239), men's and women's jobs differ greatly and the change in the structure of employment brought about by economic development are not enough to eliminate employment segregation by gender. Women tend to bear a disproportionate share of house and care responsibilities (World Bank, 2012:239). Social norms around the role of women in the household and society also influence these trade-offs. Women are thus more likely to value flexible work arrangements and to supply fewer hours of market work on average than men, putting them at risk of being channelled into lower-quality jobs. Apart from

fertility and mortality rates, migration is also a fundamental factor of population change. The importance of migration patterns will now be discussed.

4.2.1.6 Immigration and internal migration

According to StatsSA (2016:24), migration can be defined as “a change in a person’s permanent or usual place of residence”. In the case of South Africa, research has anecdotally reported more immigration numbers relative to emigration ones (StatsSA, 2016:24). Since the end of apartheid, there has been an influx of citizens from neighbouring African countries, all for the same reason namely, the expectation of an improved living standard. South Africa also shows some internal migration patterns. This phenomenon may also involve neighbouring African nationals who settle for seasonal work in the country and return back to their countries of origin when such work is no longer available or is completed (StatsSA, 2016:28). The immigration numbers in South Africa has dropped dramatically since 2015 (StatsSA, 2016). This may be the result of seasonal workers as well as xenophobic attacks. The formula as illustrated as an example in Table 4-6, are based on a combination of factors influencing population and household growth. The calculation is based on fertility, mortality and migration patterns.

TABLE 4-6: POPULATION GROWTH BASED ON FERTILITY, MORTALITY AND MIGRATION PATTERNS

Categories	Specific year	Formula and Calculation
Population	142 786	Population change = (Births - Deaths) + (Immigrants -Emigrants)
Births	3 987	$P_t = P_0 + (B - D) + (I - E)$
Deaths	1 234	
Immigration	2 138	Where: P_0 = initial population
Emmigration	550	P_t (2017) = population after time t
Migration	1 467	$P_t = 142\,786 + (3\,987 - 1\,234) + (2\,138 - 550)$
		$P_t = 147\,127$

Source: Adapted from Jarabi (2012)

Although fertility, mortality and migration are regarded as the three main factors that determine population growth, many other subfactors also influence population growth estimates, with the

majority being the reason why migration is taking place. These factors include, level of education, labour force and better health facilities.

4.2.1.7 Education

The major overhaul of the educational sector in South Africa took place between 1994 and 2016 (StatsSA, 2016:38). Education plays an important interlinked role in future urban and rural growth patterns. Many factors are influenced by education for example, the level of education will determine whether or not a person is employed or unemployed. Family life and structures are affected by education in many ways, most importantly perhaps by delaying the age of when families are started (OECD, 2011:19). Education also influences the age at which young people begin to work and become independent from the family home (OECD, 2011:19).

4.2.1.8 Labour Force

According to Kerr et al. (2014), the labour market in South Africa has received considerable scrutiny in the post-apartheid period, partly as a result of the stubbornly high levels of unemployment, poverty and inequality. Turok & Borel-Saladin (2014), argue that the degree of coincidence or mismatch between jobs and population is important for economic efficiency, social equity, ecological impacts and energy consumption from personal travel and other transactions. Access to meaningful employment is vital for income security and material well-being by affording the necessities of life in food, clothing and shelter (Turok & Borel-Saladin, 2014). Household densities and the type of dwelling which citizens live in, is an important aspect of urban and rural growth. The importance of densities and dwelling types will now be discussed.




4.2.1.9 Household Densities and Dwelling Type

Migration from rural to urban areas is causing many new migrants to end up in low-cost or informal areas and slums with attendant environmental concerns (Shackleton et al. 2013). According to Turok & Borel-Saladin (2014), the conditions people live in has a profound effect on their quality of life and vulnerability to flooding, fires, contagious diseases, landslides and other disasters. To ensure the survival, dignity and community stability of households it is important to protect communities from these elements. Future trends in the number of households and dwelling units are critical components in strategic planning for future service delivery in South Africa (Udjo, 2015).

According to DEA (2012), South African settlements are characterized by extreme low densities and sprawl. Low-density sprawl is not limited to urban settlements but also prevalent in rural settlements (DEA, 2012). For example, in uMkhanyakude District in KwaZulu-Natal the population density is less than one person per hectare despite hardly any of the population being involved in

agriculture (DEA, 2012; Umkhanyakude District Municipality, 2011). It is, however, not only the low densities per se that are problematic, but also the distribution of densities. South African settlements are characterised by higher densities located on the outskirts of the settlement (DEA, 2012). The following table depicts some different housing density types in South Africa.

TABLE 4-7: HOUSING DENSITY TYPES

Categories	Description
<p data-bbox="201 573 549 607">Medium to high-income housing</p>  <p data-bbox="344 898 539 920">Source: Digital Globe, 2017</p>	<p data-bbox="619 573 1386 1055">Since the 1990's, South African cities expanded rapidly with medium to higher income housing developments, higher income housing traditionally consisted mostly of single houses on relatively large stands, often in excess of 1,000 m². Currently as discussed in Chapter 3, there is a definite trend towards more compact and dense living with the increase of flats and townhouses. This prevents the recharge of aquifers, increases the run-off of polluted water and potential flooding down-stream, amongst others (DEA, 2012).</p>
<p data-bbox="201 1111 459 1144">Subsidized housing</p>  <p data-bbox="363 1406 560 1429">Source: Digital Globe, 2017</p>	<p data-bbox="619 1111 1386 1447">According to DEA (2012), the change to a democratic government in 1994 brought a subsidized housing programme to address housing demand. The typology of subsidized housing is mostly one house on a plot development and most likely located on the urban periphery far from job opportunities and further contributed to sprawled settlements (Smit et al. 2011).</p>
<p data-bbox="201 1491 421 1525">Informal housing</p>  <p data-bbox="355 1825 552 1848">Source: Digital Globe, 2017</p>	<p data-bbox="619 1491 1386 1928">Informal housing has become a feature of most South African settlements as the population migrates in search of housing, jobs, and education and health facilities (DEA, 2012). According to StatsSA (2010), people living in informal dwellings are more likely to experience hunger, overcrowding and inadequate services. Fires are also a risk to informal dwellings due to high densities. A growing trend is the development of informal and illegal backyard rental units (DEA, 2012).</p>

Source: Adapted from DEA (2012)

Housing types are an important indicator to consider not only to determine what customers should be planned for, but it can also determine the current housing backlog for a municipality. According to Sartorius et al. (2014), household stability in rural South Africa has been influenced by a series of long-term, medium-term and short-term historical legacies such as the 1913 land act which created separate homelands. Sartorius et al. (2014), identified the risk of household stability dissolution. Figure 4-12 depicts the dynamics of household stability.

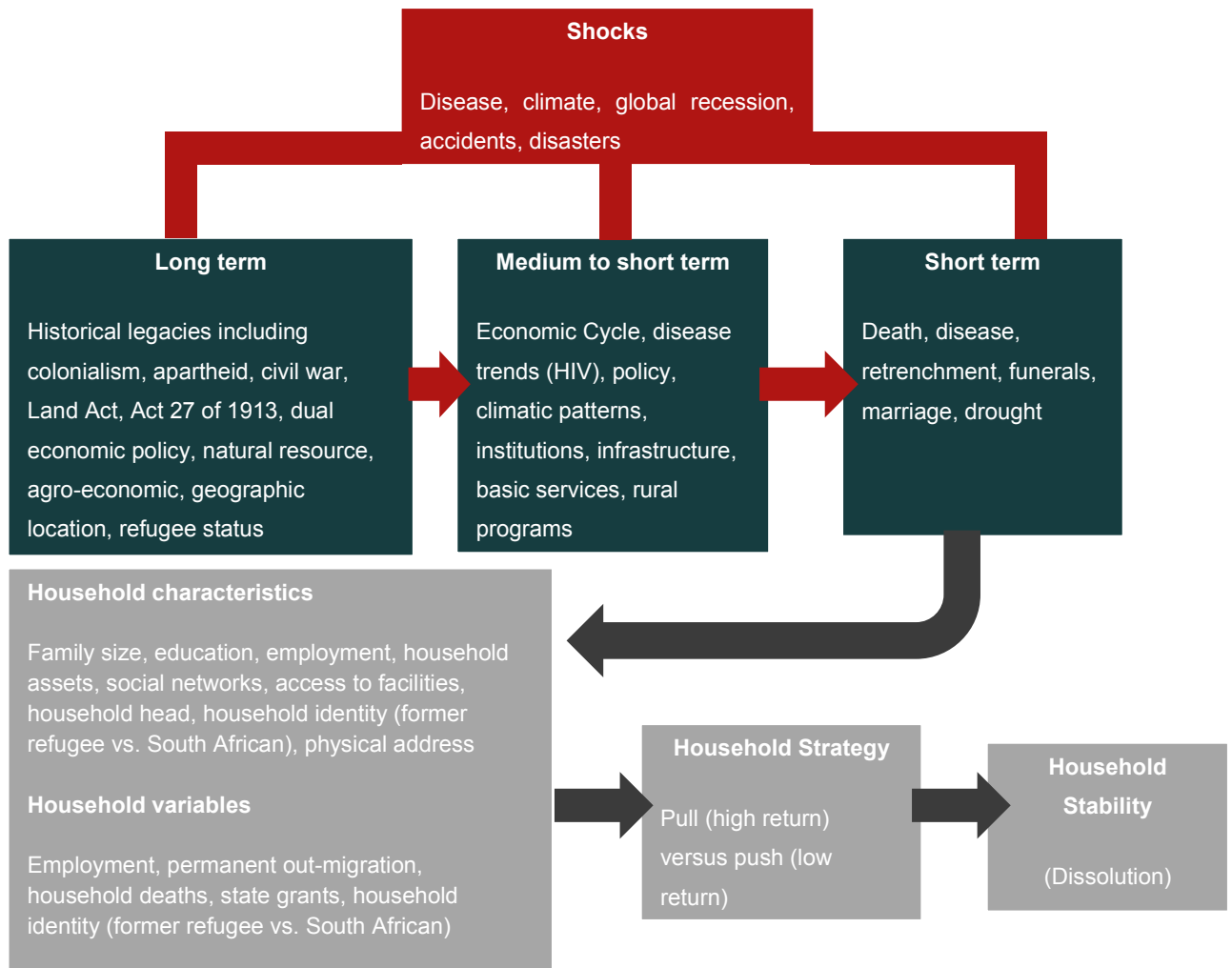


FIGURE 4-12: DYNAMICS OF HOUSEHOLD STABILITY

Source: Adapted from Sartorius et al. (2014)

According to Hosegood et al. (2004), a household dissolution occurs when the household ultimately dissolves because its last member either dies or migrates permanently out of the area. Determining the type of dwelling is a vital part of future population projections and calculations. To ensure pro-active and efficient future planning, it is important to understand for who and what spatial planners are planning for.

4.2.1.10 Conclusion

The accuracy of future population projections lingers on the availability of reliable data. From the factors discussed above, it is evident that population change reflects the interplay between fertility, mortality, and migration factors. Within these three broad categories, many other factors can cause changes in population sizes. All of the factors above should be considered for growth modelling purposes. The next section deals with the physical factors and the impact thereof on future urban and rural growth.

4.2.2 Physical Factors

Physical factors play an incremental role in determining in which direction growth can or cannot occur. The fundamental physical factors of growth will now be discussed, as illustrated in Figure 4-13.

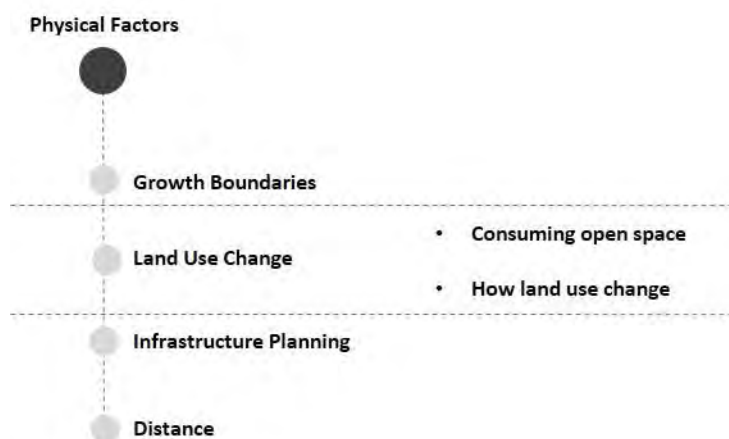


FIGURE 4-13: PHYSICAL FACTORS CONCEPTUAL MODEL

Source: Own Construction (2017)

4.2.2.1 Growth Boundaries

An important aspect of any urban or rural edge is to preserve valuable agricultural land. The agricultural sector in South Africa plays a vital role in South Africa's economy. Although agricultural land is important, there must still be a compromise between agricultural land and potential land for development. Agricultural land cannot restrict development in such a way that development cannot occur. Our cities and town will continue to grow and once all vacant land within our urban and rural boundaries are developed, new land will be required for development. Considering any urban and rural edge, the following factors will have to be considered.

- Environmental Constraints

- Current urban and rural built-up form
- Proposed future projects (e.g Housing projects)
- Current growth rate

SPLUMA requires a SDF to limit urban sprawl and indicate spatial growth and development patterns of a Municipality. The interpretation of SPLUMA suggests that this should be a requirement in SDF's to address the future expansion of urban and rural areas. Densification is an important planning strategy. Growth boundaries can be used as an instrument or tool to manage growth. Growth boundaries are also used to create a distinction between urban, potentially urban, rural villages and agricultural areas (CALLM, 2016).

Chapter 4 (12) (1) (h) of SPLUMA requires the development of any SDF and Land Use Scheme to include the previously disadvantaged areas such as the rural settlements and/or areas under traditional leadership. This means growth boundaries takes a new form. The term "Rural or "incremental" will, thus, also apply to the aforementioned areas. According to Staley et. al. (1999), growth boundaries however, have potentially negative, if unintended, side effects. By reducing the supply of developable land, for example, housing and land prices could increase, reducing housing affordability and production (Staley et al. 1999).

Therefore it is important that local policymakers and citizens need to understand the nature of these trade-offs and the impacts before they adopt any growth boundary. Before considering on a specific urban or rural edge, it is important to consider the growth of a specific area as growth rates differ from area to area. For example, a town with a growth rate of 0.2% is unlikely to experience rapid growth unless a new economic activity establishes itself (e.g. a new mine, power plant or industry). Another key determining factor of urban and rural growth is land use change.

4.2.2.2 Land use change

In general, there are two direct ways a project may affect land use (Schock, 2000:7);

1. By consuming open space
2. By the effect of how land use change

Land is one of the three major factors of production in classical economics (along with labour and capital), and it is a required input for housing and food production (Wu, 2008). Schock (2000), uses the following examples to explain how land use change can occur. A new road may need to be built or an existing one widened, additional housing may be needed for new employees, or other businesses may need to be brought in to support the new development. A new road or other transportation alternatives may open up a new part of town. Or, utility services may expand to

increase the development potential of a specific area. When these factors occur simultaneously, potentially complex situations develop (Schock, 2000). For example, a series of tax incentives and other subsidies may lure a new shopping mall to town. Developers and investors may then decide to build the mall on the outskirts of town because the property is cheaper or other attractive incentives are being offered. The location of businesses away from the urban core results in a loss in the central city’s tax base often leading to urban decay which is evident in the current towns and cities of South Africa.

Furthermore, because the mall is built on the outskirts, agricultural land or other natural resources may be consumed. To accommodate the increased traffic flow and new traffic patterns, the transportation infrastructure would need to be enhanced. These transportation efforts, in turn, could consume more open space and/ or provide pathways to additional land that are more attractive to business and residential developers. As property taxes increase, landowners that generate inadequate revenues (e.g. farmers) may be forced to sell their properties. As discussed above, when one land use change, it can trigger a change in another, creating a rippling effect. There are many impacts of land use change, some which can lead to profound changes. Table 4-8 depicts some of the socio-economic and environmental impacts of land use change.

TABLE 4-8: IMPACTS OF LAND USE CHANGE

Socioeconomic Impacts of Land–Use Changes	Conversion of farmland and forests to urban development reduces the amount of land available for food and timber production
	Soil erosion, salinization, desertification, and other soil degradations associated with agricultural production and deforestation reduce land quality and agricultural productivity
	Conversions of farmland and forests to urban development reduce the amount of open space and environmental amenities for local residents
	Urban development reduces the “critical mass” of farmland necessary for the economic survival of local agricultural economies
	Urban development patterns not only affect the lives of individuals, but also the ways in which society is organized
	Urban development has encroached upon some rural communities to such an extent that the communities identify has been lost

Environmental Impacts of Land–Use Changes	Suburbanization intensifies income segregation and economic disparities among communities
	Excessive land use control, however, may hinder the function of market forces
	Land use regulations that aim at curbing land development will raise housing prices, making housing less affordable to middle– and low-income households
	Land use regulation must strike a balance between private property rights and the public interest
	Land use and land management practices have a major impact on natural resources including water, soil, air, nutrients, plants, and animals
	Runoff from agriculture is a leading source of water pollution both in inland and coastal waters
	Draining wetlands for crop production and irrigation water diversions have had a negative impact on many wildlife species
	Irrigated agriculture has changed the water cycle and caused groundwater levels to decline in many parts of the world
	Intensive farming and deforestation may cause soil erosion, salinization, desertification, and other soil degradations
	Deforestation adds to the greenhouse effect, destroys habitats that support biodiversity, affects the hydrological cycle and increases soil erosion, runoff, flooding and landslides.
	Urban development causes air pollution, water pollution, and urban runoff and flooding
	Habitat destruction, fragmentation, and alteration associated with urban development are a leading cause of biodiversity decline and species extinctions
	Urban development and intensive agriculture in coastal areas and further inland is a major threat to the health, productivity, and biodiversity of the marine environment throughout the world

Source: Adapted from Wu (2008:6,8)

4.2.2.3 Infrastructure Planning

According to Turok & Borel-Saladin (2014), essential infrastructure includes electricity, fresh water, sanitation and refuse collection. These services improve living conditions and ensure the capabilities to progress. Rapid growth can be considered as one of the most challenging factors we are faced with today. As our cities, towns and rural settlements continue to grow we are faced with additional challenges such as high percentage of citizens living in informal settlements, inadequate urban basic level of services, urban sprawl and poor public transport. SPLUMA requires planners to analyse the existing spatial form and determine the future spatial structure as part of our Spatial Development Frameworks. SPLUMA established the following components of a Municipal SDF:

- Clearly define who and what are being planned for
- Spatially identify where and when development will occur
- Link future development needs with infrastructure requirements
- Determine who will be responsible for implementing the proposals
- Spatially determine where money should be spent.

It is important to understand that Municipal customers vary (CIDMS, 2015). Customers have different needs, preferences and abilities to pay for Municipal services. Land under traditional leadership is a whole different matter of concern. There will always be disagreements between Municipalities and traditional councils with regard to the role of traditional councils within the planning process of SPLUMA.

According to CIDMS (2015), before the planning process for infrastructure can commence, it is important to determine and understand the following:

- Determine the type or level of services received by customers
- Engage with customers on the level of services they desire, and the costs associated with providing the service they want;
- Establish the services backlog
- Plan for future customers and the levels of services they should receive
- What type of customers are they?
- How many of them are there?
- Where are they spatially located?

One of the main challenges South Africa face is service delivery. Some municipalities are struggling to keep up with settlement growth, especially in the rural areas. Therefore predicting

what will happen in the future is of utmost importance in terms of providing infrastructure. According to the GCRO (2016:8), this growth needs to be accommodated through the provision and maintenance of urban infrastructure that meets the need for services by both society and the economy. However, this leads to some urban environmental challenges. An alternative approach to the traditional provision of infrastructure is green infrastructure (GCRO, 2016:8). According to the European Commission (2013:7), green infrastructure can be broadly defined as “a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings”.

According to Scaffler et al. (2013:8), green infrastructure includes a network of planted and indigenous trees, wetlands, parks, open spaces, original grassland and woodlands, as well as building and street-level urban design interventions. It is important to consider green infrastructure when planning for future demands. Not only to protect the environment, but finding alternative methods to reduce water demand. The CIDMS report of 2015 includes a methodology to determine the current backlogs and future demands within a Municipality. This methodology will be utilised and explained within the empirical study of this paper. The next section deals with the impact travelling has on future urban and rural growth.

4.2.3 Travel Distance

Travel distance has a considerable impact on in the sense that citizens do not want to travel long distances to activity centres or nodes. Densification and mixed-use development are two important planning concepts to address the need to travel extensive distances. Densification and mixed-use development will not only reduce travel distances but also contribute to the local economy. Shorter travelling distances and mixed-use development will ensure that citizens are closer to employment opportunities. According to Stead & Marshall (2001:114), travel patterns have to be measured in a number of different ways. The study of Stead & Marshall (2001), mainly focused on studies of urban form and travel patterns. For the purpose of this study, the study of Stead & Marshall (2001), have been adapted to include rural areas. Figure 4-14 depict land use characteristics that can affect travel patterns at three different levels.



FIGURE 4-14: LAND USE CHARACTERISTICS AFFECTING TRAVEL PATTERNS

Source: Adapted from Owens (1986)

Stead & Marshall (2001:115), identified nine aspects of urban form. Table 4-9 lists the nine aspects and the relevance of each with regard to urban and rural areas.

TABLE 4-9: ASPECTS OF URBAN FORM

ASPECTS	URBAN	RURAL
Distance of residence from urban and rural centre	✓	✓
Settlement size	✓	✓
Mixed Land Use	✓	✓
Provision of local facilities	✓	✓
Density of development	✓	✓
Proximity to transport networks	✓	✓
Availability of parking	✓	
Road network type	✓	✓
Neighbourhood type	✓	

Source: Adapted from Stead & Marshall (2001:115)

The biggest difference between the urban and rural areas in South Africa in terms of travel distance, is vehicle ownership. The majority of citizens residing in rural areas do not own a vehicle, and are therefore dependant on other means of travel such as travelling by foot or making use of public transport. Thus reducing the need to travel is of utmost importance, especially in the rural areas. The environment plays an incremental role in any future planning scenario. The next section deals with the environmental factors and the impact thereof on future urban and rural growth patterns.

4.2.4 Environmental Factors

Environmental factors play a pivotal role in determining in which direction future urban and rural growth will take place. As urban and rural areas expand due to increased population, it induces more pressure on securing resources such as water and food. The figure below illustrates the determining environmental factors of future urban and rural growth direction.

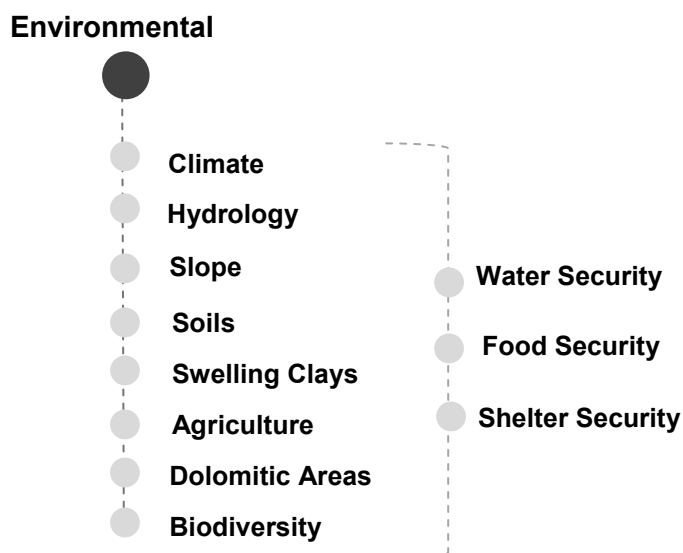


FIGURE 4-15: ENVIRONMENTAL FACTORS

Source: Own Construction (2017)

The environmental factors that drive urban and rural growth will now be discussed.

4.2.4.1 Climate Change

According to the National Climate Change Response White Paper (2011:5), climate change is already a measurable reality worldwide. South Africa is especially vulnerable to the impacts climate change poses (South Africa. Government., 2011). The impact of climate change is evident

as more frequent and intense weather systems occur with the unpredictability thereof. According to the National Climate Change Response White Paper (2011:5), some of the evident changes include:

- increases in the average temperature; with the past decade being the hottest on record;
- rises in the average global sea level;
- changes in average rainfall patterns, with some regions experiencing higher rainfall and other areas experiencing drying
- Increased frequency of heavy rainfall and extreme weather events over most land areas; and more intense and longer droughts.

South Africa being a water scarce country, it is of utmost importance that climate change is taken as a very serious matter. The White Paper on National Climate Change presents the South African Government's vision for an effective climate change response (South Africa. Government., 2011). The response to climate change has two objectives (National Climate Change Response White Paper, 2011:5):

- Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity.
- Make a fair contribution to the global effort to stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner.

Climate change influence urban and rural driving force factors in many ways. A simple example is, an area is experiencing extreme drought which causes the water level to drop and eventually run out. This will drive citizens away from the area because people will only stay in a specific place if they have access to the necessary resources.

4.2.4.2 Hydrology

South Africa has been affected by the long-standing apartheid regime as well as devastating diseases such as HIV/AIDS and other health issues. Needless to say, although these effects have had a profound impact on the Country, another crisis looms, water. As South Africa's population continue to grow, the pressure of water demand is ever increasing. Although there are many reasons for the growing water crisis as discussed in the previous section, climate change has had a massive impact on the current water pressures within the Country through infrequent

weather conditions. South Africa faces a massive challenge addressing these water pressures. The majority of the rural areas in South Africa still lack access to basic water and sanitation, increasing these pressures even more. Extreme rainfall conditions categorised by droughts and floods can have devastating impacts on especially rural areas that are engaged in agricultural production (Pablo & Antonio, 2015:2). The Rural households are also more prone to natural disasters such as flooding.

The majority of South Africa do not have accurately calculated floodline studies, especially the rural areas. An alternative solution or method is therefore required to calculate floodlines. The Gauteng Department of Agriculture and Rural Development (GDARD) introduced some basic assessments to calculate floodlines where there is none. According to GDARD (2014:11), the following are requirements for rivers and wetlands:

- Delineation of a 100m buffer zone from the edge of the riparian zone for rivers/streams outside urban areas and a 32m buffer zone from the edge of the riparian zone for rivers/streams within urban areas
- 30m for wetlands occurring inside urban areas and 50m for wetlands occurring outside urban areas

With any development close to a river, dam or wetland a detailed floodline study should always be encouraged. Floodlines are there for a reason, to save lives. Land use also has an impact on water quality. According to INTOSAI (2013:19), poor land use decisions can result in big changes to natural land watersheds and water quality. When development occurs, the new land use changes how water is transported and stored (INTOSAI, 2013:19). The combination of constraints related to impervious surfaces (driveways, roads, sidewalks, roofs, etc.) and compacted land creates a barrier to water infiltration coming from rainfall (INTOSAI, 2013:19).

Poor planning however, is evident in many parts of South Africa. An example of poor planning is in the case of a Township called Thabo Mbeki Ext 1, located in the Lephalale Local Municipality in the Limpopo Province, South Africa. The layout plan was approved without considering all the environmental considerations. Figure 4-16 and Figure 4-17 illustrates Thabo Mbeki Ext 1, where the majority of households are situated within the calculated floodline. Unfortunately, communities are sometimes unaware of the risks of residing in close proximity to rivers. It is therefore, crucial to inform the citizens through awareness programs what the dangers are of residing in close proximity to water sources.



Figure 4-16: Physical Factors - Poor planning

Source: Adapted from I@Consulting (2017)



FIGURE 4-17: PHYSICAL FACTORS - POOR PLANNING WITHIN FLOODLINE

Source: Adapted from I@Consulting (2017)

Another determining urban and rural growth factor is slope. The degree of slope will determine where development can occur. It is also more expensive developing on steeper slopes. The impact of slope will now be discussed.

4.2.4.3 Slope

The steepness of slopes is used by to determine the development of a particular site. As slopes become steeper, the provision of infrastructure become more difficult and hence more expensive. Percentages are mostly used to measure slope, where steep slope are usually classified as slopes in a range of 15% or higher. According to Lehigh Valley Planning Commission (2008), slopes more than 25% are totally discouraged for any development besides for open space and certain recreational uses. Table 4-10 depicts the potential for development at various degree classes of slope.

TABLE 4-10: DEGREE SLOPE VS DEVELOPMENTAL POTENTIAL

Degree of slope (%)	Development Potential
0% - 3%	Generally suitable for all development and uses
3% - 8%	Suitable for medium density residential development, agriculture, industrial and institutional uses
8% to 15%	Suitable for moderate to low-density residential development, but great care should be exercised in the location of any commercial, industrial or institutional uses.
15% to 25%	Only suitable for low-density residential, limited agricultural and recreational uses.
Over 25%	Only used for open space and certain recreational uses.

Source: Lehigh Valley Planning Commission (2008)

Slopes are naturally unstable. Gravity, water, wind or disturbance can cause mass movement, slide or erosion slippage. According to Lehigh Valley Planning Commission (2008), development of steep slopes, especially adjacent to stream corridors, can increase erosion of stream banks resulting in decreased water quality. Some of the dangers of developing on steep slopes are illustrated in Figure 4-18.

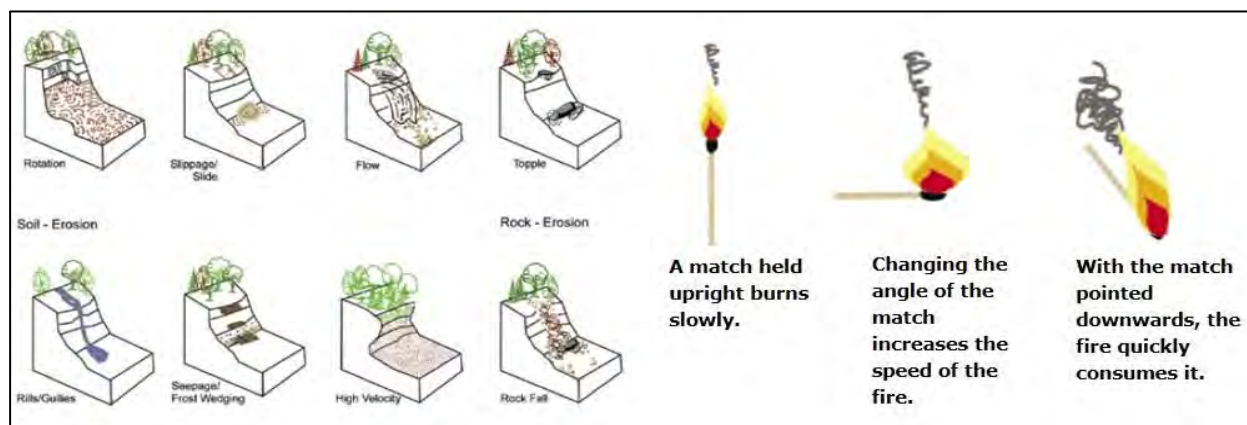


FIGURE 4-18: DANGERS OF DEVELOPMENT ON STEEP SLOPES

Source: Lehigh Valley Planning Commission (2008)

An example of the devastation fires can cause, is in the case of Knysna in the Western Cape, where steep slopes enhanced the devastating fires and left many citizens homeless (Brandt, 2017). The next section deals with soils and the importance thereof.

4.2.4.4 Soils

Marcotullio et al. (2008:201), argues that humans have lost contact with soil and the services it provides to sustain life. Cities and urban processes have had dramatic but varying impacts on soil physical and biochemical properties and pollutant loads, all of which affect the life-supporting services of soils (Marcotullio et al. 2008:201). Poor land use decisions can result in massive changes to natural land. Some of the biggest impacts on the environment include mining, overgrazing of agricultural land, degradation of water quality etc. One impact of mining on soil quality is soil erosion. According to INTOSAI WGEA (2013:21) soil erosion can release large amounts of sediment into surface water and drainage channels. Spills and leaks of hazardous chemicals and contaminated dust blown by the wind can lead to soil contamination. Various incentives, policies and plans can assist with the protection of land.

Policies can be used as instruments aimed at (INTOSAI WGEA, 2013),

- Improving soil conservation - including the introduction of farming methods and sustainable forestry to ensure long-term land productivity;
- Fighting against erosion caused by the misuse and mismanagement of land that can cause a loss of soils and surface vegetation; and
- Fighting against pollution caused by agricultural activities, including aquaculture and animal husbandry.

Not since Van Der Merwe's Soil Groups and Sub-Groups of South African has there been a comprehensive publication of South African soils that integrates what is known about the classifications of soils within South Africa (Fey, 2010:5). There has been numerous publication with well-established classification, such as the Soil Classification Working Group (1991), with 73 soil forms constituting the highest level grouping. Fey (2010) however, created a new account, which covers geographic distribution, properties (including selected profile descriptions and analytical data), classification (including correlation with major international systems), genesis, and environmental significance. Fourteen soil groups have been created, with the guiding principle being the identification of a diagnostic horizon, as defined by the Soil Classification Working Group (1991), (Fey 2010:33). The soil groups are illustrated in Table 4-11.

TABLE 4-11: SOIL GROUPS

Differentiating principle	Soil group	Concept	Diagnostic horizon or material for identification
Soils with special topsoil characteristics	1. Organic	Wetland or montane peat	Organic O
	2. Humic	Humus enrichment; free drainage; low base status; humid climate	Humic A
	3. Vertic	Swelling, cracking clay; basic parent material; semi-arid to sub-humid climate	Vertic A
	4. Melanic	Dark, structured clay; high base status; semi-arid to sub-humid climate	Melanic A
Soils with special subsoil characteristics relating to pedogenic accumulation and having an orthic topsoil	5. Silicic	Cementation by amorphous silica or sepiolite; arid climate	Dorbank (duripan) or sepiocrete
	6. Calcic	Carbonate or gypsum enrichment; arid climate	Soft or hardpan carbonate or gypsic B
	7. Duplex	Marked textural contrast through clay enrichment	Pedocutanic or prismatic B

	Soil group	Concept	Diagnostic horizon or material for identification
	8. Podzolic	Metal humate enrichment; siliceous parent material	Podzol B
	9. Plinthic	Absolute iron enrichment; localised, hydromorphic segregation with mottling or cementation	Soft or hard plinthic B
	10. Oxidic	Residual iron enrichment through weathering; uniform colour	Red apedal, yellow-brown apedal or red structured B
	11. Gleyic	Protracted reduction in an aquic subsoil or wetland	G horizon
Young soils with an orthic topsoil but weakly developed subsoil	12. Cumulic	Incipient soil formation in colluvial, alluvial or aeolian sediment	Neocutanic or neocarbonate B, regic sand, thick E horizon or stratified alluvium
	13. Lithic	Incipient soil formation on weathering rock or saprolite	Lithocutanic B or hard rock
	14. Anthropic	Human disturbance	Disturbed material

Source: Fey (2010:33)

Swelling clays is another important driver of urban and rural growth. Vertical movements of expansive clay can occur below structure foundations upon changes in moisture content. The loss of vegetation increases the moisture level in the soil as well as the clearing of large trees, this normally occurs when development takes place, preferably development should be discouraged in these areas. Leaking water or sewer pipes can have a severe impact on these soils. Substantial damage can be caused to structures, especially brick walls and surface beds (South Africa. The Department of Public Works., 2007). The different types of swelling clays are discussed below.

4.2.4.5 Swelling Clays

As a group swelling clays has a relatively high natural fertility and a resilience against nutrient depletion, particularly members with high swell-shrink potential (Class 1 and 2, see table Table 4-12) (ARC-ISCW, 2005). These cracking clays take in water readily when dry but exhibit high run-off when wet and expanded (ARC-ISCW, 2005). The window of optimal water content for ease of cultivation is narrow which makes it an “art” to cultivate these soils. The swelling clays covered by sealing topsoil’s (Classes 3 and 4 in Table 4-12), though naturally fertile, suffer from susceptibility to surface sealing, slow water infiltration, draughtiness and susceptibility to erosion (ARC-ISCW, 2005). Though it has a high potential for agriculture, swelling clays can prove problematic for geotechnical engineering. Damage can occur to structures when the potential expansiveness of the soil has not been properly taken into account during the design of the foundation (SAHITA, 2012).

TABLE 4-12: SWELLING CLAYS - SHRINK POTENTIAL

Class	Swell-shrink potential	Qualifying soil forms	Percentage qualifying soil in land type
1	High	Ar, Rg	>50
2	Moderate to high	Ar, Rg, Bo, Wo	25-50
3	Moderate	Ar, Rg, Bo, Wo, My, Mw, Ik	10-25
4	Low to moderate	Ar, Rg, Bo, Wo, My, Mw, Ik, Va, Sw, Sd	>25
5	Low	Ar, Rg, Bo, My, Mw, Ik	<10
6	Very low	Ar, Rg, Bo, My, Mw, Ik, Va, Sw, Sd	<25
7	None		

Source: ARC-ISCW (2005)

Swelling clays are soils of which the change in moisture content results in a change in the volume of the soil, i.e. swell or shrinkage of the soil skeleton are defined as expansive soils. These soils are the most commonly occurring of the problematic soils in Southern Africa. Expansive or heaving clays can occur as either residual or transported material. In residual soils the expansive

clay originates from the in situ chemical weathering of rock, in transported soils, it occurs where the expansive residual soil has been moved from its in situ position by wind, water, gravity or ice to another location (South Africa. The Department of Public Works., 2007). Another key factor to consider when planning for future urban and rural growth is agriculture.

The agriculture sector remains an important sector in South Africa in spite of the sector's small contribution to the country's GDP (South Africa. Department of Agriculture Forestry and Fisheries (DAFF), 2014). Future urban and rural expansion can sometimes be in controversy with each other. On the one hand agricultural land has to be protected in order to secure food security and job creation, but on the other side growth is taking place in our cities, towns and rural areas and this expansion has to be accommodated. The importance of agriculture in South Africa are discussed below.

4.2.4.6 Agricultural Land

South Africa has experienced devastating effects of dry weather conditions on field crops as well as animal and horticultural production. According to Calzadilla et al. (2014), the impacts of climate change on agriculture are a key reason for concern. Calzadilla et al (2014), state that climate change could modify agricultural productivity through five main factors namely, changes in precipitation, temperature, carbon dioxide (Co₂) fertilisation, climate variability, and surface water runoff. Precipitation is the main source of all freshwater resources and determines the level of soil moisture, which is critical for crop growth (Calzadilla et al. 2014). According to Calzadilla et al. (2014), temperature and soil moisture determine the length of the growing season and control the crop development and water requirements. In general, higher temperatures will shorten the frost periods, promoting cultivation in cool climate marginal croplands (Calzadilla et al. 2014). However, in arid and semi-arid areas, higher temperatures will shorten the crop cycle and reduce crop yields, because higher temperature leads to increased crop water requirements (Calzadilla et al. 2014).

It is therefore important to understand that the current decisions will impact on long term water and food insecurities. Our cities, towns and incremental areas are continuously growing which mean land must be made available. It is therefore critical to consider all implications of consuming agricultural land as it will have an impact on food security. The Department of Agriculture, Forestry and Fisheries together with the Department of Rural Development and Land Reform have a key responsibility to ensure food security within South Africa. The agricultural sector is crucial in many rural communities. The majority of rural communities are dependent on small-scale agricultural farming. According to the National Development Plan (2011), agriculture has the potential to create close to 1 million new jobs by 2030. In order to support and to ensure better livelihoods for all the rural communities, the Department of Rural Development and Land Reform introduced the

Rural Development Programme with the main purpose being: “initiate, facilitate, coordinate and catalyse the implementation of a comprehensive rural development programme that leads to sustainable, equitable and vibrant rural communities” (DRDLR, 2017). The rural development initiative is discussed within the planning initiatives section at the end of this Chapter. The next section deals with the importance of dolomitic areas.

4.2.4.7 Dolomitic Areas

According to Richardson & Oosthuizen (2011:1), South Africa is prone to sinkholes, the sudden and catastrophic collapse of ground surface which have many negative impacts. Sinkholes usually occur in areas underlain by dolomitic rock formations (Richardson & Oosthuizen, 2011). The instability of the ground surface may occur naturally, but it is usually expedited by man’s activities (Richardson, S. & Oosthuizen, A.C., 2011:4). The prime trigger mechanisms are usually;

- The ingress of water from leaking water-bearing services
- Poorly managed surface water drainage and
- Ground water level drawdown

Jennings et al. (1965), prescribed five concurrent conditions that must exist for sinkhole formation;

1. There has to be adjacent rigid material to form abutments for an arched roof. These abutments are provided by dolomite pinnacles or the sides of a steep sided sub surface canyon. The span has to be appropriate to the strength of the bridging material, since with a span which is too large or with a material which is too weak, the arch cannot form.
2. A condition of arching has to develop in the residuum, i.e. the vertically acting force due to self-weight has to be carried by arching thrusts to the abutments.
3. A void must develop in the residuum below the arch. This void can be quite small.
4. A receptacle has to exist below the arch to accept the material removed in the enlarging void. Some means of transportation, such as flowing water is also essential.
5. When a void of appropriate size has been established in the residuum, some disturbing agency has to arise to cause the roof to collapse. The void will move progressively upwards towards the surface.

Areas prone to sinkhole formations should be discouraged for any future development. Spatial planning should always occur in a sustainable manner. The environmental factors briefly discussed above should be considered when planning for future urban and rural growth. The next

section deals with the importance of human behaviour. Human behaviour can influence urban and rural growth in many ways. The factors of social change are discussed in the next section.

4.2.4.8 Biodiversity

Bioregional plans are one of a range of tools provided for in the National Environmental Management: Biodiversity Act, Act 10 of 2004, which can be used to facilitate the management and conservation of biodiversity priority areas outside the protected area network (LEDET , 2016).

According to LEDET (2016), the purpose of a bioregional plan is to inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. This is done by providing a map of biodiversity priority areas, referred to as Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs), with accompanying land-use planning and decision-making guidelines.

Bioregional plans are intended to contribute to a range of multi-sectoral planning and assessment processes, such as Environmental Management Frameworks (EMFs), Spatial Development Frameworks (SDFs), Strategic Environmental Assessments (SEAs) and Environmental Impact Assessments (EIAs); and to support decision-making that impacts on biodiversity (e.g. water use, agricultural and mining authorisations) (LEDET , 2016). For each CBA or ESA a set of land use guidelines were developed (Refer to annexure B).

In addition to the above CBA's, the following management zones have been identified as important both for the SDF as well as the land use scheme. The management zones discussed below are applicable to the area of study, namely Lephalale Local Municipality.

Environmental Management Zone 1 - Protection of Natural Vegetation, Scenic Landscape and Rock Paintings Areas, with limited appropriate tourism

This zone represents areas with a generally high natural, visual and cultural quality that provides the core natural and cultural resource base for the establishment of the Waterberg as a conservation (even wilderness) destination.

Environmental Management Zone 2 - Nature and Cultural Tourism Focus Areas within a High Quality Natural Setting

This zone represents areas with a generally high, natural, visual and cultural quality that has significant potential for the development of nature and/or culture based tourism. It also forms the area from which the conservation use in zone 1 can be explored.

4.2.5 Social change factors

The factors depicted in Figure 4-19, are all important factors determining the rate and direction of social change (Shah, 2013).

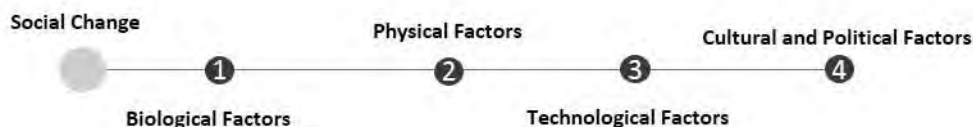


FIGURE 4-19: SOCIAL CHANGE FACTORS

Source: Own Construction (2017)

These factors are briefly discussed below.

4.2.5.1 Biological Factors

Shah (2013), refers to two factors responsible for social change;

- The plants and animals in the area and
- human beings themselves.

According to Shah (2013), the non-human biological environment affects human, social and cultural life. Man utilizes the available plant and animal life in ways determined by his culture (Shah, 2013). Geographical changes such as changes in climate, soil composition, drying up of lakes or streams kill some organisms and give birth to others which affect the nature of man's struggle for existence (Shah, 2013). The disease-producing micro-organisms present constant new problems of adjustment.

According to Shah (2013), when the growth of population threatens the standard of living, it inspires a change of attitude. Shah (2013), identifies the following defects of population growth; high birth rate, high death rate, greater number of children, greater number of old people, great number of widows and widowers, disproportionate number of male and female population, large number of disabled people, large number of rural people, high rate of infant mortality, short span of age. All these defects affect the quality of population, and consequently, affect the social structure and social institutions adversely (Shah, 2013). The second factor according to Shah are the physical factors.

4.2.5.2 Physical Factors

The physical factors of social change include factors such as natural disasters, for example, earthquakes and floods. According to Shah (2013), these changes in the physical environment sometimes bring about important changes in society. Communities residing in rural areas are more prone to flooding (Gwimbi, 2009:71). Sometimes this is caused by the lack of appropriate planning.

According to Shah (2013), it is important to remember that physical environment governs social conditions. Every culture develops some sort of physical setting (Shah, 2013). The Environment, as we have seen earlier, limits or permits the growth of civilisation although sometimes ignored. At the poles and in the deserts there can be no cities, for there is no economic surplus. Every civilization is exploitative of the resources of its environment (Shah, 2013). Technology innovations have had a profound impact on human behaviour. The technology factors affecting social change will now briefly be explained.

4.2.5.3 Technology Factors

According to Shah (2013), technology and innovations have had a profound impact on social change, affected social change on many levels. Innovations and new technologies can be expected to affect future population structures in several ways (OECD, 2011):

- Progress in medical technologies: important contributions to extending people's lives, and further advances can be expected in the years ahead, pushing life expectancies to new heights and significantly increasing the numbers of elderly.
- Information and communication technologies (ICT): potential to enhance the lives of the sick, the infirm and the elderly by increasing or restoring their autonomy, particularly in the home, and enabling them to participate more actively in family life, not least in the role of carer and/or educator.
- Distance working and distance learning: increase considerably in the coming years, as broadband availability and usage intensify and more companies, organisations and institutions avail themselves of the benefits offered by these technologies.
- Social networking: enhancing family interrelationships and interaction.

4.2.5.4 Cultural and Political Factors

Culture can be considered as a driving force of urban and rural growth. According to Ogburn (1937:161), the most often quoted definition of culture is that of Tyler: "Culture is that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society." According to Shah (2013), Ogburn distinguishes between 'material' and 'non-material' culture. By material aspects of culture he means things like tools, utensils, machines, dwellings, the manufacture of goods and transportation (Shah, 2013). In the non-material aspects, he includes family, religion, government and education (Shah, 2013). When changes occur in the material aspects, those in turn, stimulate changes in the non-material aspects (Shah, 2013).

The non-material culture, according to Ogburn, is often slow to respond to the rapid inventions in material culture (Shah, 2013). When non-material culture does not adjust itself readily to the material changes it falls behind the material culture and the result is a lag between the two (Shah, 2013). According to Shah (2013), this lag between non-material and material culture has been called "cultural lag". According to Shah (2013), Ogburn work was criticised on many occasions as most researchers believed that the distinction he made between material and non-material culture was not scientific.

According to Ravelli et al. (2014), sociologist suggests that culture has five defining features namely:

- Culture is learned: No one is born with culture. As we grow up we are constantly immersed in the cultural traditions of our parents, siblings, and peers. Everything from our language to our attitudes, values and world views are learned.
- Culture is shared: Culture develops as people interact and share experiences and meanings with each other.
- Culture is transmitted: Cultural beliefs and traditions are passed from one generation to another. Communicating cultural traditions and beliefs to the next generation is an important requirement for any culture.
- Culture is cumulative: Cultural beliefs are built on the cultural foundations of your ancestors for example, students today are far more technologically literate than students 10 years ago.
- Culture is human: Culture defines how, when, and why humans communicate with each other, and with whom. Culture defines who is appropriate for you to date and guides how and when you ask these people out.

According to Ravelli et al. (2014), culture does not define everything about you, but it does suggest that your culture modifies and influences your perceptions, values, and perspectives. This is why culture and political factors are interlinked. People may leave a specific location or even a Country if they feel undermined due to political factors. From the drivers discussed and illustrated above, some planning initiatives have been introduced to address some of the past challenges. Some of the planning initiatives are briefly discussed in the next section.

4.3 Planning initiatives:

According to the South African Government (2017), in the 2015 State of the Nation Address, President Jacob Zuma announced the Nine-point plan to boost economic growth and create much-needed jobs. Below are the various aspects.

- Resolving the energy challenge
- Revitalising agriculture and the agro-processing value chain
- Advancing beneficiation or adding value to the mineral wealth
- More effective implementation of a higher impact Industrial Action Policy Action Plan (IPAP)
- Encouraging private-sector investment
- Moderating workplace conflict
- Unlocking the potential of SMMEs, cooperatives, townships and rural enterprises
- Boosting the role of state-owned companies, information and communication technology infrastructure and broadband roll-out, water, sanitation and transport infrastructure
- Operation Phakisa, which is aimed at growing the ocean economy and other sectors

Small-scale farming is an important aspect especially within the rural communities, hence the introduction of the Rural Development Initiative. The Department of Agriculture Forestry and Fisheries and the Department of Rural Development and Land Reform jointly presented on the implementation of the one district, one agri-park programme in the context of the rural economic transformation model (PMG, 2015). According to the DRDLR (2017:3), an “Ari-park is a networked innovation system of agro-production, processing, logistics, marketing, training and extension services, located in a District Municipality.” As a network, it enables a market-driven combination and integration of various agricultural activities and rural transformation services (DRDLR, 2017:3). According to the Ehlanzeni District Municipality’s Rural Development Plan (2016), the Agri-park comprises three distinct but interrelated basic components:

1. The Farmer Production Support Unit (FPSU) - Are centres (more than one per district) of agricultural input supplies, extension support, mechanization support, local logistics support,

primary produce collection, and through-put to Agri-hubs. The FPSUs have limited sorting, packaging, storage, processing for local markets with through-put of excess product to Agri-hubs.

2. The Agri-hub (AH) - located in central places in a District Municipality, preferably places both sufficient, physical and social infrastructure to accommodate; storage/warehousing facilities; Agri-processing facilities; packaging facilities; logistics hubs; agricultural technology demonstration parks; accommodation for extension support training; housing and recreational facilities for labourers. Agri-hubs receive primary inputs form FPSU's for processing, value adding and packaging which is through-put into the Rural Urban Market Centres or exported directly to markets.

3. The Rural Urban Market Centre (RUMC) - located on the periphery of large urban areas, these facilities provide market intelligence assist farmers, processors in managing a nexus of contracts. With large warehousing and cold storage facilities to enable market management. Both FPSU's and Agri-hubs provide inputs to the RUMC. Agri-parks share RUMCs. A RUMC should have a reach of between 150km - 250km.

Another important planning initiative for both urban and rural areas is a densification strategy. a densification strategy is important for the following reasons.

1. Reduce travel distances
2. Control urban and rural sprawl
3. Provide infrastructure services more cost-effectively.
4. Protect the environment

TABLE 4-13: IMPORTANCE OF A DENSIFICATION STRATEGY

Importance of densification	
1. Reduce travel distances	By reducing the need to travel long distances, it enables citizens to be in close proximity to urban and rural centres, it reduces co2 emissions and ensures that citizens are closer to employment opportunities. Reducing travel distances is especially important within the rural areas in South Africa where the majority of citizens do not have access to transportation.

Importance of densification

<p>2. Control urban and rural sprawl</p>	<p>By implementing a densification strategy and using the urban or rural edge as a tool to manage growth, sprawl can be reduced within the urban and rural landscape.</p>
<p>3. Provide infrastructure services more cost-effectively</p>	<p>The main purpose of a densification strategy is to reduce distances in providing services to developments with the objective to provide services more cost-effectively. Figure 4-20 illustrates a scenario which is not recommended in terms of any new developments. The figure depicts a RDP layout in Mogobistad, located within the Ratlou Local Municipality in the North West Province. The layout is located one kilometre away from the current built-up area.</p>
<p>4. Protect the environment</p>	<p>It is crucial to protect any high environmental sensitive areas and high potential agricultural land. Densification together with the growth boundaries ensures that key environmental areas are protected.</p>

Source: Own Construction (2017)

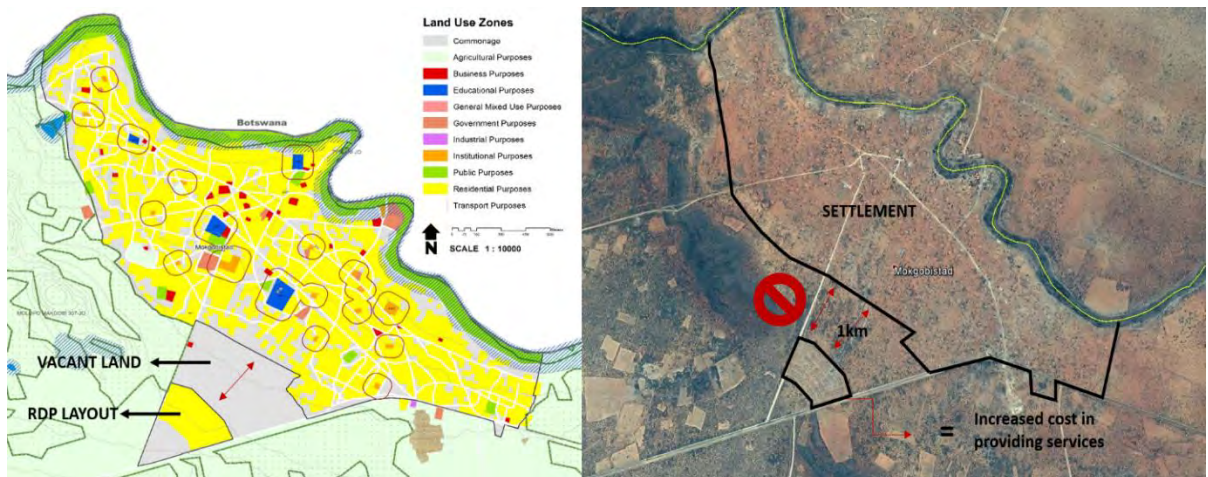


FIGURE 4-20: UNDESIRABLE DEVELOPMENT

Source: Adapted from Ratlou Local Municipality (2016); AfriGIS (2017)

The initiatives briefly discussed above, are just some examples of planning initiatives implemented in South Africa in order to address some of the challenges from the past.

4.3.3 Conclusion

Predicting future population sizes will always be based on assumptions, regardless of accurate census information. A level of uncertainty attaches to all the drivers discussed in this chapter. Population projections can always be influenced by extreme events such as natural disasters, war, economic recessions etc. Conversely, migration flows, technological developments, economic performance and employment patterns can cause much higher degrees of uncertainty. The level of detail with regard to information can also hamper the accuracy of the assumption made based on population projections.

All the driving factors of urban and rural growth discussed above are interlinked. A change in one factor may cause changes in another. It is a rippling effect that increases the complexity of predicting future urban and rural growth patterns. Spatial planners have to make difficult decisions with regard to future space and land-use projections. The drivers of growth discussed in this chapter should all be considered in order to ensure sustainable planning and development. Fortunately, many National and International land use models exist, where the factors discussed in this chapter are used to assist planners with the decision-making process of future spatial planning. Some of the models are discussed in Chapter 5.

CHAPTER 5

Land Use Models and software

5. Introduction

Chapter 4 identified some of the challenges and data required for urban and rural growth modelling. This Chapter identifies some land use models and software broadly used, both nationally and internationally which can assist with urban and rural growth modelling. Figure 5-1 illustrates the schematic representation of the sections to follow.

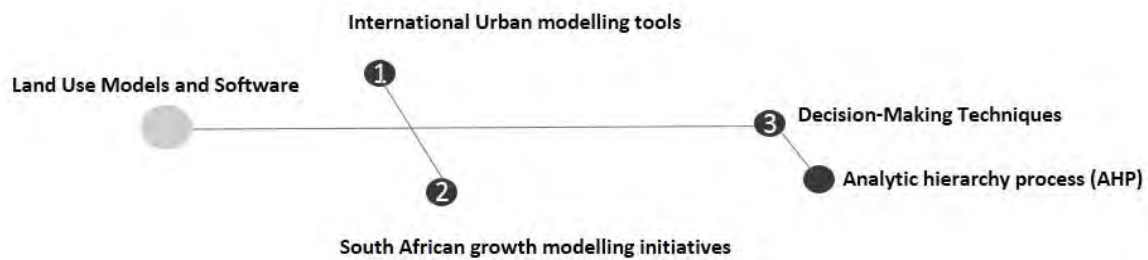


FIGURE 5-1: LAND USE MODELS AND TECHNIQUES

Source: Own Construction (2017)

According to the EPA (2000:9), determining how community growth and change affect land-use patterns can be very difficult. Fortunately, technology and improved land use modelling software can make the process easier. However, caution should be taken when using model results. Models are estimated techniques, they are not an exact science and their results should be understood in the context of the qualifications, assumptions and limitations of the model (EPA, 2000:9). Models rely on data and mathematical equations to simulate the real world which means that it is only as good as the quality of data used and decision rules and assumptions applied (EPA, 2000:9). Modelling the dynamics of urban growth therefore, necessitates different modelling techniques. The most critical component of an effective community decision-making modelling tool is its ability to address specific analytical needs and to model alternative planning approaches. According to (Abebe, 2011), there are a number of modelling techniques with the underlined aim of understanding the complexity of urban growth. Some of these models are discussed accordingly.

5.1 International Urban modelling tools

In August 2013, a report “Modelling urban spatial change: a review of International and South African Modelling Initiatives” was published (GCRO., 2013). The purpose of the report was to examine International and South African urban modelling projects that monitor or stimulate urban

spatial change. The report documented five main International urban modelling categories namely, land use transportation, system dynamic, cellular automata, agent-based and spatial economics, econometric models. These models are briefly described below:

- A variety of LUT models exists. According to the GCRO (2013:10), land use transportation models (LUTM) view urban structures mutual relationships between land use and transport. The GCRO (2013:10) argues that these models are based on the premise that transport planning decisions affect land use development and vice versa. For example, a new transport network link may result in an increased investment in land and subsequent land use changes; or if a land use is rezoned this, in turn, may influence demand for travel. According to Iacono et al (2009), the majority of LUT models are based on spatial interaction and econometric models.
- System dynamic models treat urban systems as complex, dynamic, and self-organised entities (GCRO, 2013:18). The GCRO (2013:18), argues that systems dynamic models appreciate the complex interactions that exist within urban systems, such as transport networks, housing infrastructure, water and energy supply networks and social networks. A specific strength of system dynamics is its representation of temporal processes (GCRO, 2013:18). System dynamic models are considered as a top-down approach suited to the investigation of socio-economic driving forces and simulation of complex systems (GCRO, 2013:18).
- According to the GCRO (2013:17), cellular automata models apply a set of transition rules on a two-dimensional grid of cells (derived from remote sensing images) where each cell represents a land use and the change in land use is based on the state of the neighbouring cells. Cellular automata models have been widely applied in modelling land use growth, although in some cases is considered too simplistic for modelling complex systems (GCRO, 2013:17). According to GCRO (2013:17), the advantages of cellular automata are numerous, namely: flexibility in formulating and generating complex behaviours from simple rules (Lathi, 2008) and an ability to show spatial-temporal dynamics (Sietchiping, 2004). Cellular automata are considered as a bottom-up approach that cannot handle human or socio-economic factors GCRO (2013:17).
- ABMs (Agent-based Models) and microsimulation are based on individual behaviours of actors in an urban system (GCRO, 2013:20). Some examples include UrbanSim and TRANSIMS. According to the GCRO (2013:20), ABMs modelling operates from a bottom-up approach, i.e. “from the actions of individual actors to an emerging aggregate level or

collective behaviour”. According to Haase and Schwarz (2009), ABMs model various actors including household relocating their homes, individuals using transport systems, government, and other institutional bodies. It can be used as spatially or non-spatially explicit, with the former explicit on the decision-making processes impacting land use change while the latter does not (GCRO, 2013:20). Augustijn-Beckers and Bas Retsios (2011), employed agent-based modelling to develop a vector-based, micro-scale housing model to stimulate the growth of informal settlements in Dar es Salaam, Tanzania. Their prototype, a vector-based housing model built on three simple rules of spatial change: Infilling, Extension, Enlargement of existing houses. It showed that it is possible to successfully stimulate the growth pattern in informal settlements.

- According to the GCRO (2013:21), spatial economics, econometric models (SE/EM's) focus on demography and household-driven demand-supply relation in urban regions, such as housing market developments (Haase and Schwarz, 2009). According to Haase and Scharz (2009), in most cases, these models do not consider the environment. Instead, they are set up as formalised relationships between the population, housing market and residential land use (Haase & Schwarz, 2009). Abebe (2011), used auto logistics regression modelling in Dar es Salaam, Tanzania to examine driving forces that explain informal settlement expansion and densification. He established that distances to minor roads, existing informal settlements, other urban land use and population density, proportional of informal settlements and underdeveloped land in the surrounding area, to be predictors of informal settlement expansion (Abebe, 2011). He also established that population density and distances to minor rivers, other urban land use, central business district, major rivers and major roads as predictors of informal settlement densification (Abebe, 2011). e land use models broadly used.
- Table 5-1 identifies some land use models broadly used.

TABLE 5-1: LAND USE MODEL SOFTWARE

Model	Developer	Purpose
California Urban Futures (CUF) Model: CUF-1	John Landis, Institute of Urban and Regional Planning, University of California at Berkeley	Provides a framework for simulating how growth and development policies might alter the location, pattern, and intensity of urban development

Model	Developer	Purpose
California Urban Futures (CUF) Model: CUF-2	John Landis, Institute of Urban and Regional Planning, University of California at Berkeley	Same as CUF-1 (CUF-2 addressed some of the theoretical holes of CUF-1)
California Urban and Biodiversity Analysis Model (CURBA)	John Landis, Institute of Urban and Regional Planning, University of California at Berkeley	Evaluates the possible effects of alternative urban growth patterns and policies on biodiversity and natural habitat quality
DELTA (formally DSCMODE)	David Simmonds Consultancy	Projects changes in urban areas, including the location of households, population, employment, and the amount of real estate development
Disaggregated Residential Allocation Model of Household Location and the Employment Allocation Model (DRAM/EMPAL)	S.H. Putman and Associates, Inc.	Projects the interaction and distribution of employment and housing in a specified geographical area
Growth Simulation Model (GSM)	Maryland Department of Planning, Baltimore, Maryland. Contact: Joe Tassone	Projects population growth and new development effects on land use/land cover under alternative land management
INDEX®	Criterion Planners/Engineers, Inc.	Measures the characteristics and performance of land-use plans and urban designs with “indicators” derived from community goals and policies

Model	Developer	Purpose
IRPUD Model (formally Dortmund)	Michael Wegener, Institute of Spatial Planning, University of Dortmund, Germany	Projects the impacts of long-range economic and technological change on housing, transportation, public policies, Land-uses, and infrastructure
Land Transformation Model (LTM)	Dr. Bryan C. Pijanowski, Michigan State University	Integrates a variety of land use change driving variables to project impact on land use on a watershed level
Land-Use Change Analysis System (LUCAS)	Michael W. Berry, et al., Department of Computer Sciences, University of Tennessee	Examines the impact of human activities on land use and the subsequent impacts on environmental and natural resource sustainability
Marcov Model of Residential Vacancy Transfer	Phillip Emmi and Lena Magnusson	Explores changes in demand for various types of residential housing within a community
MEPLAN	Marcial Echenique & Partners Limited. Contact: Ian Williams	Helps communities analyse the interrelated effects of land use and transportation and is designed to compare proposed plans/Policies
METROSIM	Alex Anas & Associates	Uses an economic approach forecasting interdependent effects of transportation and land use systems and land use and transport policies
Sub-Area Allocation Model-Improved Method (SAM-IM) (Formally LAM)	Planning Technologies, LLC	Creates new land use scenarios that reflect alternative development concepts for the future

Model	Developer	Purpose
The SLEUTH Model (Formally Clarke Cellular Automata)	Keith C. Clarke, Department of Geography, the University of California at Santa Barbara	Projects urban growth and examines how new urban areas consume surrounding land and impact the natural environment
Smart Growth INDEX®	Criterion Planners/Engineers, Inc. (with Fehr & Peers Associates, Inc.)	Evaluates transportation and land-use alternatives and assesses their impact on travel demand, land consumption, housing and employment density, and pollution emissions
Smart Places	Electric Power Research Institute (EPRI). Contact: Paul Radcliffe	Assists communities in the simulation and evaluation of land-use development and transportation alternatives using indicators of environmental performance
TRANUS	Modelistica	Analyses the effects of land-use and transportation policies or combinations of policies on the location of various activities and the land market
UGrow	Wilson W. Orr, Prescott College	Projects long-term changes in transportation and fiscal policies
UPLAN	Robert Johnston, Dept. of Environmental Science and Policy, the University of California at Davis	Creates alternative development patterns in response to changes in development and fiscal scenarios
UrbanSim	Paul Waddell, Daniel J. Evans School of Public	Explores how the interactions between land use, transportation, and public policy shape a

Model	Developer	Purpose
	Affairs, University of Washington	community's development trends and affect the natural environment
What if?	Dr. Richard E. Klosterman (as Community Analysis and Planning Systems, Inc)	Supports comprehensive community land-use planning in regard to determining land suitability for development, projecting future land-use demand, and providing capability to allocate the demand to the most suitable location

Source: EPA (2000:30)

The GCRO (2013:23) did some extensive research on urban growth modelling initiatives in South Africa. According to the GCRO (2013:23), the bulk of models used in South Africa is GIS-based or linked to spreadsheets that contain demographic or housing projections.

5.2 South African growth modelling initiatives

Remote sensing used in South Africa focus on historic urban land cover change GCRO (2013:23). The figure below depicts the spatial change models used in South Africa at different levels.

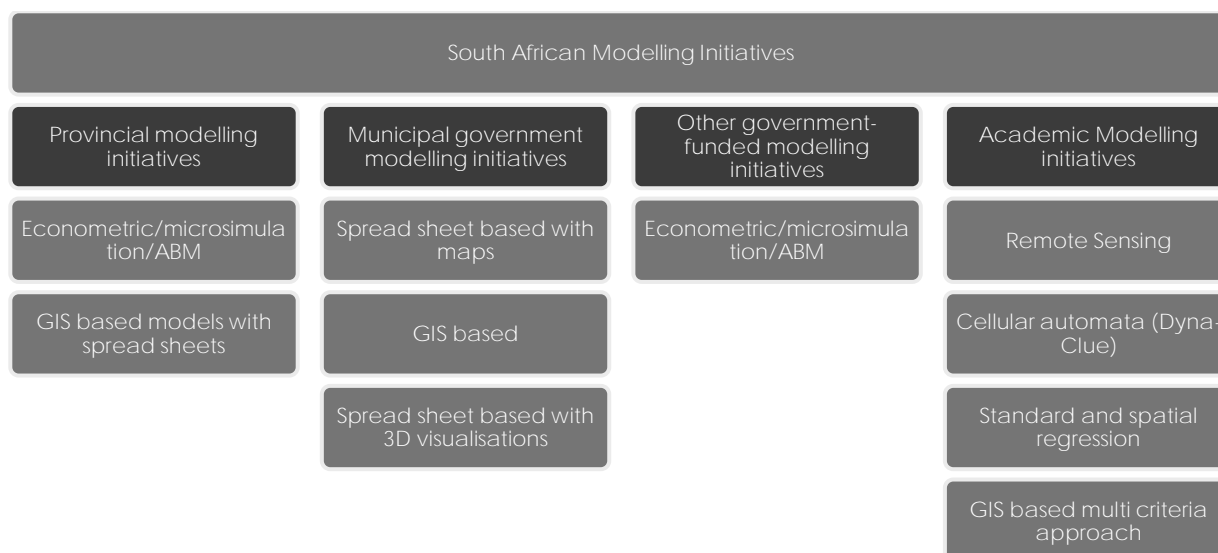


FIGURE 5-2: SOUTH AFRICAN MODELLING INITIATIVES

Source: Adapted from GCRO (2013:74)

5.3 Decision-Making Techniques

Planning for future urban and rural growth requires that important decisions have to be made. One of the most renowned techniques used to assist with the decision-making process is the Analytic Hierarchy Process (AHP). According to Triantaphyllon & Mann (1995), the AHP is a multi-criteria decision-making approach that was introduced by Thomas L. Saaty in the 1970's. The AHP is a decision support tool which can be used to solve complex decision problems (Triantaphyllon, 1995). According to Saaty (1977), it uses a multi-level hierarchical structure of objectives, criteria, subcriteria, and alternatives.

The pertinent data are derived by using a set of pairwise comparisons. These comparisons are used to obtain the weights of the importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion (Saaty, 1977). According to Saaty (2008:85), the following steps can be used to decompose decisions according to priorities.

- Define the problem and determine the kind of knowledge sought.
- Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels.
- Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
- Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority.

To make comparisons, a scale of numbers is required that indicates how many times more important or dominant one element is over another element with respect to the criterion or property with respect to which they are compared (Saaty, 2008:85). Saaty (2008:85), uses an example in which the scale is used to compare the relative consumption of drinks in the USA.

Table 5-2 exhibits the scale and Table 5-3 exhibits the comparison.

TABLE 5-2: FUNDAMENTAL SCALE

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; it's dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	

Source: Adapted from Saaty (2008:86)

The priorities, (obtained in exact form by raising the matrix to large powers and summing each row and dividing each by the total sum of all the rows, or approximately by adding each row of the matrix and dividing by their total) are shown at the bottom of the table along with the true values expressed in relative form by dividing the consumption of each drink (volume) by the sum of the consumption of all drinks. The information about actual consumption was obtained from the US Statistical Abstracts. We see the answers are very close and pair-wise comparison judgements of someone who knows can lead to very accurate results of drink consumption.

TABLE 5-3: CONSUMPTION OF DRINKS

Drink consumption in the US	Coffee	Wine	Tea	Beer	Soda	Milk	Water
Coffee	1	9	5	2	1	1	1/2
Wine	1/9	1	1/3	1/9	1/9	1/9	1/9
Tea	1/5	2	1	1/3	1/4	1/3	1/9
Beer	1/2	9	3	1	1/2	1	1/3
Soda	1	9	4	2	1	2	1/2
Milk	1	9	3	1	1/2	1	1/3
Water	2	9	9	3	2	3	1

Source: Adapted from Saaty (2008:86)

The derived scale based on the judgements in the matrix is:

0.177, 0.019, 0.042, 0.116, 0.190, 0.129, 0.327

With a consistency ratio of 0.022. the actual consumption (from statistical sources) is:

0.180, 0.010, 0.040, 0.120, 0.180, 0.140, 0.330

5.3.1 Theoretical and mathematical description of the method

Saaty (2008), describes the process in more detail. The first step would be to delineate a set in which we list the elements of the selection - the set of alternatives from which we wish to choose the best one for ourselves (Saaty, 2008). Then one should define the criteria used to compare those alternatives. The decision maker, determine the defined criteria as the result will be based on the decision maker's preferences. Saaty (2008), describes the steps in mathematical language.

"If n is the number of criteria or alternatives whose weight (priority, importance) w_i should be defined based on the assessment of the values of their ratios $a_{ij} = w_i/w_j$ ". If you form a matrix A from the ratio of their relevant importance a_{ij} , in case of consistent assessments equaling to $a_{ij} = a_{ik} \cdot a_{kj}$, it will correspond to the equation $Aw = nw$ (Saaty, 2008). Matrix A has special characteristics (all her rows are proportional to the first row, all are positive and $a_{ij} = 1/a_{ji}$ is

accurate resulting in only one of its eigenvalues being different from 0 and equal to n (Saaty, 2008). According to Saaty (2008), if a matrix has inconsistent changes (in praxis that is always the case) the importance vector w can be calculated by solving the equation $(A - \lambda w)w = 0$. The condition: $\sum w_i = 1$ is true, where λ_{max} is the biggest eigenvalue of A matrix (Saaty, 2008). Due to the characteristics of the matrix $\lambda_{max} \geq n$, and the subtraction $\lambda_{max} - n$ is used in the measuring of the assessment consistency (Saaty, 2008). With a consistency index $CI = (\lambda_{max} - n)/(n-1)$ one can calculate the consistency ratio $CR = CI/RI$ where RI is a random index (consistency index for the n row matrixes of randomly generated comparisons in pairs – a table with calculated values applies. The result is illustrated in Figure 5-3.

Value of the random index RI

n	9	10	11	12	13	14	15
RI	1,45	1,49	1,51	1,54	1,56	1,57	1,58

n	1	2	3	4	5	6	7	8
RI	0,00	0,00	0,52	0,89	1,11	1,25	1,35	1,40

If $CR \leq 0,1000$ is true for matrix A the assessments of the relative importance of the criteria (alternative priorities) are considered as acceptable. To the contrary, the reasons why the assessment inconsistency is acceptably high must be investigated.

FIGURE 5-3: AHP RESULT

Source: Saaty (2008)

According to Saaty (2008), the consistency ratio will often exceed 0.1000. That should only be taken into account as an indicator of the inconsistency level of your selection. Despite the inconsistency, one will get a suggestion of the best alternative. The next chapter deals with some case studies and the importance thereof in addressing some of the challenges spatial planners face every day. Some of the case studies also depict methods used to determine future growth.

CHAPTER 6

Case Studies

6. Case Studies

Some examples of urban growth models and software were listed and discussed in Chapter 5. This chapter deals with the implementation of some of the models and techniques discussed in Chapter 5. Some of the techniques and technical information from each case study discussed below are used within the study approach in Chapter 7, as not all of the techniques and methods from each case study are applicable to the area of study. In other instances, the techniques can be used where applicable. The different case studies discussed below is depicted in the following figure:

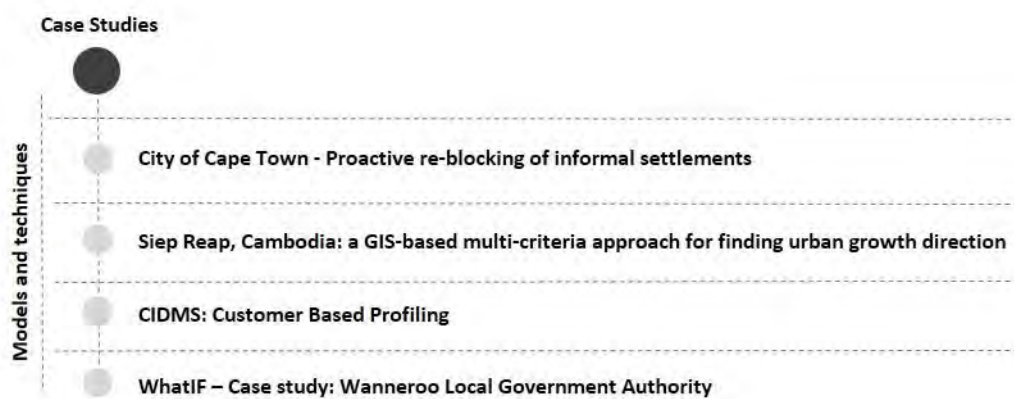


FIGURE 6-1: CASE STUDIES

Source: Own Construction (2017)

6.1 City of Cape Town - Proactive re-blocking of informal settlements

The City of Cape Town adopted a re-blocking policy in order to redress the challenges from the past and change the face of informal settlements. The housing backlog in South Africa cannot be addressed in the short term and thus alternative solutions are required to improve the living conditions of those allocated in informal settlements, hence the introduction of re-blocking.

6.1.1 Introduction of growth modelling method

Citizens living in informal settlements are disproportionately affected by many challenges. According to Luthango et al. (2016), these are largely connected to the unhealthy and unsafe physical conditions within which they live. Sietchiping (2005), categorises the driving forces of informal settlements growth as physical, economic and socio-cultural which include topography, transportation networks, existing informal settlements, availability of informal economic sector as a source of income, places of worship, and cultural and ethnic groups. Informal settlements are

usually the cause of rapid urbanisation which causes local government to be unable to keep up with the housing demand. Therefore alternative solutions are required to address the challenges at hand.

The City of Cape Town introduced a policy “proactive re-blocking of informal settlements” to address the challenges that go hand in hand with informal settlements. According to Hennings et al. (2012), “reblocking is developed by Shack Dwellers International (SDI) that is based primarily on the spatial reconfiguration of shacks in informal settlements” (South African SDI Alliance, 2012). This case study scrutinises the method used for reblocking an informal settlement called Mshini Wam located in the City of Cape Town.

6.1.2 Method

The layout of informal settlements does not have any specific layout pattern and are usually disorganised. According to SasdiAlliance (2013), the re-blocking process of the City of Cape Town is primarily based on the spatial reconfiguration of shacks. Some of the categorists include:

- Shacks are rearranged and reconstructed to maximise open space in the settlement.
- Shacks are also often built on raised platforms and the settlement graded to prevent flooding.
- Re-blocking is considered an in-situ process due to its minimal disruption of the resident’s lives throughout the duration of the project.

The figure below illustrates an example of the re-blocking process of the Mshini Wam informal settlement within the City of Cape Town.

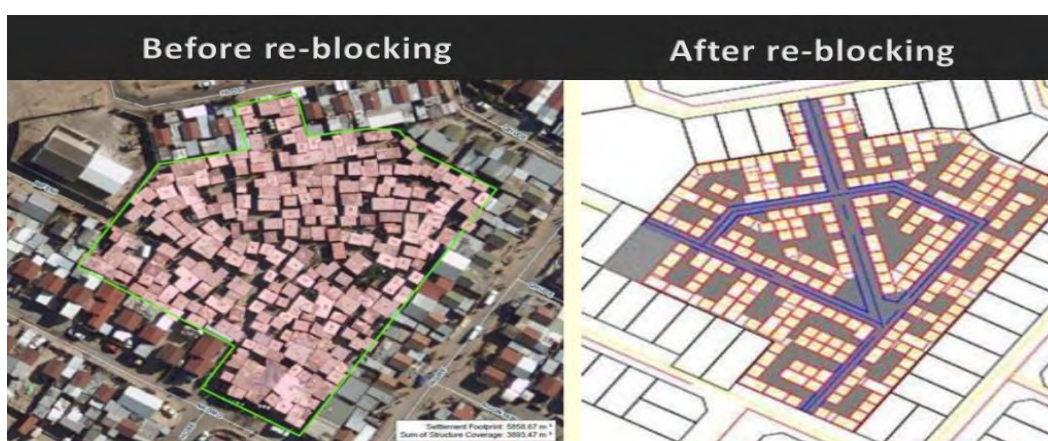


FIGURE 6-2: RE-BLOCKING

Source: Adapted from SasdiAlliance (2013)

Other innovative initiatives initiated from the project was the introduction of “vertical gardening” and “litre of light” (CTPC, 2012). Ensuring food security is of utmost importance. According to CTPC (2012), vertical gardening is an experimental form of gardening with the advantage of taking up less space. Providing infrastructure to communities is also key. The litre of light project is another innovative affordable method used to provide lighting to informal dwellers. It installation merely requires a plastic bottle filled with water and a little bit of bleach to ensure no algae build up (CTPC, 2012). The next step is to embed the bottle into the corrugated iron roof and to use sealant to prevent any leakages (CTPC, 2012). The two innovative techniques are illustrated in Figure 6-3.



FIGURE 6-3: INNOVATIVE METHODS

Source: CTPC (2012); Barlett (2012); Sohail (2016)

6.1.3 Best practices

Modelling informal settlements are a crucial part of the planning process. The reblocking of informal settlements is one method of modelling which carry many benefits, some of which include fire safety, establishing roads and other infrastructure, reducing greywater hazards, advantages of health, creating jobs and inspiring a sense of pride within the community (Hennings et al. 2012). One of the biggest advantages of reblocking is the fact that a disorganised informal settlement can be rearranged into a structured settlement each with some form of tenure status. According to the City of Cape Town (2013), tenure arrangements may take the form of either one or a combination of the following:

- The right of occupancy by virtue of numbering the structures and recording the names of the occupants in a database;
- The right of occupancy by virtue of allocating street numbers and names and recording the details of occupants together with street numbers and names on a database;
- A formal lease agreement between the City and the household;

- Incremental tenure in which occupants of an urban block are given occupancy rights.

In Dar es Salaam, Tanzania, informal settlement growth are dealt with the Logistic regression modelling approach. Logistic regression modelling is one of the statistical modelling techniques with dependent categorical variable that can be explained either by categorical or continuous independent variables. This modelling approach is advantageous to interpret urban growth patterns with regard to the underlining driving forces of growth (Abebe, 2011). Table 6-1 illustrates some of the principles and techniques applicable for the methodology.

TABLE 6-1: APPLICABLE MODELLING TECHNIQUES

Techniques/tools in terms of data preparation	Required information for future planning
<ul style="list-style-type: none"> - Community participation - GIS - Latest aerial photography - Policies and plans such as a densification strategy 	<ul style="list-style-type: none"> - ESKOM spot building count

Source: Own Construction (2017)

6.2 Siem Reap, Cambodia: a GIS-based multi-criteria approach for finding urban growth direction

Ourng et al. (2012), developed and implemented a multi-criteria method as a case study in Siem Reap, Cambodia. The objective of this case study was merely to describe a methodology to estimate in which direction urban expansion will occur in the town of Siem Reap.

6.2.1 Introduction of growth modelling method

According to Ourng et al. (2012:211), it is critical for city planners and resource managers to understand urban growth and change. The overall objective of the study was to determine the direction of urban expansion which was influenced by various factors.

6.2.2 Method

Figure 6-4 represents graphically how the process was conducted to illustrate spatial growth.

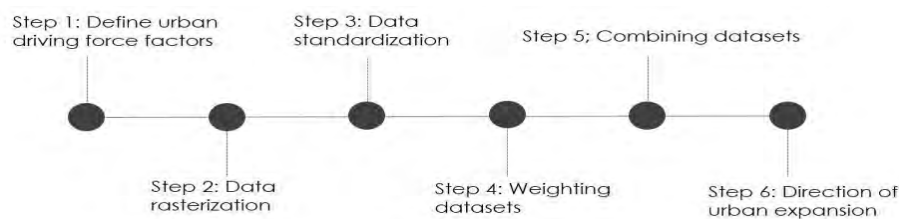


Figure 6-4: GIS-based multi-criteria urban growth direction model

Source: Adapted from Ourng et al. (2012:211)

In the first step rasterization, a GIS “vector to raster” conversion tool was used to produce raster data from vector inputs (Ourng et al. 2012:211). In order to normalize the data to the same scale, the AHP was applied to calculate the weight of each factor to be used in the analysis in order to produce the final urban growth map (Ourng et al. 2012:212). According to Ourng et al. (2012:214), LU (2003), presented fifteen variables to measure the physical suitability for urban growth in Charleston region South Carolina. The criteria included existing land use, Slope, Wetlands, distance to water front, distance to major nodes, distance to major roads, roads density, distance to waterline, distance to sewer line, population density, cost distance to central business District (CBD), existing urban, distance to existing urban, corporate boundary and protected land.

Cheng (2003), revealed that the major driving forces of urban growth are urban roads, infrastructure and developed area. In the case study of Siem Reap, tourism was identified as the major pushing factor of urban growth, while population density, road density, road networks and distance to existing urban area were the main urban driving force factors. After the data standardisation and weighting of datasets, the urban growth direction could now be mapped (Ourng et al. 2012:215). The factors affecting urban driving force in Siem Reap was the distance to roads, distance to existing urban area, and population density. The formula for mapping the urban growth was given as:

$$U = aX^1 + bX^2 + cX^3$$

Where,

U - Urban area

X1 - Distance to roads

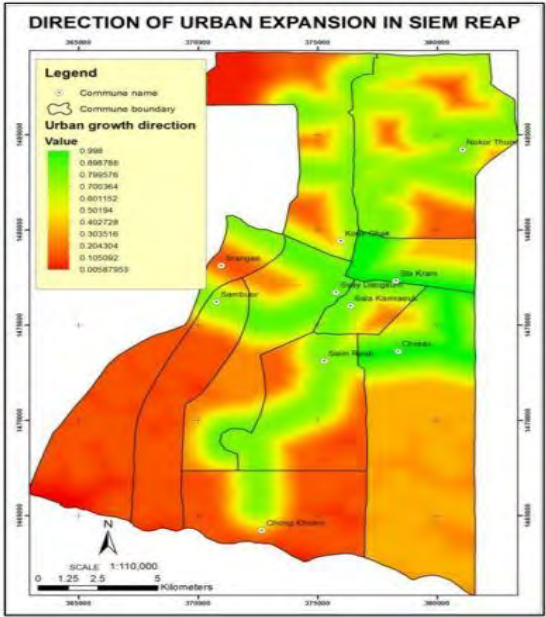
X2 - Population density

X3 - Distance to existing urban area

a, b, c - Weighting for each factor

The result is depicted in Table 6-2.

TABLE 6-2: DIRECTION OF URBAN EXPANSION, SIEM REAP

Growth Direction	Description
	<p>The image depicted in the table illustrates that urban expansion is more likely to happen in mainly four communes; Sla Kram, Chreav, Svay Dangcum, Sala Kamroek. The highest values (greener zones in map) correspond to areas where driving factors have a stronger influence, i.e., areas more susceptible to become urban. On the opposite, the lowest values (reddish zones in map) correspond to areas where the driving factors effect is weaker, i.e., areas where urban expansion is less (Ourng et al. 2012:216).</p>

Source: Ourng et al. (2012:216).

6.2.3 Best Practices

This case study identified a method which can be applied to any study to illustrate the direction of urban and rural expansion. The study also identified some important criteriums which could be advantageous in modelling future urban and rural growth. The AHP was also applied to ensure that each identified criterium has its own weight in terms of comparison.

Table 6-3 illustrates some of the principles and techniques applicable for the methodology.

TABLE 6-3: APPLICABLE MODELLING TECHNIQUES

Techniques/tools in terms of data preparation	Required information for future planning
<ul style="list-style-type: none"> - GIS: Conversion tool - Rasterization - AHP 	<ul style="list-style-type: none"> - Land use and environmental data

Source: Own Construction (2017)

6.3 Case Study: Customer Based Profiling

Before any spatial planning can commence it is vital to first determine where citizens are located and what level of planning are required in terms of income and density levels.

6.3.1 Introduction of growth modelling method

The City Infrastructure Delivery and Management Systems (CIDMS) manual, introduced a method to determine customer profiling. Customer profiling emphasise different needs, preferences and abilities (CIDMS, 2015:9), as explained in the profiling approach

6.3.2 Method

In order to prepare customer profiles, a methodology is required that utilise various software and resources (CIDMS, 2015:27). The first step is to gather all needed data in preparation for the customer profile. The data needed include:




TABLE 6-4: CUSTOMER PROFILING REQUIRED DATASETS






Level	Datasets
National datasets:	<ul style="list-style-type: none"> - Statistics SA (Census information) - Quantec - ESKOM's Spot Building Count - StatsSA Dwelling Framework - Global Insight etc.
Municipal and Departmental datasets	<ul style="list-style-type: none"> - Surveyed cadastre - Valuation rolls - Billing system data
Imagery	<ul style="list-style-type: none"> - Aerial photography & satellite images

Source: CIDMS (2015:25)

Once all the data is collected the customers need to be categorised according to “residential customers” and “non-residential customers” (CIDMS, 2015:25). This is depicted in Table 6-5.

TABLE 6-5: CLASSIFICATION SYSTEM

Classification	Customer category		Description
Residential	Formal residential		All customers of residential nature that are settled on proclaimed, surveyed stands (single or multiple residential), or residential customers residing on farms. Formal domestic is further categorised on the basis of (a) income levels and (b) density.
	Informal residential		Areas where groups of housing units have been constructed on land that the occupants have no legal claim to, or occupy illegally; or unplanned settlements and areas where housing is not in compliance with current planning and building regulations (unauthorized housing).
	Traditional rural residential		This category of customer refers to villages or settlements under the administration of tribal or traditional authorities.
	Backyard residential (shacks)		Backyard residential (shacks) are additional informal units on a plot of land that is rented out by the land owner as a significant income to the main householder.
Non-residential	Agriculture, forestry and fisheries		This customer category is dedicated to the practice of farming (including cultivation of the soil for the growing of crops and the rearing of animals or fish to provide food, wool, and other products) as well as forestry.
	Business		The term in this instance is used to describe both a retail as well as an office related land use.

Classification	Customer category		Description
	Commercial & industrial		Factories, storage, manufacturing etc.
	Institutional		A customer category devoted to the promotion of a particular cause or program of a public, educational, or charitable character (schools, clinics, community halls etc.). Note that institutional also includes sports facilities such as sport stadiums
	Mining		Mining includes not only the extraction of valuable minerals or other geological materials from the earth, but also the beneficiation of extracted materials or substances (e.g. smelters and refineries).
	Ports and airports		Airports and ports are defined as tracts of land or water with facilities for the arrival, departure, shelter, supply, and repair of aircraft and marine vehicles used for receiving or discharging passengers and cargo. This category includes ports, airports and airfields that are municipally owned.
	Public service industries (PSI)		This category of customer means roads, storm water-, water-, sewer-, power- or electricity- and railway infrastructure under public or parastatal control.

Source: CIDMS (2015:26)

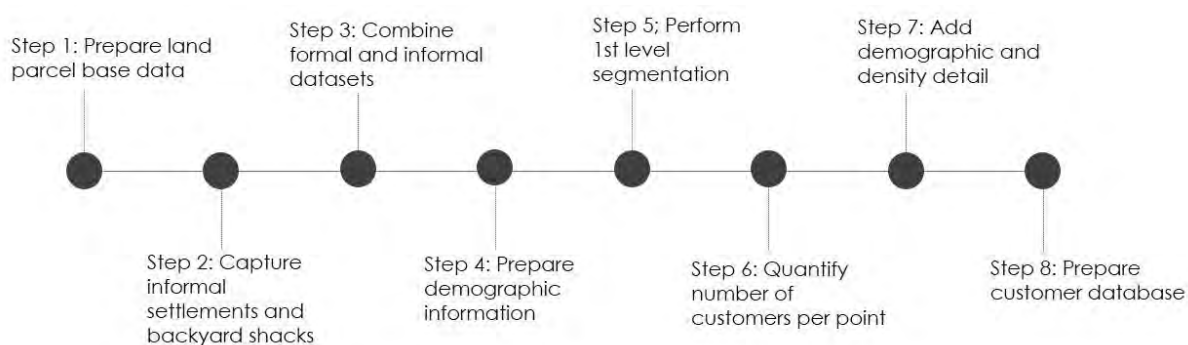
Customers in the “Formal Residential” category are further categorised based on income and density (CIDMS, 2015:27).

TABLE 6-6: INCOME & DENSITY CATEGORIES

Income category	Annual household income threshold
Poor	R0 - R 76 400
Low income	R 76 401 - R 153 800
Medium income	R 153 801 - R 307 600
High income	R 307 601 +
Density category	Number of units per hectare
Low	0 - 35 units/ha
Medium	35 - 69 units/ha
High	70

Source: CIDMS (2015:27)

Figure 6-5 and depicts the methodology for spatial profiling of customers, while Table 6-7 illustrates the information required to compile a customer profile.


FIGURE 6-5: METHODOLOGY FOR THE SPATIAL PROFILING OF CUSTOMERS

Source: Adapted from CIDMS (2015:27)

TABLE 6-7: SPATIAL PROFILING METHODOLOGY

Step	Method	Description	Source:
1	Prepare land parcel base data	Prepare all the necessary data to describe all customers on a formally proclaimed land parcel (e.g. erf, holding, or farm portion). <ul style="list-style-type: none"> • Updated Cadastre • Municipal zoning scheme 	(CIDMS, 2015:28)

Step	Method	Description	Source:
		<ul style="list-style-type: none"> • Municipal land-use data • Municipal valuation roll • Billing system data • Latest aerial photography 	
2	Capture informal settlements and backyard shacks	<p>Accounts for all customers residing in informal settlements, backyard shacks and traditional villages. Most cities do have GIS data available on the location and extent of informal structure, but additional data sets that can assist cities include:</p> <ul style="list-style-type: none"> - Department of Human Settlements (housing demand database); - Stats SA – South African Dwelling Frame; - Eskom – Spot building count; and - Commercial data sets available from data vendors (e.g. GeoTerraImage). <p>The data above can be used as starting point and updated by capturing the latest structures using the latest satellite imagery or aerial photography.</p>	(CIDMS, 2015:29)
3	Combine formal and informal data	Combine the formal and informal datasets. Convert the formal cadastre to centroids (or points) and then combine (or merge) with informal data sets points.	(CIDMS, 2015:30)

Step	Method	Description	Source:
4	Prepare demographic data	Source latest census information from StatsSa. The data should be extracted at the lowest level of geographic detail (Small-area layer). With the above-mentioned data calculate the gross density (Number of households divided by the geographic extent of the sub place in hectares). In addition, the average annual household income need to be calculated for the sub place	(CIDMS, 2015:31)
5	Perform first level segmentation	Rework the existing land-use data for each point into one of the customer's categories. The category should be added as an additional data field to the customer database.	(CIDMS, 2015:31)
6	Quantify the number of customers per point	<p>Calculate the number of customers at a specific location (Customer category must be assigned to each spatial point). Consider the following when calculating the number of customers.</p> <ul style="list-style-type: none"> - Sectional title schemes, where multiple households (or businesses) can be located on one property or in one building; or - Multi-storey buildings (for example the central business districts of cities) where more than one customer can be situated in a single building 	(CIDMS, 2015:31)

Step	Method	Description	Source:
		To assist with the above mentioned, source the water or electricity meters per point as calculated in step 1.	
7	Add demographic and density indicators	Segment all formal residential, informal residential, traditional rural residential and backyard shack customers by adding the density and income levels calculated earlier.	(CIDMS, 2015:31)
8	Prepare municipal customer database	The final customer database should contain the following data fields <ul style="list-style-type: none"> - SG21 identifier - Town/Farm name - Stand number - Extent - Existing land use - Owner name - Customer category - Number of customers - Average annual income category - Gross residential density category 	(CIDMS, 2015:31)

Source: Adapted from CIDMS (2015)

Having applied the methodology above, the customer profile can now be generated. The following are examples of customer profiles in Buffalo City Local Municipality and Ekurhuleni Metropolitan Municipality. Table 6-8 presents the customer profile for Buffalo City. All customers per category have been quantified and allocated to each of the priority zones adopted in the spatial development framework of the city (CIDMS, 2015:32).

TABLE 6-8: BUFFALO CITY METROPOLITAN MUNICIPAL CUSTOMER PROFILE

Customer category	Customer group	Customer type	Density category	Priority Zone 1 – Central	Priority Zone 2 – West Bank	Priority Zone 3a – Berlin	Priority Zone 3b – Quennera	Rural	Total
Residential	Formal residential	High income	High	754	26	75	229	14	1 097
			Medium	448	48	136	803	29	1 464
			Low	6 442	766	2 341	3 240	1 169	13 959
		Medium income	High	1 492	47	178	176	38	1 931
			Medium	580	76	191	631	49	1 527
			Low	7 500	941	3 048	1 816	1 402	14 707
		Low income	High	1 756	46	198	91	43	2 133
			Medium	761	97	305	417	78	1 659
			Low	8 854	794	3 318	1 132	1 993	16 090
		Poor	High	4 772	73	529	138	562	6 074
			Medium	3 890	227	1 113	631	892	6 753

Customer category	Customer group	Customer type	Density category	Priority Zone 1 – Central	Priority Zone 2 – West Bank	Priority Zone 3a – Berlin	Priority Zone 3b – Quennera	Rural	Total
			Low	55 238	3 255	17 488	4 680	34 027	114 687
	Informal residential	25 969	3 111	1 840	4 406	7 547	42 872		
	Backyard shacks	5 789	467	1 295	1 392	2 391	11 334		
Non-residential	Business	2 085	64	551	169	54	2 923		
	Commercial and industrial	607	172	161	45	115	1 100		
	Institutional	703	94	225	61	173	1 256		
	Public sector infrastructure	2 380	151	512	416	251	3 710		
Total	130 020	10 455	33 500	20 473	50 828	245 277			

Source: CIDMS (2015:33)

Figure 6-6 and Figure 6-7 presents the distribution and clustering of customers across the municipal space and within the demarcated priority zones and the income distribution of households.

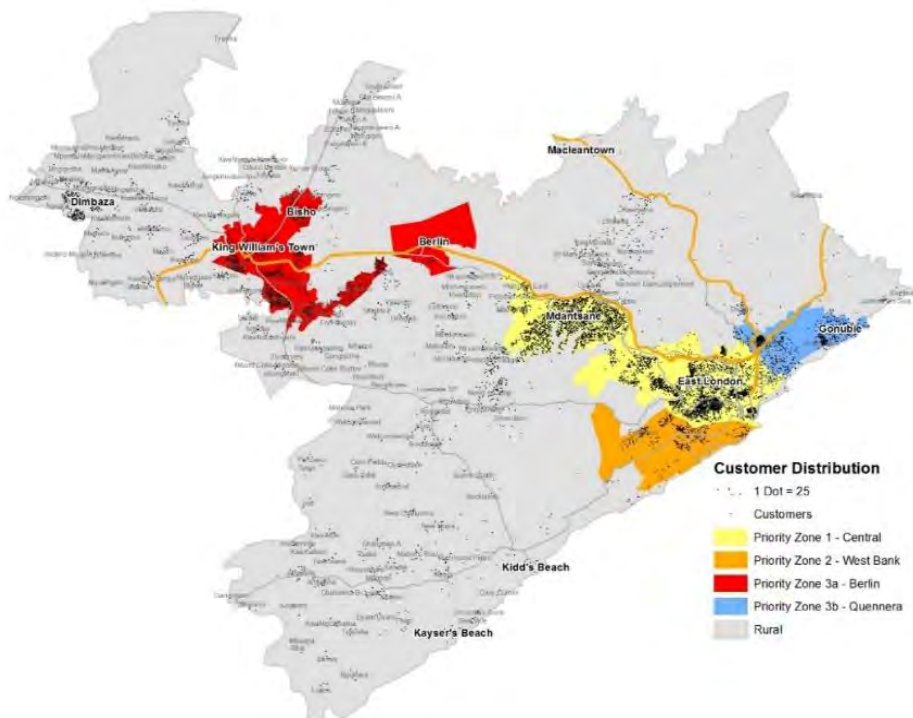


FIGURE 6-6: CUSTOMER DISTRIBUTION ACROSS PRIORITY ZONES

Source: CIDMS (2015:33)

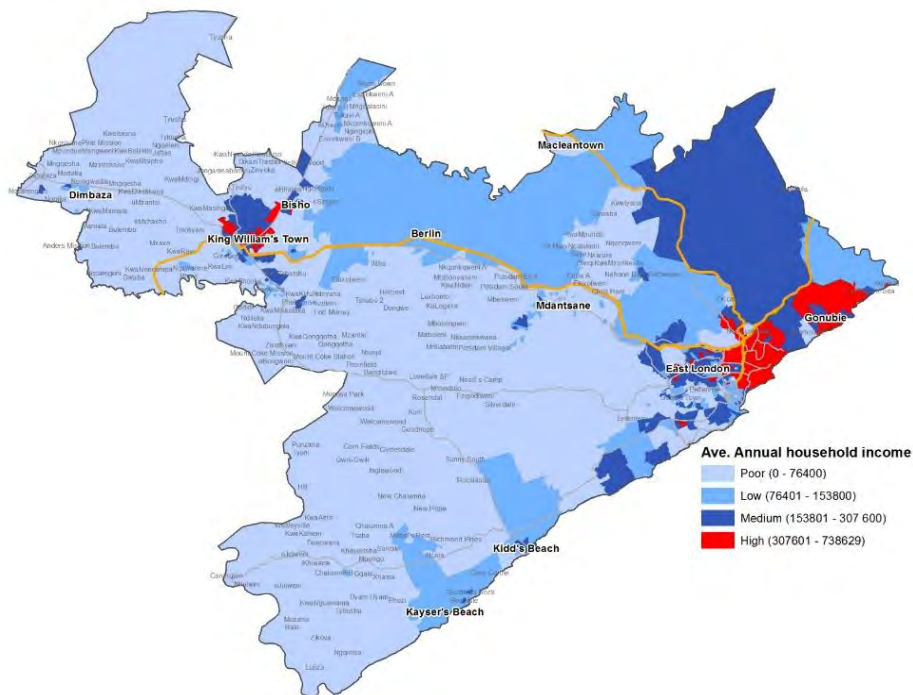


FIGURE 6-7: ANNUAL HOUSEHOLD INCOME LEVELS

Source: CIDMS (2015:33)

The following figures have been compiled from the customer database of Ekurhuleni Metropolitan Municipality (EMM) (CIDMS, 2015:34). They provide an essential layer in the spatially-based capital investment framework of a city, as required by SPLUMA, where revenue generation is deemed a strategic priority for the city (CIDMS, 2015:34).

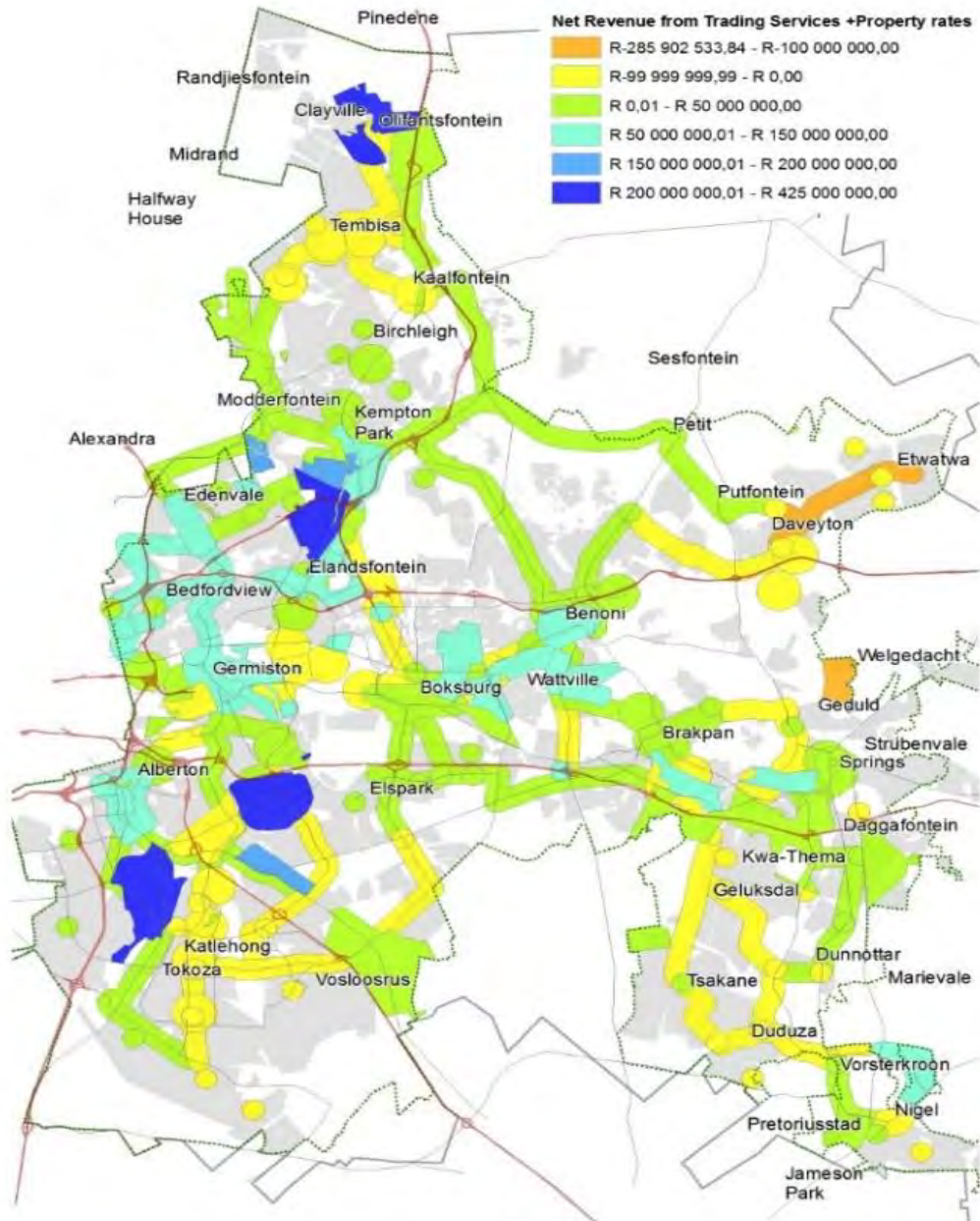


FIGURE 6-8: EMM - SPATIAL REVENUE PROFILES

Source: CIDMS (2015:34)

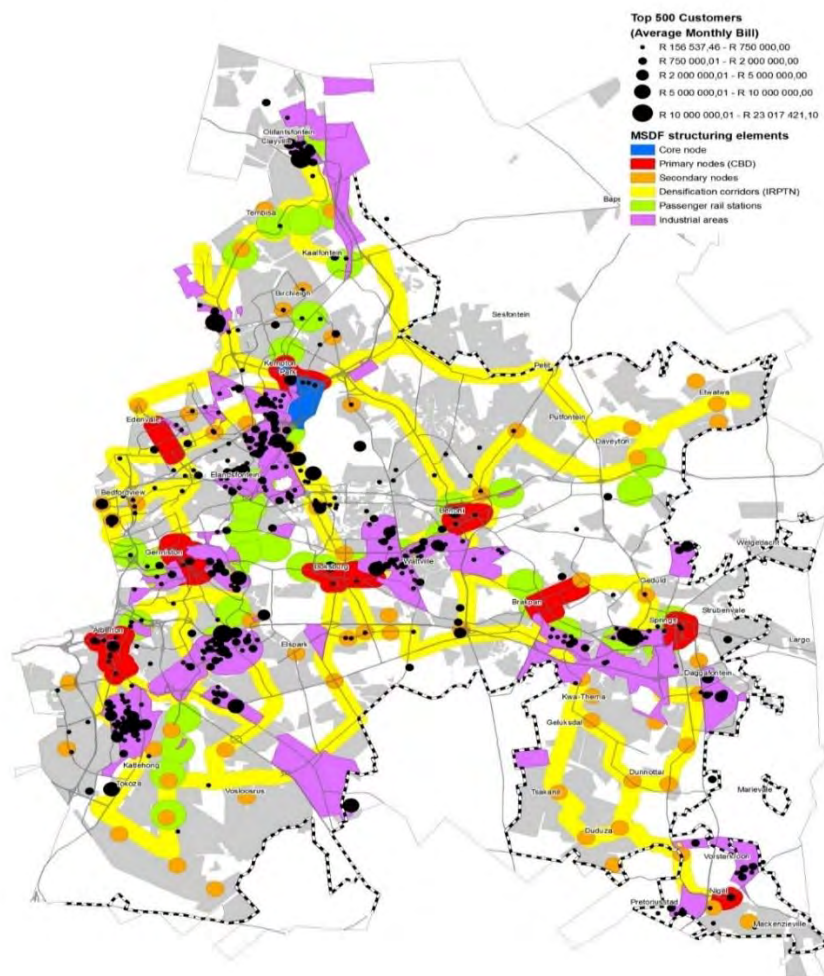


FIGURE 6-9: EMM - TOP 500 CUSTOMERS IN RELATION TO SPATIAL STRUCTURING ELEMENTS

Source: CIDMS (2015:35)

6.3.3 Best Practices

Profiles as presented in Figure 6-8 and Figure 6-9, have multiple applications relating to urban and rural growth modelling, some of which according to CIDMS (2015:35) include:

- They provide valuable information on the strength of nodes, corridors and other spatial structuring elements, and the revenue yield of the city compared to municipal investments made in these areas. Information of this nature can also be used to rank and, where appropriate, rationalise the number of spatial structuring elements and priority investment areas.
- Information on top customers is useful in many ways, including decisions on differentiated standards of service for various areas to retain key clients and attract more investment,

consideration of specially-designated development zones (e.g. industrial parks), and the design of public transportation systems.

Table 6-9 illustrates some of the principles and techniques applicable for the methodology.

TABLE 6-9: APPLICABLE MODELLING TECHNIQUES

Techniques/tools in terms of data preparation	Required information for future planning
<ul style="list-style-type: none"> - GIS: Data Management and analysis tools - Latest aerial photography 	<ul style="list-style-type: none"> - Current demographic data - ESKOM Spot Building Count - StatsSA Dwelling Framework - Updated Cadastre - Municipal zoning scheme - Municipal valuation roll - Billing system data

Source: Own Construction (2017)

The next case study is based on a land use modelling tool called WhatIf.

6.4 WhatIf – Case study: Wanneroo Local Government Authority

The City of Wanneroo is a local government area located in the northern suburbs of Perth. In order to improve the lives of communities, an innovative modelling support system were required, hence the Online Whatif (OWI) modelling support system.

6.4.1 Introduction of growth modelling method

OWI is a GIS-based online, open source planning support system (PPS) that has been developed as part of the Australian Urban Research Infrastructure Network (AURIN) workbench. It deals with important and difficult aspects of the land planning processes such as: Analysing the suitability of land for different uses, projecting future land use demands, and allocating the projected demands to the most suitable locations (AURIN, 2017). It can also be used to determine long-term projections for future land uses, population and housing, and employment for a user-defined area. According to AURIN (2017), OWI does not attempt to predict future conditions exactly. Instead, it is an explicitly policy-orientated planning tool that can be used to determine what would happen if certain policy choices are made and their assumptions concerning the future are correct (AURIN, 2017).

6.4.2 Method

OWI was applied to the Wanneroo Local Government Authority, a political division of the Perth Metropolitan Area in Western Australia. The OWI setup component includes the following options;

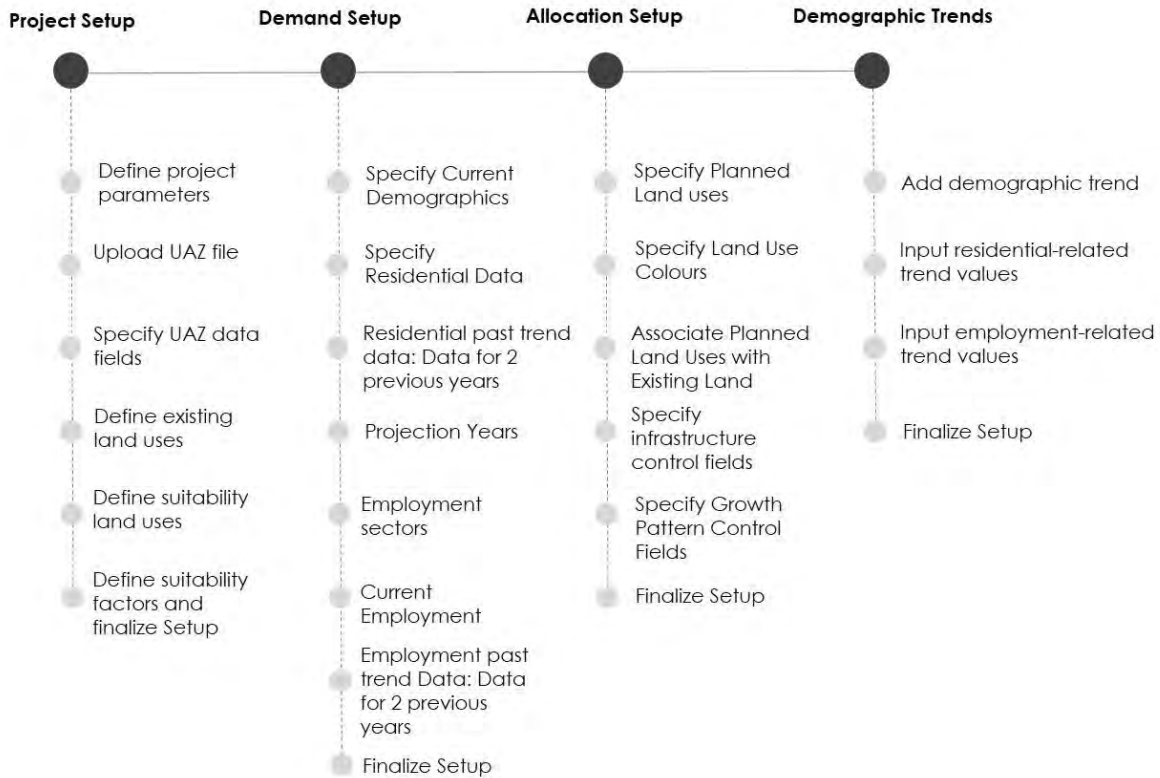


FIGURE 6-10: OWI SETUP

Source: Adapted from AURIN (2017)

According to AURIN (2017), the “Suitability Scenarios” component provides procedures for determining the relative suitability of different locations for different land uses. The scenario suitability analysis implemented in WhatIf uses Multi-criteria Evaluation techniques to calculate the Suitability Score, a numeric value, indicating a location’s overall suitability for a given land use (AURIN, 2017).

Creating and using the OWI suitability scenarios involves the following steps:

- Creating a suitability scenario;
- Specifying land use conversions;
- Specifying importance weights and suitability ratings;
- Computing suitability scores;
- Viewing suitability maps; and

- Viewing suitability reports.

But before the modelling tool can be used the first step is to prepare the various datasets for the proposed project. Data preparation include the following.

- Combining GIS Layers
- Removing multi-part Features;
- Removing slivers;
- Creating/correcting topology;
- Deleting unnecessary data fields
- Creating the UAZ shapefile.

Once all the data has been prepared, the UAZ file can be uploaded into the project setup which will initiate the process. For the purpose of this study, the details of the OWI will not be discussed. It was merely used to illustrate the capabilities of modelling tools. The following figures illustrate a suitability scenario within the Wanneroo case study. The figures depict the suitability for the following land uses, Commercial, Industrial, Residential, Medical and Educational. The legend depicts the suitability level for each use.

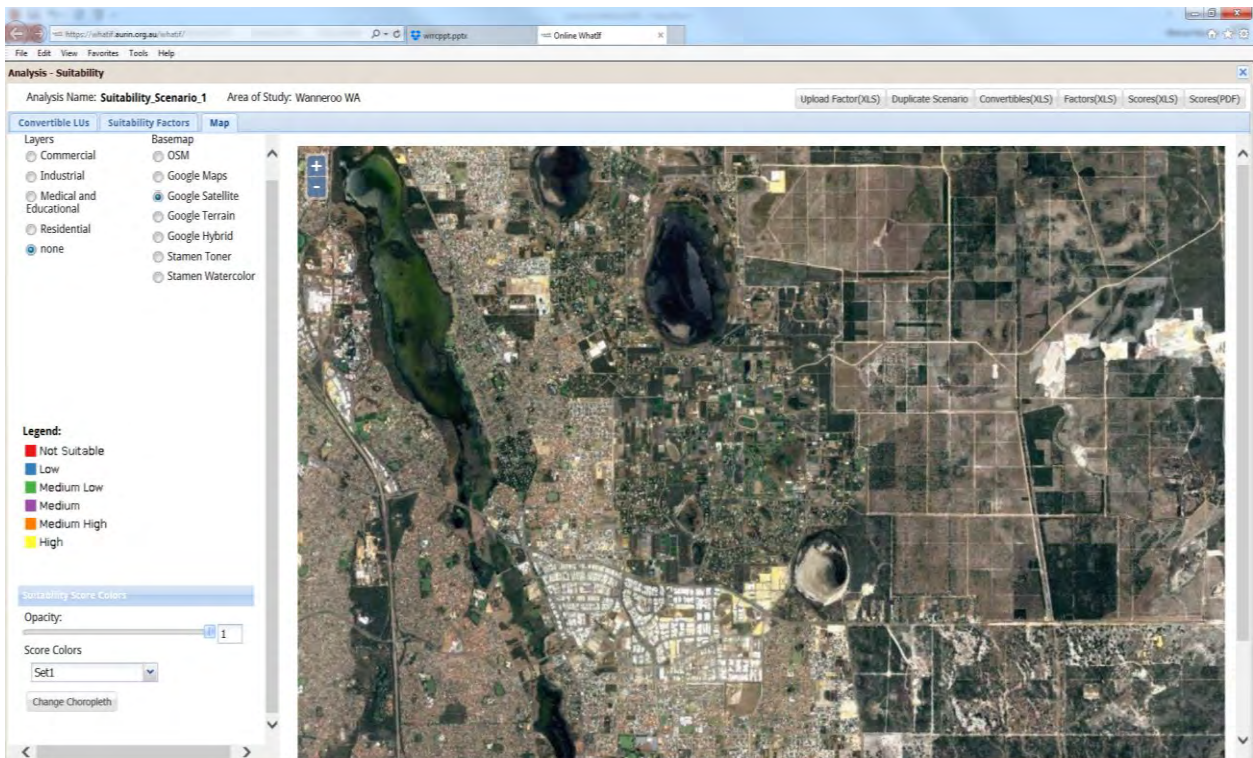


FIGURE 6-11: WANNEROO CASE STUDY

Source: AURIN (2017)

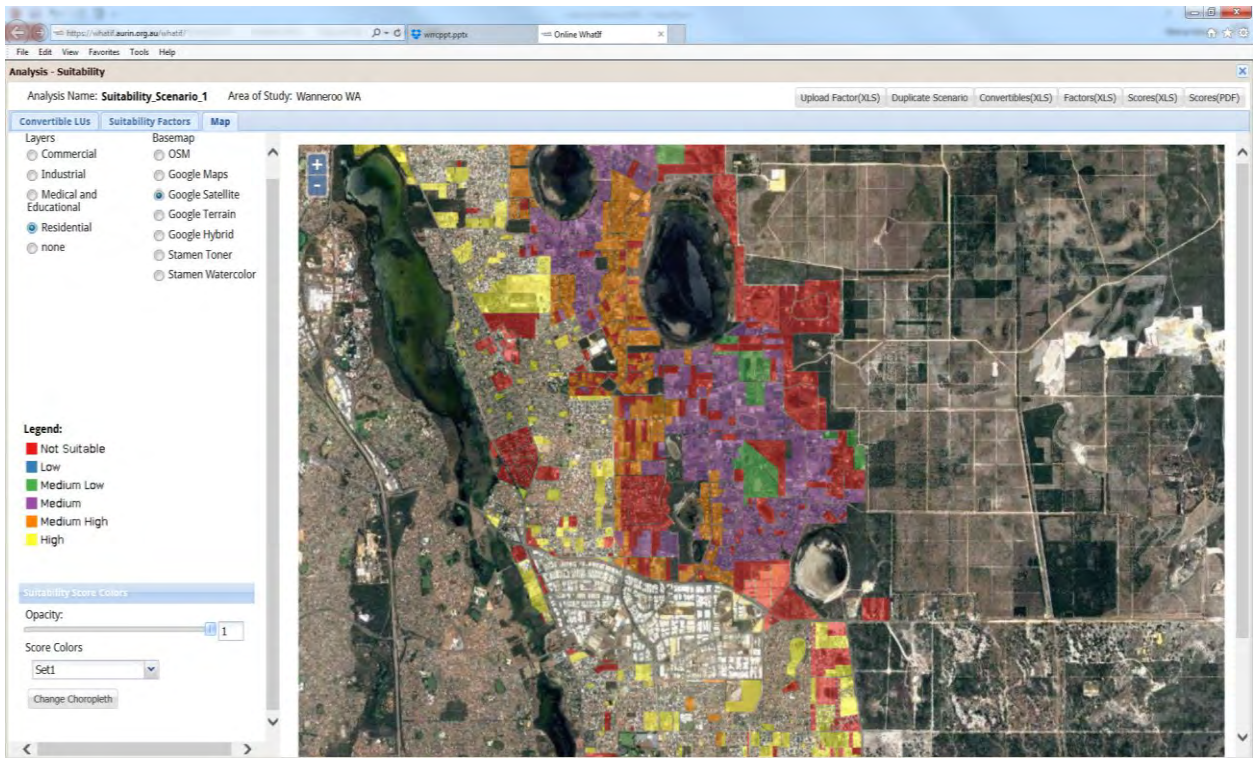


FIGURE 6-12: RESIDENTIAL SUITABILITY

Source: AURIN (2017)

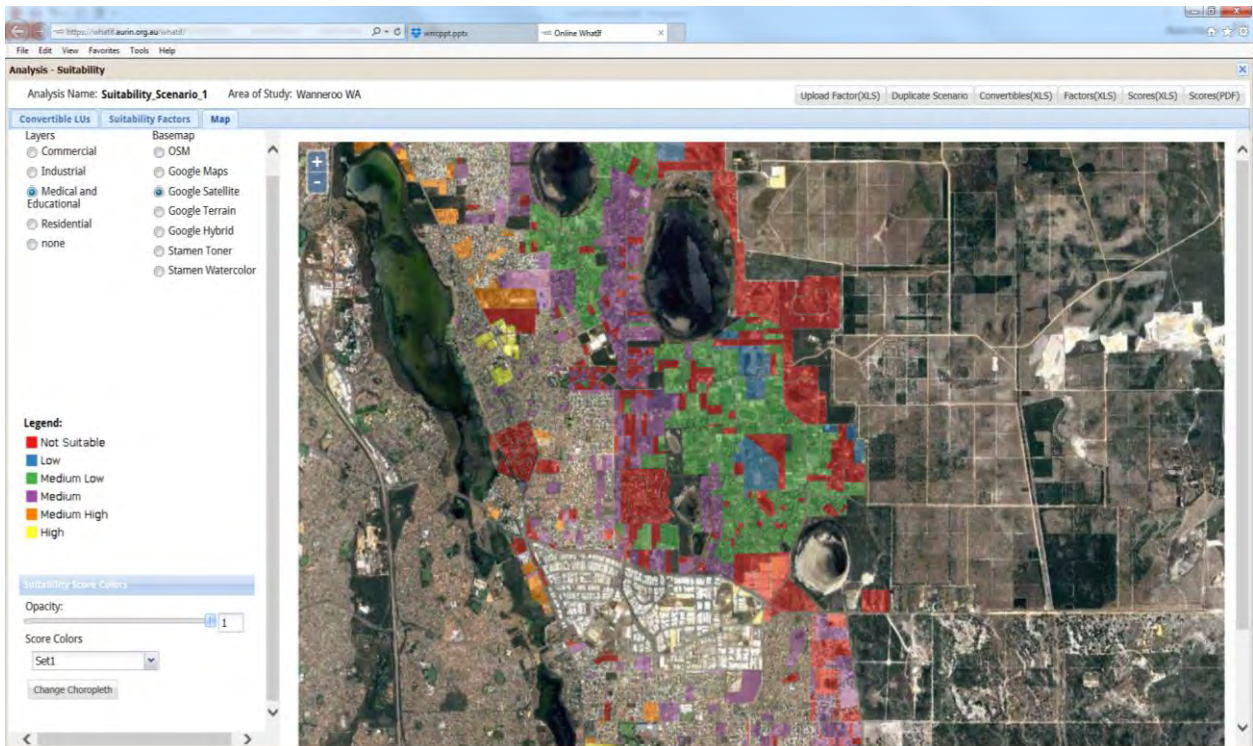


FIGURE 6-13: MEDICAL & EDUCATIONAL SUITABILITY

Source: AURIN (2017)

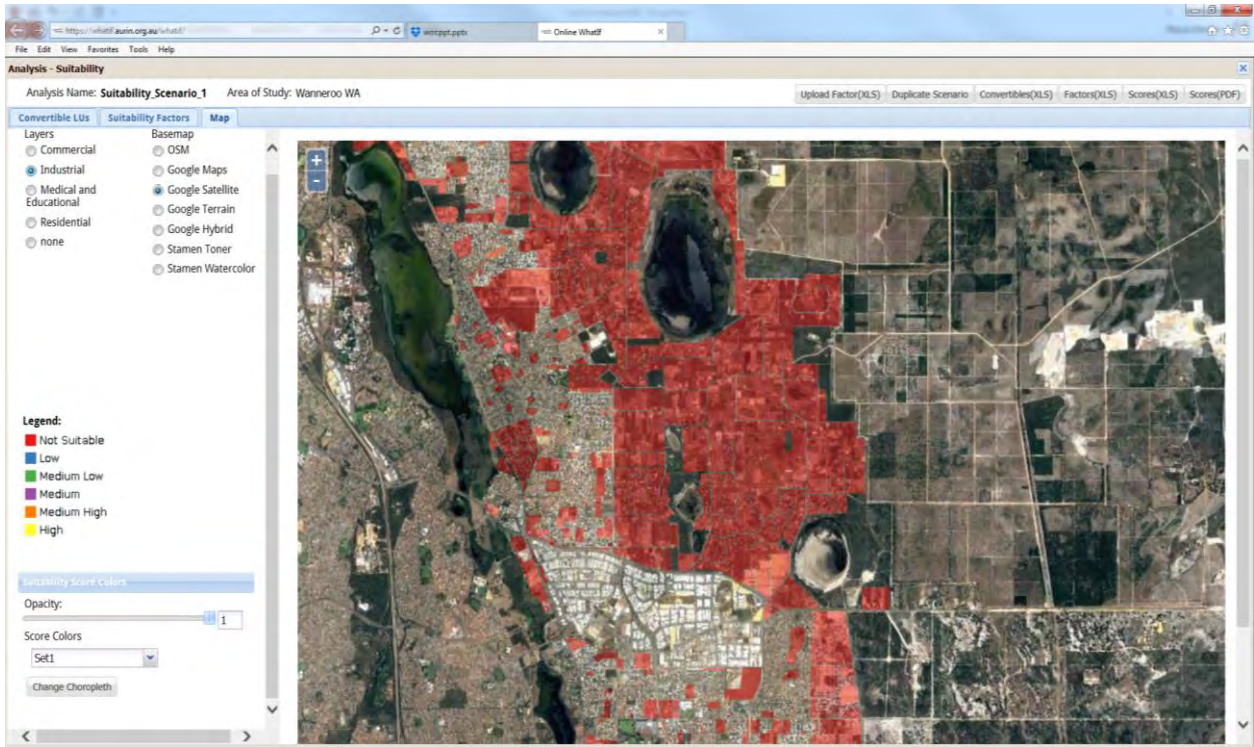


FIGURE 6-14: INDUSTRIAL SUITABILITY

Source: AURIN (2017)

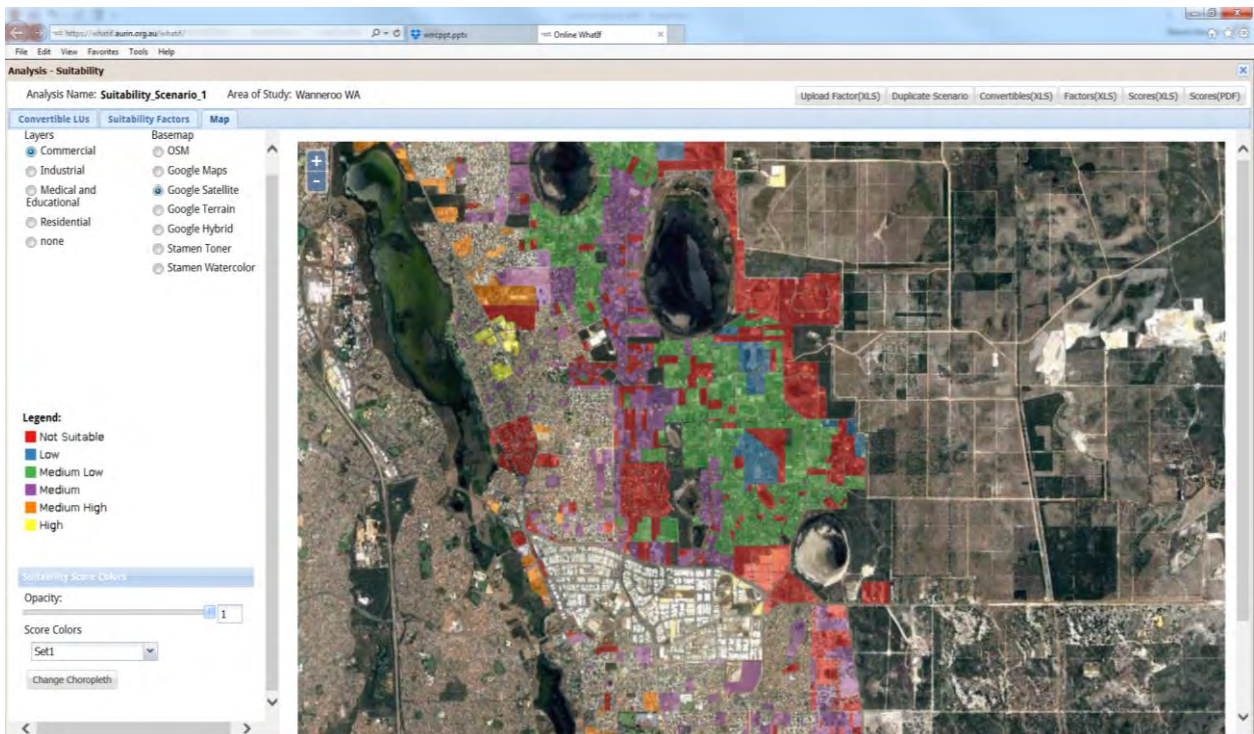


FIGURE 6-15: COMMERCIAL SUITABILITY

Source: AURIN (2017)

6.4.3 Best Practices

Technology is ever involving and there are many tools available to assist us with planning for the future. The Whatif model is just one example of many other modelling initiatives relating to urban and rural growth. The principles and techniques applicable for the methodology are depicted in Table 6-10.

TABLE 6-10: APPLICABLE PRINCIPLES AND TECHNIQUES

Techniques/tools in terms of data preparation	Required information for future planning
<ul style="list-style-type: none"> - Combining GIS Layers - Removing multi-part Features; - Removing slivers; - Creating/correcting topology; - Deleting unnecessary data fields - AHP 	<ul style="list-style-type: none"> - Current demographic data - Current land use data

Source: Own Construction (2017)

6.5 Conclusion

This chapter captured various techniques, tools and software that could assist in the urban and rural growth modelling. Table 6-11 captures the best practices of each case study.

TABLE 6-11: SUMMARY OF CASE STUDIES

Case Study	Location	Method	Best Practices of urban and rural modelling
1. Re-blocking of informal settlements	South Africa: City of Cape Town	Community participation	Driving forces of informal settlements
2. GIS-based multi-criteria approach	Cambodia: Siep Reap	GIS	Driving forces of growth. GIS techniques and the AHP process
3. Customer Based Profiling	South Africa: Ekurhuleni and Buffalo City	GIS based technique with	Determining customer based levels (Who and what are being planned

Case Study	Location	Method	Best Practices of urban and rural modelling
		other required data sources	for) – SPLUMA requirement
4. Whatif modelling	Australia: Wanneroo Local Government Authority	Online Modelling tool	Growth Modelling software and techniques to assist spatial planners with the future spatial planning process

Source: Own Construction (2017)

Selected methods were employed as part of the empirical research of this study, as elaborated on in the next chapter.

CHAPTER 7

A South African urban and rural growth modelling approach

7. Methodology

This chapter aims to illustrate the complexities of urban and rural areas in South Africa by considering the town of Lephalale located in the Limpopo Province. Planning, in any country, are subject to a specific legislative framework. The methodology employed in this chapter is aligned with SPLUMA and entails the content as depicted in section 21 of the act. The overall objective of Chapter 7 is to provide a method or “toolset” illustrating a practical approach to urban and rural growth modelling, which spatial planners can utilise in the preparation of Spatial Development Frameworks.

One of the requirements from SPLUMA in terms of Spatial Development Frameworks is that spatial planners have to plan for a five, ten and twenty year period (as reflected in Chapter 3). The selected case study is a good example of growth projections that were not accurate. With the announcement of the Mdupi Power Plant, assumptions were made that the town of Lephalale would grow immensely however, that was not the case and now the town is left with many vacant stands and undeveloped land.

The empirical method employed in this chapter firstly considers the drivers of growth discussed in Chapter 4 and then identify suitable methods to model this data as listed in Chapter 5 and Chapter 6. Assumptions were then applied to model different planning scenarios. The last part of the chapter illustrates the outcome of the methodology applied to the area of study. Table 7-1 depicts the step by step growth modelling process that was employed for the case study Lephalale as captured in the remainder of this chapter.

TABLE 7-1: METHODOLOGY EMPLOYED IN THIS CHAPTER

Methodology	Classification	Reference
Objective 1	Understanding the status quo	
Step 1	Delineation of the area of study	Chapter 2
Step 2	Growth progression	Chapter 3
Objective 2	Prepare customer based profile	
Step 1	Prepare land parcel base data	

Methodology	Classification	Reference
Step 2	Capture informal settlements and backyard shacks	Chapter 6
Step 3	Combine formal and informal data	
Step 4	Prepare demographic data	
Step 5	Perform first level segmentation	
Step 6	Quantify the number of customers per point	
Step 7	Add demographic and density indicators	
Step 8	Prepare municipal customer database	
Objective 3	Identify driving forces of Urban and rural growth (Refer to Figure 4-6)	
Step 1	Socio-economic factors	
Step 2	Physical factors	
Step 3	Environmental factors	
Step 4	Social change factors	
Objective 4	Prepare identified datasets	Chapter 5 (AHP) Chapter 6 (WhatIF)
Step 1	Socio-economic factors	
Step 2	Physical factors	
Step 3	Environmental factors	
Step 4	Social change factors	
Step 5	Data preparation – Combination process	
Objective 5	Analyse possible conflicts between datasets and derive a suitability layer	Chapter 5 (AHP)

Methodology	Classification	Reference
Objective 6	Identify land suitability	
Objective 7	Develop urban/rural growth scenarios (5, 10, 20 years)	

Source: Own Construction (2017)

The aim of each objective is listed in Table 7-2.

TABLE 7-2: METHODOLOGY - AIMS OF OBJECTIVES

Objectives and aims
Objective 1: Understanding the status quo
Before any modelling should commence it is imperative to understand the status quo of an area. The first objective deals with the delineation and growth of the study area with the aim of understanding the area of study and how growth has taken place since 2005.
Objective 2: Prepare customer based profile
The second objective dealt with the data preparation for the customer profile with the aim of determining the number and location of citizens in order to determine the level required for future planning.
Objective 3: Identify the driving forces of Urban and rural growth
The aim of this objective were to identify the driving forces of urban and rural growth which are applicable to the area of study.
Objective 4: Prepare identified datasets
Once all the data were collected, the next process involved preparing the identified datasets for objective 7.
Objective 5: Analyse possible dataset conflicts and derive a suitability layer
This objective involved analysing possible dataset conflicts with the aims of deriving a suitability layer which are also a requirement in order to develop a future growth scenario.

Objective 6: Identify land suitability

This objective commenced with identifying land suitable for future urban and rural growth.

Objective 7: Develop urban/rural growth scenarios (5, 10, 20 years)

The last objective involved making sense of all the information prepared in the previous objectives with the aim of preparing different urban and rural growth scenarios as stipulated in SPLUMA.

Source: Own Construction (2017)

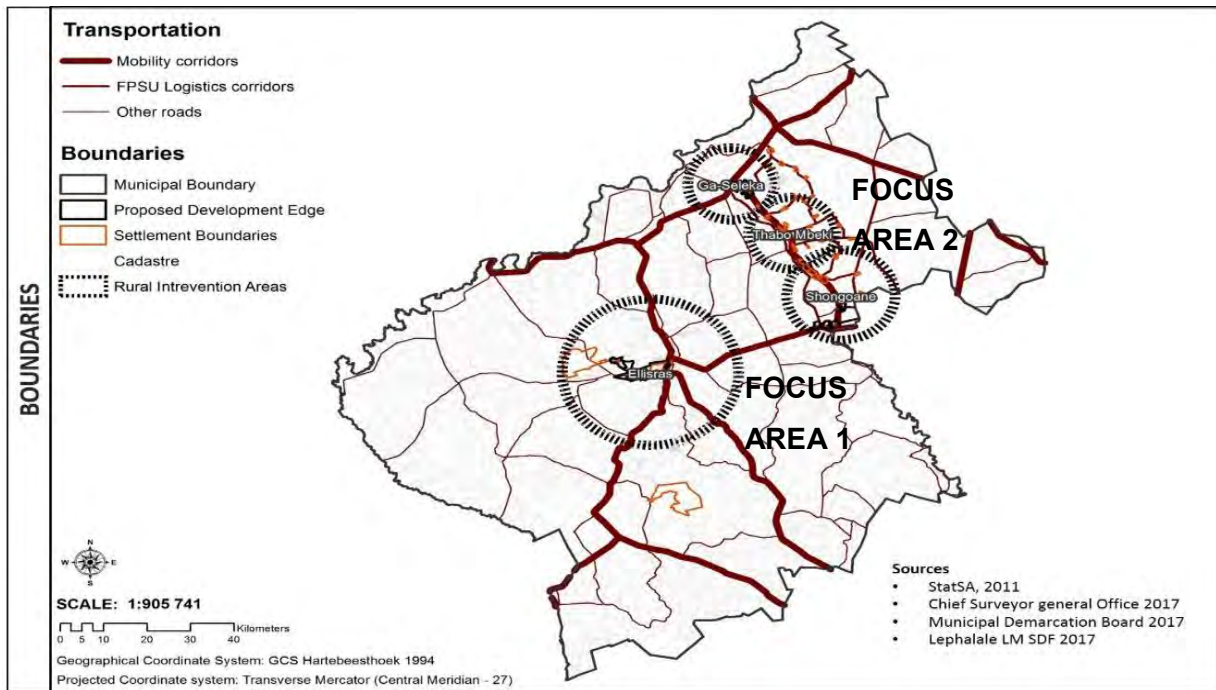
7.1 Objective 1: Delineation and growth of the study area

The selected area of study is the Local Municipality of Lephalale. According to the Government (2017), Lephalale Local Municipality is located in the north-western part of the Waterberg District in the Limpopo province. It borders with four local municipalities: Blouberg, Mookgophong/Modimolle, Mogalakwena and Thabazimbi (Government, 2017). The Lephalale Local Municipality is the biggest Municipality in the Limpopo province. The Municipality consists of a large number of incremental rural areas “villages”. For the purpose of this study, the area was divided into two focus areas as illustrated in Table 7-3 and depicted in Map 7-1.

TABLE 7-3: DELINEATION OF THE STUDY AREA

Focus area	Settlement Type	Name
1	Urban	<ul style="list-style-type: none"> • Lephalale (Ellisras)
2	Rural	<ul style="list-style-type: none"> • Shongoane • Thabo Mbeki • Ga-Seleka

Source: (Own Construction, 2017)



MAP 7-1: STUDY AREA - LEPHALALE LM

Source: Own Construction (2017)

The growth perspective for both focus areas is illustrated below.

Focus Area 1: Lephalale/Marapong

Figure 7-1 illustrates the growth that has taken place since 2005 within the town of Lephalale. The sources represent South Africa's national landcover (built-up areas) of 2005 and 2014. The 2017 data represents built-up areas compiled by a land use survey. Growth started off slowly, but with the commencement of the Mdupi Power Plant, growth suddenly increased. The majority of growth took place within the Marapong Township, mainly because of the workers residing within the Township. As previously discussed the Town currently experience a situation where there are approved layout plans where no development has yet occurred due to wrong growth expectations.

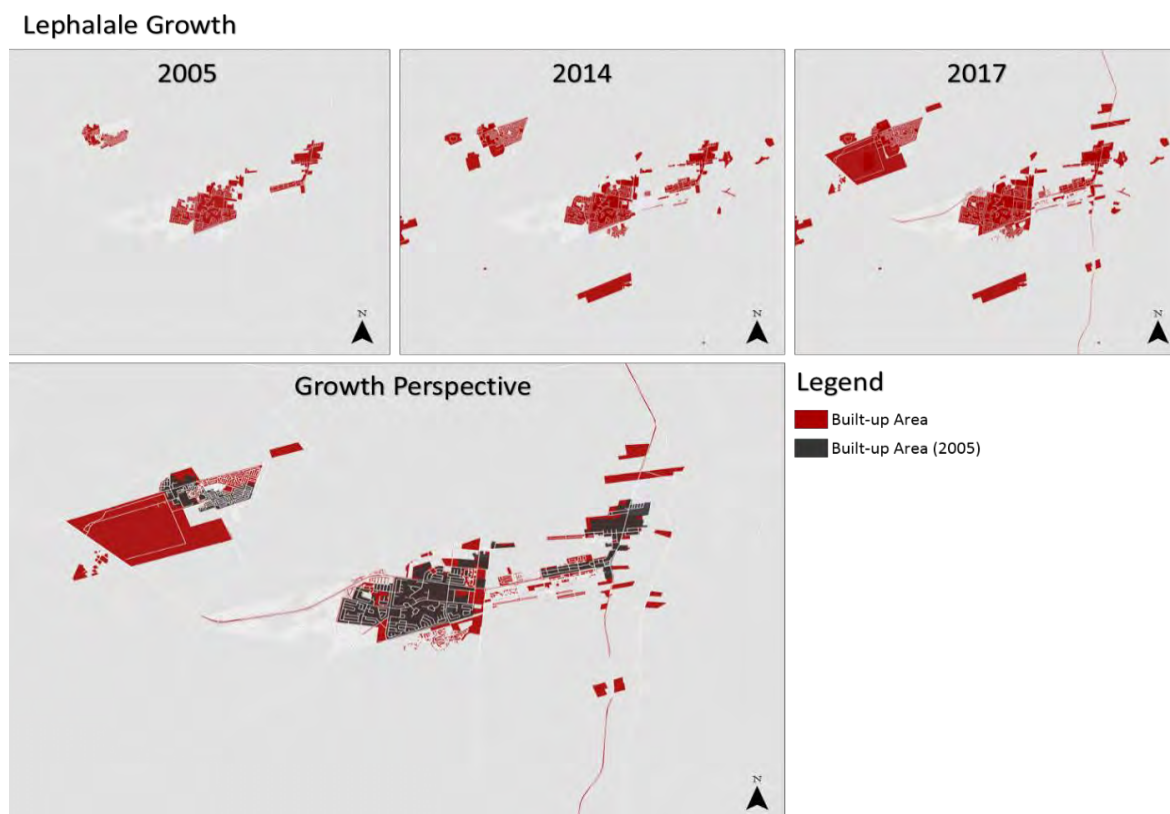


FIGURE 7-1: LEPHALALE GROWTH PERSPECTIVE

Source: Own Construction (2017)

Focus Area 2: Ga-Seleka, Thabo Mbeki, Shongoane

Focus area 2 depicts the incremental (rural) areas within the Municipality. Ga-Seleka and Shongoane/Setateng are categorised as rural service delivery points, while Thabo Mbeki is categorised as a Municipal Growth point (Lephalale Local Municipality, 2017). Figure 7-2 to Figure 7-4 illustrates the growth that has taken place within focus area 2 since 2005.

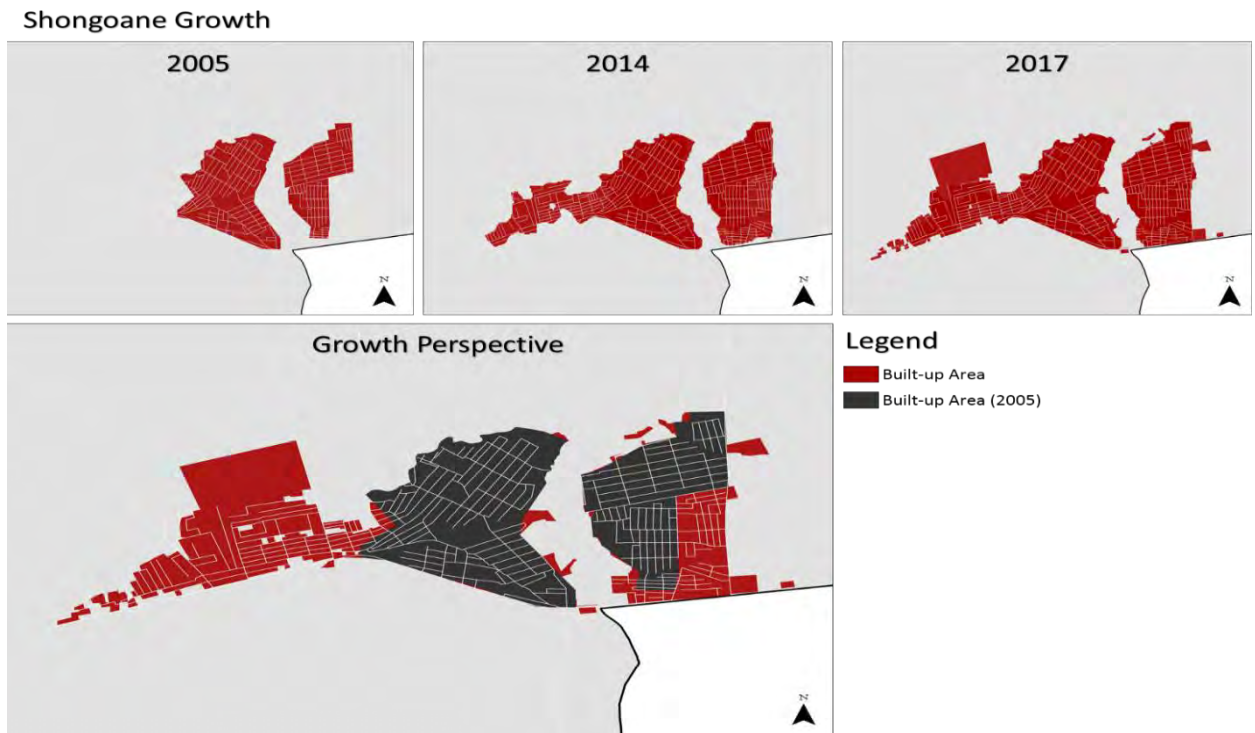


FIGURE 7-2: SHONGOANE GROWTH PERSPECTIVE

Source: Own Construction (2017)

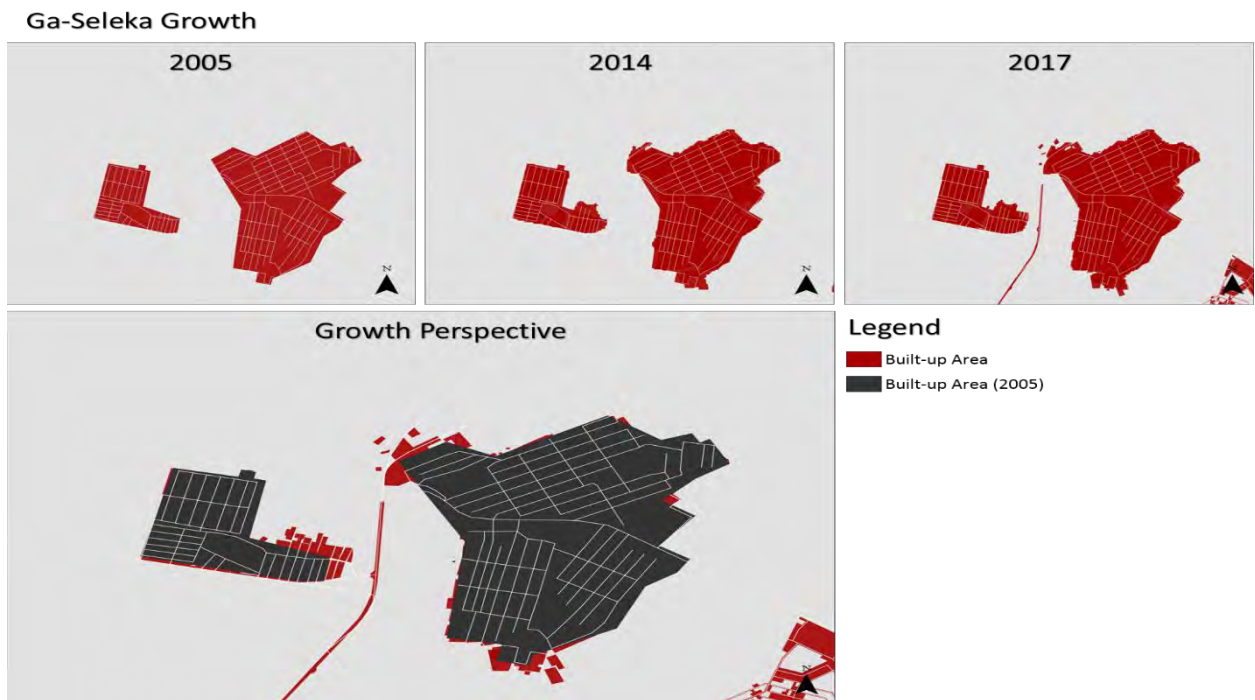


FIGURE 7-3: GA-SELEKA GROWTH PERSPECTIVE

Source: Own Construction (2017)

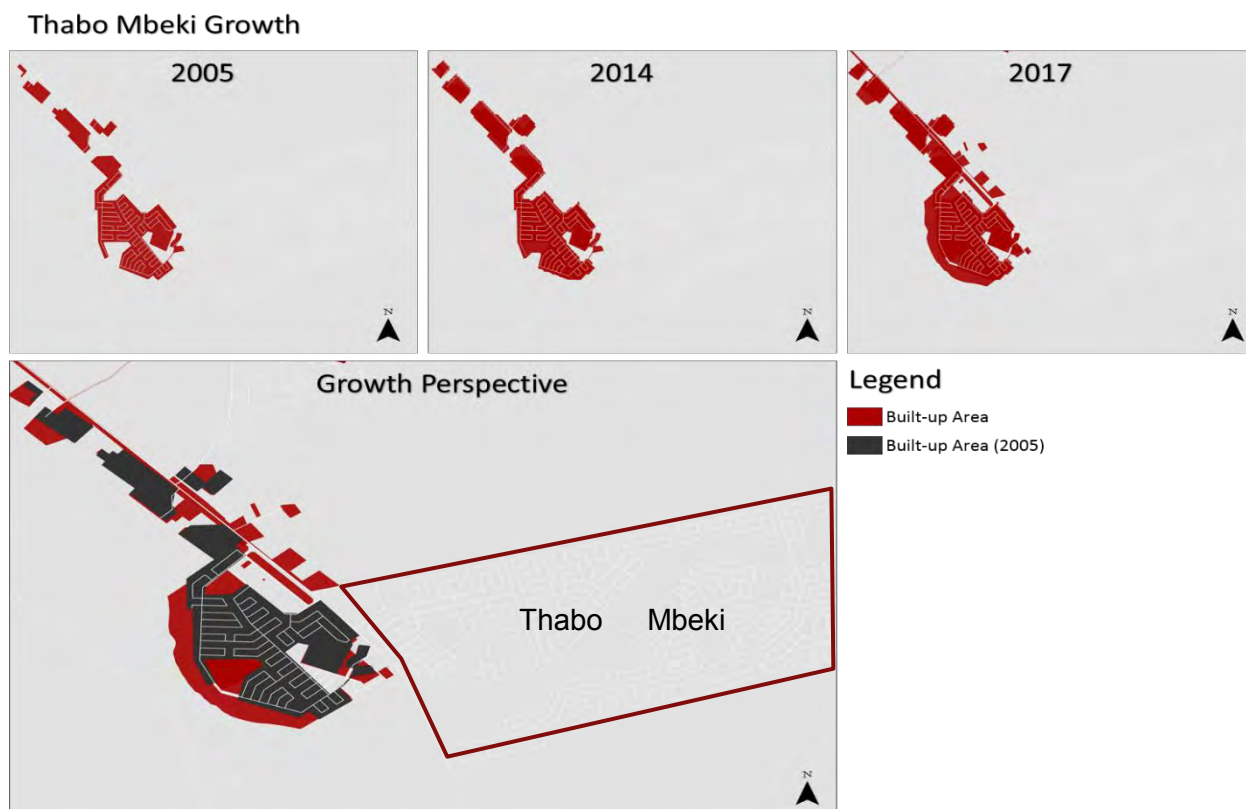


FIGURE 7-4: THABO MBEKI GROWTH PERSPECTIVE

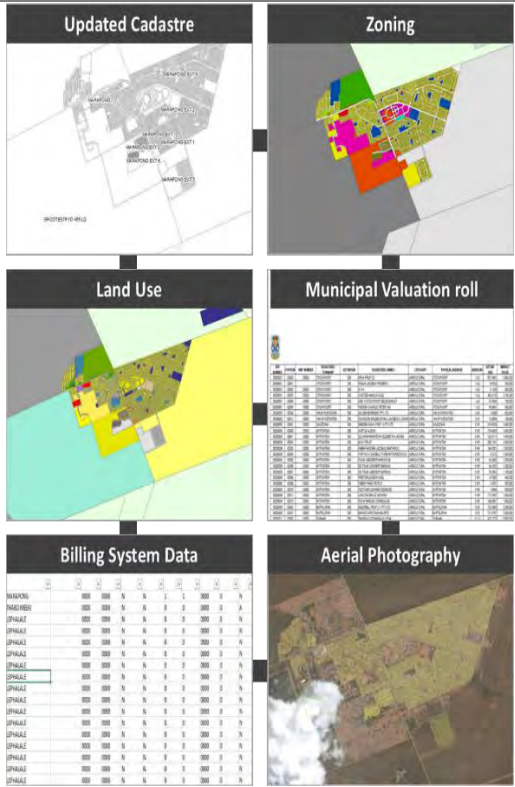
Source: Own Construction (2017)

The two rural service delivery points, Shongoane and Ga-Seleka are connected with Thabo Mbeki through the district road D3110 (Lephalale Local Municipality, 2017). Currently, Thabo Mbeki Ext 2 is still vacant. Over time the area will be populated as growth takes place. As previously discussed, a large population in Thabo Mbeki are located within the calculated floodline. These households should be reallocated to Thabo Mbeki Ext 2. Farmer production support units will also enhance growth within these areas. The process that was followed in determining future growth areas within the Lephalale LM will now be discussed.

7.2 Objective 2: Methodology for spatial profiling of customers

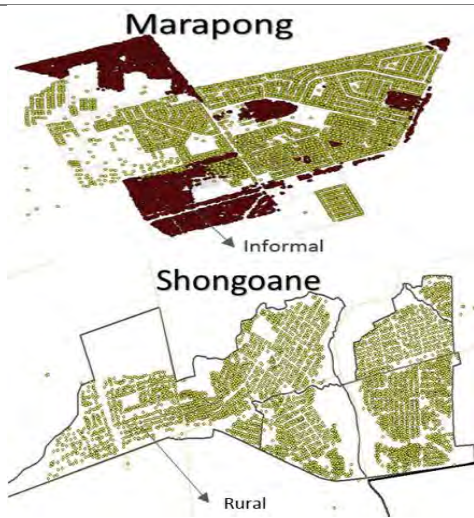
The second objective dealt with the data preparation for the customer profile. The customer profile is a different approach to determine household figures for a given area.

TABLE 7-4: LEPHALALE CUSTOMER PROFILE

Execution	
Step 1: Land parcel data preparation	
	<p>Once the cadastre was updated the Municipal Valuation Roll and Billing System Data information could be spatially joined with the Cadastre using GIS and the unique SG or LPI code of each parcel. The SG or LPI code is a unique 21 digit code. Each formal land parcel has its own unique code. The figure below illustrates the 21 digit code. The key is compiled as follows:</p>
<p>TOIQ00990000012300001</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>SG Office and registration division</p> </div> <div style="text-align: center;"> <p>Numeric code for townships, holdings or Administration Districts</p> </div> <div style="text-align: center;"> <p>Parcel number</p> </div> <div style="text-align: center;"> <p>Portion number</p> </div> </div>	
<p>Source: Chief Surveyor-General (2017)</p> <p>Once all the information were spatially joined with the cadastre, some analysis was done to populate the following fields: <i>SG21 identifier, Town/farm name, Stand number, Extent, Existing land use, Owner name, Number of water meters and Number of electricity meters</i> (CIDMS, 2015).</p>	

Execution

Step 2: Capturing of informal settlements and backyard shacks



Source: Adapted from Eskom (2011); StatsSA (2016a)

The first step accounted for customers located on formal land parcels. Step 2 involved identifying customers residing in informal settlements, backyard shacks and traditional villages (Incremental Areas). StatsSA dwelling framework and Eskom’s Spot building count data were sourced to identify the required information. The figure on the left illustrates the process.

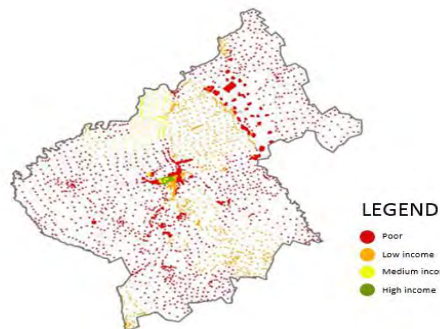
Each point (housing structure) captured in an informal settlement or traditional village, or backyard shack represents one customer (CIDMS, 2015:30). Once the necessary fields were added (*SG21 identifier, Town/farm name, Stand number, Existing land use and Number of customers*), the next step involved combining the informal and formal datasets.

Step 3 to Step 5: Combine formal and informal data, prepare demographic data and perform segmentation

SP_CODE	SP_NAME
978007001	Bossche Diesch SP
978013001	Botsalanong SP
978005001	Botshabelo SP
978032005	Dikgopeng
978030001	Dimpompong SP
978031001	Ditloung SP
978021001	Ga-Machoko SP
978033001	Ga-Maeteletsa
978035001	Ga-Monyeki SP

Source: StatsSA (2011)

ANNUAL INCOME



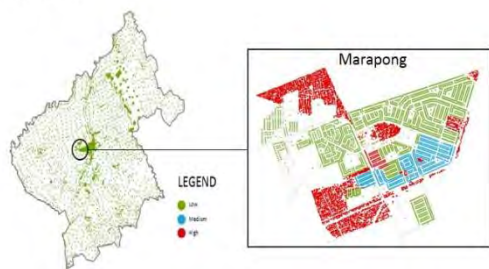
Step 3 involved combining the formal and informal datasets with each other, but before that could be done the formal data firstly had to be converted to Centroids/points whilst using GIS. Step 4 relied on the latest census information from StatSA. The following information was extracted at the lowest level of geographic detail (Small-Area Layer) – refer to Figure 4-7.

- Number of households;
- Annual Households.

The information was then spatially joined in GIS with StatsSA “Small Area Layer” using the unique SP code.

Execution

DENSITY



Source: Adapted from StatsSA (2011)

From the above data the gross density was calculated (the number of households divided by the geographic extent of the SAL in hectares). The figures below illustrate the annual income and density levels within the Municipality (Note: The income and density categories are based on the CIDMS guidelines).

Step 5 involved reworking the existing land use data of each point into the customer categories defined in Table 6-5.

Step 6: Quantify the number of customers per point

Once the customer category was assigned to each spatial point, the number of customers were calculated. The sectional title and multi-storey building information were sourced from the Valuation Roll, Billing system data and StatsSA Dwelling Framework Data (2016).

Step 7 and Step 8: Demographic and density indicators and Customer Database preparation

Step 7 consisted of the classification and quantification of the customers. The final customer database consists of the following fields:

- SG21 identifier; Town/farm name; Stand number; Extent; Existing land use; Owner name; Customer category; Number of customers; Average annual income category; Gross residential density category

Source: Own Construction (2017)

The result from the customer profile is depicted in Table 7-5.

7.2.1 Customer Profile Outcome

TABLE 7-5: LEPHALALE LOCAL MUNICIPALITY CUSTOMER DATABASE

Customer Category	Income Level	Density Category	Formal	Rural	Total	
Residential	High	High			0	
		Medium			0	
		Low	1 985		1 985	
	Medium	High			0	
		Medium			0	
		Low	2 957		2 957	
	Low	High			0	
		Medium	332		332	
		Low	676	2 893	3 569	
	Poor	High	3 235		135	
		Medium	1 225		1 225	
		Low	5 140	16 617	24 857	
			HH	15 550	19 510	35 060
	Non-Residential	Business/Industrial/Commercial/Institutional		1 921	1 007	2 928
	Grand Total					37 988

Source: Adapted from StatsSA (2016a)

Table 7-5 above illustrates the residential and non-residential customers calculated for the study area. The figures calculated above only represent the customers located within the two focus areas as illustrated in Figure 7-5.

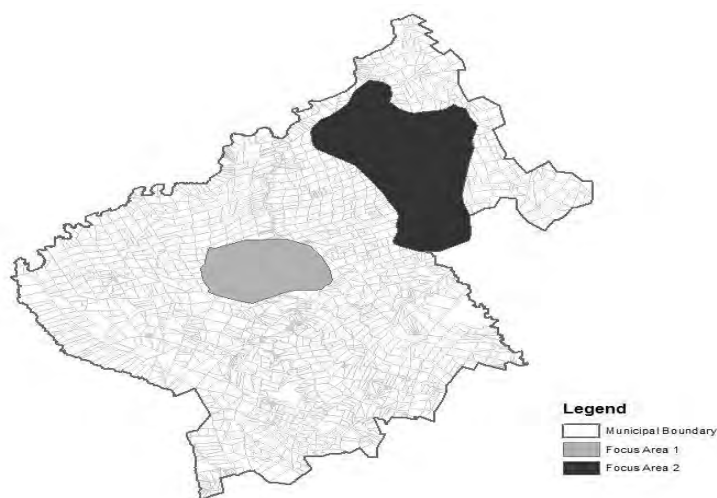


FIGURE 7-5: FOCUS AREAS FOR CUSTOMER PROFILE

Source: Adapted from StatsSA (2016a); Lephale Local Municipality (2017)

Objective 3 deals with the drivers of urban and rural growth in the Lephale Local Municipality.

7.3 Objective 3: Identify driving forces of Urban and Rural Growth

The socio-economic information was sourced from StatsSa (2011), StatsSa Community Survey (2016) and Quantec easy data (Quantec, 2017). The table below depicts the driving forces identified within the Lephale LM.

TABLE 7-6: URBAN AND RURAL DRIVING FORCES

Categories	Socio-Economic Factors	Physical Factors	Environmental Factors	Social Change Factors
Population Growth	✓			
Fertility Rate	✓			
Mortality Rate	✓			
Migration	✓			

Categories	Socio-Economic Factors	Physical Factors	Environmental Factors	Social Change Factors
Household Densities	✓			
Dwelling Type	✓			
Growth Boundaries		✓		
Land Use Change		✓		
Infrastructure Planning		✓		
Distance		✓		
Slope			✓	
Agriculture			✓	
Biodiversity			✓	
Hydrology			✓	
Swelling Clays			✓	
Soils			✓	
Dolomitic Areas			x	
Biological				x
Physical				x
Technology				x
Cultural				x

Source: Own Construction (2017)

Some shortcomings exist in terms of data availability based on human behaviour for the Lephalale LM. Human behaviour however, remains an important determining factor of urban and rural growth. For the best results, a detailed study should always be pursued. Some of the models identified in Chapter 5 can address human behaviour. The next objective deals with preparing the identified datasets.

7.4 Objective 4: Preparing identified datasets

According to Cilliers (2010:69), there are two types of spatial data structures that can be used in the analysis of a GIS-based land-use suitability model, namely, vector and raster datasets. It is known that although vector datasets can be used in some types of GIS-based land-use suitability analysis, they are not the most desirable choice (Cilliers, 2010:69). For the purpose of preparing the datasets, the data was first prepared as vector datasets. For preparing the suitability model, the data was converted within GIS as raster datasets. The suitability model is discussed and illustrated within objective 5.

7.4.1 Socio-economic Factors:

The socio-economic drivers below were discussed in Chapter 4 and are reflected in Figure 7-6. Utilising Statistics South Africa’s information and datasets, the applicable statistics were compiled within Microsoft Excel. For 2016 data, the StatsSA Community survey were applied.

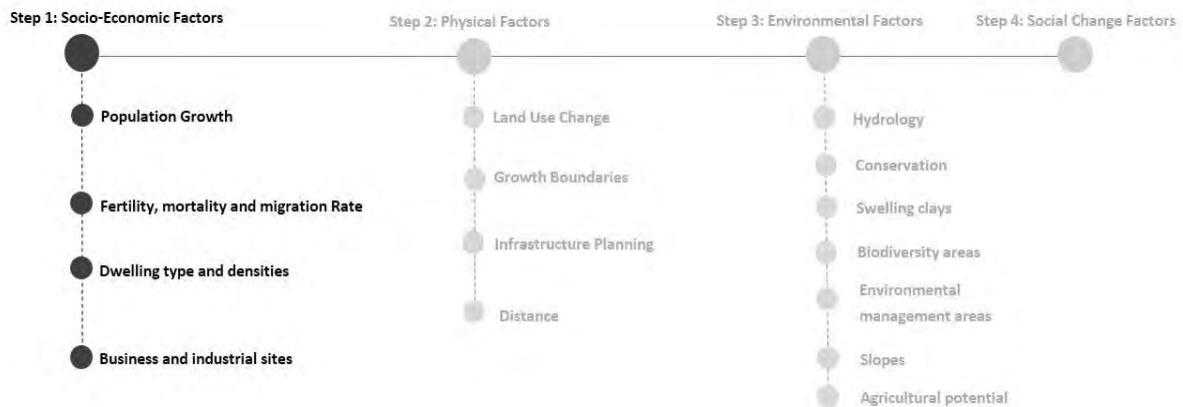


FIGURE 7-6: METHODOLOGY - SOCIO-ECONOMIC FACTORS

Source: Own Construction (2017)

7.4.1.1 Population Growth

Chapter 4 introduced different methods to calculate population growth. From the calculation illustrated in Chapter 4, two assumptions were utilised to calculate the population and household

growth for the Municipality. The purpose for the inclusion of two assumptions was solely to distinguish what could happen with the population and household figures, should the growth in the Municipality occur at different rates. The assumptions applicable is illustrated in Table 7-7.

TABLE 7-7: GROWTH RATE CALCULATIONS

Assumption 1: Growth rate from the past 5 years	
Description	Formula
To determine the population and household figures for the year 2017, the growth rate for the previous five years were calculated.	$\frac{((\text{Latest year} - \text{Previous year}) / (\text{Previous year}))}{(\text{Number of years between the latest and previous year})} * 100$
Assumption 2: Fertility/Mortality/Migration growth rate	
Description	Formula
These are crucial determining factors of urban and rural growth. Method 2 however, only depicted the population growth rate and not the household growth rate	<p>Population change = (Births - Deaths) + (Immigrants - Emigrants)</p> $P_t = P_0 + (B - D) + (I - E)$ <p>Where: P₀ = initial population</p> <p>P_t (2017) = population after time t</p>

Source: Own Construction (2017)

Assumption 1:

Table 7-8 depicts 2011, 2015 and 2016 population and household figures for the study area. The statistics were sourced from StatsSA (2011), StatsSA Community Survey (2016) and Quantec Easy data (2015).

TABLE 7-8: POPULATION AND HOUSEHOLDS

Lephalale Local Municipality	2011	2015	2016
Population			
Census Households	29 884	31 755	42 073
Census Population	115 767	124 679	136 626

Source: StatsSA (2011); StatsSA Community Survey (2016); Quantec Easy data (2015).

The reason for the inclusion of the 2015 statistics is due to a new Municipal Demarcation which took place in 2016. This meant the Municipality received an additional population, which meant that calculating the population and household growth rate would not really be a true reflection of what is currently happening within the Municipality. The population and household growth rates as reflected in Table 7-8, were calculated using the formula “Assumption 1” as illustrated in Table 7-7. The result is depicted below in Table 7-9.

TABLE 7-9: POPULATION AND HOUSEHOLD GROWTH RATE

Growth Rate	2011 - 2016	2011 - 2015
Household	8.16%	1.57%
Population	3.60%	1.92%

Source: StatsSA (2011); StatsSA Community Survey (2016); Quantec Easy data (2015).

From the table above it is evident that the Municipal Demarcation influenced both the population and household growth rates. The 2011 to 2015 growth rate is thus a more realistic figure to work with. There are various methods used to predict population growth for a given area as discussed in Chapter 4. The next assumption illustrates the growth rate calculated in terms of fertility, mortality and migration patterns.

Assumption 2:

Three of the most common statistical measures of population change as discussed in Chapter 4, is the crude birth rate (CBR), crude death rate (CDR) and the rate of migration. Below are the calculations and results for the study area.

TABLE 7-10: METHODOLOGY – FERTILITY, MORTALITY AND MIGRATION RATE

Fertility and Mortality Rate																	
Formula: Birth rate/Death rate/Rate of natural increase																	
Birthrate/1000 population = Births per year/Total Population *1000																	
Death Rate/1000 population = Deaths per year/Total Population *1000																	
RNI = (CBR - CDR) * 10																	
Source: AAG (2011)																	
Calculation	Conclusion																
<p>The table below depicts the statistical results for the Municipality</p> <table border="1"> <thead> <tr> <th>Category</th> <th>2016</th> <th></th> <th>Rate</th> </tr> </thead> <tbody> <tr> <td>Total Population</td> <td>136 626</td> <td>RNI</td> <td>2.5%</td> </tr> <tr> <td>Total Births</td> <td>3 432</td> <td>CBR</td> <td>25.1%</td> </tr> <tr> <td>Total Deaths</td> <td>1 158</td> <td>CDR</td> <td>8.5%</td> </tr> </tbody> </table> <p>Source: StatsSA (2011)</p> <p>Given a RNI of 2.5%, we can predict that the population of Lephalale will grow by 3 416 people in one year (136 626 x 2.5% = 3 416)</p>	Category	2016		Rate	Total Population	136 626	RNI	2.5%	Total Births	3 432	CBR	25.1%	Total Deaths	1 158	CDR	8.5%	<p>Based on the results on the left, it is evident that the growth rate is much higher than assumed in Table 7-14. 2.5% relative high growth rate for the Municipality. If the Municipality growth by 2.5%, the total population will growth by 3 416 citizens. This means an additional 793 citizens are expected (Only considering fertility and mortality rate).</p>
Category	2016		Rate														
Total Population	136 626	RNI	2.5%														
Total Births	3 432	CBR	25.1%														
Total Deaths	1 158	CDR	8.5%														
Migration																	
Statistics	Description																
<p>The table below depicts the 2016 statistical figures of the migration patterns for the area of study.</p>	<p>Migration is an important factor of urban and rural growth. Both in and out-migration can have</p>																

Categories	2016	Percentage of population	a tremendous impact on a given population. Conclusion From statistics on the left, it is evident that the Municipality received an additional 1 048 citizens in 2016 through migration patterns.
Total Population	136 626	100%	
In-Migration	1 196	0.88%	
Out-Migration	148	0.11%	

Source: StatsSA (2016a)

(In Migration – Out-migration = Additional population
= 1 196 – 148 = 1 048).

Source: Adapted from AAG (2011); StatsSA (2011); StatsSA (2016a)

Table 7-11 illustrate the combination of the fertility, mortality and migration factors for the study area.

TABLE 7-11: POPULATION CHANGE FACTORS

Categories	2016	Percentage of total population
Population	136 626	100%
Births	3 432	2.5%
Deaths	1 158	0.8%
In-migration	1 196	0.9%
Out-migration	148	0.1%
Migration	1 048 (1 196 – 148)	0.8%

Source: StatsSA (2016a)

The results above were used to calculate the population change for the study area. The calculation and result are depicted in Table 7-12.

TABLE 7-12: METHODOLOGY - POPULATION CHANGE

Population Change	
Formula	Conclusion
Population change = (Births - Deaths) + (Immigrants - Emigrants) $P_t = P_0 + (B - D) + (I - E)$ Where: P_0 = initial population P_t (2017) = population after time t	From the calculations on the left, the projected population for the year 2017 is 139 948. While the RNI is depicted as 2.4%. That is 0.1 % less as illustrated in the fertility and mortality calculations.
Calculation	
$P_t = 136\ 626 + (3\ 432 - 1\ 158) + (1\ 196 - 148)$ $P_t = 139\ 948$ $RNI = ((139\ 948 - 136\ 626) / 136\ 626) = 2.4\%$	

Source: Own Construction (2017)

Once the growth rate was established, the next step involved making assumptions based on the additional years. The assumptions for assumption one were based on normal steady growth, while for assumption 2, the growth rate represented a higher population and household growth rate. The following assumptions were made in terms of the population and household growth rates.

TABLE 7-13: GROWTH ASSUMPTIONS

Assumption	Category	2017	2018-2020	2021-2022	2023-2027	2028-2031	2032-2035	2036-2037
1	HH growth rate	1.57%	1.57%	1.58%	1.60%	1.65%	1.67%	1.68%
	Population Growth rate	1.92%	1.92%	1.93%	1.95%	2.00%	2.20%	2.30%

Assumption	Category	2017	2018-2020	2021-2022	2023-2027	2028-2031	2032-2035	2036-2037
2	HH rowth rate	1.57%	1.57%	2.0%	2.1%	2.0%	2.3%	2.2%
	Population Growth rate	2.4%	2.4%	2.2%	2.0%	2.1%	2.2%	2.4%

Source: Own Constuction (2017)

For the purpose of this study, the following formula was used to calculate the future population:

Formula: (Latest population or household number * (1 + population or household growth rate of the following year)

The growth rate used for the 2017 population and household figures were based on the growth rate depicted in Table 7-13. Different scenarios can be applied to the model. As previously discussed, there is always a chance for a rapid increase or perhaps decrease in population numbers, for example in the case of Lephalale, a new mine can open which might generate new employment opportunities. Although natural disasters are not a frequent occurrence, the possibilities exist. This could mean the loss of lives which in turn means a decrease in population numbers. Table 7-14 and Figure 7-7 illustrates the household and population figures for the Municipality as predicted for the year of 2017 to 2037.

TABLE 7-14: POPULATION & HOUSEHOLD GROWTH

Assumption	Category	2011	2016	2017	2020	2025	2035	2037
1	Households	29 884	42 073	42 732	44 770	48 449	57 052	58 985
	Population	115 767	136 626	139 249	147 425	162 307	199 212	208 481
	HH Size	3.9	3.2	3.3	3.3	3.4	3.5	3.5
	HH Growth rate	1.37%	32.49%	1.57%	1.57%	1.60%	1.67%	1.68%
	Population Growth rate	3.09%	9.58%	1.92%	1.92%	1.95%	2.20%	2.30%
2	Households	29 884	42 073	42 732	44 770	49 575	61 265	63 991
	Population	115 767	136 626	139 905	150 222	166 508	205 373	215 349
	HH Size	3.9	3.2	3.3	3.4	3.4	3.4	3.4
	HH Growth rate	1.37%	32.49%	1.57%	1.57%	2.10%	2.30%	2.20%
	Population Growth rate	3.09%	9.58%	2.40%	2.40%	2.00%	2.20%	2.40%

Source: Adapted from StatsSA (2011); StatsSA community survey (2016)

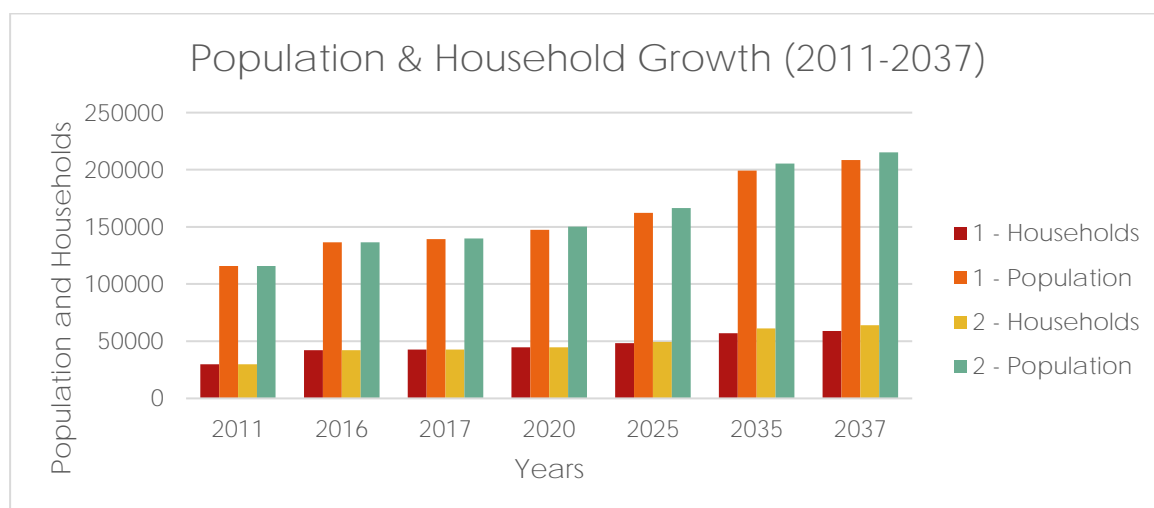


FIGURE 7-7: POPULATION AND HOUSEHOLD GROWTH

Source: StatsSA (2011); StatsSA community survey (2016); Own construction (2017)

The household size for each year was calculated by dividing the total population by the total households, for example (refer to Table 7-14: for the year 2020, the following calculation was used; $(147\,425/44\,770 = 3.29 \approx 3.3)$). The cumulative growth in citizens are depicted in Table 7-15 and Figure 7-8:

TABLE 7-15: CUMULATIVE GROWTH IN POPULATION

Assumption	Year	2017	2018	2020	2021	2025	2035	2037
1	1 - Cumulative Growth	2 623	5 297	10 799	13 644	25 681	62 586	71 855
2	2 - Cumulative Growth	3 279	6 637	13 596	16 901	29 882	68 747	78 723

Source: Own Construction (2017)

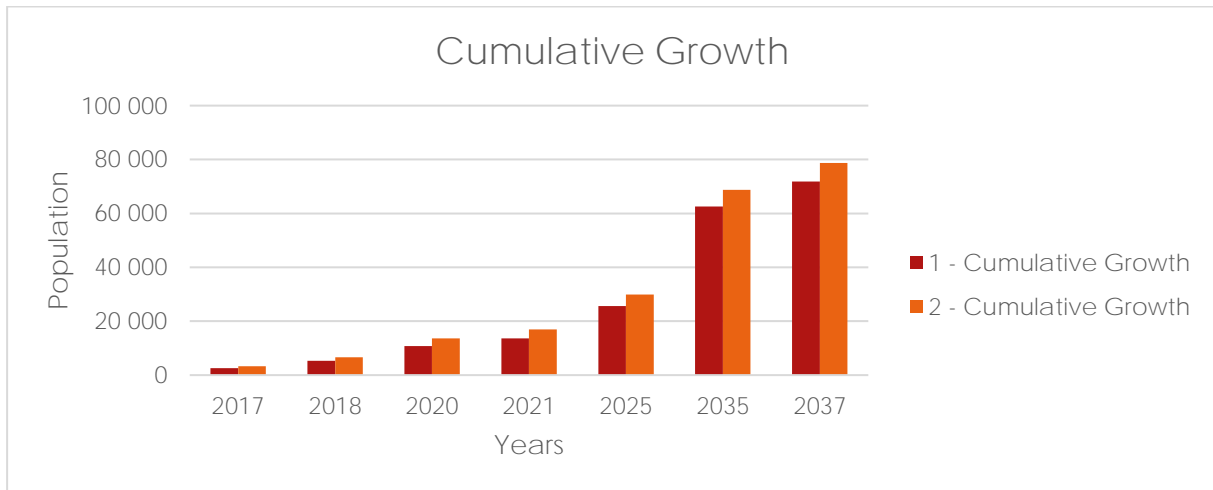


FIGURE 7-8: CUMULATIVE GROWTH

Source: Own Construction (2017)

The cumulative growth was populated in the following manner: For the year 2017, the cumulative growth was calculated by subtracting the 2016 and 2017 population as reflected in Table 7-14 (Assumption 1: 139 249 - 136 626 = 2 623). This meant in one year the population would increase by 2 623 citizens. Now that the foundation has been set for future population figures, the next step involved compiling information based on household densities and dwelling type.

7.4.1.3 Dwelling type

The household figures were populated based on following the process illustrated in Figure 7-9. The statistics were sourced from StatsSA (2011).

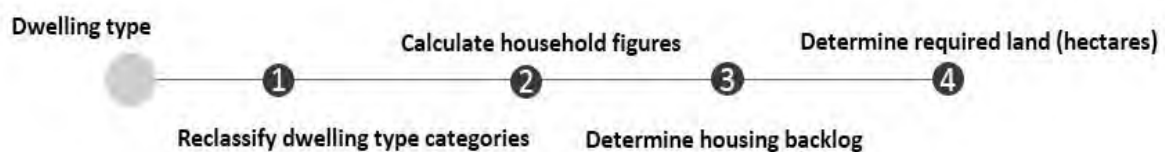
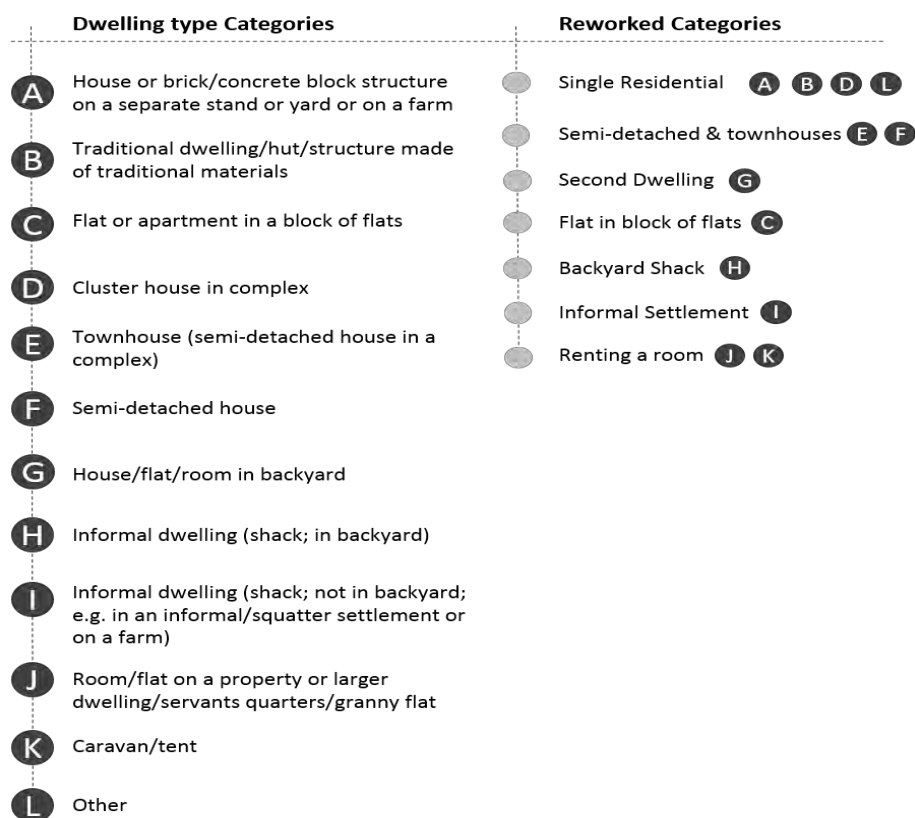


FIGURE 7-9: METHODOLOGY - DWELLING TYPE

Source: Own Construction (2017)

1 Reclassify dwelling type categories

The statistics depict the different dwelling types as per categorised by StatsSA (2011) namely, “urban area, tribal or traditional area and farm”. The statistics were then reworked into new categories as depicted in Figure 7-10 with the objective of simplifying the categories.


FIGURE 7-10: DWELLING TYPE CATEGORIES

Source: Adapted from StatsSA (2011b)

Table 7-16 illustrates the total number of dwellings per category in 2011.

TABLE 7-16: DWELLING TYPE

Census 2011	Urban area	Tribal or Traditional area	Farm	Total	Percentage
Single Residential	9 281	10 857	3 429	23 567	78.86%
Semi-detached & townhouses	144	12	22	178	0.60%
Second Dwelling	288	28	23	339	1.13%
Flat in block of flats	795	36	18	849	2.84%
Backyard Shack	1 242	541	316	2 099	7.02%

Census 2011	Urban area	Tribal or Traditional area	Farm	Total	Percentage
Informal Settlement	1 218	116	1 123	2 457	8.22%
Renting a room	137	26	232	395	1.32%
Total	13 105	11 616	5 163	29 884	100.00%

Source: StatsSA (2011b)

2 Calculate household figures

Based on the socio-economic indicators, household numbers and

Table 7-16, it was possible to calculate the future housing need for the Municipality. The calculations were based on the two household growth rate assumptions made in Table 7-14. Table 7-17 depicts the given and presumed future household figures, while Table 7-18 illustrates the future household figures per category for the Municipality.

TABLE 7-17: HOUSEHOLD FIGURES

Assumption	2011	2015	2016	2020	2025	2035	2037
1	29 884	31 755	42 073	44 770	48 449	57 052	58 985
2	29 884	31 755	42 073	44 770	49 575	61 265	63 991

Source: Adapted from StatsSA (2011b); StatsSA (2016a)

TABLE 7-18: FUTURE HOUSEHOLD FIGURES

Assumption	Category	2011	2015	2016	2020	2025	2035	2037
1	Single Residential	23 567	25 043	33 179	35 306	38 207	44 992	46 516
	Semi-detached & townhouses	178	189	251	267	289	340	351
	Second Dwelling	339	360	477	508	550	647	669
	Flat in block of flats	849	902	1 195	1 272	1 376	1 621	1 676
	Renting a room	395	420	556	592	640	754	780
	Backyard & Informal	4 556	3 210	3 072	1 631	0	0	0
	Subsidised Housing	0	1 631	3 342	5 194	7 386	8 698	8 993
	Total Housing Units	29 884	31 755	42 073	44 770	48 449	57 052	58 985
2	Single Residential	23 567	25 043	33 179	35 306	39 095	48 315	50 464
	Semi-detached & townhouses	178	189	251	267	295	365	381
	Second Dwelling	339	360	477	508	562	695	726
	Flat in block of flats	849	902	1 195	1 272	1 408	1 741	1 818

Assumption	Category	2011	2015	2016	2020	2025	2035	2037
	Renting a room	395	420	556	592	655	810	846
	Backyard & Informal	4 556	3 210	3 072	1 631	0	0	0
	Subsidised Housing	0	1 631	3 342	5 194	7 558	9 340	9 756
	Total Housing Units	29 884	31 755	42 073	44 770	49 575	61 265	63 991

Source: Adapted from StatsSA (2011b)

The following calculations were used for both assumptions: For the base year 2011, the 2011 census information was sourced as depicted in Table 7-16. To calculate the households for the additional years, the household figures as depicted in Table 7-17 was multiplied by the percentage of each category as illustrated in Table 7-16 however, with regard to the backyard and informal category a different approach was required.

3 Determine housing backlog

It is presumed that as time goes by the backlog will be eradicated. In order to calculate the eradication of backyard shacks and informal settlements, another assumption had to be made. The assumption and calculations are depicted in Table 7-19. Although assumption one was used as the example illustrated below, the same method and calculations were applied for calculating the backlog for assumption two.

TABLE 7-19: METHODOLOGY - HOUSING BACKLOG

Housing Backlog	
Formula:	Description
Backlog = Backyard Shack + Informal Settlement	For the base year 2011, the backlog was calculated using the formula on the left. The statistical information was sourced from StatsSA (2011) – Refer to Table 7-16
Calculation	
(2 099 + 2 457 = 4 556)	
Backlog eradication	
Assumption:	Description
Eradication of 400 units per year	Based on historical performance, the assumption used was that the Municipality would eradicate 400 units per year for the next 20 years (Lephalale Local Municipality, 2017).

Formula:	Calculation
[Backlog eradication = Backlog (2011) * (1 + Household growth rate (2012)) – unit assumption]	$(4\ 556 * (1 + 1.57\%)) - 400 = 4\ 227$ The backlog for 2012 was 4 227 units. The results are illustrated in Table 7-20.

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Based on the calculations, it is presumed that by the year 2025, the housing backlog will be eradicated. The results are depicted in Table 7-20.

TABLE 7-20: HOUSING BACKLOG

Assumption	Years	2011	2012	2016	2021	2024	2025
1	Current Backlog	4 556	4 227	3 072	1 257	98	0
	Historic Performance	400	400	400	400	400	400
2	Current Backlog	4 556	4 227	3072	1264	118	0
	Historic Performance	400	400	400	400	400	400

Source: Adapted from StatsSA (2011b)

4 Determine required land (hectares)

Once the backlog was calculated the next step involved calculating the required land for future housing. Again an assumption was used to calculate the required land. Table 7-21 illustrates the assumption used.

TABLE 7-21: DENSITY ASSUMPTIONS

Density Targets	Density (units/ha)	Land Size (m ²)	Allocation for Roads
Single Residential	13	769.23	18%

Density Targets	Density (units/ha)	Land Size (m ²)	Allocation for Roads
Semi-detached & townhouses	40	250.00	15%
Second Dwelling	0	0.00	18%
Flat in block of flats	500	20.00	5%
Backyard Shack	-	0.00	-
Informal Settlement	-	0.00	-
Renting a room	500	20.00	18%
Subsidised Housing	65	153.85	15%

Source: I@Consulting (2017)

The final step was to calculate the future required units and land.

TABLE 7-22: FUTURE REQUIRED HOUSING

Assumption	Required Housing Units	2021		2026		2035	
		Units	Hectare	Units	Hectare	Units	Hectare
1	Single Residential	2 127	193.0	5 028	456.4	11 813	1072.2
	Semi-detached & townhouses	16	0.5	38	1.1	89	2.6
	Second Dwelling	31	0.0	72	0.0	170	0.0
	Flat in block of flats	77	0.2	181	0.4	426	0.9
	Renting a room	36	0.0	84	0.0	198	0.0
	Backyard & Informal	0	0.0	0	0.0	0	0.0

Assumption	Required Housing Units	2021		2026		2035	
		Units	Hectare	Units	Hectare	Units	Hectare
	Subsidised Housing	1 852	4.4	4 044	9.5	5 356	12.6
	Total Housing Units	4 138	198	9 448	467	18 051	1 088
2	Single Residential	2 127	193.0	5 916	537.0	15 135	1 373.8
	Semi-detached & townhouses	16	0.5	45	1.3	114	3.3
	Second Dwelling	31	0.0	85	0.0	218	0.0
	Flat in block of flats	77	0.2	213	0.4	545	1.1
	Renting a room	36	0.0	99	0.0	254	0.0
	Backyard & Informal	0	0.0	0	0.0	0	0.0
	Subsidised Housing	1 852	4.4	4 216	9.9	5 998	14.2
	Total Housing Units	4138	198	10 574	549	22 264	1392

Source: Own Construction (2017)

The calculations for both assumptions were: To calculate the units for 2021, the total households per category were used. Thus for 2021, the 2020 and 2016 household figures were divided by each other (Single Residential: $35\,306 - 33\,179 = 2\,127$ (Refer to Table 7-18)). For the year 2026, 2025 and 2016 were divided by each other and so forth.

To calculate the required land in hectares the following calculation was used.

$((\text{Units (refer to Table 7-22)} * \text{Assumption Land size (m}^2\text{) (refer to Table 7-21)}) * (1 + \text{assumption Allocation for roads (refer to Table 7-21)})) / 10\,000$

Thus $((2\,127 * 769.23) * (1 + 18\%)) / 10\,000 = 193\text{ Ha}$

The calculations were repeated for the additional categories. Now that the population, households and required land were established, the next step involved determining the required business, industrial and community facilities for the future.

7.4.1.4 Business, industrial and community facilities required

In order to calculate the additional business and industrial units required, the first step involved calculating the total stands and hectares per use. The process as depicted in Figure 7-11 was a twofold process as the datasets consisted of a formal dataset (cadastre) and a rural dataset (rural land uses and zonings captured).

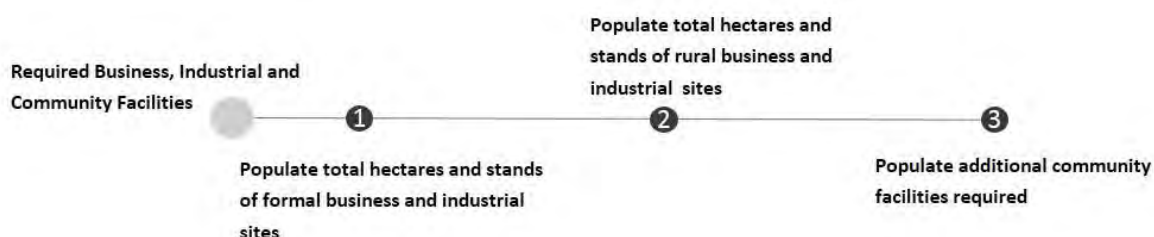


FIGURE 7-11: METHODOLOGY - REQUIRED BUSINESS, INDUSTRIAL AND COMMUNITY FACILITIES

Source: Own Construction (2017)

The method applied to calculate the additional business and industrial sites required are illustrated in Table 7-23.

TABLE 7-23: METHODOLOGY - POPULATING ADDITIONAL BUSINESS AND INDUSTRIAL SITES REQUIRED

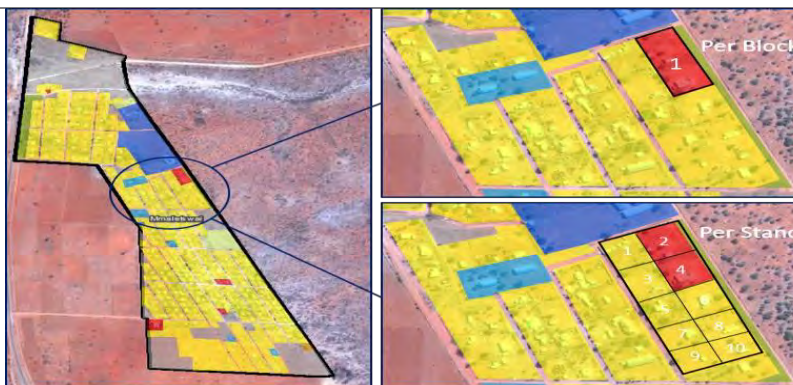
Formal Dataset	
Method	Calculations
The first step involved utilising the spatial dataset (cadastre) from Municipality. Making use of ArcGIS software, the total stands and square metres were populated for all business and industrial sites. An	<p>The square metres per use per household for 2016, was formulated using the following calculation:</p> <p>Total Area (m²) / Total Households (2016)</p> <p>Thus: Business = (781 486.76 / 42 073 (Refer to Table 7-14)) = 19</p> <p>Industrial = (1 100 220.98 / 42 073 (Refer to Table 7-14)) = 26</p>

average stand size was then populated in excel using a pivot table.	Result				
	The table below depicts the total number of stands with the average stand size in square metres				
	Use	Stands	SQM	Total Area (m ²)	m ² per household (2016)
	Business	203	6357.1	781 486.76	19
	Industrial	166	3985.4	1 100 220.98	26
Source: Own Construction (2017)					

Rural Datasets

Method

For the non-formal rural areas, the same process was followed with the only difference, the method used to calculate the hectares of business and industrial sites. The reason for this was because the rural areas were captured per block and not per stand (refer to the figure on the right).



Source: Adapted from AfriGIS (2017)

Capturing rural land uses per block or per stand depends on a project timeframe and budget. If there is limited time to complete projects and the budget is low, it makes more sense to capture the land uses per block.

Calculation

The figure depicted in the method were used as an example to illustrate the calculations required. To calculate the average hectares for the formal stands, it merely required a

selection per stand. However, when calculating the average hectares per land use when stands are captured as blocks required a different, yet also simple method. StatsSA dwelling frame spatial data were sourced to determine the total units per block.



Land Use	Business	Residential
Units	2	11
Hectares	0.286383	0.207342636
Calculation	(Ha/Units)*10 000	
Average Size (sqm)	2 864	2 073

Source: Adapted from StatsSA (2016a); AfriGIS (2017)

Result

Once the average area for business and industrial sites were calculated the same calculations were used as illustrated in the formal dataset calculations. The results are depicted below.

Use	Stands	Ave Area (m ²)	Tot Area (m ²)	m ² per Household (2016)
Industrial	23	10350.70733	212174.285	5
Business	241	9045.664899	3136467.816	75

Source: Own Construction (2017)

Source: Adapted from StatsSA (2016a); AfriGIS (2017); I@Consulting (2017)

In order to calculate the additional business and industrial sites required for the next five, ten and twenty years, the following calculation was required.

Calculation for Hectares: ((HH Growth rate 2020 - HH Growth rate 2016) * m² per Households 2016 (refer to Table 7-14 and Table 7-23) / 10 000)

Calculation for additional units: ((Hectares * 10 000) / Average area m² (refer to Table 7-14 and Table 7-23)).

For the additional years, the same formula was used, with the only difference the different years used (2025 and 2035).

TABLE 7-24: FUTURE BUSINESS AND INDUSTRIAL REQUIREMENTS

Method	Category	2021		2026		2035	
		Units	Hectare	Units	Hectare	Units	Hectare
1	Industrial (Formal)	8	5.0	19	11.8	44	27.8
	Business (Formal)	18	7.1	42	16.7	98	39.2
	Industrial (Rural)	1	1.4	3	3.2	7	7.6
	Business (Rural)	22	20.1	53	47.5	123	111.7
	Industrial (Combined)	9	6.4	22	15.1	51	35.4
	Business (Combined)	40	27.2	94	64.2	222	150.8
2	Industrial (Formal)	8	5.0	22	13.9	56	35.6
	Business (Formal)	18	7.1	49	19.6	126	50.2
	Industrial (Rural)	1	1.4	4	3.8	9	9.7
	Business (Rural)	22	20.1	62	55.9	158	143.1
	Industrial (Combined)	9	6.4	26	17.7	65	45.3
	Business (Combined)	40	27.2	111	75.5	284	193.3

Source: Own Construction (2017)

The next step involved calculating the additional future facilities required. The assumptions used are based on the CSIR guidelines (CSIR, 2012). The facilities were clustered together into the following categories:

- Health and Emergency Services
- Social and Cultural (Public Service Facilities)
- Civic
- Social Services
- Education
- Recreation (Sports and Parks)

The assumptions and standards used are illustrated in Annexure A. To calculate the additional facilities required for the next five years the following formula was utilised in excel:

$$= \text{ROUNDDOWN}(\text{Cumulative growth in people} / \text{Population threshold used}, 0)$$

$$\text{Thus: } (= \text{ROUNDDOWN}((10\ 799 \text{ (refer to Table 7-15)} / 2\ 400\ 000 \text{ (refer to Annexure A)}, 0) = 0$$

This means for the next 5 years no tertiary hospital will be required within the Municipality. To calculate the land that will be required in the next five years the following formula were utilised in excel:

$$= \text{ROUNDDOWN}(\text{Additional facilities required in the next 5 years} * \text{Site size (m}^2\text{) (refer to Annexure A)}, 0 / 10\ 000$$

$$\text{Thus: } (= \text{ROUNDDOWN}((0 * 350\ 000), 0 / 10\ 000) = 0$$

For the additional years, the same formula was used, with the only difference the different years used (2025 and 2035). The final result for the required housing units, business, industrial and community facilities are depicted in Table 7-25.

TABLE 7-25: SUMMARY OF CUMULATIVE GROWTH

Method	Category	2021		2026		2035	
		Units	Hectare	Units	Hectare	Units	Hectare
1	Housing Units	4 138	198.0	9 448	467.4	18 051	1 088.3
	Health and Emergency Services	0	0.0	0	0.0	1	0.5
	Social and Cultural (Public Service Facilities)	0	0.0	0	0.0	2	0.8
	Civic	0	0.0	0	0.0	1	0.0
	Social Services	5	5.0	15	12.9	42	32.2
	Education	15	2.9	41	18.3	104	47.2

	Recreation (Sports and Parks)	3	2.2	9	8.6	33	44.5
	Industrial	30	27.6	22	15.1	51	35.4
	Business	40	27.2	94	64.2	222	150.8
	Total	4 186	220.2	9 573	535.7	18 376	1 280.6
2	Housing Units	4 138	198.0	10 574	548.7	22 264	1 392.4
	Health and Emergency Services	0	0.0	0	0.0	1	0.5
	Social and Cultural (Public Service Facilities)	0	0.0	0	0.0	2	0.8
	Civic	0	0.0	0	0.0	1	0.0
	Social Services	7	5.7	16	13.4	45	35.2
	Education	20	7.7	48	21.1	113	50.1
	Recreation (Sports and Parks)	3	2.2	9	8.6	34	45.5
	Industrial	8	5.0	22	13.9	56	35.6
	Business	18	7.1	49	19.6	126	50.2
	Total	4 193	225.7	10 718	625.3	22 642	1 610.4

Source: Own Construction (2017)

The next section deals with the physical factors applicable to the study area.

7.4.2 Physical Factors:

The figure below illustrates the process followed to compile the physical factors for the municipality.

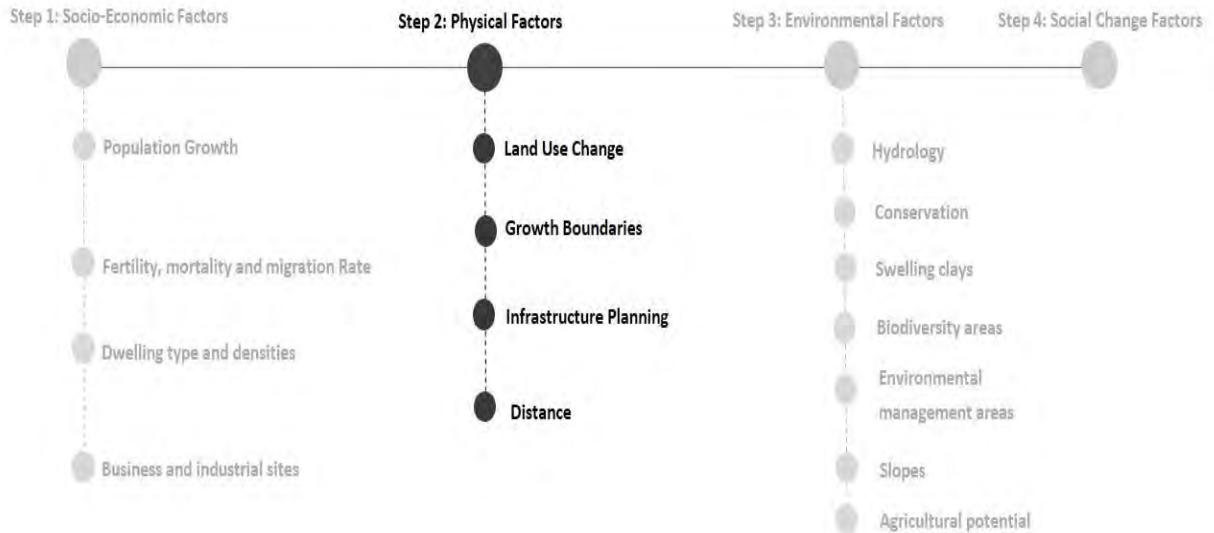


FIGURE 7-12: METHODOLOGY - PHYSICAL FACTORS

Source: Own Construction (2017)

One of the first steps in compiling the GIS data applicable to the study was to compile and prepare the cadastral datasets. The cadastral information was updated in the compilation of the customer database.

7.4.2.1 Land Use Change

The following figures illustrate the land use and zoning data that was prepared for both focus areas.

Focus Area 1

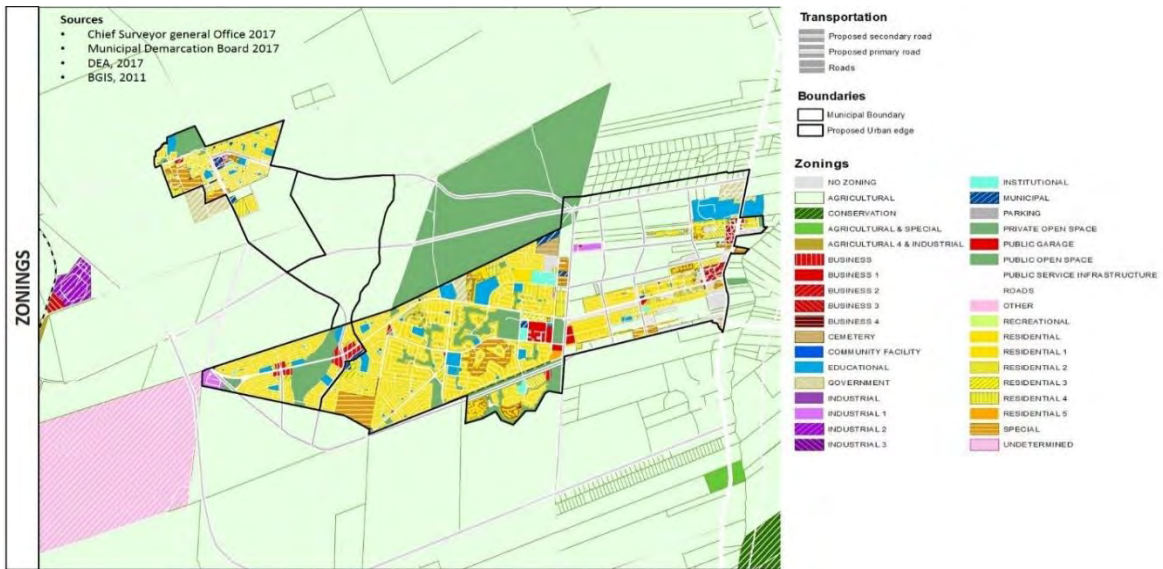


FIGURE 7-13: FOCUS AREA 1 - ZONING MAP

Source: Adapted from I@Consulting (2017)

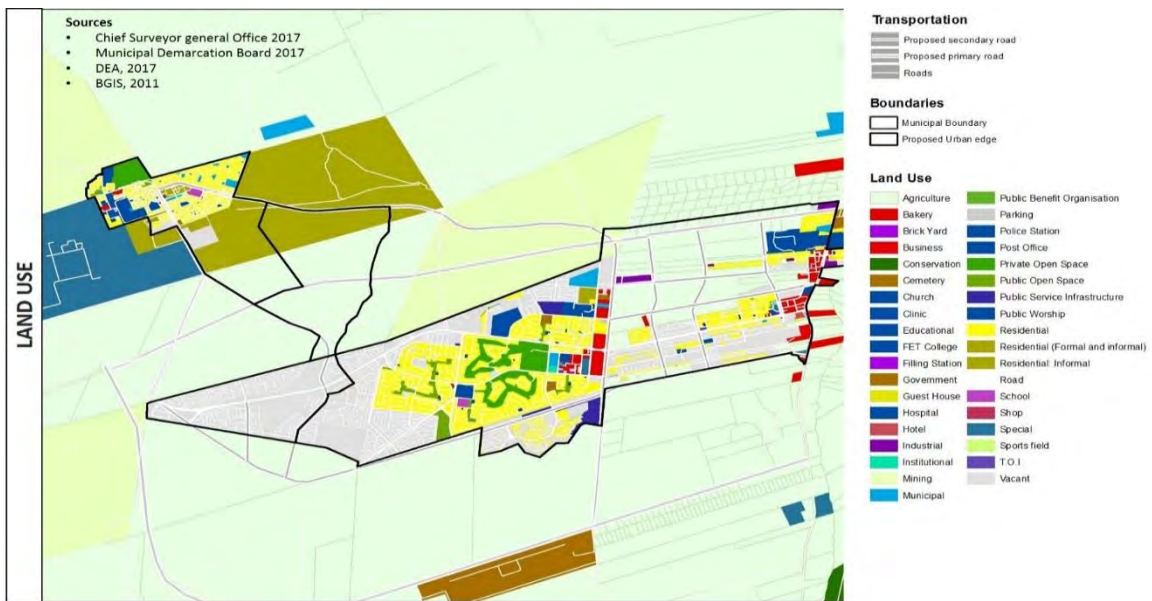


FIGURE 7-14: FOCUS AREA 1 - LAND USE MAP

Source: Adapted from I@Consulting (2017)

Focus Area 2

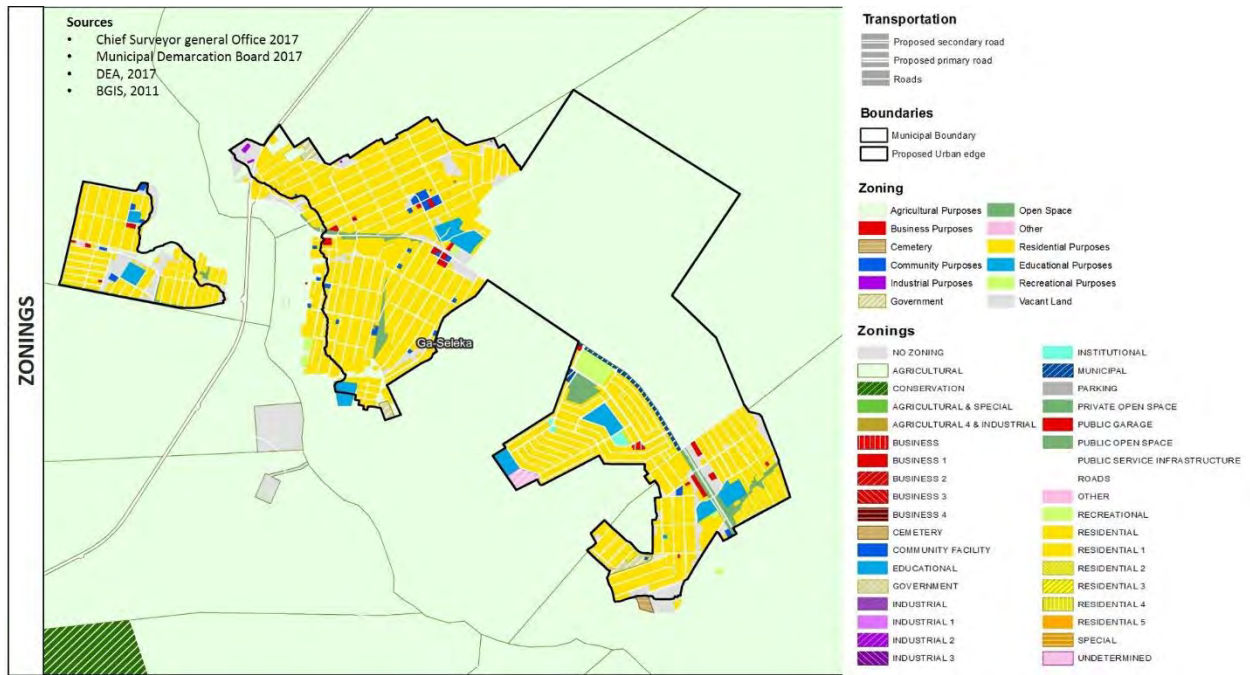


FIGURE 7-15: FOCUS AREA 2 - GA-SELEKA ZONING MAP

Source: Adapted from I@Consulting (2017)

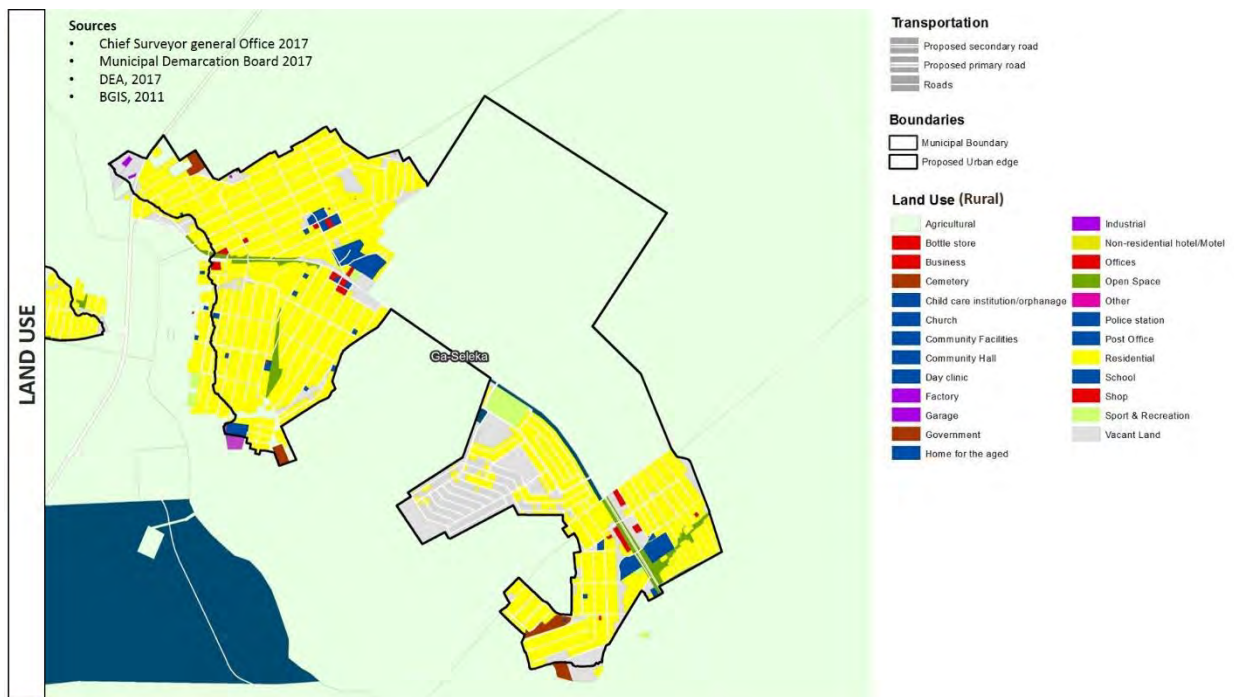


FIGURE 7-16: FOCUS AREA 2 – GA-SELEKA LAND USE MAP

Source: Adapted from I@Consulting (2017)

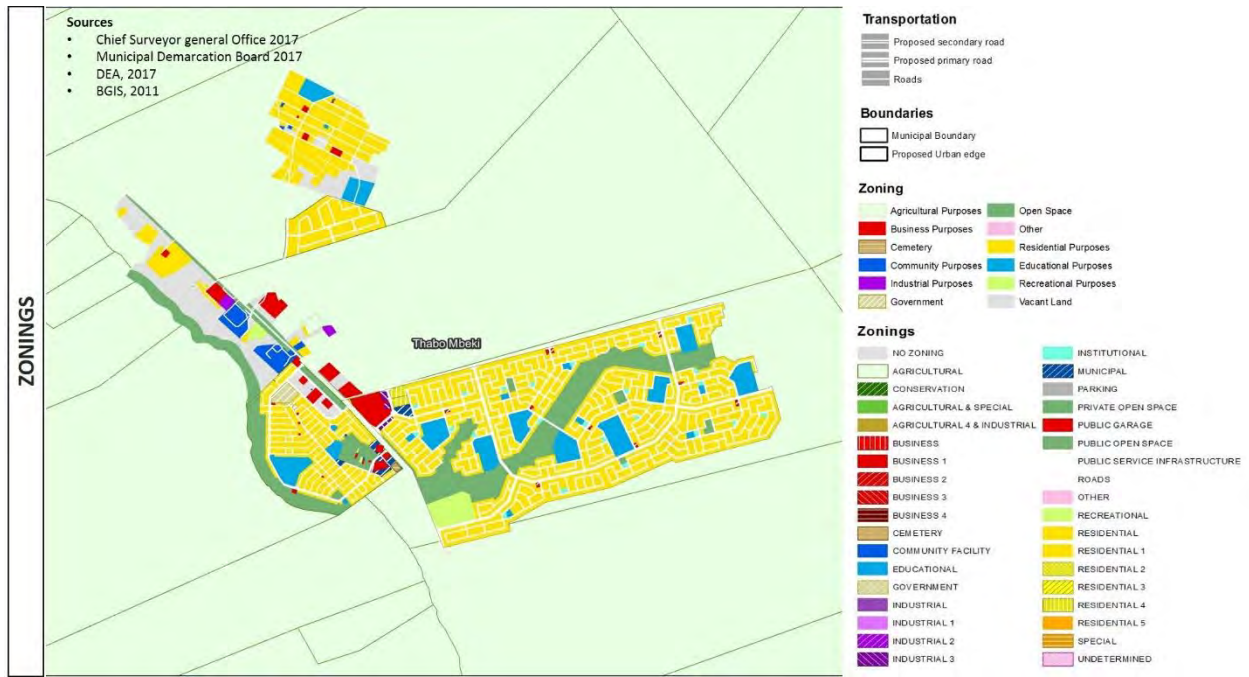


FIGURE 7-17: FOCUS AREA 2 - THABO MBEKI ZONING MAP

Source: Adapted from I@Consulting (2017)

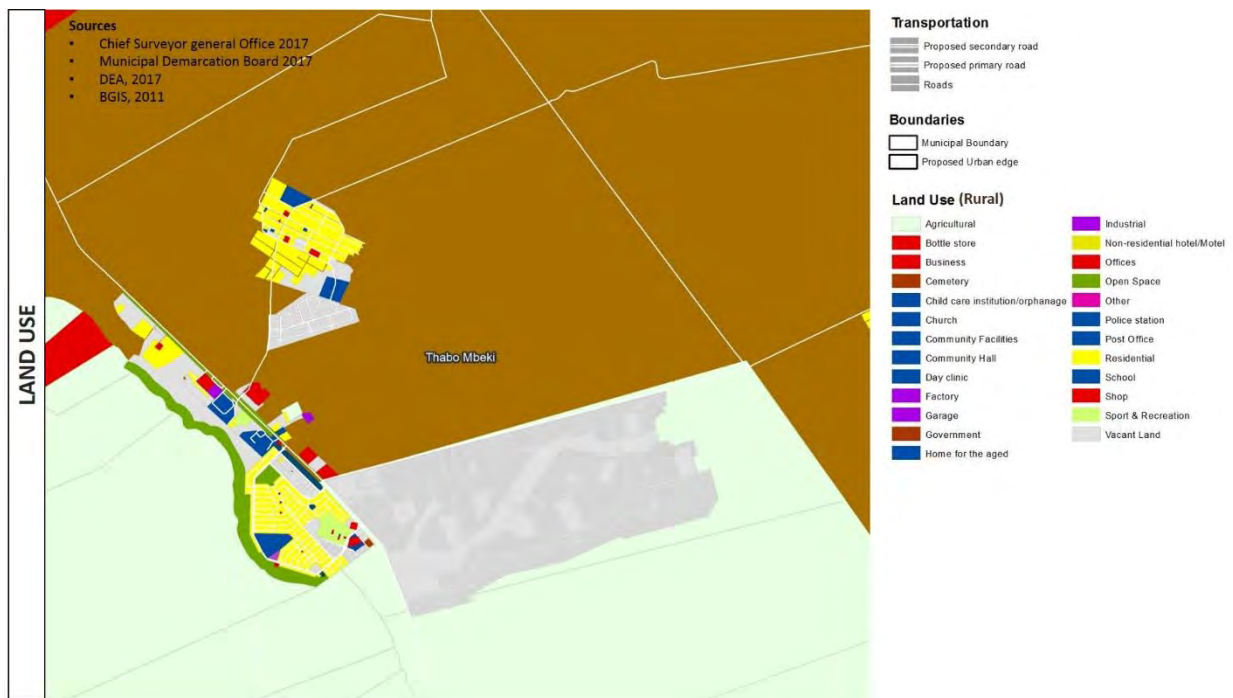


FIGURE 7-18: FOCUS AREA 2 - THABO MBEKI LAND USE MAP

Source: Adapted from I@Consulting (2017)

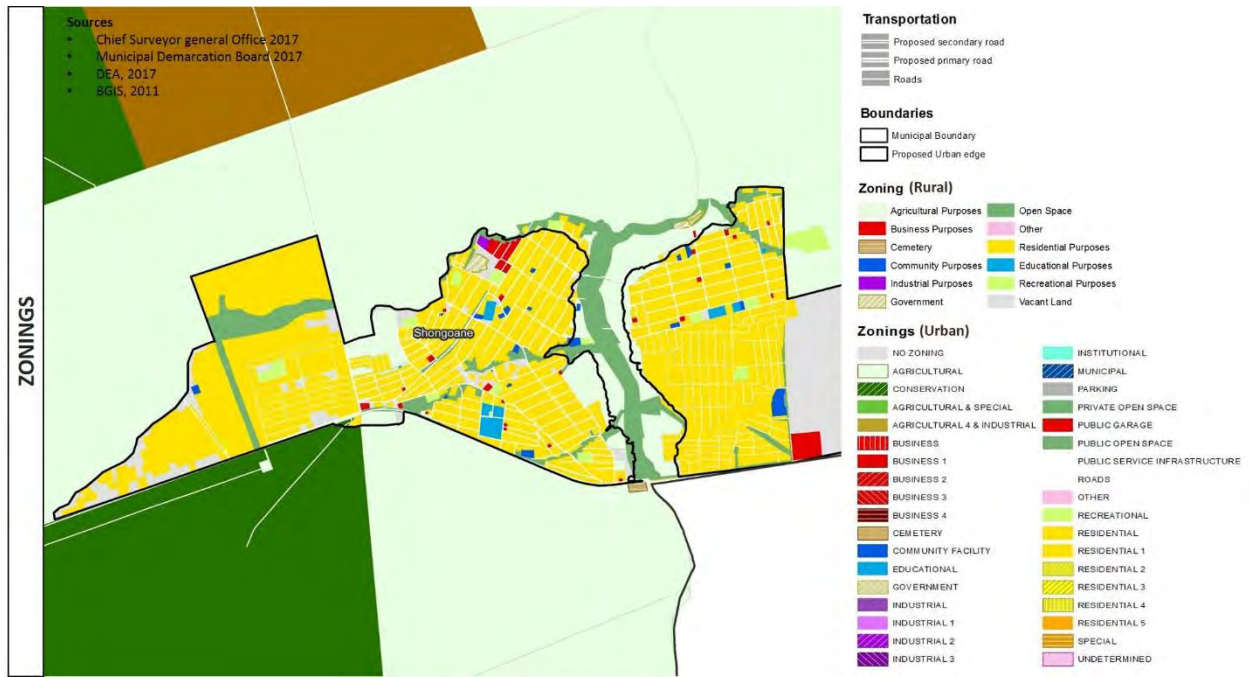


FIGURE 7-19: FOCUS AREA 2 - SHONGOANE ZONING MAP

Source: Adapted from I@Consulting (2017)

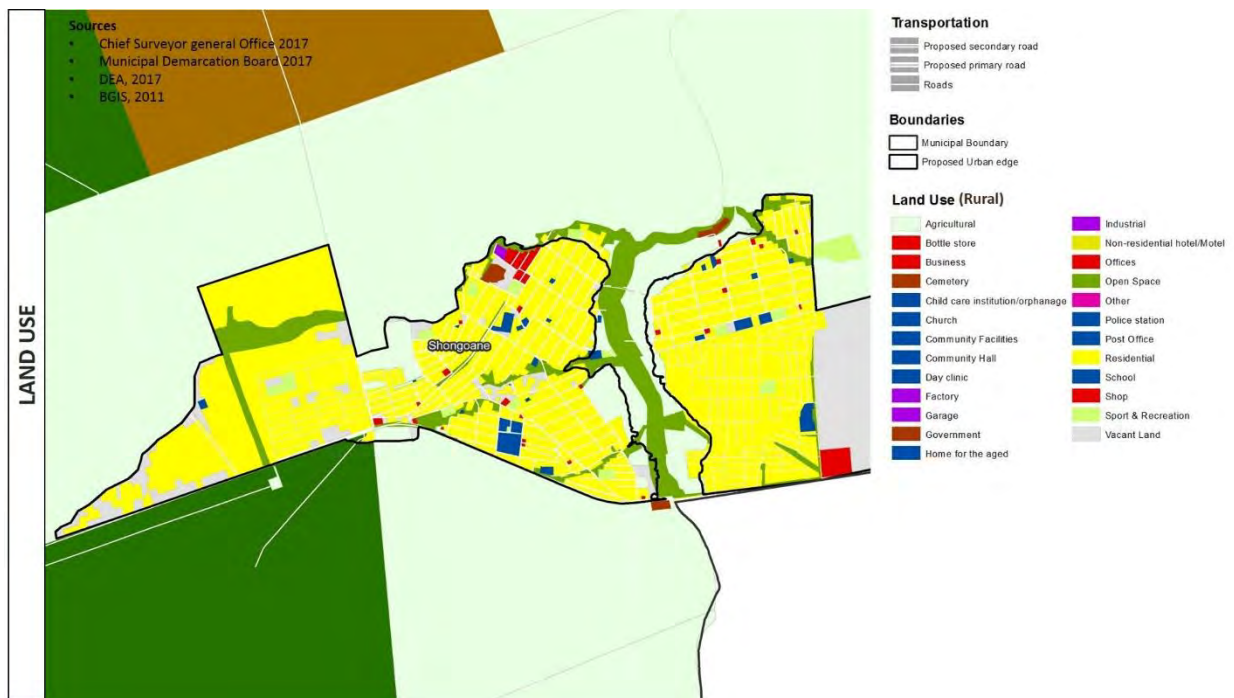


FIGURE 7-20: FOCUS AREA 2 - SHONGOANE LAND USE MAP

Source: Adapted from I@Consulting (2017)

7.4.2.2 Growth Boundaries

The importance of growth boundaries was discussed in chapter 4. Within any SDF, strict development control measures exist, such as proposed urban and rural edges/boundaries, which forces development to occur only within the boundary or edge. Land use models can be used for various purposes amongst other things;

- Identifying land suitable for future development
- Identifying land suitable for various land use purposes

Modelling tools can be utilised to assist with the scenario process of what could happen if land use change within the urban and rural edges. Once all land has been developed within the proposed urban and rural edges, new land will be required. This is where growth modelling tools play an incremental role. The modelling tools and techniques can be used to assist spatial planners to make accurate assumptions with regard to future development.

For the purpose of this study, the following boundaries were applicable.

TABLE 7-26: GROWTH BOUNDARIES

Growth Boundary	Result
Municipal Boundary	The Municipal boundary was updated according to the new Municipal Demarcation.
Rural Boundaries	The first step was to update the settlement boundaries according to the settlement growth since 2011.
Formal/Urban Boundaries	The General Plan boundaries were sourced from the surveyor general office and updated accordingly.
Urban Edge	The new proposed urban edge was sourced from the Lephalale LM SDF of 2017. This is an important boundary, as it will determine the limit to where the town of Lephalale and Marapong can grow for the next five years before the SDF is revised.

Source: Own construction (2017)



FIGURE 7-21: GROWTH BOUNDARIES

Source: Own Construction (2017)

The next section deals with the infrastructure required for the next five years within the Municipality.

7.4.2.3 Infrastructure Planning

Calculating future Infrastructure requirements is a crucial aspect of future urban and rural growth. It is presumed that populations and household numbers will increase over time. It is therefore vital to have information available in terms of future infrastructure requirements in order to make future provision not only to determine the total demand for infrastructure but the costs as well. In order to determine the demand for infrastructure for the future, the first step involved distinguishing between residential and non-residential uses. The calculations were based on the customer profile compiled in Table 7-5. In Microsoft Excel, the calculations were populated to obtain the sum total of all residential and non-residential uses. This is reflected in Table 7-27.

TABLE 7-27: RESIDENTIAL & NON-RESIDENTIAL USES

Spatial Areas	Sum of Residential Uses	% Residential	Sum of Non Residential	% Non-Residential
Focus Area 1	15 550	44.4%	1 921	65.6%
Focus Area 2	19 510	55.6%	1 007	34.4%

Spatial Areas	Sum of Residential Uses	% Residential	Sum of Non Residential	% Non-Residential
Total	35 060	100%	2 928	100%

Source: StatsSA (2016a)

Once the residential and non-residential land uses were established the next step was to utilise the average infrastructure rates in order to determine the consumption for the next five years (Section 21(h) of SPLUMA). The rates were obtained from an interview with key engineering and asset management specialists working for a company called I@Consulting. The data is based on average usages compiled for various municipalities as per use. Data dependability could be questioned. Further reseach in terms of electricty and water usage should be pursued to ensure that the correct planning standards are utilised.

TABLE 7-28: ELECTRICITY USAGE

Category	kVA	KW Hrs/day	Unit
Domestic low income	2	1.70	stand
Domestic normal	4.5	3.83	stand
Domestic Upmarket	7	5.95	stand
Business	0.08	0.07	m ²
Industrial	0.1	0.09	m ²

Source: I@Consulting (2017) (Note: 0.85 kVA to KW Hrs)

TABLE 7-29: RATES

Category	Water	Waste Water	m of road (Street Frontage/2)	Electricity
	Kilolitre per households per day	Kilolitre per households per day		Kilowatt Hours / day

Residential Rural (low)	0.3		26	
Residential Rural (medium)	0.5	0.3		1.70
Residential Rural (high)	0.7			
Residential Urban (low)	0.5	0.5	13	
Residential Urban (medium)	0.8	0.75		3.83
Residential Urban (high)	1.2	1		
Education (per 100m2)	0.6	0.6	124	
Business and Industrial (per 100m2)	0.8	0.8	35	0.8

Source: I@Consulting (2017)

Table 7-30 below illustrates the total demand for services and road infrastructure for the next five years.

TABLE 7-30: TOTAL CONSUMPTION

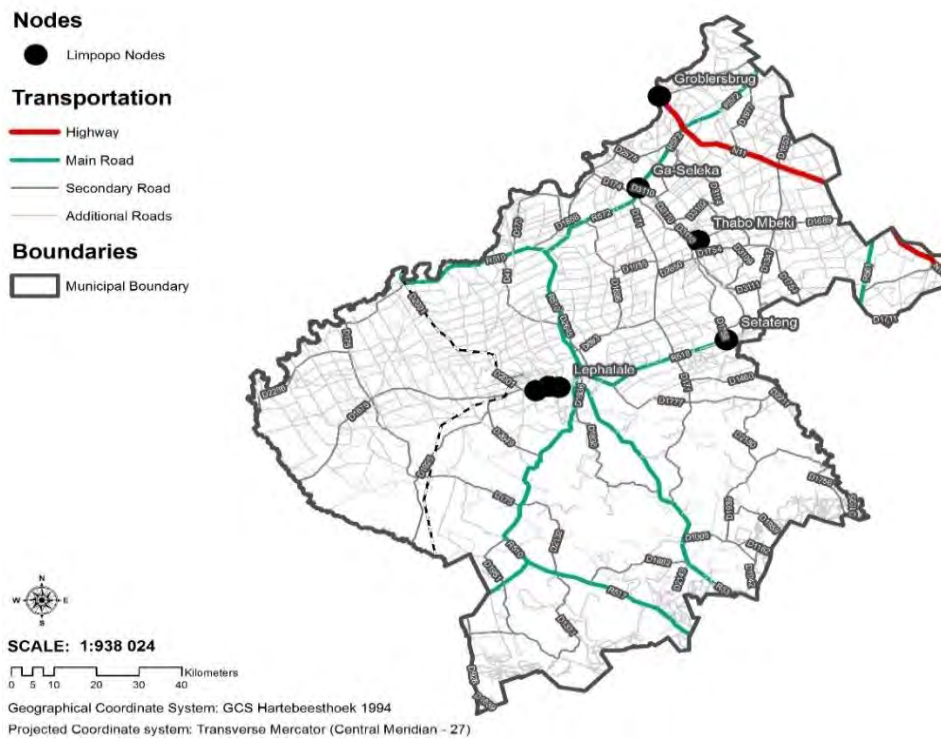
<i>Spatial Area</i>	<i>Water</i>	<i>Sanitation (Waste water)</i>	<i>Electricity</i>	<i>Roads</i>
	<i>(Kilolitres per day)</i>	<i>(Kilolitres per day)</i>	<i>Kilowatt hours per day</i>	<i>Km</i>
Focus Area 1	1 468	1 376	7 020	12
Focus Area 2	1 151	691	3 914	30
<i>Grand Total</i>	2 619	2 067	10 934	42

Source: Own Construction (2017)

Distance is a key determining factor of urban and rural growth. Citizens prefer to be in close proximity to business activities and community facilities such as shopping centres, healthcare services, schools, police and fire stations. The provision of infrastructure is also more cost-effective if developments are in close proximity to one another. The next section illustrates the results populated for the Lephalale LM with regard to distance.

7.4.2.4 Distance

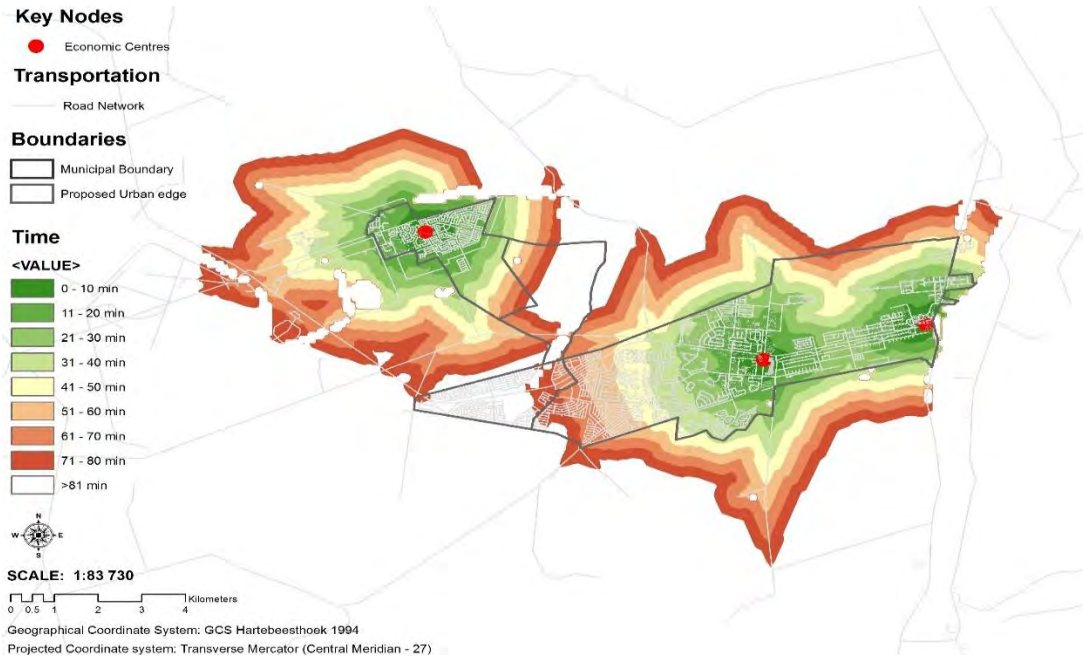
An accessibility analysis was populated to depict the total travel time it would take citizens to reach either important community facilities or key business nodes. The calculations were based on travelling by foot or vehicle. As many citizens residing in rural areas do not have access to a vehicle, it was important to include the calculation for travelling by foot. The map below illustrates the current transportation network in the study area.



MAP 7-2: TRANSPORTATION NETWORK

Source: Adapted from I@Consulting (2017)

The maps to follow illustrate the accessibility analysis calculated for both focus areas.



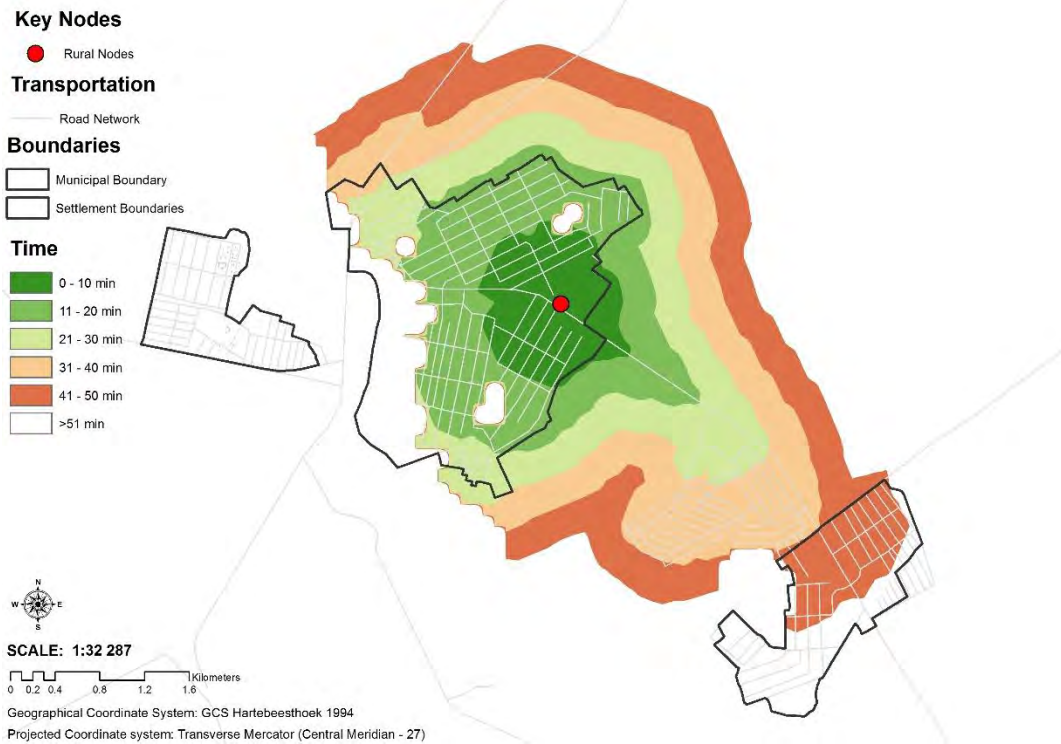
MAP 7-3: FOCUS AREA 1 – ECONOMIC CENTRE (WALKING DISTANCE)

Source: Adapted from I@Consulting (2017)



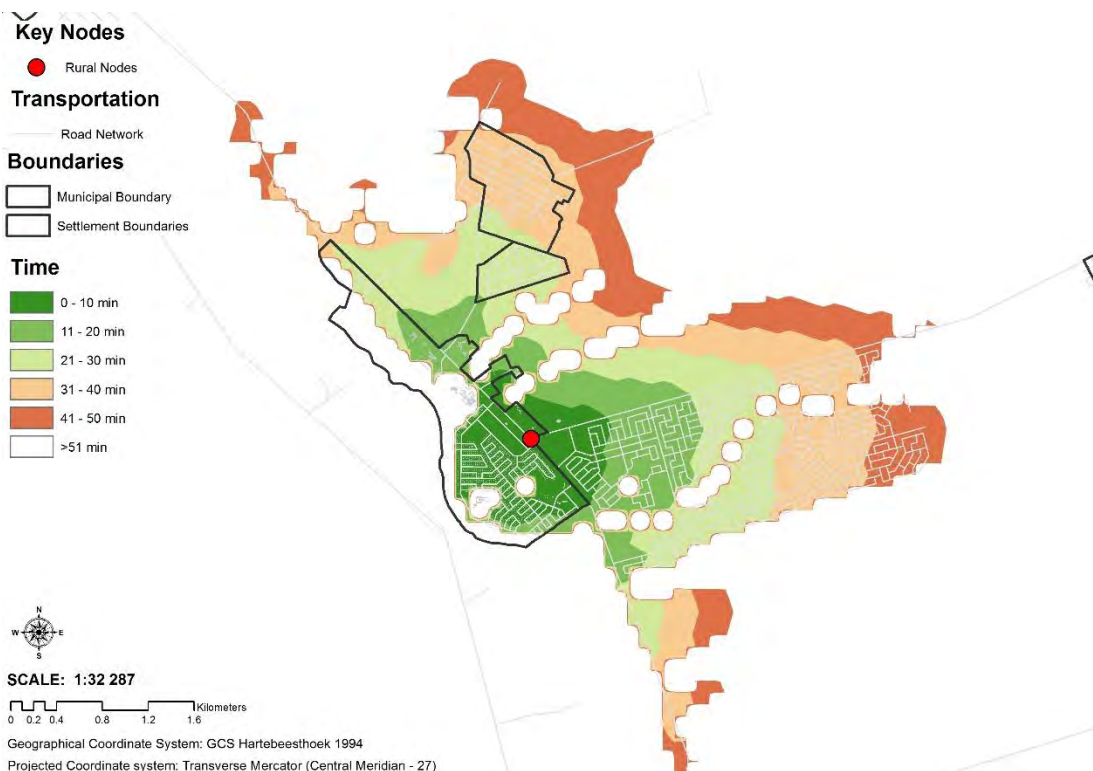
MAP 7-4: FOCUS AREA 1 – ECONOMIC CENTRE (DRIVING DISTANCE)

Source: Adapted from I@Consulting (2017)



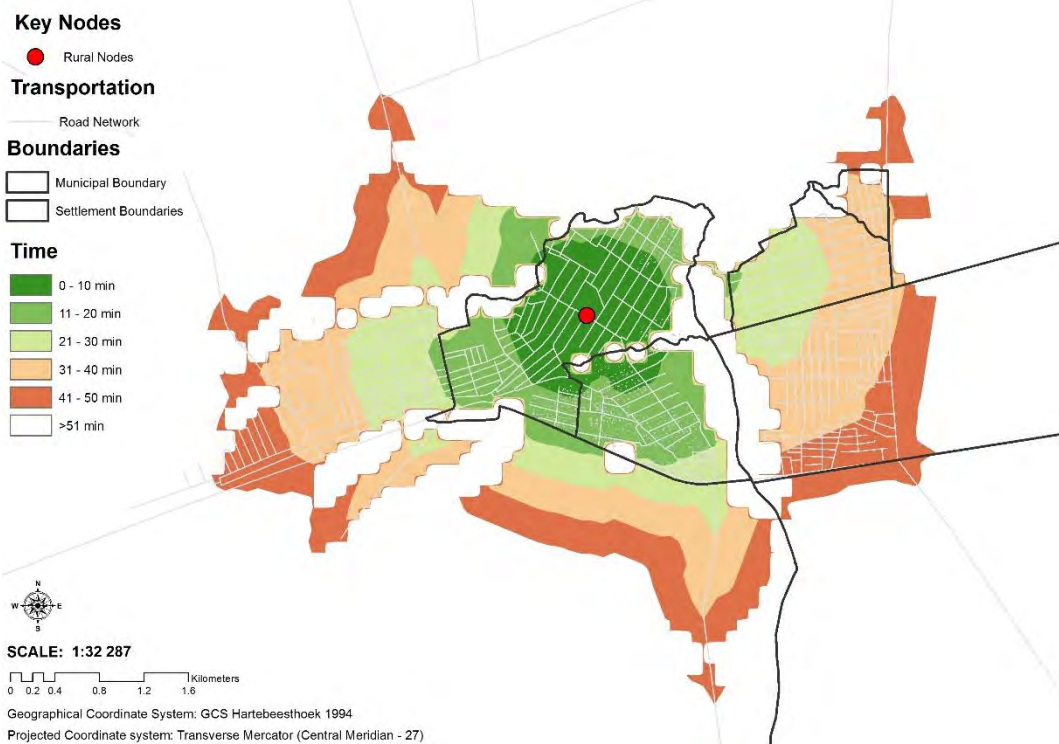
MAP 7-5: FOCUS AREA 2 - GA-SELEKA WALKING DISTANCE

Source: Adapted from I@Consulting (2017)



MAP 7-6: FOCUS AREA 2 - THABO MBEKI WALKING DISTANCE

Source: Adapted from I@Consulting (2017)



MAP 7-7: FOCUS AREA 2 - SHONGOANE WALKING DISTANCE

Source: Adapted from I@Consulting (2017)



MAP 7-8: FOCUS AREA 2 - DRIVING DISTANCE

Source: Adapted from I@Consulting (2017)



MAP 7-9: FOCUS AREA 1 – WALKING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)



MAP 7-10: FOCUS AREA 1 - DRIVING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)



MAP 7-11: FOCUS AREA 2 - GA-SELEKA WALKING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)



MAP 7-12: FOCUS AREA 2 - THABO MBEKI WALKING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)



MAP 7-13: FOCUS AREA 2 - SHONGOANE WALKING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)



MAP 7-14: FOCUS AREA 2 - DRIVING TRAVEL TIME TO COMMUNITY FACILITIES

Source: Adapted from I@Consulting (2017)

The calculations above are taken into account in objective 7.

7.4.3 Environmental Factors:

All the environmental factors as discussed in Chapter 4 is important to consider within any SDF. The factors will determine where development can and cannot occur. The environmental factors as illustrated in Figure 7-22, were used within the area of study.

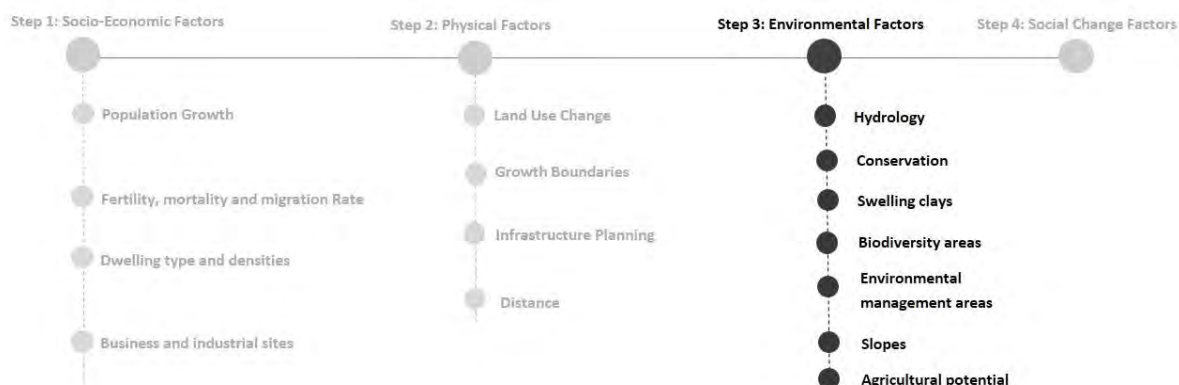


FIGURE 7-22: METHODOLOGY - ENVIRONMENTAL FACTORS

Source: Own Construction (2017)

The table below illustrates the methodology used in compiling the hydrology information for the study area.

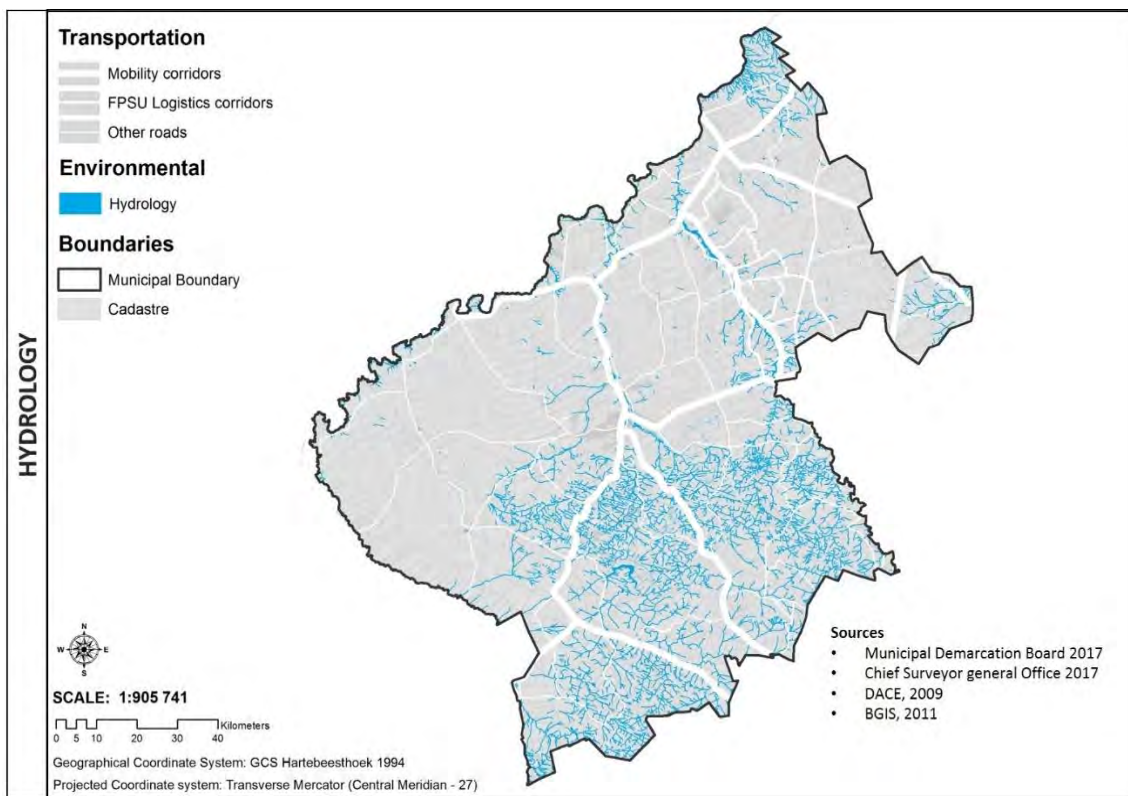
TABLE 7-31: METHODOLOGY - HYDROLOGY

Spatial Data	Methodology
Line Features	Floodlines were only available along the main route of the rural focus area. Therefore an alternative solution was required to calculate floodlines for the remaining rivers systems within the Municipality.
Rivers and existing floodlines	According to DACE (2009:17), the following standards apply for rivers systems, 100m buffer zone from the edge of the riparian zone for rivers/streams outside the urban edge and a 32m buffer zone from the edge of the riparian zone for rivers/streams within the urban edge.
Polygon Feature	Flood lines also had to be calculated for dams and wetlands.

Dams and Wetlands	<p>According to DACE (2009:17), the following standards apply for dams and wetlands</p> <ul style="list-style-type: none"> - 30m for wetlands occurring inside the urban edge - 50m for wetlands occurring outside the urban edge
Result	<p>The result is depicted in Map 7-15. The buffered rivers systems were merged with the wetland and dams features to create a combined Hydrology polygon feature.</p>

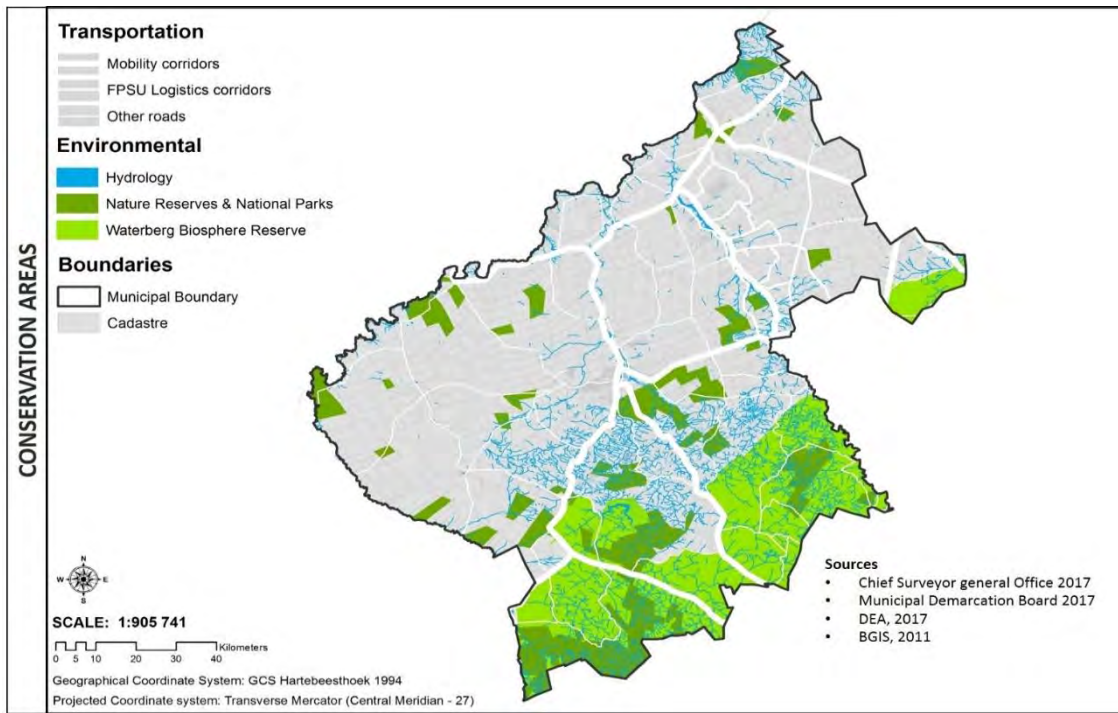
Source: Own Construction (2017)

The maps to follow after the hydrology map, illustrate the remaining environmental datasets that were prepared for the analysis.



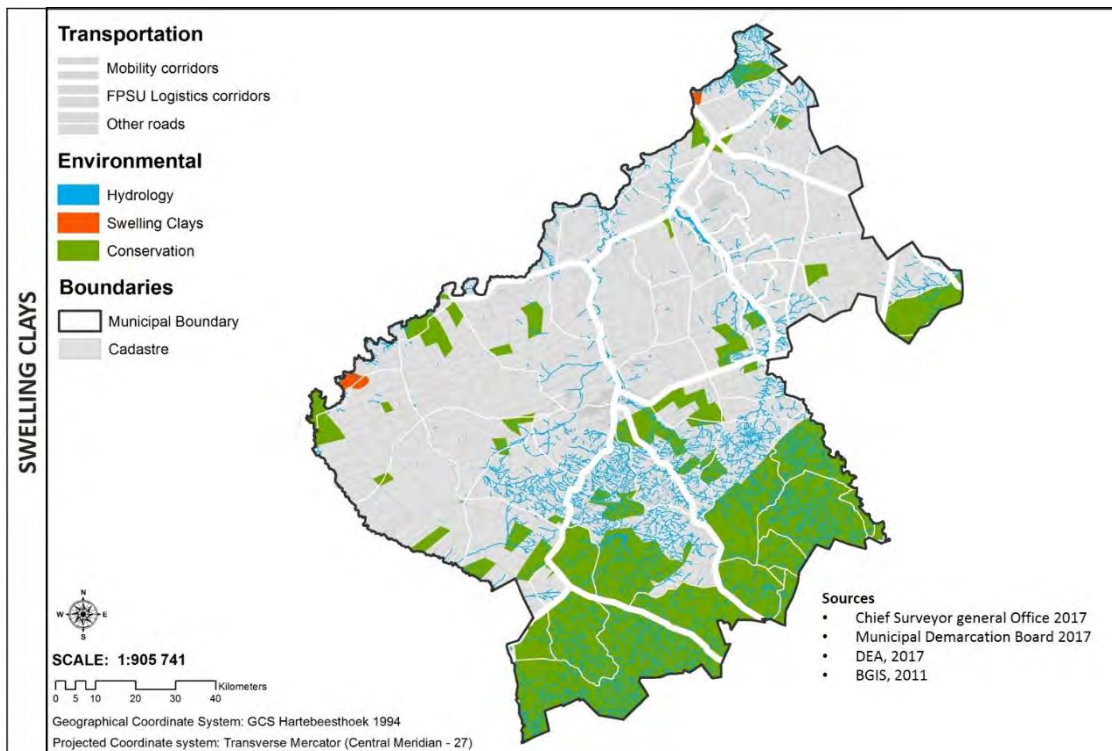
MAP 7-15: HYDROLOGY

Source: Adapted from I@Consulting (2017)



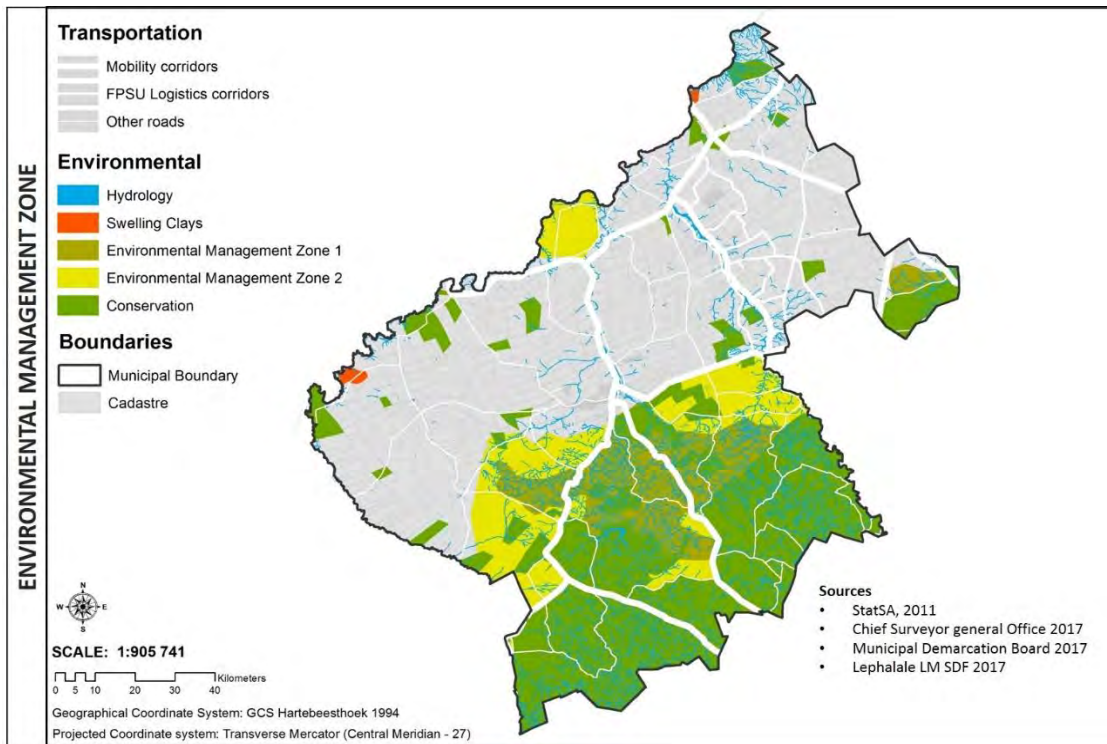
MAP 7-16: CONSERVATION AREAS

Source: Adapted from I@Consulting (2017)



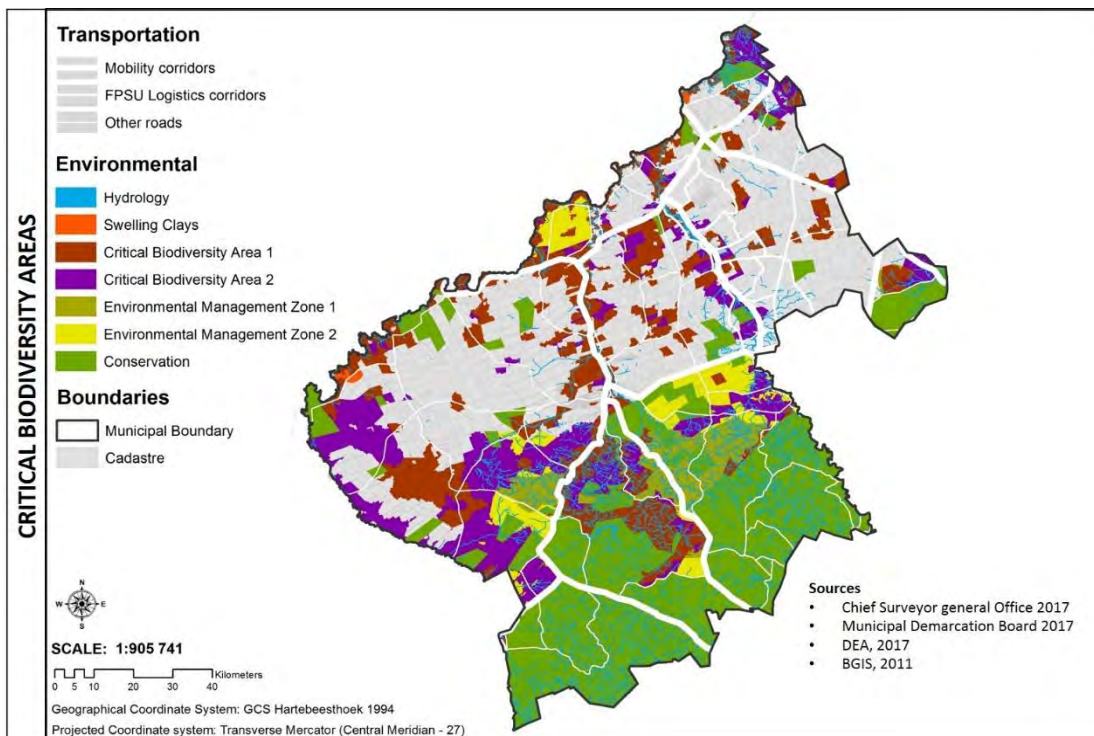
MAP 7-17: SWELLING CLAYS

Source: Adapted from I@Consulting (2017)



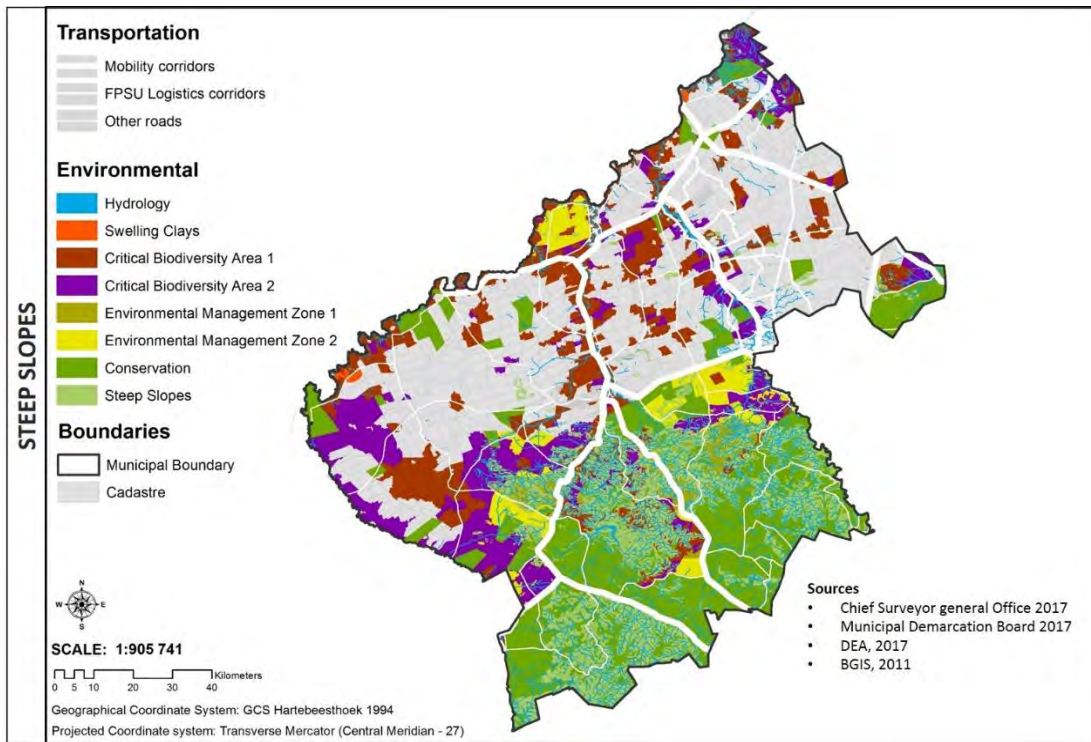
MAP 7-18: ENVIRONMENTAL MANAGEMENT ZONES

Source: Adapted from I@Consulting (2017)



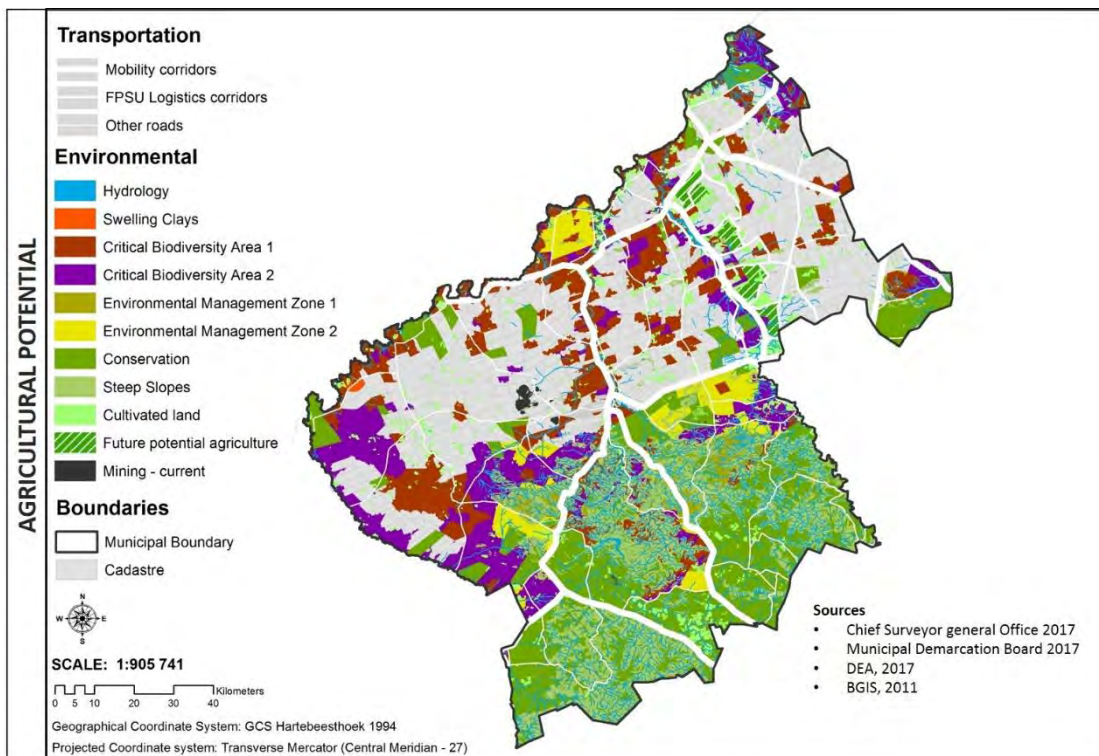
MAP 7-19: CRITICAL BIODIVERSITY AREAS

Source: Adapted from I@Consulting (2017)



MAP 7-20: STEEP SLOPES

Source: Adapted from I@Consulting (2017)



MAP 7-21: AGRICULTURAL POTENTIAL

Source: Adapted from I@Consulting (2017)

With all the environmental datasets compiled, the data had to be classified into a single class with each having its own weight. The purpose for this was that all environmental layers differ in terms of importance. The suitability layer is discussed in objective 5.

7.4.4 Social Change Factors:

As previously discussed in Chapter 3, human behaviour plays an incremental role in urban and rural growth. Determining human behaviour is a complex study and due to the limitations of available information and the complexness of information, no detailed study was compiled for this case study. Assumption however, were used to determine what could or would happen if certain scenarios occur. It however, remains an important factor of urban and rural growth and should always be considered. It is important to note that all the required feature layers are now overlaying each other. In order to create one layer dataset (Shapefile), all the layers illustrated above must be combined to create one layer file.

7.5 Data preparation – Combination process

In order to achieve a combined layer, the process as depicted in Table 7-32 were followed.

TABLE 7-32: DATA PREPARATION - COMBINATION PROCESS

Data Preparation - Combining Process:	
Steps	Method
Combining GIS layers	<p>To combine all the GIS layers into one shapefile the following steps were used;</p> <ul style="list-style-type: none"> - ArcToolbox, Analysis Tool, Overlay, Union. - Geographic Coordinate System: GCS Hartebeeshoek 1994 - Projected Coordinate systems: Transverse Mercator (Central Meridian 27).
Removing multi-part features	<p>With the process of combining all the datasets, the analysis created multi-part features which had to be removed. The reason for this step is to ensure that there are no unnecessary additional layers before the</p>

	<p>commencement of the final analysis. The following steps were used;</p> <ul style="list-style-type: none"> - ArcToolbox, Data Management Tools, Features, Multi-part to singlepart option
<p>Removing slivers</p>	<p>The process of combining GIS layers into a single layer and then eliminating multi-part polygons may create polygons that are extremely small in size (Slivers). This process will remove area too small to be developed and it will also speed up the analysis process. However, before eliminating the polygons below a particular threshold size the following procedure was used; Create a new field in the attribute table of the combined GIS layer named (HA) and calculate the geometry in Hectares. Specify the criterion for selecting the polygons to be eliminated. For this study, all shapes with smaller than 0.3 Ha were selected. The following steps were used to delete the small polygons;</p> <ul style="list-style-type: none"> - ArcToolbox, Data Management Tools, Generalization, Eliminate option <p>The Eliminating polygon by border option was used. (This option specifies that the deleted polygons will be merged with the neighbouring polygons with the largest shared border.</p>
<p>Topology</p>	<p>The next procedure involves creating and validating a topology. ESRI (2017), defined a topology as follows “Topology is a collection of rules that, coupled with a set of editing tools and techniques, enables the geodatabase to more accurately model geometric relationships”. ArcGIS implements topology through a set of rules that define how features may share a geographic space and a set of editing tools that work with features that share geometry in an integrated fashion (ESRI, 2017). According to ESRI (2017), a</p>

	topology is fundamental for the specific reason; it ensures data quality of the spatial relationships and to aid in data compilation. The following topology rules were used for this study; “must not overlap” and “must not have gaps”.
Deleting unnecessary data fields	The combined datasets created a large number of data fields. All the unnecessary data fields were removed.

Source: Own Construction (2017)

The next step involved adding the additional required fields in GIS for the purpose of the modelling analysis. The additional fields required is illustrated in Table 7-33.

TABLE 7-33: ADDITIONAL FIELDS

Additional fields	Objective of field
Formal_Rural	The purpose of this field is to distinguish between rural and formal areas
Hydrology	This field will be used as an indicator depicting hydrology areas with the purpose of restricting development within these areas
Slope	This field will be used as an indicator depicting areas of slope >25% with the purpose of restricting development.
EMZ	This field will be used as an indicator depicting EMZ. Areas with EMZ's does not necessarily mean no development will be allowed. It will merely be used as a form of restriction however, areas with high importance will be discouraged for any development unless approval is granted by key environmental role players.
CBA	This field will be used as an indicator depicting CBA's. CBA's does not necessarily mean no development will be allowed. It will merely be used as a form of restriction however, areas with high importance will be discouraged

Additional fields	Objective of field
	for any development unless approval is granted by key environmental role players.
Conservation	The purpose of this field is to depict areas of protection, this includes National Parks, Private game reserves etc. Areas with a conservation status do not necessarily mean no development will be allowed however the protection of conservation areas are crucial and therefore allowing any development will be a lot more strict as in the case with EMZ's and CBA's.
Swelling Clays	The purpose of this field is to depict high swelling clays within the Municipality. Areas with high swelling clays do not necessarily mean no development will be allowed however, development will be discouraged from these areas as high swelling clays can lead to cracked houses as the ground are not stable.
Infill	This field will indicate areas of infill development. The Municipality has many approved general plans and layout plans which are currently vacant. A zoning has already been allocated to these stands which simplify the process of determining which type of infill development will be allowed. The current Draft SDF also illustrates areas with proposed zonings which have not yet been formally proclaimed.
Urban/rural expansion	The sole purpose of this field will be to depict areas illustrating of expansion and areas where no development can occur
Type	This field will consist of a combination of all the other separate environmental and other key fields. The field will depict areas such as agricultural land, areas of conservation, mining areas, vacant land, built-up areas and areas of no expansion.

Additional fields	Objective of field
F_CFDiving (Focus Area 1)	This field depicts the total travel time in minutes it will take citizens travelling by vehicle to the nearest community facility
F_CFWalking (Focus Area 1)	This field depicts the total travel time in minutes it will take citizens travelling by foot to the nearest community facility
F_BDriving (Focus Area 1)	This field depicts the total travel time in minutes it will take citizens travelling by vehicle to the nearest node
F_BWalking (Focus Area 1)	This field depicts the total travel time in minutes it will take citizens travelling by foot to the nearest node
R_CFDiving (Focus Area 2)	This field depicts the total travel time in minutes it will take citizens travelling by vehicle to the nearest community facility
R_CFWalking (Focus Area 2)	This field depicts the total travel time it will take citizens travelling by foot to the nearest community facility
R_BDriving (Focus Area 2)	This field depicts the total travel time in minutes it will take citizens travelling by vehicle to the nearest node
R_BWalking (Focus Area 2)	This field depicts the total travel time in minutes it will take citizens travelling by foot to the nearest node
Urban/Rural Value	This field depicts the different weight assigned to each environmental driver of urban and rural growth. The values were used to determine land suitable for future expansion

Source: Own Construction (2017)

Combining all these layers however, can be troublesome as there will always be conflicting datasets. The process of determining which layers are more important or are regarded as a higher order will now be discussed.

7.6 Objective 5: Analysing dataset **conflicts** and deriving a **suitability layer**

This step involved analysing any conflicts between datasets. While preparing the final combined dataset, it was inevitable that certain datasets will be in conflict with each other. Figure 7-23 illustrates a part of the attribute table of the derived dataset. From Figure 7-23, it is evident that the hydrology, slope and EMZ are in conflict with each other. Figure 7-24 is a spatial representation of conflicting datasets.

Hydrology	Slope	EMZ	CBA	Conservation	Swelling_Clay
Hydrology	Slope	EMZ	None	None	None
Hydrology	Slope	EMZ 1	None	None	None
Hydrology	Slope	EMZ 1	None	None	None

FIGURE 7-23: CONFLICTING DATASETS

Source: Adapted from I@Consulting (2017)

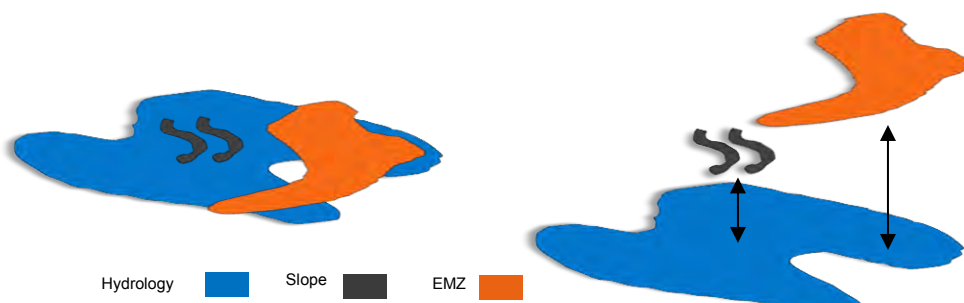


FIGURE 7-24: OVERLAYING LAYERS

Source: Own Construction (2017)

In order to rectify this conflict, a suitability analysis was required. The following conceptual steps were used to help build a suitability model (ArcGIS, 2017).

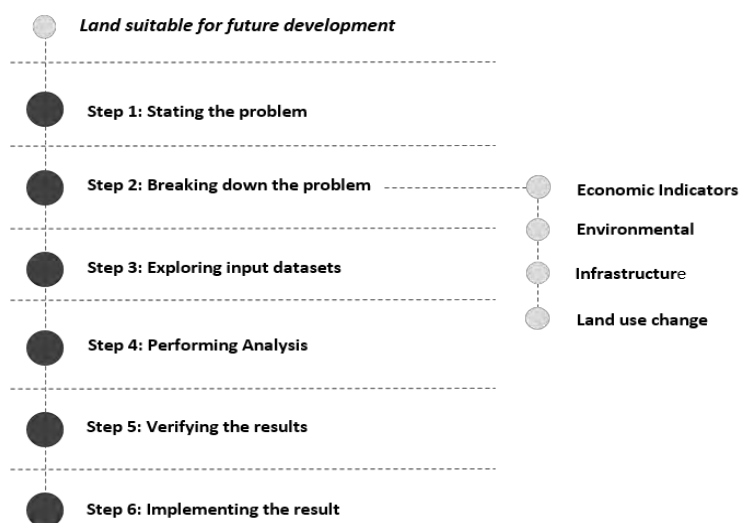


FIGURE 7-25: LAND SUITABLE FOR FUTURE DEVELOPMENT

Source: Adapted from ArcGIS (2017)

The conceptual steps for the study area are depicted in Table 7-34.

TABLE 7-34: CONCEPTUAL STEPS FOR SUITABILITY MODEL

Steps	Description
Step 1: Stating the problem	Conflicting datasets exist within the spatial data
Step 2: Breaking down the problem	<p>In order to address the issue, the analytic hierarchy process was utilised to convert the evaluations to numerical values which could be processed and compared over the entire range of the problem. The AHP was applied as a twofold process, firstly analysing the environmental factors and secondly analysing the additional growth factors of growth. The process followed is depicted in the figure below.</p> <p>The flowchart shows a four-step process: 1. Analyse possible conflicts (with sub-step 'Derive environmental suitability model'), 2. Define criteria scale, 3. Identify and compare remaining factors, and 4. Result.</p>

Steps	Description
Step 3: Exploring input datasets	<p>The AHP was applied to the environmental dataset and the physical drivers of growth. Not all the physical drivers however, can be physically mapped. Thus the weights in terms of the physical drivers will only be used to identify the importance of each factor. The different weights of the environmental factors will be utilised within a field in the attribute table of the spatial dataset.</p>
Step 4: Performing Analysis	<p>The first process involved deriving an environmental suitability model using the AHP. Firstly the different criteria had to be identified. The criteria are depicted in Figure 7-26. Alternative factors were also added to the process namely, developable and undevelopable. This factors will depict the significance of each factor in terms of development. The objective of this process was to derive one field depicting the factor with the highest weight, thus the factor highest importance in terms of developable or undevelopable land.</p> <p>The second process involved using the scale depicted in Table 7-35 to define the importance of the identified criteria. Using the same scale rating as depicted in Table 7-35, the last process involved identifying the remaining drivers of growth and comparing it to each other using AHP. The intermediate step is illustrated in Table 7-37.</p>
Step 5: Verifying the results	<p>The results for the environmental suitability model as depicted in Figure 7-27 and Figure 7-28, were verified</p>
Step 6: Implement the results	<p>The results from Table 7-38 was used as a suitability model for the environmental drivers</p>

Source: Own Construction (2017)

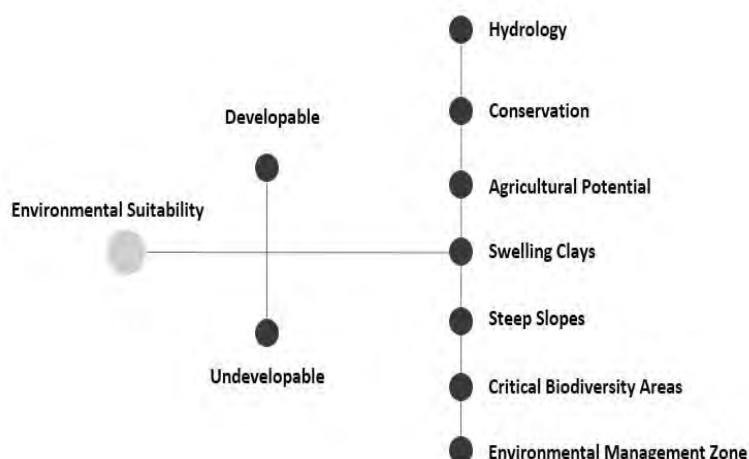


Figure 7-26: Environmental Suitability Criteria

Source: Own Construction (2017)

TABLE 7-35: CRITERIA SCALE

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one activity over another
5	Strong importance	Experience and judgment strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	

Source: Adapted from Saaty (2008)

Each criterion was then compared to each other by rating the criteria in terms of importance. The intermediate steps are shown in Table 7-36.

TABLE 7-36: INTERMEDIATE STEPS

Criteria	Hydrology	Conservation	Agricultural Potential	Swelling Clays	Steep Slopes	Critical Biodiversity Areas	Environmental Management Zone
1. Hydrology	1	9	9	9	9	9	9
2. Conservation	1/9	1	8	9	6	9	9
3. Agricultural Potential	1/9	1/8	1	7	1/9	8	8
4. Swelling Clays	1/9	1/9	1/7	1	1/9	1/6	1/6
5. Steep Slopes	1/9	1/6		9	1	9	9
6. Critical Biodiversity Areas	1/9	1/9	1/8	6	1/9	1	6
7. Environmental Management Zone	1/9	1/9	1/8	6	1/9	1/6	1

CI: 0.5163 CR: 0.3825 : 10.0979

Source: Adapted from MCMD (2017)

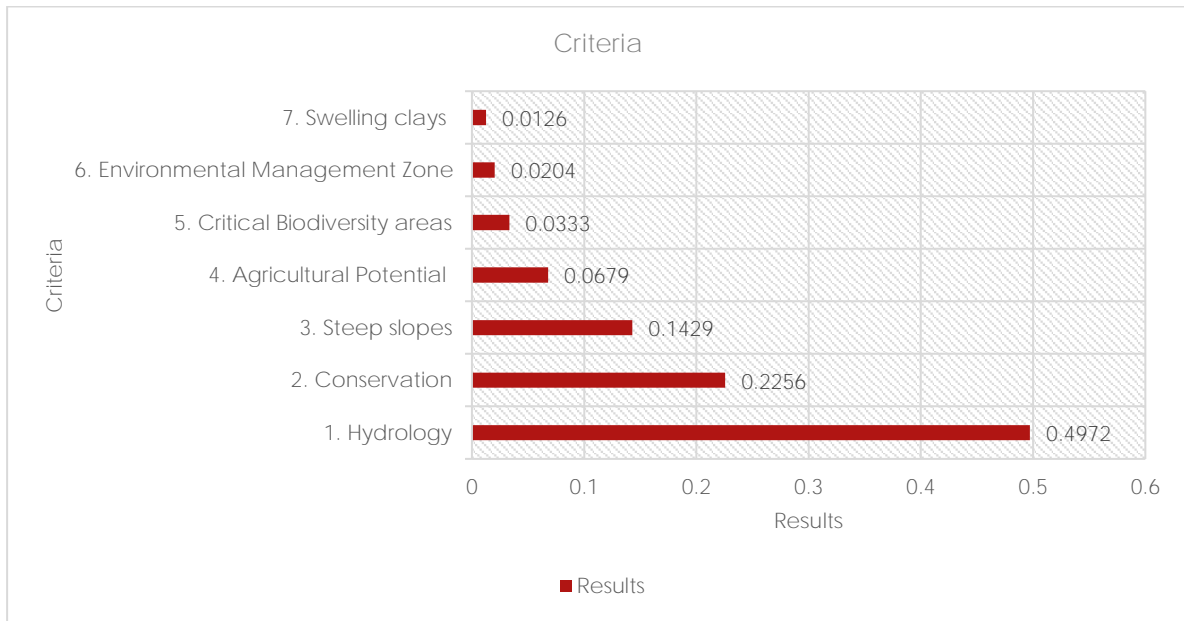


FIGURE 7-27: ENVIRONMENTAL SUITABILITY CRITERIA

Source: Adapted from MCMD (2017)

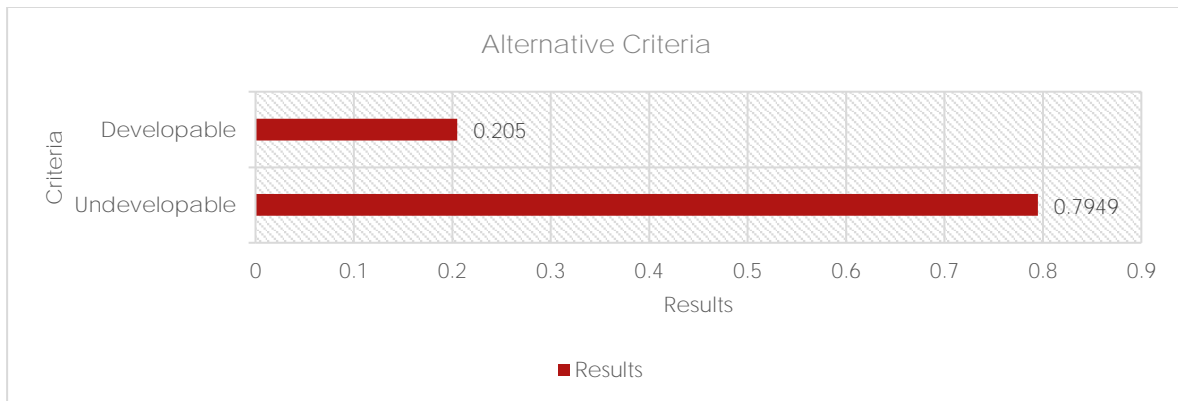


FIGURE 7-28: ALTERNATIVE ENVIRONMENTAL SUITABILITY CRITERIA

Source: Adapted from MCMD (2017)

From the results above it is evident that the most important factor in terms of undevelopable land was hydrology, followed by conservation and steep slopes. No development will be allowed in the areas depicted as hydrology on the maps to follow. The remaining factors do not necessarily mean no development will be allowed. The correct process involving key environmental departments and geotechnical studies will however, be required. The next step comprised of identifying the importance of the remaining growth factors.

TABLE 7-37: GROWTH FACTOR CRITERIA

Criteria	Fertility Rate	Mortality Rate	Migration	Dwelling Type	Land Use Change	Growth Boundaries	Infrastructure Planning	Distance	Biological Factors	Physical Factors	Technology Factors	Cultural Factors
Fertility Rate	1	5	5	1	1/9	1/9	1/9	1/5	1/5	1/9	5	1
Mortality Rate	1/5	1	1/6	1	1/6	1/9	1/9	1/9	1/8	1/9	1/3	1/3
Migration	1/5	6	1	6	1	1/9	1/9	1/9	6	1/6	1	1
Dwelling Type	1	1	1/6	1	1/4	1/9	1/9	1/9	7	1/5	5	5
Land Use Change	9	6	1	4	1	1/9	1/9	1/9	5	1/2	5	5
Growth Boundaries	9	9	9	9	9	1	9	9	9	9	9	9
Infrastructure Planning	9	9	9	9	9	1/9	1	9	9	9	9	9
Distance	5	9	9	9	9	1/9	1/9	1	9	9	9	9
Biological Factors	5	8	1/6	1/7	1/5	1/9	1/9	1/9	1	9	9	9
Physical Factors	9	9	6	5	2	1/9	1/9	1/9	1/9	1	9	9
Technology Factors	1/5	3	1	1/5	1/5	1/9	1/9	1/9	1/9	1/9	1	9
Cultural Factors	1	3	1	1/5	1/5	1/9	1/9	1/9	1/9	1/9	1/9	1

CI: 0,7044 CR: 0,4574 λ: 19,7485 Source: Adapted from MCMD (2017)

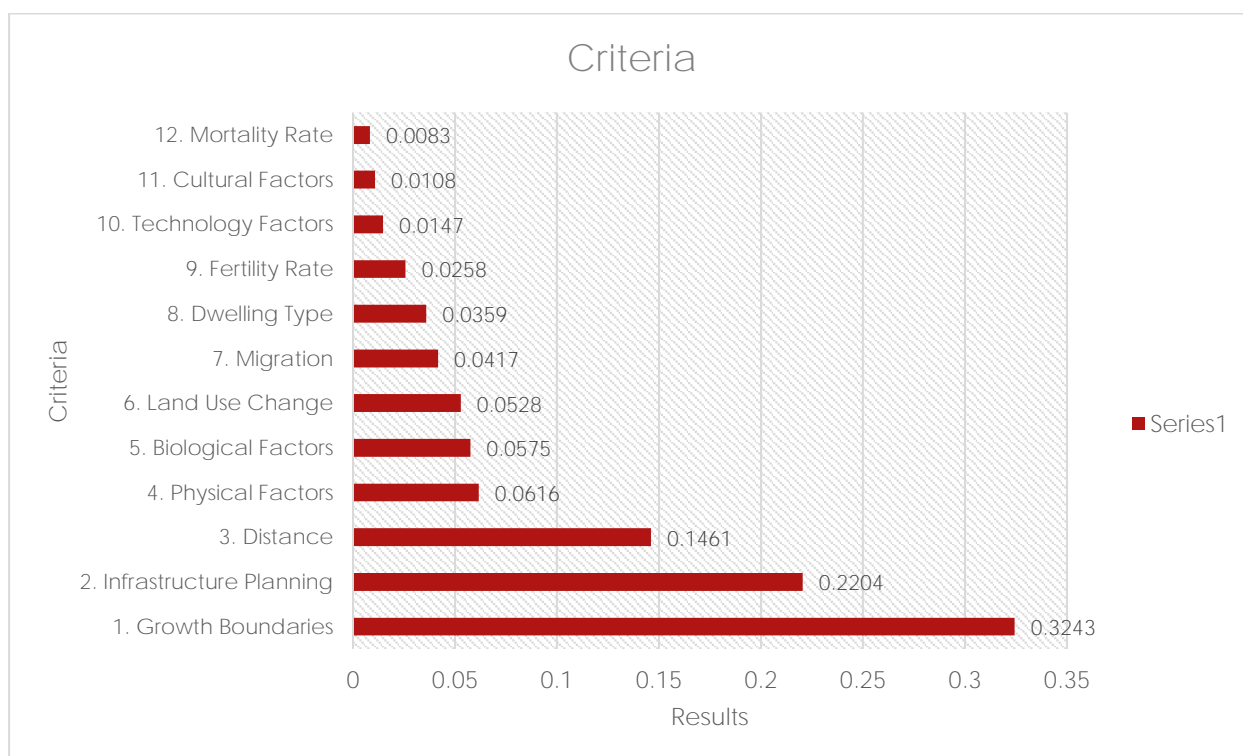


FIGURE 7-29: GROWTH FACTOR SUITABILITY CRITERIA

Source: Adapted from MCMD (2017)

From Figure 7-29, it is clear that growth boundaries are an incremental factor of growth, followed by infrastructure planning and distance. Table 7-38 illustrates the final results applied to a driving force matrix. A rating score (RS) was given for each criterion in terms of importance. The original weight as calculated from the AHP was then used and multiplied by the given RS in order to depict a suitable weight for each criterion.

TABLE 7-38: DRIVING FORCE MATRIX OF URBAN AND RURAL GROWTH

Physical Environmental Determining Factors				
Driving Forces	Weight	Rating Score (RS): 7 = High 1 = Low	Score	Description
	0.01: Low, 0.5: High	RS	RS * Weight	
Hydrology	0.4972	7	3.4804	Undevelopable

Conservation	0.2256	6	1.3536	Undevelopable unless approval obtained from key environmental departments
Steep Slopes	0.1429	5	0.7145	
Agricultural Potential	0.0679	4	0.2716	
CBA	0.0333	3	0.0999	
EMZ	0.0204	2	0.0408	
Swelling Clays	0.0126	1	0.0126	Geotechnical studies required

Determining Factors of Growth

Driving Forces	Weight	Rating Score (RS): 12 = High 1 = Low	Score
	0.008: Low, 0.3: High	RS	RS * Weight

Determining Factors

Growth Boundaries	0.3243	12	3.8916
Infrastructure	0.2204	11	2.4244
Distance	0.1461	10	1.461
Physical Factors	0.0616	9	0.5544
Biological Factors	0.0575	8	0.46
Land use change	0.0528	7	0.3696
Migration	0.0417	6	0.2502

Dwelling type	0.0359	5	0.1795
Fertility Rate	0.0258	4	0.1032
Technology Factors	0.0147	3	0.0441
Cultural Factors	0.0108	2	0.0216
Mortality Rate	0.0083	1	0.0083

Source: Adapted from ArcGIS (2017)

The environmental weight was added in the urban value field within the spatial data. Additional weights were added for vacant land, built-up areas and agricultural land. The weights are depicted in Table 7-39.

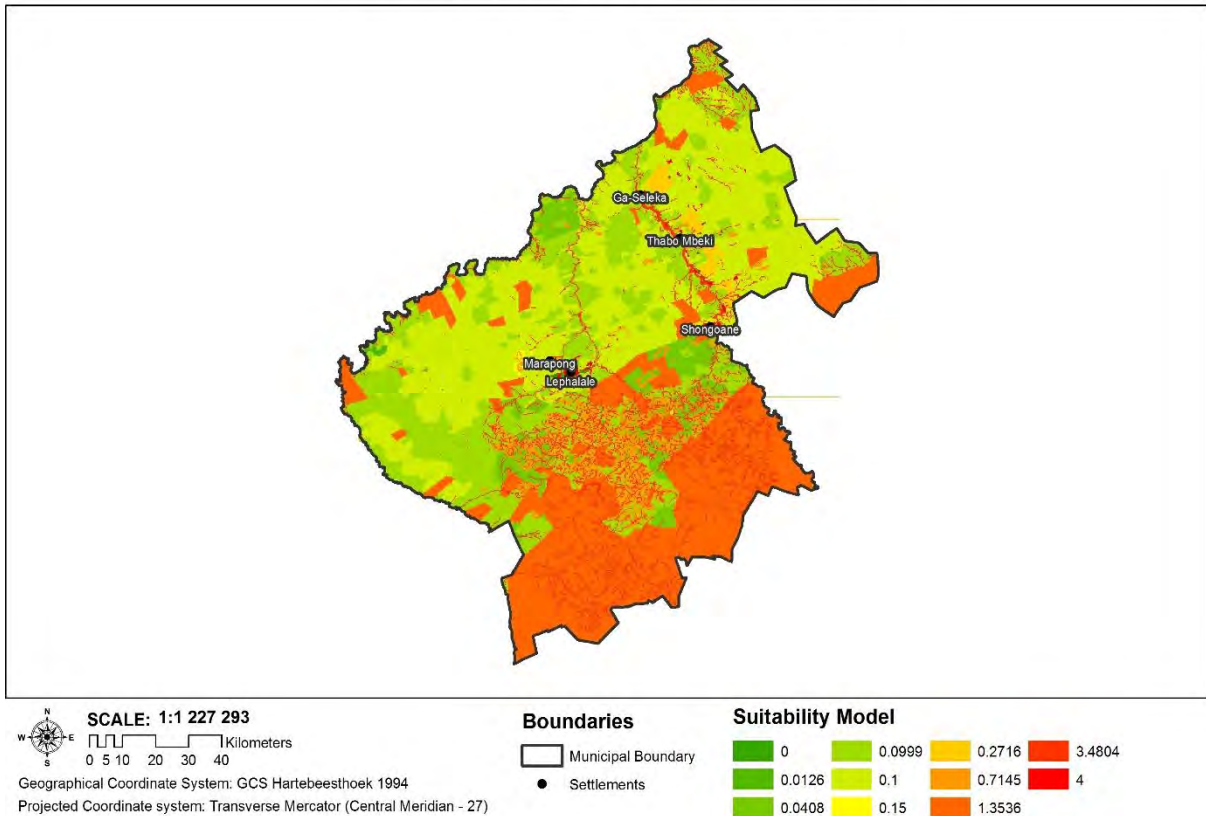
TABLE 7-39: ADDITIONAL DEVELOPMENTAL WEIGHTS

Current Use	Weight	Description
Built-up	4	Undevelopable
Open Space	4	Undevelopable
Mining	0.15	Undevelopable to developable depending on correct processes followed
Agriculture	0.1	Developable to undevelopable depending on approval from key environmental departments
Vacant Land	0	Developable – If the correct process were followed in terms of township establishments etc.

Source: Own Construction (2017)

Map 7-22 illustrate the results from the calculation above.

LEPHALALE LOCAL MUNICIPALITY: AHP PROCESS



MAP 7-22: SUITABILITY MODEL

Source: Adapted from I@Consulting (2017)

The next objective dealt with identifying land suitable for development. The section illustrates a breakdown of the process followed above.

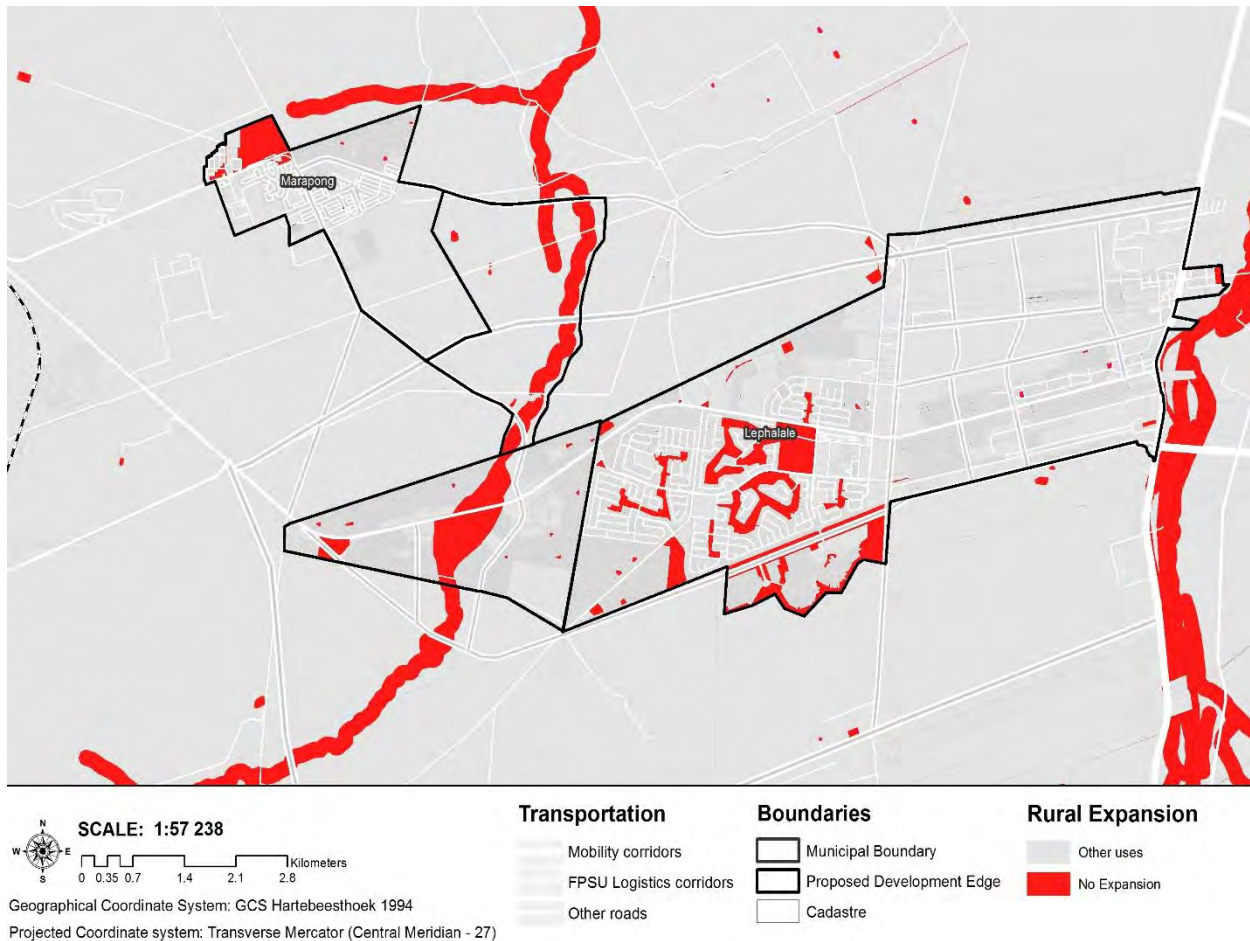
7.7 Objective 6: Identify land suitability

Before applying the final suitability analysis, the first step was to identify existing land suitable for development based on the prepared datasets. The analysis was based on both focus areas. This step involved a three-fold process:

- Identify land not suitable for development
- Identify existing vacant parcels
- Identify areas for infill development

7.7.1 Focus Area 1: Land not suitable for development

The areas depicted in red on the map illustrate the areas where no development can occur. These areas include any public open space network, hydrology system, conservation area and any area with a slope more than 25%.



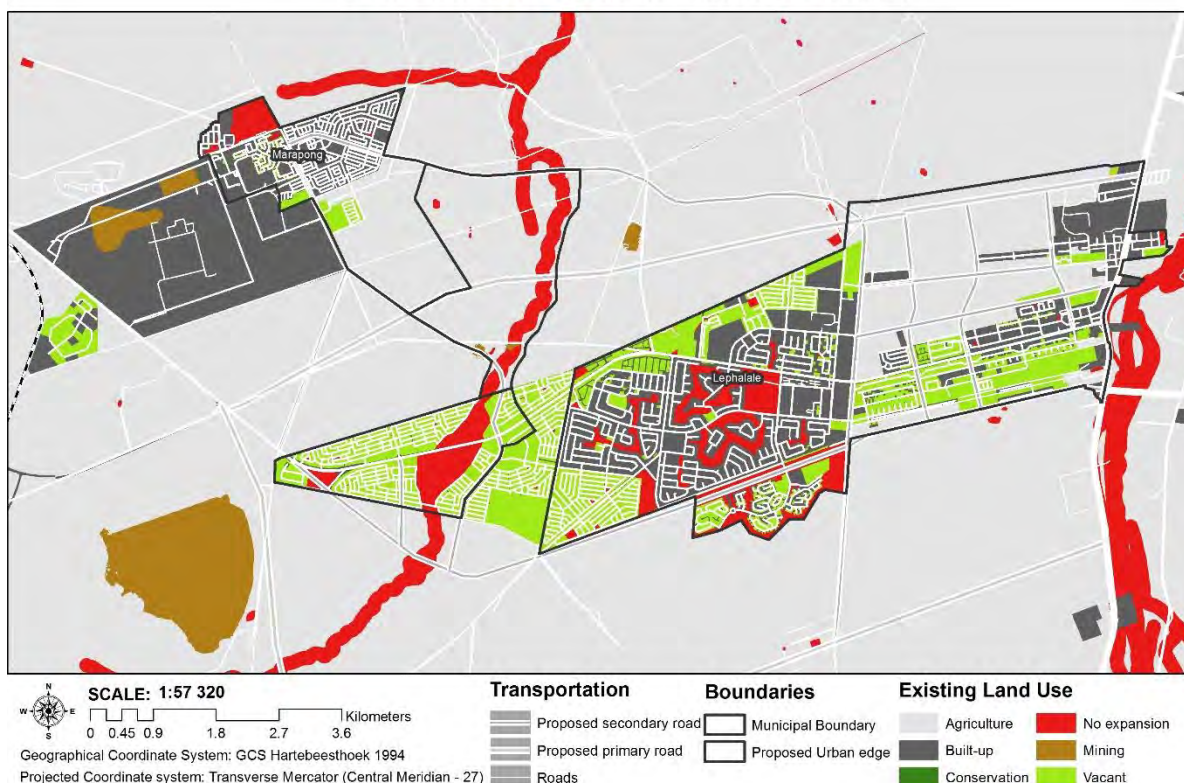
MAP 7-23: LAND NOT SUITABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalele Local Municipality (2017)

7.7.2 Focus Area 1: Existing land available for development (Vacant parcels)

The areas depicted in green on the map below illustrates existing land available for future development. This includes approved general plans and layout plans (Note: the assumption was made that the approved general plans and layout plans would be proclaimed in the near future).

LEPHALALE LOCAL MUNICIPALITY: FOCUS AREA 1



MAP 7-24: EXISTING LAND USES

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

It is evident based on Map 7-24, that focus area one consist of a lot of vacant stands. The vacancy figures are depicted in Table 7-40. The figures are based on the existing vacant stands within focus area one. The focus area consists of a total figure of 9 665 vacant stands (1 097 hectares). Table 7-25 depicted the total cumulative growth of the Municipality. Based on the figure depicted in Table 7-40 (9 665), it is clear that focus area one already has enough space to cover the proposed growth for the whole municipality until 2026. Income levels however will play an incremental role. The type of infill development will depend on the income level. For citizens residing in the rural areas, focus area one may be too unaffordable.

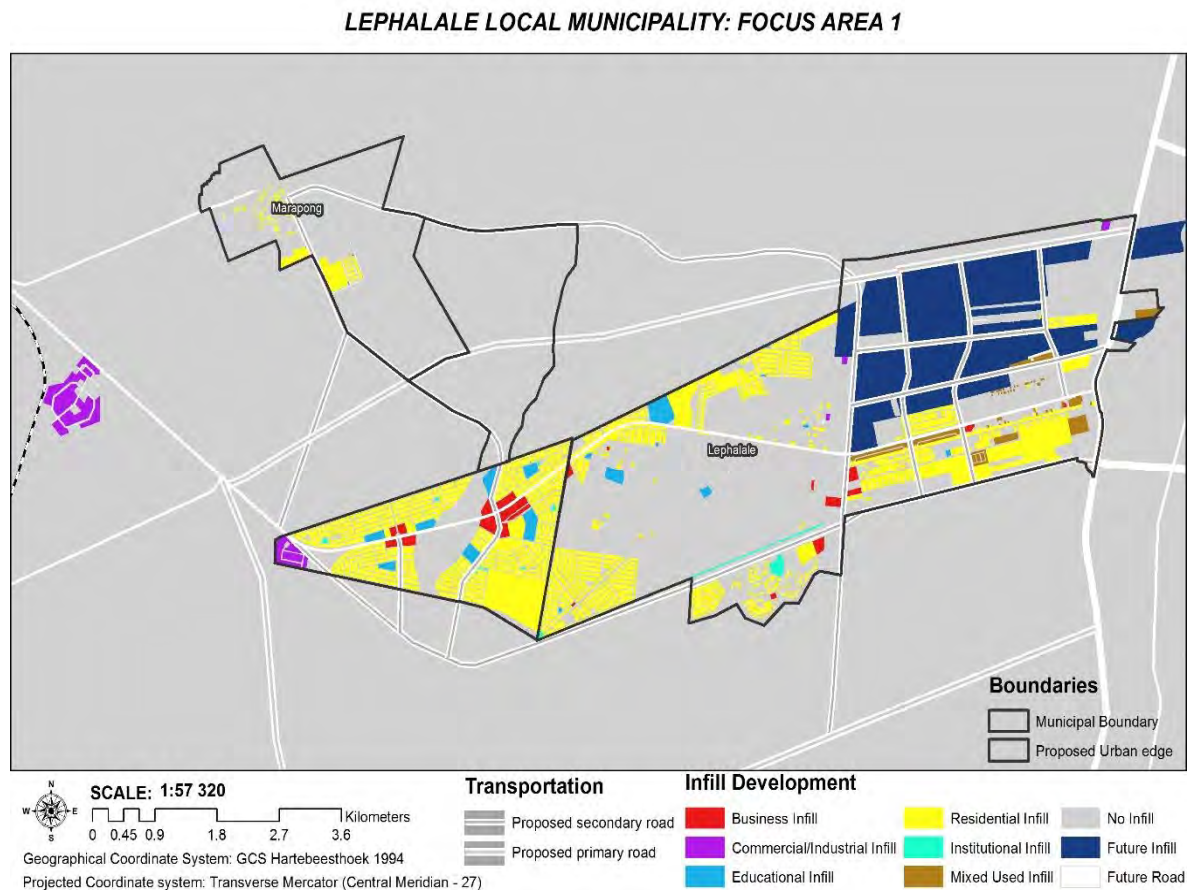
TABLE 7-40: FOCUS AREA 1 - VACANCY

Type	Total number of vacant stands	Total hectares available
Formal	9 665	1097.17

Source: Own Construction (2017)

7.7.3 Focus Area 1: Land available per land use: Infill Development

The field “infill” were utilised to spatially depict what type of infill development will occur based on the approved amendments. The infill development was based on all land currently classified as vacant land (refer to Map 7-25). The light grey areas depict built-up areas, agricultural land, mining and conservation etc. The areas depicted in dark blue illustrates land inside the urban edge that was proposed for future development within the Draft SDF of the Municipality.



MAP 7-25: INFILL DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalele Local Municipality (2017)

Table 7-41 below illustrate the infill development per use for all formal stands within the focus area.

TABLE 7-41: FORMAL INFILL DEVELOPMENT

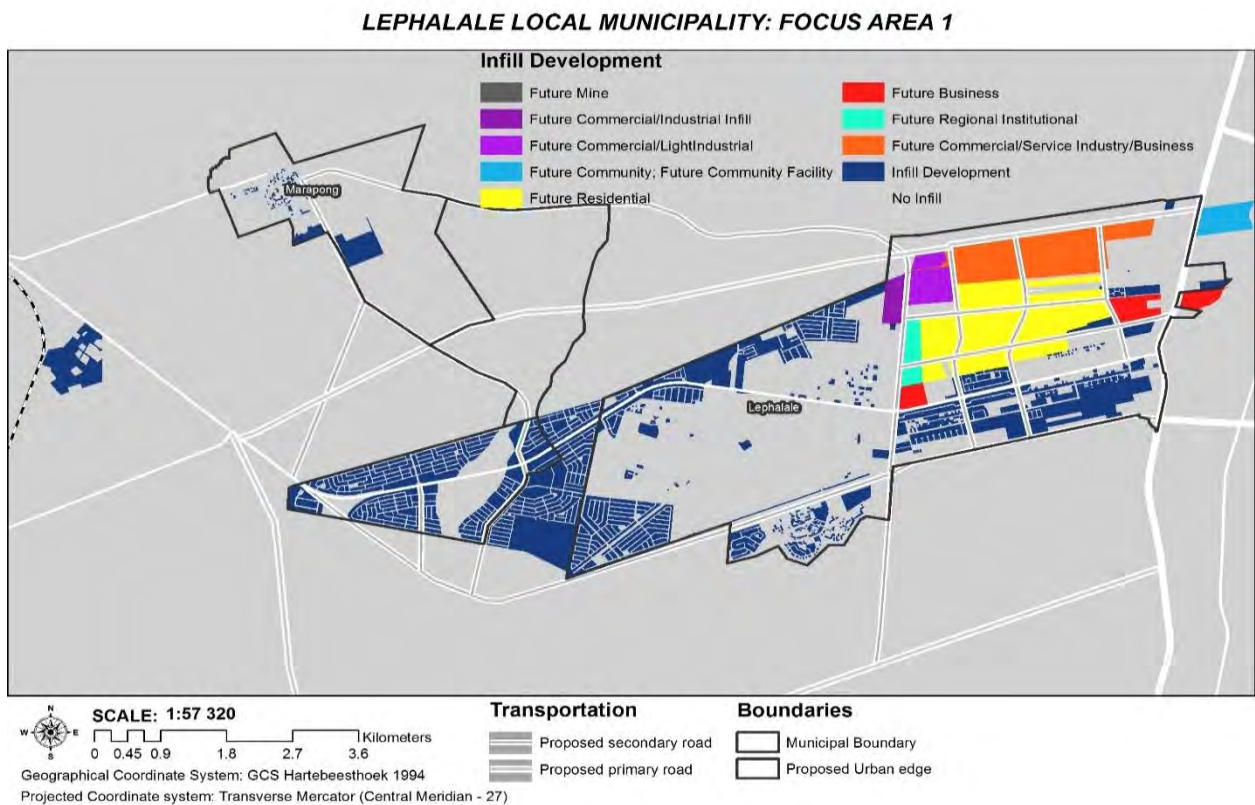
Type	Total number of vacant stands	Total hectares available
Focus Area 1	9 665	1 097.17

Type	Total number of vacant stands	Total hectares available
Business	31	36.42
Industrial	85	49.52
Institutional	35	52.09
Residential	9 211	552.16

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.4 Focus Area 1: Future proposed land identified for infill Development

The map below illustrates the proposals in terms of the Draft SDF for the Municipality. The dark blue areas depict vacant land available for future infill development and the light grey illustrates all other existing land uses such as built-up areas, agricultural land, and other environmental areas.



MAP 7-26: LAND FOR FUTURE DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Table 7-42 depicts the total figure of land proposed for infill development per use.

TABLE 7-42: PROPOSED FUTURE INFILL DEVELOPMENT

Future proposed type	Total number of vacant stands	Total hectares available
Regional Institutional	2	23.87
Commercial/Service industry/Business	3	161.10
Future Community	1	30.83
Future Residential	8	251.97
Future Industrial	2	66.54

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

The next part deals with the incremental areas (Focus area 2).

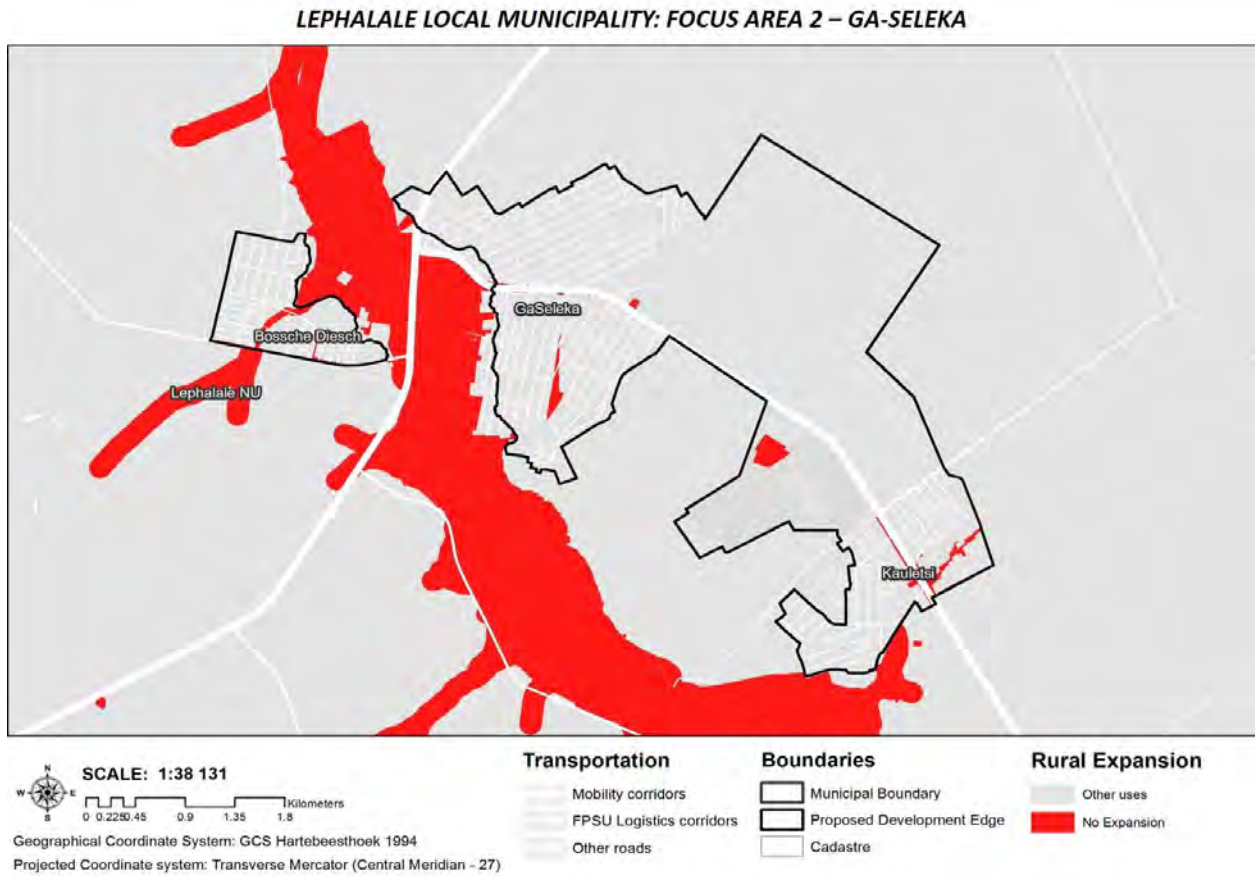
7.7.5 Incremental Areas – Focus Area 2

- Ga-Seleka
- Thabo Mbeki
- Shongoane

The vacancy level of focus area 2 was based on the formally proclaimed stands and the rural datasets which were spatially captured per block.

7.7.5.1 Focus Area 2: Ga-Seleka - Land not suitable for development

The areas depicted in red on Map 7-27 illustrate the areas where no development can occur. These areas include any open space network, hydrology system, conservation area and any area with a slope more than 25%.

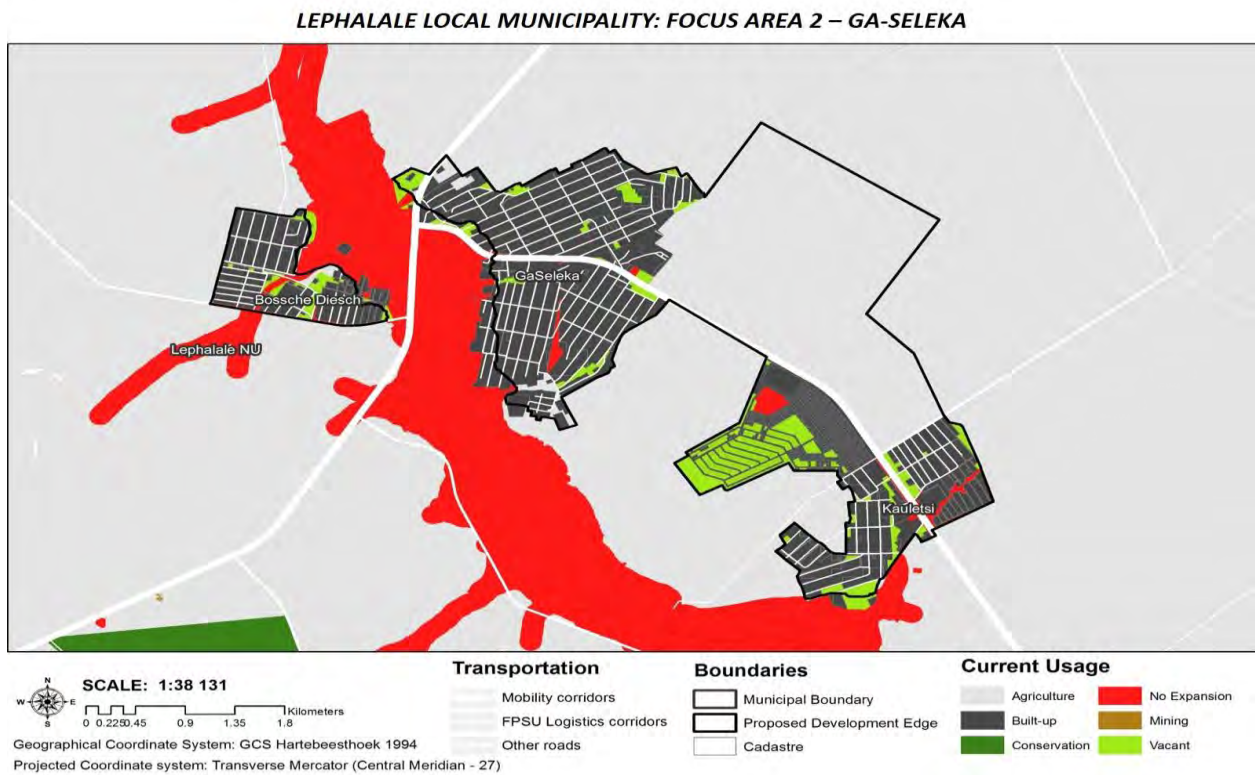


MAP 7-27: GA-SELEKA - LAND NOT SUITABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalele Local Municipality (2017)

7.7.5.2 Focus Area 2: Ga-Seleka - Existing land available for development (Vacant parcels or commonage areas)

Map 7-28 illustrates the existing built-up and vacant areas within the Ga-Seleka village.



MAP 7-28: GA-SELEKA – EXISTING LAND AVAILABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Table 7-43 below depicts the vacancy figures of the Ga-Seleka village. The formally proclaimed stands consist of a figure of 517 stands while 70 hectares of land is available for development based on the rural “commonage areas”. It was proposed that the commonage areas within focus area 2 would be utilised for mixed-use development.

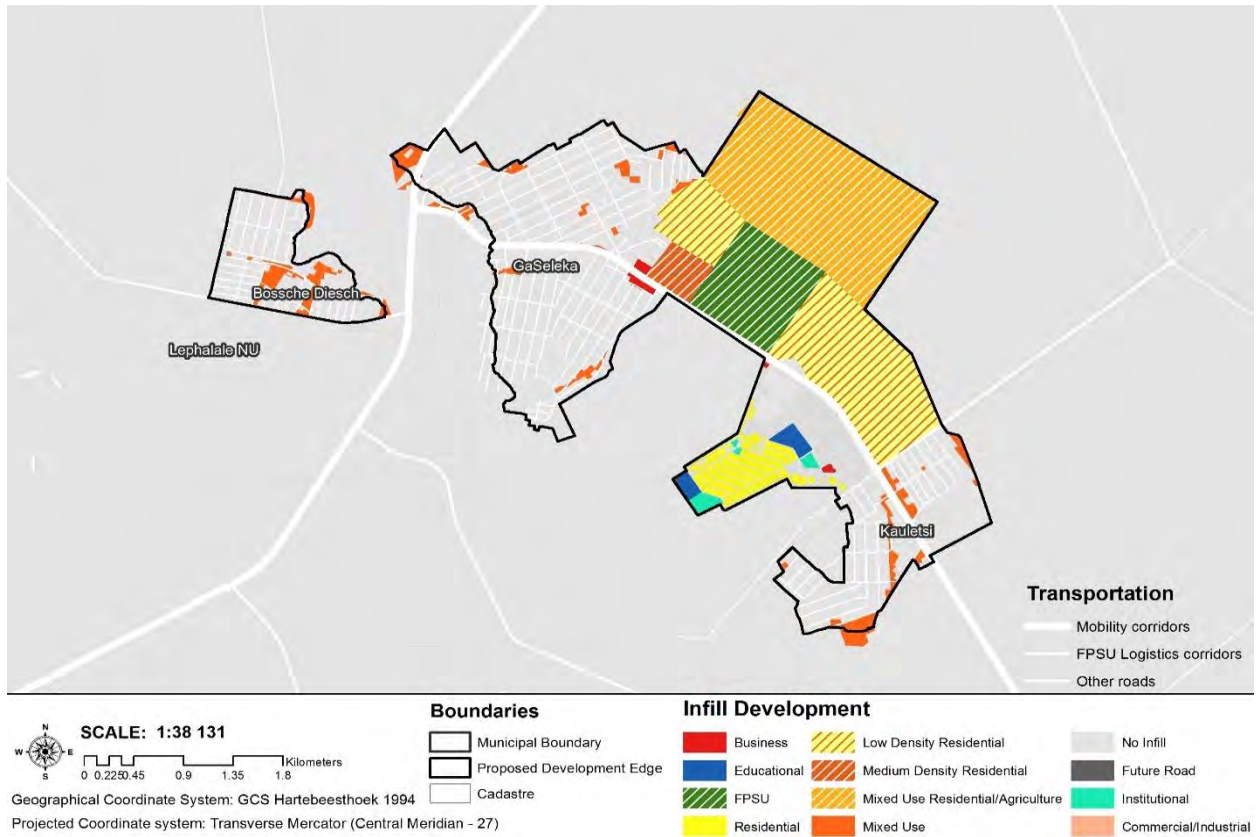
TABLE 7-43: GA-SELEKA - VACANCY

Type	Total number of vacant stands	Total hectares available
Formal	517	58.89
Rural	49 (Blocks – Commonage areas)	69.94

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.3 Focus Area 2: Ga-Seleka - Land available for infill development per land use

Map 7-29 below illustrates the proposals within the draft SDF for future infill development.



MAP 7-29: GA-SELEKA – INFILL DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Table 7-44 depicts the total figure of land available for future development.

TABLE 7-44: EXISTING AND FUTURE VACANCY PER USE

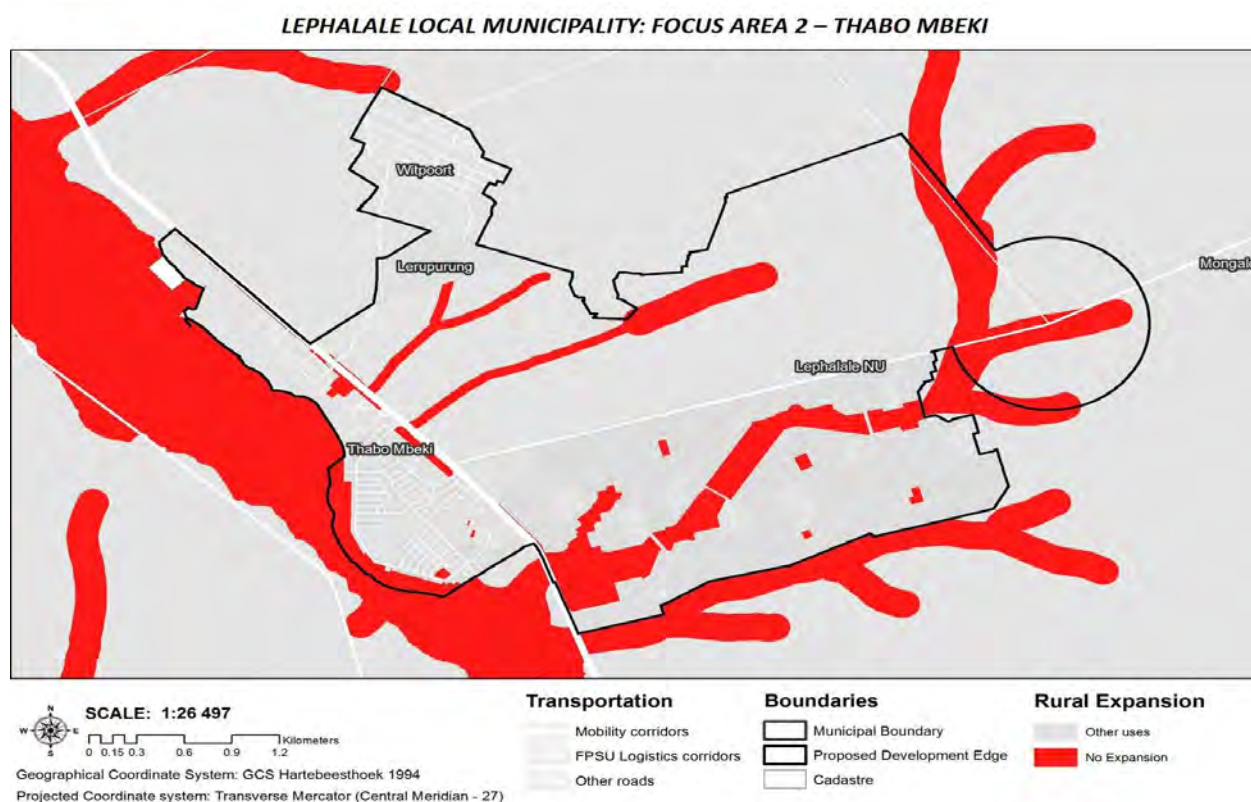
Type		Total number of vacant stands	Total hectares available
Existing	Business	2	0.97
	Industrial	0	0
	Institutional	6	11.55
	Residential	507	36.33

Type		Total number of vacant stands	Total hectares available
Proposed	Low density residential	2 (Blocks)	180.2587
	Medium density residential	1 (Block)	18.61079
	Mixed-use residential/Agriculture	1 (Block)	213.3275
	FPSU	1 (Block)	81.65547

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.4 Focus Area 2: Thabo Mbeki - Land not suitable for development

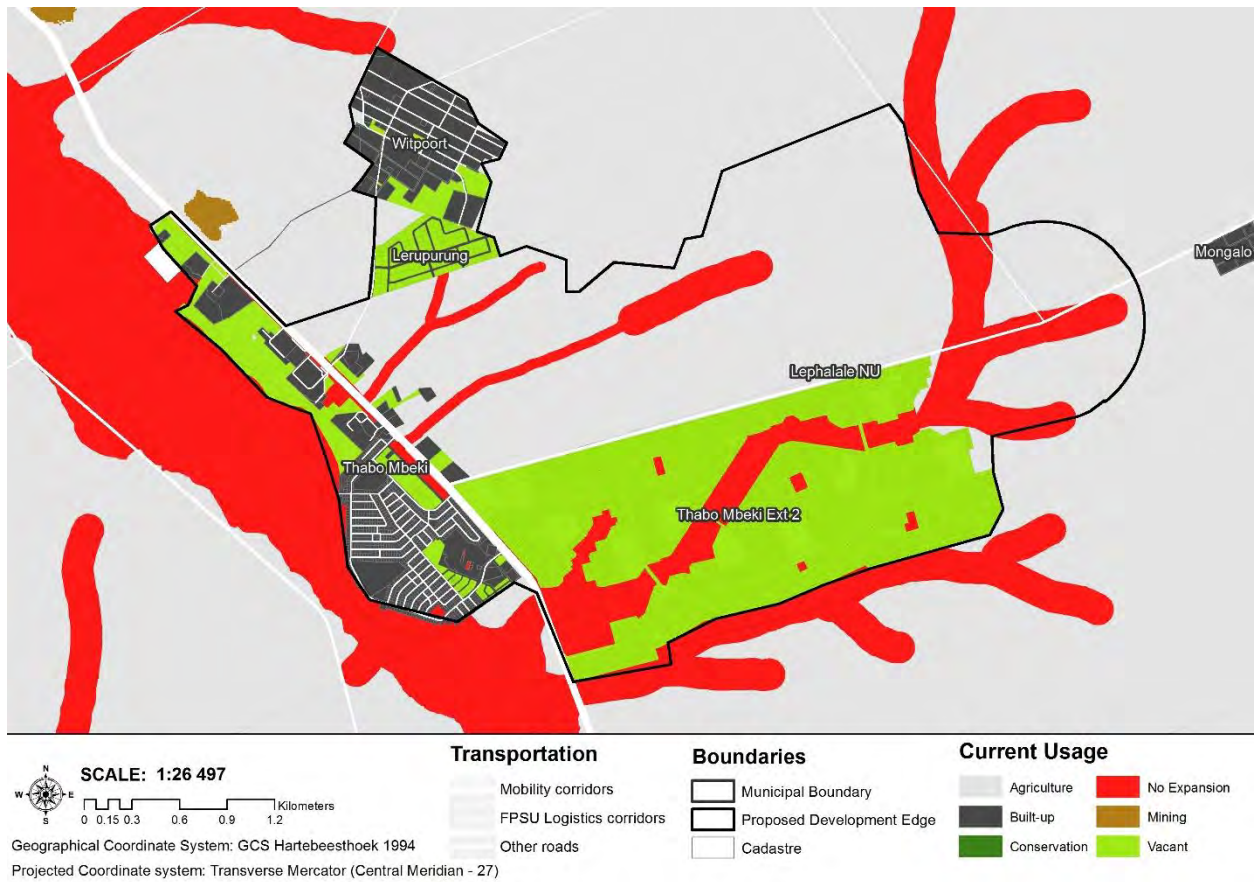
The areas depicted in red on the map below illustrate the areas where no development can occur. These areas include any open space network, hydrology system, conservation area and any area with a slope more than 25%.



MAP 7-30: THABO MBEKI - LAND NOT SUITABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.5 Focus Area 2: Thabo Mbeki - Existing land available for development (Vacant parcels or commonage areas)



MAP 7-31: THABO MBEKI - EXISTING LAND AVAILABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

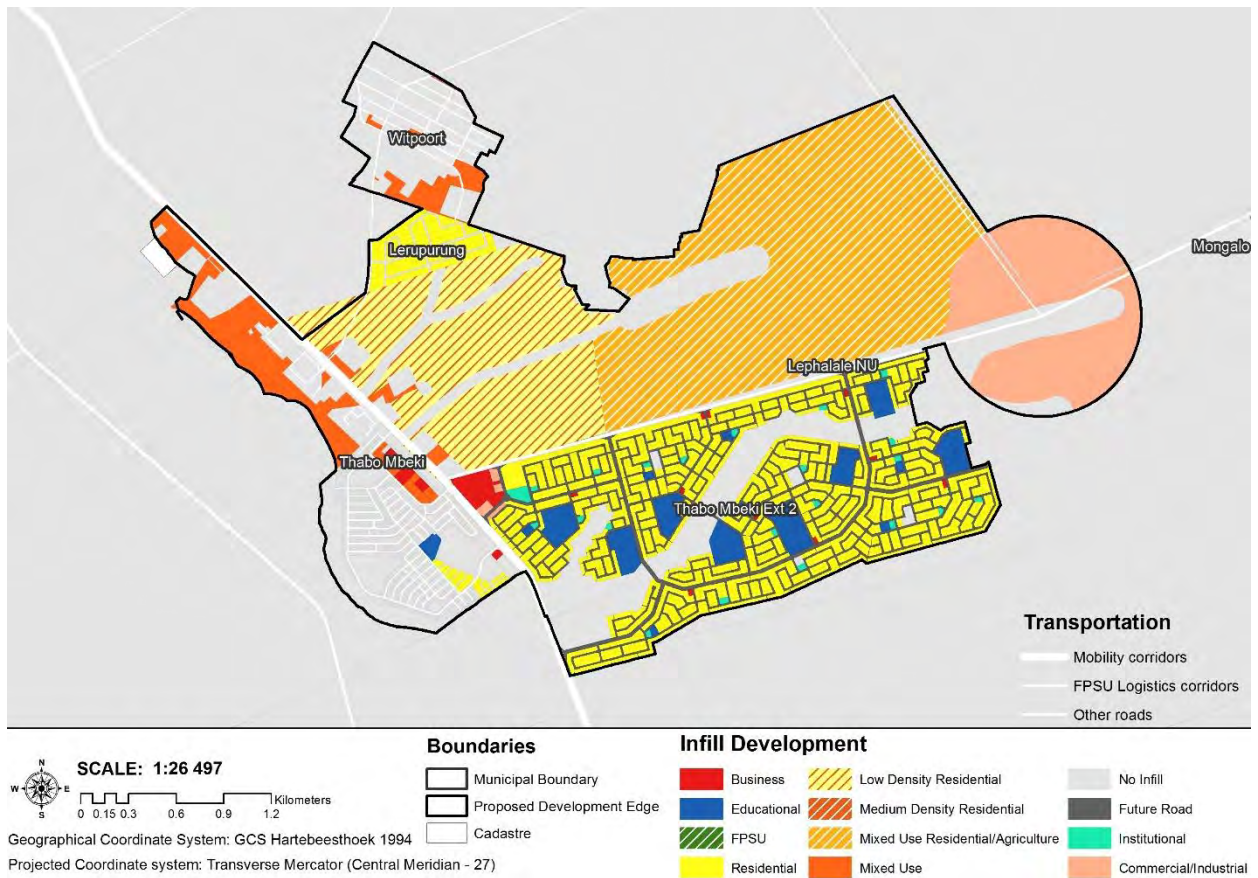
A large portion of Thabo Mbeki Ext 1 falls within the calculated floodline. No development has yet taken place in the proposed township - Thabo Mbeki Ext 2.

TABLE 7-45: THABO MBEKI VACANCY LEVEL

Type	Total number of vacant stands	Total hectares available
Formal	4 302	344.09
Rural	16 (Blocks – Commonage areas)	47.99

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.6 Focus Area 2: Thabo Mbeki - Future and existing land available for infill development per land use



MAP 7-32: THABO MBEKI - INFILL DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephale Local Municipality (2017)

TABLE 7-46: THABO MBEKI - EXISTING AND FUTURE PROPOSED LAND FOR INFILL DEVELOPMENT

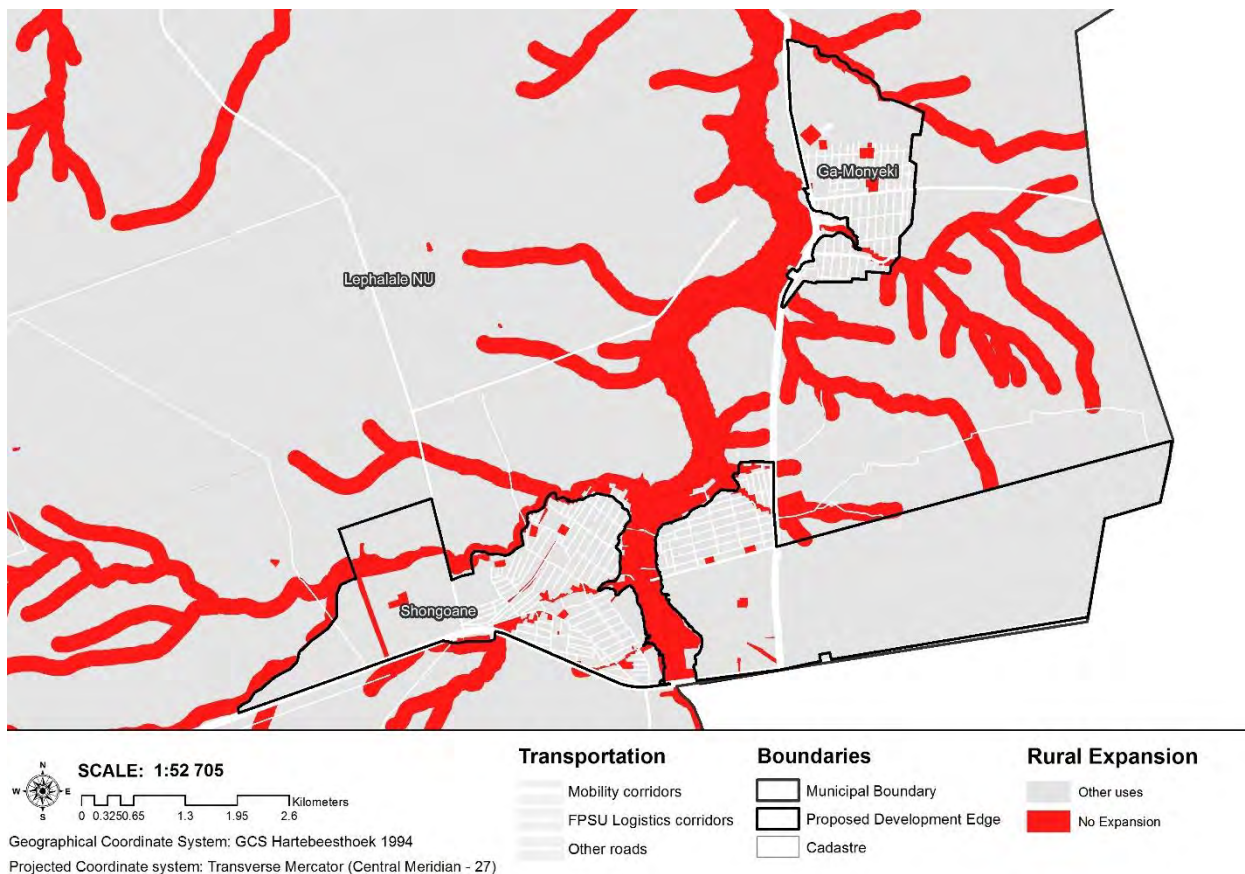
Type		Total number of vacant stands	Total hectares available
Existing	Business	10	5.79
	Industrial	15	1.55
	Institutional	35	35.41
	Residential	4231	151.16
Proposed	Low density residential	1 (Block)	150.95

Type	Total number of vacant stands	Total hectares available
Mixed-use residential/Agriculture	1 (Block)	257.83
Commercial/Industrial	1 (Block)	83.27

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.7 Focus Area 2: Shongoane - Land not suitable for development

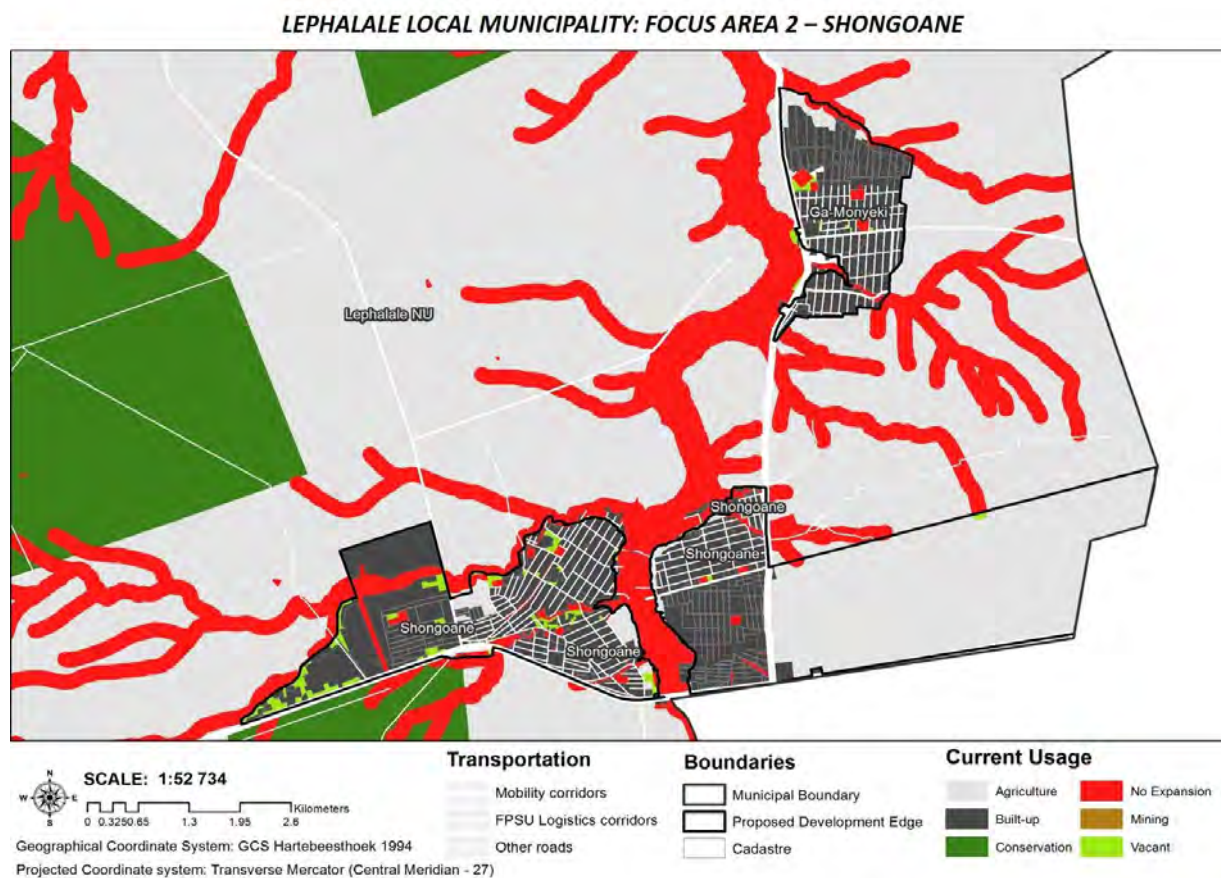
The areas depicted in red on the map below illustrate the areas where no development can occur. These areas include any open space network, hydrology system, conservation area and any area with a slope more than 25%.



MAP 7-33: SHONGOANE - LAND NOT SUITABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.8 Focus Area 2: Shongoane - Existing land available for development (Vacant parcels or commonage areas)



MAP 7-34: SHONGOANE - EXISTING LAND AVAILABLE FOR DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

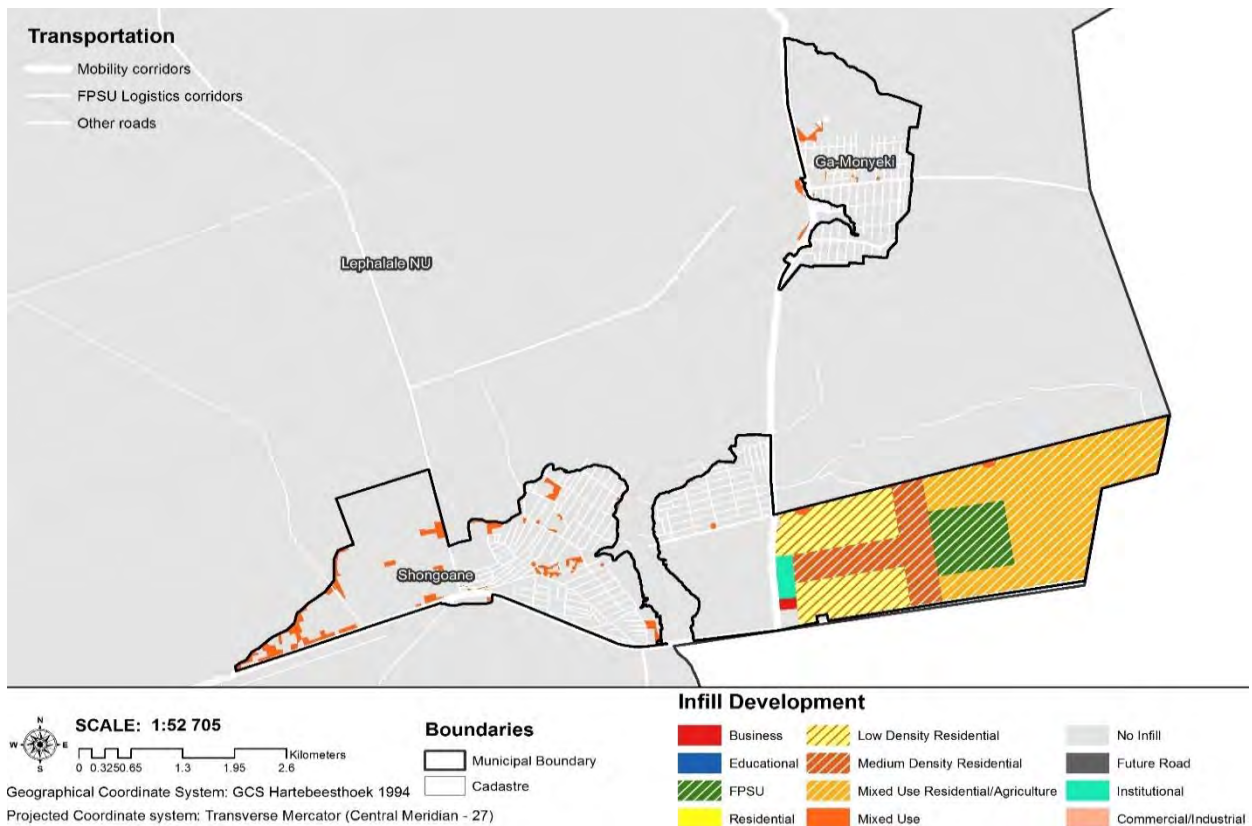
Table 7-47 illustrates the total figure of land available for future mixed-use development. A total figure of 817 hectares of land is available for future mixed-use development within Shongoane.

TABLE 7-47: SHONGOANE VACANCY

Type	Total number of vacant stands	Total hectares available
Rural	39 (Blocks – Commonage areas)	817.03

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.9 Focus Area 2: Shongoane - Future and existing land available for infill development per land use



MAP 7-35: SHONGOANE – INFILL DEVELOPMENT

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Table 7-48 depicts the total figure of land available for future proposed infill development.

TABLE 7-48: SHONGOANE FUTURE PROPOSED USE

Type	Block	Total hectares available
Low density residential	2 (Blocks)	177.9418
Medium density residential	1 (Block)	122.0342
Mixed-use residential/Agriculture	1 (Block)	361.1655
FPSU	1 (Block)	83.98836

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7.5.10 Combined summary of available land for future development

TABLE 7-49: VACANT LAND SUMMARY

Type	Total number of vacant stands	Total hectares available
Formal (Focus Area 1)	9 665	1097.17
Formal Focus Area 2)	7 971	899.15
Total (Formal)	17 637	1996.32
Rural (Focus Area 2)	314 (Blocks – Commonage areas)	1306.43

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

TABLE 7-50: LAND AVAILABLE PER LAND USE

	Business	Ha	Industrial	Ha	Institutional	Ha	Res	Ha
Formal (Focus Area 1)	31	36.42	85	49.52	35	52.09	9 211	552.16
Formal Focus Area 2)	16	4.18	15	1.55	28	16.10	7193	392.40
Total (Formal)	47	40.60	100	51.07	63	68.19	16 404	944.57
Rural (Focus Area 2)	314 (Blocks – Commonage areas) – Mixed Use							1306.43

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

TABLE 7-51: FUTURE PROPOSED LAND USE

Proposed type	Proposed Future Uses per block	Total hectares per block
Proposed Formal		
Regional Institutional	2	23.86855
Commercial/Service industry/Business	3	161.1031
Future Community	1	30.82965
Future Residential	8	251.9692
Future Industrial	2	66.5442
Proposed Rural		
Low density residential	5	509.1509
Medium density residential	2	140.645
Mixed-use residential/Agriculture	3	832.3228
Commercial/Industrial	2	165.6438
FPSU	1	83.26633
Total	29	2265.34

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

7.7 Objective 7: Develop urban/rural growth scenarios (5, 10, 20 years)

The last objective involved some scenario planning. It is a clear requirement from SPLUMA that future planning has to happen at a level of three distinctive years, namely planning for a five, ten and twenty year period. Objective 2 concluded who are being planned for while objective 4 depicted the accessibility analysis and the additional land required in terms of population, household and infrastructure demand. Objective 5 concluded the current level of vacancy within the Municipality. The first step in objective 6, was to utilise the information calculated in objective 2, 4 and 5, and to populate a growth scenario in terms of the requirements for the additional years as set out in objective 4.

TABLE 7-52: CURRENT VACANCY LEVEL AND ADDITIONAL UNITS EXPECTED

Method	Current vacancy level stands/parcels			Additional units expected		
	Formal focus area 1	Formal Focus area 2	Rural focus area 2	2021	2026	2035
1	9 665	7 971	314 blocks	4 186	9 573	18 376
2			(1 306Ha)	4 193	10 718	22 642

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Based on Table 7-23, the average residential stand size within the rural incremental areas is 2 073 sqm, while the average business stand size is 2 864 sqm. 1 306 ha commonage areas are available for development within rural areas as depicted in Table 7-52. Commonage areas consist of mixed-use development, such as residential, business, community facilities etc. It is thus impossible to determine what type of land use will allocate within the commonage areas in the future, but let's say for example, the 1 306 ha will be used for residential purposes. This means that an additional 6 300 stands are currently available for residential development $((1\ 306\text{ha} / 10\ 000) / 2073 = 6\ 300)$.

17 637 formal stands/parcels are currently available for development within the Municipality. Referring to Table 7-52, which means considering the current vacancy level for both formal and rural areas, there is enough space to accommodate the additional units expected for the next ten to twenty years. From all the calculations above a basis was now established in terms of the additional units expected and the current vacant level within the Municipality. The next part dealt with illustrating where and how growth will take place within the Municipality. It is expected that

the majority of growth will take place within the proposed focus areas as the areas were also identified as nodes within the Spatial Development Framework (Lephalale Local Municipality, 2017). It is important to take into account that urban and rural growth differ. In some instances, growth in rural areas may be taking place at a much higher rate than let's say in your more urban areas. According to a land survey compiled for the Municipality, the growth rate of the rural incremental areas is much higher than in the case of the Lephalale/Marapong area (Focus area 1) (I@Consulting, Lephalale Land Use Survey, 2017).

In order to differentiate between the two focus areas, the customer profile as illustrated in objective 2 were used. Some assumptions had to be made in terms of growth rates taking into account the projected Municipal growth rate as depicted in Table 7-13. In the population calculations in objective 4, two assumptions were made in terms of growth rate. For the purpose of this section, the second assumption was used for focus area 1. The growth rate for focus area 2 is much higher than focus area 1, thus a new assumption was used with higher growth rates. The results are illustrated in the table below.

TABLE 7-53: CUMULATIVE GROWTH

Assumption 2				New Rural Growth Assumption		
Focus Area 1				Focus Area 2		
Years	HH	Growth Rate	Cumulative growth	HH	Growth Rate	Cumulative growth
2017	17 471			20 517		
2018	17 744	1.57%	273	21 645	5.50%	1 128
2019	18 022	1.57%	551	22 728	5.00%	2 211
2020	18 304	1.57%	833	23 750	4.50%	3 233
2021	18 670	2.00%	1 199	24 795	4.40%	4 278
2022	19 044	2.00%	1 573	25 862	4.30%	5 345
2023	19 444	2.10%	1 973	26 948	4.20%	6 431
2024	19 852	2.10%	2 381	28 053	4.10%	7 536

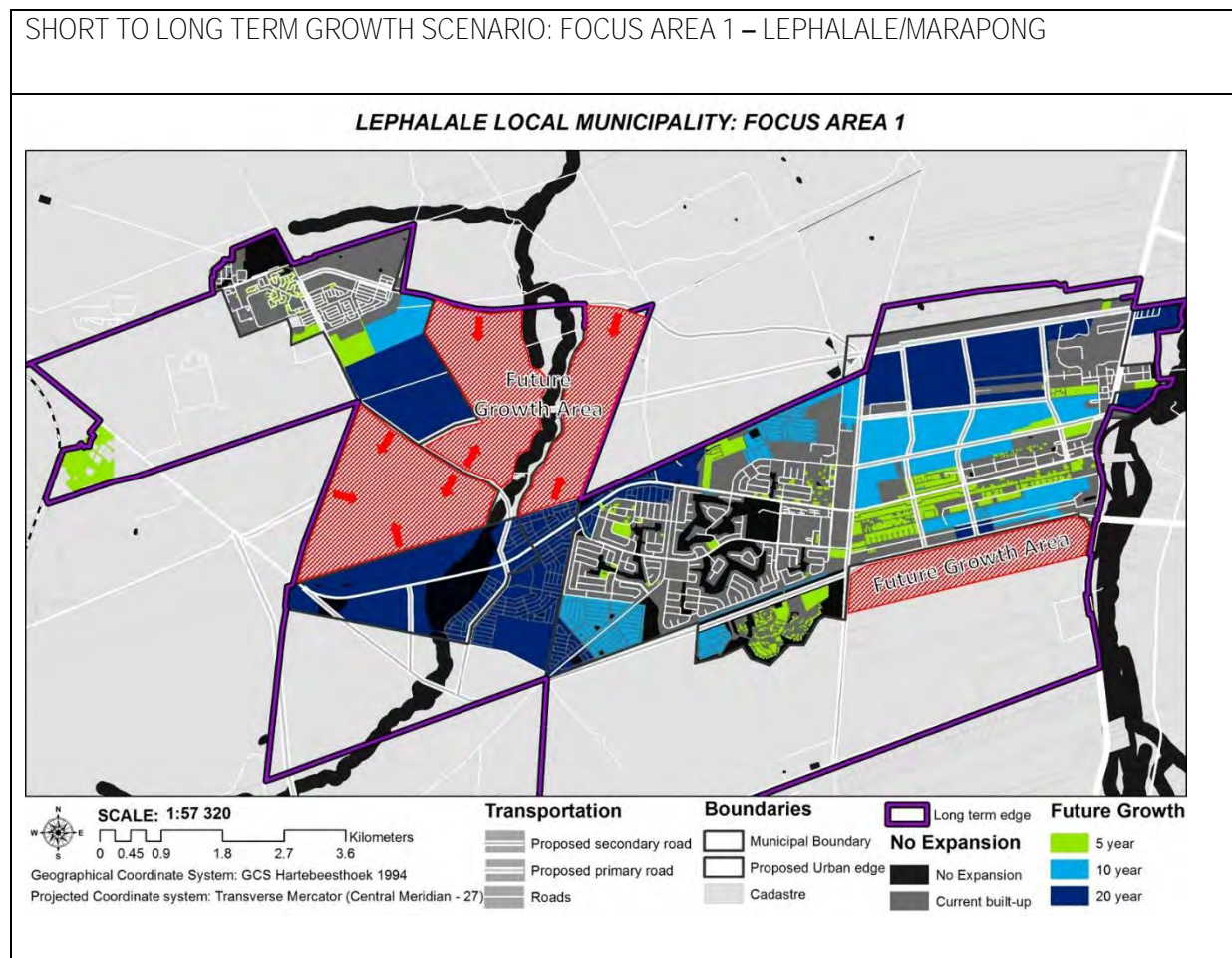
Assumption 2				New Rural Growth Assumption		
Focus Area 1				Focus Area 2		
Years	HH	Growth Rate	Cumulative growth	HH	Growth Rate	Cumulative growth
2025	20 269	2.10%	2 798	29 119	3.80%	8 602
2026	20 695	2.10%	3 224	30 196	3.70%	9 679
2027	21 129	2.10%	3 658	31 283	3.60%	10 766
2028	21 552	2.00%	4 081	32 378	3.50%	11 861
2029	21 983	2.00%	4 512	33 414	3.20%	12 897
2030	22 422	2.00%	4 951	34 450	3.10%	13 933
2031	22 871	2.00%	5 400	35 415	2.80%	14 898
2032	23 397	2.30%	5 926	36 335	2.60%	15 818
2033	23 935	2.30%	6 464	37 171	2.30%	16 654
2034	24 486	2.30%	7 015	38 026	2.30%	17 509
2035	25 049	2.30%	7 578	38 863	2.20%	18 346
2036	25 600	2.20%	8 129	39 718	2.20%	19 201
2037	26 163	2.20%	8 692	40 552	2.10%	20 035

Source: Own Construction (2017)

Table 7-53 depicts that by the year 2037, focus area 1 will growth by an additional 8 692 households, while focus area two will growth by an additional 20 035 households. As soon as all land within the identified urban or rural edge has been developed, additional land will be required. From workshops with key environmental departments, the following proposal was made.

- Create a new long-term urban edge.

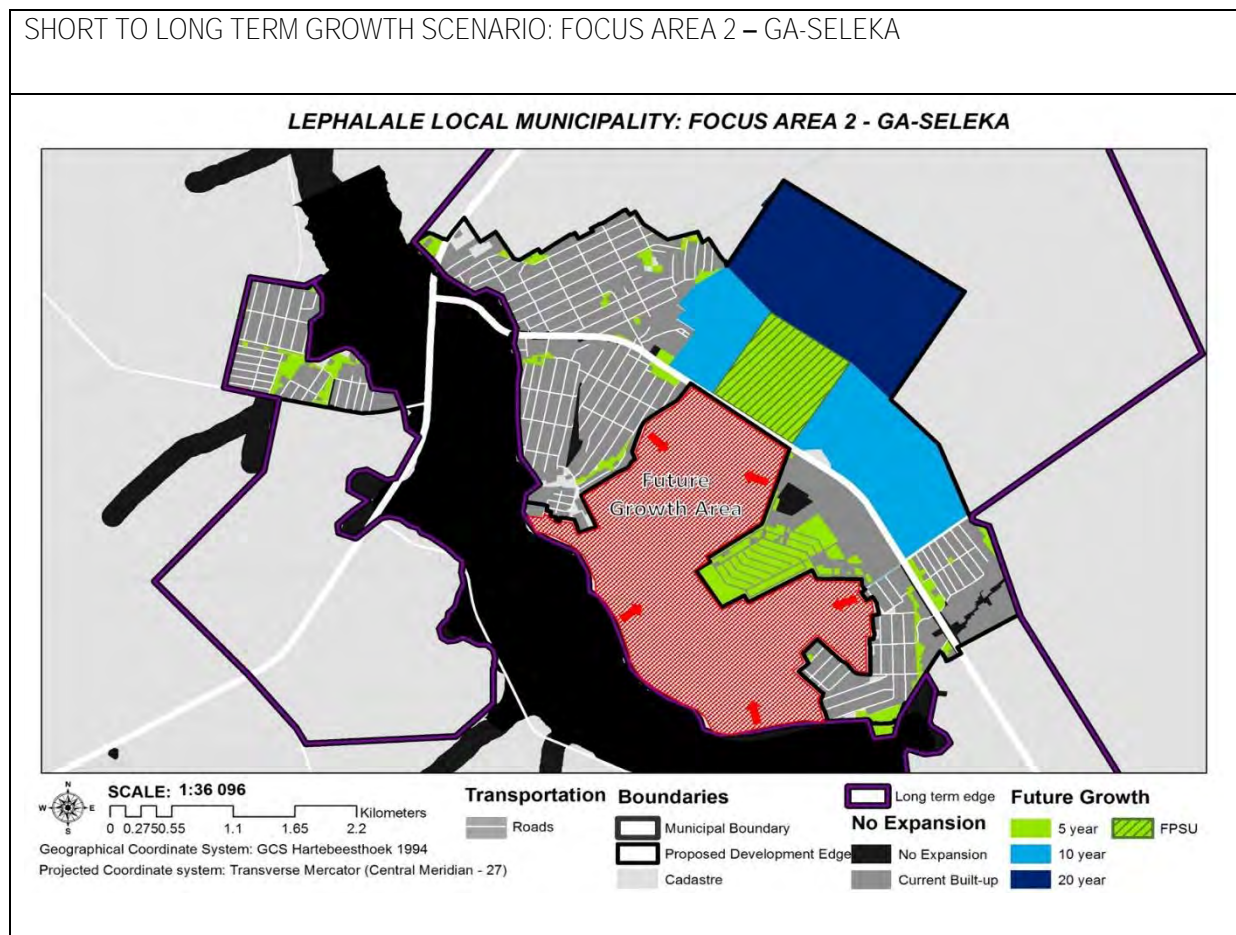
All land in between the new proposed long-term urban edge and current urban/rural edge will still be zoned agricultural land bearing in mind that the subdivision of agricultural land Act, Act 70 of 1970 is still enacted which means all land outside current urban edge will be regarded as agricultural land. The Department of Agriculture and Environmental affairs however, still need to approve the boundary in terms of allowing the agricultural land in between the short and long-term boundary to be deemed as a different zoning, e.g. influential zone. Neither to say agricultural land inside the short to long-term boundary can still be zoned agricultural land. It only takes a new kind of zoning, e.g. urban agriculture. The DEA also suggested that they are willing to exclude any land that has been gazetted in terms of conservation from agricultural land. The Department is also willing to let go of mines with open cast mining activities with licences, as the land will not really ever be rehabilitated into agricultural land. The different growth scenarios for both focus areas are illustrated in the maps to follow.



Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Many vacant parcels and land exist within focus area 1. The dark grey and black areas as depicted on Map 7-36, illustrates areas where no development can occur, either environmental areas, open

space or built-up areas. The parcels depicted in green illustrate the projected five-year growth scenario, while the light blue to dark blue depicts the ten to twenty-year growth scenario. All the areas that have not yet been formally proclaimed still have to go through the whole township establishment process and other requirements before any development can occur. The areas depicted in red represents proposed areas for future growth if all other growth areas have been developed. The future growth area was included in the map to make provision for the instance where growth might occur at a more rapid pace as projected. a long-term edge was also introduced to both focus areas to make further provision for future development. Ownership will play a major role in obtaining additional land for development. If the farm portions are privately owned, negotiation will have to take place in order to purchase the land. Approval from key environmental departments will also be vital. The light grey area represents agricultural land and some areas where mining activities occur.

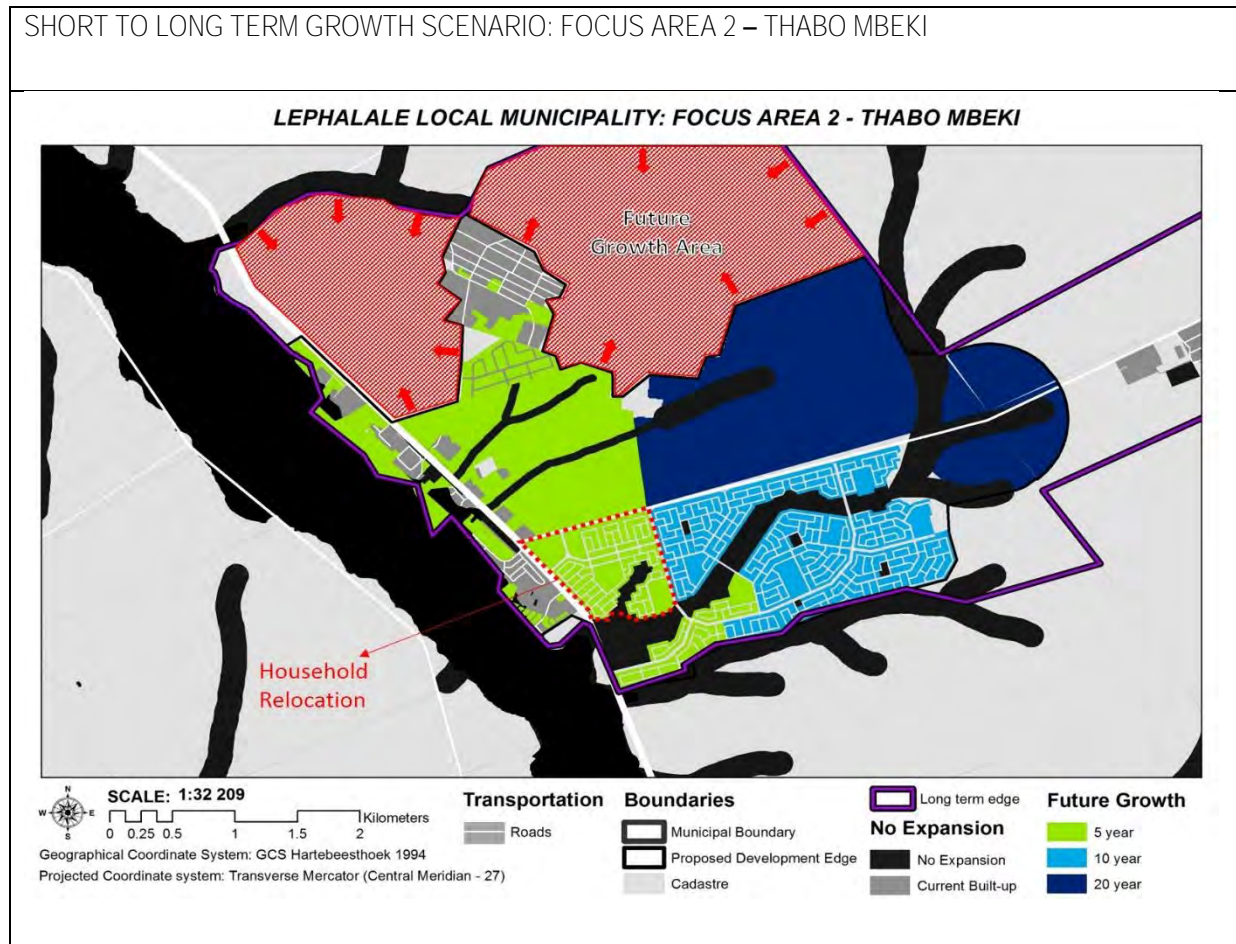


MAP 7-37: FOCUS AREA 2 - GA-SELEKA FUTURE SPATIAL GROWTH

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

Growth within focus area 2 is expected to occur at a more rapid pace and then gradually decrease over time. The same colours as depicted in Map 7-36, were used to illustrate the growth scenario for Ga-Seleka. The proposed FPSU are vital for the area and surrounding areas (Lephalale Local

Municipality, 2017). The FPSU should be established within the first five years in order to support the rural communities. The areas depicted in black and dark grey represents areas where no development can occur. The area illustrated in red depicts the future proposed area for development should all other land be developed. The long-term edge was also introduced to make provision for any additional future growth.

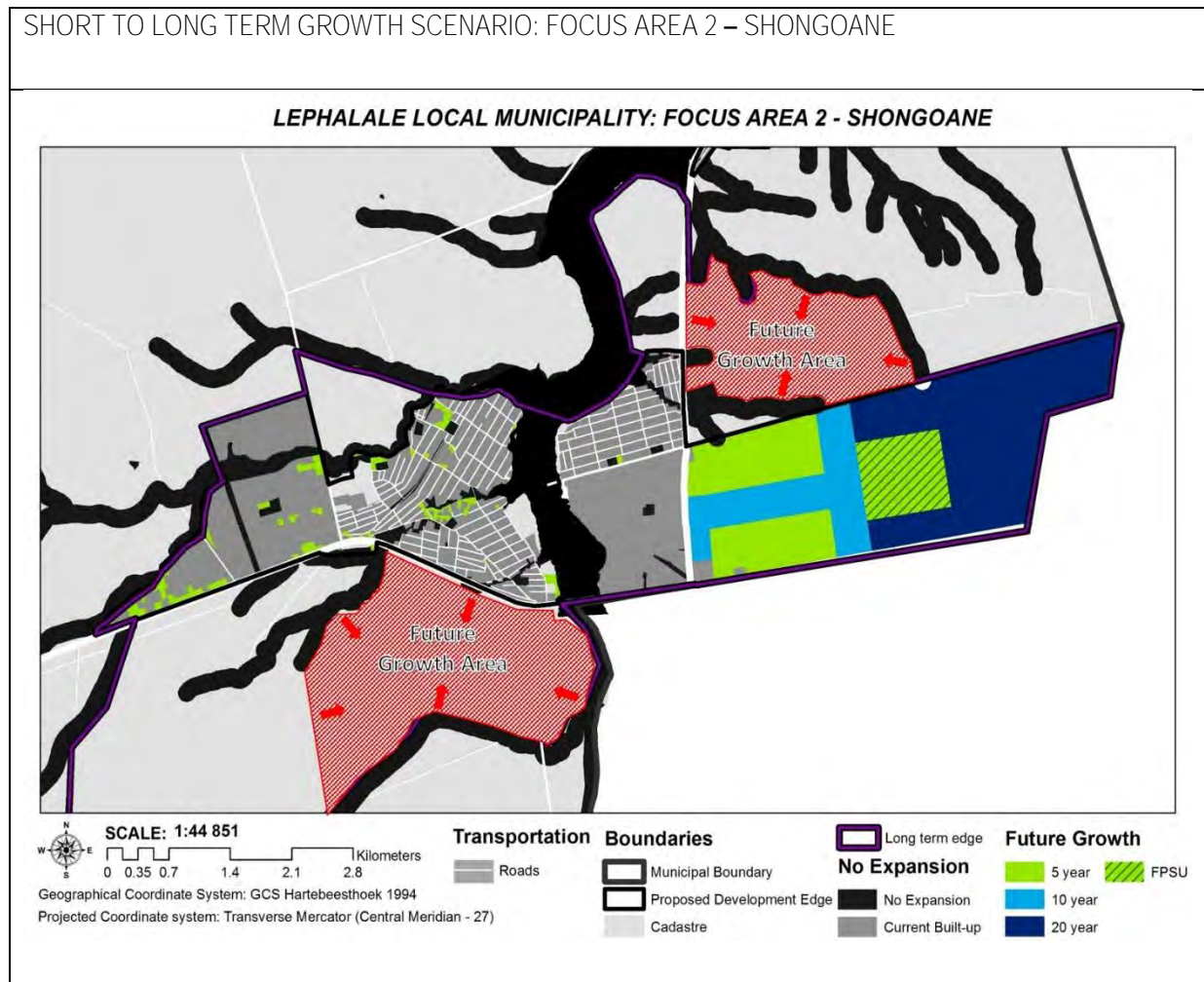


MAP 7-38: FOCUS AREA 2 - THABO MBEKI FUTURE SPATIAL GROWTH

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

A general plan already exists for Thabo Mbeki extension 2. The same principles as previously discussed apply for Thabo Mbeki. Should any future development occur, the correct procedures have to be followed. A large portion of Thabo Mbeki extension 1 have to be relocated to Thabo Mbeki extension 2 as the majority of households are located within the floodline. The boundary depicted in red on Map 7-38, illustrates the proposed area within Thabo Mbeki extension 2 for the relocation of households. Considering access, the main development for the next five years should occur in close proximity to the main access road.

Provision was also made for future development, should the area growth at a higher rate as expected. The areas for future growth are illustrated in red in Map 7-38. For additional growth, provision was made in terms of the long-term edge.



MAP 7-39: FOCUS AREA 2 - SHONGOANE FUTURE SPATIAL GROWTH

Source: Adapted from I@Consulting (2017); Lephalale Local Municipality (2017)

The Shongoane node has grown tremendously over the past years. Key to this node will be to establish the FPSU, in order to support the small-scale farmers within the node and surrounding areas (Lephalale Local Municipality, 2017). The FPSU should be established within the first five years. The areas illustrated in light green depict the 5-year future growth scenario for Shongoane, while the light to dark blue illustrates the ten to twenty-year growth scenario. The areas in red depict the areas identified for future growth as soon as space for future development becomes problematic. The areas depicted in black and dark grey illustrate areas where no development can occur. The long-term edge was also introduced in the Shongoane node to make provision for any future growth. Growth can occur at different rates due to different factors. The next Chapter concludes the study by addressing some of the research questions asked.

CHAPTER 8

Conclusion

8. Introduction

This research considered the theory and practice of urban and rural growth modelling, in an attempt to develop a methodology to predict spatial patterns. The linkage between theory and practice are well debated in terms of the various challenges it poses (Klabnik, 2012). Spatial planning, as applied as a science, is constantly seeking linkages between theory and practice in an attempt to enforce context-based planning. This chapter considers the theoretical investigation and empirical research captured in this dissertation in an attempt to a) answer the respective research questions, and to b) identify linkages between theory and practice, specifically relating to urban and rural growth modelling. Research questions as stated in Chapter 1 will be addressed accordingly.

8.1 Planning theories that inform the spatial form

The research identified planning theories which informed spatial form. The central place theory was considered as it applies to both urban and rural areas. This theory informs spatial planning by stating the differences of settlements in terms of importance and order. It is often within the lower order facilities (predominant rural areas) that lack of data is evident, and which pose various challenges for spatial modelling. Various urban models also provide insight on spatial patterns, that is still relevant in the current context. In South Africa, the apartheid model captures the spatial pattern where segregation of land use are visible. Each theory and model discussed in Chapter 2 is important to consider when modelling urban and rural growth. Many characteristics and aspects from the theories and models, should also be considered for growth modelling where applicable.

8.2 Driving forces of urban and rural growth

Populations are rapidly increasing as a result of urbanisation. Chapter 4 commenced with identifying the key drivers of urban and rural growth. The key drivers identified in Chapter 4 include socio-economic, physical, environmental and social change factors. The drivers which inform spatial form is depicted in Figure 8-1.

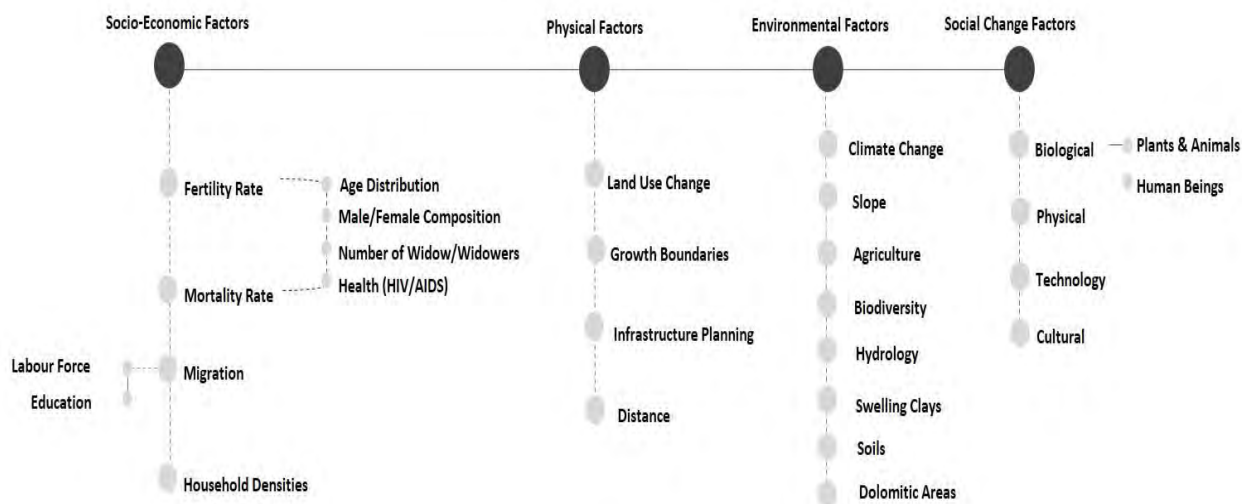


FIGURE 8-1: DRIVERS OF URBAN AND RURAL GROWTH

Source: Own Construction (2017)

These drivers are complexed and interlinked, implying that a change in one factor may cause changes in others. It remains vital however, to consider all the drivers of growth when making assumptions for future spatial planning and modelling.

8.3 The employment of urban and rural growth modelling in practice

The research identified and considered various methods and models deployed in practice with regard to predicting urban and rural growth patterns. Chapter 5 identified and listed the land use models broadly used globally and locally as well as what the capabilities of the models are. From the research, it was clear that some limitations exist in terms of advanced modelling tools and software for urban spatial change. According to Lee (1973), some of the first generation of large-scale urban models was too expensive, complicated, and technical. Some models and techniques used today were concluded to be complex, especially referring to research of the GCRO (2013:22) that stated a need to integrate and align the various modelling efforts, to enhance accessibility of spatial data and accessible geodatabases, to extend modelling beyond provincial boundaries and especially consider rural villages within South Africa. The current practical approach to urban and rural modelling were concluded to have various gaps, but also provides an opportunity to further develop spatial tools. This research as such, considered a methodology for urban and rural growth modelling.

8.4 Predicting urban and rural spatial patterns in South Africa

Spatial planning is constantly trying to balance conflicts between land uses. As populations increase along with urbanisation, pressure on land use is also increasing. In order to address the current spatial challenges, it is important to determine the number of users, the location of users and the need of these users linked to preferences and ability to pay for such. The recently enacted planning legislation in South Africa (SPLUMA) aims to address the imbalances of the past. As such, SPLUMA now requires spatial planners to identify additional infrastructure demand that might be required for the future. Scenario planning now needs to be substantiated with adequate data, in order to predict future spatial patterns. The customer based profile discussed in Chapter 6 and the methodology introduced in Chapter 7 illustrates some methods that might contribute in this regard. Another consideration is the wide disparities between rural and urban landscape in South Africa (refer to Chapter 4). As SPLUMA requires “wall to wall” planning, the inclusion of rural areas, and rural villages, in South Africa has become a crucial part of spatial planning. Limited information and data are available for these areas, and therefore limited spatial modelling has been conducted in the past. In the attempt to adhere to objectives of integration and equality, spatial modelling in South Africa should be expanded to include these rural areas. Innovative solutions are needed to assist spatial planners with the process of predicting future urban and rural growth in South Africa.

8.5 Impact of legislation on urban and rural growth in South Africa

As previously mentioned, the previous legislation in South Africa set the wheels in motion for segregation policies pertaining to land ownership and occupation. The apartheid regime played an incremental role in the current spatial form of South Africa. As discussed in Chapter 3, the enactment of SPLUMA is a game changer in terms of planning legislation in South Africa. SPLUMA set the wheels in motion to address the imbalances of the past and to ensure sustainable future spatial planning. Although the Subdivision of Agricultural Land Act, Act 70 of 1970 is still enacted, the Act is bound to be replaced by the new by the Preservation and Development of Agricultural Land Framework Act, which will be aligned with SPLUMA and entail much more detail.

8.6 Methodology for the prediction of urban and rural spatial form

The overall objective of this research study was to develop a methodology to model urban and rural growth. Figure 8-2 illustrates a schematic representation of the process followed in developing a methodology for urban and rural growth modelling.

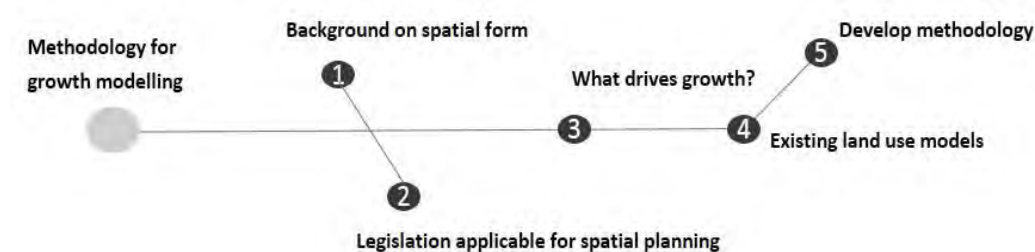


FIGURE 8-2: SCHEMATIC REPRESENTATION OF DEVELOPING A METHODOLOGY FOR GROWTH MODELLING

Source: Own Construction (2017)

Before the methodology could be developed, it was important to understand what led to the current urban and rural spatial form. Chapter 2 commenced with a comprehensive background on the various urban models and theories which led to the current urban and rural spatial form. Chapter 2 also consisted of many important characteristics, which are important factors to consider for urban and rural growth modelling.

Chapter 3 introduced the importance of legislation and how it informs spatial form. The legislation introduced in Chapter 3 was based on South African context. Regardless in which country, planning legislation will always inform spatial form, and is therefore of utmost importance to consider when developing a methodology for urban and rural growth modelling. Chapter 4 introduced the drivers of growth and the importance thereof when modelling urban and rural growth. The models and software introduced in Chapter 5, can be employed for urban and rural growth modelling however, some of the models and software are too complex and need to be simplified and translated to planning context. Chapter 6 introduced some case studies of urban and rural growth modelling broadly employed. A methodology based on South African context, were then developed in Chapter 7 to model urban and rural growth. The methodology aimed at linking both theory and practice with the aim of ensuring sustainable future urban and rural environments. After the methodology was developed, it had to be tested to determine whether or not it could be successfully applied to South African context, which led to the next question.

8.6.1 The methodology applied to South African context?

The research considered the town of Lephalale located in the Limpopo Province as case study. The methodology developed were applied to the study area. Some limitations however, were noted. These include the availability of reliable statistical data as well as information with regard to human behaviour. Regardless of these limitations, the methodology could still be successfully applied to the area of study.

8.7 Conclusion

Based on the theoretical and empirical investigation captured in this document, specific conclusions could be drawn relating to urban and rural growth modelling as explained accordingly.

8.7.1 Conclusion regarding the link between theory and practice

The research illustrated the disparities in terms of urban and rural areas, with specific reference to the data compilation process. As discussed in Chapter 4, the biggest difference between urban and rural areas is the fact that the majority of rural areas fall under the jurisdiction of traditional leadership. In terms of socio-economic conditions, some of the biggest differences are in terms of income and density levels. The income levels in rural areas are way less than the income levels in more urban areas. This causes the migration rate to be higher as well as the citizens residing in rural areas to migrate in search of better employment opportunities. The theoretical perspective of spatial modelling could not be employed similar for urban and rural areas. A unique methodology for spatial modelling in rural areas is needed. Theory could provide the point of departure, but context-based research should inform the practical application thereof.

8.7.2 Lessons learned from this research

In order to execute urban and rural growth modelling, key information is required. This includes socio-economic, physical, environmental and social change factors. Limitation however, exist in obtaining many of this information as it is not freely accessible. Predicting urban and rural growth modelling is a complex process. A change in one factor may cause changes in others and vice versa. The development of a methodology was therefore, crucial to assist with spatial growth modelling. Legislation, together with key policies and plans, plays an incremental role in the planning process as they inform the spatial planning process. It is therefore vital to align growth modelling with key spatial plans in order to ensure sustainable development.

8.7.3 Identification of further research

A limitation of this research refers to human behaviour. As discussed in Chapter 4, many factors can influence human behaviour. Detailed studies with regard to human behaviour will always be considered and should be included as part of spatial modelling. Other limitations include the issue of spatial scale. As discussed in Chapter 4, limitations exist in terms of data availability at detailed levels. Another limitation is in terms of statistical reliability. The last census from StatsSA occurred in 2011. Which means the gap in terms of statistical reliability could be questioned. Fortunately Quantec updates statistical information on a quarterly basis. Quantec utilises StatsSA statistics and update the statistics based on quarterly surveys compiled.

Further research should be pursued in terms of average water and electricity consumption as the data utilised in Chapter 7 could be questioned as it is not fixed planning standards. Based on the conclusions made in this chapter, the following chapter provides planning recommendations, superficially to guide urban and rural spatial patterns and modelling.

9. Introduction

Planning for the future is vital in order to ensure harmonious planning and sustainable communities. The aim of this research was to consider the theory and practice of urban and rural growth modelling, in an attempt to develop a methodology to predict spatial patterns in South Africa. This chapter provides planning recommendations based on theoretical and empirical investigation captured in this document, in an attempt to guide future spatial patterns and the modelling of urban and rural growth.

9.1 Recommendation 1: Theory should be translated to the local context

Theory should always provide the point of departure, but context-based research should inform the practical application thereof. Spatial planning should constantly seek linkages between theory and practice in an attempt to enforce local context-based planning.

9.2 Recommendation 2: The drivers of urban and rural growth should be identified and understood.

Every location is unique in its own specific way. A driver of growth in one location, may not be applicable in another location. It is therefore recommended to identify and understand what drives and informs growth in both urban and rural areas. This is a crucial aspect of urban and rural growth modelling.

9.3 Recommendation 3: Urban and rural growth modelling should be employed to strengthen spatial planning approaches.

Linking theory and practice is an incremental part of spatial planning and growth modelling. Alignment of key sector plans such as SDF's, IDP's and Land Use Schemes are vital to ensure a harmonious planning approach. Growth modelling should be employed to strengthen these sector plans, not only within spatial proposals, but infrastructure requirements as well.

9.4 Recommendation 4: South Africa should develop and employ a context-based methodology to predict urban and rural spatial patterns

Many modelling software and tools exist however, the majority of models and techniques used are still too complex. Thus there was a need for a simplified, yet effective methodology which is also SPLUMA compliant. Chapter 7 employed a methodology which can be broadly used in South African Municipalities with regard to SDF's. Some limitation however, with regard to future spatial planning still exists. These limitations are discussed below.

9.4.1 Urban and rural growth modelling limitations in South Africa

With the enactment of SPLUMA, Act 16 of 2013, there has never been a greater need for growth modelling initiatives in South Africa. As discussed in Chapter 7, some critique of techniques and models used are the duplication of models. Limitations also exist in terms of statistical availability. The last census compiled on a detailed level (per sub place), was compiled in 2011, the statistics cannot portray a true reflection of the current situation in South Africa. Other limitations are the lack of data availability which could hamper the whole spatial planning process. Limited research also exists in terms of modelling growth in rural villages in South Africa. The GCRO (2013:22), argues that there is a need to extend modelling beyond provincial boundaries as many growth modelling initiatives only focus on specific locations and do not consider the driving factors of surrounding areas. Although some limitations exist, there are solutions available to address the challenges spatial planners are faced with every day. The recommendations are discussed below.

9.4.2 Urban and rural growth modelling recommendations

It is proposed that the recommendations made in this section could improve the way in which spatial plans are developed in South Africa and that the proposed approach could assist planners and policy makers with decision-making processes. The methodology employed in Chapter 7, which is depicted in Table 9-1, can be utilised to determine future urban and rural growth patterns in South Africa.

TABLE 9-1: SOUTH AFRICAN GROWTH MODELLING METHODOLOGY

Methodology	Classification	Reference
Objective 1	Understanding the status quo	
Step 1	Delineation of the area of study	Chapter 2
Step 2	Growth progression	Chapter 3
Objective 2	Prepare customer based profile	
Step 1	Prepare land parcel base data	
Step 2	Capture informal settlements and backyard shacks	
Step 3	Combine formal and informal data	
Step 4	Prepare demographic data	Chapter 6

Methodology	Classification	Reference
Step 5	Perform first level segmentation	
Step 6	Quantify the number of customers per point	
Step 7	Add demographic and density indicators	
Step 8	Prepare municipal customer database	
Objective 3	Identify driving forces of Urban and rural growth	Chapter 4
Step 1	Socio-economic factors	
Step 2	Physical factors	
Step 3	Environmental factors	
Step 4	Social change factors	
Objective 4	Prepare identified datasets	Chapter 5
Step 1	Socio-economic factors	
Step 2	Physical factors	(AHP)
Step 3	Environmental factors	Chapter 6
Step 4	Social change factors	(WhatIF)
Step 5	Data preparation – Combination process	
Objective 5	Analyse possible conflicts between datasets and derive a suitability layer	
Objective 6	Identify land suitability	
Objective 7	Develop urban/rural growth scenarios (5, 10, 20 years)	

Source: Own Construction (2017)

As stated in Chapter 8, there are limitations of reliable statistical information at a detailed level. In order to address this limitation, it is recommended that a National census should be compiled at

least every five years. Other limitations include the lack of data availability. This is a challenge many planners face as data are not freely available and there are also cost involve with regard to many spatial information. Open source software could be a solution to this challenge as citizens and government entities can modify and share data which will enhance the whole planning process and which would also assist with modelling future urban and rural growth. In other instances, for example determining human behaviour, more detailed studies are required which focus on the behaviour and movement of citizens. There is also a need to extend urban and rural growth modelling well beyond the former municipal boundaries. This is in cases for example where a settlement are located on the boundary of a municipality with another settlement adjacent to the settlement, but located in a different municipality, which serves a certain function to the first settlement. The function might be in terms of retail, which could serve as a driver of growth, driving the two settlements towards each other. Figure 9-1 illustrates a schematic representation of the research limitations and recommendations in South Africa.

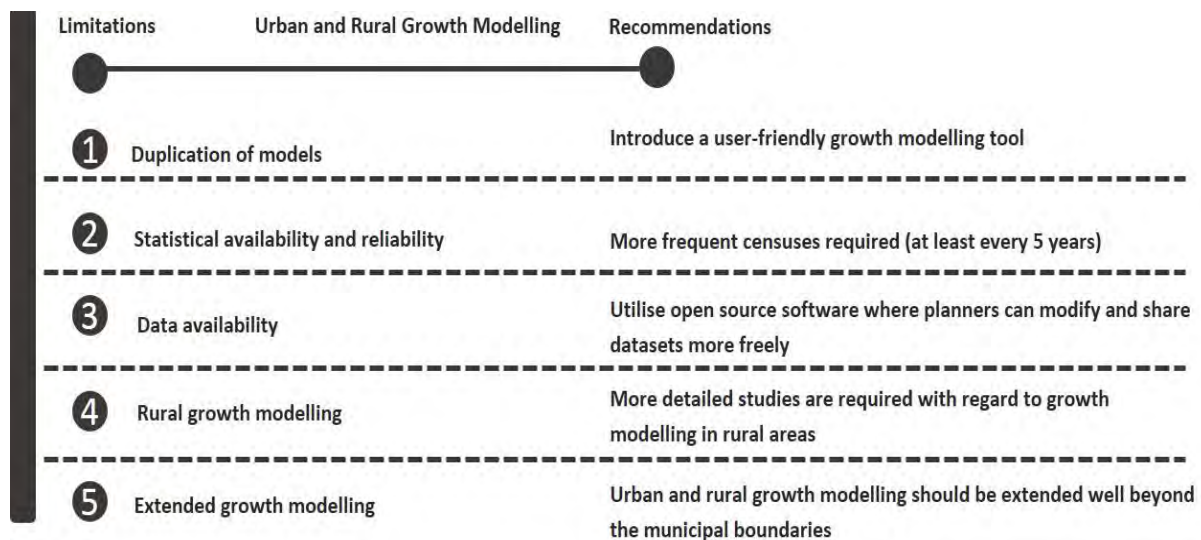


FIGURE 9-1: RESEARCH LIMITATIONS AND RECOMMENDATIONS

Source: Own Construction (2017)

Planning for the future starts today. With spatial modelling tools, predicting future growth can be more accurate which in the end will ensure sustainable development.

10. Annexure A

Type	Site size (m2)	Suggested Population threshold	Population threshold used
Tertiary Hospital L3	350 000	2 400 000	2 400 000
Regional Hospital L2	70 000	1 770 000	1 770 000
District Hospital L1	50 000	300000 - 900000	600 000
Community Health Centre	15 000	100000 - 140000	120 000
Primary Health Clinic	5 000	24000 - 70000	47 000
Fire Station	12 000	60000-100000	80 000
Police Station	5 000	60000-100000	80 000
Performing Arts Centre	5 000		9 999 999 999 999
Community Performing Arts Centre	5 000	50 000	50 000
Museum – large	5 000	500 000	500 000
Museum – medium/small Variable	5 000	variable	9 999 999 999 999
Regional Library - Reference	1 000	450 000	450 000
Regional Library	5 000	200 000	200 000
Local Library	3 000	20000-70000	50 000
Mobile Library	0	Variable	9 999 999 999 999
Major Public Event Venue	30 000	1000000+	1 000 000
Home Affairs - Large Office	200	400 000	400 000
Home Affairs - Medium Office	200	160 000	160 000
Home Affairs - Small Office	200	40 000	40 000
Thusong Centre	200	1 per municipality	9 999 999 999 999
Labour office	100	Variable	9 999 999 999 999
Magistrates Court	2 000	Variable	9 999 999 999 999
Municipal Office/Civic Centre	10 000	1 per municipality	9 999 999 999 999
Prison and place of safety	50 000	Variable	9 999 999 999 999
Solid waste disposal site and recycling depot		Variable	9 999 999 999 999
Community Hall – large	5 000	60 000	60 000
Community Hall – Medium/Small	2 000	10000-15000	12 500
Childrens Home	10 000	Variable	9 999 999 999 999
Home for the Aged	20 000	Variable	9 999 999 999 999
Hospice and Health Care	5 000	Variable	9 999 999 999 999
ICT Access Point		10000 +	10 000
Post Office/Agency with post boxes	300	10000-20000	15 000
SASSA Office (Social Service Office)	500	Variable	9 999 999 999 999
Social Grant Pay Point	500	40 000	40 000
Cemetery (large)		17.2 Ha/100000	9 999 999 999 999
Crematorium		200 000	200 000
Local market	20 000	5 000	5 000
Worship Centre	5 000	3000-6000	4 500
University/University of Technology	80 000	1 000 000	1 000 000
Post-matric Skill	10 000	400 000	400 000
ABET/Skill Training		Variable	9 999 999 999 999
Secondary School	48 000	12 500	12 500
Primary school	28 000	7 000	7 000
Grade R Class at Primary School		1 000	1 000
Small creche/earlly childhood devlopment centre	200	2400-3000	2 400
ECD Resource Hub and Care Centre	1 000	20 000	20 000
International Sports Complex	30 000	1 500 000	1 500 000
Indoor Sports Hall (medium/large)	30 000	250000-500000	375 000
Regional sports stadium	30 000	200000-300000	250 000
Sports Complex with 9 - 12 court sports hall, etc.	30 000	200 000	200 000
Grassed surface (2 football fields equivalent)	30 000	15 000	15 000
Sports Complex (Grouping of fields and/or sports complexes)	30 000	60 000	50 000
Grassed field (2 football fields equivalent) with 500-seat stand	30 000	30 000	30 000
Cricket Oval	30 000	60 000	60 000
Athletics/Cricket Stadium (grassed field and athletics track and stand – 3 000+ seats)	30 000	60 000	60 000
Combi-court surface (x2)	1 300	15 000	15 000
Combi-court surface (x4)	2 600	60 000	60 000
Multi-purpose Sports Hall (2 court)	1 300	100 000	100 000
Multi-purpose Sports Hall (4 court)	2 600	160 000	160 000
Swimming Pool Complex (25 m to 33 m pool)	2 500	80 000	80 000
Community pool	2 100	10 000	10 000
Swimming Pool (50 m pool)	2 500	500000-1000000	750 000
Strategic Park	40 000	500000-1000000	750 000
District Park	3 000	60000-100000	80 000
Community park with play equipment	35 000	60 000	60 000
Urban Park	15 000	Variable	9 999 999 999 999
Local/Neighbourhood Park	10 000	3000-15000	5 000

FIGURE 10-1: CSIR SOCIAL FACILITY GUIDELINES

Source: Adapted from CSIR (2012)

11. Annexure B

No	Land use Zone	Associated Land use Activities	CBA1	CBA2	ESA1	ESA2
1	Environmental Conservation	Conservation management, low-intensity eco-tourism activities and sustainable consumptive activities.	Y	Y	Y	Y
2	CBA Map Overlay Zone / Bioregional Planning Overlay Zone	These are areas that are designated as biodiversity priority areas, namely CBAs and ESAs;	Y	Y	Y	Y
3	Tourism and Accommodation	Low Impact Tourism / Recreational and Accommodation.	R	R	Y	Y
		High Impact Tourism / Recreational and Accommodation (e.g. golf estates).	N	N	N	R
4	Rural Residential	Low density rural housing or eco-estates.	R	R	R	R
		Traditional Areas (existing) and Rural Communal Settlement (New).	N	N	R	R
5	Agriculture	Extensive Game Farming	Y	Y	Y	Y
		Extensive Livestock Production	Y	Y	Y	Y
		Game Breeding / Intensive Game Farming	N	N	N	N
		Arable Land - Dryland and Irrigated Crop Cultivation	N	N	R	Y
		Plantation Forestry: Timber Production.	N	N	N	Y
		Agricultural Infrastructure - Intensive Animal Farming (e.g. feedlot, dairy, piggery, chicken battery).	N	N	N	N
6	Municipal Commonage	Local agri-economic development.	N	R	R	Y
7	Open-Space	Public or Private Open-Space, including recreational areas, parks etc.	Y	Y	Y	Y
8	Residential	Low, low-medium, medium-high, and high density urban residential development. (= NW = Urban & Business Development)	N	N	N	N
9	Urban Influence	An amalgamation of land use zones, including Institutional, Urban Influence, General Mixed Use, Low Impact Mixed Use, Suburban Mixed Use and General Business. (= NW = Urban & Business Development)	N	N	N	N
10	Low or High Impact and General Industry	Low Impact, General Industry and High Impact Industry (Urban & Business Development).	N	N	N	N
12	Transport Services	Transportation service land uses e.g. airports, railway stations, petro-ports and truck stops, bus and taxi ranks and other transport depots. = NW = Linear Engineering Structures)	R	R	R	R
13	Roads and Railways	Existing and planned linear infrastructure such as hardened roads and railways, including activities and buildings associated with road construction and maintenance, e.g. toll booths, construction camps and road depot sites. (Linear Engineering Structures)	R	R	R	R
14	Utilities	Linear engineering structures, such as pipelines, canals and power lines. (Linear Engineering Structures)	R	R	R	R
		Small-scale Infrastructural installations, including wastewater treatment works and energy sub-stations	N	R	R	R
		Large-scale Infrastructure installations, including bulk water transfer schemes, impoundments (Water Projects & Transfers), and energy-generation facilities (powers stations).	N	N	N	N
		Renewable Energy (PV farms and solar arrays)	N	N	N	N
		Renewable Energy (wind farms)	N	R	R	R
15	Quarrying and Mining	Prospecting and Underground Mining	N	R	R	R
		Quarrying and opencast mining (includes surface mining, dumping & dredging).	N	N	N	N
		Hydraulic Fracturing	N	N	R	R
Y	YES, permitted and actively encouraged activity					
N	NO, not permitted, actively discouraged activity					
R	RESTRICTED to compulsory, site-specific conditions & controls when unavoidable, not usually permitted					

FIGURE 11-1: LAND USE GUIDELINES FOR CBA'S AND ESA'S:

Source: (Lephalale Local Municipality, 2017)

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Departments **see** South Africa

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LAST UPDATED: 16 FEBRUARY 2018