

**SPATIAL TEMPORAL CHANGE OF HUMAN SETTLEMENTS DEVELOPMENT  
PATTERN IN AFROMONTANE REGION: CASESTUDY OF THABO  
MOFUTSANYANA MUNICIPAL DISTRICT**



**CANDIDATE: TITILOPE FUNMBI ONAOLAPO**

**PROMOTERS: DR. TOM WERE OKELLO**

**PROF. SAMUEL ADEWALE ADELABU**

**A THESIS SUBMITTED TO THE FACULTY OF AGRICULTURE AND NATURAL  
SCIENCE IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL GEOGRAPHY, UNIVERSITY OF  
THE FREE STATE, PHUTHADITJHABA, SOUTH AFRICA.**

**AUGUST 2020**

## **Abstract**

The issue of settlement development change in mountainous regions has received little or no significant attention in global urban sustainable development, and this is one of the reasons why the United Nations included Sustainable Mountain Development in the Programme of Sustainable Development Goals (SDGs). As cities expand daily because of urbanization, the surroundings of mountains are not left behind in the development and growth. However, this important feature is not fully integrated into the holistic development framework of the region. Moreover, there are many constraints to settlement growth due to liberty to own land and houses because of various policies and enhancement provided by the democratic government. However, the spatial development framework does the work of zoning in the urban areas; there is little or no control in the locations (rural areas), where development springs up every day, anywhere, and anyhow.

The increase in demand for land for urban development has extended to the land in and around the mountains that result in different changes in other land use and land cover, degradation of ecosystems, and social changes within urban populations. In the same way, mountainous cities in Eastern Free State have experienced urbanization like most of the major cities in sub-Saharan Africa. These are evident in the increase in built-up over the years and the demand for land for building. The motivation for the study is the quest to monitor the trend of change in settlement development in the Afromontane region and to channel that towards a sustainable settlement development pattern.

This study investigates spatial-temporal change in human settlement development pattern was conducted in Thabo Mofutsanyane municipality within the Drakensburg mountain of the Afromontane region. The objectives are to assess the land use pattern and development changes and to determine the spatio-temporal change of human settlement development patterns in the study areas using GIS, remote sensing and spatial metrics. Also, to identify and assess the factors responsible for the changes in human settlement development patterns as well as evaluating the current level of development based on the above objectives and modeling a sustainable human settlement development pattern study areas. To achieve the objectives, the study utilised

GIS images downloaded from Glovis and classified using CART classifier, a cross-validation of 70% training and 30% test; the accuracy assessment was calculated for each settlement using a cross-tabulation matrix. The result showed the effectiveness of the method in monitoring land use pattern and development changes as well as importance for future planning. The result was further analyzed to describe the spatial-temporal pattern of settlement development using spatial metrics. In order to identify and assess the factors responsible for the developmental changes, a study on the perception of the community leaders, government agencies in charge of settlement development, developers, and farmers' representative was conducted through the use of interview guides.

Furthermore, the study found that there was a steady expansion in the built-up areas in the years under study, the highest increment for the three settlements was from 1989 to 1999, Harrismith experienced 136.5% (4km<sup>2</sup> to 9.46km<sup>2</sup>), Ladybrand had 149.8% (2.73km<sup>2</sup> to 6.82km<sup>2</sup>) while Vrede experienced 218.8% (0.53km<sup>2</sup> to 1.69km<sup>2</sup>) increment. Though there is no sufficient population data to justify this, the available data showed a slight population increase from 2001 to 2011 and a record of migration into the settlements within these years range. The increment was also due to the democratic government's effort in the provision of housing for the masses through the Reconstruction and development program, which aimed at building over one million houses in a year.

Moreover, Harrismith was found to be the most fragmented settlement out of the three because of its undulating landform, which defined its development, Ladybrand and Vrede are more aggregated and physically connected than Harrismith. The GIS classified image correlated with the information collected from the interview confirming that the study area has experienced different land-use change, especially with urban expansion. The political factor, which is the change in government from minority to majority, various policies related to human settlement and access to housing, economic and demographic factors, and land fragmentation were the main factors that led to settlement development and in the municipality of Thabo Mofutsanyane.

The effect of political factors, which is the transformation from minority government to majority rule, has a direct impact on the landscape of the municipality. With the expansion of the built-up area between five years before and five years after 1994, and the current unsustainable emerging trends of housing units at the peripheral location around cities, the indirect effect will be haphazard environment and exorbitant infrastructural cost in the long run.

However, most of the changes do not pose any danger for now in most of the settlements except in few places where the allocation of land is done traditionally without any formal development control. The absence of integrated frameworks in the traditionally controlled areas is another challenge for settlement development; the study went ahead to propose a sustainable human development pattern.

## Declaration 1-Plagiarism

1. The research reported in this thesis, except where otherwise indicated, is my original research.
  
2. This thesis has not been submitted for any degree or examination at any other University.
  
3. This thesis does not contain other persons' data, pictures, graphs, or other information unless specifically acknowledged as being sourced from other persons.
  
4. This thesis does not contain other persons' writing unless explicitly acknowledged as being sourced from other researchers. Where other written sources have been explicitly quoted, then:
  - a. Their words have been re-written, but the general information attributed to them has been referenced.
  
  - b. Where exact words have been used, then their writing has been placed in italics and inside quotation marks and referenced.
  
5. This thesis does not contain text, graphics, or tables copied and pasted from the Internet unless expressly acknowledged and the source being detailed in the thesis and the References section.

Titilope Funmbi Onaolapo Signed: \_\_\_\_\_ Date: \_\_\_\_\_

As the candidate's promoter, I certify the above statement and have approved this thesis for submission.

1. Dr. Tom Were Okello Signed: \_\_\_\_\_ Date: \_\_\_\_\_

2. Prof. Samuel Adewale Adelabu Signed \_\_\_\_\_ Date: \_\_\_\_\_  
\_\_\_\_\_

## Declaration 2- Publication and Manuscripts

1. **Onaolapo T. F.**<sup>1</sup>, Okello T. W.<sup>2</sup>, Adelabu S. A.<sup>3</sup> and Adepoju K. “*Evaluating Settlement Development Change pre and post 1994 in the Drakensberg Mountain of Afromontane Region, South Africa using Remote Sensing*”. Submitted to South African Geographical Journal. (ID: RSAG-2020-0016).

2. **Titilope F. Onaolapo**, Tom W. Okello & Samuel A. Adelabu (2020) “*Assessing spatio-temporal settlement patterns in Eastern Free State, South Africa, pre and post-transition from apartheid to majority rule.*” Journal of Transactions of the Royal Society of South Africa, DOI: 10.1080/0035919X.2020.1755743

3. **Onaolapo T. F.**, Okello T. W. and Adelabu S. A. “*Post 1994-Perception of Settlement Development Pattern in Eastern Free State, South Africa*”. Submitted to Applied Geography. (JAPG\_2020\_755).

4. **Onaolapo T.**, Okello T. & Adelabu S. “*Issues of Sustainability in Settlement Development Pattern in Cities of South Africa. A Case study of Thabo Mofutsanyane District*”. In Preparation

Signed \_\_\_\_\_

## **Dedication**

This thesis is dedicated to The Almighty God, *the father of life in whom there is no variableness nor shadow of turning* who counted me worthy to be alive to see the end of this program. He is worthy of all my praise.

I also dedicate the work to my husband, Prince Adeniyi Onaolapo, who loves and sacrifices all for me.

## **Acknowledgements**

*Being confident of this very thing, that he which hath begun a good work will perform it until the day of Jesus Christ.* My heartfelt gratitude and appreciation to my father in heaven, who loves and cares for me beyond my understanding. He started with me and saw me through; all praises are unto His name. I also appreciate many people who made this PhD. research possible, special thanks to my promoter and co-promoter, Dr. Tom Okello and Prof. Sam Adelabu respectively, for their supervision, guidance, encouragement, support, timely advice, and cooperation, they have both impacted so much in me, and I know that I am not the same person who started the program in 2017. May God continue to bless and lift you. I am highly indebted to Dr Adagbasa Efosa; you were always there to help even when it was not convenient, I am very grateful to you, and I pray you to find helpers in your future endeavors. I also appreciate Salewa Odebiri and Dr Kayode Adepoju, my research group members, my colleagues, and all the staff members of the Department of Geography, University of The Free State, Phuthaditjhaba, for their support during my study. My gratitude goes to Dr. Michael Olagbegi, who put me through a statistical package of social science for the analysis of social-economic survey data of this research, your head shall continually be lifted.

My sincere thanks go to The Ethics Committee at the University of Free State; you made my fieldwork easier and interesting. I also appreciate the support of the Afromontane Research Unit (ARU) and the Risk and Vulnerability Science Center (RVSC-NRF) under the grant number 128386 for providing research grants to conduct this study, especially the director, Dr Ralph Vincent, for his keen interest in students' welfares, promoting grassroots research and willingness to help at all times. I appreciate the cooperation of directors and managers at the Department of Human settlement, Town planning, and Housing at the local municipalities under study.

Special thanks to my parents Elder and Mrs Samuel and Victoria Oladijo, whose wishes have been fulfilled in their lifetime, you are the world's best parents, you will both live long

to eat the fruits of your labour. I also appreciate my siblings Oluseun, Olufemi, and Mofoluwaso for their supports in prayers and words of encouragement. I could not have chosen a better family than this one. Each of you has contributed to the success of this program, and I pray that God will surprise each one of them pleasantly; their plans shall be fulfilled, and they will never be stranded in life. I love them beyond words of mouth.

I appreciate Prof. Sam & Dr. Dolapo Adelabu for accommodating me during my course of study, they are indeed faithful servants of God, I pray that He will continue to increase their blessing. Last but certainly not least, special gratitude to my husband (Adeniyi), my crown, and a faithful companion in the journey of life, he was the strong pillar behind this project, his sacrifice and love are priceless. He took care of the children alone while away for the research work without complaining, God bless and reward him abundantly, he will continue to be the head and never the tail. To my children Oluwakemisola Grace, Oluwadoyinsolami John, and Oluwabusolami David, they are the best for allowing mummy to research with less stress; I say thank you for my precious gifts of life. To my spiritual dad and mum, Pastor and Pastor Mrs. Adejinmi, I appreciate their love and prayers, the good Lord will continue to bless their ministries, they shall see the desire of their hearts over their children come to fulfillment. I will not forget the family members of the Chapel of Praise, The Redeemed Christian Church of God in Durban, they are indeed a family of God.

Finally, to everyone I did not remember to mention but have contributed to the success of this work in one way or the other, God will remember and reward them diligently. Thanks a bunch.

# Contents

Abstract .....	ii
Declaration 1-Plagiarism .....	v
Declaration 2- Publication and Manuscripts.....	vii
Dedication .....	viii
Acknowledgements .....	ix
List of Figures.....	xv
List of Tables .....	xvi
Glossary .....	xvii
CHAPTER 1 .....	1
INTRODUCTION AND BACKGROUND TO THE STUDY .....	1
1.1 Background to Settlement studies in a Mountainous Region .....	2
1.2 Problem Statement .....	6
1.3 Study Aim .....	7
1.4 Study Objectives .....	7
1.5 Research Questions.....	8
The study research questions are as follows:.....	8
1.6 Description of the Study Area .....	8
1.7 Outline of the Thesis .....	11
1.8 Ethical Considerations .....	13
CHAPTER 2 .....	14
LITERATURE REVIEW.....	14
2.1 Introduction .....	15
2.2 Literature Review .....	16
2.2.1 History of Human Settlement in South Africa.....	16
2.3 Drivers of Settlement Development Change.....	20
2.3.1 Settlement Development Change External Drivers .....	21
2.3.2. Settlement Development Change Internal Drivers .....	22
2.4 Introduction to Urbanization .....	24
2.4.1 Theories of Urbanization .....	24
2.4.2 Urbanization as a Development Indicator .....	26

2.4.3 Urbanization in other countries of the world.....	27
2.4.4. South Africa's Urbanization.....	29
2.4.5 Causes of rapid urbanization in Africa .....	31
2.4.6. Population .....	32
2.4.7. Urban Patterns of Free State Province .....	33
2.5 Introduction to Land Use/Cover Change (LUCC) .....	33
2.6. Urbanization, LUCC and Settlement Development .....	34
2.7 Conceptual/Theoretical Framework .....	36
2.7.1 Concept of Political Ecology.....	36
2.7.2. Concept of Sustainable Human Settlement Development.....	37
2.8. Human Settlement Policies that have impacted the landscape of Thabo Mofutsanyane Municipality and South Africa.....	38
2.9 Application of Spatial Analysis Method to Settlement studies .....	39
2.10 Remote Sensing and GIS in Monitoring Settlement Development.....	43
<b>CHAPTER 3 .....</b>	<b>45</b>
<b>LAND USE PATTERN AND DEVELOPMENT CHANGES IN THE AFROMONTANE REGION .....</b>	<b>45</b>
Abstract .....	46
3.1 Introduction.....	46
3.2 Description of the Study Area .....	49
3.3 Research Methodology .....	51
3.3.1 Image Pre-Processing.....	52
3.3.2 Image Processing and Classification .....	53
3.3.3 Validation.....	54
3.4 Results .....	55
3.4.1 General Analysis of the Settlement Development (Built-Up) between 1989 and 2018 .....	62
3.4.2 Specific Analysis of Spatial Patterns of Settlement Development Pre and Post 1994 .....	64
3.5 Discussions .....	66
3.6 Conclusion.....	67
<b>CHAPTER 4 .....</b>	<b>69</b>
<b>SPATIO-TEMPORAL PATTERN OF HUMAN SETTLEMENT DEVELOPMENT IN THE AFROMONTANE REGION USING GIS, REMOTE SENSING, AND SPATIAL METRICS.....</b>	<b>69</b>
Abstract .....	70
4.1 Introduction .....	71
4.2 Research Methodology .....	75
4.2.1 Study area.....	75
4.2.2 Data source and image preprocessing .....	76

4.2.3 Image classification .....	77
4.2.4 Landscape fragmentation and spatial metrics analysis .....	78
4.3 Results and Discussions .....	81
4.3.1 Land-use change before and after the transition from apartheid to majority rule .....	86
4.3.2 Landscape-level analysis .....	90
4.3.3 Class level analysis .....	95
4.4 Conclusions and Recommendations .....	103
CHAPTER 5 .....	105
FACTORS RESPONSIBLE FOR THE CHANGES IN HUMAN SETTLEMENT DEVELOPMENT PATTERNS IN THE AFROMONTANE REGION.....	105
Abstract .....	106
5.1 Introduction .....	107
5.2 Research Methodology .....	111
5.2.1 The Study Area .....	111
5.2.2 Data Collection .....	113
5.3 Results and Discussion.....	115
5.3.1 The trend of human settlement development .....	117
5.3.2 Factors responsible for Change in Settlement Development Pattern after 1994 .....	119
5.3.3 Assessment of the effects of the identified factors on the environment .....	123
5.3.4 Roles of the participants in the development of the settlement pattern?.....	123
5.3.5 Policies are available to control settlement development in their various communities? .....	123
5.4 Statistical Test of the Result .....	124
5.5 Summary of Findings .....	125
5.6 Policy Recommendation and Conclusion .....	126
CHAPTER 6 .....	128
MODELING A SUSTAINABLE SETTLEMENT DEVELOPMENT PATTERN .....	128
Abstract .....	129
6.1 Introduction .....	129
6.2 Conceptual and Theoretical Overview .....	131
6.3 Human Settlement Development during Minority Rule.....	134
6.4 Human Settlement Development in Post-Minority Rule.....	136
6.6 Modelling Sustainable Human Settlement Development Pattern for South Africa's Settlement ....	140
6.7 Community participation and Government Intervention on Sustainable Settlement Development	143
6.7 Conclusion and Policy Recommendation .....	145
CHAPTER 7 .....	147
SUMMARY OF FINDINGS AND CONCLUSION.....	147

7.1 Introduction .....	148
7.2 Evaluation of Political Ecology Concept.....	148
7.3 Summary of Findings and Conclusions .....	149
7.4 Recommendations .....	152
7.5 Contribution to the Body of Knowledge.....	153
7.6 Study Limitation.....	154
7.7 Areas for Further Studies .....	155
References.....	156
APPENDICES .....	175
APPENDIX I: INTERVIEW GUIDE 1 .....	175
APPENDIX II: INTERVIEW GUIDE 2 .....	179
APPENDIX III: ETHICS CLEARANCE.....	184
APPENDIX IV: CONSENT TO PARTICIPATE IN THIS STUDY .....	185
APPENDIX V: MAP OF THABO MOFUTSANYANE MUNICIPALITY IN THE CONTEXT OF THE FREE STATE PROVINCE, SOUTH AFRICA.....	186
APPENDIX VI: SHAPE MAP OF HARRISMITH.....	187
APPENDIX VII: SHAPE MAP OF LADYBRAND .....	188
APPENDIX VIII: SHAPE MAP OF VREDE .....	189
APPENDIX IX: LANDSCAPE METRIC TABLES.....	190
APPENDIX X: CLASS METRIC TABLES .....	193

## List of Figures

Figure 1.1: Thabo Mofutsanyane Municipality Map in the context of Free State Province and South Africa. .....	11
Figure 2.1: Literature review flowchart for the study.....	16
Figure 3.1: Map of Thabo Mofutsanyana municipality in the context of Free State province and South Africa. .....	51
Figure 3.2: Land use land cover classification, Harrismith. ....	56
Figure 3.3: Land use land cover classification, Ladybrand.....	58
Figure 3.4: Land use land cover classification, Vrede .....	60
(a) Figure 3.5a: Spatial pattern of settlement development, Harrismith. ....	66
(b) Figure 3.5b: Spatial pattern of settlement development, Ladybrand.....	66
(c) Figure 3.5c: Spatial pattern of settlement development, Vrede. ....	66
Figure 3.6. Percentage increase in built-up in years under study.....	66
Figure 4.1: Map of South Africa showing Free State Province and Thabo Mofutsanyane with the settlements under study. ....	76
Figure 4.2: Methodology flowchart.....	77
Figure 4.3: Land use land cover classification for Harrismith. ....	82
Figure 4.4: Land use land cover classification for Vrede .....	83
Figure 4.5: Land use land cover classification for Ladybrand.....	84
Figure 4.6: Harrismith land use land cover distribution.....	86
Figure 4.7: Vrede land use land cover distribution .....	87
Figure 4.8: Ladybrand land use land cover distribution .....	87
Figure 4.9 (a-i). Spatial metrics at the landscape level.....	95
Figure 4.10(a-h). Spatial metrics at the class level.....	101
Figure 5.1: Map of the study area: Thabo Mofutsanyane District municipality, the Free State province, South Africa.....	113
Figure 5.2a: Respondents' demographic data in Harrismith.....	117
Figure 5.2b: Respondents' demographic data in Vrede .....	117
Figure 5.2c: Respondents' demographic data in Ladybrand .....	117
Figure 5.3. Participants' responses in Harrismith .....	121
Figure 5.4. Participants' responses in Vrede .....	122
Figure 5.5: Participants' responses in Ladybrand.....	122
Figure 6.1: Proposed Model of a Sustainable Human Settlement Development Pattern. <b>Error! Bookmark not defined.</b>	
Adapted from (Musvoto, 2011) model.....	<b>Error! Bookmark not defined.</b>
Figure 6.2: Arnstein Ladder of Citizen Participation (Arnstein, 2015).....	144
Figure 7.1: A Diagram of the factors and driving forces responsible for settlement development patterns in the Thabo Mofutsanyane municipality. ....	151

## List of Tables

Table 2.1: A review of Settlement Studies using Remote sensing Approach.....	43
Table 3.1: Sources of study data .....	51
Table 3.2: Land use and land cover classes.....	54
Table 3.3: Classification of land use land cover of Harrismith .....	57
Table 3.4: Classification of land use land cover of Ladybrand .....	59
Table 3.5: Classification of land use land cover of Vrede .....	61
Table 3.6: Classified settlement development between 1989 and 2018 (area in Km <sup>2</sup> ) .....	61
Table 4.1: Description of land use and land cover classes.....	78
Table 4.2.a: Accuracy Assessment for Harrismith .....	85
Table 4.2.b: Accuracy Assessment for Vrede.....	85
Table 4.2.c: Accuracy Assessment for Ladybrand .....	85
Table 5.1: Settlement Development (Built-up) Pattern between 1989 and 2018 (Area in Km <sup>2</sup> ).....	118
Table 5.2: Population distribution across the study areas .....	118
Table 5.3: Factors responsible for the change in settlement development pattern in the locality. ....	124
Table 5.4: Causative agents responsible for the factors changing Built-up to other land use.....	125

## Glossary

**Aerial photo:** Aerial photo or imagery are digital pictures or photography taken from the air.

**Apartheid:** is a government of segregation where the minority rule over the majority.

**ArcGIS:** is a program that combines software, hardware, and data for capturing, evaluating, monitoring, and presenting different forms of geographical data. It allows viewing, querying, comprehending, interpreting, and visualizing data in several forms that show connections, trends, and patterns in the form of graphs, charts, reports, and maps.

**Hectare (ha):** is a metric unit of area which equals 10,000m<sup>2</sup> or 10 dunams.

**Land use/cover change (LUCC) driving forces:** are the forces that cause observed landscape changes, i.e., they are significant processes that change the face of the landscape.

**Remote sensing (RS):** it means data acquisition of an area or object using a sensor that is far away from the object. RS includes radar imagery, satellite imagery, and aerial photography.

**Reconstruction Development Programme (RDP):** Housing projects of the democratic government in South Africa, African National Congress. (ANC)

**Sustainable Development Goal (SDG):** an agenda of the United Nations targeted at 2030.

**Spatial Development Framework (SDF):** official document guiding physical development.

**Spatial resolution:** means pixel density in an image per unit length. The resolution also means the relative fuzziness or crispness (clarity) of an image.

**Spatial Planning and Land Use Management Act (SPLUMA):** is a national law passed by Parliament in 2013 and published on 23<sup>rd</sup> March, 2015, it is a new framework to govern planning permissions and approvals.

**Sustainable land use:** means the use of land and its resources in a way that will be useful for the present generation without jeopardizing the use of the future generation.

**Urban growth:** Urban growth means the change in percentage of the total number of urban dwellers every year.

**Urbanization:** Urbanization is a process in which the percentage of the number of people living in urban settlement increases in a year (i.e., towns or cities).

# CHAPTER 1

## INTRODUCTION AND BACKGROUND TO THE STUDY



## 1.1 Background to Settlement studies in Mountainous Regions

Mountains account for 25% of the world's land surface and also support 12% of the global population residing in mountainous regions in terms of water supply, food, energy source, economy, tourism, shelter e.t.c. The United Nations included sustainable mountain development in chapter 13 of Agenda 21 of the Sustainable Development Programme (SDGs) because of the role mountains play in the sustenance of the environment not only for mountain people but also for the entire people living in the region. As uncontrolled urbanization, settlement development, and land use land cover change cause environmental degradation, so also can they degrade the mountain's ecosystem, which can eventually lead to huge issues for the livelihood of mountain residents (De Los Andes, 2012).

Settlement development change, which affects all landforms, whether mountain or plain, is an important phenomenon in land-use land-cover (LULC) studies. Moreover, the effect of urbanization, which is a key factor of settlement development, will continue to dominate environmental changes as cities continue to proliferate in the next few decades (Rana, 2011). Several developing countries are experiencing an increase in population growth and urbanization (Chen *et al.*, 2014), and this will continue to have significant effects on the environment (Raddad, 2016). As cities grow in developing countries, the urban population is growing uncontrollably and unpredictably. This is due to natural increase and migration, which may make future management and implementation of policy for population growth difficult (Cohen, 2015). The risks of uncontrollable population growth include health problems, social vices, overutilization of natural resources and exorbitant infrastructural cost.

Most developing nations of the world have experienced a massive movement of people to the urban settlement in search of better lives, access to a better health care system, education, and job opportunities leading to settlement expansion in cities. In 1972, the percentage of people living in urban settlements was 27%; it increased to 40% in 2000. It is estimated that by 2030, the percentage of people living in urban settlements will be 60% which is 5 billion urban dwellers in the world. Furthermore, it has been observed that

the developing world is experiencing an urban growth rate of about 2.4% annually, which is twice the global growth rate (UNGA, 2017). Moreover, the United Nations predicted that by 2030, 1.405 billion Africans would be living in urban settlements as rural-urban migration continue to increase in sub-Saharan Africa with an urbanization rate of 3.5% per annum. South Africa, like the rest of the developing countries, has a similar trend (Musvoto, 2011). For instance, the percentage of people living in urban settlements rose from 53% to 58% in 2011 between 1999 and 2011 (UNGA, 2017). This growth affects both humans and their natural environments, and calls for monitoring and the management of its patterns.

The settlement patterns and trends have been mainly influenced by urbanization in both developing and developed countries of the world (Kaplan & Holloway, 2014).

The history of most of the modern-day settlements in former colonies has been traced to the colonialism of European settlers, who came as businessmen looking for mineral resources for the manufacturing industries in their homeland or temporarily lived around seaports to ease their movement between their homeland and the place of a colony (Musvoto, 2011). In the same way in South Africa, colonial and apartheid policies shaped the spatial pattern of settlement. The Group Areas Act and Bantu Self Government Act of 1950 informed the pattern of settlements and economic opportunities along the racial and social statuses of the population group. The post-apartheid government after 1994 tried to reverse this by way of formulating the policy “Breaking New Ground 2004,” which was to address inequalities of the past (Masondo, 2009).

At the Human Settlement Habitat II Conference of the United Nations in Istanbul, Turkey, in 1996, an agenda for sustainable development of human settlement was developed. South Africa responded to this by the creation of sustainable settlements which focused on three of the program areas drawn from Chapter 7 of Agenda 21 of the documents. These are: *“the provision of adequate shelter for all; the improvement of human settlement management; and the promotion of sustainable land-use management”* (Cohen, 2015; Okpala, 1996). Nevertheless, unbalanced development and unsustainable

settlement patterns have been observed due to the lack of harmony in sustainability's goals (Musvoto, 2011; Network, 2006).

Furthermore, the transformation from minority government to the majority in 1994 brought a new challenge of development control before stakeholders in environmental planning, thereby playing a significant part in the shaping and development of South African societies (Lindley, 2014). Though the impact varies from one settlement, municipality, and province to the other in terms of extent (AbuHafeetha, 2014; Lagerquist, 2003). They are felt on the economy, social activities, the environment and family, education and health facilities, labor markets, and security (Lindley, 2014). Therefore understanding human settlement growth and development is significant to geographers and other environmental experts because of its impact on nature which is necessary for human health and recreation. The success of environmental planning depends mainly on the effective development and management of housing and other land use activities (Cho *et al.*, 2005).

Moreover, current rates of rapid change in urban land use and urbanization have now become pressing political issues, and hence continuous monitoring is needed. In the last three decades, there has been a noticeable demand for spatial data to accommodate the level of current urban growth as well as their impacts on the residents and the environments.

The use of Geographical Information Sciences (GIS) and Remote Sensing (RS) in monitoring the spatial extent and patterns of urban growth has been evolving (Pathiranage *et al.*, 2018; Song *et al.*, 2016). This is important because of the information these techniques provide on the past and current socio-economic aspects of human existence. Moreover, they give data that is spatially reliable and cover vast expanses with great spatial detail and high temporal frequency, thereby providing information for decision-makers to achieve sustainable settlement development. Monitoring land cover or land use is currently a typical means of mapping out changes, describing a landscape, and measuring its physical changes. This has led to a significant improvement in

geospatial technologies, namely multispectral satellite data and GIS software. Since the early 1970s, remote sensing data have become operationally accessible opening the way to studies on land cover or land use. These data offer researchers spatial, temporal, and high spectral resolution data that have led to the development of applications to monitor the environment, such as change detection (Jensen, 1996; Macleod & Congalton, 1998). To detect land cover change, satellite imageries taken at separate times could be compared to assess the spectral reflectance or temporal changes that have taken place among the images (Yuan & Elvidge, 1998). An analysis of the change detected is done to monitor land-use and development change in the region, to know the rate, extent, and nature of the change in land cover and degradation over space and time. The outcomes reflect the patterns of land cover change providing an accurate, cost-effective record in a spatio-temporal outline that could be employed in policy and management decisions concerning different issues including land degradation, water management, urbanization, deforestation and depletion of natural resources.

The significance of the present geospatial information pattern and trends on land use and land cover cannot be over-emphasized, notably, in the understanding of the evolution of several land-use systems and the analysis of drastic changes in such land use globally, nationally, and locally as well as in exploring future change. Remotely sensed images give resourceful ways of getting data on spatial dispersal and temporal trends of urban areas essential for understanding, analyzing, and projecting land changes (Elvidge *et al.*, 2004). Recently, there has been much interest in the application of information on land use and land cover changes and how the changes affect environmental deprivation. More often, these changes place substantial stress on the available farmland, current land cover, and natural resources. Also, information on land use and land cover change (LULCC) is vital for environmental analysis that helps to inform decision-making. When this information is presented in the form of a digital map, its worth and utility for performing geospatial analysis and monitoring and incorporation with other geographic information is further enhanced. Nevertheless, until now, only a few studies have documented the temporal and spatial dynamics of land use employing GIS methods and remote sensing

imageries for spatial planning and monitoring at a local scale, especially in sub-Saharan Africa.

This study aims at assessing and analyzing the spatio-temporal change in human settlement development pattern in the mountainous region of Afromontane through the use of GIS, remote sensing and spatial metrics, taking Thabo Mofutsanyane municipality as a case study. The study is one of the very few studies about spatial analysis in mountainous areas in the world and, most importantly, sub-Saharan Africa and specifically South Africa. It also aims at complementing spatial studies in human settlement development patterns, especially in mountainous regions.

## **1.2 Problem Statement**

In any region where mountains are found, they always stand out as important features that are both economic and historical in nature. In ancient times, mountains served as shelters and safety abodes in cases of war, and with this uniqueness, mountainous regions deserve planning, conservation, and management of which they are getting little or none. The Afromontane region is a region with high hills, agricultural land with flora and fauna, as well as residential settlements that are not well controlled, leading to the disruption of the ecosystem and biodiversity. Over the last two decades, the region has experienced rapid population growth, which has led to irregular patterns of social, economic, and landscape change (Krannich *et al.*, 2011; McGranahan, 1999; Urban *et al.*, 2016). This mismanagement of the mountainous environment has led to land misuse, land degradation, illegal conversion, and depletion of natural resources as well as other environmental problems. Most of the problems arise from a lack of knowledge about spatial planning in the mountainous region of sub-Saharan Africa. Unplanned and uncontrolled development has impacted the environmental components such as water, forest, and agricultural land leading to unsustainable development, pollution, deforestation, loss of farmland, and pasture. For instance, Thabo Mofutsanyane Municipality in the Afromontane region loses almost 50 acres of farmland every year due to the indiscriminate conversion of land use (Fischer *et al.*, 2010) and encroachment into

the available open spaces and agricultural land uses. Few studies were available on spatial analysis of settlement development around the mountainous region, hence the need for more research on this subject. In order to solve the existing problems and prevent future recurrence, there is a need to monitor developmental growth and change through spatial techniques of remote sensing and GIS. There is also a need for the existing policies to accommodate holistic, proactive measures to settlement planning, which will prevent indiscriminate development, as well as enforcing the implementation of the development plan, thereby achieving the process of sustainable human settlement.

### **1.3 Aim of the Study**

The aim of this research was to analyze and assess the spatio-temporal change in human settlement development patterns in the mountainous area of the Afromontane region, with Thabo Mofutsanyane district municipality, as a case study. Furthermore, it was intended to suggest a model for sustainable settlement development patterns.

### **1.4 Objectives of the Study**

The specific objectives of this research are:

1. To assess the land use patterns and development changes in the study area pre and post 1994.
2. To determine the spatio-temporal changes in human settlement development patterns in the study area using GIS, remote sensing, and spatial metrics.
3. To identify and assess the factors responsible for the changes in human settlement development patterns in the study area.
4. To propose and justify a model for a sustainable human settlement development pattern for the study area.

## **1.5 Research Questions**

**The research questions for this study are as follows:**

1. What are the past and current patterns of land use land cover as well as settlement development in the study area pre and post 1994?
2. To what extent has the change in settlement patterns impacted environmental land use in the study area?
3. What are the driving forces behind the factors responsible for the change in land use land cover and settlement development in the study area?
4. What are the best practicable development control and management approaches to sustain and manage development in the study area as well as other settlements around the mountain?

## **1.6 Description of the Study Area**

The Afromontane region ranges from the Red Sea and the East African Rift Valley; it is more prevalent in the Albertine Rift Mountains of Uganda, Ethiopian Highlands, Tanzania, the Democratic Republic of the Congo, Rwanda, Burundi and the Eastern Arc highlands of Kenya and Tanzania. The region occurs from altitude as low as 310 meters in the Knysna-Amatole Mountain forest of South Africa to 2,000 meters in parts of East Africa. The Drakensberg mountains of South Africa are also prominent parts of the Afromontane region.

Thabo Mofutsanyane Municipal District is one of the five (5) districts in the Free State province of South Africa. It is located in the northeastern part of the Free State but is commonly referred to as part of the Eastern Free State. The district includes the Drakensberg mountainous area of the Afromontane region. These mountains form the border between Eastern Free State and KwaZulu-Natal, Eastern Cape, and Lesotho. The district population of 736 238 people in 2001, with 217,884 households with an average household size of 3.3 persons. The district's population increased to 769,761 people in 2011, with a population density of 28.9 people per Km<sup>2</sup> (Stats, 2018). The land surface covers an area of 33 269 Km<sup>2</sup>, which houses 25% of the Free State population.

The primary economic activities of the district are agriculture and tourism. The district has one of the most fertile soils in the Free State province, which encourages agriculture. It also holds considerable potential for tourism development because of its scenic beauty and cultural heritage. The famous Golden Gate Park is located at the foot of the Maluti Drakensberg Mountain range. The park attracts both local and foreign tourists. Also, the roots, leaves, and bark of the plants in the park serve as a source of raw material for herbal medicine to the residents; these have been of economic value to the inhabitants (AbuHafeetha, 2014; Proos, 2015). Despite these resources, the district makes the second smallest contribution to the GDP of the Free State with trade, retail, wholesale, financial, and community services being the core contributing sectors. Furthermore, its annual importing and exporting value is the second smallest among the five districts.

Due to its regional characteristics, the Eastern Free State performs two main economic activities, which are agricultural production and tourism. The Free State is the breadbasket of South Africa because of its substantial contribution to the country in terms of agricultural production. Its production of livestock, vegetables, cream, milk, mohair, wool, maize, sunflower seeds, grain sorghum, and wheat cannot be underestimated. Significant percentages of beef and mutton production are attributed to Free State farmers. Though the local municipality is usually referred to as rural local municipality because of its primary function (Myeni & Moeletsi, 2020). South Africa's Statistics approved the concept of 'rural' to be lightly populated areas (not necessarily agricultural), farmsteads, forest areas, desert, temporary camps far-away from townships, lesser towns, villages, evacuated urban areas and settlement groups that rely on transfers till 1995 (Steytler, 2005). Though they are the smallest parts in the group of settlement from where demographic data can be received, the Enumeration Area (EA) is combined to other higher administrative centres such as local municipalities, municipal districts, electoral wards or province to be processed into useful data for development plans and national growth (Steytler, 2005). The urban areas in the district are Harrismith, Puthaditjhaba, Bethlehem, Ficksburg, Senekal, Reitz, and Warden. Maluti-A-Phofung, which contains 55.5% of the district's total population and the most populated.

The Municipality is situated in a rural area in the eastern Free State, and it includes the former homeland of Qwa-Qwa. It was also declared a Presidential Node in the early 2000s. The population of Thabo Mofutsanyane is the third largest among the District Municipalities in the Free State, contributing 26.45% to the total population of the Free-State Province (Stats, 2012). The District is subdivided into six sub-districts, namely Maluti-A-Phofung, Nketoana, Phumelela, Setsoto, Dihlabeng, and Mantsopa as shown in figure 1.1. Maluti-A-Phofung is the smallest sub-district but has the largest population. Thabo Mofutsanyane has the highest less-urban population (59.8%) in the province. The choice of three settlements selected for this study was based on their geographical locations and settlement forms (urban, semi-urban and rural). The settlements were Harrismith, Vrede, and Ladybrand, located in the sub-districts of Maluti-A-Phofung, Phumelela, and Mantsopa respectively.

Harrismith's land area and population are the second largest in the local district Maluti-A-Phofung local municipality which is in the northern part of the Thabo Mofutsanyane district municipality map as shown in figure 1.1. Harrismith is strategically placed between two prominent cities of South Africa, which are Johannesburg and Durban. It represents the urban settlement out of the three selected settlements under study. It has a population of 27,869. Maluti-A-Phofung has the largest population figure and lowest land area amongst the other local municipalities in the areas understudy; it represents the urban settlement of this research. Vrede has a second land area with a very low population amongst other settlements in Phumelela local municipality. It has a small population below 2000 people, according to Statistics SA (2018) publication, with a large area for farming. It represents the least in the hierarchy of the three settlements under study (Stats, 2018). Phumelela has the largest land area and lowest population in the Thabo Mofutsanyane; it represents the less urban settlement in the municipality. Ladybrand has an average population amongst the settlements and a large land area in Mantsopa local municipality, it is close to the Lesotho border at Maseru. This is very significant to the town's development pattern, and it represents an average town between the three settlements under study. It has a population of 4218 in 2011 (Stats, 2011). Mantsopa has an average population and land area, it is located in the southern part on the map of Thabo Mofutsanyane



Chapter 1 is the introductory part. It gives the background to the topic on spatio-temporal change in human settlement development patterns in mountainous areas. It also states the research problems, aim, and objectives, research questions, the significance of the study and the description of the study area.

Chapter 2 presents the general literature review about the concept of human settlement spatial patterns, and driving forces behind settlement development. Also, the chapter highlights the relationship between settlement development and change in political power. It also discusses the main policies that played major role in forming the pattern and landscape with emphasis on the change in government that happened in 1994. Finally, it discusses the influence that the change in government had on the spatial human settlement development pattern in the region.

Chapter 3 presents the understanding of land use development with an emphasis on change in settlement patterns in the study area, pre and post 1994, using remote sensing and GIS.

Chapter 4 discusses the assessment and description of spatio-temporal settlement patterns using spatial metrics (fragmentation/landscape) in the study area, pre and post-transition from apartheid in 1994.

Chapter 5 discusses the influence of politics as well as other factors on the change in settlement pattern and the effects of such factors on the environment of the study area

Chapter 6 discusses the issues of balancing development and sustainability in settlement development change in the study area by evaluating the current level of development and modeling a sustainable human settlement development pattern for the study area

Chapter 7 presents general conclusions, the contribution of the research to the body of knowledge, limitations of the study, and areas with potential for further research. Lastly, the appendices comprise the approval letter from the Ethical Committee, spatial metrics tables, and the two sets of interview guides used for data collection.

## **1.8 Ethical Considerations**

In any research involving a study of humans or animals, it is required that the University of Free State gives ethical approval before the research is conducted. A complete ethics form with a consent letter was submitted for authorization to the committee, which was approved for this research. The interviewees were given a copy of the consent letter to sign after agreeing to participate in the research. The consent letter contained the breakdown of what the research was about and the respondent's privacy section. It was also stated that the participants could withdraw from the study anytime they felt betrayed or uncomfortable with the proceedings. The collected data were safely stored by the researcher in a locker until the end of the research and the successful defense of the thesis as the documents were confidential.

## CHAPTER 2

### LITERATURE REVIEW



## **2.1 Introduction**

This study was based on changes that occurred in the settlement development patterns in the selected mountainous area of the Afromontane region. It begins with the history of human settlement development in South Africa. It discusses essential aspects of settlement development patterns such as theories, drivers, and causes of urbanization, monitoring land use land cover change, which is the key factor of urbanization through the use of GIS, remote sensing, spatial analysis and quantitative methods. Also, it discusses the impact of settlement development change on environmental sustainability as well as the concept of political ecology and settlement sustainability; these helped in framing the objectives, research questions as well as collection and analysis of data. Studies revealed that uncontrolled development could lead to environmental consequences, infrastructural cost, and sustainability problems (Dave, 2010; Dhakal & Chevalier, 2017; Monstadt, 2009). A diagram for the arrangement for the literature review is shown in figure 2.1.

## 2.2 Literature Review

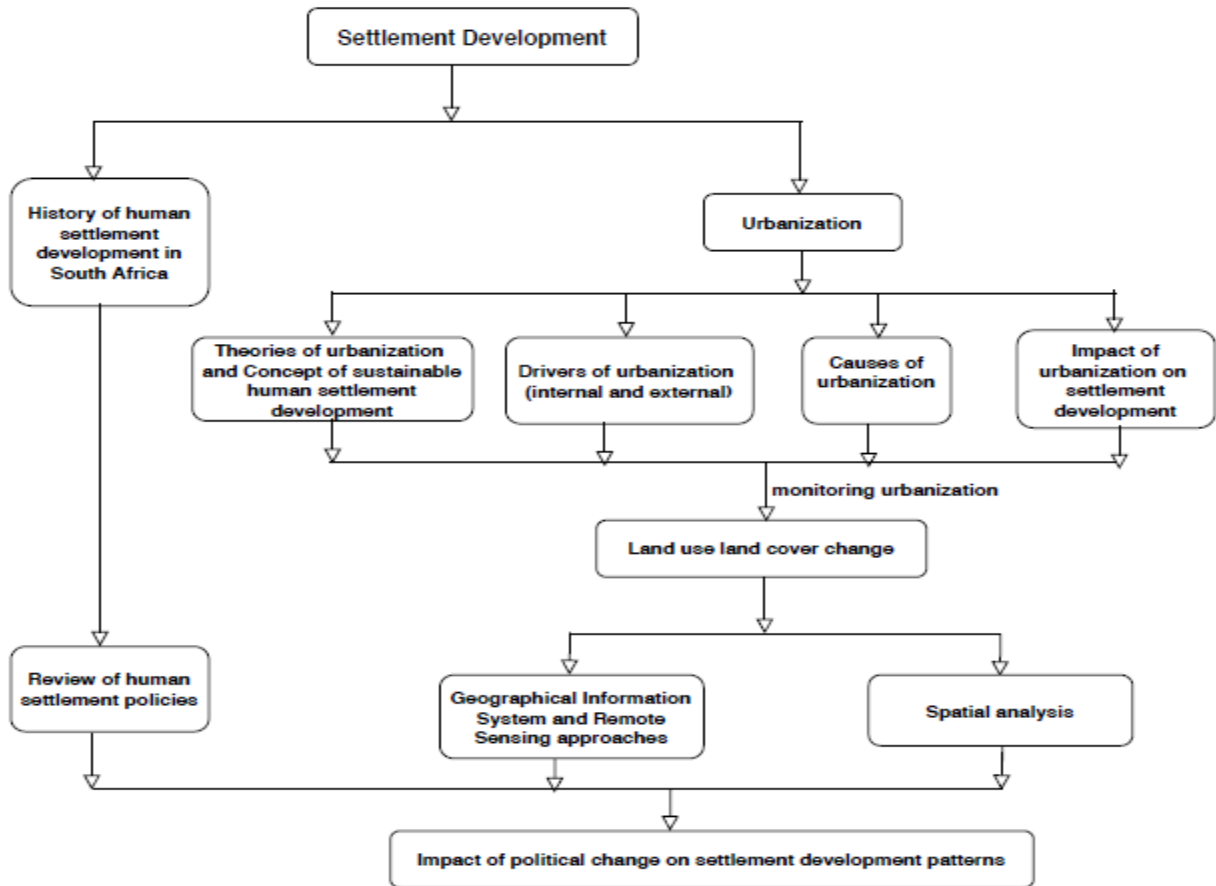


Figure 2.1: Literature review flowchart for the study

### 2.2.1 History of Human Settlement in South Africa

The history of human settlement in South Africa is assumed to have begun over 1000 centuries ago with a record of different ethnic groups at the inception. The country has witnessed five distinctive stages of human settlement, namely pre-colonial, colonial, post-colonial, apartheid and post-apartheid eras. Researchers believe that the present South Africa was once a centre of human evolution and was occupied by Australopithecines not

less than 2.5 million years ago. The modern human settlement happened about 125,000 years ago in the middle stone age, according to archaeological findings at Klasies River Caves (Woodhouse, 1996). The first dwellers are linked by DNA to groups from the northwestern part of Southern Africa, which are still dominant among local Khoisan (Khoi and San). Another set of dwellers were migrants of a different ethnic, black-African Bantu from the northwestern region of Southern Africa (Epprecht, 2013; Onslow, 2009; Tankard *et al.*, 2012).

Professor R. Dart discovered a skull of 2.51 million-year-old Taung Child at Blombos cave in 1924. Like Dart, Robert Broom also made a more robust discovery of a hominid in 1938, and in 1947, discovered numerous other instances of *Australopithecus africanus* at Sterkfontein. More research at Blombos cave in 2002 found stones carved with cross-hatch patterns were believed to be 70,000 years old. This discovery was believed to be among the first samples of abstract or symbolic art made by *Homo sapiens* (Amos, 2005).

Several other species of early hominid have been discovered recently. In 2015, an earlier unknown specie was discovered near Johannesburg and was named Homo Naledi. It is believed to be one of the most vital paleontological discoveries in recent times (Berger *et al.*, 2015).

### **San and Khoikhoi**

The San and Khoikhoi are notable for their occupations, and they are jointly called Khoisan, although the San were hunters and gatherers, while Khoikhoi were pastoral-herders (Giliomee, 2003).

The discovery of cattle skeletons on the Cape Peninsula by Archaeologists revealed that the Khoikhoi had been around for about 2000 years (Mitchell, 2002). Between the late 15<sup>th</sup> and early 16<sup>th</sup> centuries, Portuguese mariners came across pastoral Khoikhoi, then later, the English and Dutch seafarers in late 16<sup>th</sup> and 17<sup>th</sup> centuries swapped metals for livestock with the Khoikhoi (Sadr & Sampson, 2006).

The location of the Dutch East India Company's staging post at Cape Town in 1652 started a conflict with the Khoikhoi over the ownership of land. This was followed by the stealing of livestock, and the Khoikhoi were ousted from the peninsula with force after several battles. The first and second wars were fought in 1659 and 1673, respectively. While the third war was fought between 1674 and 1677. The Khoikhoi were defeated and thrown out of the peninsula. A smallpox epidemic destroyed the remaining Khoikhoi people. The illness was believed to have come from the Dutch mariners (Nell, 2004).

## **Bantus**

The spread of the Bantu was a crucial demographic movement in Africa's history, covering much of the continent between the first and second millennia BC (Berniell-Lee *et al.*, 2009; Stull *et al.*, 2016). The race was believed to have come to South Africa from Congo basin in the early century. Bantu expanded and infringed the Khoikhoi land, making the Khoikhoi go further to arid areas. The migrants, ancestral to the now Nguni people (the Zulu, Xhosa, Swazi, and Ndebele), chose to live close to the eastern coast of present South Africa (Kuper, 1993). Others like Sotho-Tswana people (Tswana, Pedi, and Sotho) settled on the plateau known as the Highveld (Legassick, 2010; Moodley, 2008) while the Venda, Lemba and Shangaan-Tsonga communities lived in the north-eastern areas of South Africa (Alcock, 2014; Marasinghe, 1993; Nettleton, 1992).

The Mapungubwe king formed the north boundary of what is now South Africa, at the convergence of Shashe and Limpopo rivers close to the current Botswana and Zimbabwe border. This was South Africa's earliest local kingdom in the middle of 900 to 1300 AD. It became the biggest empire in the sub-continent but later declined because of climatic conditions in the 14<sup>th</sup> century. The kingdom engaged in copper, gold, and iron trade for home-used and export business through the East African ports to Arabia, China, India, and other southern African countries (Singh & Chetty, 2010).

## **Early European Exploration**

### **Portuguese Role**

The Portuguese sailor, Bartolomeu Dias, was the earliest sailor from Europe to travel round the coast of South Africa in 1488 while trying to reach the far-eastern part of Asia via Africa's southern cape, which he called Cabo das Tormentas meaning Cape of Storms in 1497. In the later part of the year 1497, a fleet of ships controlled by Vasco da Gama got to the Cape of Good Hope. By 16th December, the fleet went past the Great Fish River on South Africa's southern coast where Dias had turned back before. Da Gama named the coast Natal, which means Christmas in Portuguese. He was able to sail through northward to Zanzibar and then eastward, to reach India, thus creating a new route between Asia and Europe (Axelson, 1988; de Beer, 2016; Gunn & Codd, 1981; Swanson, 2017).

### **Dutch Role**

The Dutch East India Company decided to set up a settlement at the Cape. The Vereenigde Oostindische Compagnie (VOC), sailed through to the east with no intention of colonizing the area but only wanted to secure a base camp where sailors could stay to relax and service their ships (Davenport & Saunders, 2000; Ross, 1983). A small VOC tour under Jan van Riebeeck got to Table Bay on 6<sup>th</sup> April 1652 (Hunt, 2005), but as the Khoikhoi were pastoral and not cultivating farmers, food was not available for the VOC at the Cape. They later brought in some Dutch farmers to start cultivating land to produce foods for the sailors and the already growing settlement. The Dutch farmers progressively proliferated in population; and their farms began to encroach on Khoikhoi land (Hunt, 2005). The VOC later brought 71,000 slaves to Cape Town from India, Indonesia, East Africa, Madagascar, and Mauritius (Beck, 2013).

## **British Role**

The French revolution in 1787, the Patriot Party, a group inside the Dutch Republic's politics, tried to take over the reign of Stadtholder William V. Although unsuccessful then, it came back later when the French invaded the Netherland in 1794/1795 which made Stadtholder flee the country. The radical Patriot Party then proclaimed the Batavian Republic, which became an ally to revolutionary France. The exiled Stadtholder, who was in England, sent Kew letters asking colonial governors to capitulate to the British. The British then took control of the Cape in 1795 to prevent French from taking over but it was later handed back to the Dutch in 1803 (Beck, 2013; Turner, 1978). The British were later given the Cape as a price during the Napoleonic war again, getting hold of the Cape from the French-ruling Kingdom of Holland that had turned to the Batavian Republic (Beck, 2013; Davenport & Saunders, 2000).

Just like the Dutch, the British did not have the intention of colonizing the Cape but only to use it as a port; British control of the Cape was acknowledged at the Congress of Vienna in 1815, the Dutch collecting 6 million pounds from the deal. The assignment of the British was to stop the usage of the Dutch language of the Dutch in 1806 with the plan to transform the language and culture of European colonists to language and culture of the British (Kachru *et al.*, 2009; Nasson *et al.*, 2011). This action compelled many of the Dutch colonists to leave the British administrative area. In 1820 the British authorities convinced about 5,000 middle-class British immigrants who were mostly traders to move to the Cape; most of these migrants later settled in Grahamstown and Port Elizabeth.

## **2.3 Drivers of Settlement Development Change**

Drivers of settlement development change will be categorized into two, (Kanagalakshmi & Nagan, 2013; Lu *et al.*, 2011) they are;

1. The external drivers including urbanization and urban growth, industrialization & technology, infrastructural development, and governmental policies.

2. The internal drivers namely, the location (slope, natural features, land prospective and tenure), socio-economic, and political factors.

### **2.3.1 External Drivers of Settlement Development Change**

1. Urbanization and Urban growth: Two major factors influencing urbanization are population growth (increase in birth rate and a decrease in mortality rate) and rural-urban migration, which is another factor for economic development.

*Urbanization rate* is a process in which the percentage of the number of people living in urban settlement (i.e., towns or cities) increases in a year, when the number of people in the rural settlements decreases and the number in the urban settlements increases. Thus, there will be a zero urbanization rate if the two types of settlements' (i.e., urban and rural) populations grow at the same pace. The main cause of the urbanization process is when people migrate from rural areas to temporarily or permanently stay in urban areas.

Urban growth is the increase in the urban population that occurs as a result of any or a combination of rural to urban migration, natural increases, boundary changes or reclassification of rural villages/territories into the urban area (UNGA, 2017).

It usually happens as a result of natural population increase among urban dwellers; migration from rural to urban settlements; and when a rural area changes in status (based on an increase in population leading to increase built up. increase in infrastructural facilities and industries), then it is fit to be called urban settlements (Cohen, 2015; Rana, 2011). Studies have shown a direct link between urban growths (a measurement of urbanization) and change in land use as an increase in population leads to urban development in terms of building houses and provision of jobs which happen at the expense of other land uses (Cohen, 2015; Rana, 2011).

- 2 Industrialization; Industrialization is a major driver of economic development, which is a logical impetus of urbanization (zu Selhausen, 2017). Industrial, commercial, and residential land uses are seen to be the reasons for land use cover change and industrialization is seen as the reason why farmers abandoned

rural areas to search for better lives in the urban (AbuHafeetha, 2014). More often than not, industries in the developing nations are usually located in urban areas, which can lead to the rapid migration of rural people to urban areas in search of job opportunities (Lu *et al.*, 2011).

- 3 Technology: The advent of technology increases the workforce for the manufacturing sector, and the quest for where employed migrants will live, leading to the demand for more land for housings. Consequently, the more expansion of urban settlements to peripheral areas, the more changes in land cover land use. (Rana, 2011)

4. Infrastructural Facilities and Services: Rana (2011) supporting urban bias theory of urbanization, stated that essential facilities are mostly located in urban areas (Rana, 2011). Facilities such as tertiary schools and hospitals, public libraries, recreation parks, and other major public facilities are pull factors attracting rural dwellers to urban environments. Only farming-related facilities are provided for residents of rural areas, who are mostly farmers, facilities like agricultural machinery, farm-irrigation, and silos are often provided to rural population (AbuHafeetha, 2014).

5. Policy: Most of the developmental policies by the government tend to favour economic growth, which directly or indirectly brings about change in the use of land in several developing nations (Lu *et al.*, 2011). Also, policies on spatial growth, which allocates different uses to land area lead to change in land use land cover (Rana, 2011). Currently, various Human Settlement Acts in South Africa such as Housing Acts, 1997 (Act 107 of 1997), Rental Housing Act, 1999 (Act 50 of 1999) amended as Rental Housing Act 2007 (Act 43 of 2007) and Social Housing Act of 2008 (Act 16 of 2008) encourage the spread of built up land in all the areas of the countries (Pesaresi *et al.*, 2015).

### **2.3.2. Internal Drivers of Settlement Development Change**

1. Location: distance to nearest cities, especially if it is a major city and major highways are variables assumed as factors encouraging settlement development or any other land-

use change. Such locations usually attract building, and economic growth and urbanization in these areas are generally expected (Nazer *et al.*, 2010).

a. Slope: The topography of a land area will determine the kind of use it will be put to, areas with very high slopes may not likely be developed into residential because of cost implication (Nazer *et al.*, 2010).

b. Natural features: Factors such as availability of water, favourable climatic condition, and nature of soil affect settlement development or any other land use (Nazer *et al.*, 2010).

c. Land prospective and tenure: The potentials embedded in lands such as present or future value of the land and the title (for example, ownership or leasehold) one has over the land can influence settlement development.

2. Socio-economic factors: Gender, income, level of education, marital status, living standard, and the number of people living in a household are internal drivers for settlement development (Nazer *et al.*, 2010). The land is an essential variable that is usually measured by the scale of the economy and value. Property investors would instead choose a large land area than a small one to maximize profit; this makes large parcel of land more valuable than small ones (Kazemzadeh-Zow *et al.*, 2017).

3. Political factor: One crucial factor that will be intensely evaluated in the course of this research is the political factor; the advent of democratic rule enabled housing for all the citizens of South Africa.

It is worth noting that the political factor has a different level of impacts in the three settlements of the study area. More details about the influence of political factors in the study area and South Africa will be discussed extensively in the subsequent chapter. All the above driving forces contribute to settlement development change in most countries of the world.

## **2.4 Introduction to Urbanization**

Urbanization is a key indicator of settlement development. This section gives an overview of the descriptions of urbanization, leading factors of urbanization, and the impact of the political factors on settlement development expansion and economic growth; it is herewith explained to enhance the framework for this research. It is one of the elements of the foundation for the research design and drafting of interview guides.

The United Nations (2009) described *urbanization as the shift from a rural to an urban society, which involves an increase in the number of people in urban areas in a given year*. The United Nations indicated that urbanization is the consequence of economic, political, and social developments, which make the population to be concentrated in urban settlements and later leads to the expansion of the cities. It also causes land-use change as well as changing settlement form from the lower level to a higher one, for example, rural areas to urban. Urbanization influences the progressions of population growth, and urban settlement patterns making urban areas become an ecological matrix (Zhang, 2016).

### **2.4.1 Theories of Urbanization**

The key theories of urbanization which explain the important roles urbanization plays in settlement development are herewith discussed in this research. They are the modernization theory, dependency theory, and urban bias theory.

#### **2.4.1.1 Modernization Theory**

Modernization theory describes the perception of urbanization in nations that are developing by using the modern - traditional economic dichotomy and demographic transition theory (Zaidi & Morgan, 2017). According to the theory, the growth of cities in developing nations can be linked to the traditional gap in equilibrating fertility and mortality disparities as well as the huge migration of rural people to urban centres as a result of

rural push and urban pull factors (Rana, 2011). Firstly, the theory is that most developing countries have easily dispersed mortality-reducing technology, whereas it is not the same case with the institutional/industrial web of modernity. When modernization began, developing nations concentrated on investment and, therefore, that put the population in one or a few large cities (UN-HABITAT, 2015). Secondly, the attraction of modern cities and constrained opportunities in rural areas led to rural-urban migration (Hoffmann *et al.*, 2019). Furthermore, the age discrimination of the migrants and their high fertility rate grew urban settlements beyond their capability to provide employment, housing, and infrastructural facilities (Tacoli *et al.*, 2015).

#### **2.4.1.2 Dependency Theory**

This theory is based on historical events to explain the transformations that happen in the formation of urban settlements as a result of the shift from pre-capitalist to the capitalist mode of production (Surya, 2014). It, therefore, highlight the dependency nature of capitalist developments in developing nations that depend on external economic forces to study city development (Mihalache-O'Keef & Li, 2011). This school of thought believed that the advanced nations of the world use developing nations as a place to get the materials needed to expand development (Balcilar *et al.*, 2017). This creates a reduction in small-scale farmers in rural areas and encourages foreign investment in huge capital based manufacturing industries, which leads to increased productivities in urban settlements. It also causes rural-urban migration with the impression of getting better lives by rural dwellers in the cities where they ended up disappointed and eventually end up in the informal sector (Lu *et al.*, 2011; Rana, 2011).

#### **2.4.1.3 Urban Bias Theory**

This theory of urbanization shifts the importance of development in the city from economic to political point of view. This perception by Guzey (2016) argued that policies favor urban settlements. He believed there is a concentration of infrastructures such as teaching hospitals, libraries, education, and advantageous conditions in the urban areas at the

disadvantage of the rural areas, which are only provided with farmers' loans, moderate irrigation facilities, and agricultural equipment (Güzey, 2016). Also, the governments of developing countries are more inclined to invest in the capital on developmental projects, which are usually located in urban settlements with a larger population (Cohen, 2015). This tends to motivate rural people to move to urban settlements to enjoy promising policies (Rana, 2011).

The application of these theories to this research explains the formation and development of cities based on population distributions and political situations. The first two theories indicated that the city develops because of population distribution. Modernization theory explained that a city grows when the fertility rate is higher than the mortality rate and when rural-urban migration occurs due to the "good life" in urban settlements such as industries and basic infrastructures cause. Dependency theory explained the dependency of developed nations on developing nations to get a supply of their raw materials to develop themselves. The same way urban settlements get the materials needed to grow their economies at the expense of the rural areas, thereby causing a rural-urban migration. This third theory is the most applicable to this study, it attributes urban development to the government's policies, plans, and programs that mostly target the development of urban areas more than the rural areas.

#### **2.4.2 Urbanization as a Development Indicator**

Urbanization can be viewed from an economic point of view, for example, a constant change from agricultural practice to manufacturing and other secondary occupations. These manufacturing and secondary jobs act as pull factors, which may be the reason for people's movement from rural to urban settlements (Lu *et al.*, 2011). When a nation has 50% or more of its population living in urban settlements, then it is said to be urbanized (Lu *et al.*, 2011).

There is a constant increase in urbanization in both the developed and developing nations of the world (Tacoli *et al.*, 2015). The world has experienced ten fold increase in urban

population figures between the last century and this, growing from 224 million in 1900 to 2.9 billion in 1999 an increase from 14% to 50%. It was predicted that by 2030, over 60% (4.9 billion) of the projected world population (8.1 billion) would reside in urban areas; 83.5% in developed countries (1.01 billion), and 56.2% in the developing countries (3.88 billion) with a high percentage of the poor (Zlotnik, 2017).

### **2.4.3 Urbanization in other countries of the world**

Fox (2012) highlighted that urbanization started in the world as a result of technologies and breakthroughs in the controlling of diseases. These factors caused a reduction in the mortality rate in the world. They later led to growth in the urban population, thereby increasing the natural growth rate of migration to urban areas (Fox, 2012).

It was predicted that by 2030, 60% of the world's population would dwell in urban areas (Sarkar, 2010), between 2018 to 2030 urban population is expected to increase in size while rural population would decrease as, at 2018, the rural population was 45% and is expected to fall to 40% by 2030. In a situation where there is a rapid shift from agrarian to industrial services, and most people of the world are living in urban areas, human settlement, housing, and food security are becoming unsustainable (Kanagalakshmi & Nagan, 2013; Sassen, 2018).

It was reported in UN 2017 that 90% of the population of people (3.4 billion) that lived in the rural area dwelled in underdeveloped continents of Africa and Asia. It was also predicted that by 2050 (in 30 years), the figure of the rural dwellers would reduce to 3.1 billion as the population of urban residents would be more than rural dwellers, especially in Africa. In 2015, sub-Sahara Africa had a yearly urban population growth rate of 4.1%, above the average global rate of 2%. As of 2018, 14 countries in Africa have urban growth rates exceeding 2% already (Saghir & Santoro, 2018; UNGA, 2017).

In 2009, China's National Bureau of Statistics recorded that the urbanization rate was 48.34%, and in 2014, China proclaimed that the country's urbanization had exceeded the

extreme threshold of 50% to reach 52% which meant that 711.8 million out of 1354 million people in the country lived in urban settlements.(Kunzmann, 2015).

Urbanization in Africa is believed to have begun in the late colonial period and then increased in the post-colonial period due to demographic, political, and economic factors (Güneralp *et al.*, 2017). However, Kemal Ozden disagreed; to him, urbanization started when hunters and gatherers of food moved everywhere without the mind of settling in any place (Özden & Enwere, 2012).

Desa in 2014 predicted that the population of the African continent would grow more than three times from 395 million in 2010 to 1.339 billion in 2050, which would account for 21% of the predicted urban population in the world. Currently, there are seven megacities in Africa with a population of over 10 million each; these cities include Kenya in Nairobi, Lagos in Nigeria Cairo in Egypt, Accra in Ghana, Kinshasha in Congo, Khartum in Sudan and Johannesburg-Pretoria in South Africa. It was predicted that by 2050, almost 55% of Africa's population will be dwelling in urban settlements, this is a major rise in urbanization rate as only 10% resided in an urban settlement in 1950. This is happening through the transformation of nearby rural areas, and medium-sized towns are adjoining to cities, thereby expanding the urban landscape (Güneralp *et al.*, 2017; Kaneda *et al.*, 2015; Pieterse & Parnell, 2014).

As the urban population increases in Africa, it is expected that there will be development in urban land and settlements. It was predicted that development in urban land areas in Africa would increase by almost 600% between 2000 and 2030, and the development would be experienced more in five major areas in the continent. These are; Kano State in northern Nigeria, Nile River in Egypt, Lake Victoria in Kenya, Addis Ababa in Ethiopia, and the coast of West Africa along the Gulf of Guinea. The United Nations already considered four of these areas as high-fertility areas within their various countries (Güneralp *et al.*, 2017).

Though there may be similarities between Africa's urbanization and other countries or continents like China and Asia, worthy of note are the reasons for the rapid rate in Africa, which range from uncontrolled development, poverty, weak planning laws, and policies e.t.c. (Güneralp *et al.*, 2017; Pieterse & Parnell, 2014)

#### **2.4.4. South Africa's Urbanization**

Mabin (2003) reported that urbanization in South Africa started as a result of rural-urban migration when the colonial and of Boer' republics' authorities' recruited labor for farming and mining. This industrial revolution changed the nature of physical development not only in mining areas but also in the ports within the towns (Mabin, 2003). Mabin (2005) reiterated that the kind of rural-urban migration that took place in 1870 had never been witnessed before in the history of South Africa because of the aggressive recruitment for mining and other booming commercial activities (Mabin, 2005).

Migration played a major role in the growth of urban settlements and urbanization in South Africa when business interest from Australia, North America, and Britain discovered precious stones-diamond and gold (Platzky, 1994). This discovery of precious stones and the exploration that followed brought about more migration as the gold depot in the Transvaal needed shaft mining and the employment of expatriates from developed countries, especially Britain. Mining played an important role in the population distribution of urban settlements in South Africa. Harries noted that the effect of the discovery of diamond and gold was the reason for the continuous demand for labor, and an enormous and diverse labor force (Harries, 1994). Several nationalities from Australia, America, Germany, and England, as well as people from all over the world, were coming in, and migration between 1890 and 1913 was almost 24,000 yearly. Mineworkers from Canada, Wales, and Cornwall got used to the highly industrial life and began to behave like citizens already. Much later, there were more than 50,000 Chinese laborers. The discovery of diamonds and gold played a remarkable role in South Africa's urbanization and urban growth.

Mining had a major impact on the formation and function of settlements in South Africa, and this led to a variety of useful relationships among settlements that were different, having competitive and comparative advantages. Stilwell, Minnitt, Monson, & Kuhn (2000) highlighted that mining opportunities increased spatial integration by way of economic development and growth and thereby brought regional development in areas with potentials for growth and development in the area of mining (Stilwell *et al.*, 2000). They also noted that before the era of mining, only Cape Town was recognized as the main centre for economic activity because of farming and port activities; much later, Durban and Johannesburg outgrew Cape Town. Durban grew because of farming activities among the Whites in the adjoining environment and also because of easy trading routes for the mining business. Linking railways between the mining centres facilitated the enlargement of the seaport in Durban (Platzky, 1994).

Residential separation during the apartheid period presented in different ways. In Durban, White colonial settlers dominated the Indian settlers to restrained them from business rivalry, Licensing Act of 1897 enabled the Whites to prevent the Indians from obtaining a license to trade (Ross, 2008). For Johannesburg and Cape Town, the separation happened along with mining towns of Kimberley and Johannesburg. Businessmen housed their labourers in a nearby single apartment compound, in order to reduce the cost of accommodation (Platzky, 1994). Mabin (2003) highlighted that provision of such an apartment compound was a way of residential separation, which later formed the pattern of South Africa's cities(Mabin, 2003).

United Nation in 2018 estimated South African population to 59,309 million in 2020 and 75.518 million by 2050 with a growth rate of 1.4%. This estimation was based on the trend of population figure through 1996, 2001 and 2011 Census with estimates of the subsequent trends of fertility, mortality and international migration (UNWUP, 2018). South Africa experienced a reversed trend of urbanization in the mid 1990s due to urban economic decline, abundant food in the rural areas, HIV/AIDS, however, this trend

changed in the 2000s as South Africa began to experience an influx of international migrants. Southern Africa had the highest proportion of urban dwellers in Africa (61.6%) and South Africa is one of the prominent countries that witnessed an increase in the population of people in urban slums (UNGA, 2017).

#### **2.4.5 Causes of rapid urbanization in Africa**

Several works have linked urbanization to economic, social, and human development. Industrialization in urban centres had resulted in rural-urban migration (Lu *et al.*, 2011; Rana, 2011). Modernization theory of urbanization explains rural-urban migration through pull and push factors, i.e., urban-pull and rural-push—the population shifts from rural to cities. In most developing countries, migration to the cities usually leaves agriculture in distress. Migrants see movement to the cities as an opportunity for better lives, which usually puts pressure on the urban centres, unlike in the developed countries where migration to the urban area was usually enabled by large-scale industrialization and the need for human factors without necessarily distressing the urban area (Rana, 2011). Migration to urban centres occurs because of a better standard of living, employment opportunities, and the gap in earnings, which are the pull factors. Also, Africans migrate because of the spatial distribution of cultural, political, and social opportunities in the cities, where they believe they will not be marginalized. (Barbero-Sierra *et al.*, 2013).

Literature also shows that people migrate because of climate change, especially rain; when it is erratic; this may lead to low agricultural productivity, famine, flooding, family crises or civil war in the rural areas. All these are push factors. Brückner (2012) reiterated how low agricultural prices caused a significant increase in urbanization in African countries between 1960 and 2007, while Poelhekke (2011) views migration from rural to urban as an insurance mechanism against agricultural risks (Brückner, 2012; Poelhekke, 2011).

People also migrate from rural to urban areas because of the presence of tertiary hospitals where chronic diseases are treatable, unlike the rural areas where the health system is primary. Sometimes though most of these migrants end up living in the slums, which may pose another health challenge to them. Access to better transport systems,

infrastructural facilities, utilities, and services are also parts of the reason for rapid urbanization (Arouri *et al.*, 2014).

Though cases are usually different between countries (Rana, 2011), United Nations noted natural growth, which is when the birth rate is more than the mortality rate is usually responsible for 60% urban growth while migration from rural to urban area accounts for 40% (Tacoli *et al.*, 2015). Rapid urbanization causes land use cover change; this implies that some of the driving forces of LUCC are the same for urbanization (Jing-bing *et al.*, 2009). They are geographical, economic, population, transportation, as well as policy and planning.

#### **2.4.6. Population**

Christopher (2011) recorded that South Africa's population in 1911 was about 5,973,394 (Christopher, 2011). However, the years between 1911 to 1921, the population at all age-range dropped because of the prevalence of influenza disease which raised mortality rate beyond the birth rates. This affected all racial groups in the country (Feinstein, 2005; Perkins *et al.*, 2005). After the epidemic, the population improved to over 21 million in 1970, and there was also an increase in income per capita. The population increased from 40,583, 573 in 1996 to 44,819,778 in 2001. The population density increased from 33 persons per Km<sup>2</sup> in 1996 to 40 persons per Km<sup>2</sup> in 2007 (Feinstein, 2005; Musvoto, 2011).

Based on the years under study, which were 1989,1999,2009 and 2018, South Africa's population increased from 29.908 million in 1989 to 43.054 million in 1999 and from 50,152,000 in 2009 to 57,458,000 in 2018 and urbanization rate moved from 61.69% to 66.36% (Stats, 2018). The average population increase is estimated to between 1.3% to 1.4% growth per annum, while the household population increase is estimated at 2.4% per annum. The household population is believed to be outpacing population growth, the rapid household growth and population relocation are the reason for the housing shortage in the country (Stats, 2018).

#### **2.4.7. Urban Patterns of Free State Province**

Free State had a total land area of 12,943,700 ha and a total population of 2.746 million, which was 6% of total South Africa's population in 2011 (Stats, 2012). Several features influence the patterns of settlements in the Free State province. The availability of land for various purposes, topography, which makes the province a centre of tourism, the surrounding agricultural activities and hinterlands (because it is the food basket of the nation), the location (it is centrally placed amongst other provinces on the map of South Africa). Location and natural features are among the factors that inform the growth and the shaping of its urban patterns. Some towns in Thabo Mofutsanyane district municipality are strategic locations within the province. The settlements selected for the research have certain features that influence their urban pattern, for instance, Ladybrand is the closest city to Maseru, Lesotho border town, Harrismith is the half-way town between Johannesburg and Durban, and Vrede has the history of being South Africa's capital for a day. The urban pattern of these settlements was shaped by their functions and location in relation to other neighbouring urban centres. Other factors that could influence settlement development patterns are natural resources, for example, water, land area, potentials of neighbouring settlements, and administrative or commercial function such settlement perform.

### **2.5 Introduction to Land Use Land Cover Change (LULCC)**

Land use land cover change is a major factor which leads to urbanization and, monitoring it through the use of remote sensing and spatial analysis are the methods employed in the research.

Land use could be referred to as both land cover and land use (Klein *et al.*, 2012). Land cover means the natural state of the surface of the earth, which includes both physical features, for example, soil, water bodies, hills, agricultural lands, and forests (Anderson, 1976). Land cover change is in two ways, which are: conversion of land cover and modification of land cover (Geist & Lambin, 2002). Conversion of land cover is a total

transformation in the land cover classification through a whole substitution of one form of land cover to another form because of urban extent change or deforestation. Modification means a change in land cover that does not involve going through a total change in the classification (Geist & Lambin, 2002).

Land use is the means or purpose to which people employ land and its resources (Serra *et al.*, 2014) such as residential, mining, commercial, farming, logging, or recreation e.t.c. Thus, change in land use is the utilization of land cover either in alteration or transformation over a period to meet the needs of people (Veldkamp & Verburg, 2004). Land use/land cover changes (LUCC) are the leading factors for change in the components of the environment in both rural and urban settlements (Verburg *et al.*, 2006). LUCC directly affects water bodies, climate, wildlife habitat, and other environmental components (Quan *et al.*, 2010; Zhang *et al.*, 2014a).

Drivers of changes in land-use cover include:

1. Physical/Biological factors like climate and soil; they are biophysical because they influence humans to the appropriateness of land for a particular use (Meyer & Turner, 1996).
2. Population distribution and social lifestyle: this includes gender, household size, status, income (UN-HABITAT, 2015).
3. Institutional factor: these include legal, government, and traditional bodies that are in charge of land allocation and distribution (GUO & REN, 2007).
4. Economic factor: Individuals or organizations respond to the land decision in various ways, the decisions to invest in the land by land speculators for consumption, profit, or factor of production is an economic factor that can drive LUCC (Ananda, 2007).

Some of these drivers (underlining factors causing) of LUCC are also drivers of urbanization (Geist & Lambin, 2002).

## **2.6. Urbanization, LUCC and Settlement Development**

Considering United Nations' keywords in the definition of "urbanization"- *drift from rural to urban*, increase in population per year, *an outcome of economic, political and social*

*development resulting in the concentration of urban settlements, expansion of cities, change in the use of land and conversion of rural settlement to the metropolis* and Lu Liang's definition as a *proliferating shift from agrarian to industrial services*. These show that urbanization and land use cover change are among the most important factors that lead to settlement development worldwide. That is the reason their influences on change in settlement development has been widely studied (Kanagalakshmi & Nagan, 2013). Urban areas in the world are estimated to be increasing at almost 1% every year. Rising urban population and continuous shift from farming to industrial services cause demand for shelter and basic facilities in the cities, hence the constant change in land use and cover and growth of cities. In order to sustain urban development, there is a need for proper planning and constant monitoring of settlement patterns (Aronson *et al.*, 2014).

United Nations predicted that with the rate urban areas continue to outgrow the rural areas, there are likely going to be more megacities (cities with a population of over 10 million) by 2030. Megacities in the world increased from three in 1975 to twenty in 2005, to thirty-three megacities, and forty-eight cities with a population of between 5 to 10 million people in 2018. It was predicted that by 2030, there would be forty-three megacities and forty-eight cities with a population of between 5 to 10 million. Out of the forty-eight, ten would become megacities by then. In 2018, 6.9% of the world's population (529 million people) lived in megacities, and by 2030 it would increase to 8.8% (752 million). Currently, there are seven megacities in Africa. As a result of these, the 21<sup>st</sup> century is termed the "urban century" because half of the population in the world would be dwelling in urban settlements. These show an endless link among urbanization, land use cover change, and settlement development (Derudder & Taylor, 2005; Keivani, 2010; Sassen, 2018; Taubenböck *et al.*, 2012).

## 2.7 Conceptual/Theoretical Framework

### 2.7.1 Concept of Political Ecology

Political ecology studies the interactions between economic, social, and political factors with environmental issues and on the other hand changes (Gerber *et al.*, 2009; Watts, 2015). It focuses on imbalance in power relations, disagreement, and cultural “modernization” in a global capitalist political economy. It serves as a significant force in redesigning and disrupting the human relationship with the immediate environment (Gerber *et al.*, 2009; Simmons *et al.*, 2016). Bryant (2015) describes political ecology as “*the notion that politics should be put first in the attempt to understand how human-environment interaction may be linked to the spread of environmental degradation*” (Bryant, 2015). Studies of political ecology indicates a social and environmental situation instituted via unbalanced power relations (Gerber *et al.*, 2009). Rocheleau and Roth (2007) described that power at one level means the capability of an actor to exercise authority on other people’s environment, at times the authority in contradiction and sometimes with (in harmony) (Rocheleau & Roth, 2007). The study of unequal power relations is evident in the third world’s political environment on the disagreement on how people can access various resources in the environment (Bryant *et al.*, 2011).

Political ecology’s concept applies to this study because of the valuable knowledge it provides to tackle crises and problems in the environment, especially when it is politically related (Wainwright *et al.*, 2015). This knowledge helps to understand and addresses social and economic inequities (AbuHafeetha, 2014; Simmons *et al.*, 2016). More explanations on the relevance of the concept to the study will be provided in chapter 7 of the thesis.

### **2.7.2. Concept of Sustainable Human Settlement Development**

Human settlement (as a concept) is from the science of human and settlement, which means people's relationship with their immediate environment (Liang-yong, 2001; Zhiming *et al.*, 2010). Sustainability concept was dated to the old publication of the United Nations' Brundtland Report in 1987; it means the ability to meet the needs of "today" without jeopardizing the need of future generations (Redclift, 2007). It is a common concept among housing, urban and environmental planning, and it comes from three fundamental goals, which are social equity, economic development, and environmental protection (Connelly, 2007). To achieve the three goals particularly social equity, environmental protection and betterment of the less privileged are very important (Higgins *et al.*, 2011; Sullivan & Ward, 2012)

Promotion of human settlement that is sustainable is under the 7th chapter on Agenda 21 which aimed at the provision of adequate housing, improvement in the management of human settlement, promotion of planning and sustainably managing land use, promotion of integrated provision of basic infrastructural facilities like sanitation, water, drainage, and waste management. Others are the promotion of energy and transportation system that are sustainable for human settlement, promotion of sustainable construction industries, and promotion of capacity building and human resource development for sustainable human settlement development (Sullivan & Ward, 2012; UN-HABITAT, 2015).

This concept was promulgated and accepted by the United Nations to ensure that human beings use the environment in a way that does not put the present and future population at a disadvantage. Most of the countries of the world also adopted the pronouncement in order to guide development at all levels of government. It is also essential for this study to adopt the concept to measure the trend of development and evaluate it. Further explanation will be provided in chapter 6 of the thesis.

## **2.8. Human Settlement Policies that have impacted the landscape of Thabo Mofutsanyane Municipality and South Africa**

Since 1994, the eventful transformation from minority government to majority rule in the country, democratic governments have formulated various policies that influenced the landscape of South Africa. Some of the policies that influence South Africa's landscape, such as urban and infrastructural development include:

1. Development Facilitation Act of 1995: It introduced a spatial pattern strategy which ended the segregation between the White and Black race. It enabled the Black (the majority) to own land with title deed (James, 2007; Rigby & Diab, 2003), writing off their debt, have a discount benefit scheme, and registration rights under the Housing Acts 107 of 1997 (James, 2007; Rigby & Diab, 2003).
2. Sectional Title Schemes Management Act 2011 (Act 8 of 2011), made provisions for the formation of corporate bodies to control and manage public properties.
3. Community Scheme Omnibus Service Act 2011 (Act 9 of 2011). It created a body that would resolve complaints and conflicts on finance, behavior, and facilities arising from people living in public houses.
4. Housing Act of 1997 (Act 106 of 1997). It facilitated a sustainable housing development process at all levels of government and also provides finance for all national housing programs.
5. Rental Housing Act 1999 (Act 50 of 1999): It promoted access to sustainable housing by ensuring proper operational rental housing market. It also established tribunal that had the authority to make guidelines for magistrates' court. It made provisions for good relationships between landlord and tenants, thereby making requirements for leases.
6. Rental Amendment Act (Act 43 of 2007): It enabled tribunals to address issues around leases and extend the time for the filling of openings in rental housing tribunals.
7. Social Housing Act 2008 (Act 16 of 2008): It explained the function of all levels of government in the provision of social housing, made provision for the formation of Social Housing Regulation Authority (SHRA) to control all social housing

institutions that have procured government funds. Human Settlement Department has helped the government in the endorsement of the Social Housing Act and the formation of SHRA. The government at the provincial level can manage Social Housing Programme as well as allocate and approve grants while the local government is charged with the responsibility of providing land, district facilities, and services for municipals' approved projects within the allocated zones (Msindo, 2018).

8. Spatial Planning and Land Use Management (SPLUMA) Act, 2013: It was published on 23<sup>rd</sup> March, 2015 and aims to develop a new framework to govern planning permissions and approvals, sets parameters for new developments and provides for different lawful land uses in South Africa. It made provision for an overall framework for spatial planning policies and land use management for the country and empowered traditional rulers who are duly elected to allocate land for use and development. It annulled most of the irregular and complex land laws during minority rule. However, there are concerns about the allocation of land for use by the traditional rulers from different quarters (Nel, 2016b).

By the year 2015, which was 21 years after the change of government from minority to majority, 5.6 million formal housing units has been added to the country's official housing units, making the number of formal housing units to have increased by 50% (Msindo, 2018).

## **2.9 Application of Spatial Analysis Method to Settlement Studies**

Spatial analysis has been used several times in the studies of population distribution, dispersal of species, transportation flow as well as settlement planning (Gontia *et al.*, 2020; Taubenböck *et al.*, 2019).

Assessing and analyzing spatial patterns of settlements is essential in planning and monitoring sustainable settlements (Taubenböck *et al.*, 2019).

Various metrics have been used to describe patterns of settlement; landscape and class metrics have been described using the number on metrics, edge density, patch density largest patch index, fractal dimensional index, and cohesion, e.t.c. A comparison of the results of these metrics defines the level of fragmentation or aggregation (physical connectedness) of a settlement. The metrics configuration help in measuring the settlement's pattern and growth dynamics based on its spatial dispersal. (Tang *et al.*, 2005; Tinker *et al.*, 2003). Also, several studies have evaluated settlement growth in terms of change detection methods (Hurskainen & Pellikka, 2004; Kleynhans *et al.*, 2012; Vatsavai & Graesser, 2012).

Serra *et al* (2008) used remote and spatial analysis data to examine the driving forces of land use land cover change in the Mediterranean region, Europe. They used remote sensing data of 1977–1993 with MultiSpectra Scanner (MSS), and 1991–1997 with Thematic Mapper (TM) to determine land use land cover change, multiple logistic regression, and biophysical and human variables to analyze driving forces and described land dynamics using landscape metrics. The result shows the intensification of subsidized herbaceous crops on the coastal agricultural plain, the abandonment of olive trees and vineyard as well as restoration in the mountainous sub-region (Serra *et al.*, 2008).

Rutherford *et al.* (2008) modeled land cover change of a mountainous region in Switzerland using land-use statistics. They employed two sequential datasets of 1979 – 1985 and 1992 – 1997 for the assessment. They applied generalized linear modeling to develop a spatially statistical model for land use transition between agricultural land, forest, climate, and soil using socio-economic variables as potential predictors of land cover change. He found out that the analysis of the sequential land cover dataset using his developed statistical model offered a better method to explore the ecological process (Rutherford *et al.*, 2008).

Jiang Guanghui (2006) researched the impact of the distribution changes of rural residential land on the natural environment, product environment, and socio-economic environment in the mountainous area of Beijing using GIS and ecology landscape.

Results showed that spatial distribution of rural residence is influenced by slope, altitude, and distance to farmland; also, there is a significant correlation between spatial distribution change of rural residence and distance from farm to town and roads (Guanghui *et al.*, 2006).

Liu *et al.* (2010) investigated drivers of change in land use and spatial pattern in recent times in China using remote sensing, he designed a new dynamic regionalization, which analyzed physical, economic, and micro policy factors. His results showed that land-use patterns experienced rapid changes in the whole country, the built up, and residential area took over most of the agricultural zone, for example, Huang-Huai-Hai. He concluded that various agrarian policies and the implementation of strategy on land use and regional development enabled overall economic growth (Liu *et al.*, 2010).

Hengyu Gu (2019) used the 2016 population data from National Migrant Dynamics Monitoring in China to establish a migrant workers' interprovincial relationship network. He used the spatial analysis method and the eigenvector spatial filtering gravity to investigate the spatial pattern of the hukou transfer intention network. He concluded that most of the provincial migrant workers had little education, and his result presented a clustered and uneven spatial pattern (Gu *et al.*, 2020).

Veronica and Bianchi (2019) used spatial analysis to characterize a mining space in Chile and Australia. They checked the influence of the socio-environment in the mining industry on the settlements. Based on the four mining spaces they used, they found out that the present spatial perception of mining is limited to the measure and nature description without considering the impact that the large scale mining industries have on the settlements. They proposed the representation and concept of a mining space that reflects two dialectic dimensions. The research also added to literatures on mining policies and made recommendations for government and relevant stakeholders on how to understand and manage the region involved in large-scale mining. (Devenin & Bianchi, 2019).

Bellefon et al. (2019) delineated urban areas in France using building density (a dartboard method) through information from a map of buildings. He defined the urban areas using statistically significant excess building density; they distinguished core urban pixels and detected centres and sub-centres. They later developed a 2-sided test that provided a numerical basis by which maps with different delineations could be compared (De Bellefon *et al.*, 2019).

Chen et al. (2019) studied the rural settlements' spatial distributions in the undulating region in China based on vehicular movement and natural features using remote sensing data from 2015 image. They used a logistic regression model and other methods to quantify the spatial distribution of characteristics influencing factors of rural areas. The result showed that the rural area of Bata Districts was located near a river, township seat, and farmland. Also, the country's level road and accessibility of transport had significant effects on the spatial distribution of a settlement than the accessibility of traffic to the country (Chen *et al.*, 2019).

LI et al. (2011) employed GIS technology and landscape ecology to study the uniformity of spatial distribution characteristics of rural areas in a mountainous area of Qixia city of China. They discussed the influence of terrain niche index on rural settlement distribution. The results showed that rural settlement distribution in the study area was random, and the four rural settlement were clustered distributions with the terrain index increasing, the average patch shape index and average patch fractal dimension increased, with the number of patches decreased. They concluded that the high road influenced the factor of rural settlement spatial distribution (LI *et al.*, 2011a).

This reviewed literature contained various spatial analysis techniques used at different levels in the classification of land use and detecting of change in the pattern of land use in various places with little or no references to studies in South Africa. This research used spatial metrics to analyze and describe the settlements under study. Also, it went further to analyze the changes before and after the shift from minority to majority rule and other

likely factors responsible for those changes as well as their effects on the environmental components such as water and land.

## 2.10 Remote Sensing and GIS in Monitoring Settlement Development

Many researchers have used the application of remote sensing to settlement studies, and several studies have been done using numerous image classification algorithms (Blaschke *et al.*, 2008; Lu *et al.*, 2006; Sinha *et al.*, 2015). The growing accessibility of geographic information data and remote sensing has significantly helped in the planning, monitoring, and detecting of change in settlements such as rural, cities, regions, and countries of the world. It has also been useful in the protection and conservation of natural resources such as water bodies, mountains and mining areas as well as the preservation of the economy worldwide (Kantola *et al.*, 2010; Rodrigues, 2015). The use of different kinds of remote sensing data that were used in the past for settlement monitoring, planning and management have proven to be successful. Table 2.1 shows the reviews of studies that used remote sensing methods to analyze, monitor, and plan settlement development patterns.

Table 2.1: A review of Settlement Studies using Remote sensing Approach

Study	Study area	Method	Image data date	Results	References
Settlements' spatial growth pattern	Adam's rural Kwazulu natal, South Africa	Change Detection	2001 - 2012	Spatial coverage for human settlement and population in the same period has doubled with a commensurate loss of agric land	Siboniso M Dlamini.2015
Monitoring LULC	Hawal bagh block district Almora, Uttarakhand India	Digital Change Detection	2004-2014	Increase in vegetation and built up with a decrease in agric, barren land and water bodies	Rawat 2014
Monitoring Land use change dynamics	Several coastal regions of China	Stochastic modeling	1989-1997	The use of RS and GIS were effective in evaluating LU change and modeling	Weng 2002

Urbanization's impact on Sustainable agricultural after the erection of the separation wall	Tulkarem, Palestine	Change Detection	1999 - 2009	Significant increase in the built-up area and a tremendous decrease in agricultural land as a result of separation wall( government policy)	Maha AbuHafeetha 2014
Reflection of the spatial pattern of urbanization and land consumption in a different socio-economic context.	European region	LULCC, Spatial metrics, Statistical analysis, principal component correlation, and Regression.	2006 and 2012	Eastern cities were to consume the highest rate of land use, followed by Western and Southern cities of Europe.	Luca Salvati 2018
Estimation of the influence of land cover change on stream salamander population.	North Carolina, United States	LUCC	1972 and 2000	There was a decline in southern two-lined salamander population from 44% to 32% and northern dusky salamanders from 30% to 21% due to urbanization	Steven J. Price 2006
Expert-driven semi-automated geomorphological mapping for a mountainous area	Australia	laser DTM  Digital Elevation Dataset		High-resolution topographical data derived from laser DTMs are useful for the extraction of geomorphological units in mountain areas.	S. van Asselin 2006
Eco-environmental vulnerability evaluation in mountainous Region land-use change	Minjiang River, China	remote sensing and GIS  Spatial principal component analysis	1972 - 2000	The method is not only useful for the evaluate eco-environment vulnerability in the mountainous region, but also for the river-valley.	Ainong Li 2005

## 2.11. Conclusion

This chapter dealt with a literature review of the entire thesis, various related topics that assess the spatial settlement development pattern. Theories and concepts as well as urbanizations, land use and land cover and the use of GIS and remote sensing in monitoring land use land cover and settlement change across the world and Africa were discussed as related to the research. Findings by different authors were examined in order to identify the gaps, which this research intends to bridge, and contribute meaningfully to the body of knowledge.

# CHAPTER 3

## CHANGES IN LAND USE PATTERN AND DEVELOPMENT IN THE AFROMONTANE REGION



This chapter is based on:

**Onaolapo T. F.**<sup>1</sup>, Okello T. W.<sup>2</sup>, Adelabu S. A.<sup>3</sup>, and Adepoju K. *“Evaluating Settlement Development Change pre and post 1994 in the Drakensberg Mountain of Fromontane Region, South Africa using Remote Sensing”*. Submitted to South African Geographical Journal. (ID: RSAG-2020-0016).

## **Abstract**

Human settlement development is a predominant form of land cover change in any part of South Africa. This article provides an outline of the development pattern changes in three settlements of Thabo Mofutsanyana district municipality in Drakensberg mountain of South Africa for the past 29 years (1989-2018) with emphasis on 1994, the year when governance changed from minority to majority rule in South Africa. This research aims at understanding settlement pattern change using time series data compiled from satellite images through remote sensing methods. A dynamic spatial pattern of development was observed in the study area, which helped in establishing development trends. The main findings of the study revealed that the land area for settlement development (built-up) increased rapidly with the proportional loss of other land uses from 1989, five years before the change in government to 1999, five years after the change. This is related to various policies that enabled land ownership by all South Africans. Statistics South Africa's (Statistics SA) available demographic data also confirmed a population increase for the study area for the years under study.

Keywords: Settlement development, remote sensing, apartheid, spatial pattern.

### **3.1 Introduction**

Recent changes in human settlement development and their effects on the environment call for serious environmental concerns by experts and the human population. The effects include climate change, land degradation, loss of biodiversity, and pollution of air and water. Loss of agricultural land to human settlement development was noted as the highest form of land cover change in South Africa (Musakwa & Van Niekerk, 2013). This forms the focus of this study; to determine the changes in the development of settlement patterns in the three selected settlements of Thabo Mofutsanyana municipality in the Drakensberg mountain of Afromontane region, the Free State province of South Africa using Landsat and time-series data. This study is important because of its peculiarity of settlement development in the mountainous area of Drakensberg mountain of Afromontane region. The topography of the area is characterized by low/ high mountain

and irregular land, which occurs above 1,500 to 2000m elevation near the equator (Brand *et al.*, 2008). Though, there is no universally accepted definition for mountain, elevation, volume, relief, steepness, spacing and continuity have been used as criteria for defining a mountain. In the United Kingdom and Ireland, a mountain is defined as any summit of at least 610m high (Nuttall & Nuttall, 2008; Wilson, 2001). The United Nation Environmental Programme's definition of a mountain includes elevation of at least 300m and could even be as high as 2500m or above (Blyth *et al.*, 2002a; Blyth *et al.*, 2002b)

Human settlements refer to *"the totality of the human community, whether city, town or village with the social, material, organizational, spiritual and cultural element to sustain it"* (Habitat, 1976). Settlement development change, as well as urbanization, are global phenomena that are important developmental procedures impacting the physical environment via numerous socioeconomic and ecological procedures (Basiago, 1998). Settlement can be divided into two; urban and rural settlement. Urban settlements are towns, cities, informal settlements, and peri-urban areas and are usually characterized by high populations while rural settlements are areas in which people depend directly on their immediate environments through agriculture, fishing and the collection of resources for their daily needs and are usually characterized by a low population (Habitat, 1976). Settlement patterns all over the world differ from one place to another at different times. Thus, the study of spatial analysis to human beings and environmental sustainability is of great importance. These spatial relationships between and amongst settlements are shaped by commerce, people's ideas, government policies, and the processing of raw materials into finished products (Cannon, 1990; Owusu, 2005). Thus, settlement patterns influence the environment, population distributions, the use of natural resources, which can generate economic prosperity (Sarkar, 2010).

The history of socio-political change in the South African government is substantially connected with urbanization, which is a major force in settlement development. The change from minority rule to the majority rule is perceived to have brought up a different situation that poses challenges before key players in the environment (Madlingozi, 2007). The change in governance informs the pattern of development in most communities in

South Africa (Pallister-Wilkins, 2011; Turok, 2014b). Some of the effects of the changes in government are haphazard development in the form of shacks and other informal settlements in and around cities (Onaolapo *et al.*, 2020), and one of the major ways to monitor such land cover changes is through the use of satellite data from remote sensing (Coppin *et al.*, 2004; Kleynhans *et al.*, 2012; Lu *et al.*, 2004).

The use of GIS and remote sensing to monitor land use pattern and developmental change requires downloading two or several images with high resolutions at different times, compilation and arrangement of the images and grouping of each pixel which enables the researcher to put the images into different classes (Moser *et al.*, 2007; Radke *et al.*, 2005b). Land use patterns and developmental changes in small and large settlements have been successfully monitored using these techniques (Coops *et al.*, 2009b; Hansen *et al.*, 2003; Hansen *et al.*, 2000; Mildrexler *et al.*, 2007; Mildrexler *et al.*, 2009).

The Remote sensing data collection technology gives room for computer analysis and less human involvement, thereby enabling the processing of large datasets in less time. The areas that are most affected by these changes in settlement development could further be looked into as “areas of special planning”. Mapping changes through remote sensing is time-saving, cost-saving, and resource-effective. High, medium, or low-resolution aerial or satellite images help in mapping out old or new settlements, comparison of images taken at different periods helps in determining the changes over time as well as the emergence of new settlements (AbuHafeetha, 2014). Lloryd *et al.* (2016) emphasized the need for GIS tools to monitor and plan for land use development for Monrovia in Liberia after the civil war in 2003. He discovered a haphazard development during the war created a problem of development control in which 1.2 million people had settled over a large space of land without any restriction (Lloyd *et al.*, 2016).

Drastic land use and socioeconomic changes have led to urbanization and environmental concerns. Such a change in population and environment coupled with less functional land use planning and lack of development control resulted in the environmental decline,

indiscriminate landscape development, misuse of land, and strain on the ecosystem structure. Consequently, more forest areas and farmland have changed to built-up areas and other urban development in recent years (Coppin *et al.*, 2002). This is also the case in Thabo Mofutsanyana district municipality in the Afromontane region (Krannich *et al.*, 2011; McGranahan, 1999; Urban *et al.*, 2016). Mountainous areas received little or no attention with regard to spatial planning. Their unique nature demands for adequate monitoring and planning, hence, the need for an in-depth study of the land-use patterns and assessing developmental trends over the period of time, which is important for future development and management. This article identifies the changes in human settlement developments in the three selected settlements of Thabo Mofutsanyana municipality, within Drakensberg mountain, Free State province using remote sensing and GIS.

### **3.2 Description of the Study Area**

Thabo Mofutsanyana municipality is within Drakensberg Mountain, Free State province of South Africa (Figure 3.1). Free State is made up of five district municipalities and each district municipality is made up of several local municipalities. Thabo Mofutsanyana district municipality has six local municipalities, which are Maluti-A-Phofung, Phumelela, Nketoana, Dihlabeng, Setsoto, and Mantsopa. It has a total population of 769,761 people, a population density of 28.9 people per Km<sup>2</sup> and a land surface area of 33 269 km<sup>2</sup> (Statistics, 2012). The majority of its people speak Sesotho (2011 Census). The primary economic activity of the municipality is agriculture and the administrative office is at Phuthaditjhaba. The municipality is bounded by Maluti, Drakensberg and Eastern Free State mountains and by the Eastern Cape, KwaZulu-Natal and Lesotho, which project a charming and beautiful scenery for tourism in the region (Statistics, 2012). The municipality makes the second smallest contribution to the GDP of the Free State with trade, retail, wholesale, financial, and community services being the core contributing sectors. Furthermore, its annual importing and exporting value is the second smallest among the five municipalities (Statistics, 2012). The municipality is situated in a rural area in the eastern Free State, and it includes the former homeland of Qwaqwa. It was also declared a Presidential Node in the early 2000s. The topography of the study area is a

low mountain and irregular shapes. Maluti-A-Phofung contains 55.5% of the municipality's total population. Three settlements were selected one from each of three local municipalities for this research; Maluti-A-Phofung local municipality – Highest population/lowest land area in the municipality; and Harrismith, which is strategically placed between two prominent cities of South Africa, which are Johannesburg and Durban, it represents the urban settlement out of the three settlements under study, it has a population of 27,869 (Statistics, 2012). Phumelela local municipality – Lowest population/ largest land area, Vrede has a small population below 2000 people with a large area for farming; it represents the least urbanized in the hierarchy of the three settlements under study (Statistics, 2012). Mantsopa – Average land extent and population, it is located at the southern part of the municipality and Ladybrand is a town close to Maseru the Lesotho border, (This is very significant to the town's development pattern), and it represents an average town between the three settlements under study. It has a population of 4218 in 2011 (Statistics, 2012).

The periods of study were chosen at interval of about ten years. (i.e., 1989, 1999, 2009 & 2018) for even monitoring; the first year represents five years before s-+ while the second year represents five years after the change of government from minority to majority rule.

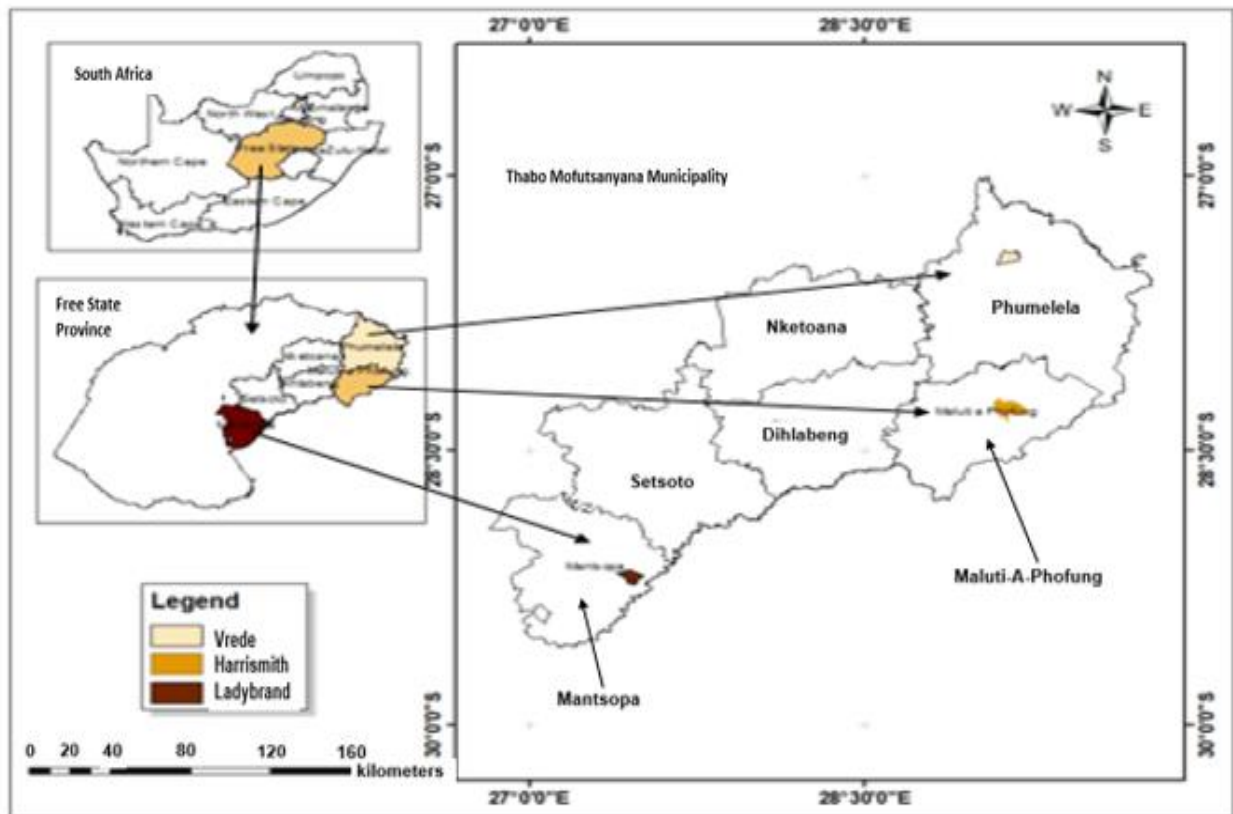


Figure 3.1: Map of Thabo Mofutsanyana municipality in the context of Free State province and South Africa.

### 3.3 Research Methodology

Satellite imagery makes available spatially dependable data sets covering a vast space with high temporal frequency and high spatial details (Jensen, 2009; Thapa & Murayama, 2009a, 2009b). Remote sensing is also capable of providing dependable historical time-series data that dates as far back as the 1970s (Rogan & Chen, 2004) In this research, temporal changes in the patterns of the landscape were identified using high resolution data from (LANDSAT TM and OLI). Table 3.1 contains a list of data used in this research.

Table 3.1: Sources of study data

Date of Acquisition	Source/Sensors	Resolution
03/1989	Landsat 4-5TM	30m
03/1999	Landsat 4-5TM	30m
02/2009	Landsat 4-5TM	30m
02/2018	Landsat 8 OLI	30m

A preliminary survey was done to gather data for the development of a classification scheme and to serve as physical data validation for classification and assessment of the images that were classified. Three scenes of Landsat4-5 Thematic mapper (TM) for 1989, 1999, and 2009 images and one scene of Landsat-8 Operational Land Imager (OLI) of 190/55 acquired images were the data sources (Table 3.1), downloaded from the United States Geological Survey (USGS) Glovis website. The images were downloaded based on the clearest visibility as they appeared on the satellite within the same season of the year. Imageries were pre-processed. Six image bands used for this study were geometrically rectified to Geographic Coordinate System.

Landsat images of 1989, 1999, 2009, and 2018, an interval of a decade (or near decade) were chosen to monitor a continuous change in the human settlement. Also the first two years represented five years before and five years after 1994 (i.e., 1989 and 1999) respectively. Various images used in change detection analysis were the captured images that were gathered around the same time of the year, which certainly boost the accuracy of the result of the spatial changes.

### 3.3.1 Image Pre-Processing

The images appeared in distinct data\_sets like tiles for the same coverage of the same year and therefore needed to be joined together to form a full image of the area under-study. Each distinct image was then mosaicked together with others to form a unified data\_set that was assessed to detect the changes. ArcGIS software was used for spatial referencing of every resulting mosaic; it was then clipped and worked upon to get the spatial changes for the study area.

### 3.3.2 Image Processing and Classification

After pre-processing, every mosaicked image was segmented into four land cover and land use classes, which are; built-up (i.e., human settlement), vegetation (Agriculture, forest (trees, bushes, shrubs, and grasses)), bare soil (undeveloped and over-grazed land), and water (streams and rivers, etc.) as described in Table 3.2. Several researchers have used the application of remote sensing in settlement studies, and many studies have been done using different image classification algorithms (Blaschke *et al.*, 2008; Lu *et al.*, 2006; Sinha *et al.*, 2015). The unsupervised classification was explored, and the likelihood algorithm was assessed for accuracy. Other researchers have posited that Maximum likelihood was the best (Dean & Smith, 2003). Hence, it was employed for classification of the images for years 1989, 1999, 2009 and 2018 and was later used to determine the changes.

For an improvement in the visual interpretation, the images were enhanced, their contrasts stretched and false-colour composites were generated to increase the distinctions between their features. Initially, association analysis, texture, and knowledge-based visual interpretation were performed, followed by a careful analysis of the Landsat images while working on the land use classes.

This preliminary interpretation limited the artificial errors and facilitated the selection of the most appropriate clusters for further processing. The process used for supervised classification required the extraction of recognized samples from the images representing every class as training data. Spectral signatures, created from the resulting training data, were then used to represent each class used for classification. The method, which has the maximum likelihood parameter, was used for accuracy improvement of the land use classification for the images for all four dates (1989, 1999, 2009 and 2018). Then, the CART classifier was used in classifying the maps using cross-validation of 70% training and 30% test; the accuracy assessment was calculated for each settlement using a cross-tabulation matrix (Foody, 2002). The results of the classifications are the map.

Table 3.2: Land use and land cover classes

	Classes	Class Description
1	Built-up	Settlements, Man-made structures and Roads
2	Bare land	Undeveloped and grazed land
3	Vegetation	Agriculture, forest (trees, bushes, shrubs, and grasses)
4	Water	Streams and rivers etc.

### 3.3.3 Validation

Accuracy assessment was done based on both qualitative and quantitative assessments to validate the result of the classification. It was first done visually, which was not absolutely reliable. In order to validate the previous images, historical data through the information received from community leaders in the study areas was used to confirm most of the results from the research. The other quantitative phase was that the accuracy was assessed by comparing the area ratio of the produced map to that of the reference data. The setback for this method was that validation could only be done on the current image based on the field data collected. The assumption was that the previous years were correct based on the accuracy of the recent image. The producer and user accuracy explained the classification accuracy. The error matrix is generally accepted as a tool for land-use classification accuracy (Li & Song, 2019).

The results of supervised classification, when compared with the unsupervised classification, give an accuracy of between 82% and 92% of the computed sample size after performing an accuracy assessment test using a cross-tabulation matrix. Generally, an accuracy of between 80-85% is acceptable for land cover maps (Foody, 2002). The overall accuracy of classification was 87% for Harrismith, 92% for Vrede, and 82% for Ladybrand.

### **3.4 Results**

Each of the classified images produced a noticeable land use land cover change in Harrismith with various increases and decreases for all the years (Figure 3.2). The built-up areas proliferated progressively in those years under study with a consistent increase of 3.82% to 9.06% and 11.15% to 18.71% in the years 1989, 1999, 2009 and 2018 respectively. There was a little increase in vegetation area coverage from 44.83% in 1989 to 47.79% in 1999 but later declined greatly by 2009 to 32.40% and later to 16.61% in 2018. The bare surface varied with decrease and increases from 50.47% to 41.65% and 54.29% to 62.17% in 1989, 1999, 2009, and 2018 respectively. Water bodies increased slightly in the first three years under study with 0.88%, 1.47%, and 2.59% but later decreased to 2.48% in 2018; this depended on the precipitation rate during the years. Accuracy assessment for Harrismith maps was 87%. The analysis of the images for Harrismith map was presented in Figure 3.2.

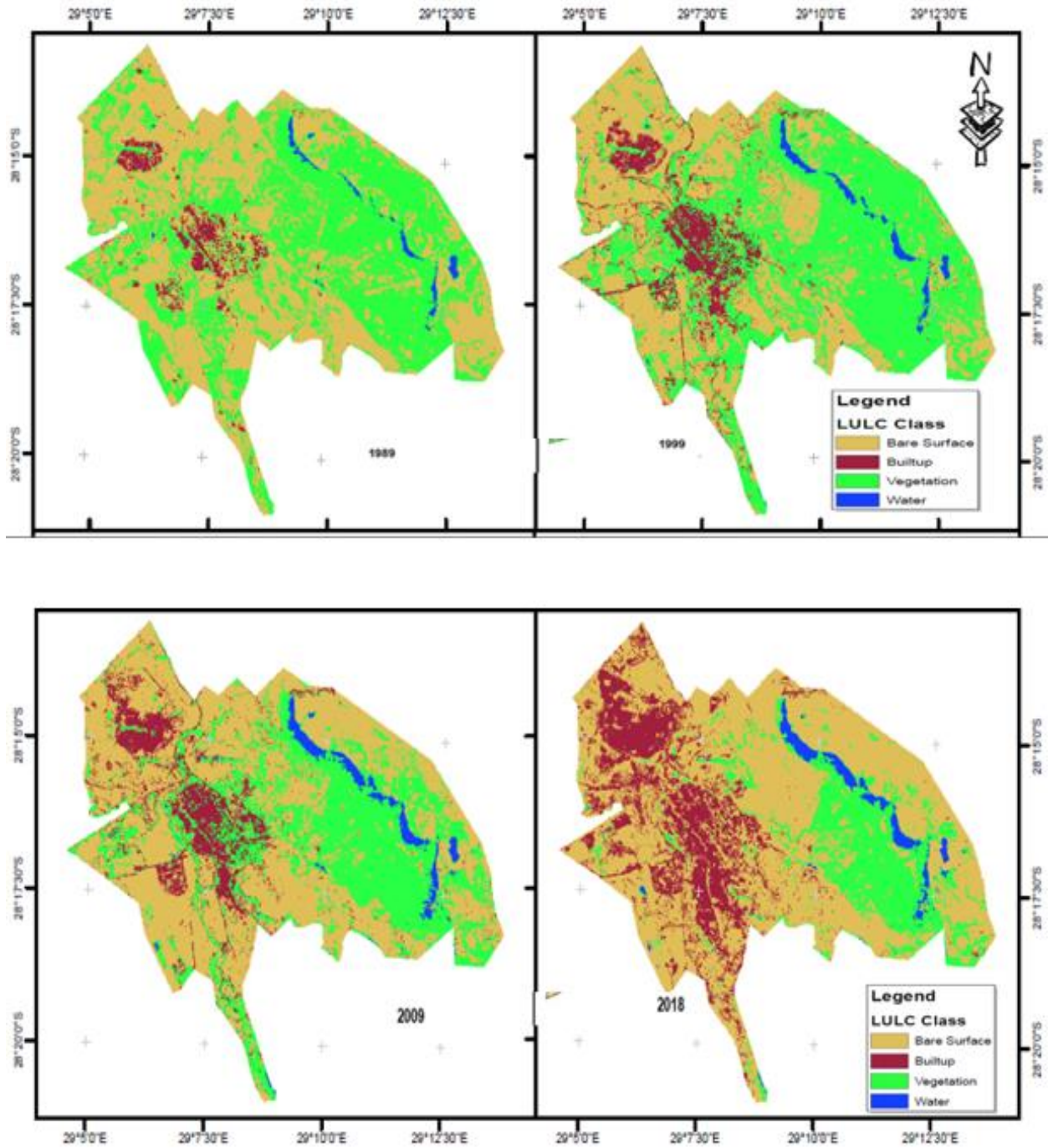


Figure 3.2: Land use land cover classification, Harrismith.

Table 3.3 shows in figures the coverage for each land cover/land use classes on Harrismith maps. It displays a constant increase in settlement development from the year

1989 to the year 2018. Bare surface and vegetation revealed matching changes in the same way.

Table 3.3: Classification of land use land cover of Harrismith

Class	1989		1999		2009		2018	
	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)
<b>Builtup</b>	3.9780	3.82	9.4545	9.06	11.6379	11.15	19.5255	18.71
<b>Vegetation</b>	46.8054	44.83	49.8859	47.79	33.3837	32.40	17.3358	16.61
<b>Bare Surface</b>	52.6428	50.47	43.4745	41.65	56.6793	54.29	64.8963	62.17
<b>Water</b>	0.9216	0.88	1.5336	1.47	2.6469	2.59	2.5902	2.48
<b>Total</b>	104.4	100	104.4	100	104.4	100	104.4	100

Each of the classified images produced a noticeable land use land cover change in Ladybrand with various increases and decreases for all the years (Figure 3.3). The built-up areas proliferated progressively from 5.03%, 12.53%, 13.0%, and 16.02% in those years, with a stable and rapid increase in vegetation area coverage from 41.13%, 44.87%, 66.51% and 70.63% in the years 1989, 1999, 2009 and 2018 respectively. Bare surface constantly decreases from 53.42%, 42.51%, 20.45%, and 13.29% in the years, respectively, while water bodies decreased drastically from 0.42%, 0.092%, 0.092%, and later 0.055% this might have indicated a period of drought during the years. Accuracy assessment for Ladybrand maps was 82%. The analysis of the images for Ladybrand map was presented in Figure 3.3.

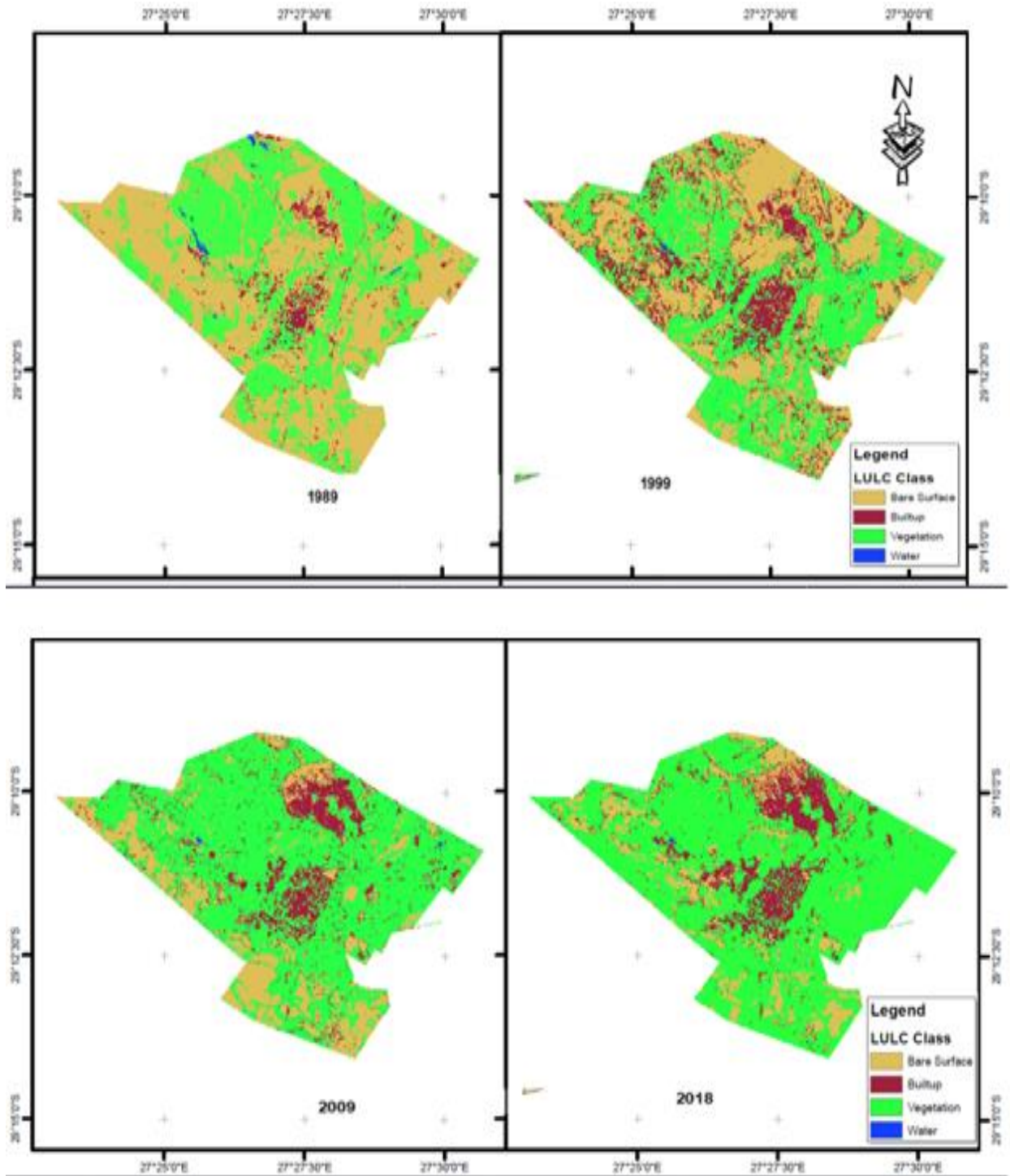


Figure 3.3: Land use land cover classification, Ladybrand

Table 3.4 shows in figures the coverage for each land cover/land use classes on the Ladybrand maps. It displayed a constant increase in settlement development from the year 1989 to the year 2018. Bare surface constantly declined while vegetation proliferates steadily. Water bodies constantly decreased.

Table 3.4: Classification of land use land cover of Ladybrand

Class	1989		1999		2009		2018	
	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)
<b>Builtup</b>	2.73	5.03	6.81	12.53	7.06	13.00	8.71	16.02
<b>Vegetation</b>	22.35	41.13	24.38	44.87	36.13	66.51	38.38	70.63
<b>Bare Surface</b>	29.03	53.42	23.10	42.51	11.10	20.45	7.22	13.29
<b>Water</b>	0.23	0.42	0.05	0.092	0.05	0.092	0.03	0.055
<b>Total</b>	54.34	100	54.34	100	54.34	100	54.34	100

Each of the classified images produced a noticeable land use land cover change in Vrede with various increases and decreases for all the years (Figure 3.4). The built-up areas proliferated progressively in those years with percentages of 1.06%, 3.37%, 3.39%, and 9.58% respectively, there was also a slight decrease in vegetation area coverage from 48.46% to 35.79% in 1989 to 1999 but later increased greatly to 47.80% in 1999 and later to 74.63% in 2018. Bare surface fluctuated as it first increased from 49.50% in 1989 to 60.16% in 1999 but gradually decreased to 48.20% in 1999 and 14.88% in 2018 while water bodies decreased drastically from 0.98% in 1989 to 0.68% in 1999 and further decreased slightly to 0.62% in 2009 but later increased to 0.92% afterward. Accuracy assessment for Vrede maps was 92%. The analysis of the images for Vrede map was presented in Figure 3.4

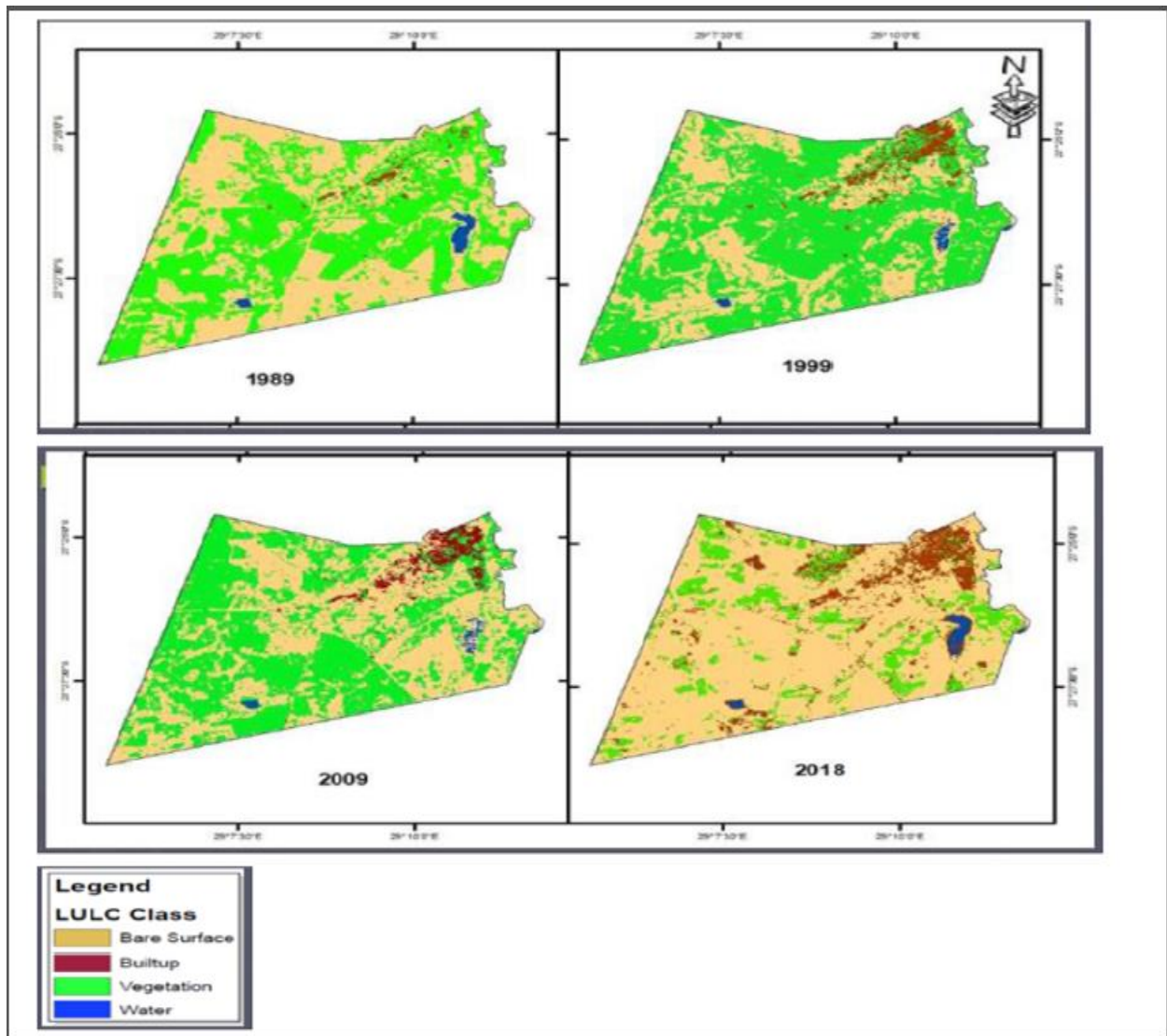


Figure 3.4: Land use land cover classification, Vrede

Table 3.5 shows in figures the coverage for each land cover/land use classes on Vrede maps. It displays a constant increase in settlement development from the year 1989 to the year 2018. Bare surface and vegetation revealed a matching change, fluctuating over the years. Water bodies decreased at first but later slightly increased in the year 2018.

Table 3.5: Classification of land use land cover of Vrede

Class	1989		1999		2009		2018	
	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)	Area (km <sup>2</sup> )	Percent (%)
<b>Built up</b>	0.53	1.06	1.69	3.37	1.70	3.39	4.80	9.58
<b>Vegetation</b>	24.29	48.46	17.94	35.79	23.96	47.80	37.41	74.63
<b>Bare Surface</b>	24.81	49.50	30.16	60.16	24.16	48.20	7.46	14.88
<b>Water</b>	0.50	0.98	0.34	0.68	0.31	0.62	0.46	0.92
<b>Total</b>	50.13	100	50.13	100	50.13	<b>100</b>	50.13	100

Classification of every image generated a noticeable change in land cover and land use, as shown in Figures 3.2, 3.3, and 3.4, with their respective Tables 3.3, 3.4, and 3.5 for the years under study. A rapid increase was observed for the built-up areas from 1989 to 1999 for the three settlements (Harrismith, Verde, and Ladybrand). On the other hand, between 1999 and 2009, Harrismith experienced a moderate increase, Ladybrand experienced a relatively low increase while Vrede had the lowest increase. The years between 2009 and 2018, there was an average increase in the built-up area in Harrismith, Ladybrand had a relatively low increase while Vrede experienced a very rapid increase.

Table 3.6 shows the built-up figures, which is a settlement development trend for the three settlements (Harrismith, Ladybrand, and Vrede) for the years under study (1989, 1999, 2009 and 2018). The figures showed an increase all along the year intervals.

Table 3.6: Classified settlement development between 1989 and 2018 (area in Km<sup>2</sup>)

Settlements	1989	1999	2009	2018
<b>Harrismith</b>	4.0	9.46	11.64	19.53
<b>Ladybrand</b>	2.73	6.81	7.00	8.71
<b>Vrede</b>	0.53	1.69	1.70	4.80

### **3.4.1 General Analysis of the Built-Up Settlement Development between 1989 and 2018**

The post-classification change detection used in Figures 3.2, 3.3, and 3.4, with their respective tables 3.3, 3.4, and 3.5, established an increase for human settlements as coverage for the built-up areas as revealed from the analyzed results showing a constant growth for the years under study. The result from 1989 to 1999 showed the highest increment in built-up areas among the range of years considered. Harrismith experienced an increase of 136.50%, an increase in built-up areas from 4.0km<sup>2</sup> in 1989 to 9.46km<sup>2</sup> in 1999, which is very rapid; Ladybrand experienced a more rapid increase than Harrismith, an increase of 149.80%, an increase in built-up areas from 2.73km<sup>2</sup> in 1989 to 6.82km<sup>2</sup> in 1999. On the other hand, Vrede experienced the most rapid increase than the other two settlements, an increase of 218.87%, a proliferation in built-up areas from 0.53km<sup>2</sup> in 1989 to 1.69km<sup>2</sup> in 1999.

This analysis revealed the situation of settlement development after the 1994 transformation of government from minority to majority rule, when various policies on human settlement development had been put in place. Two such policies which are very prominent are the Development Facilitation Act of 1995 and Housing Act 107 of 1997. These two Acts enabled any eligible citizen to own land and house, get debt relief and discount benefits and also register such property at the same time. Another important factor for the settlement expansion is that the African National Congress (ANC), the ruling political party in South Africa, proposed construction of 1 million housing units all over the country every year since their resumption in office in 1994 (Thring, 2003). As of 2001, over 1.1 million housing units had been built housing 5 million out of 12.5 million citizens living in indecent houses (Lodge & Phillip, 2003).

Usually, major political events such as independence, expiration of war, or new policy formulations are important factors for settlement development. AbuHaffetha (2014), examined the impact on urbanization of the separation wall on the sustainability of agriculture in Palestine. He discovered that this government policy led to the loss of agricultural land and a major increase in built-up areas (AbuHafeetha, 2014). Mansaray (2016) used remote sensing tools to map out urban expansion and rate of deforestation

in Freetown, Sierra Leone, pre and post-war (which occurred between 1999 and 2002). He classified land cover change between 1986 and 2015 and discovered an increase in built-up at the loss of grassland; also, the rate of land cover change increased by 28.5% between 2001 and 2015 as against 20.9% between 1986 and 2001. This happened because of the increase in population, infrastructural development, and economic growth after the civil war in 2002 (Mansaray *et al.*, 2016).

In the result for the years 1999 to 2009, the increment experienced by the three settlements is the lowest as compared to other year ranges. Here Harrismith experienced a 23% increment, an increase in built-up areas from 9.46km<sup>2</sup> in 1999 to 11.64km<sup>2</sup> in 2009. Ladybrand follows this with a 9.53% increment; an increase in built-up areas from 6.82km<sup>2</sup> in 1999 to 7.17km<sup>2</sup> in 2009, and lastly, Vrede with a 0.59% increment; an increase in built-up areas from 1.69km<sup>2</sup> in 1999 to 1.70km<sup>2</sup> in 2009. This may be because there was less pressure on the political leaders as they had delivered and seemed to have improved on the former government in meeting masses housing needs in the first five years of their rule. Then came a time to relent and focus more on other aspects of the political campaign. There was also a case of HIV epidemics between 1999 and 2008 (Shisana *et al.*, 2009), which claimed lots of lives and caused population decline, the government at this period needed to focus more on the health sector than housing.

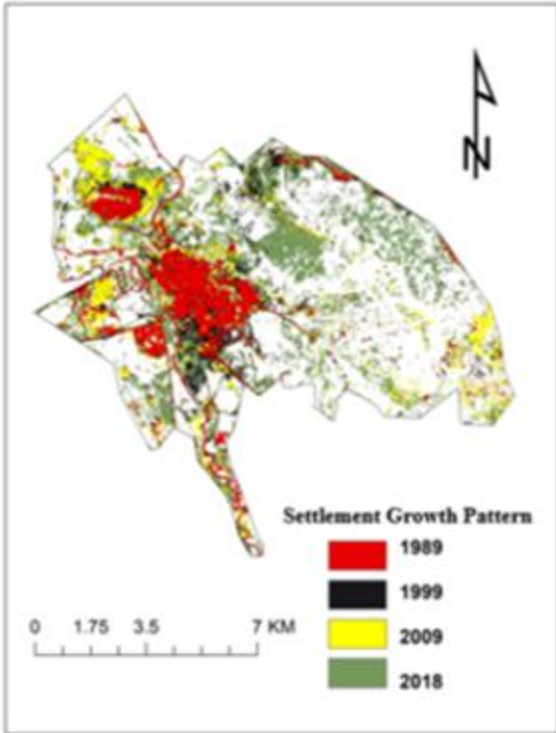
The result for 2009 to 2018 showed a moderate increase in built-up areas for the three settlements as compared to other year ranges. Vrede led in the increase with 182.35%; an increase in built-up areas from 1.70km<sup>2</sup> in 2009 to 4.80km<sup>2</sup> in 2018. Harrismith followed this with 67.73%, an increase in built-up areas from 11.64km<sup>2</sup> in 2009 to 19.53km<sup>2</sup> in 2018. Lastly, Ladybrand with 23.01%, an increase in built-up areas from 7.17km<sup>2</sup> in 2009 to 8.82km<sup>2</sup> in 2018. This was a pick-up period in the nation, and the battle of the epidemics seemed to have been won; housing activities were coming back to the limelight, and the population seemed to be stable again.

The secondary population data available was not sufficient to justify the increase in the built-up areas against population figures available. Turok assumed that historical

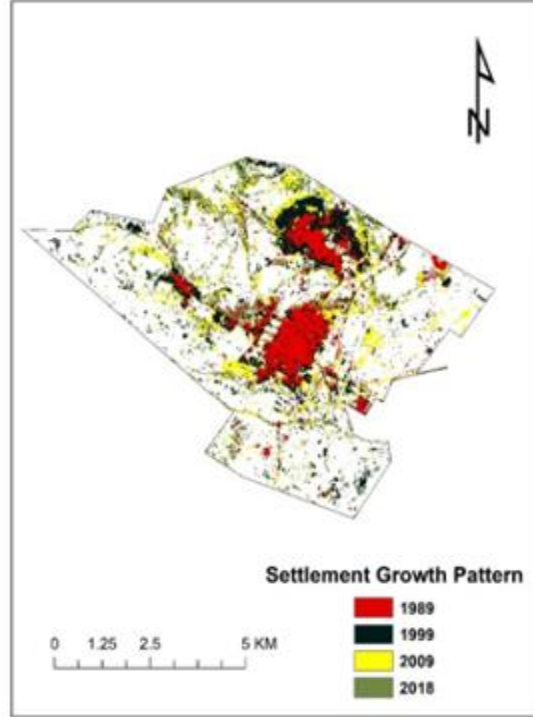
population statistics in South Africa are unreliable, believing that minority governments did not take accurate statistics of the black population before 1994. As a result of this, getting an accurate population figure for 1989, five years before transition to majority rule, is almost impossible (Turok, 2012). However, the available data for 2001 and 2011 show a minimum and average increase in population figures. The population figure in Thabo Mofutsanyana increased from 725,932 to 736, 238, and the population density from 21.8/km<sup>2</sup> to 22km<sup>2</sup>, respectively, between 2001 and 2011. Harrismith's population figure increased from 26,090 in 2001 to 27,869 in 2011, which is a 6.82% increase. The Vrede population figure increased from 1478 in 2001 to 1961 in 2011, which is 32.68%. The population figure from the Statistics SA shows different fluctuations that vary from year to year. This may be due to change in boundaries (administrative and political) from time to time and other factors which will be discovered in the course of the research.

#### **3.4.2 Specific Analysis of Spatial Patterns of Settlement Development Pre and Post 1994**

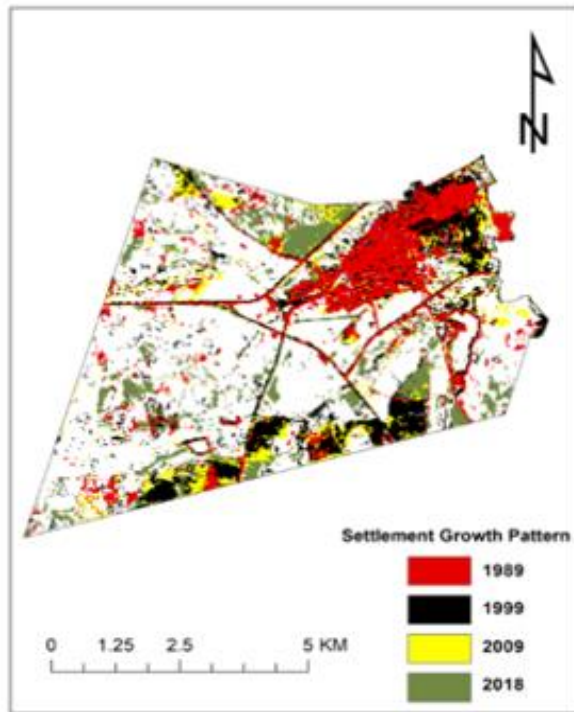
Three built up transition layer maps for the years' intervals 1989–1999, 1999–2009, and 2009–2018 were presented to show a detailed settlement development change pattern. Figures 3.5a, 3.5b, and 3.5c below show maps of settlement (built-up) development. The spatio-temporal maps revealed an expansion in the built-up area of the study area within the years of study, years 1989, 1999, 2009, and 2018 when the maps were overlaid.



a.



b.



c.

- (a) Figure 3.5a: Spatial pattern of settlement development, Harrismith.
- (b) Figure 3.5b: Spatial pattern of settlement development, Ladybrand.
- (c) Figure 3.5c: Spatial pattern of settlement development, Vrede.

Figure 3.6 illustrates the percentage increase in built-up land in the years under study (1989, 1999, 2009, and 2018) for the three settlements. The figure shows a growth in the percentage changes in the built-up area of the study areas within the years under study.

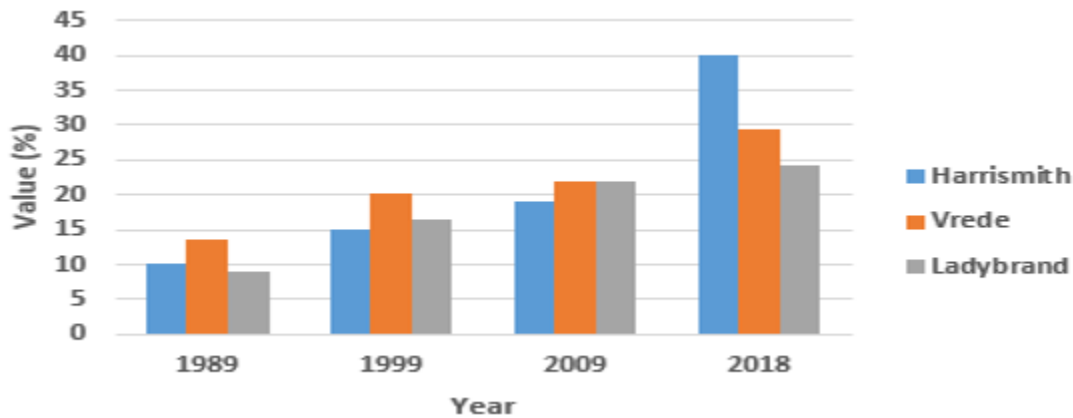


Figure 3.6. Percentage increase in built-up land in years under study.

### 3.5 Discussion

The built-up area in Harrismith increased from 3.82% (3.98km<sup>2</sup>) of the total land area in 1989, five years before 1994 to 9.06% (9.46km<sup>2</sup>) in 1999, five years after 1994. Ladybrand also increased in built-up from 5.03% (2.73km<sup>2</sup>) in 1989 to 13.02% (6.81km<sup>2</sup>) in 1999. Vrede's built-up area increased from 1.06% (0.53km<sup>2</sup>) of total land area in 1989 to 3.37% (1.69km<sup>2</sup>) in 1999. A field survey was conducted and revealed that the rapid increase experienced by these three settlements was due to the new policies after 1994, which gave rights to both Blacks and Whites to own land and have title deeds in any part of the country (James, 2007). This gave rise to tent dwellers before 1994 registering them by way of grants from Housing Acts 107 of 1997 (James, 2007).

Furthermore, this study attributed the change that occurred in land use land cover of the nation, to the transition of government from minority to majority rule, and this has in one way or the other affected the entire landscape of South Africa. In developing countries, less attention has been given to settlement planning and development in and around the mountainous region, whereas mountains provide shelter, tourism, economy, energy source, water supply, and food. The liberty created by the majority rule to own land and houses which in a way is pro poor seemed to be taken for granted especially in the less urban areas in the municipality. This made development around these places to be less controlled, rendering the important feature (the mountain) to be misused and degraded. Effective and functional planning and development schemes need to be put in place to curb this misuse and preserve the essential features. These in a way will improve the livelihood of the residents and help achieve sustainable mountain development which is one of the United Nation's goals on Sustainable development (De Los Andes, 2012).

Other land uses such as agricultural, shrubs and grassland in Harrismith and Ladybrand show a little increase from 44.83% in 1989 to 47.79% in 1999 and 41.08% in 1989 to 42.75% in 1999 respectively, then decrease in percentage in the later years in Harrismith, but increase in percentage in the later years in Ladybrand. Vrede's decrease from 48.46% in 1989 to 35.78% in 1999, then increased in the later years after the change from the apartheid system of government to majority rule in 1994, which may be due to an increase in agricultural activities.

### **3.6 Conclusion**

Research findings have confirmed the application of remote sensing methods in mapping spatial changes in settlement development in the mountainous region. The present land use results reflecting the changing patterns over-time are essential in Thabo Mofutsanyana municipality, particularly for the management of resources in spatial development and land distribution. It can then be inferred that remote sensing is a highly useful tool to establish patterns of land-use change and for facilitating land management and spatial planning. This phenomenon was confirmed in this study using Harrismith, Ladybrand, and Vrede. The images showed that the expansion of settlements was

particularly noticeable around tarred and untarred road areas. However, it is ascertained from the study that the transition of government was a significant factor in land use land cover change in Thabo Mofutsanyana. Also, the economic factor as a result of tourism attraction created by the mountains could be responsible for settlement development in terms of temporary homes and camps. Harrismith is a town between two major cities of South Africa, which are Johannesburg and Durban; this location factor may somehow be responsible for some people's settling there. Ladybrand is a city that is very close to Maseru, a border town and capital of Lesotho. Migrants from Lesotho are likely going to settle at Ladybrand temporarily or permanently when they first get to South Africa. More research will be conducted on other possible reasons for settlement development in the study area.

Settlement development (built-up area) is an apparent land cover change in the area as compared with other land uses in the study area. This implies that the environment is much affected by human activities in settlement expansion. Few works of literature have highlighted physical factors like geographical location, topography, and water bodies, or economic, political, and social reasons as forces behind settlement development patterns and forms (Berry, 2015; Hall, 1997; Thapa & Murayama, 2009a). Further studies could also look at spatio-temporal distributions of settlement change and factors influencing those changes. They would be complementary studies for this research. This study endeavoured to create awareness in the area of mountain development, sustainable settlement planning, as well as a comprehensive development control strategy to preserve the environment around the mountain.

## CHAPTER 4

### SPATIO-TEMPORAL PATTERN OF HUMAN SETTLEMENT DEVELOPMENT IN THE AFROMONTANE REGION USING GIS, REMOTE SENSING, AND SPATIAL METRICS



This chapter is based on:

**Titilope F. Onalapo**, Tom W. Okello & Samuel A. Adelabu (2020) “*Assessing spatio-temporal settlement patterns in Eastern Free State, South Africa, pre and post-transition from apartheid to majority rule.*” *Journal of Transactions of the Royal Society of South Africa*, DOI: 10.1080/0035919X.2020.1755743

## **Abstract**

The spatial pattern of human settlements, its changes, and their geographical implications are important for understanding the drivers of land use and land cover change. This paper examines the spatio-temporal pattern of settlement development in three different settlements of Thabo Mofutsanyane municipal district, namely Harrismith, Vrede, and Ladybrand, using GIS, remote sensing, and spatial metrics techniques. The study is based on 30-years of time series data compiled from satellite images with emphasis on pre and post 1994 (the year of change in government from apartheid to majority rule) spatial changes in settlements development. Landsat 4-5 imageries for 1989, 1999, 2009, and Landsat 8 OLI for 2018 were downloaded and classified for land use land cover change. Also, landscape and class metrics were computed using Fragstats QGIS 2.18.9 to generate spatial analysis. A dynamic spatial pattern is observed in the settlements under study. Urban built-up areas had a rapid trend of growth in Harrismith from 1989 (5 years before the transition from minority to majority rule) to 1999 (5 years after the transition from apartheid to majority rule) but later slowed down in the subsequent years under study. Ladybrand and Vrede had a moderate growth trend in the years under study. The settlement development process has developed fragmented and heterogeneous land-use combinations in the years after 1994. At the landscape level, land fragmentation occurred due to land-use changes and significant urban expansion. Ladybrand experienced more physical connectedness than Harrismith and Vrede; while at class level, Ladybrand and Vrede are more aggregated or physically connected than Harrismith. This means Harrismith was relatively more fragmented than the other two settlements. The study results show that LULCC and landscape metrics integrated approach is effective in analyzing and describing the spatial patterns of urban landscapes.

**Keywords:** land-use change; spatial metrics; Landscape metrics; GIS; remote sensing; spatial pattern; fragmentation; Land use land cover classification.

## 4.1 Introduction

There are variations in the spatial exhibition of settlement patterns and their impacts on the ecosystems of the world's population (Miller & Small, 2003; Thapa & Murayama, 2009a). Spatial arrangements of human settlements directly affect water qualities, bio-diversities as well as land use land cover change. (Gude *et al.*, 2006). Therefore, human settlement is the central connection between the population and the globe and reveals the relationship between human beings and their surroundings. The availability of social amenities, food production capacities, communications, and economic factors determine settlement locations (Fragkias & Seto, 2009; Lin *et al.*, 2012). Factors such as water availability, nearness to transport facilities, and topography often influence settlement locations (Robinson *et al.*, 2012; Su *et al.*, 2011), thereby leading to uneven distribution of human settlements across different spatial measures. In-depth cognizance of ecological procedures, land use, and land cover changes, lifestyles, and cultures are derived when spatial patterns of settlements are analyzed. There have been several case studies recently, which analyzed the spatial patterns of human settlements (Su *et al.*, 2011; Tian *et al.*, 2012), unlike previous studies which emphasized the shape, density, and area of human settlements (Fan *et al.*, 2009). However, this research moved further to examine the factor of politics to analyze the changes in the Spatio-temporal pattern. Spatio-temporal pattern change of settlement development using fragmentation, landscape, and class level metrics have not been given much attention in South Africa (Gatrell *et al.*, 1996; Tian *et al.*, 2012).

Geographical factors that are based on site and the situation can affect human settlement patterns. Topographical factors were examined in China by Liu *et al.* (2005), and it was discovered that the lands with a lower gradient were usually preferred for development (Liu *et al.*, 2005). The spatial pattern of human settlements considering geographical differences and environmental suitability in some locations in China were studied by Li *et al.* (2011), and it was concluded that the distribution of human settlements is proportional to the terrain (Li *et al.*, 2011b). Wei *et al.* (2013) examined the Shiyang River Basin population's spatial pattern and realized that severe environmental limitations such as hilly terrain, changing climate and the growing deserts affected their spatial distributions

(Wei *et al.*, 2013). Also were the patterns of development in the Wen-Tai region of China, specific geographical factors affected development patterns in different counties (Zhang *et al.*, 2014b). Vizzari & Sigura (Vizzari & Sigura, 2015) analyzed the physical features of border areas (in a rural area of central Italy) using landscape gradients metrics - the shape complexity, patch density, and landscape diversity. He concluded that effective land-use planning must consider a landscape gradient. Estoque *et al.* (2014) classified land use and class metrics for spatial analysis using remote sensing. Their analysis of the urban landscape pattern showed that the physical connection and density of built-up areas in three major cities in Southeastern Asia are inversely proportional to the gradient of the distance from the city centre (Estoque Ronald *et al.*, 2014). Gbanie *et al.* (2018), using classified images before and after the war in Western Serra Leone to investigate the land use cover dynamics found a decline in protected and other forests and an increase in the built-up and urban agriculture while landscape fragmentation increased (Gbanie *et al.*, 2018a).

Mapping of morphology and growth of urban areas using remote sensing has been an age-long practice. The density, form and land use of urban areas are mapped with respect to their structure, shape, pattern, configuration, and organization of land use (Lillesand *et al.*, 2014; Thapa & Murayama, 2009b). A summarized view of vast expanse areas that are impossible to capture using conventional survey methods is made possible using satellite imagery (Tang *et al.*, 2005). Many remote sensing application using active and passive sensors are in use today such as the analysis of landscape pattern (Tang *et al.*, 2005; Yu & Ng, 2006), quantification of land-use change and urban growth (Herold *et al.*, 2003; Weber & Puissant, 2003), application to socioeconomic factors (Seto & Kaufmann, 2003), urbanization (Weng, 2007), categorization of urban infrastructure (Mesev, 2003), hydrology and microclimate (Carlson & Arthur, 2000), mapping of topography (Zandbergen, 2008) and enhancement of life quality (Gatrell & Jensen, 2008).

Land cover changes could be observed and assessed using satellite data from remote sensing (Kleynhans *et al.*, 2012; Lu *et al.*, 2004). Usually, more than one registered high-resolution images were downloaded at various times, compared and grouped by pixels (depending on the method employed) to know the changes in the land use classes (Moser

*et al.*, 2007; Radke *et al.*, 2005a). Settlement and other land use developments over large areas have been adequately monitored using these resolution time-series methods (Coops *et al.*, 2009a; Kleynhans *et al.*, 2012) as well as percentages of increase (Hansen *et al.*, 2003).

Landscape structural characteristics were explored using landscape pattern analysis by applying several spatial metrics either in the modeling of land-use change or in the studies of urban growth (Leitao & Ahern, 2002; Liu *et al.*, 2004). On this basis, the transect method has been applied in analyzing urban to rural gradients (McDonnell & Hahs, 2008; Zhao *et al.*, 2011) and in the detection of Spatio-temporal patterns (Fichera *et al.*, 2012; Li *et al.*, 2013). Nevertheless, metrics comparison may lead to inadequate comprehension of how the configuration of landscape gradient evolved and the spatial structure of transitional landscapes (Vizzari, 2011; Vizzari & Sigura, 2015).

Empirical studies have substantiated the use of both spatial metrics and remote sensing in urban modeling (Herold *et al.*, 2003; Tang *et al.*, 2005). The use of spatial metrics has provided a new platform for describing the spatial land use and land cover heterogeneity and morphological characteristics within the urban environment (Herold *et al.*, 2003). Spatial metrics are already commonly used to quantify the shape and pattern of landscapes (Tang *et al.*, 2005). Recently, there has been an increasing interest in applying spatial metric techniques in an urban environment to link land-use heterogeneity to structures and dynamic changes in urban land use (Li *et al.*, 2013).

For effective distribution of resources, socio-economic development, management, and settlement planning, it is necessary to know the pattern, size, and spatial distribution of human settlements (Arthur, 2008; Linard *et al.*, 2012). On the other hand, when the distribution of human settlement is unplanned, the ability of an ecosystem to deliver services is impaired, thereby raising diverse environmental problems such as the disruption of water cycles, increase in the risk to public health, reduction in species diversity and pollution of rivers and soils (Narayanaraj & Wimberly, 2012).

Similarly, the socio-political history of change in the government of South Africa has been associated with the issue of urbanization, which is one of the key factors of settlement

growth and development (Pallister-Wilkins, 2011). The transition from the system of apartheid to majority rule in 1994 is believed to have imposed a new situation and put various challenges before urban planners and other stakeholders (Turok, 2014a). The transition plays a major role in the form and expansion of the South African communities (Pallister-Wilkins, 2011; Turok, 2014a). It has also led to the development of a haphazard environment in the form of shacks and other informal settlements in and around cities. The impact of this change in government varies from town to town in terms of the size and nature of the damage (AbuHafeetha, 2014; Alatout, 2009).

Urbanization and its environmental effects resulted from population increase, socioeconomic developments, and land-use changes (Fragkias & Seto, 2009). In the past decades, catering for the rapid demographic and environmental changes using weak land use planning has led to the development of haphazard landscape, stress on the structure of the ecosystem, and the deterioration of the environment (Liebhold & Gurevitch, 2002). Forest and agricultural lands have been changed to human settlements and urban areas over decades (Fragkias & Seto, 2009). Hence, to monitor the urbanization and environmental consequences in the three settlements, there is a need to quantify the land use patterns and analyze the changes over time. Hanoi's urbanization decreased the spatial heterogeneity of landscape, resulting in homogenization of urban landscape structure due to several residential housing projects limited by insufficient infrastructural systems which made urban growth unevenly distributed (Nong *et al.*, 2014).

Kathmandu valley, Nepal's urbanization process, caused fragmentation of landscape and heterogeneous land use development. Haphazard and uncontrolled development generated environmental problems due to industrialization in the 70s to 80s. Urbanization also decreased due to spatial heterogeneity of landscape, resulting in homogenization of urban landscape structure (Thapa & Murayama, 2009a). This article's main objective is to examine the spatio-temporal settlements patterns in the three locations using remote sensing and spatial metrics approaches.

## 4.2 Research Methodology

### 4.2.1 Study area

Thabo Mofutsanyane is one of the five district municipalities in the Free State province, South Africa. It is also within the Afromontane region, with a spatial extent of 27°03'–29°08'S and 119°37'–121°26'E. It contains six local district municipalities, which are Setsoto, Dihlabeng, Nketoana, Mantsopa, Maluti-A-Phofung, and Phumelela. It covers 33,269 km<sup>2</sup> and had a population of about 769,761 in 2011 with a population density of 28.9 persons per km<sup>2</sup> (Statistics, 2001). It performs agricultural function primarily with the administrative centre at Maluti-A-Phofung; it is also a tourist centre of the country. It is located in the Eastern part Free State bounded with Drakensberg and Maluti mountain, Lesotho, Kwazulu\_Natal, and Eastern Cape. The topography of this region is a low mountain and irregular land; it occurs between 1,500m and 2000m elevation. Vegetation is mainly mundane grasses – with a few rocky ridges, sheetrock, and rubble patches – by numerous seasonal wetlands and by a few permanent open playas (Brand *et al.*, 2008). This region has a hot mid-summer and very cold winter, low precipitation, and distinct seasons, with daily mean maximum temperatures fluctuating between 22° and 24°C for the hottest month of January. During the coldest months (June and July), the daily mean temperature ranges from minus 2° to 0°C (Brand *et al.*, 2008). For this research, three settlements were selected from three local districts; Maluti-A-Phofung (Harrismith) – Highest population and lowest land area, Phumelela (Vrede) – Lowest population and largest land area, Mantsopa (Ladybrand)– Average population and average land area, located on the southern part of the district municipality (See Figure 4.1 for the map of South Africa containing the three settlements). Harrismith has the second-largest land area and also the second-largest population in Maluti-A-Phofung local district, Vrede has the second-largest land area and lowest population in Phumelela local district. In contrast Ladybrand has the mean population in the range of settlements and second-largest area in landmass in Mantsopa local district. Years 1989, 1999, 2009 and 2018 were chosen at the interval of 10 years (or almost) for continuous monitoring with the first two years (i.e., 1989 and 1999) representing five years before and after the transition from apartheid to majority rule respectively. Furthermore, this paper applied spatial pattern change analysis

to understand human settlement development and other land use patterns in the selected settlements of the Afromontane region.

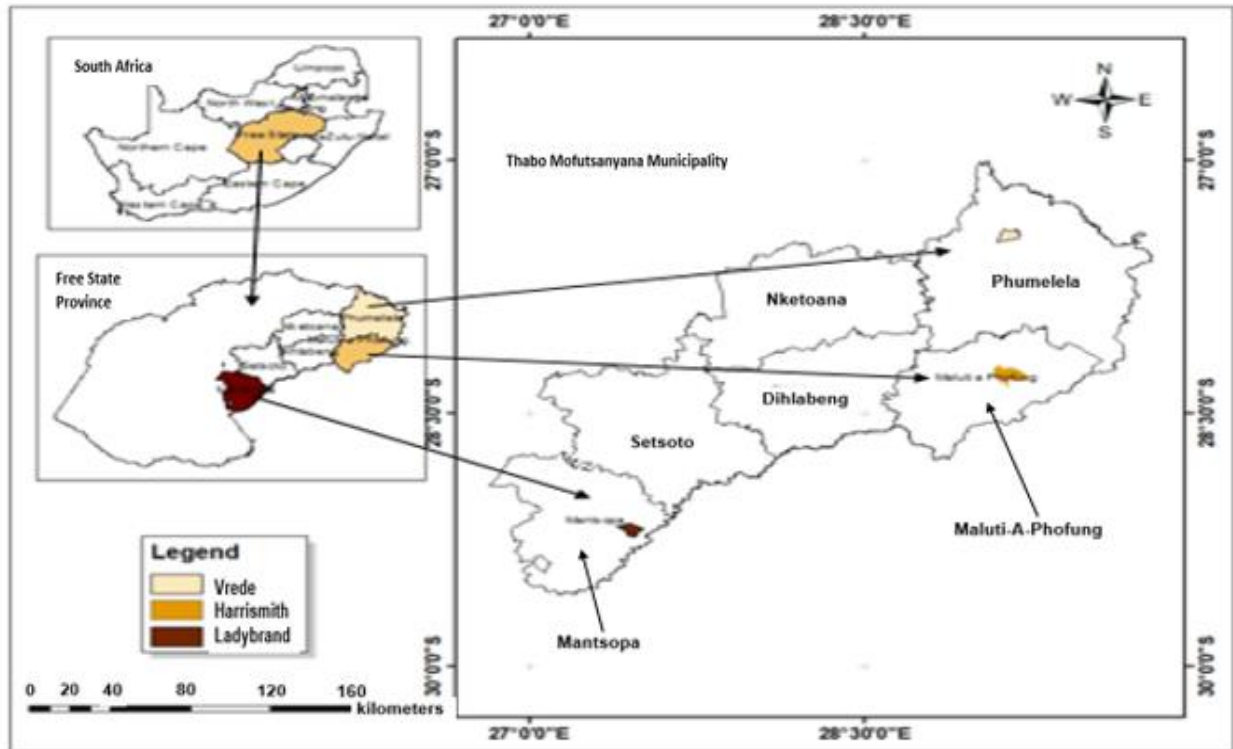


Figure 4.1: Map of South Africa showing Free State Province and Thabo Mofutsanyane with the settlements under study.

#### 4.2.2 Data source and image preprocessing

This research made use of Landsat 4-5 Thematic Mapper (TM) scenes acquired in 1989, 1999, 2009, and Landsat-8 Operational Land Imager (OLI) of (190/55) for 2018. The resolution of the images is 30m. Extractions of the datasets were done at the website of the United States Geological Survey (USGS) Glovis. Pre-processing was carried out on the six image bands; they were geometrically rectified to Geographic Coordinate System; WGS 84 UTM Zone 31S. Atmospheric rectifications, spatial filtering, histogram equalization, and contrast modification were also carried out to improve the spectral

information of the bands' combination, for land cover change evaluation. Figure 4.2 shows the methodology flowchart for this chapter.

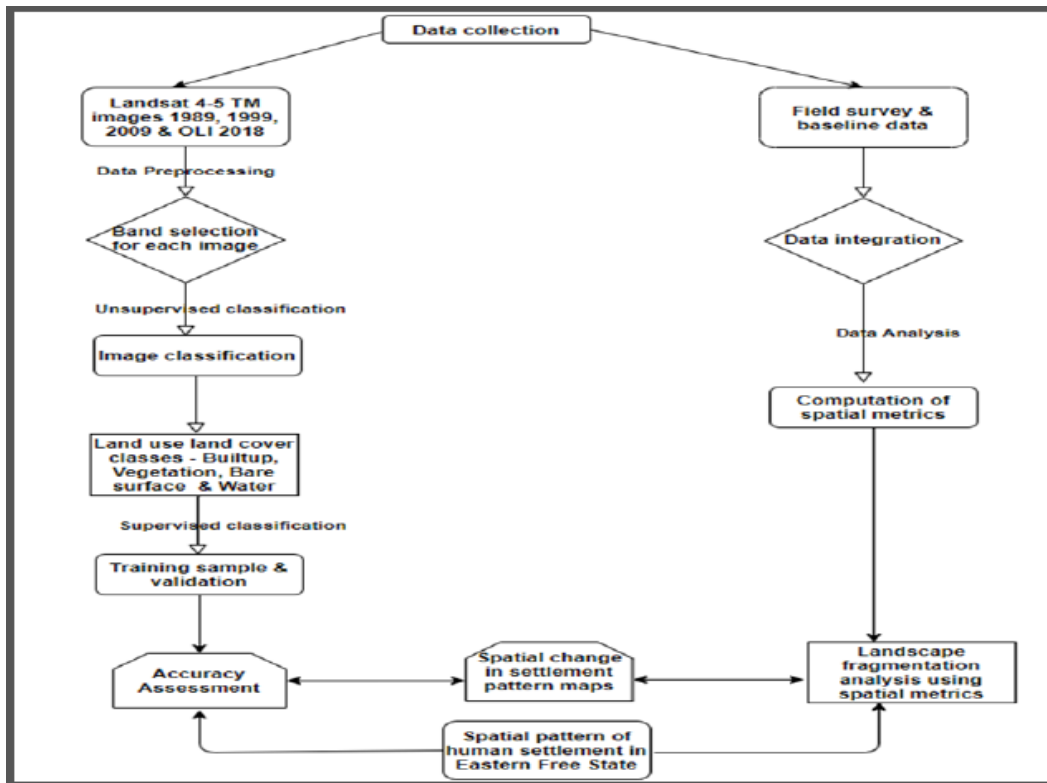


Figure 4.2: Methodology flowchart

### 4.2.3 Image classification

Image pixels were classified using the following steps: sample selection, signature evaluation, and feature selection, and finally, the classification of the image with the parametric maximum likelihood classifier. A total of 6 bands were initially used for the classification, that is, six original bands (Bands 1, 2, 3, 4, 5, and 7) (Boria *et al.*, 2014). Land use land cover classification system was modified to classify the images into four land-use classes (Table 4.1). These are, the built-up (settlements, human-made structures, and roads); vegetation (green plants, green area, green land, agricultural land,

shrubs, grasslands, and trees); bare surface (open spaces, undeveloped land, and rocks); and water (streams and river).

Table 4.1: Description of land use and land cover classes

S/N	Classes	Class Description
1	Built-up	Settlements, man-made structures and roads
2	Green plants	Agricultural land, shrubs, grasslands, trees, etc
3	Bare Surface	Open spaces, undeveloped land, rocks
4	Water	Streams, rivers, etc.

The images were classified using the maximum likelihood supervised classification system in ERDAS IMAGINE 9.2 software. CART (Classification and Regression Tree for Machine Learning) classifier was used to get the accuracy assessment using cross-validation of 70% training and 30% test. Accuracy assessment data for the first three periods under study, which are 1989, 1999, and 2009 were generated from reliable historical data as well as visual interpretation and comparison of TM and ETM color composites of the 1986 and 2000 imageries respectively (Adepoju & Salami, 2017). Images were mosaicked and joined together, registered in a reference coordinate system, and clipped, forming a unified layer of the study area for each of the periods taken into consideration.

#### 4.2.4 Landscape fragmentation and spatial metrics analysis

Metrics describe the composition and configuration of landscape pattern changes in the settlements; the metrics were computed for each land use map at the class and landscape levels. Metrics at the class level are helpful for understanding landscape development, while those at the landscape level provide relatively general information on the assessment (Bailey & Gatrell, 1995). All these metrics were calculated using the Fragstats software (Diggle, 1983), while ERDAS Imagine and ArcGIS software were used for image analysis and GIS data processing.

Considering the spatial characteristics of the system and ecological processes, nine (9) landscape-level metrics and eight (8) class level metrics were selected to analyze the Spatio-temporal changes in the landscape composition and configuration of the study area between 1989 and 2018. The raster version of Fragstats software, which was embedded into QGIS 2.18.9, was used in this study. Complete descriptions of these metrics and equations for their calculation are provided in (McGarigal *et al.*, 2002). Using Fragstats to compute landscape metrics, recode, and modeling processes were first carried out on the classified images of 1989, 1999, 2009 and 2018 in ERDAS Imagine 9.2 software. The resulting images were stored as signed-8 bit files. An eight-neighborhood criterion for the definition of patches was used. As adapted by (Tinker *et al.*, 2003), those metrics which were standardized per unit area to carry out a comparison of metrics between different periods were selected using 100 m edge influence to assess mean core area (Jaafari *et al.*, 2005; Jose *et al.*, 2011). Eight class-level metrics were derived to capture the urban landscape patterns of each of the three major settlements. They are:

The number of patches (NP): It is the total number of patches in the class. The number of patches is probably most valuable, however, as the basis for computing other, more interpretable metrics. The higher the NP, the greater the level of fragmentation.

Patch density (PD)/100 ha: Patch density has the same basic utility as the number of patches as an index, except that it expresses the number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size. Patch Density equals the number of patches in the landscape, divided by total landscape area (m<sup>2</sup>) and multiplied by 10,000 and 100 (to convert to 100 hectares).

$$PD= N/A \times (10000)(100) \quad (1)$$

N= Total number of patches in the landscape

A= Total landscape area (m<sup>2</sup>)

There is a direct correlation between patch density and the degree of disturbance. The higher the value of patch density (PD), the higher the disturbance magnitude and vice versa.

Largest Patch Index (LPI): It is the percentage of total landscape area occupied by the largest-sized built\_up patch. It is a simple measure of dominance (McGarigal & Marks, 1994). If a landscape contains one large patch occupying a large amount of the total landscape area, that patch may have a dominant and important role in the function of the entire landscape.

Fractal-Dimension Index (FDI): Fractal dimension has been used for measurement, simulation, and as a spatial analytic tool in the mapping sciences. The fractal dimension is an index of the complexity of shapes on the landscape. If the landscape is composed of simple geometric shapes like squares and rectangles, the fractal dimension will be small, approaching 1.0. If the landscape contains many patches with complex and convoluted shapes, the fractal dimension will be large.

Cohesion is a measure of physical connectedness; it approaches 0 as the portion of the landscape comprised of the focal class decreases and becomes increasingly subdivided and less physically connected.

Percentage of Land (PLAND) equals the percentage of landscape comprised of the corresponding class patches. The Class Area (CA) metrics calculate the area of the particular class in hectares. While the Mean patch size (MPS) is a measure of subdivision of the class or landscape.

The metrics were chosen to discover the spatial patterns .e.g. the aggregation, composition, and fragmentation of the landscapes of the three settlements. In previous studies, these metrics have found applications (Estoque & Murayama, 2013; Kamusoko & Aniya, 2007). These metrics were derived using the Fragstats program (McGarigal, 2014) from the input clipped Land Use Classification maps of the study areas. The metrics were computed for each land use map at the class and landscape levels. Metrics at the class level help to understand landscape development, while those at the landscape level give insights to general information on the assessment (Thapa & Murayama, 2009a).

### **4.3 Results and Discussions**

Land use classification of each of the images produced visually visible changes in land cover/land use over the period under study (Figure 4.3). The built-up areas can be seen to have increased steadily from 1989 to 2018. In 1989, 1999, 2009, and 2018 images in Figure 4.3, there was a slight increase in green area coverage from 1989 to 1999 but later decreased drastically in 2009 and 2018. There were fluctuations in the land use for bare surface. The average classification accuracy assessment of the maps in this figure (Figure 4.3) was 87%. The resultant clipped, geo-referenced mosaics of the study area for years 1989, 1999, 2009, and 2018 explained the land use/land cover changes for Harrismith.

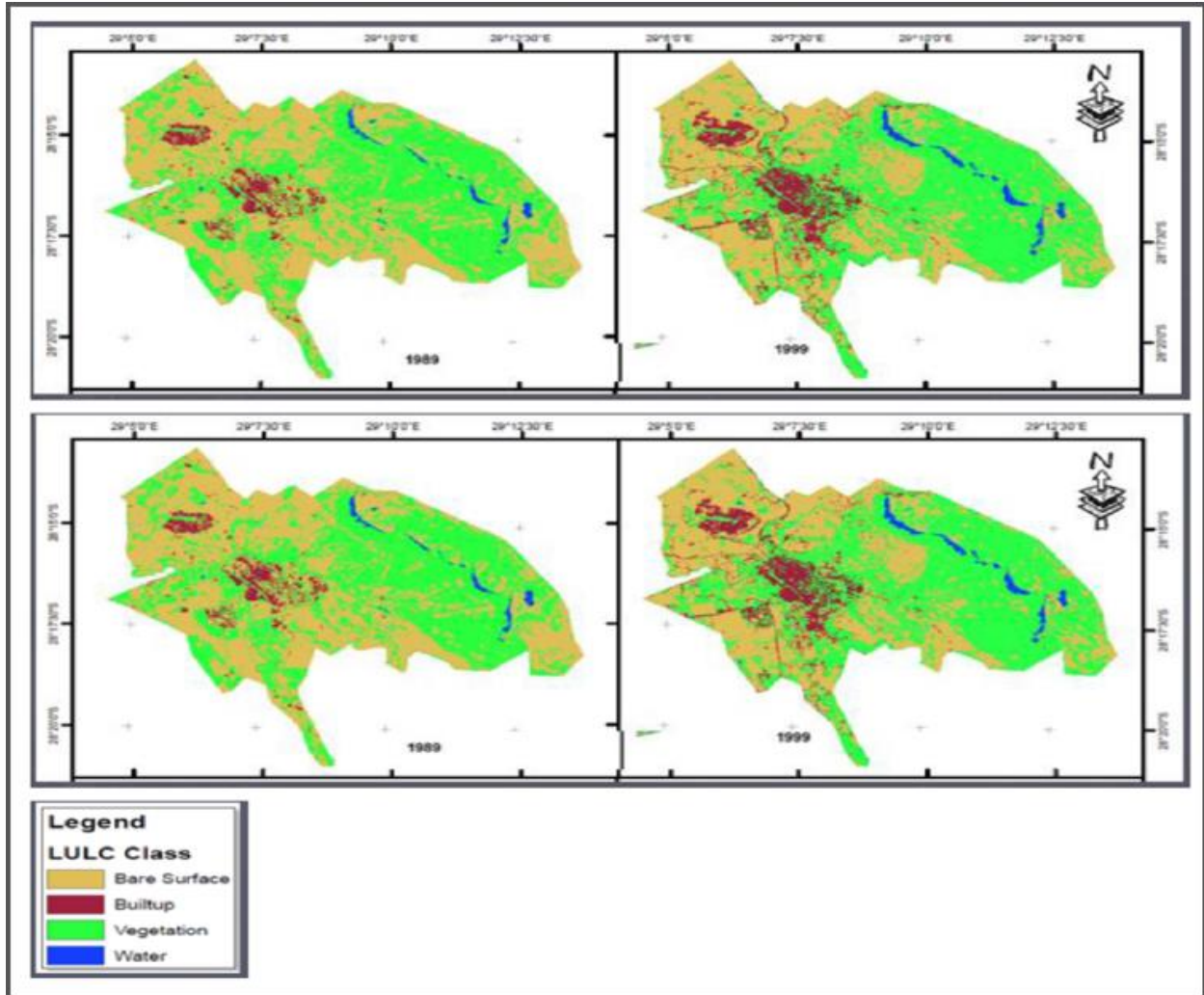


Figure 4.3: Land use land cover classification for Harrismith.

The built-up areas in Figure 4.4 can be seen to have increased rapidly from 1989 to 2018. Also, in 1989, 1999, 2009 and 2018 images in Figure 4.4, there was a slight decrease in green area coverage from 1989 to 1999 but later increased drastically in the year 1999 to 2018. There were fluctuations in the land use for the bare surface as it first increases from 1989 to 1999 but later decreases steadily from 1999 to 2018. The average classification accuracy assessment of the maps in this figure (Figure 4.5) was 92%. The resultant clipped, geo-referenced mosaics of the study area for years 1989, 1999, 2009, and 2018 explained the land use/land cover changes for Vrede.

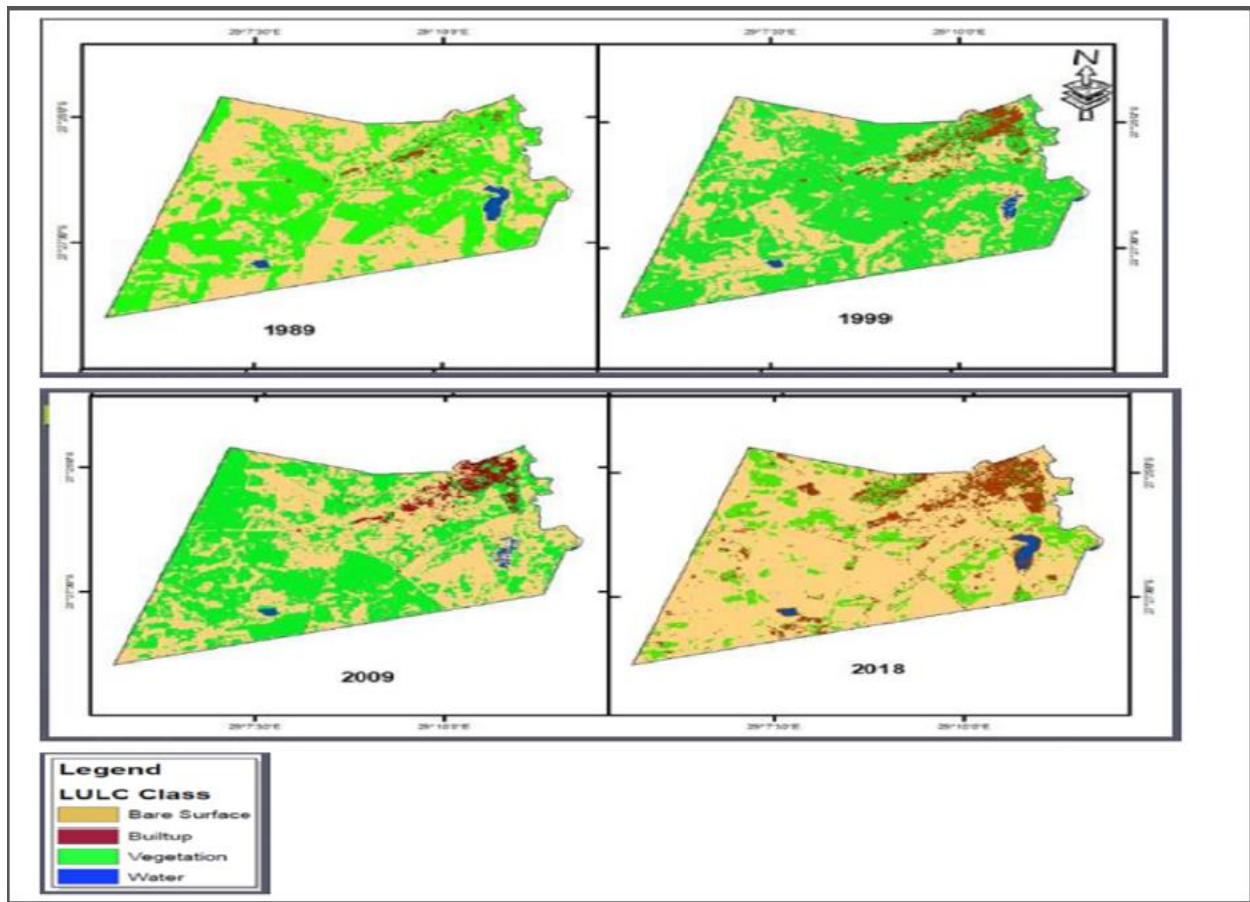


Figure 4.4: Land use land cover classification for Vrede

Figure 4.5 revealed that the built-up areas had increased steadily from 1989 to 2018. 1989, 1999, 2009, and 2018 images in the same figure showed a steady and rapid increase in green area coverage from 1989 to 2018 while there was a consistent decrease in the land use for bare surface. The average classification accuracy assessment of the maps in this figure (Figure 4.5) was 82%. The resultant clipped, geo-referenced mosaics of the study area for years 1989, 1999, 2009, and 2018 explained the land use/land cover changes for Ladybrand.

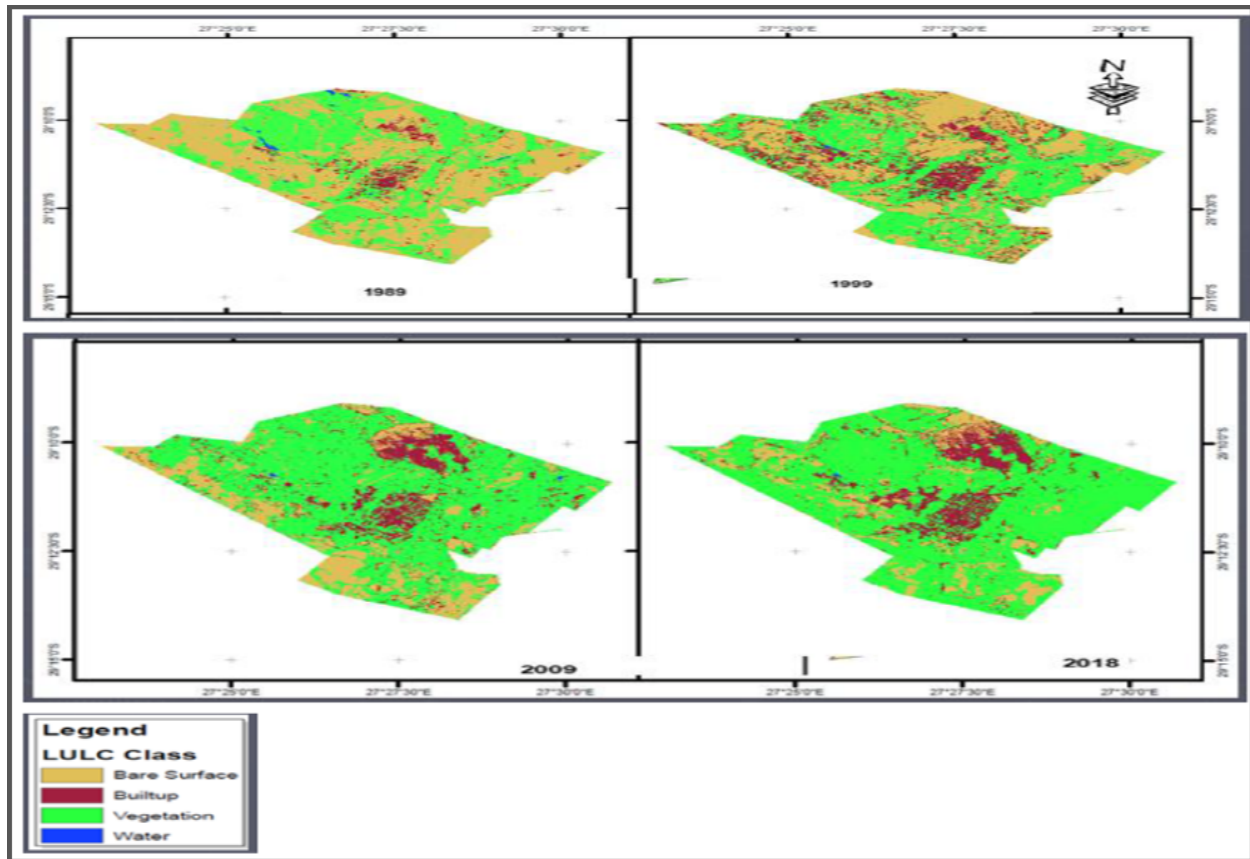


Figure 4.5: Land use land cover classification for Ladybrand

CART (Classification and Regression Tree for Machine Learning) classifier was used to get the accuracy assessment using cross-validation of 70% training and 30% test. The average classification accuracy assessment of the resultant maps was between 82% and 92% (as shown in Tables 4.2a, 4.2b, and 4.2c); with Harrismith having an accuracy of 87%, Vrede has 92% while Ladybrand has 82%.

Table 4.2.a: Accuracy Assessment for Harrismith

	Builtup	Vegetation	Bare surface	Water	Total
Builtup	25	0	1	0	26
Vegetation	0	12	0	0	12
Bare surface	4	1	4	0	9
Water	1	0	0	5	6
Total	30	13	5	5	46
Omission	0.033333	0	0.8	0	53
Commission	0.038462	0	0	0.166667	
Producer accuracy	0.833333	0.9230769	0.8	1	
User accuracy	0.961538	1	0.44444444	0.833333	
Total accuracy	87%				

Table 4.2.b. Accuracy Assessment for Vrede

	Builtup	Vegetation	Bare surface	Water	Total
Builtup	5	0	1	0	6
Vegetation	0	13	0	0	13
Bare surface	1	0	3	0	4
Water	0	0	0	1	1
Total	6	13	4	1	22
Omission	0	0	0.75	0	24
Commission	0.166667	0	0	0	
Producer accuracy	0.833333	1	0.75	1	
User accuracy	0.833333	1	0.75	1	
Total accuracy	92%				

Table 4.2.c. Accuracy Assessment for Ladybrand

	Builtup	Vegetation	Bare surface	Water	Total
Builtup	11	1	1	0	13
Vegetation	1	5	0	0	6
Bare surface	2	0	5	0	7
water	0	0	0	2	2
Total	14	6	6	2	23
Omission	0	0	0.83333333	0	28
Commission	0.076923	0	0	0	

Producer accuracy	0.785714	0.8333333	0.833333333	1	
User accuracy	0.846154	0.8333333	0.714285714	1	
Total accuracy	82%				

### 4.3.1 Land-use change before and after the transition from apartheid to majority rule

Quantification of the spatial coverage of each of the land cover/land use categories on the classified image of Harrismith showed a steady increase in built-up areas between 1989 and 2018 (Figure 4.6). The Green area and bare surface show a commensurate change in the same figure with the fluctuating changes within the period under study.

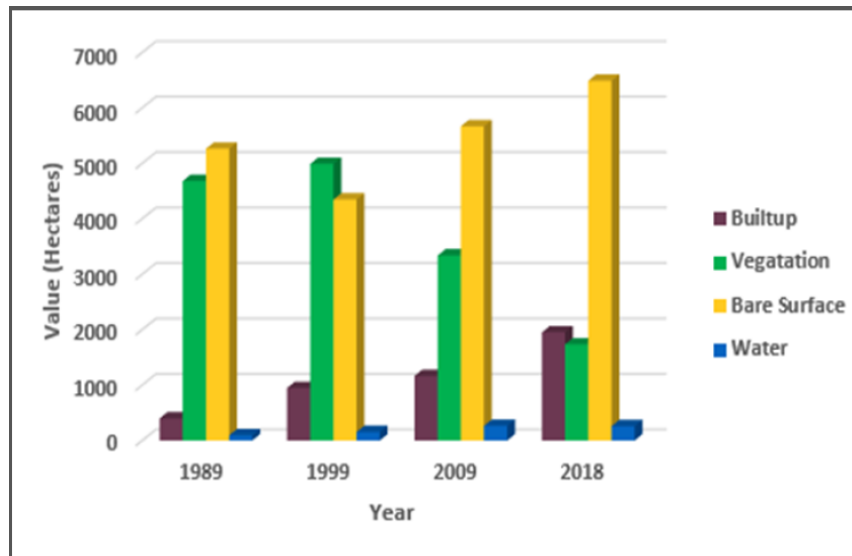


Figure 4.6: Harrismith land use land cover distribution.

The spatial coverage of each of the land cover/land use categories on the classified image in Vrede showed a steady increase in built-up areas between 1989 and 2018 (Figure 4.7). The Green area and bare surface show a commensurate change in the same figure with the fluctuating changes within the period under study.

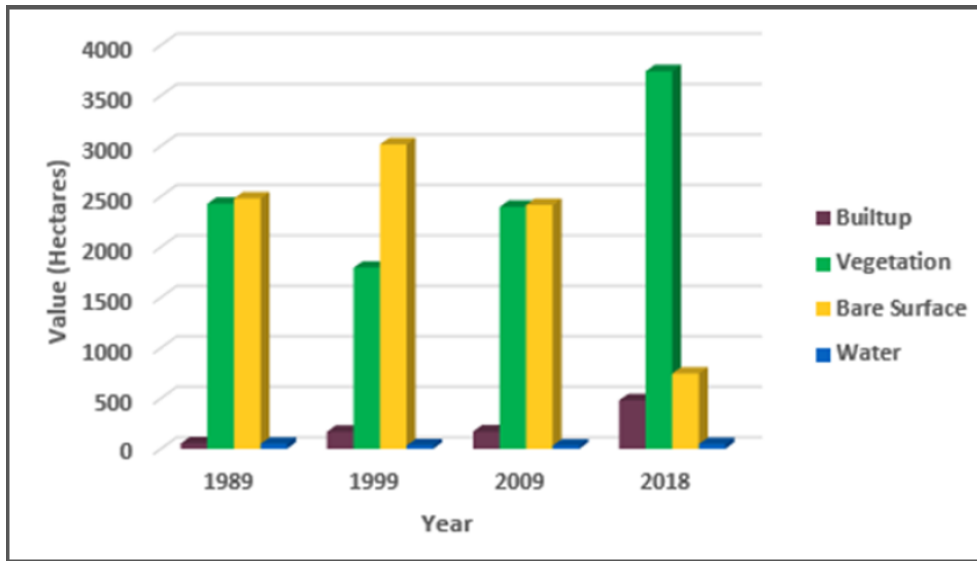


Figure 4.7: Vrede land use land cover distribution

Quantification of the spatial coverage of each of the land cover/land use categories on the classified image in Ladybrand showed a steady increase in built-up areas between 1989 and 2018 (Figure 4.7). The Green area increased steadily while the bare surface decreased consistently in the same figure 4.7 over the period under study. Field study revealed that Vrede is a settlement dominated by farmers.

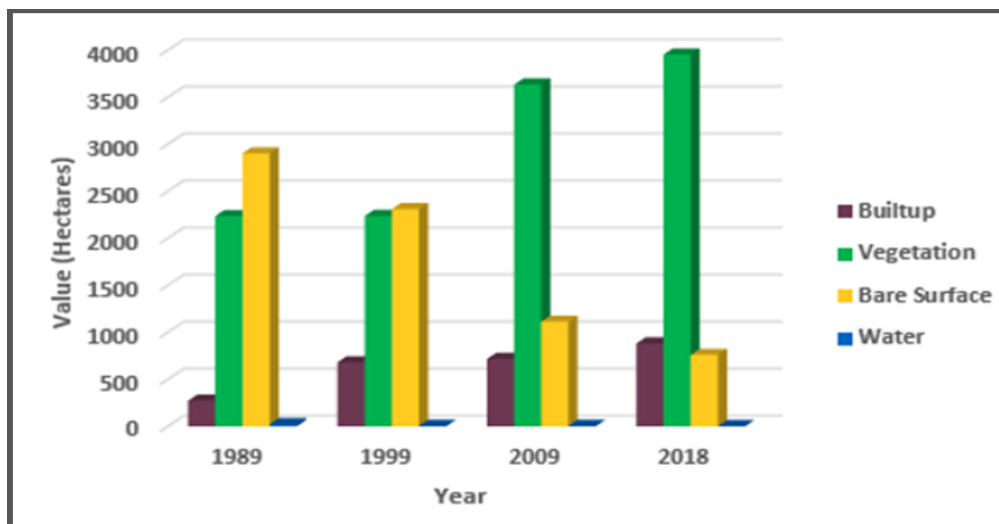


Figure 4.8: Ladybrand land use land cover distribution

The discussion of this research will focus on the human settlement aspect, which is represented by the built-up land-use class. Three settlements were considered for this study: Harrismith which covers 10434.51 ha; Vrede 5013.09 ha, and Ladybrand 5433.03 ha. The years under study were 1989, 1999, 2009, and 2018. It was observed that the built-up areas in the three settlements increased steadily in the years under study with Harrismith increasing from 3.82% (397.80ha) in 1989, five years before 1994 to 9.06% (945.45ha) in 1999, five years after the transition from apartheid to majority rule, having an urbanization growth of 5.27%. Vrede, also increased from 1.06% (53.00ha) in 1989 to 3.37% (169.00ha) in 1999, while Ladybrand increased from 5.03% (273.15ha) in 1989 to 13.02% (681.30ha) which is more than double in 1999. The explanations above are illustrated in Figures 4.6, 4.7, and 4.8. A field survey was conducted, and it was revealed that the increases experienced were due to major policies enacted after the change in government from apartheid to democracy in 1994. Development Facilitation Act was enacted. It dealt with the spatial pattern which closed the buffer between former white and black areas. It gave rise to the black people (who are the majority) to own land and have title deeds (James, 2007). Another is the 7500 Discount Benefits Scheme and Conventional Act of 1998, and the writing off of debts of the Blacks, giving them rights to register their tents by way of grants after 1994 under Housing Acts 107 of 1997 (James, 2007). Some other related policies are still under review, such as the Integrated Land Use Management System (LUMS) (Nel, 2011). It was believed that there was no reliable historical population statistics in South Africa, with submissions that the colonial and apartheid governments did not bother to collect reliable statistics on the black population pre-1994. This made it difficult to get an accurate population figure for 1989, five years before transition to majority rule (Turok, 2012). However, according to United Nations Population Division, World Population Prospect (2011), there was a decline in urban growth in the mid-1990s due to decline in the natural growth rate (birth minus death) associated with HIV/AIDS and tuberculosis as there was no medical breakthrough as it is now (Bloom, 2011).

Nevertheless, after the change in government in 1994, the democratic government of ANC, whose policies are pro-poor, promised Reconstruction and Development Program

(RDP) (Cameron, 1996), which was to meet the basic needs of people. i.e., job, land, housing, water, electricity, transport e t c. The program embarked on building over one million houses, provided clean water and sanitation to all, electrified 2.5 million homes, providing affordable health care for all etc. The RDP committed the government to provide one million low-income houses in its first term of office. This vow was, in part, grounded on the critical shortage of low- income houses in South Africa. In fulfilling the target of a million houses in five years, the government also hoped to reach the poorest areas of the country, and act in response to urbanization pressures (Thring, 2003).

The main reasons for migration in most of the world are not different in the case of South Africa - Economic opportunities, availability of infrastructural resources for business and availability of natural resources (which include access to land ownership) were some of the reasons for settlement expansion especially in the urban areas. Also, urban areas are more productive in goods and services (Duranton & Puga, 2004). The migration rate went up in the years between 1994 and 1998; there was a record that 160 in 1000 females and 80 out of 1000 males between these year-ranges were migrants in South Africa (Turok, 2012). This explains the reason behind the expansion in the built-up area, even when there was a decline in natural growth rate and an increase in in-migration in the years after 1994.

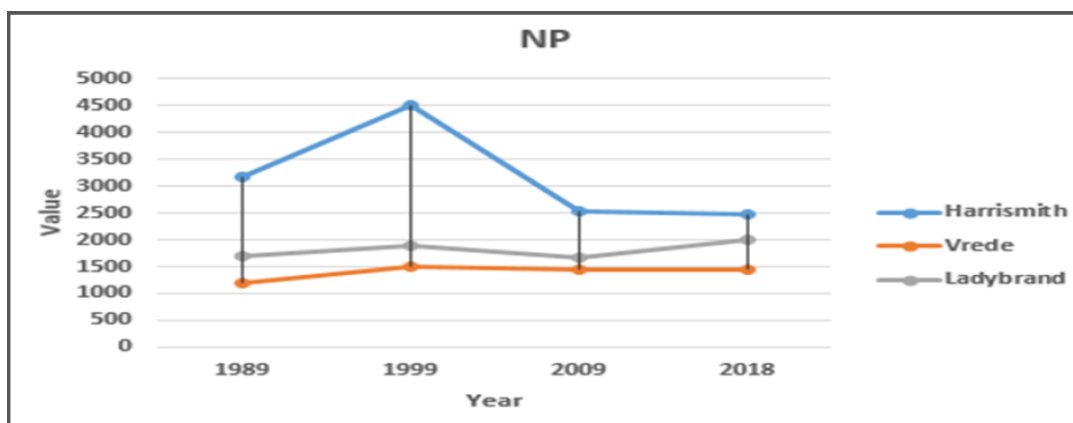
Other land-use also experienced changes at different times; Figures 4.6, 4.7 and 4.8 show green area increased a little from 44.83% (4680.54ha) to 47.79% (4988.59ha) in Harrismith and also increased in Ladybrand from 41.08% (2235.60ha) in 1989 to 42.75% (2236.95ha) in 1999. Free State province is known as the food basket of South Africa. Agriculture continues to be the mainstay of the province, and this accounts for the increase in the size of land for green land which are cropland, grazing land, forests, and vegetation. On the contrary, for Vrede, green area decreased drastically from 48.46% in 1989 to 35.78% in 1999 but later increased steadily in the years later, i.e., 2009 and 2018. In the first five years after the change in government, activity was shifted from cultivation to building as these years also witnessed more economic and commercial activities, but after that, agricultural activities resumed steadily. However, the Bare surface decrease significantly from 50.47% (5264.28ha) to 41.65% (4347.45ha) in Harrismith and

decreased drastically from 53.46% (2902.86ha) in 1989 to 44.17% (2310.39ha) in 1999 in Ladybrand. Most of the land that was bare before 1994 due to restrictive laws against land ownership turned into built-up after 1994 when land and houses became more accessible to people. Whereas in Vrede, it increased rapidly from 49.50% (2481.00ha) in 1989 to 60.17% (3017.00ha) in 1999. Vrede, being the less urban area of the three settlements, seemed to be going in the opposite direction to the other two. The percentages of water (land use class) in the three settlements for years under study fluctuated. Free State province is usually known as a low precipitation area, as the average annual precipitation for the study area ranges between 800 and 1,200 mm per annum (Brand *et al.*, 2008).

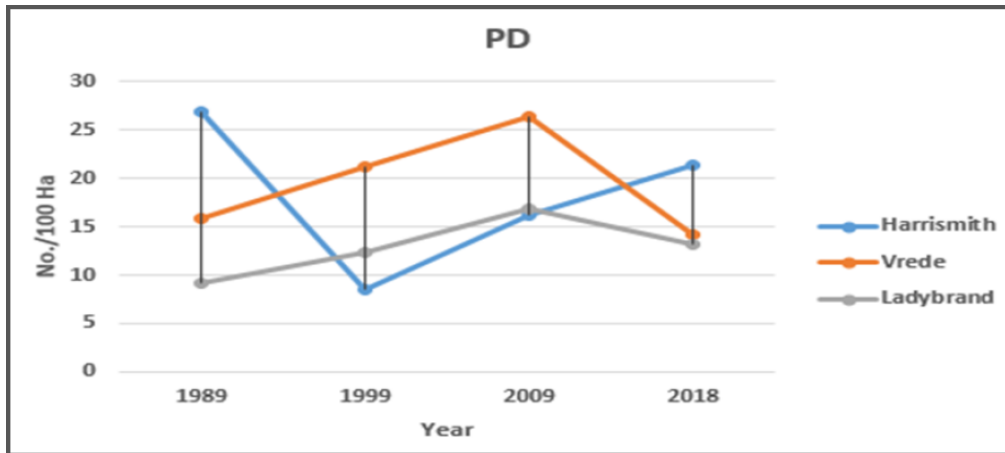
#### **4.3.2 Landscape-level analysis**

At the landscape level, the number of patches (NP), Figure 4.9(a) in the landscape, significantly increased from 1989 to 1999 in all three settlements. NP increased in Harrismith from 3,160 to 4524, in Ladybrand from 1682 to 1893 and in Vrede from 1196 to 1489. The patch density (PD) – Figure 4.9(b) in Harrismith decreased from 26.8168 in 1989 (5 years before the transition from apartheid to majority rule) to 8.5103 in 1999 (five years after the transition), while it increased from 15.9222 to 21.1746 and 9.0926 to 12.3633 in Vrede and Ladybrand respectively during the same period. The ED, as shown in Figure 4.9(c), also increased in the whole study period, increasing steadily in 1989 and 1999 in the settlements. This implies land use fragmentations occurred due to land-use changes, significant urban expansion as well as the emergence of various fragmented patches in the landscape. In the three settlements, it is observed that the number of patches in the urban built-up area increased between 1989 and 1999, as well as of PD and ED. Except for Harrismith's PD, which decreased from 9.4207 in the year 1989 to 1.7059 in the year 1999. However, the dominance index (LPI), Figure 4.9(d), significantly increased in Harrismith and Vrede from 46.7868% and 47.6508% in 1989 to 49.7063% and 66.6020% in 1999 respectively; but decreased in Ladybrand from 76.3944 in 1989 to 65.2939 in 1999.

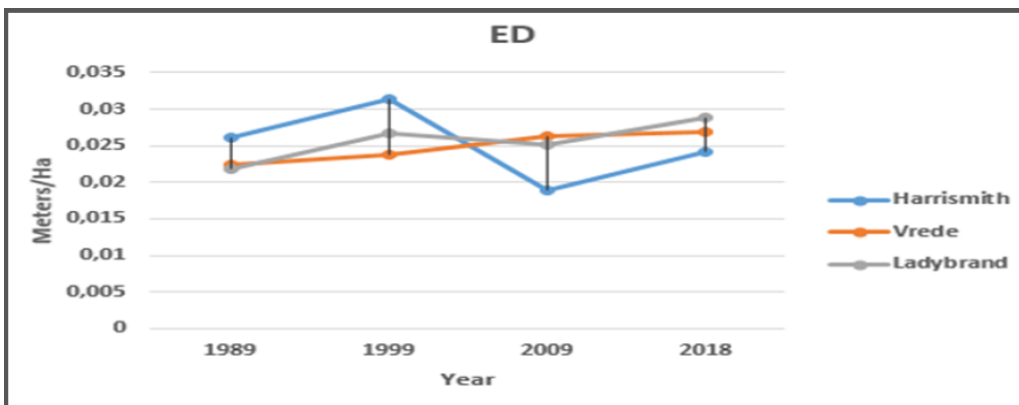
The FDI in Figure 4.9(f) slightly increased, reporting the degree that the shapes of the patches became more complex in the three settlements in the years under study. The physical connectedness decreased slightly in Harrismith and Vrede as against Ladybrand, where it slightly increased from 1989 to 1999, as shown by the COHESION index in Figure 4.9(e). The diversity of land uses in the area also increased. Shannon's Diversity and Simpson's Diversity Indices, which explain fragmentation, increased in Harrismith and Ladybrand from 1989 – 1999 and decreased slightly in Vrede during the same period. Shannon's Diversity Index (SHDI) for Harrismith and Ladybrand in Figure 4.9(g) increased by 4.76 percent (0.9906 to 1.0449) and 19.48% (0.8476 to 1.0525) respectively from 1989 and 1999, an increase of the patch diversity (SHDI) presented a clear picture of increasing the landscape heterogeneity in the settlements; SHDI for Vrede's decreased from (1.0428 to 1.0227) from 1989 and 1999. Simpson's Diversity Index (SIDI), Figure 4.9(h), and Shannon's Equitability Index (SHEI), Figure 4.9(i), also increased in Harrismith and Ladybrand. In Harrismith, SIDI increased from 0.5796 to 0.6235 and SHEI from 0.7146 to 0.7537 between 1989 and 1999. In Ladybrand, however, SIDI increased from 0.4624 to 0.5904 and SHEI from 0.6114 to 0.7592 during the same period. Vrede's SIDI value decreased from 0.6118 to 0.5866 and SHEI decreased from 0.7522 to 0.7377, with both of these indices moving away from zero between 1989 and 1999, the landscape showed more of fragmentation than aggregation.



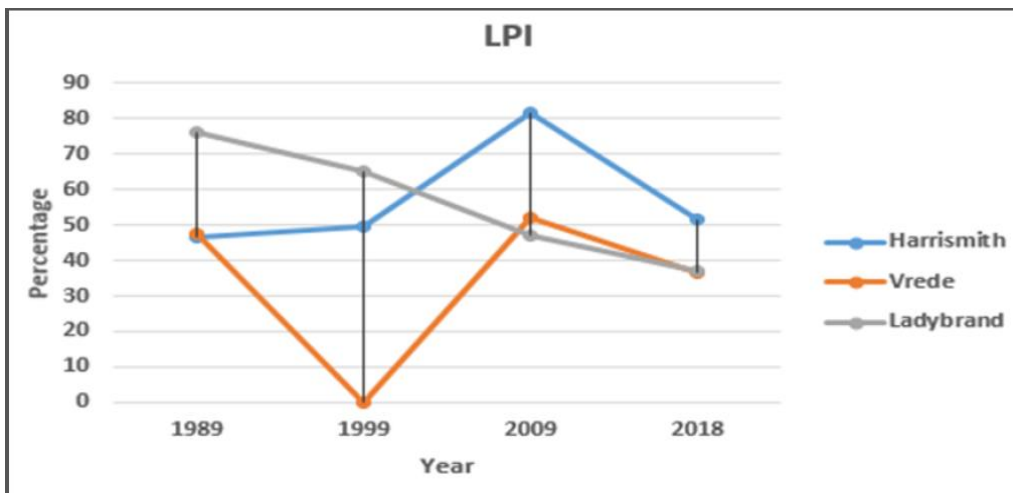
(a)



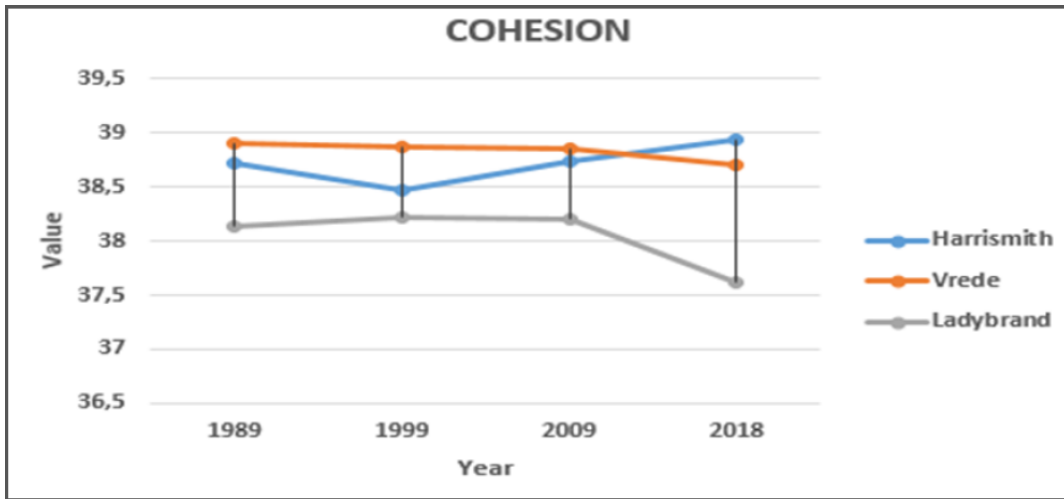
(b)



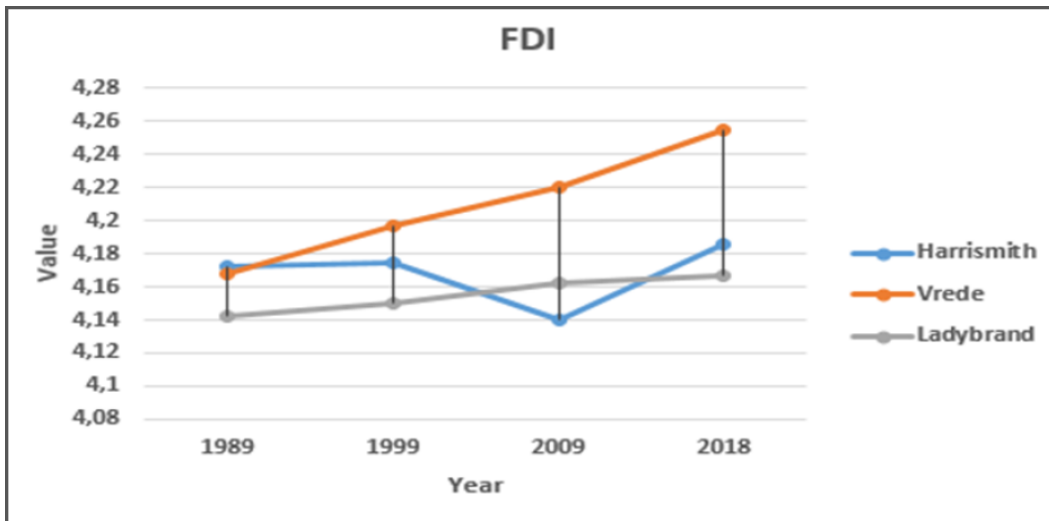
(c)



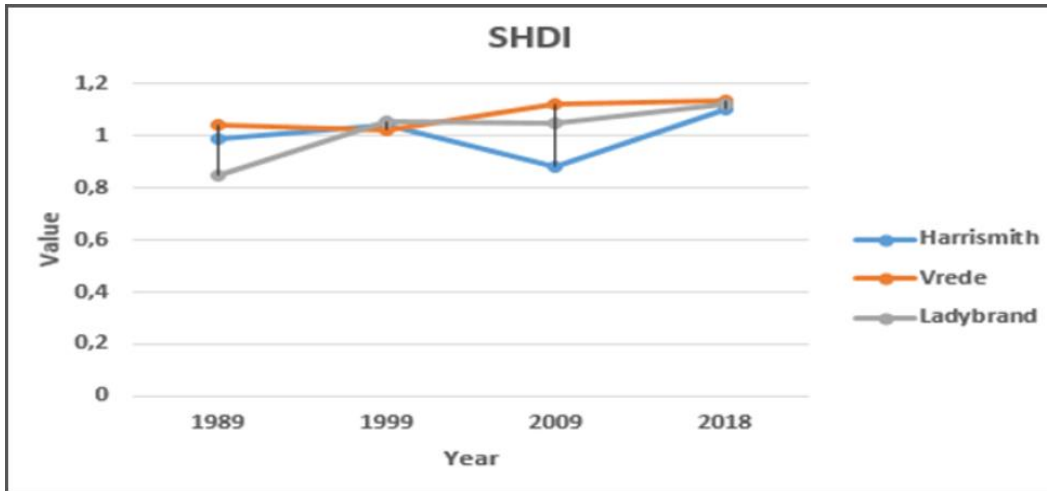
(d)



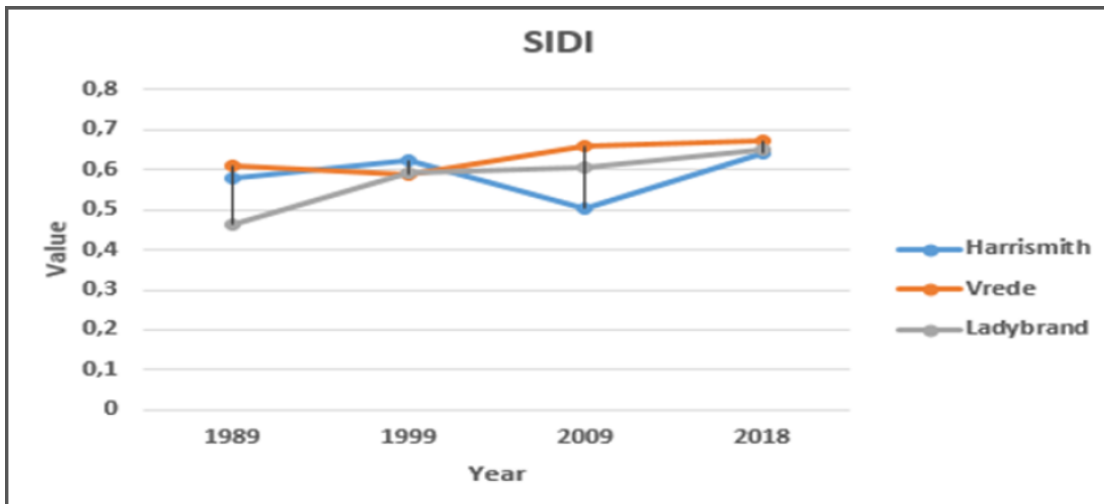
(e)



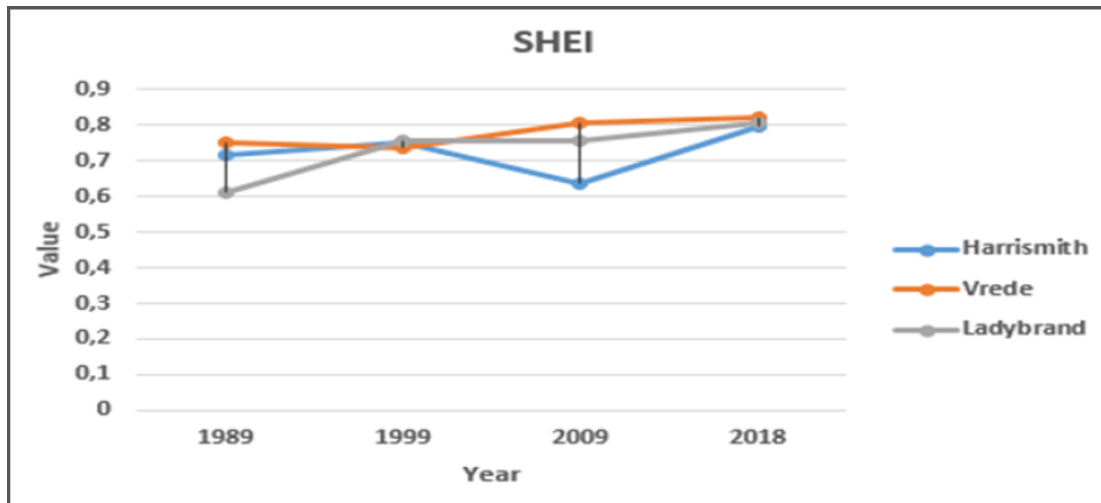
(f)



(g)



(h)



(i)

Figure 4.9 (a-i). Spatial metrics at the landscape level

### 4.3.3 Class level analysis

There are several review papers of fragmentation metrics that categorize and review the utility of landscape metrics (Adepoju & Salami, 2017; Calabrese & Fagan, 2004); (Calabrese & Fagan, 2004). Built-up in Harrismith reveals that NP, LPI increased between 1989 and 1999. An increase in NP from 983 in 1989 to 1780 in 1999 indicates land fragmentation in Harrismith during this period, giving rise to a complex assemblage of isolated and diverse landscape patches and ecological processes (Fletcher *et al.*, 2007; Ries & Sisk, 2010). Associated with this are increased edge habitats and their effects (Couvillion, 2005) and greater loss of connectivity. This is because edges tend to change the biological and physical conditions around patch boundaries and within adjacent patches (Fletcher *et al.*, 2007). Fragmentation of a landscape itself is of greater concern, not least because it creates a natural imbalance in terms of size, shape, and distribution of mosaic of patches found within the dominant human landscapes (O'Neill *et al.*, 1999). The significance of this is that it influences the dynamics of species and material in the landscape (Palmer, 2004), giving various ecosystems their unique structure and function. The 44.78% (983 to 1780), 8.33% (715 to 780), and 26.33% (512 to 695) increase in NP from 1989 to 1999 in Harrismith, Ladybrand and Vrede respectively could be attributed to

increased human activities (that characterised this period). In terms of the NP of the three cities' built-up lands, Harrismith has the highest followed by Ladybrand, then Vrede in 1989, Figure 4.10(a). This indicates that based on the NP, the urban landscape of Harrismith, Ladybrand and Vrede experienced land fragmentation.

Patch density is an indicator of urban fragmentation. As the number of patches increases, patch density also increases, which means higher fragmentation. The patch density in Figure 4.10b also showed a similar trend as the number of patches that increased in the urban patches in years after the change in government; this indicated the more fragmentation of the urban patches in the three settlements. It decreased later in Harrismith in 2009 and 2018. In Vrede, urban patches were more compact in 2009 (Figure 4.10b), in the core areas and gradually increased as development moved away from the core area. This indicated the level of fragmentation in the landscape. It also indicated that the smaller patches that had come up were aggregating to form a single large patch. Higher patch density all through the years understudy in Ladybrand signified fragmentation and sprawl in the settlement. An increase in patch density emphasized the intense urbanization in the city centre and sprawl on the outskirts. Such a conclusion is also supported by results for the Fractal Dimension Index (FDI) in Figure 4.10(d), which showed spatial aggregation of patches, with a decline in Harrismith and Vrede between 1989 and 1999, but a slight increase in Ladybrand. Such a reduction towards zero indicates more disaggregation and vice-versa (McGarigal & Marks, 1995). There was a lesser aggregation of patches in the study area during the ten years (1989 – 1999) in Harrismith and Vrede than the 10-year period (2009 to 2018), which were -2.29% (64.61 to 63.13) and 5.77% (56.88 to 60.16) respectively. Such aggregation took place when similar isolated patches joined their edges to one another. This means existing corridors between similar patches were eliminated to enable their aggregation.

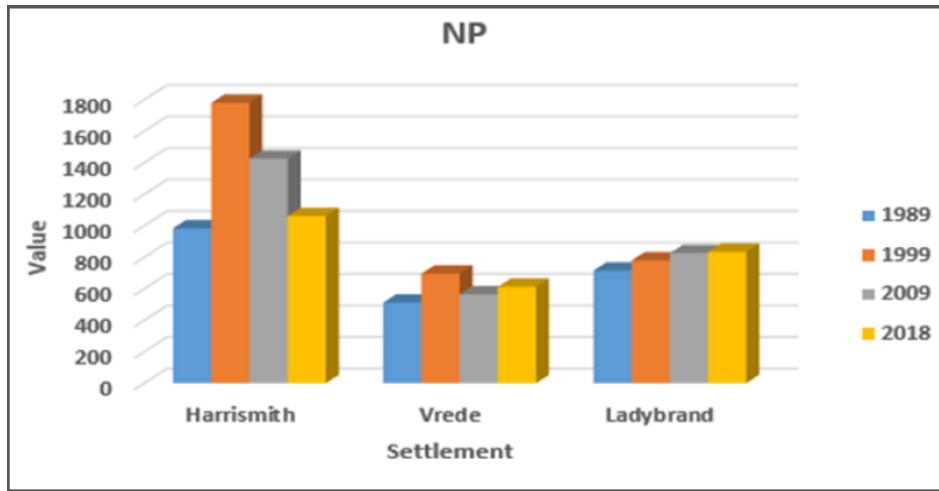
Largest Patch Index LPI in Figure 4.10(c) increased significantly in Harrismith from 4.83% in 1989 to 8.15% in 1999 and a moderate increase in Ladybrand and Vrede with 3.55% to 4.90% and 8.06% to 11.22% in 1989 (pre-transition from apartheid to majority rule) and 1999 (after transition) respectively. This clearly showed that some land use classes dominated the landscape throughout these periods. For example, it is likely that while

cleared land might have expanded, more agricultural fields were also put under cultivation, especially between 1989 and 1999. During this period, impervious layers, including bare surfaces, buildings, and roads, were expanded and increased.

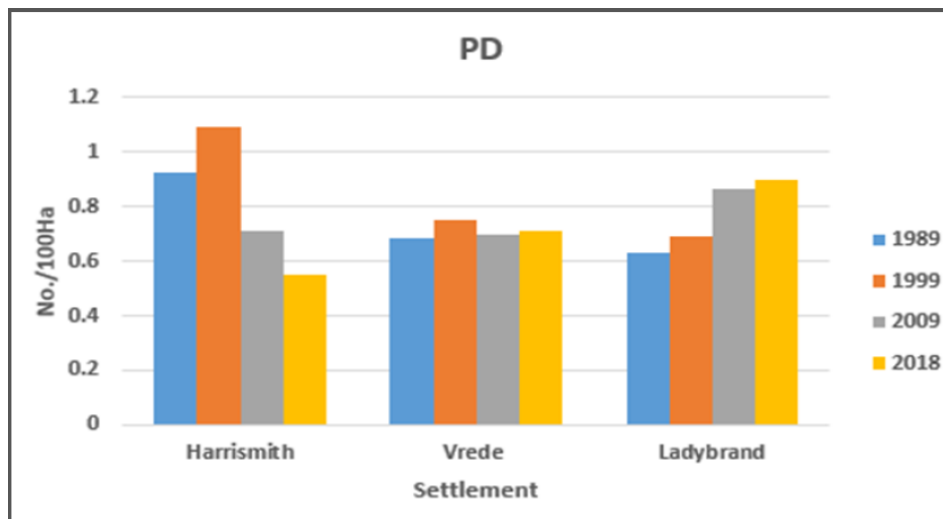
Results for Cohesion in Figure 4.10(e), slightly increased throughout the study period for built-up classes for the three settlements between 1989 and 1999 but a slight decrease for Ladybrand from 2009 which was 9.8423 to 9.8170 in 2018. Connectivity increased for built-up between 1989 and 1999 in all the settlements, five years before the transition, and five years after transition. In Figure 4.10(e), Ladybrand was less physically connected than Harrismith and Vrede. The degree of physical connectedness of urban/built-up areas also gradually increased over time. The merging of built-up areas between the previously separated urban structures close to roads, especially in the city core and fringe areas, could result in such an increase. For Harrismith, the results show that the COHESION of its patches of built-up was stable in the years but decreased a little in 2009. By contrast, the COHESION of the patches of the built-up lands of Ladybrand showed a decrease between 2009 and 2018; however, this means that the urban landscape patterns of Vrede and Harrismith were relatively more aggregated or physically connected than those of Ladybrand as can also be observed in Figure 4.10(e). The spatial metrics technique is more effective in the description and analysis of the urban landscape because of its comparative assessment of the various parameters over other techniques. These combinations and comparisons help in understanding the dynamics of the spatial pattern of urban land use (Jain *et al.*, 2011).

Percentage of Land (PLAND) equals the percentage of landscape consisting of the corresponding class patches. The built-up percentage was calculated to understand the ratio of built-up to other land-use class and its increase in the landscape in Figure 4.10f. The analysis showed that the percentage of urban landscape increased in all the settlements all through the years under study. The overall analysis portrayed an increase in urbanization in all the study areas. The Class Area (CA) metrics calculate the area of the particular class in hectares. Figure 4.10g shows the class area metrics where urban areas increased like PLAND. A drastic increase in the class area occurred in the years after the change in government. The Mean patch size (MPS) is a measure of subdivision

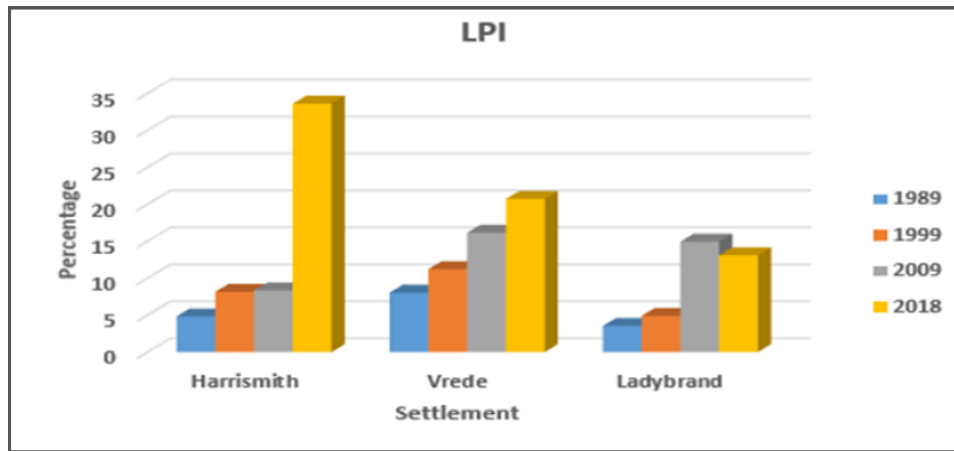
of the class or landscape. MPS of the urban class is inversely related to the degree of fragmentation, with lower MPS indicating greater fragmentation, and higher values reflecting aggregated growth in the city centre. Figure 4.10h indicated that fragmentation increased in Harrismith, while for Vrede and Ladybrand, higher values show urban land aggregate.



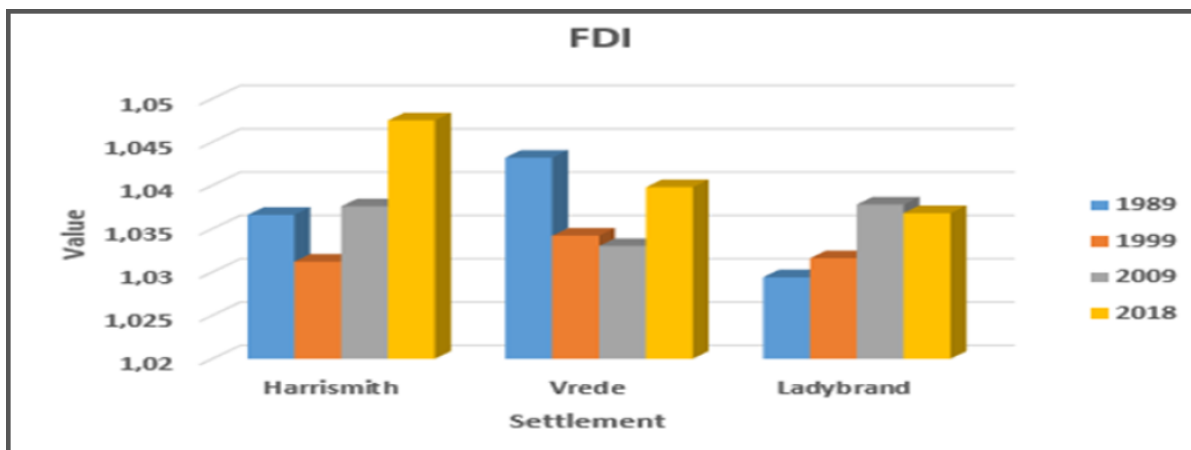
(a)



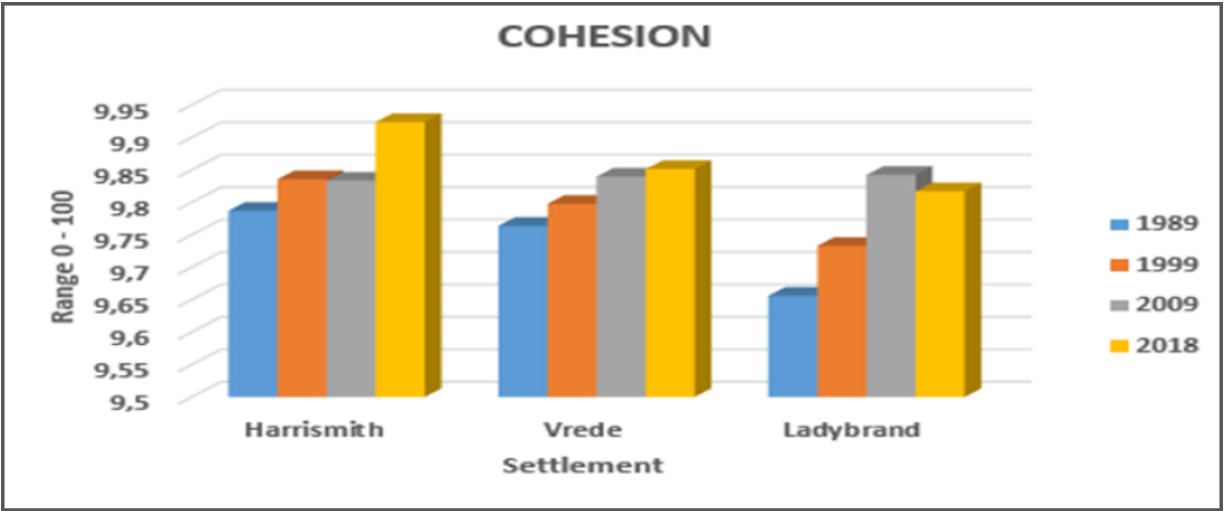
(b)



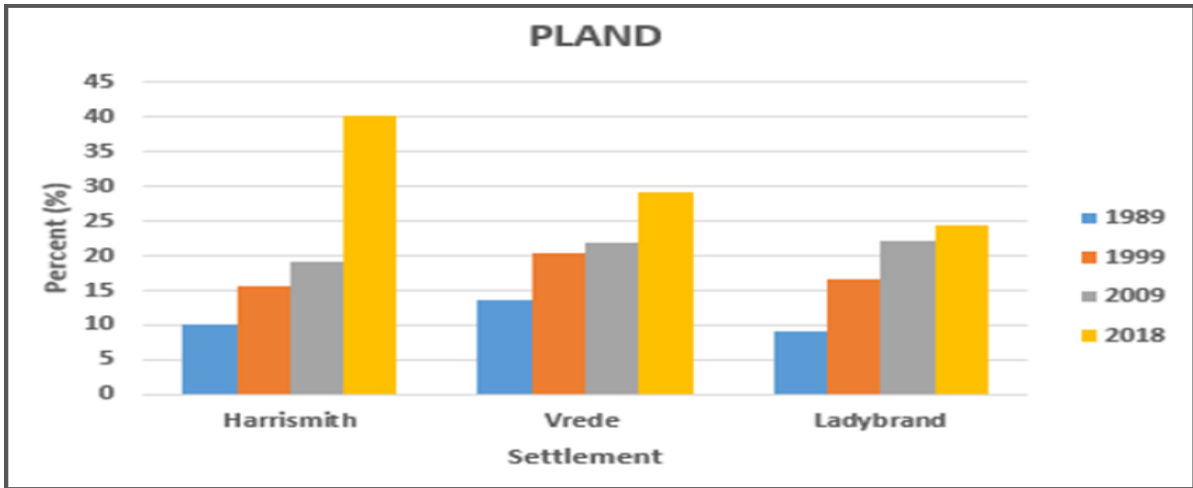
(c)



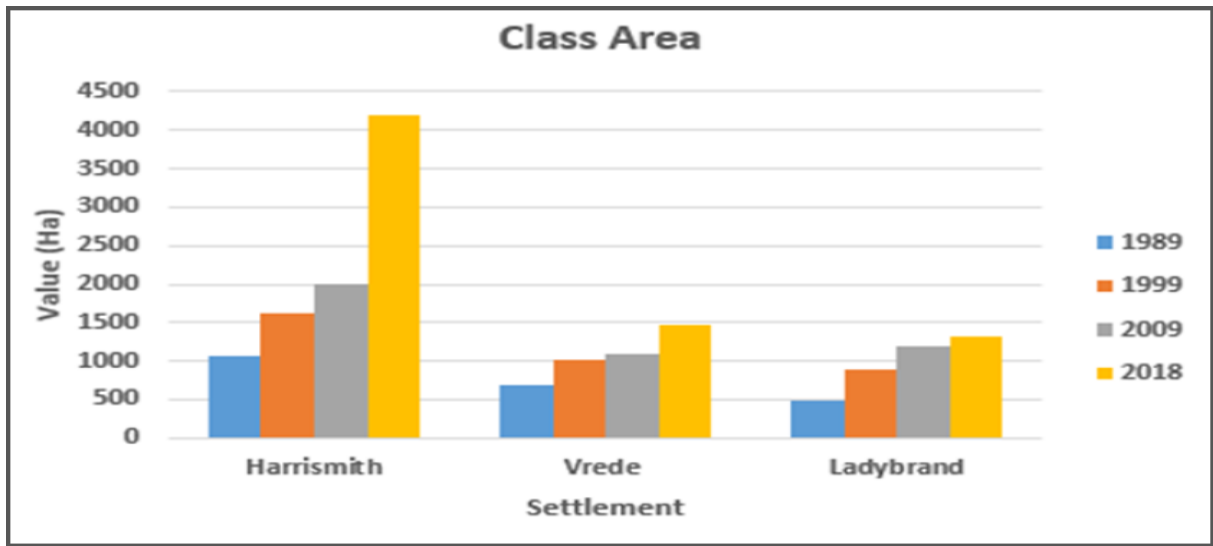
(d)



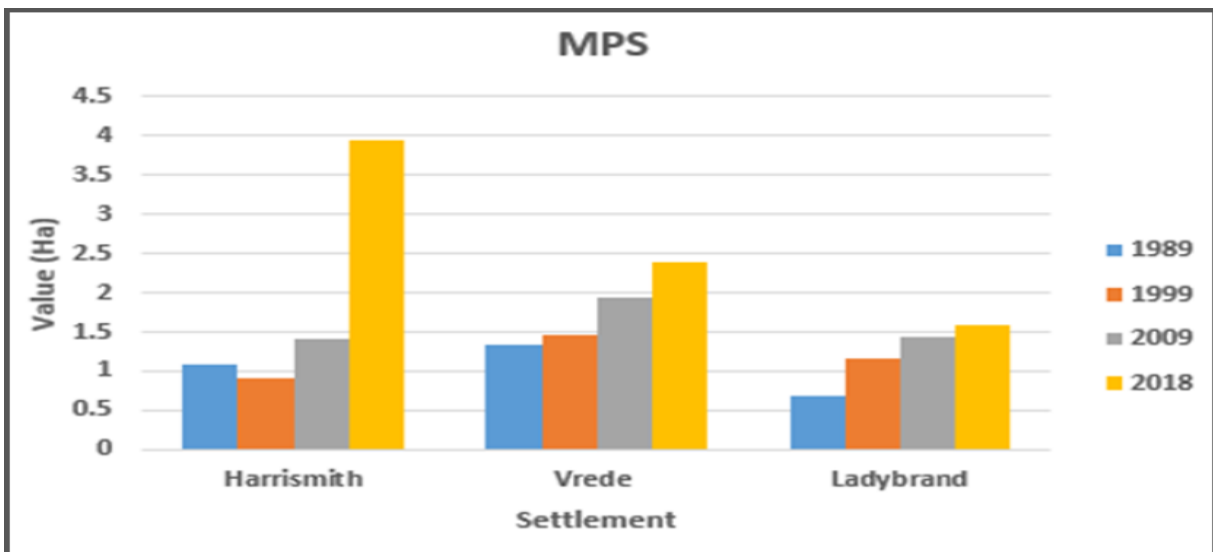
(e)



(f)



(g)



(h)

Figure 4.10(a-h). Spatial metrics at the class level.

Settlement development in the Free State is dynamic in the spatial pattern since the change of government from apartheid to majority rule in 1994. Few parameters in Harrismith, Ladybrand, and Vrede showed similar results. Harrismith and Vrede emerged with similar growth types and real growth, corresponding in the spatio-temporal urbanization and built-up density, identical spatial density, as well as the ratio of the urban core to dispersed patches. Both settlements only differ in the mean patch size (MPS). MPS increased in Vrede from 1989 to 1999 while it decreased in Harrismith, but the results of other metrics interpreted similar growth types. Due to different settlement development factors, mostly with socio-economic and political factors, settlements in Thabo Mofutsanyane do not exhibit a standard form.

It was observed that urbanization in the 29 years under study showed different dynamics of phases, South Africa's dispersed urban forms also differ between cities. The varied spatial form reflects their unique physical topographies, social and cultural composition, and the rate and character of economic development and demographic growth. The metropolis of Cape Town, eThekweni, and Gauteng, like the three settlements under study, also experienced fragmentation with eThekweni being most fragmented. Gauteng has exceptional fragmented settlement, the three cities of Johannesburg, Tshwane, and Ekurheleni combined because of proximity as a settlement. Cape Town's built up fragmentation was shaped by policies, racial segregation, and separation of different land use to commercial and industrial activities out of the black township, ensuring dependency on the white areas. EThekweni is fragmented with three major separated zones; medium-high density, with other low-density suburban sprawls and traditional rural areas as is the case with Harrismith. The fragmentation characteristics form as a result of state policies of separation development or undulating topography, which complicate coherent physical development. Gauteng's exceptional fragmentation was due to a lack of immediate constraints of urban growth at the time of the rapid expansion of the mining industry (Turok, 2012).

Considering other cities outside South Africa, Thapa and Murayama believe fragmentation occurred due to haphazard land development and uncontrolled development in Kathmandu valley (Thapa & Murayama, 2009a). Nong et al. (2014)

concluded that the city of Hanoi was connected through the establishment of several housing projects and commercial activity attracting population in the first two phases of 1993 to 2001 and 2001 to 2006 but later experienced what they describe as diffusion stage between 2006 and 2010 (Nong *et al.*, 2014). They believed urbanization decrease due to heterogeneity resulting to homogenization of urban landscape in most cities of China.

This chapter further compared three different settlements' urban space considering the influence of political factors, which influenced urban development to understand their processes of urbanization, thereby bridging the gap between remote sensing models and socio-economic data.

#### **4.4 Conclusions and Recommendations**

This chapter shows an overview of the spatial attributes of landscape fragments and their implications on ecological processes in the selected settlements of Thabo Mofutsanyane district municipality. It also investigated the spatio-temporal patterns of human settlement in the district municipality using remote sensing and spatial metrics techniques. The landscape of the settlements is diverse and complex and comprises both homogeneous and heterogeneous surface features. The results show that the built-up development of the three settlements got more intense after the transition from apartheid to majority rule. Harrismith and Vrede experienced more intensity after the transition than Ladybrand. Also, it can be concluded that the urban landscape of Harrismith was relatively more fragmented (dispersed) than Ladybrand and Vrede in that order before 1994. Furthermore, the urban landscape of Ladybrand and Vrede became much more aggregated or physically connected than Harrismith after 1994.

Generally, the use of Land Use Land Cover Classification and landscape metrics integrated method, as applied in this study using a common spatial unit of analysis, has helped determine and, at the same time, compare objectively the spatial patterns of urban landscapes of three settlement. However, some limitations need to be considered in future studies. For example, the availability of population figures for the years under study

and the change in boundaries of settlements due to political factors from time to time, especially for Ladybrand.

In future studies, there is a need to focus more on other land-use classes. In addition, to contribute further to the field of urban ecological research, more detailed and accurate Land Use/Cover maps are needed in future studies. For example, the non-built class can be separated into several more detailed classes, including those that can represent vegetated areas such as forest, cropland, and grassland. So many studies would be conducted on what land use has been lost to the other. These more detailed Land Use/Cover maps might be useful in the analysis of the potential environmental or ecological impacts of urbanization in the major towns of Free State and South Africa as a whole, and could also be compared to the present development plan of the district municipality, which are important in the context of environmental sustainability studies for a holistic, sustainable development plan in the province.

## CHAPTER 5

# FACTORS RESPONSIBLE FOR THE CHANGES IN HUMAN SETTLEMENT DEVELOPMENT PATTERNS IN THE AFROMONTANE REGION.



This chapter is based on:

**Onalapo T. F.**, Okello T. W. and Adelabu S. A. (under review) *“Post 1994-Perception of Settlement Development Pattern in Eastern Free State, South Africa”*. Submitted to Applied Geography. (JAPG\_2020\_755).

## **Abstract**

Following the event that led to the transfer of government from minority to majority rule in 1994, almost all aspects of South African society in terms of politics, privileges, physical environment, and social life changed. Part of the major changes includes the right to vote, freedom of movement, improvement in social status, and property ownership, which enabled access to land and housing by all (both Blacks and Whites). These changes have had serious impacts on the settlement development of the nation. In view of this, the article aimed at identifying and assessing the factors responsible for the changes as well as their effects on environmental components. A perception study to identify various factors responsible for changes in settlement development pattern and assessment of the effect of the settlement changes due to change in government were conducted within three different communities in Thabo Mofutsanyane District of Free State Province in South Africa. A qualitative analysis of twenty-six structured interview guides was used for data collection. Key informants from three settlements of Harrismith, Vrede, and Ladybrand were identified and selected through purposive sampling, They were considered to be active stakeholders in human settlement development in the selected study areas. The interviewees included government officials, heads of farmers' association, head of Developers' association and community leaders.

The main findings of the study include that 1). Settlement development is greatly influenced by the liberty received after the change in government from minority White leadership to majority rule. 2). There are formulated policies after 1994, which enable Blacks to own land and develop it, which also led to settlement development within the study area. 3). The little or lack of development control, in former Black settlements or rural areas, reduced the cost of land for development, but it very likely resulted in environmental consequences and long term infrastructure costs. It is recommended that proper integration of other land uses, especially agriculture in zoning and development framework, should be done. Similarly, adequate follow-up and enforcement of the spatial framework should be carried out by agencies concerned.

Keywords: Settlement Development, Settlement Pattern, Urbanization, Governance, and South Africa.

## 5.1 Introduction

Urbanization is an important factor in human settlement changes. The United Nations *explains that urbanization process is a change in population from the one spread across rural areas which are dominated by agricultural activity as its mainstay towards a bigger, denser and more concentrated populated urban areas which is dominated by industries and service centres* (Nations, 2014, p. 5).

The settlement development pattern is usually perceived to have been influenced by social, economic, industrial, historical, as well as political factors (AbuHafeetha, 2014). Cities are proliferating as a result of urbanization, and the emergence of innovations in the mentioned factors has brought significant changes to settlement development patterns. Historically, the present-day settlement pattern was believed to have been shaped by the industrial revolution, which led to an increase in rural-urban migration and overcrowding in the urban centres, which later resulted in many other environmental hazards (Musvoto, 2011).

The apartheid government in South Africa formulated various policies that shaped the pattern of settlement development. Some of the major policies were Bantu Self-Government Act, 1959, the Amendment to Urban Areas Act of 1952, 1957, 1964, and 1971 (Musvoto, 2011). These policies were allegedly in favor of the White against the Blacks, and because of these, the settlements and residences were delineated along with the race the area had been allocated to. Native Areas Act of 1945 was amended to Urban Area Acts of 1952 to intensify to the constraint of the Black majority. Prevention of Illegal Squatting Act of 1951 and Urban Area Act of 1952 established the control of Whites to define spatial development, access to infrastructure, and economic opportunities (Marais & Ntema, 2013).

The change from minority government to the majority in South Africa in 1994 was one symbolic event in the history of South Africa, It shaped all aspects of South African society in term of race, power and privileges lifestyle and landscape. The pre and post-1994 periods are historic to South Africans because of many changes the era brought

into the country. The enactment of the Housing Act under the National Housing Policy in the Constitution of South Africa (Franklin, 2016; Jarbandhan *et al.*, 2016; Manomano *et al.*, 2016; Msindo, 2018; Nel, 2016a; Tissington, 2010).

Within the interactions of human-environment; human settlements take the centre-stage of global efforts geared towards addressing diverse challenges confronting sustainable development, and this is one of the reasons why significant goals concerning human settlement were set under the principles highlighted in Agenda 21 and the Habitat Agendas, Millennium Development Goal which targeted 2015. The new Sustainable Development Goal 1(SDG), which targets 2030 aimed at better health and housing, is an extension of millennium development goal (MDG) poverty eradication, better health, and urban environment. SDG 3 targeted sustainable water security while goal five targeted ecosystem services and sustainable biodiversity through better conservation, management, measurement, valuation, and restoration (DISLEY, 2013). In this context and the socio-political connection of settlement engineering, the human settlement pattern is multi-faceted and complex in contemporary South Africa. Establishing a representation that depicts different settlement types characterizing South Africa's landscape would be useful.

However, since this transformation in 1994, settlement development patterns in towns and locations of the country manifest in various forms The hierarchy of urban settlements is identified in the following (Davies, 2012); from 1) Primate Metropolitan Area, 2) The Metropolitan Area, 3) Metropolitan Area, 4) Major country towns, 5) Country towns, 6) Minor country towns, 7) Local service centres, 8) Low-order service centres. The patterns are seen in the range from order 4, a major country town to low order service towns in Thabo Mofutsanyane district (study area). The change in government in 1994 played a key role in the form and development of the South African communities (Pallister-Wilkins, 2011; Turok, 2014a). Some of the adverse effects include uncontrolled development and disorganized residential setting like shacks and informal settlements all over the cities. The effects vary in locations and magnitude (AbuHafeetha, 2014; Alatout, 2009).

The human settlement encompasses the entirety of the human community, whether a village or city with all the culture, spirit, material, social, and organizational elements sustaining it. Human settlements fabric is made up of physical elements and the material support services provided by the elements. It referred to villages, towns, cities, and other locations of human populations inhabiting a certain area or segment of the environment (Allendorf *et al.*, 2007). Development control is also known as 'Land use management,' *land administration* 'land regulation,' or *development 'codes'* (Enemark, 2005; Goonetilleke *et al.*, 2005; Talen, 2005). It usually includes policy and legislation of the environment, information on land, such as the cadastral survey (Enemark, 2005, 2006). Healey (2006) reiterated that development control means collective management of local environments which may or may not become development plan or be implemented (Coyle *et al.*, 2016; Görgens & Denoon-Stevens, 2013; Healey, 2006; Todes *et al.*, 2010; Van Wyk, 2013; Van Wyk & Oranje, 2014).

Madu (2016) characterized the act of rural development as the expansion of the socioeconomic and spatial surroundings, which results in the improvement of the ability of each individual in caring and sustaining his or her well-being (Madu, 2016). Alternatively, development is expected to improve peoples' lives in all aspects. This is what (Madu, 2003; Malikhao & Servaes, 2014) termed a multi-dimensional development. Maha AbuHafeetha (2014) studied the impact of Urbanization on agricultural sustainability in Palestine after the construction of a separate wall, the case-study of the city of Tulkarem (AbuHafeetha, 2014), he used primary data source by interviewing 30 participants which included different professionals. He concluded that the political factor of the separation wall had subjected the study area to land-use change, especially in urban expansion and threats to agricultural land. In the same way, Mustovo (2011) developed a framework to assess a sustainable settlement development plan in the province of Kwazulu\_Natal in South Africa. He interviewed the four Heads of Planning Departments in the region, ward councillors, Head of Economic Department, and had a focus group discussion with the Integrated Development Planning representatives. He modelled a development plan based on population, land use management, and the development of the local economy (Musvoto, 2011).

Winters et al. (2010) reiterated that the factors which cause growth experience and drive development process vary considerably (Winters *et al.*, 2010). For instance, Galor *et al.* (2009) conducted a pragmatic study of development and land ownership in Taiwan, Korea, Russia, Japan, Latin America, and North America and established a correlation between development process, education reforms, and land ownership (Galor *et al.*, 2009). Also, Akinboye et al. (2007), in their study of the Yoruba indigenes of Ogun State of Nigeria observed that critical factors that impeded development in most communities in the state were inadequate grassroots level support from the government, parental influence and disproportionate recognition of the role played by the youths in the communities. (Akinboye *et al.*, 2007; Okoampa, 2011).

Simmons et al. (2016) engaged in spatial discourse in conservation planning and landscape ecology of Amazonia in Brazil. They noticed a fishbone fragmentation settlement pattern, which was not only due to colonization policies of over four decades (Simmons *et al.*, 2016). To this extent, they demonstrated the significance of road building by private citizens as a key to explain a specific development geometry. They used a case study of the Trans-amazon Highway (BR-230), in central Pará state, a major region of fishbone fragmentation where they interviewed 113 individuals who had long resided along the road that structured its fishbone pattern. Participants were selected through systematic sampling of residents at every 10km along the settlement road. They suggested a fishbone fragmentation may promote human welfare.

In the same way, Ismael (2013) studied settlement size and its effects on sustainable rural developments in Erbil, Kurdistan Region, Iraq. He categorized the villages in Erbil using census data (population figures), then established relationships between the size of villages and how the dwellers were able to access basic infrastructure (Ismael, 2013). He observed that socio-economic prosperity, progress, quality, and availability of infrastructural facilities are impacted by the dispersion of landmass and the spread of people by group and size. Moreover, that socioeconomically speaking, the residents of large villages are better advanced in comparison to residents of smaller villages. Also, Samuel Adam et al. (2011) studied the connection between settlement patterns and economic development in Twifo – Lower Denkyira district in Ghana. They used both

primary and secondary data sources through questionnaires to 108 participants who were indigenes, settlers, and mixed communities in 6 communities and secondary data from the District Assembly and Area Development Program office of World vision, Ghana. They found out that the politicization of resource allocation compromised the equality of development projects among indigenes and settlers (Solomon *et al.*, 2011).

A previous study by (Onaolapo *et al.*, 2020) has found that there has been a change in the land use pattern and the spatial-temporal distribution of the study area. The current study aims at identifying and assessing the factors responsible for those changes and also evaluate the effects of those changes on the environmental components. This study contributes to the literature on settlement development patterns based on the perceptions of relevant stakeholders, particularly leaders in the communities and government representatives in the three selected settlements in Thabo Mofutsanyane District of Free State province.

## **5.2 Research Methodology**

### **5.2.1 The Study Area**

Thabo Mofutsanyane district municipality in Eastern Free State Province of South Africa is one of the five district municipalities in the province and also within Drakensburg mountain of the Afromontane region. Three settlements which were selected based on their geographical locations and forms, were Harrismith, Vrede, and Ladybrand, which were selected from three local municipalities out of six in the district municipality, which are Maluti-A-Phofung, Phumelela, and Mantsopa respectively. Harrismith has the second-largest land area and population figure in Maluti-A-Phofung local municipality, which is in the northern part of the Thabo Mofutsanyane district municipality map. Harrismith is strategically placed between two prominent cities of South Africa, which are

Johannesburg and Durban. It represents the urban settlement out of the three settlements under study. It had a population of 27,869. Maluti-A-Phofung has the largest population figure and lowest land area amongst the other local municipalities. It represents the urban settlement of this research. Vrede in Phumelela has the second highest land area and lowest population. It has a population below 2000 people according to Statistics SA (2011). With a large area for farming, it represents the least urbanized of the three settlements under study (Stats, 2011). Phumelela has the largest land area and lowest population in the Thabo Mofutsanyane; it represents the less urban settlement in the municipality. Ladybrand has the mean population in the range of settlements and second-largest land area in Mantsopa local municipality, it is close to the Lesotho border, Maseru, this is very significant to the town's development pattern, and it represents an average town between the three settlements under study. It has a population of 4218 in 2011 (Stats, 2011). Mantsopa has an average population and land area, it is located in the southern part on the map of Thabo Mofutsanyane municipality, and it represents the mid urban settlement in this research. This is important to get a good representation of other settlements in the region as well as the country. Figure 5.1 shows the map of Thabo Mofutsanyane and the locations of the selected local municipalities. This study is a contribution to the significance of policy formation and its implications both politically and socio-economically, particularly in Africa's setting (Brand *et al.*, 2008).

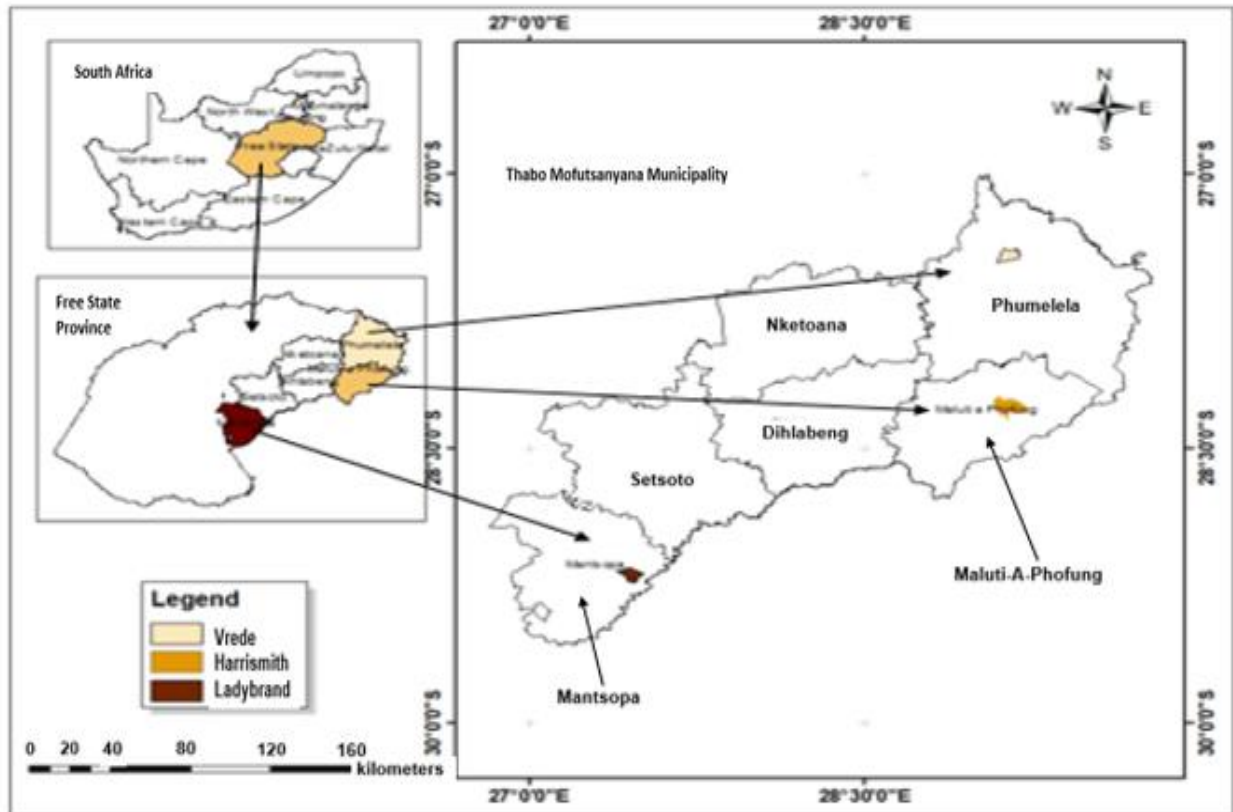


Figure 5.1: Map of the study area: Thabo Mofutsanyane District municipality, the Free State province, South Africa.

### 5.2.2 Data Collection

The collection of data was mainly influenced by a previous study that assessed the change in land development and the spatio-temporal pattern of the study area (Onalapo *et al.*, 2020). Key informants who were stakeholders in settlement development were interviewed, with particular attention to ages, professions, and socioeconomic status. The selection of participants was made after a discussion with heads from the three selected settlements, managers, and directors in related departments of the selected local municipalities. (Esch *et al.*, 2014; Holmes & Barker, 2006; Turok, 2012). The stratification of the sampled population revealed that the representation was not in any way biased.

The interviews were done in Sotho, Zulu, and English Language with the support of an interpreter that was necessary for the study. In addition to individual interviews, observations, as well as free conversations with residents, were also done. Voiced interviews were done with adults that were old enough to understand the situations around the change of government. However, the minimum of the interviewees was 18. A series of open-ended questions were asked regarding stakeholders' perception on factors responsible for settlement development in the municipality. Prior questions were also quickly asked to determine the respondent's age, gender, marital status, educational qualification, years in the office, etc. In total, twenty-six informants were identified as the key informants for this research purpose. (Note that this is a key informant socio-economic survey which does not require population sample). An average of 95 minutes was spent on each interview. The respondents were made up of 3 ward councillors out of 5 wards in Harrismith; (these three were selected randomly, which is a 60% sample frame) and the traditional ruler. Three ward councillors from the three wards in Vrede and in Ladybrand four councillors from the four wards; three government officials from three local districts as well as the heads of farmers' and developers' association were selected.

The responses from the exercise were arranged accordingly in a logical method, converting the manuscript into discrete categories of data (Krippendorff, 2018). The output was used to identify factors responsible for the changes. This give a baseline for assessing the stakeholders' perceptions of settlement change in Thabo Mofutsanyane. Furthermore, the responses were structured and coded so that words, phrases, and short sentences that meant the same were grouped together, taking into consideration the variety of words used insinuations and synonyms. Afterwards, the data were analyzed to identify various factors and their influences on settlement change among the settlements surveyed.

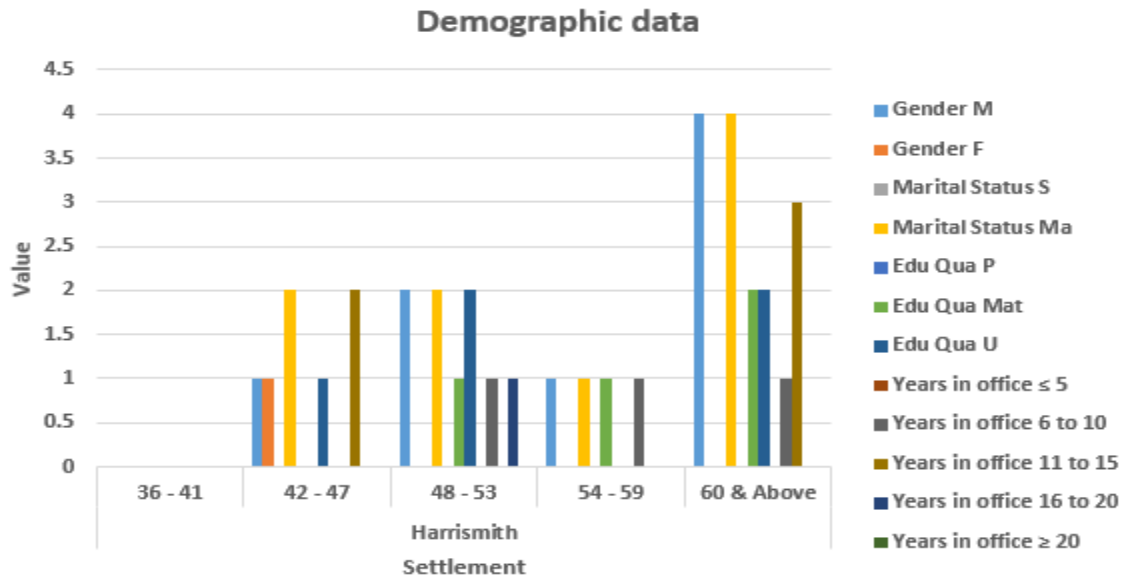
Consequently, the answers provided in the interview guides were totalled together to 100%. The majority of the questions were close-ended questions (options provided) with a few open-ended questions. Questions addressed the stakeholders' perceptions of factors responsible for settlement patterns. The participants were requested to fill the already ranked factors from 1 to 5, where 1 stands for least important and 5 stands for

(most) very important, based on their perceptions. Qualitative variables were chosen for this study because their analyses are easier to perform. Frequency, Crosstab, and Normality tests were the statistical tools used for data analysis. Other necessary available data were acquired from the three local municipalities of the selected settlements

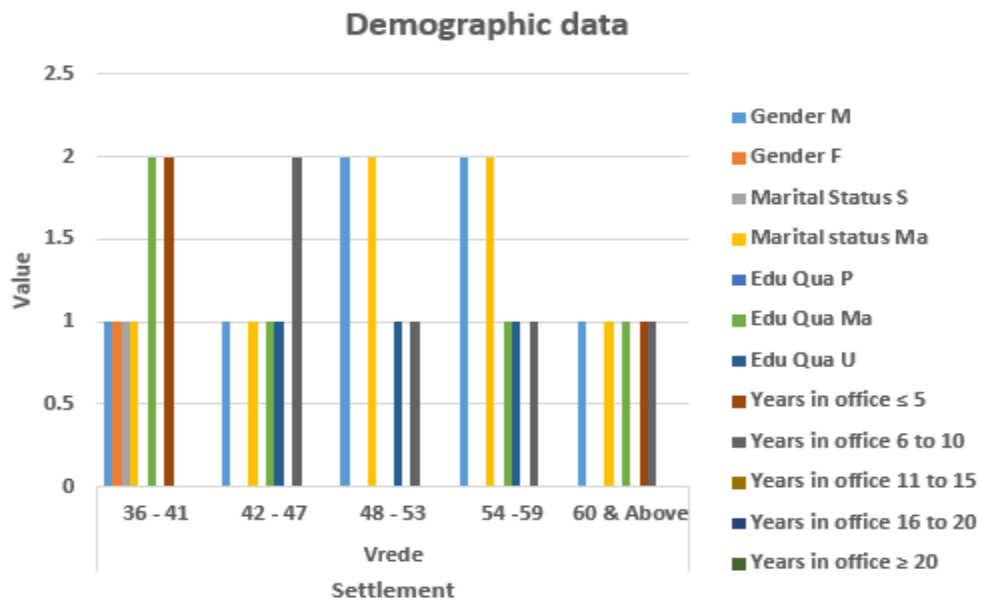
### **5.3 Results and Discussion**

#### **Demographic information on respondents:**

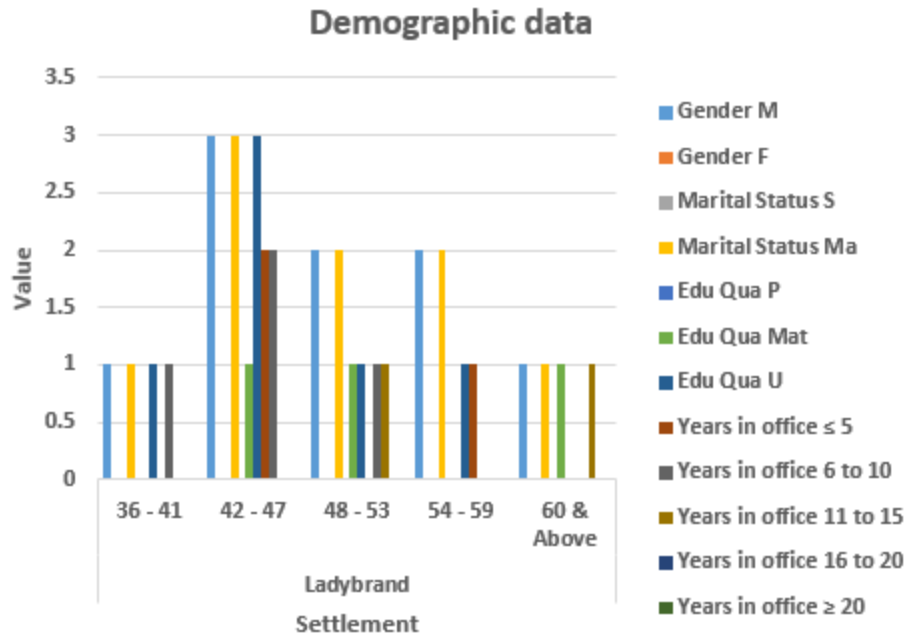
The age, designation, years in office, and other socio-economic data are illustrated in this section in Figures 5.2a, 5.2b, and 5.2c. For the three settlements, the modal age group was the 42-47-year age group, which represents 30.8% of the total respondents, two from Harrismith, three from Vrede, and three from Ladybrand. This analysis indicates that most of the interviewees were fully aware of the situations of change in government. The modal age showed that the people in this category were between ages 16 and 21 at the time of change. Thus, of the 26 respondents, 8 (30.8%) are 42-47 year category, which spread across government officials and community leaders (ward councillors), followed by age group 60 & above, which represents 23.1% ( 6 respondents) of the sampled population. This category came from the three heads of farmers' association, the traditional ruler and community leaders from Harrismith. The majority were married (96.2%) while 42.3% had matric qualification, 46.2 had a university degree and 3.8% had primary school certificate. The modal years in office the 6-10 year category with 38.5% (10 respondents), years in the office here only indicate the time they had been in the position at the time of the interview as most of them had risen from a lower position to higher ones as managers, directors, and heads of department. 65.4% (17) were categorized as senior officers, while 34.6% (9 respondents) were junior. This is presented in figure 5.2a – c.



a.



b.



c.

Figure 5.2a: Respondents' demographic data in Harrismith

Figure 5.2b: Respondents' demographic data in Vrede

Figure 5.2c: Respondents' demographic data in Ladybrand

### 5.3.1 The trend of human settlement development

Table 5.1 shows a previous study done on change in settlement development patterns in the study area. It showed the changes in km<sup>2</sup> of increase in built-up area Harrismith, Ladybrand, and Vrede (which are the study areas) between 1989, 1999, 2009 and 2018. It summarizes the development trend in 29 years with the first column representing five years before the 1994 change in government and the second column representing five years after the change in government. The table shows that there was over 100% increase from 1989 to 1999, which is the space of 10 years for the three settlements (Onaolapo *et al.*, 2020). The interviewed community heads agreed that there were clear indications that development was static before 1994, then gradually move towards rapid development after the change in government.

*“The structure put in place by the apartheid government restricted development, especially to the black.”*

*“No infrastructural facilities to enable spatial development in the areas allocated for the Blacks before 1994”.*

Table 5.1: Settlement Development (Built-up) Pattern between 1989 and 2018 (Area in Km<sup>2</sup>).

Settlements	1989	1999	2009	2018
Harrismith	4.0	9.46	11.64	19.53
Ladybrand	2.73	6.82	7.17	8.82
Vrede	0.53	1.69	1.70	4.80

The results of the change in settlement development (built-up area) above were the analysis of a previous study (Onaolapo *et al.*, 2020) based on data obtained from GIS results with accuracy assessment from Classification and Regression Tree for Machine Learning classifier. The accuracy assessment of the resultant maps was: Harrismith: 87%, Vrede: 92%, and Ladybrand: 82%.

Table 5.2: Population distribution across the study areas

Location	1996 Pop Figure	Pop Density	2001 Pop Figure	Pop Density Per Km <sup>2</sup>	2011	Pop Density Per Km <sup>2</sup>
Harrismith			6338	45.66	27860	200
Vrede			1478	31.77	1961	42.18
Ladybrand					4211	100

Source: (Stats, 2018)

Thabo Mofutsanyane district covers a land area of 33,269km<sup>2</sup>; its population increased from 725,932 to 736, 238 with a population density of 21.8/km<sup>2</sup> to 22km<sup>2</sup> respectively from 2001 to 2011. Harrismith covers a land area of 138.8km<sup>2</sup>, Vrede a land area of 46.52km<sup>2</sup>, and Ladybrand covers 42km<sup>2</sup> land area, the population density of Harrismith increased

from 45.66/km<sup>2</sup> to 200/km<sup>2</sup>, Vrede's population density from 31.77/km<sup>2</sup> to 42.18/km<sup>2</sup> while Ladybrand had a population density of 100/km<sup>2</sup> in 2011. The missing information in figure 5.2 was due to the unavailability of relevant population data and change in districts and local districts boundaries at different times, there were no definite boundaries for districts and local districts in 1996, and Ladybrand was not part of Thabo Mofutsanyane in 2001 (Stats, 2018). With the available data in table 5.2, there was a significant increase in Harrismith's population density and a moderate increase in Vrede's population density. Despite this fluctuation in population growth between 1999 and 2011 in the district according to (Insight, 2013), the democratic government continued to build housing units through the Reconstruction and Development Programme in fulfillment of the campaign promises of providing 1 million houses yearly all over the country. This led to questions about the change and factors responsible. All the participants indicated that there were obvious changes in settlement development after the change of government in 1994. The changes showed in the consistent increase in the area of built-up in the years under study were due to the policies formulated which favor the black to own land and houses in any part of the country and which has led to more buildings year in year out. A prominent policy, amongst others, is the Housing Act 107 of 1995.

It was gathered that before 1994, only the white, colored, and Indians were allowed to have title deeds on land and buildings, the Blacks were prevented from owning land and houses but were instead given permission to occupy. The second decade after 1994, the first democratic constitution of the Republic of South Africa gave rise to the bill of right as well as the objects of Local Government which must ensure (i) democracy and accountability, (ii) promote local development and (iii) promote safety and health of communities (Tibane & Honwane, 2015).

### **5.3.2 Factors responsible for Change in Settlement Development Pattern after 1994**

Studies revealed there were noticeable changes in the settlement pattern of all the three settlements under study. This was confirmed by all the participants (100%) in the study

areas, and the majority of these changes which are access to land for building for residential and other kind uses as well as farming, access to social housing by the government (Onaolapo *et al.*, 2020). About 90% of the participants in the three study areas believed there was a total restriction of the black to own land and houses before 1994, while the other 10% believed there was limited access to land and buildings. The change in settlement development is linked to the policies and programs formulated by the democratic government in power. 61.5% participants believed that the changes in land use land cover was to built-up while 34.6% believed the changes were amongst different land uses (i.e., agriculture, built\_up. bare surface), only 3.9% believed the changes were built\_up to abandoned buildings which are now covered with bushes, this was in Vrede where people abandoned their far away houses and moved to the main centre of town. Settlement development moved gradually from scattered to clustered; the rapid development occurred after 1994.

Factors that are usually known to be responsible for urbanization, as well as settlement development patterns, are political, economic, urban/physical development, demography, social and communal, policy and planning (AbuHafeetha, 2014; Malik & Ali, 2015).

Figure 5.3 shows the participants' responses in Harrismith; results showed that the political factor which was admitted by 67% of the respondents as a moderately important factor to settlement development, 56% believed demographic factor is important while 44% indicated that policy and planning factor is important to settlement development.

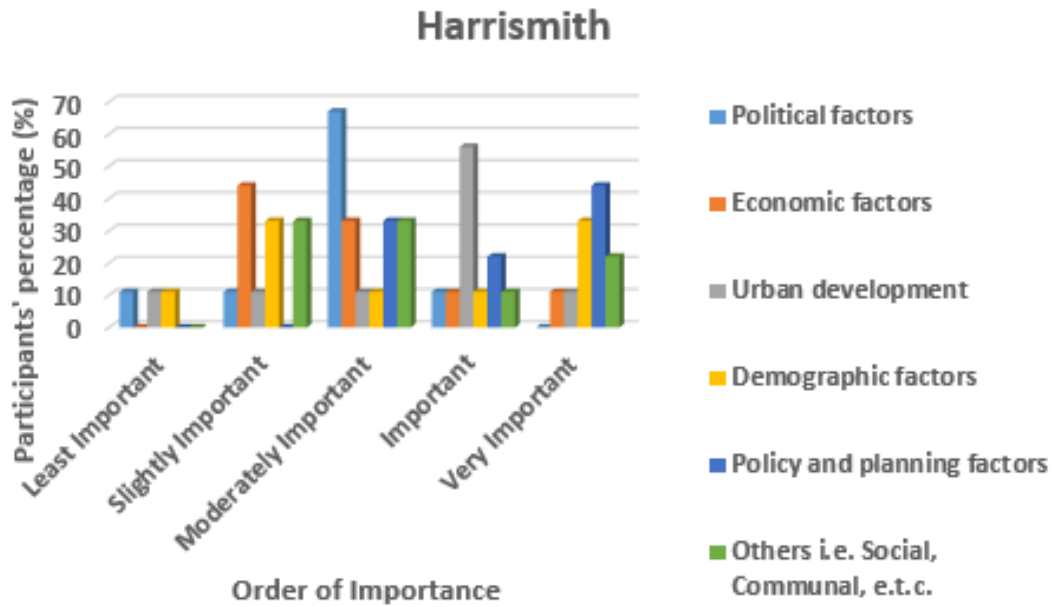


Figure 5.3. Participants' responses in Harrismith

In Vrede (figure 5.4), 50% of the respondents believed policy and planning is an important factor for settlement development; other important factors are political, economic, urban development, social and communal; these factors are picked by 38% of respondents. Policies and planning laws are factors borne out of change in political power. Vrede is considered as a communal (rural) area where people of common lifestyle and social status live together which is the reason why another 38% also indicated that social and communal factor is a strongly important factor for the development.

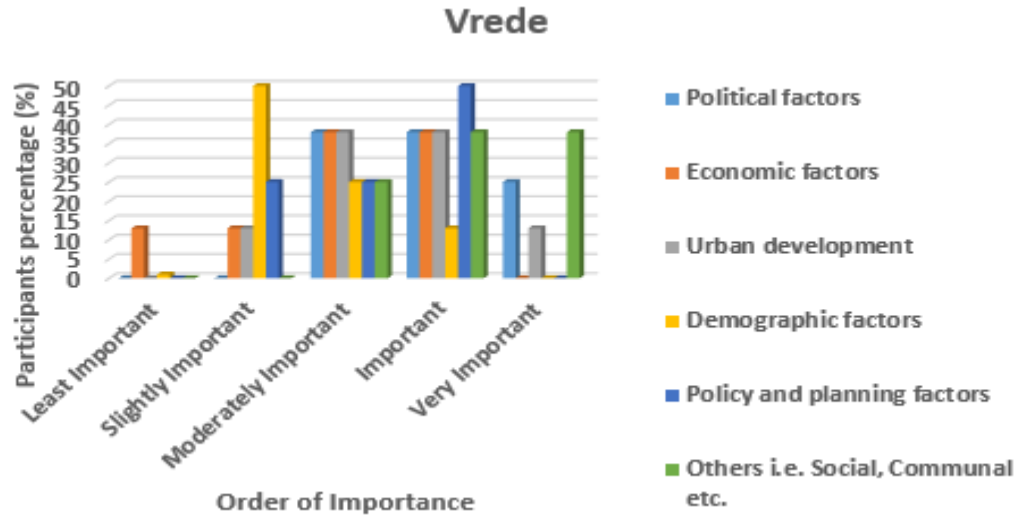


Figure 5.4. Participants' responses in Vrede

In Ladybrand (figure 5.5), 67% admitted that both political and economic factors are important factors for settlement development in the study area, 56% agreed that policy and planning factor is very important, 44% urban development and demographic factors are also important. Ladybrand is a town that is next to the border of another country. This makes it the first stop for migrants from the neighbouring country, and it is also a commercial centre of Mantsopa local district as it also engages in farming activities. These make demographic and economic factors important.

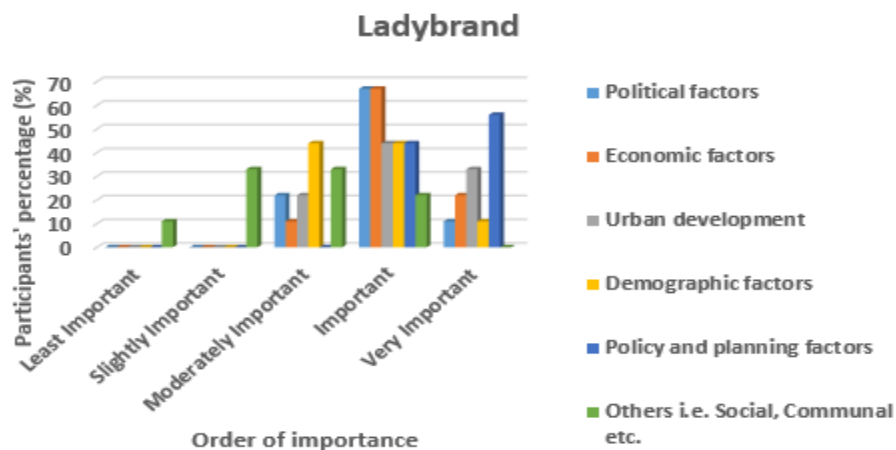


Figure 5.5: Participants' responses in Ladybrand

### **5.3.3 Assessment of the effects of the identified factors on the environment**

The data analysis from the interview guide revealed that 58% of the participants believed the expansion of built-up did not have any negative effect such as water or environmental pollution on the environment as they perceived there were enough land for settlement expansions. 19% believed uncontrolled development has led to land degradation. This was noticed in part of the study areas, 8% believed the effects of the factors were loss of agricultural land, another 8% said waterlogged land is the effect on the environment. The other 8% believed the effect was a conflict of political interest, in a situation where community and government had a different interest in a piece of land.

### **5. 3.4 Roles of the participants in the development of the settlement pattern**

The traditional ruler and one other community leader who participated in Harrismith pointed out that in his domain, they gave out land at their discretions whenever they were approached by anyone or any group, especially cooperative societies. Plots of land were given without government's approval. However, in other places, approval for any development would be sought from the town planning unit at the local municipality. The town planning unit permits anyone to build if the kind of development falls within the zoning area for such development.

### **5.3.5 Are policies available to control settlement development in their various communities?**

33% of participants out of the representatives from Harrismith, which were the government representatives, revealed that the form of development control used is SPLUMA (Spatial Planning and Land Use Management Act of 2013). It is based on the principles of proper management of land use, environmental sustainability, preservation of infrastructural facilities and resources, protection of human lives from environmental and economic disasters, and functional and comprehensive approach to environmental planning and development management.

SDF (Spatial Development Framework) and Zoning were used to control development. The other community leaders who represent 67% of participants in the same location used strict warning as a measure to control development. In Vrede, 37.5% representing government officials stated that zoning was used in development control while 33% in Ladybrand noted that Zoning and SDF were measures used in controlling development. The other community leaders from the formal and less urban settlement who participated in the research reiterated that they only used strict warning as a measure to control development, governments' zoning were not duly followed but preferably local zoning, which was at the leaders' discretions.

## 5.4 Statistical Test of the Result

The data section analysis table 5.3 & 5.4 presented discussions of each variable deliberated in the research. However, comprehensive information for both cases where statistical significance is found and the cases without statistical significance were expressed in Table 5.3.

Table 5.3: Factors responsible for the change in settlement development pattern in the locality.

Variable	Settlements Mean Rank			p-value
	Harrismith	Vrede	Ladybrand	
Political factors	7.72	16.19	16.89	0.011*
Economic factor	9.94	11.31	19.00	0.019*
Urban development	12.39	11.56	16.33	0.334
Demographic factors	13.94	8.88	17.17	0.070
Policy and Planning	14.22	7.88	17.78	0.018*
Others .i.e. social, communal etc	12.72	18.81	9.56	0.034*

\*indicates significance at  $p < 0.05$

The P-values for the normality test for political, economic, policy & planning, social & communal factors are 0.011, 0.019, 0.018 and 0.034 respectively, p-values represent that the test for the above variables were significant while the results obtained for urban

development and demographic factors were not statistically significant p-value of 0.334 and 0.070 respectively. This result shows that the political factor is the most significant, then policy & planning, economic and social & communal follow in that order because the more the value tends to 0, the more significant the variable. Also, the participants were asked to rank the causative agents behind the factors responsible for settlement development patterns. The result of the participant's responses is presented in Table 5.4. The following observations can be drawn.

Table 5.4: Causative agents responsible for the factors changing Built-up to other land use.

Variable	Settlements Mean Rank			p-value
	Harrismith	Vrede	Ladybrand	
Income level/Standard of living	16.56	08.00	15.33	0.037*
Market value of land	15.67	8.31	15.94	0.058
Level of education	17.50	10.31	12.33	0.110
Availability of loan facility	18.83	04.50	16.17	0.000*
Increase in population	08.89	13.44	18.17	0.024*
Population migration to the city	11.94	08.13	19.83	0.004*
Cost of living	15.00	11.00	14.22	0.495
Proximity to water	14.17	15.38	11.17	0.427
The change in the political system from apartheid to majority rule	07.50	15.75	17.50	0.007*
Proximity to basic infrastructures	14.11	13.63	12.78	0.924
Safety and security	15.50	13.94	11.11	0.346
Planning policy	15.50	07.88	16.50	0.035*
Lack of implementing developmental plan/control	13.39	12.81	6.00	0.067
Lack of implementing developmental law to guide the development	16.72	14.06	07.75	0.030*
Size of land/ land fragmentation	10.50	08.93	07.60	0.622
Lack of guidance	07.60	10.57	03.00	0.031*
Absence of planning law to safeguard the agricultural land	10.80	10.43	05.20	0.102

\*indicates significance at  $p < 0.05$

the p-value is the Asymptotic Significance

## 5.5 Summary of Findings

In summary, from the historical information, results of the land use land classification, survey results, interviews, and observations from the field, it can be deduced that change from the minority to majority rule and policies formulated to enable ownership of land by the Black and all other eligible person in any part of the country had a significant impact on the current and future development pattern of the settlements in the country.

This assertion supports Mustova (2011) that the pre-apartheid period is associated with restriction of the black owning land or houses but rather given temporary occupancy, which limited the growth and development of settlement development and makes South Africa's settlement patterns develop strictly along with apartheid (Musvoto, 2011).

This revealed that while the change in government from minority to majority rule, which encompassed policy and planning were political factors, it helped many people own land and houses after 1994; an increase in population as a result of new birth and in-migration (which is associated with demographic change) because of availability of land in the other part of Harrismith affect development. Policy and planning also enabled land and house ownership legally.

Also, the political factor directly influenced the proliferation of the built-up areas and indirectly, the loss of farmlands and bare surface in the study area. For example, income level and standard of living and availability of loan facilities are causative agents behind economic factors while migration and population increase (natural birth and decline in mortality rate) are agents behind demographic factors.

## **5.6 Policy Recommendation and Conclusion**

This study evaluated the perception of settlements development patterns after 1994 when governance changed from minority to majority rule in the context of three settlements in the Free State province of South Africa. Findings indicated that there is a need for monitoring formal or informal development of built-up areas which is important both to ensure validation of development strategies and to avoid problems that may arise from uncontrolled settlements around towns.

Though planning policies such as zoning and Spatial Planning and Land Use Management Acts (SPLUMA) are effective in controlling development in urban centres, it is not applied in locations and rural areas. The liberty of owning land and houses is taken for granted, leading to a haphazard environment. Especially as the allocation of land for building and farming is at the discretion of the community leaders who claimed they would rather see their people living in a crowded environment rather than homeless. Although

the professionals interviewed were aware of the challenges, none of them indicated any resolute action from the concerned key players to stop the uncontrolled and indiscriminate expansion.

The links between the identified factors which are leading to settlement development have causal effects; for example, minority to majority rule in South Africa causes an increase in the number of built-up, which led to indiscriminate buildings, especially in locations (rural areas). Change of government from minority to majority rule, policy and planning are political factors. Since agriculture is a major economic activity in Free State, it will be essential to integrate agricultural land use in the zoning, and the spatial development framework in each municipality and its implementation should be ensured and enforced even in the location. This will enhance the sustainable urban development process.

## CHAPTER 6

# MODELING A SUSTAINABLE SETTLEMENT DEVELOPMENT PATTERN



This chapter is based on:

**Onalapo T. F.**, Okello T. W. and Adelabu S. A. (under preparation) *“Issues of Sustainability in Settlement Development Patterns in Cities of South Africa, Case Study of Thabo Mofutsanyane Municipality.”*

## **Abstract**

Sustainable development of the environment is of great importance to rapidly urbanized cities, especially in developing countries of the world. Balancing spatial development with environmental protection without resulting in environmental consequences and long term infrastructure costs may be challenging. Like most urban areas globally, settlements within the Thabo Mofutsanyane municipality have also experienced different changes of development, especially after the post-apartheid period in 1994. In order to attain sustainable development in the cities of South Africa, this article focuses on spatial discourses in development planning and environmental sustainability. This is done by assessing the current level of development and proposing a model for sustainable human settlement development patterns, which embrace community participation and government involvement. The paper concludes by making policy recommendations.

Keywords: sustainable development; community participation; spatial planning; human settlement and development control

## **6.1 Introduction**

Studies on sustainable cities have been stirred up in recent times because of the rising cases of social and environmental problems relating to urban development (Ye *et al.*, 2015). The link between land use and sustainability is one of the key aspects of environmental sustainability studies (Aditjandra, 2013). More studies have revealed that city expansion, referring to the urban sprawl development towards rural settlements at the periphery area of urban settlements, usually leads to environmental consequences and long term infrastructural cost (Frumkin, 2016; Jabareen, 2006). However, when studying the structure of the settlement development pattern, intense development is not a solution to the city expansion (Bontje, 2003; Song *et al.*, 2017). One prominent definition of sustainable development is that it is the development that satisfies the needs of the present population without jeopardizing the needs of the future generation (Griggs *et al.*, 2013).

In 2012, the United Nations conference in Brazil mandated governments to create a set of sustainable development goals (SDGs) which would be incorporated as a sequel of the Millennium Development Goals (MDGs) at the end of 2015 target (Leggett & Carter, 2012; Makkar & Vasishta, 2017). It was agreed that poverty eradication and the safety of the earth's surface should be the most important aims of SDGs because of the interference of humans, which could alter development's progress. Studies have shown that when components of the earth's surface like forest, atmosphere, water bodies, and biodiversity are functioning uninterruptedly, then the world will thrive better (Makkar & Vasishta, 2017). As the world's population is set to reach 9 billion by 2050, Griggs recommended that sustainable development must have a revised definition that will contain the safety of the planet and the people (DISLEY, 2013; Griggs *et al.*, 2013).

Thabo Mofutsanyane municipality has one of the most fertile lands in Free State; this makes it productive for agricultural purposes. Tshiame town in Maluti-A-Phofung local district was adjudged to be the best place for agric-hub in the municipality because of its location between Gauteng and Durban. Five agricultural projects were already proposed for this area, but the agricultural sector is said not to be receiving enough attention to the extent of yielding results. The sector is still dominated by the White farmers, though government and Black commercial farmers are making efforts; inadequate funding for mechanized farming equipments and tools, lack of training, and continuous monitoring from the government's side make it difficult for the sector to make progress. There are some other notable areas within the municipality where agricultural projects are taking place. Nketoana local district cultivates potatoes, maize, and wheat as well as the production of livestock. Bethlehem in Dihlabeng local district focuses on cultivation and stock farming and special dairy farming. Ficksburg and Clocolan in Mantsopa local district, the southern part of Thabo Mofutsanyane are doing well with vegetable and fruits farming, Setsoto local district specializes in all kinds of farming (HLONGWANE, 2015; Strydom *et al.*, 2015).

This research assumed that settlement development patterns in the less urban areas of the study area, especially the traditionally controlled settlements, were not sustainable. This was confirmed through observations and the focus group interviews conducted in

those places as there was a land misuse, no spatial development framework, and a lack of local economic development strategies. It was also observed that the majority of residents who had once been farmers abandoned farming and trek several kilometres daily in search of daily bread. They are facing hard times because of financial constraints, which makes production cost too high to bear, poor road networks within the settlements as well as a natural disaster like fire incidences (HLONGWANE, 2015; Strydom *et al.*, 2015). Given this, a proposed alternative is recommended for public-private partnerships for the district municipality and local municipality based on the great potential of different economic points, both within and outside the settlement. Thus, the proposed model is a contribution to knowledge and a pattern that guides sustainable settlement development plans based on three components of settlements, namely, function, population, and form.

Given the above, this paper aims to:

- review human settlement development during the minority rule.
- review human settlement development after the minority rule
- evaluate sustainable settlement development in South Africa
- propose a model for sustainable human settlement development patterns.
- make a policy recommendation for efficient, sustainable development plan

## **6.2 Conceptual and Theoretical Overview**

The concepts of development and theories of urban forms are considered in this study. These are relevant to the study of sustainable settlement development in that most times, theories of how settlement developed are usually related to primary economic activities and more developed through secondary activities. To sustain development in a settlement, it is important first to identify areas of potential wealth, classify them into renewable and non-renewable resources. Renewable resources should be judiciously used while non-renewable should be recycled if possible to make provision for the use by future generations. Central place theory as postulated by Walter Christaller and modified by Losch focused on settlement development and is based on economic activities.

Development can be viewed from a different angle and has been defined differently by diverse field of studies; but generally, the development encompasses the conditions that social groups can access essential services (which are health, education, housing, and), have access to organizations and most importantly, have their traditions and cultures respected within a particular country's social framework (Reyes, 2001).

Kindleberger et al. (2016), Hirschman (2013) and Stiglitz (1997) explained economic development to be a change in the living condition of the society in terms of education and health improvements as well as a proliferation in productivity which leads to a rise in per capita income (Hirschman, 2013; Kindleberger *et al.*, 2016; Stiglitz, 1997). Hence, it indicates transformations in the inputs and the distribution of the inputs. It was argued that economic growth might not lead to social development, so there is a need for an all-inclusive approach to achieve or promote economic development (Atal *et al.*, 2009; Myers & Forrest, 2000). Madu (2007) describes the importance of developing a rural settlement as an enhancement of the socio-economic and spatial environment of the rural settings, which leads to the betterment of the individual residents' capability to maintain and sustain their well-being (Madu, 2007).

Harnessing the community's natural resources and potentials, exercising freedom rights, and ethics help to achieve cultural change, social and environmental progress (Inglehart, 2005). Moberg and Granholm (2012) see culture as a vital resource for the economy and that the proficiencies and products which come out of culture are important components of economic strength (Moberg & Granholm, 2012). Hence, development happens as a result of economic, educational, cultural, political, historical, and environmental factors.

Central place theory deals with spatial equilibrium, which focuses on the economic view to city development. It describe the spreading of city space on the bases of utilities and services they provide within a particular region (Strautnieks & Grīne, 2011). It indicated that the demand for a utility or services taking place at the centre is the reason for the central places of development. It also emphasizes the importance of the transport system (accessibility) to the central places and their functions. Walter Christaller, in 1933 developed Central place theory, using Germany settlements for his study. His assumptions were (Crumley, 1976):

1. A business owner usually considers locating his business where he makes more customers and reduces running cost (rents and transportation e.t.c)
2. The competition for favourable locations of businesses among entrepreneurs causes a concentration of numerous businesses in populated areas.
3. The residents' buying patterns indicate that buyers will frequent the closest shop that delivers the best products.

The central place in this context is referred to as the city centre that serves the residents and the periphery areas with less population, which is called “complementary region.” Complementary region and the central place share a dependence relationship, the complementary region receives particular goods and services from the central place; they also produce agricultural and raw materials needed by the residents of the central place. The spatial relationship in this assumption is revealed in the order of hierarchy among central places and complementary regions (Crumley, 1976).

Losch, in 1954, modified Christaller's theory on central place theory, emphasizing the services and threshold population. The threshold population means the required population to sustain certain services before the owner can make a profit, which depends on the number of people making the demand. He added the importance of the distance a willing consumer is ready to make to get the services. He stresses that if the cost of travelling is more than the cost of the service(s), then the reason for low range and low order goods for low thresholds in smaller settlements while high range goods and large threshold will be in larger settlements.

Some of the shortfalls of Christaller's theory are that it shows only a one-way settlement pattern's model that do not consider distance, peoples' convenience, household income or status, accessibility to the services, or mode of communication, which makes it look like a pre-planned city with no natural formation. Another major shortcoming is the view of city development without historical background (Musvoto, 2011).

### **6.3 Human Settlement Development during Minority Rule**

Spatial development in urban settlements during apartheid was done through zoning, which was believed to be aimed at racial exclusion. Haarhoff believes 'Township Layout' in 'Native Location' from 'Residential Area' meant the word 'Location' was meant for the Black occupation area and 'Residential Area' was for the Whites' occupation. He also reiterates that the Black area occupation was located at the periphery of the town. There were usually buffer zones in the form of railway, bridges, and highways to separate the two races (Haarhoff, 2011).

During the apartheid period, modernist planning principle was used in designing the 'Residential Areas' of the White. Haarhoff explains that in order to impose residential exclusion law, there was a mass construction of housing for the Blacks at a minimized cost. Centre for Scientific and Industrial Research (CSIR) was tasked with the construction. The separated towns were conceptualized along with the plan of new towns (Haarhoff, 2011).

In 1952, the Bantu Self-Government Act was passed into law to uphold the residential exclusion policy. The Act acknowledged eight units of African nationals based on ethnicity and a committee was set up to ensure the development of self-government bodies (Seekings & Natrass, 2008). They pointed out that one exceptional characteristic of these states was the spatial disintegration as only one which was Qwaqwa consisted of a single unit (Seekings & Natrass, 2008). This (the Act) was done to encourage the self-development of the Bantu settlement so that they would not consider moving to urban settlements. Therefore the Act would complement the earlier Acts on the ground, which were formulated for urban settlements. This Act also supported the Blacks (Abolition of Passes and Co-ordination of Documents) Act No 67 of 1952. The Black would not have minded staying in their location if there was socio-economic development (Musvoto, 2011). As a result of this, the government hired the Tomlinson Commission to investigate the condition of Africans. The claim was that the Whites were maltreating the Blacks, and the resolution was to either integrate or separate totally (Tomlinson, 2017). In order to discourage migration of the black to the white areas, some policies were implemented to

improve the Blacks' socio-economic status in the location: the creation of industries around the borders and the Settlement Betterment Program.

Border industries were created to generate employment opportunities in the locations to restrain migration of Blacks into Residential Areas. The minority government did this to reject the Tomlinson Commission's proposals to solve the rural dwellers' problems in the location. The Tomlinson Commission's proposals encouraged Black farmers and promoted the manufacturing industry in the farmstead (Platzky, 1994)). Platzky (1994) notes that rather than developing industries at the location, the minority rulers preferred the policy of 'border industry'. The policy received several encouragements (Tomlinson, 2017). The minority government promulgated a Physical Planning and Utilization of Resource Acts of 1967 to control the spread of border industries into the metropolis and restricted the zoning of industrial land use in the metropolis. Another part of the Act constrained the Bantus from being employed in the existing industries without the government's consent but was instead giving employment at mines and farms with low wages (Planning, 1967).

The 'Settlement betterment Program' was intended to improve agricultural production and other land uses in the rural settlements. The fundamental concept of the program was that once a place (rural) had been declared a 'betterment' area, dispersed farmhouses would be brought together, and land suitable for cultivation would at that moment be reserved for agriculture; the rest would be enclosed for pasture (Houghton, 2013). Traditional farmsteads that were dispersed and built over the years were demolished, and people were asked to build their homes together in a layout manner, grid formation without services or facilities (Platzky, 1994). This created an unexpected impact on agriculture for women who could not travel to and from the farm and led to a reduction in subsistence farming. The Border Industry Policy and Settlement Betterment Programme eventually led to the expansion of several informal settlements around the border and nearby farmstead (Mabin, 2003).

The minority government, through the National Physical Development Plan, used the spatial planning approach to resolve the national economic challenges in 1975. They created 42 regional planning areas based on natural resources, population distributions,

economic potentials and infrastructure (Platzky, 1994). Robinson (2011) evaluates the creation of a rural service centre as an approach to facilitate economic growth and curb the influx of “poor rural” to the cities in the 70s. This led to the promulgation of the Identification Act of 1986, which was called the Abolition of Influx Control Act 68 of 1986 (Robinson, 2011). Other policies along this line were; Land Measures Act No 208 of 1991, which replaced the Black Land Act 1913 and 1936, the upgrading Land Tenure Right 112 of 1991, Less Formal Township Establishment Act, which enabled immediate land development process for migrants (Mabin, 2003). Between 1990 and 1994, there was a negotiation between the National Party-led minority rulers and several freedom activists headed by the African National Congress that was to redefine apartheid boundaries (Mabin, 2003). There were indications that from 1950 till 1994, the nation’s economy and urbanization grew along policies formulated by the minority rulers (Geyer, 2003). Urban growth and urbanization at the period were a result of migration from rural to urban to escape poverty in the rural areas, not minding unfair laws and low wages (Ndegwa, 2008). During this period, spatial development plans were designed by the White town planners, whose technicality focused on neighbourhood designed plan and building standard of an international model (Haarhoff, 2011; Özdemir, 2007). However, towards the end of the minority rule, their influence on the execution of housing policy started to weaken as this became evident in the privatization of public assets, sales of houses, recognition of informal settlements and the transient of Less Formal Township Establishment Act (LFTEA) in 1991 (Musvoto, 2011; Platzky, 1994).

#### **6.4 Human Settlement Development in Post-Minority Rule**

Most settlement patterns in the developing countries were influenced by several factors from the colonial rule and still inform the present pattern even years after their rule. In the same way, the spatial pattern of settlements in South Africa has a replication of the apartheid period. As earlier said, most Black citizens were restricted to the rural settlements and low-cost housing built at the periphery areas in a separated neighbourhood at the border. The end of minority rule ended the restriction of influx, opened up both formal and informal houses (Geyer *et al.*, 2011). After 1994, the following

various forms of housing units, according to the Shisaka Development Management Services (SDMS) became prominent housing scheme in South Africa: the Reconstruction and Development Programme (RDP) housing, Informal housing, old township housing and private housing stocks became common dwellings for the low-income Blacks. The RDP housing provision was the program of the ANC democratic government in South Africa since 1994. It has a target of building 1 million housing units yearly all over South Africa. However, there were opinions that some houses were located away from infrastructural facilities. Informal housing units are usually found at the periphery areas of the town believed to be away from employment prospects. Though not in all cases, there were situations where development spread towards such locations, and they enjoy almost the same facilities as the main city. An example is Mayville in Durban (Geyer *et al.*, 2011). Old township housing units are usually the derelict and unplanned houses; nevertheless, they have access to infrastructures due to the expansion of the city into the metropolis. Private sector housing units were facilitated by the decree of the 99 years leasehold for the township residents in the 1980s. According to SDMS (2003), since the middle of 1997, at stage two of the Home Loan Guarantee Company (HLGC), loans were provided to support homeownership (Robins, 2003; Tomlinson, 2007).

Policies which are related to human settlement development after the minority rule in South Africa are:

- a) The Development Facilitation Act of 1995: this policy came into existence after 1994. It is a spatial pattern strategy that terminated the separation that had long existed between the Black and White residential areas. It allowed ownership of land and houses by the Blacks who were the majority with a certificate of ownership (James, 2007).
- b) The Housing Act of 1997 (Act 106 of 1997): this policy was enacted to enable a sustainable housing development process at all levels of government; it also funds all programs under the national housing scheme. It explained the expected roles of national, provincial and municipality government in housing provisions.
- c) Social Housing Act 2008 (Act 16 of 2008): this policy made provision for the creation of Social Housing Regulation Authority (SHRA). It describes the

responsibility of government at all levels, their roles in the provision of social housing and land for district facilities and services (Msindo, 2018).

- d) Spatial Planning and Land Use Management (SPLUMA) Act, 2013: it made provision for an overall framework for spatial planning policies and land use management for the country.

## **6.5 Evaluation of Sustainable Human Settlement Development in South Africa**

Following the precept of sustainable settlement by United Nations Agenda as outlined in Chapter 7 of Agenda 21, South African government after 1994 drafted a settlement policy and law documents to address the issues of separation in the nation's economic and spatial development. This was accompanied by the provision of social housing, service, and infrastructure to the less privileged communities. To achieve Agenda 21, South Africa concentrated on three broad programs which are 1) Adequate Shelter for all 2) Improvement in human settlement management and 3) promotion of Land use management. These were the first three goals under chapter 7 in Agenda 21 of UNs SDG (Sullivan & Ward, 2012; UN-HABITAT, 2015).

### **Adequate Shelter for All**

In an attempt to provide shelter for all the citizens of South Africa, a subsidy of R25,580 was budgeted for the less privileged who were able to meet certain criteria, and before the year 2004, about 1.5 million housing units had been built for almost 6.5 million citizens at the cost of R24.22 billion (\$3.5billion). Beneficiaries get freehold tenure on the property. However, some limitations were noticed during the period; these include the ability to integrate the housing environment due to poor alignment of housing plans and funding distributions. Another limitation was the inability of the beneficiaries to see the house as an asset which negates the objectives of the National Housing Programme. Also, the financial bodies were reluctant to participate because of the low repayment plan. Continuous growth of informal settlement frustrate the objectives of social housing.

## **Improving Human Settlement Management through Local Government**

Integrated Development Plans was created by the Department of Provincial and Local Government to enable developments at the local government level; it empowers them to cleverly identify and budget for local services and infrastructural developmental needs. Integrated Development Plan has become an instrument for ensuring integrated sustainable development at the local government level. Service delivery is an important aspect of settlement development in South Africa, so the local government needs to have the necessary funds for the execution of infrastructural projects and services. In order to measure the impact of development, the Integrated Environmental Management process was created to provide structure for the integration of environmental assessment and management principles into resolutions on issues about the environment through some assessment tools, which is Environmental Impact Assessment (EIA). One more way to manage settlement is disaster management, especially in the densely populated areas. Some of the limitations here include the non-releasing of funds to the local government by the national and provincial governments to execute projects as outlined in the policy and the inability of some local government to execute huge developmental projects due to lack of workforce and professionals. Another is the inability of the local government to generate their income, especially from some traditionally controlled areas outside Local government jurisdiction. Also, some people perceived the tools as simply procedural exercise and not practicable (Cilliers *et al.*, 2014).

## **Promotion of Sustainable Land-use Planning and Management**

Land use management has since 1994 focused on correcting unsustainable land ownership, where the black (who are the majority) were compelled to live on a small portion of the nation's land area. Three approaches to correct this include 1) Land restitution, 2) Land redistribution, and 3) the Tenure reform program.

Land restitution program resettled people who were forced out of their land after 1913 following segregationist policy to their land or compensated monetarily.

The land redistribution program gave access and the right to land ownership for residential and other purposes.

Land Tenure Reform program dealt with the problem of the Black who could not secure tenure on their property before 1994 by giving them titles and also provide value-added public land information and services to people on land. Some of the limitations of this program include the slow rate of land restitution and redistributions at the beginning. Again, the majority preferred the option of monetary compensation rather than land, which indirectly affect redistribution (Cilliers *et al.*, 2014).

Evaluation of the performance of sustainable human settlement development above revealed two inadequacies in the achievement of its purposes. They are; 1) Lack of workforce and professionals to handle developmental projects at the local government and 2) Lack of collaboration between the community and local government, especially in the areas of harnessing the potentials that can stimulate local economic development. Given this, the following two proposals are recommended:

- a. Modelling Sustainable Human Settlement Development Pattern for South Africa's Settlement, which will be a comprehensive approach to attaining sustainable settlement development.
- b. Community participation and Government Intervention on Sustainable Settlement Development

## **6.6 Modelling Sustainable Human Settlement Development Pattern for South Africa's Settlement**

This model in figure 6.1 explains sustainable settlement development patterns from the view of settlement theory. It shows the relationship between the main aspects of settlements, namely, population, function, and forms. The population is the bases of the existence of a human settlement. The function of settlements explains the commercial roles and service delivery as they are in the theory of central places. The role can also be economical, which is facilitated by road accessibility, industrialization, and the availability of infrastructural facilities depending on the potentials and natural resources available in the settlement. Also, stakeholders like government and community leaders can influence the function a settlement will perform apart from the way the central place theory explained it.

The model explains that the service delivery, industrialization, infrastructures, and commercial factors affect the residents of a settlement. This is revealed in demography (social, economic, and physical, economic features of residents). This brings about urbanization and urban growth connected with birthrate, mortality rate, and migration patterns attached to demographic characteristics (such as household size, social status, and income level) due to residents' preference for service delivery commercial and economic functions.

The Urban-ecology model of settlement form explained settlement form based on politics and economy, which are usually controlled by the government (Musvoto, 2011; Pacione, 2009). The proposed model indicates that population and function influence the form of settlements, various governmental policies on economy and governance influence the pattern of settlement, which in turn affect the population (increase or decrease) and function. For example, an administrative seat of the government is likely to attract more population and generate several economic and commercial activities. This is the basis for the corresponding roles in the form, function, and population.

Also, worthy of note in the proposed model is the influence of government policies on service delivery, socio-physical economic activities of people within the settlement, and how these affect the pattern of settlement. It is also important to link these not only to the interaction within settlement but also outside the settlement and within the regional scale. This aspect of the model is to harness the potentials that may not be within the settlement but in other settlements within the region and build a network which, in turn, builds competitive and comparative economic advantage within the neighbourhood or region.

The last phase of the model is the preparation of sustainable settlement development plans that are based on analytical studies of the previous points. Local economic development must be based on the potential for economic growth within the settlement and other settlements within the region based on the functional analysis of the current and projected population distributions, social and economic characteristics of the settlement. Local Economic Development strategies must be supported by governmental planning, and policies aimed at the less privileged must be adopted, dependent on the nature and amount of natural resources available.

Likewise, local economic development projects should be attached to the economic potential, subject to competitive and comparative advantage. Relevant stakeholders at the international, national, and local levels must be involved in all the processes to achieve the goals of sustainable development.

The proposed model consists of five chronological parts, which are the application of the existing theories to the analysis of practices and policies in settlement development in the modelling of sustainable settlement development plans (Musvoto, 2011).

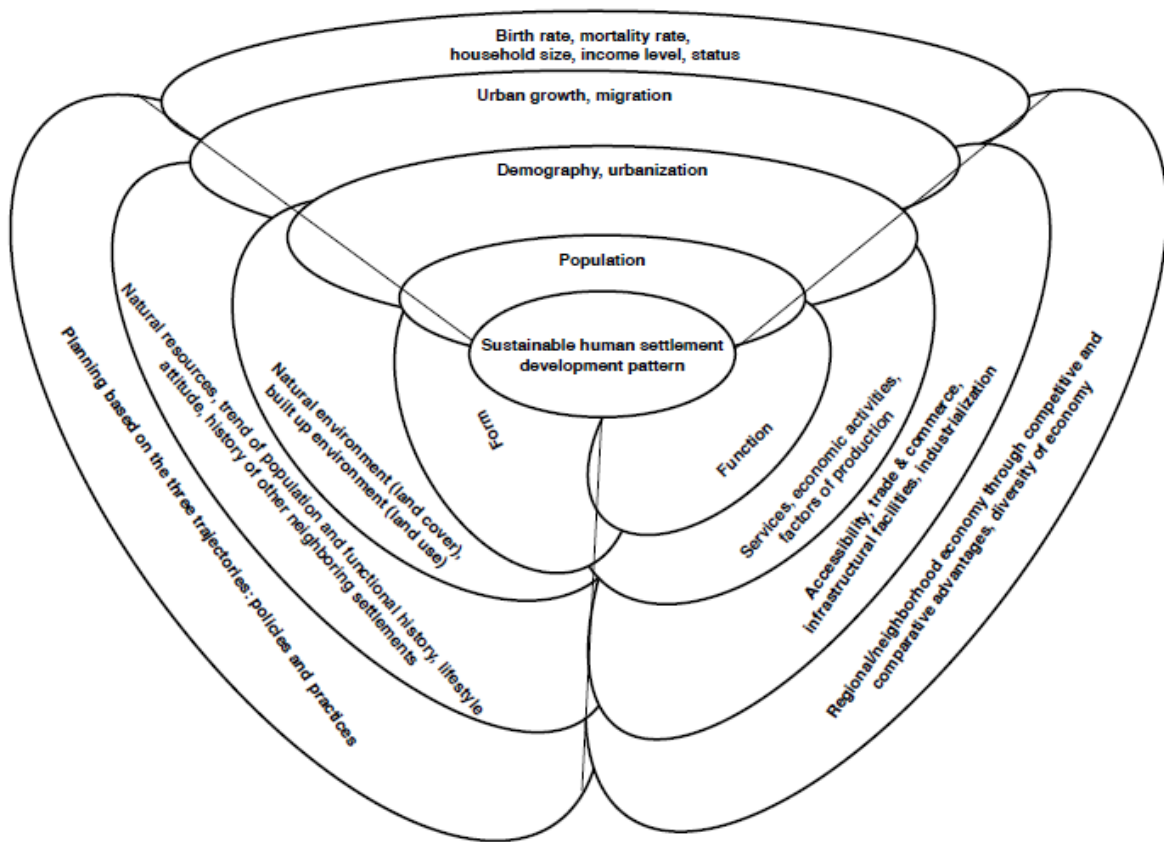


Figure 6.1: Proposed Model of a Sustainable Human Settlement Development Pattern.

Adapted from (Musvoto, 2011) model.

## **6.7 Community participation and Government Intervention on Sustainable Settlement Development**

As a consequence, settlement development processes are faced with several challenges in the Eastern part of Free State. These include community participation, self-independence, environmental preservation, liberty mentality, and social exclusivity, though it is commonly believed that community participation is an important requirement for a sustainable environment. The involvement of the community and making them believe a particular developmental project is all theirs, will give the local community a sense of ownership and a slight chance to experience the bottom-up planning process and give them the opportunity to take part in important decisions in their locality. Dreier (1996) highlighted that community participation does not only relate to the residents but is a process where environmental stakeholders come together to solve people's problems and also harness the community's potentials for development (Dreier, 1996). Ironically, people feel left out when they are not involved in any developmental projects in their environment. They feel excluded and infringed upon, and so such a project is vehemently opposed. (Hall, 1998).

Community involvement can occur at any stage of the planning process as Markey, Connelly, and Roseland (2010) pointed out. Firstly, in the formation of goals and objectives. Secondly, in the selection and execution of development plans; and thirdly through the use of natural resources in the locality as important elements of the project. Community participation remains collaborative, a pulling together of efforts of a continuous discourse between residents of the community, major players in the environment, expertise, and decision-makers (Markey *et al.*, 2010).

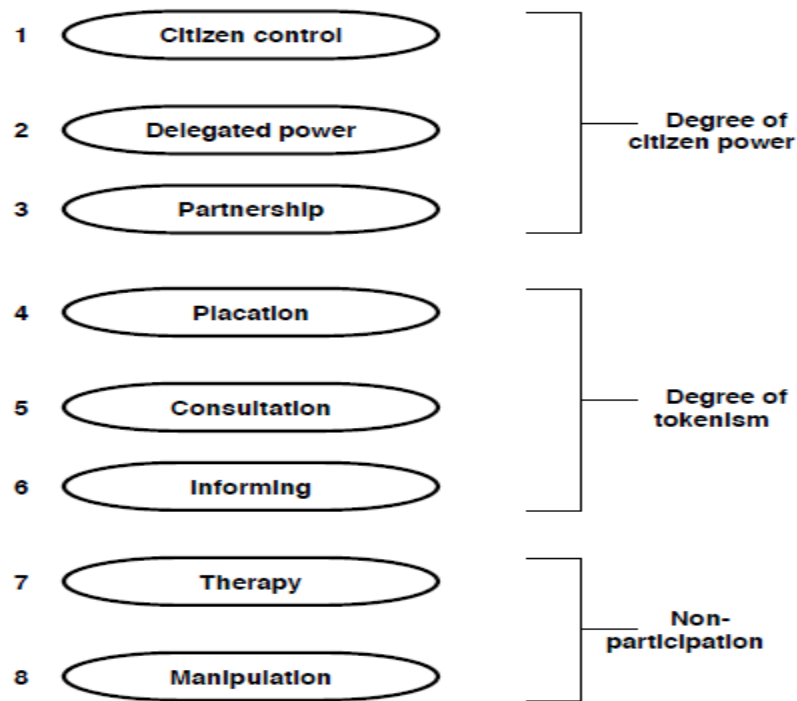


Figure 6.2: Arnstein Ladder of Citizen Participation (Arnstein, 2015)

The ladder in figure 6.2 was divided into three levels; non-participatory, degree of tokenism, and degree of citizen power. The first level comprises manipulation and therapy, which is also known as non-participatory. At this stage, the decision-makers only educate and try to impose their decisions on citizens through a top-down approach in the planning process. The second level comprises informing, consultation, and placation, which is also known as the degree of tokenism; at this stage, the involvement of citizens is enhanced. Placation, which is the highest level of tokenism through which the citizen has a say, but the decision-makers have the power to act. The third level comprises of the partnership, delegated power, and citizen control. It is also known as citizen control. Citizens control the extent of the institution's control on plan initiation, decision, and implementation. The application of this concept will enable a sustainable human settlement development plan.

## 6.8 Conclusion and Policy Recommendation

Goal 8 of the 7<sup>th</sup> chapter in Agenda 21 of the SDGs says promotion of capacity building and human resources development for human settlement development, looking inward with not too much effort to achieve this, the following recommendation is made.

Massive fertile land in Thabo Mofutsanyane municipality is a natural resource that needs to be fully utilized, so also is the huge number of rural dwellers (in the location) who leave home every morning and return late in the evening in search of “perceived better employment” is a human resource. A sustainable settlement development plan is the tool to bridge the gap between the two resources.

From the government’s intervention angle;

- It is recommended that they create a “government intervention scheme” in the form of training matric graduates to solve the problem of inadequate manpower in the execution of developmental projects at the local government level.
- Also, graduates from the school of agriculture can also be employed as agricultural officers to train local farmers in modernized farming to reach a commercial scale.
- Government can provide funding in the form of a soft loan, which will be closely monitored by the agricultural officers to make sure such loans are judiciously used to maximize profit. They can also offer to buy their farm produce in commercial quantities, store them up with guaranteed storage, and use some middle-men to be in charge of sales. With this win-win situation, the government will develop the local economy, get returns on their investment, and also, the rural population will be economically established.

Achieving a sustainable settlement development in the era of government of the majority rule in Eastern Free State and South Africa may face many challenges because of its pro-poor nature, however;

- Government intervention and community partnerships are needed to achieve long-term environmental sustainability.

- Several environmental and spatial planning issues are likely to come up between the development that is already in control by traditional rulers even before 1994 to date and the one that will be enforced and controlled by the government.
- The government intervention and community participation in physical and spatial planning of the environment will proliferate opportunities for rural dwellers and, in turn, act as a basic resource for the farm-based economy and sustained through community-based local enterprises. This will drive integrated rural development, discourage rural-urban migration, increase internal revenue, sustain the cultural heritage, and improve the local economy and rural household income.

Though, the kind of development during democratic rule which upholds cultural beliefs may pose some difficult challenges to environmental sustainability in the next few decades. Much more research is required for the workability of this proposal. Thus, sustaining and conserving development in the periphery area of the settlements in the municipality will require careful planning and political efforts, particularly if the healthy, aesthetically pleasing, and the functional environment will be achieved (Wallis *et al.*, 2011).

Potential policy recommendation involves the designation and enforcement of growth boundaries that limit settlement beyond a specified spatial extent, in addition to greater government oversight of the Protected Area settlement formation process, as opposed to the unrestrictive approach of traditional policy. For other settlements in the municipality, the occupation should be conditioned to promote a development geometry that will encourage conservation corridors while maximizing the potential for new settlers to advance their welfare. In so doing, public policy should remain attentive to the fact that the ecological impacts of the settlement are related to the spatial patterns of land acquisition for human use. It will be proposed that highway corridors provide an optimal configuration along several dimensions of ecological concern, in particular in its consistency with the maintenance of biodiversity corridors. Thus, if new occupations are deemed necessary, or prove to be difficult to control, it is obligatory on government agencies and institutions to attempt spatial interventions that guide more sustainable occupations of the landscape than might otherwise occur (Simmons *et al.*, 2016).

## CHAPTER 7

### SUMMARY OF FINDINGS AND CONCLUSION



## 7.1 Introduction

The purpose of this study was to analyze the spatio-temporal pattern of human settlement development in Afromontane regions: a case of Thabo Mofutsanyane, understand the land use land cover development in the municipality with emphasis on built-up areas before and after minority government to the majority in 1994, describe the patterns of settlement using spatial metrics, identify and assess the factors responsible for the settlement development pattern, evaluate the effects of those factors on the environmental components and bridging the gap between physical development and sustainable environment. The study intended to complement other studies on spatial analysis of settlement development, especially in mountainous areas and also inform stakeholders in environmental development, decision-makers both at local, national, and international levels. These objectives have been achieved and have already been discussed in the previous chapters. A summary of the findings in all the chapters is, therefore, put together in this chapter. Hence, this chapter introduces the evaluation of the political concept adopted as a framework for this study, the summary of findings and conclusion, contributions to the body of knowledge, limitation, and areas for further studies.

## 7.2 Evaluation of Political Ecology Concept

As earlier discussed in chapter 2, political ecology as a concept adopted for this research helps to comprehend the link between humans and their immediate surroundings. The concept provides vital perception into the way environmental issues and challenges may be socially addressed. Bryant explained the concept as “*the notion that politics should be put first in the attempt to understand how human-environment interaction may be linked to the spread of environmental degradation*” (Bryant, 2015). The concept of political ecology explains how human activities impacted on both land and natural resources. The transformation from minority to majority rule impacted greatly on settlement development both positively and adversely, as discussed in chapter 5. This calls for more awareness about the long-term effects of environmental threats if settlement development remains

uncontrolled, as this may render the environment unsustainable for the future generations. Political ecology also indicates a social and environmental situation instituted via unbalanced power relations (Gerber *et al.*, 2009). The power here may indicate how someone with authority controls the environment of another, whether the latter likes it or not (Rocheleau & Roth, 2007). This describes the situation when there was a change in government from the minority, which restricted development to the ones that enable development with little or no restriction.

From the interview conducted and the data analysis in chapter 5, it could be deduced that the political ecology concept (change in government from minority to majority rule and access to land for development) had a direct impact on the landscape of Thabo Mofutsanyane and most settlements in South Africa. Also, the political factor indirectly impacted other land uses in terms of increases and decreases during the years under study. An example is a case where farmers abandoned their farms and houses in the location and migrated to reside in town centres in search of “convenient livelihood” due to inadequate funding for mechanized farming and follow-up on agricultural training, as discussed in chapter 6.

This concept has been used in the study of urbanization in Tulkarem city, Palestine (AbuHafeetha, 2014). It can as well be used elsewhere to explain the role politics play in the development pattern of a settlement.

### **7.3 Summary of Findings and Conclusions**

Monitoring the growth and changes in urban development is key to planning and making appropriate environmental decisions which are important for environmental sustainability as well as avoiding unnecessary future infrastructural cost. In this regards, the following conclusions are drawn from this research:

1. Analysis from the classified images showed that there was evidence of land use cover change, especially in the area of built-up environment, which recorded more than 100% change between five years before the change in government and five years after the change in the three settlements under study. This was due to

democratic government's commitment to providing houses for the masses through Reconstruction and Development Programme (RDP) which aimed at building over 1 million houses in a year, a record of migration and a little increase in natural population growth from the available population data of 2001 and 2011. Although, this expansion of the built-up area does not pose any environmental threats as at now except in a few places that are controlled by traditional rulers where development has become haphazard and uncontrolled.

2. Interviews conducted with the community leaders validated the results of the classified image from the map, the change in government had given liberty to own land and houses in any part backed by various housing policies which include giving grants as well as RDP housing scheme. However, there was no adequate population data for the year before the change in government the available population data after the change and record of migration validated the study.
3. Lack of governmental control on physical development in traditionally controlled places created an overcrowded clustered unsustainable environment, which may lead to a health hazard in the event of epidemics. The study revealed that the government only came into traditionally controlled areas when siting public infrastructure.
4. Even though factors of urbanization such as small and medium industries, infrastructural facilities and access roads which bring about economic development were present, they were not as strong as a political factor in causing settlement development in the study area (Gbanie *et al.*, 2018b; Lu *et al.*, 2011).
5. The policy of owning land and houses "where you want" has caused many peasant farmers, especially in less urban areas like Vrede to abandon their far-away homes where they lived and farmed to ask for land from traditional leaders to build close to the main town where they could get a form of employment.
6. Then the impact of the political factor on the spatial pattern of Thabo Mofutsanyane is evident; other land uses have been converted to built-up land while there were changes amongst other land uses, too, which were not focused on in this study. This built-up land consists of residential, commercial, and industrial land use, which sprang up at the loss of either agricultural land, vegetation, or bare land.

7. The landscape of the three settlements in the study area experienced fragmentation in the years after 1994, with Harrismith being the most fragmented. The two remaining settlements namely Ladybrand and Vrede were more aggregated. Harrismith has an undulating landform which defines the extent of development.
8. Figure 7.1 shows the factors and driving forces for settlement development. They are emphasized (coloured) according to the respondents' opinion. The green-coloured which are major factors were ranked strongly important. The factors/driving forces in color blue are not too important or less significant factors that lead to settlement development expansion in the study areas from the participants' opinion. The red-coloured were considered as not too relevant factors to the study, while the yellow one is a new factor discovered during this study.

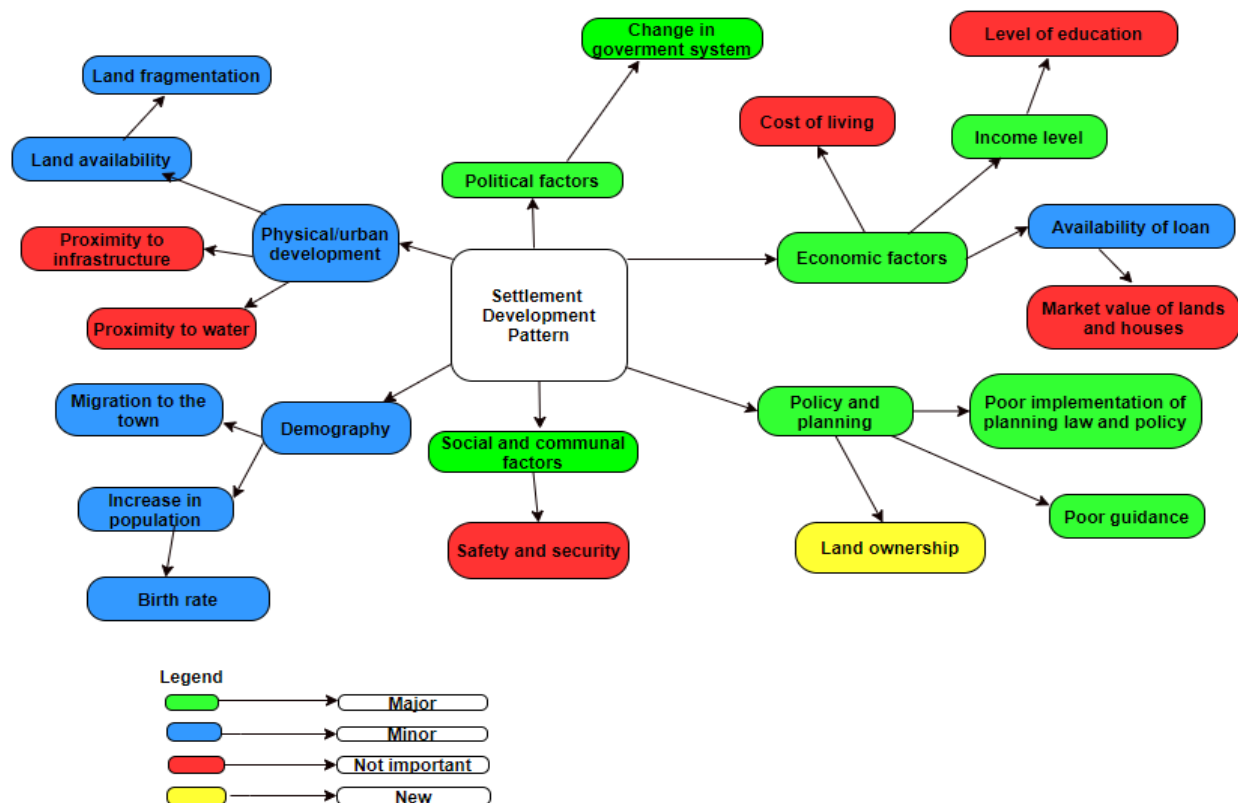


Figure 7.1: A Diagram of the factors and driving forces responsible for settlement development patterns in the Thabo Mofutsanyane municipality.

## 7.4 Recommendations

From the results of this research, the recommendations are based on the control of spatial development and achieving sustainable settlements in Thabo Mofutsanyane municipality as well as other mountainous cities in South Africa.

There is a need for proper monitoring of informal development of built-up areas; this can be done by the inclusion of locations and peri-urban settlements into the integrated development framework plan of the municipality with adequate follow up. There should be a collaboration with the traditional rulers so that it does not look like an imposition on the residents of the community. This can be achieved through zoning and building permit approval from both authorities.

Allocation of land for building, farming, grazing, and other major land use should be done with the knowledge of all the stakeholders in settlement development. This will curb the indiscriminate expansion of built-up land and prevent loss of fertile land (which is good and more profitable for agriculture) to built-up land. This also could give room for the local economic business to thrive.

Agriculture and tourism are major economic activities in Eastern Free State and considering Goal 8 of the 7<sup>th</sup> chapter in Agenda 21 of the SDGs, which aimed at the promotion of capacity building and human resources development for sustainable human settlement development; also, chapter 13 of Agenda 21 on sustainable mountain development of the same SDG. It is recommended that the government should focus more on these two local economies and use them to develop the municipality and the province.

As already discussed in chapters 1 and 6 of this study, to attain sustainable settlement development in South Africa and other developing nations, environmental challenges in the form of interference with the ecosystem, land misuse, depletion of natural resources and environmental degradation are major issues in sustainable development and therefore need serious attention and planning. Judicious monitoring and management of

development will help to curb some of these severe environmental challenges. Various stakeholders, such as government agencies in charge of physical and economic development and representatives of the community, have to collaborate in the policy formation to ensure that the potential and natural resources are well harnessed to sustain development in the region. This policy document should be reviewed often to make room for necessary adjustments.

## **7.5 Contribution to the Body of Knowledge**

This research was undertaken to understand the change in settlement development pattern and identify the factors responsible for the changes in the Thabo Mofutsanyane municipality. It contributes theoretical and methodological knowledge in studying land use cover change and spatial analysis in settlement development in areas of interest. Some of these contributions are particular to the settlements under study for the impacts of political factors, while other contributions are essential for a better knowledge of the spatial analysis and settlement development change in general.

Despite the level of global urbanization, there has been very little comprehensive documentation on the spatio-temporal change of human settlement development in mountainous areas, and the effects of those changes on the environmental components. Thabo Mofutsanyane, which is a municipality within Drakensburg mountain in the Afromontane region, has experienced growth and overpopulation in the last decade like every other municipality of developing countries which has resulted in changes in land use. Hence, this research documents the effects of these changes on settlement development in mountainous areas, especially in the area of policy change, pre and post-apartheid era as well as highlighting possible factors responsible for those changes. This research is envisioned to deliver up-to-date information on the spatial pattern of human settlements development in the region. The study is one of the pioneering research project of this kind in the region, and the outcome would inform the stakeholders and policymakers on what to do in terms of present and future planning.

The research provides detailed studies steered in the field of physical and human geography with studies of humans in their places of habitation using remote sensing and socio-economic survey. It also contributed to the field of urban and regional planning, demographic studies, sociology, economics in studying factors, and driving forces of urbanization as well as ecology. It also made a crucial contribution in the field of political science by showing the extent to which the lifestyle of a community can change through governmental policies and laws (Menze & Ur, 2012; Raddad *et al.*, 2010).

It will also complement other available literature on spatio-temporal change of human settlement development in Free State province and other parts of the country (AbuHafeetha, 2014; Adepoju & Salami, 2017).

## **7.6 Study Limitation**

One of the major challenges of this research was the unavailability of secondary data at relevant agencies, getting the required information on demographic data, income data, and other socio-economic data from SA Statistics was difficult. Three censuses have been held since 1994, which were 1996, 2001, and 2011). Population data for the years before 1994 used in this research were not available at the Statistics office. In order to overcome this challenge, an extensive search of past literature (of the late 1980s and early 1990s) was done to pull out the necessary data, even at that not all required data were found.

Another limitation was a barrier in the language; most of the interviewees preferred to communicate in their local language. The use of interpreters somewhat helped overcome this limitation. Booking appointments for interviews and lack of cooperation on the part of officials have presumed reasons for the non-releasing of some available data. This prolonged the period of data collection as bookings were eventually done after several calls and failed appointments. Also, fieldwork is somehow gender-sensitive, particularly

for female researchers, and this was overcome by building cordial relationships with reliable male colleagues who accompanied the researcher on the field trips.

One challenge that was difficult to overcome was the issue of the political boundary, which changed during one of the years under study. Part of Mantsopa local municipality was at a time outside Thabo Mofutsanyana for a while before it was fully returned. Other data, such as the number of building units before and after 1994, the number of people who got government housing, and their income could not be accessed. Inaccessibility and lack of up to date data made it challenging to predict development in the near future.

## **7.7 Areas for Further Studies**

Regardless of the limitations encountered, this research on the mountainous region was one of the fundamental studies to be conducted in the municipality and provinces. Therefore, the approaches here can be adapted to other similar settlements in South Africa, as well as any settlement that is politically or socially impacted upon around the world.

This study can be further explored by assessing the implementation of the Integrated Development Framework Plan as well as other policy documents on land use management in the municipality; this will help to understand the level of performance and make a further recommendation on better performance.

Furthermore, it should be noted that for the proposed model of the sustainable settlement development plan pattern to work satisfactorily, there is a need for collaboration of various key players and experts. Harnessing the proficiencies of professionals in the field of demography, economics, project management, urban and regional planning who will synchronize the plan for public and private partnerships to attain sustainable economic growth will be needed.

## References

- AbuHafeetha, M. (2014). The impacts of urbanization on agricultural sustainability in Palestine after the construction of the Separation Wall: The case of the city of Tulkarem. *Ph.D. Thesis, University of Calgary, Canada*.
- Adepoju, K. A., & Salami, A. T. (2017). Geospatial assessment of forest fragmentation and its implications for ecological processes in tropical forests. *Journal of Landscape Ecology, 10*(2), 19-34.
- Aditjandra, P. T. (2013). The impact of urban development patterns on travel behaviour: Lessons learned from a British metropolitan region using macro-analysis and micro-analysis in addressing the sustainability agenda. *Research in Transportation Business & Management, 7*, 69-80.
- Akinboye, O., Ayanwuyi, E., Kuponiyi, F., & Oyetero, J. (2007). Factors affecting youth participation in community development in Remo North Government Area of Ogun State. *The Social Sciences, 2*(3), 307-311.
- Alatout, S. (2009). Bringing abundance into environmental politics: Constructing a Zionist network of water abundance, immigration, and colonization. *Social Studies of Science, 39*(3), 363-394.
- Alcock, P. (2014). Venus Rising. In.
- Allendorf, F. W., Luikart, G., & Aitken, S. N. (2007). Conservation and the genetics of populations. *mammalia, 2007*(2007), 189-197.
- Amos, J. (2005). Ancient phallus unearthed in cave. *BBC News, July, 25*.
- Ananda, J. (2007). Implementing participatory decision making in forest planning. *Environmental Management, 39*(4), 534.
- Anderson, J. R. (1976). *A land use and land cover classification system for use with remote sensor data* (Vol. 964): US Government Printing Office.
- Arnstein, S. R. (2015). A ladder of citizen participation. *The city reader, 279*.
- Aronson, M. F., La Sorte, F. A., Nilon, C. H., Katti, M., Goddard, M. A., Lepczyk, C. A., Warren, P. S., Williams, N. S., Cilliers, S., & Clarkson, B. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B: Biological Sciences, 281*(1780), 20133330.
- Arouri, M. E. H., Youssef, A. B., Nguyen-Viet, C., & Soucat, A. (2014). Effects of urbanization on economic growth and human capital formation in Africa.
- Arthur, C. (2008). The archaeology of indigenous herders in the Western Cape of South Africa. *Southern African Humanities, 20*(1), 205-220.
- Atal, J., Ñopo, H., & Winder, N. (2009). New century, old disparities: gender and ethnic wage gaps in Latin America.
- Axelson, E. (1988). *The Dias Voyage, 1487-1488: Toponymy and Padrões* (Vol. 189): UC Biblioteca Geral 1.
- Bailey, T. C., & Gatrell, A. C. (1995). *Interactive spatial data analysis* (Vol. 413): Longman Scientific & Technical Essex.
- Balcilar, M., Kutan, A. M., & Yaya, M. E. (2017). Testing the dependency theory on small island economies: The case of Cyprus. *Economic Modelling, 61*, 1-11.

- Barbero-Sierra, C., Marques, M.-J., & Ruíz-Pérez, M. (2013). The case of urban sprawl in Spain as an active and irreversible driving force for desertification. *Journal of Arid Environments*, 90, 95-102.
- Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. *Environmentalist*, 19(2), 145-161.
- Beck, R. B. (2013). *The History of South Africa: ABC-CLIO*.
- Berger, L. R., Hawks, J., de Ruiter, D. J., Churchill, S. E., Schmid, P., Delezene, L. K., Kivell, T. L., Garvin, H. M., Williams, S. A., & DeSilva, J. M. (2015). Homo naledi, a new species of the genus Homo from the Dinaledi Chamber, South Africa. *elife*, 4, e09560.
- Berniell-Lee, G., Calafell, F., Bosch, E., Heyer, E., Sica, L., Mouguiama-Daouda, P., Van der Veen, L., Hombert, J.-M., Quintana-Murci, L., & Comas, D. (2009). Genetic and demographic implications of the Bantu expansion: insights from human paternal lineages. *Molecular biology and evolution*, 26(7), 1581-1589.
- Berry, B. J. (2015). *THE HUMAN CONSEQUENCES OF URBANISATION*: Macmillan International Higher Education.
- Blaschke, T., Lang, S., & Hay, G. (2008). *OBJECT-BASED IMAGE ANALYSIS: SPATIAL CONCEPTS FOR KNOWLEDGE-DRIVEN REMOTE SENSING APPLICATIONS*: Springer Science & Business Media.
- Bloom, D. E. (2011). 7 billion and counting. *Science*, 333(6042), 562-569.
- Blyth, S., Groombridge, B., Lysenko, I., Miles, L., & Newton, A. (2002a). Mountain watch. *Cambridge, UK: UNEP World Conservation Monitoring Centre*.
- Blyth, S., Groombridge, B., Lysenko, I., Miles, L., & Newton, A. (2002b). UNEP–WCMC (United Nations Environment Programme–World Conservation Monitoring Centre) Report, Mountain watch: environmental change and sustainable development in mountains. *UNEP World Conservation Monitoring Centre, Cambridge, UK*, 19.
- Bontje, M. (2003). A Planner's Paradise'Lost? Past, Present and Future of Dutch National Urbanization Policy. *European urban and regional studies*, 10(2), 135-151.
- Boria, R. A., Olson, L. E., Goodman, S. M., & Anderson, R. P. (2014). Spatial filtering to reduce sampling bias can improve the performance of ecological niche models. *Ecological Modelling*, 275, 73-77.
- Brand, R. F., Du Preez, P. J., & Brown, L. R. (2008). A floristic description of the Afromontane Fynbos communities on Platberg, Eastern Free State, South Africa. *Koedoe*, 50(1), 202-231.
- Brückner, M. (2012). Economic growth, size of the agricultural sector, and urbanization in Africa. *Journal of Urban Economics*, 71(1), 26-36.
- Bryant, R. L. (2015). *The international handbook of political ecology*: Edward Elgar Publishing.
- Bryant, R. L., Paniagua, A., & Kizos, T. (2011). Conceptualising 'shadow landscape' in political ecology and rural studies. *Land Use Policy*, 28(3), 460-471.
- Calabrese, J. M., & Fagan, W. F. (2004). A comparison-shopper's guide to connectivity metrics. *Frontiers in Ecology and the Environment*, 2(10), 529-536.
- Cameron, R. (1996). The reconstruction and development programme. *Journal of Theoretical Politics*, 8(2), 283-294.
- Cannon, T. (1990). Regions: spatial inequality and regional policy. *The Geography of Contemporary China: The Impact of Deng Xiaoping's Decade*, 28-60.

- Carlson, T. N., & Arthur, S. T. (2000). The impact of land use—land cover changes due to urbanization on surface microclimate and hydrology: a satellite perspective. *Global and planetary change*, 25(1-2), 49-65.
- Chen, Huang, Y., Tang, Z., Lu, D., Liu, H., & Ma, L. (2014). The provincial pattern of the relationship between urbanization and economic development in China. *Journal of Geographical Sciences*, 24(1), 33-45.
- Chen, Z., Liu, Y., Feng, W., Li, Y., & Li, L. (2019). Study on spatial tropism distribution of rural settlements in the Loess Hilly and Gully Region based on natural factors and traffic accessibility. *Journal of Rural Studies*.
- Cho, S.-H., English, B. C., & Roberts, R. K. (2005). A spatial analysis of housing growth. *The Review of Regional Studies*, 35(3), 311.
- Christopher, A. J. (2011). The Union of South Africa censuses 1911-1960: an incomplete record. *Historia*, 56(2), 01-18.
- Cilliers, S., Du Toit, M., Cilliers, J., Drewes, E., & Retief, F. (2014). Sustainable urban landscapes: South African perspectives on transdisciplinary possibilities. *Landscape and Urban Planning*, 125, 260-270.
- Cohen, B. (2015). Urbanization, City growth, and the New United Nations development agenda. *Cornerstone*, 3(2), 4-7.
- Connelly, S. (2007). Mapping sustainable development as a contested concept. *Local environment*, 12(3), 259-278.
- Coops, N. C., Wulder, M. A., & Iwanicka, D. (2009a). Large area monitoring with a MODIS-based Disturbance Index (DI) sensitive to annual and seasonal variations. *Remote sensing of environment*, 113(6), 1250-1261.
- Coops, N. C., Wulder, M. A., & Iwanicka, D. (2009b). Large area monitoring with a MODIS-based Disturbance Index (DI) sensitive to annual and seasonal variations. *Remote Sensing of Environment*. 113(6), 1250-1261.
- Coppin, P., Jonckheere, I., Nackaerts, K., Muys, B., & Lambin, E. (2004). Digital change detection methods in ecosystem monitoring: a review. *International Journal of Remote Sensing*. 25(9), 1565-1596.
- Coppin, P., Lambin, E., Jonckheere, I., & Muys, B. (2002). Digital change detection methods in natural ecosystem monitoring: A review. In *Analysis of Multi-Temporal Remote Sensing Images* (pp. 3-36): World Scientific.
- Couvillion, B. R. (2005). Spatial heterogeneity in forested landscapes: an examination of forest fragmentation and suburban sprawl in the Florida parishes of Louisiana.
- Coyle, C., Creamer, R. E., Schulte, R. P., O'Sullivan, L., & Jordan, P. (2016). A functional land management conceptual framework under soil drainage and land use scenarios. *Environmental Science & Policy*, 56, 39-48.
- Crumley, C. L. (1976). Toward a locational definition of state systems of settlement. *American Anthropologist*, 78(1), 59-73.
- Dave, S. (2010). High urban densities in developing countries: A sustainable solution? *Built environment*, 36(1), 9-27.
- Davenport, T., & Saunders, C. (2000). *South Africa: A modern history*: Springer.
- Davies, M. I. (2012). Some thoughts on a 'useable'African archaeology: settlement, population and intensive farming among the Pokot of northwest Kenya. *African Archaeological Review*, 29(4), 319-353.

- de Beer, J. (2016). The dawn of South African geophysics: Early geomagnetic observations and studies. *The History of Geophysics in Southern Africa*, 2.
- De Bellefon, M.-P., Combes, P.-P., Duranton, G., Gobillon, L., & Gorin, C. (2019). Delineating urban areas using building density. *Journal of Urban Economics*, 103226.
- De Los Andes, C. (2012). Mountains as the water towers of the world: A call for action on the sustainable development goals (SDGs). *Policy*.
- Dean, A., & Smith, G. (2003). An evaluation of per-parcel land cover mapping using maximum likelihood class probabilities. *International Journal of Remote Sensing*, 24(14), 2905-2920.
- Derudder, B., & Taylor, P. (2005). The cliquishness of world cities. *Global Networks*, 5(1), 71-91.
- Devenin, V., & Bianchi, C. (2019). Characterizing a mining space: Analysis from case studies in Chile and Australia. *Resources policy*, 63, 101402.
- Dhakal, K. P., & Chevalier, L. R. (2017). Managing urban stormwater for urban sustainability: Barriers and policy solutions for green infrastructure application. *Journal of environmental management*, 203, 171-181.
- Diggle, P. J. (1983). *Statistical analysis of spatial point patterns*: Academic press.
- DISLEY, Y. P. (2013). Sustainable development goals for people and planet. *Nature*, 495, 21.
- Dreier, P. (1996). Community empowerment strategies: The limits and potential of community organizing in urban neighborhoods. *Cityscape*, 121-159.
- Duranton, G., & Puga, D. (2004). Micro-foundations of urban agglomeration economies. In *Handbook of regional and urban economics* (Vol. 4, pp. 2063-2117): Elsevier.
- Elvidge, C. D., Dietz, J. B., Berkelmans, R., Andrefouet, S., Skirving, W., Strong, A. E., & Tuttle, B. T. (2004). Satellite observation of Keppel Islands (Great Barrier Reef) 2002 coral bleaching using IKONOS data. *Coral Reefs*, 23(1), 123-132.
- Enemark, S. (2005). *Land management and development*. Paper presented at the CLGE International Conference.
- Enemark, S. (2006). *Land management and means of planning control*. Paper presented at the National Congress of Licensed Surveyors. Saint-Malo.
- Epprecht, M. (2013). *Hungochani: The history of a dissident sexuality in southern Africa*: McGill-Queen's Press-MQUP.
- Esch, T., Marconcini, M., Marmanis, D., Zeidler, J., Elsayed, S., Metz, A., Müller, A., & Dech, S. (2014). Dimensioning urbanization—An advanced procedure for characterizing human settlement properties and patterns using spatial network analysis. *Applied Geography*, 55, 212-228.
- Estoque, R. C., & Murayama, Y. (2013). Landscape pattern and ecosystem service value changes: Implications for environmental sustainability planning for the rapidly urbanizing summer capital of the Philippines. *Landscape and Urban Planning*, 116, 60-72.
- Estoque Ronald, C., Yuji, M., Courage, K., & Akio, Y. (2014). Geospatial analysis of urban landscape patterns in three major cities of Southeast Asia.
- Fan, F., Wang, Y., Qiu, M., & Wang, Z. (2009). Evaluating the temporal and spatial urban expansion patterns of Guangzhou from 1979 to 2003 by remote sensing and GIS

- methods. *International Journal of Geographical Information Science*, 23(11), 1371-1388.
- Feinstein, C. H. (2005). *An economic history of South Africa: Conquest, discrimination, and development*. Cambridge University Press.
- Fichera, C. R., Modica, G., & Pollino, M. (2012). Land Cover classification and change-detection analysis using multi-temporal remote sensed imagery and landscape metrics. *European Journal of Remote Sensing*, 45(1), 1-18.
- Fischer, M., Bossdorf, O., Gockel, S., Hänsel, F., Hemp, A., Hessenmöller, D., Korte, G., Nieschulze, J., Pfeiffer, S., & Prati, D. (2010). Implementing large-scale and long-term functional biodiversity research: The Biodiversity Exploratories. *Basic and Applied Ecology*, 11(6), 473-485.
- Fletcher, J., Robert J, Ries, L., Battin, J., & Chalfoun, A. D. (2007). The role of habitat area and edge in fragmented landscapes: definitively distinct or inevitably intertwined? *Canadian journal of zoology*, 85(10), 1017-1030.
- Foody, G. M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment*. 80(1), 185-201.
- Fox, S. (2012). Urbanization as a global historical process: Theory and evidence from sub-Saharan Africa. *Population and Development Review*, 38(2), 285-310.
- Fragkias, M., & Seto, K. C. (2009). Evolving rank-size distributions of intra-metropolitan urban clusters in South China. *Computers, Environment and Urban Systems*, 33(3), 189-199.
- Franklin, S. (2016). Enabled to work: the impact of government housing on slum dwellers in south africa.
- Frumkin, H. (2016). Urban sprawl and public health. *Public health reports*.
- Galor, O., Moav, O., & Vollrath, D. (2009). Inequality in landownership, the emergence of human-capital promoting institutions, and the great divergence. *The Review of economic studies*, 76(1), 143-179.
- Gatrell, A. C., Bailey, T. C., Diggle, P. J., & Rowlingson, B. S. (1996). Spatial point pattern analysis and its application in geographical epidemiology. *Transactions of the Institute of British geographers*, 256-274.
- Gatrell, J. D., & Jensen, R. R. (2008). Sociospatial applications of remote sensing in urban environments. *Geography Compass*, 2(3), 728-743.
- Gbanie, S., Griffin, A., & Thornton, A. (2018a). Impacts on the urban environment: land cover change trajectories and landscape fragmentation in Post-War Western Area, Sierra Leone. *Remote Sensing*, 10(1), 129.
- Gbanie, S. P., Griffin, A. L., & Thornton, A. (2018b). Impacts on the urban environment: Land cover change trajectories and landscape fragmentation in post-war Western Area, Sierra Leone. *Remote Sensing*, 10(1), 129.
- Geist, H. J., & Lambin, E. F. (2002). Proximate Causes and Underlying Driving Forces of Tropical DeforestationTropical forests are disappearing as the result of many pressures, both local and regional, acting in various combinations in different geographical locations. *BioScience*, 52(2), 143-150.
- Gerber, J.-F., Veuthey, S., & Martínez-Alier, J. (2009). Linking political ecology with ecological economics in tree plantation conflicts in Cameroon and Ecuador. *Ecological Economics*, 68(12), 2885-2889.

- Geyer, H. S. (2003). Differential urbanisation in South Africa—a further exploration. *Tijdschrift voor Economische en Sociale Geografie*, 94(1), 89-99.
- Geyer, H. S., Coetzee, H., Du Plessis, D., Donaldson, R., & Nijkamp, P. (2011). Recent business transformation in intermediate-sized cities in South Africa. *Habitat International*, 35(2), 265-274.
- Giliomee, H. B. (2003). *The Afrikaners: Biography of a people*: University of Virginia Press.
- Gontia, P., Thuvander, L., & Wallbaum, H. (2020). Spatio-temporal characteristics of residential material stocks and flows in urban, commuter, and rural settlements. *Journal of Cleaner Production*, 251, 119435.
- Goonetilleke, A., Thomas, E., Ginn, S., & Gilbert, D. (2005). Understanding the role of land use in urban stormwater quality management. *Journal of environmental management*, 74(1), 31-42.
- Görgens, T., & Denoon-Stevens, S. (2013). *Towards Facilitative and Pro-poor Land-Use Management in South African Urban Areas: Learning from International Experience*. Paper presented at the Urban Forum.
- Griggs, D., Stafford-Smith, M., Gaffney, O., Rockström, J., Öhman, M. C., Shyamsundar, P., Steffen, W., Glaser, G., Kanie, N., & Noble, I. (2013). Sustainable development goals for people and planet. *Nature*, 495(7441), 305-307. doi:10.1038/495305a
- Gu, H., Liu, Z., & Shen, T. (2020). Spatial pattern and determinants of migrant workers' interprovincial hukou transfer intention in China: Evidence from a National Migrant Population Dynamic Monitoring Survey in 2016. *Population, Space and Place*, 26(2), e2250.
- Guanghui, J., Fengrong, Z., Jing, Q., Lin, Z., & Pan, G. (2006). Relationship between distribution changes of rural residential land and environment in mountainous areas of Beijing [J]. *Transactions of the Chinese Society of Agricultural Engineering*, 11.
- Gude, P. H., Hansen, A. J., Rasker, R., & Maxwell, B. (2006). Rates and drivers of rural residential development in the Greater Yellowstone. *Landscape and Urban Planning*, 77(1-2), 131-151.
- Güneralp, B., Lwasa, S., Masundire, H., Parnell, S., & Seto, K. C. (2017). Urbanization in Africa: challenges and opportunities for conservation. *Environmental Research Letters*, 13(1), 015002.
- Gunn, M., & Codd, L. E. W. (1981). *Botanical Exploration Southern Africa*: CRC Press.
- GUO, B., & REN, Z.-y. (2007). Research in choose best band of landsat images used in land use and land cover change [J]. *Journal of Shaanxi Normal University (Natural Science Edition)*, 2.
- Güzey, Ö. (2016). The last round in restructuring the city: Urban regeneration becomes a state policy of disaster prevention in Turkey. *Cities*, 50, 40-53.
- Haarhoff, E. J. (2011). Appropriating modernism: Apartheid and the South African township. *A/Z ITU Journal of the Faculty of Architecture*, 8(1), 184-195.
- Habitat, U. (1976). The Vancouver declaration on human settlements. In: Nairobi: UN Habitat.
- Hall, D. R. (1998). Tourism development and sustainability issues in Central and South-Eastern Europe. *Tourism Management*, 19(5), 423-431.

- Hall, S. (1997). The local and the global: Globalization and ethnicity. *Cultural Politics*. 11, 173-187.
- Hansen, M., DeFries, R., Townshend, J., Carroll, M., Dimiceli, C., & Sohlberg, R. (2003). Global percent tree cover at a spatial resolution of 500 meters: First results of the MODIS vegetation continuous fields algorithm. *Earth Interactions*, 7(10), 1-15.
- Hansen, M. C., DeFries, R. S., Townshend, J. R., & Sohlberg, R. (2000). Global land cover classification at 1 km spatial resolution using a classification tree approach. *International Journal of Remote Sensing*, 21(6-7), 1331-1364.
- Harries, P. (1994). *Work, culture, and identity: migrant laborers in Mozambique and South Africa, c. 1860-1910*: Pearson Education Ltd.
- Healey, P. (2006). *Making strategic spatial plans*: Routledge.
- Herold, M., Goldstein, N. C., & Clarke, K. C. (2003). The spatio-temporal form of urban growth: measurement, analysis and modeling. *Remote sensing of Environment*, 86(3), 286-302.
- Higgins, C., Milne, M., & van Gramberg, B. (2011). Towards a more nuanced understanding of sustainable development reporting in Australia. *School of Management & Information Systems, Victoria University, Melbourne*.
- Hirschman, A. O. (2013). *The Essential Hirschman*: Princeton University Press.
- HLONGWANE, N. (2015). *Breeding Admixture of Cattle Populations Kept in the Thabo Mofutsanyane District*. Bloemfontein: Central University of Technology, Free State,
- Hoffmann, E. M., Konerding, V., Nautiyal, S., & Buerkert, A. (2019). Is the push-pull paradigm useful to explain rural-urban migration? A case study in Uttarakhand, India. *PloS one*, 14(4), e0214511.
- Holmes, P., & Barker, C. H. (2006). Geological and geomorphological controls on the physical landscape of the Free State. *South African Geographical Journal*, 88(1), 3-10.
- Houghton, J. (2013). Local-global influences on project-led urban renewal in Durban, South Africa. In *The Routledge companion to urban regeneration* (pp. 127-136): Routledge.
- Hunt, J. (2005). *Dutch South Africa: early settlers at the Cape, 1652-1708*: Troubador Publishing Ltd.
- Hurskainen, P., & Pellikka, P. (2004). *Change detection of informal settlements using multi-temporal aerial photographs—the case of Voi, SE-Kenya*. Paper presented at the Proceedings of the 5th African Association of Remote Sensing of the Environment conference, Nairobi, Kenya, unpaginated CD-ROM.
- Inglehart, R. (2005). Christian Welzel Modernization, Cultural Change, and Democracy The Human Development Sequence. In: Cambridge-" Cambridge University Press.
- Insight, G. (2013). IHS global insight regional explorer encyclopedia. *Johannesburg: IHS Global Insight*.
- Ismael, A. K. (2013). Settlement size and its effect on sustainable rural development: A case study of Erbil, Kurdistan Region/Iraq. *Journal of Economics and Sustainable Development*, 20(4), 139-147.
- Jaafari, S., Shabani, A. A., Danehkar, A., Nazarisamani, A., Aplin, P., Batistella, M., Robeson, S., Moran, E., Bonta, M., & Leitao, B. (2005). FRAGSTATS: Spatial

- pattern analysis program for quantifying landscape structure. *Research Journal of Environmental Sciences*, 8(2), 104-113.
- Jabareen, Y. R. (2006). Sustainable urban forms: Their typologies, models, and concepts. *Journal of planning education and research*, 26(1), 38-52.
- Jain, S., Kohli, D., Rao, R. M., & Bijker, W. (2011). Spatial metrics to analyse the impact of regional factors on pattern of urbanisation in Gurgaon, India. *Journal of the Indian Society of Remote Sensing*, 39(2), 203-212.
- James, D. (2007). *Gaining Ground?: Rights and Property in South African Land Reform*: Routledge-Cavendish.
- Jarbandhan, D. B., Viljoen, K., de Beer, J., & Blaauw, D. (2016). Low-Cost Housing Finance and Delivery Challenges in South Africa. *Loyola Journal of Social Sciences*, 30(2).
- Jensen. (1996). *An introduction to Bayesian networks* (Vol. 210): UCL press London.
- Jensen, J. R. (2009). *Remote Sensing of the Environment: An Earth Resource Perspective 2/e*: Pearson Education India.
- Jing-bing, G., Lin, L., & Shan-jin, L. (2009). Characteristics and mechanism of tourism urbanization of Lijiang city. *Scientia Geographica Sinica*, 1, 134-140.
- Jose, S., Kumar, S., Varghese, A., & Madhu, G. (2011). Landscape metric modeling-a technique for forest disturbance assessment in Shendurney wildlife sanctuary. *Environmental Research, Engineering and Management*, 58(4), 34-41.
- Kachru, B., Kachru, Y., & Nelson, C. (2009). *The handbook of world Englishes* (Vol. 48): John Wiley & Sons.
- Kamusoko, C., & Aniya, M. (2007). Land use/cover change and landscape fragmentation analysis in the Bindura District, Zimbabwe. *Land degradation & development*, 18(2), 221-233.
- Kanagalakshmi, A., & Nagan, S. (2013). Impact of Land Use on Environmental Quality Due to Urbanization a Case Study–Tirumangalam Taluk, Madurai.
- Kaneda, T., Dupuis, G., & Bietsch, K. (2015). 2015 World Population Data Sheet. *Washington, DC: Population Reference Bureau*. Accessed September, 13, 2014.
- Kantola, T., Vastaranta, M., Yu, X., Lyytikainen-Saarenmaa, P., Holopainen, M., Talvitie, M., Kaasalainen, S., Solberg, S., & Hyyppa, J. (2010). Classification of defoliated trees using tree-level airborne laser scanning data combined with aerial images. *Remote Sensing*, 2(12), 2665-2679.
- Kaplan, D. H., & Holloway, S. (2014). *Urban geography*: Wiley Global Education.
- Kazemzadeh-Zow, A., Zanganeh Shahraki, S., Salvati, L., & Samani, N. N. (2017). A spatial zoning approach to calibrate and validate urban growth models. *International Journal of Geographical Information Science*, 31(4), 763-782.
- Keivani, R. (2010). A review of the main challenges to urban sustainability. *International Journal of Urban Sustainable Development*, 1(1-2), 5-16.
- Kindleberger, C. P., Di Tella, G., & Di Tella, G. (2016). *Economics in the Long View: essays in honour of WW Rostow*: Springer.
- Klein, I., Gessner, U., & Kuenzer, C. (2012). Regional land cover mapping and change detection in Central Asia using MODIS time-series. *Applied Geography*, 35(1-2), 219-234.
- Kleynhans, W., Salmon, B. P., Olivier, J. C., Van den Bergh, F., Wessels, K. J., Grobler, T. L., & Steenkamp, K. C. (2012). Land cover change detection using

- autocorrelation analysis on MODIS time-series data: Detection of new human settlements in the Gauteng Province of South Africa. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 5(3), 777-783.
- Krannich, R. S., Luloff, A. E., & Field, D. R. (2011). *PEOPLE, PLACES AND LANDSCAPES: SOCIAL CHANGE IN HIGH AMENITY RURAL AREAS* (Vol. 14): Springer Science & Business Media.
- Krippendorff, K. (2018). *Content analysis: An introduction to its methodology*: Sage publications.
- Kunzmann, K. R. (2015). Urbanization in China: learning from Europe? A European perspective. *International Journal of Urban Sciences*, 19(2), 119-135.
- Kuper, A. (1993). The 'House' and Zulu political structure in the nineteenth century. *The Journal of African History*, 34(3), 469-487.
- Lagerquist, P. (2003). Privatizing the occupation: The political economy of an Oslo development project. *Journal of Palestine Studies*, 32(2), 5-20.
- Legassick, M. C. (2010). *The politics of a South African frontier: The Griqua, the Sotho-Tswana and the missionaries, 1780-1840*: Basler Afrika Bibliographien.
- Leggett, J. A., & Carter, N. T. (2012). *Rio+ 20: The United Nations Conference on Sustainable Development, June 2012*.
- Leitao, A. B., & Ahern, J. (2002). Applying landscape ecological concepts and metrics in sustainable landscape planning. *Landscape and Urban Planning*, 59(2), 65-93.
- Li, C., Li, J., & Wu, J. (2013). Quantifying the speed, growth modes, and landscape pattern changes of urbanization: a hierarchical patch dynamics approach. *Landscape ecology*, 28(10), 1875-1888.
- Li, H., & Song, W. (2019). Expansion of rural settlements on high-quality arable land in Tongzhou District in Beijing, China. *Sustainability*, 11(19), 5153.
- LI, Y.-q., QI, W., WANG, D., YAN, Y., LU, C., WANG, N.-n., & QIN, T.-t. (2011a). Research on Spatial Distribution Characteristics of Rural Settlements in Mountainous Areas at County Level Based on GIS: A Case Study in Qixia City [J]. *Geography and Geo-Information Science*, 3, 73-77.
- Li, Y., Liu, C., Zhang, H., & Gao, X. (2011). Evaluation on the human settlements environment suitability in the Three Gorges Reservoir Area of Chongqing based on RS and GIS. *Journal of Geographical Sciences*, 21(2), 346.
- Liang-yong, W. (2001). Search for the Theory of Science of Human Settlement [J]. *Planners*, 17(6), 5-8.
- Liebhold, A., & Gurevitch, J. (2002). Integrating the statistical analysis of spatial data in ecology. *Ecography*, 25(5), 553-557.
- Lillesand, T., Kiefer, R. W., & Chipman, J. (2014). *Remote sensing and image interpretation*: John Wiley & Sons.
- Lin, Y.-P., Hong, N.-M., Chiang, L.-C., Liu, Y.-L., & Chu, H.-J. (2012). Adaptation of land-use demands to the impact of climate change on the hydrological processes of an urbanized watershed. *International journal of environmental research and public health*, 9(11), 4083-4102.
- Linard, C., Gilbert, M., Snow, R. W., Noor, A. M., & Tatem, A. J. (2012). Population distribution, settlement patterns and accessibility across Africa in 2010. *PloS one*, 7(2), e31743.
- Lindley, A. (2014). *Crisis and migration: critical perspectives*: Routledge.

- Liu, H., Zhang, S., & Lu, X. (2004). Wetland landscape structure and the spatial-temporal changes in 50 years in the Sanjiang Plain. *ACTA GEOGRAPHICA SINICA-CHINESE EDITION*-, 59(3), 400-407.
- Liu, J., Zhan, J., & Deng, X. (2005). Spatio-temporal patterns and driving forces of urban land expansion in China during the economic reform era. *AMBIO: a journal of the human environment*, 34(6), 450-456.
- Liu, J., Zhang, Z., Xu, X., Kuang, W., Zhou, W., Zhang, S., Li, R., Yan, C., Yu, D., & Wu, S. (2010). Spatial patterns and driving forces of land use change in China during the early 21st century. *Journal of Geographical Sciences*, 20(4), 483-494.
- Lloyd, E. K., Bhatt, B. V., & Padhya, H. J. (2016). *Urban land use planning scopes in post-war city of Monrovia, Republic of Liberia. International Journal of Advanced Research in Engineering, Science & Management (IJARESM)*. .
- Lodge, T., & Phillip, D. (2003). The RDP: Delivery and performance in politics in south africa: From mandela to mbeki. *Cape Town: Oxford*.
- Lu, D., Mausel, P., Brondizio, E., & Moran, E. (2004). Change detection techniques. *International journal of remote sensing*, 25(12), 2365-2401.
- Lu, D., Weng, Q., & Li, G. (2006). Residential population estimation using a remote sensing derived impervious surface approach. *International Journal of Remote Sensing*. 27(16), 3553-3570.
- Lu, Q., Liang, F., Bi, X., Duffy, R., & Zhao, Z. (2011). Effects of urbanization and industrialization on agricultural land use in Shandong Peninsula of China. *Ecological Indicators*, 11(6), 1710-1714.
- Mabin, A. (2003). Dispossession, exploitation and struggle: an historical overview of South African urbanization. In *The apartheid city and beyond* (pp. 24-36): Routledge.
- Mabin, A. (2005). Suburbanisation, segregation, and government of territorial transformations. *Transformation: Critical Perspectives on Southern Africa*, 57(1), 41-63.
- Macleod, R. D., & Congalton, R. G. (1998). A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. *Photogrammetric engineering and remote sensing*, 64(3), 207-216.
- Madlingozi, T. (2007). Post-apartheid social movements and the quest for the elusive 'new' south africa. *Journal of Law and Society*, 34(1), 77-98.
- Madu, I. (2003). Agricultural land use intensification and environmental degradation in south eastern Nigeria: The need for a sustainable land management system. *Onokala PC, PO Phil-eze and IA.. Madu (Eds). Environment and Poverty in Nigeria Enugu, Jamoe enterprises*, 100-113.
- Madu, I. (2016). Geographic perspective: the missing link in Nigeria" s quest for rural development. In.
- Madu, I. A. (2007). Spatial Patterns and the Underlying Factors of Rural Development in the Nsukka Region, Southeastern Nigeria. *Journal of Rural and Community Development*, 2(2).
- Makkar, P., & Vasishta, S. (2017). Sustainability through innovation. *International Journal of Education and Management Studies*, 7(4), 614-617.

- Malik, R., & Ali, M. (2015). The impact of urbanization on agriculture sector: A case study of Peshawar, Pakistan. *Journal of resources development and management*, 8, 79-85.
- Malikhao, P., & Servaes, J. (2014). Health communication strategies for sustainable development in a globalized world. In *Strategic Urban Health Communication* (pp. 143-158): Springer.
- Manomano, T., Tanga, P. T., & Tanyi, P. (2016). Housing problems and programs in South Africa: a literature review. *Journal of Sociology and Social Anthropology*, 7(2), 111-117.
- Mansaray, L. R., Huang, J., & Kamara, A. A. (2016). Mapping deforestation and urban expansion in Freetown, Sierra Leone, from pre-to post-war economic recovery. *Environmental Monitoring and Assessment.*, 188(8), 470.
- Marais, L., & Ntema, J. (2013). The upgrading of an informal settlement in South Africa: Two decades onwards. *Habitat International*, 39, 85-95.
- Marasinghe, L. (1993). Constitutional Reform in South Africa. *International & Comparative Law Quarterly*, 42(4), 827-854.
- Markey, S., Connelly, S., & Roseland, M. (2010). 'Back of the Envelope': Pragmatic Planning for Sustainable Rural Community Development. *Planning Practice & Research*, 25(1), 1-23.
- Masondo, A. (2009). The 2009 'State of the City' address. In.
- McDonnell, M. J., & Hahs, A. K. (2008). The use of gradient analysis studies in advancing our understanding of the ecology of urbanizing landscapes: current status and future directions. *Landscape Ecology*, 23(10), 1143-1155.
- McGarigal, K. (2014). Landscape pattern metrics. *Wiley StatsRef: Statistics Reference Online*.
- McGarigal, K., Cushman, S. A., Neel, M. C., & Ene, E. (2002). FRAGSTATS: spatial pattern analysis program for categorical maps.
- McGarigal, K., & Marks, B. J. (1994). FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Version 2.0. *Forest Science Department, Oregon State University, Corvallis*, 67.
- McGarigal, K., & Marks, B. J. (1995). FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. *Gen. Tech. Rep. PNW-GTR-351. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 122 p, 351.*
- McGranahan, D. A. (1999). *Natural amenities drive rural population change* (Vol. 781): US Department of Agriculture, ERS.
- Menze, B. H., & Ur, J. A. (2012). Mapping patterns of long-term settlement in Northern Mesopotamia at a large scale. *Proceedings of the National Academy of Sciences*, 109(14), E778-E787.
- Mesev, V. (2003). Urban land use uncertainty: Bayesian approaches to urban image classification. *Remotely sensed cities. Taylor & Francis, New York*, 207-222.
- Meyer, W. B., & Turner, B. (1996). Land-use/land-cover change: challenges for geographers. *GeoJournal*, 39(3), 237-240.
- Mihalache-O'Keef, A., & Li, Q. (2011). Modernization vs. dependency revisited: effects of foreign direct investment on food security in less developed countries. *International Studies Quarterly*, 55(1), 71-93.

- Mildrexler, D. J., Zhao, M., Heinsch, F. A., & Running, S. W. (2007). A new satellite-based methodology for continental-scale disturbance detection. *Ecological Applications*, 17(1), 235-250.
- Mildrexler, D. J., Zhao, M., & Running, S. W. (2009). Testing a MODIS global disturbance index across North America. *Remote Sensing of Environment*, 113(10), 2103-2117.
- Miller, R. B., & Small, C. (2003). Cities from space: potential applications of remote sensing in urban environmental research and policy. *Environmental Science & Policy*, 6(2), 129-137.
- Mitchell, P. (2002). *The archaeology of southern Africa*: Cambridge University Press.
- Moberg, M., & Granholm, K. (2012). The Concept of the Post-Secular and the Contemporary Nexus of Religion, Media, Popular Culture, and Consumer Culture. *Post-secular society*, 95-127.
- Monstadt, J. (2009). Conceptualizing the political ecology of urban infrastructures: insights from technology and urban studies. *Environment and planning A*, 41(8), 1924-1942.
- Moodley, S. (2008). Koma: The crocodile motif in the rock art of the Northern Sotho. *The South African Archaeological Bulletin*, 116-124.
- Moser, G., Serpico, S., & Vernazza, G. (2007). Unsupervised change detection from multichannel SAR images. *IEEE Geoscience and Remote Sensing Letters*, 4(2), 278-282.
- Msindo, E. (2018). Housing Backlog: Protests and the demand for housing in South Africa. In: Public Service Accountability Monitor (PSAM).
- Musakwa, W., & Van Niekerk, A. (2013). Implications of land use change for the sustainability of urban areas: A case study of Stellenbosch, South Africa. *Cities*, 32, 143-156.
- Musvoto, G. G. (2011). *Towards a framework for assessing settlement patterns and trends in South Africa to guide sustainable settlement development planning: a case study of KwaZulu-Natal province*.
- Myers, H., & Forrest, S. (2000). Making change: Economic development in Pond Inlet, 1987 to 1997. *Arctic*, 134-145.
- Narayanaraj, G., & Wimberly, M. C. (2012). Influences of forest roads on the spatial patterns of human-and lightning-caused wildfire ignitions. *Applied Geography*, 32(2), 878-888.
- Nasson, B., Penn, N., & Town, C. T. (2011). The War for South Africa. In.
- Nations, U. (2014). World urbanization prospects: The 2014 revision, highlights. department of economic and social affairs. *Population Division, United Nations*, 32.
- Nazer, S., Abu Hammad, A., Jergonsen, K., & Geelmuyden, A. K. (2010). Perception of Landscape Change: Artas Valley/Palestine.
- Ndegwa, D. (2008). MIGRATION AND POVERTY IN AFRICA: LEGACIES OF COLONIAL RESIDENTIAL SEGREGATION. *Poverty Alleviation: 21st Century Issues and Challenges*.
- Nel, V. (2011). Land-use management system as a tool towards achieving low-carbon cities in South Africa. *Town and Regional Planning*, 58, 1-5.
- Nel, V. (2016a). A better zoning system for South Africa? *Land Use Policy*, 55, 257-264.

- Nel, V. (2016b). *SPLUMA, zoning and effective land use management in South Africa*. Paper presented at the Urban Forum.
- Nell, J. (2004). Melting of platinum group metal concentrates in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*, 104(7), 423-428.
- Nettleton, A. (1992). Ethnic and gender identities in Venda Domba statues. *African Studies*, 51(2), 203-230.
- Network, S. A. C. (2006). South African state of the cities report 2006. In: Braamfontein: SACN.
- Nong, D., Lepczyk, C., Miura, T., Fox, J., Spencer, J., & Chen, Q. (2014). Quantify spatio-temporal patterns of urban growth in Hanoi using time series spatial metrics and urbanization gradient approach.
- Nuttall, J., & Nuttall, A. (2008). *The Mountains of England and Wales: Vol 2 England* (Vol. 2): Cicerone Press Limited.
- O'Neill, R. V., Riitters, K. H., Wickham, J. D., & Jones, K. B. (1999). Landscape pattern metrics and regional assessment. *Ecosystem health*, 5(4), 225-233.
- Okoampa, E. (2011). SETTLEMENT PATTERNS AND ECONOMIC DEVELOPMENT-A CASE STUDY OF THE TWIFO-LOWER DENKYIRA DISTRICT (CENTRAL REGION OF GHANA). *Researchers World*, 2(2), 202.
- Okpala, D. (1996). The Second United Nations Conference on Human Settlements (Habitat II). *Third World Planning Review*, 18(2), 3.
- Onaolapo, T. F., Okello, T. W., & Adelabu, S. A. (2020). Assessing spatio-temporal settlement patterns in Eastern Free State, South Africa, pre and post transition from apartheid to majority rule. *Transactions of the Royal Society of South Africa*, 1-19.
- Onslow, S. (2009). *Cold War in Southern Africa: white power, black liberation*: Routledge.
- Owusu, G. (2005). The role of district capitals in regional development: Linking small towns, rural–urban linkages and decentralisation in Ghana. *International Development Planning Review*, 27(1), 59-89.
- Özdemir, M. B. (2007). *History, presbyterianism and the confessional state: David Calderwood and his writings in the post-reformation Scotland*. Bilkent University,
- Özden, K., & Enwere, C. (2012). Urbanization and its political challenges in developing countries. *Eurasian Journal of Business and Economics*, 5(10), 99-120.
- Pacione, M. (2009). *Urban geography: A global perspective*: Routledge.
- Pallister-Wilkins, P. (2011). The separation wall: A symbol of power and a site of resistance? *Antipode*, 43(5), 1851-1882.
- Palmer, J. F. (2004). Using spatial metrics to predict scenic perception in a changing landscape: Dennis, Massachusetts. *Landscape and Urban Planning*, 69(2-3), 201-218.
- Pathiranage, I. S. S., Kankakumar, L. N., & Sundaramoorthy, S. (2018). Remote sensing data and SLEUTH urban growth model: As decision support tools for urban planning. *Chinese geographical science*, 28(2), 274-286.
- Perkins, P., Fedderke, J., & Luiz, J. (2005). An analysis of economic infrastructure investment in South Africa. *South African Journal of Economics*, 73(2), 211-228.
- Pesaresi, M., Ehrlich, D., Ferri, S., Florczyk, A., Freire, S., Haag, F., Halkia, M., Julea, A., Kemper, T., & Soille, P. (2015). Global human settlement analysis for disaster risk

- reduction. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 40(7), 837.
- Pieterse, D. E., & Parnell, S. (2014). *Africa's urban revolution*: Zed Books Ltd.
- Planning, P. (1967). Utilization of Resources Act. In: Act.
- Platzky, L. (1994). *The development impact of South Africa's industrial location policies: an unforeseen legacy*: Institute of Social Studies, Netherlands.
- Poelhekke, S. (2011). Urban growth and uninsured rural risk: Booming towns in bust times. *Journal of Development Economics*, 96(2), 461-475.
- Proos, E. (2015). *Assessing the Marketing and Management Effectiveness of the Free State Section of the Maloti Drakensberg Route*. Bloemfontein: Central University of Technology, Free State,
- Quan, R.-S., Liu, M., Lu, M., Zhang, L.-J., Wang, J.-J., & Xu, S.-Y. (2010). Waterlogging risk assessment based on land use/cover change: a case study in Pudong New Area, Shanghai. *Environmental Earth Sciences*, 61(6), 1113-1121.
- Raddad, S. (2016). Integrated a GIS and multi criteria evaluation approach for suitability analysis of urban expansion in southeastern Jerusalem region-Palestine.
- Raddad, S., Salleh, A. G., & Samat, N. (2010). Determinants of agriculture land use change in Palestinian urban environment: urban planners at local governments perspective. *American-Eurasian Journal of Sustainable Agriculture*, 4(1), 30-38.
- Radke, R. J., Andra, S., Al-Kofahi, O., & Roysam, B. (2005a). Image change detection algorithms: a systematic survey. *IEEE transactions on image processing*, 14(3), 294-307.
- Radke, R. J., Andra, S., Al-Kofahi, O., & Roysam, B. (2005b). Image change detection algorithms: a systematic survey. *IEEE Transactions on Image Processing*, 14(3), 294-307.
- Rana, M. M. P. (2011). Urbanization and sustainability: challenges and strategies for sustainable urban development in Bangladesh. *Environment, Development and Sustainability*, 13(1), 237-256.
- Redclift, M. R. (2007). Sustainable development (1987-2005): an oxymoron comes of age. *Horizontes Antropológicos*, 3(SE), 0-0.
- Reyes, G. E. (2001). Four main theories of development: modernization, dependency, world-systems and globalization. *Nómadas. Revista Crítica de Ciencias Sociales y Jurídicas*, 4(2), 109-124.
- Ries, L., & Sisk, T. D. (2010). What is an edge species? The implications of sensitivity to habitat edges. *Oikos*, 119(10), 1636-1642.
- Rigby, S.-A., & Diab, R. (2003). Environmental Sustainability and the Development Facilitation Act in South Africa. *Journal of Environmental Law*, 27-38.
- Robins, S. (2003). Literature Review on the Socio-cultural Dimensions of Township (Residential) Property Markets. *Prepared for Shisaka Development Management Services, for research into the Working of Township Property Markets. DRAFT*, 2, 19.
- Robinson, D. T., Murray-Rust, D., Rieser, V., Milicic, V., & Rounsevell, M. (2012). Modelling the impacts of land system dynamics on human well-being: Using an agent-based approach to cope with data limitations in Koper, Slovenia. *Computers, Environment and Urban Systems*, 36(2), 164-176.

- Robinson, J. (2011). Cities in a world of cities: the comparative gesture. *International journal of urban and regional research*, 35(1), 1-23.
- Rocheleau, D., & Roth, R. (2007). Rooted networks, relational webs and powers of connection: Rethinking human and political ecologies. *Geoforum*, 38(3), 433-438.
- Rodrigues, M. (2015). A spatial typology for settlement pattern analysis in small islands. *GeoFocus. Revista Internacional de Ciencia y Tecnología de la Información Geográfica*(15), 3-26.
- Rogan, J., & Chen, D. (2004). Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in Planning*. 61(4), 301-325.
- Ross, R. (2008). *A concise history of South Africa*: Cambridge University Press.
- Ross, R. J. (1983). Cape of torments: Slavery and resistance in South Africa.
- Rutherford, G. N., Bebi, P., Edwards, P. J., & Zimmermann, N. E. (2008). Assessing land-use statistics to model land cover change in a mountainous landscape in the European Alps. *Ecological modelling*, 212(3-4), 460-471.
- Sadr, K., & Sampson, C. G. (2006). Through thick and thin: early pottery in southern Africa. *Journal of African Archaeology*, 4(2), 235-252.
- Saghir, J., & Santoro, J. (2018). Urbanization in Sub-Saharan Africa: meeting challenges by bridging stakeholders. Centre for Strategic and International Studies. In.
- Sarkar, A. (2010). Analysis of human settlement patterns using RS and GIS in the plains of West Bengal. *The On-Line Indian Journal of Spatial Science*, 1(1), 1.1-1.16.
- Sassen, S. (2018). *Cities in a world economy*: Sage Publications.
- Seekings, J., & Nattrass, N. (2008). *Class, race, and inequality in South Africa*: Yale University Press.
- Serra, P., Pons, X., & Saurí, D. (2008). Land-cover and land-use change in a Mediterranean landscape: a spatial analysis of driving forces integrating biophysical and human factors. *Applied Geography*, 28(3), 189-209.
- Serra, P., Vera, A., Tulla, A. F., & Salvati, L. (2014). Beyond urban–rural dichotomy: Exploring socioeconomic and land-use processes of change in Spain (1991–2011). *Applied Geography*, 55, 71-81.
- Seto, K. C., & Kaufmann, R. K. (2003). Modeling the drivers of urban land use change in the Pearl River Delta, China: integrating remote sensing with socioeconomic data. *Land Economics*, 79(1), 106-121.
- Shisana, O., Rehle, T., Simbayi, L., Zuma, K., Jooste, S., Wyk, P.-V., Mbelle, N., Van Zyl, J., Parker, W., & Zungu, N. (2009). South African national HIV prevalence, incidence, behaviour and communication survey, 2008: a turning tide among teenagers? *Human Sciences Research Council (HSRC)*.
- Simmons, C., Walker, R., Perz, S., Arima, E., Aldrich, S., & Caldas, M. (2016). Spatial patterns of frontier settlement: Balancing conservation and development. *Journal of Latin American Geography*, 33-58.
- Singh, J. K., & Chetty, R. (2010). *Trauma, resistance, reconstruction in post-1994 South African writing* (Vol. 7): Peter Lang.
- Sinha, S., Jeganathan, C., Sharma, L., & Nathawat, M. (2015). A review of radar remote sensing for biomass estimation. *International Journal of Environmental Science and Technology*, 12(5), 1779-1792.

- Solomon, O., Samuel, J., & Altär–Samuel, A. (2011). Study Of The Relationship Between Economic Growth, Volatility And Innovation For The Eu-27 And Ceec Countries. *Journal of Information Systems & Operations Management*, 5(1), 82-90.
- Song, X.-P., Sexton, J. O., Huang, C., Channan, S., & Townshend, J. R. (2016). Characterizing the magnitude, timing and duration of urban growth from time series of Landsat-based estimates of impervious cover. *Remote sensing of environment*, 175, 1-13.
- Song, Y., Shao, G., Song, X., Liu, Y., Pan, L., & Ye, H. (2017). The relationships between urban form and urban commuting: An empirical study in China. *Sustainability*, 9(7), 1150.
- Statistics. (2012). Census 2011 release - P0301.4. Pretoria, Statistics South Africa.
- Statistics, S. (2001). Census 2001. Office for National Statistics.
- Stats, S. (2011). Statistics South Africa. *Formal census*.
- Stats, S. (2012). Census 2011 statistical release. Pretoria, South Africa: Statistics South Africa.
- Stats, S. (2018). Statistical Publications, July 2018. In.
- Steytler, N. (2005). Republic of South Africa. *Constitutional Origins, Structure, and Change in Federal Countries*, 312-346.
- Stiglitz, J. E. (1997). *The role of government in economic development*. Paper presented at the Annual World Bank Conference on Development Economics.
- Stilwell, L., Minnitt, R., Monson, T., & Kuhn, G. (2000). An input–output analysis of the impact of mining on the South African economy. *Resources policy*, 26(1), 17-30.
- Strautnieks, I., & Grīne, I. (2011). *Lake Engure catchment area as an example of the interaction of natural conditions, settlement pattern and economic activities*. Paper presented at the Proceedings of the Latvian Academy of Sciences. Section B. Natural, Exact, and Applied Sciences.
- Strydom, A. J., Mangope, D., & Henama, U. S. (2015). Economic sustainability guidelines for a Community Based Tourism Project: The Case of Thabo Mofutsanyane, Free State Province. *African Journal of Hospitality, Tourism and Leisure*, 6(3), 1-17.
- Stull, K., Kenyhercz, M., Tise, M., L'Abbé, E., & Tuamsuk, P. (2016). The craniometric implications of a complex population history in South Africa. In *Biological Distance Analysis* (pp. 245-263): Elsevier.
- Su, S., Zhang, Q., Zhang, Z., Zhi, J., & Wu, J. (2011). Rural settlement expansion and paddy soil loss across an ex-urbanizing watershed in eastern coastal China during market transition. *Regional Environmental Change*, 11(3), 651-662.
- Sullivan, E., & Ward, P. M. (2012). Sustainable housing applications and policies for low-income self-build and housing rehab. *Habitat International*, 36(2), 312-323.
- Surya, B. (2014). Social Change, Spatial Articulation in the Dynamics of Boomtown Construction and Development (Case Satudy of Metro Tanjung Bunga Boomtown, Makassar). *Modern Applied Science*, 8(4), 238.
- Swanson, J. (2017). *Bartolomeu Dias: First European Sailor to Reach the Indian Ocean*: The Rosen Publishing Group, Inc.
- Tacoli, C., McGranahan, G., & Satterthwaite, D. (2015). *Urbanisation, rural-urban migration and urban poverty*. JSTOR.
- Talen, E. (2005). Land use zoning and human diversity: Exploring the connection. *Journal of Urban Planning and Development*, 131(4), 214-232.

- Tang, J., Wang, L., & Zhang, S. (2005). Investigating landscape pattern and its dynamics in Daqing, China. *International journal of remote sensing*, 26(11), 2259-2280.
- Tankard, A. J., Martin, M., Eriksson, K., Hobday, D., Hunter, D., & Minter, W. (2012). *Crustal evolution of southern Africa: 3.8 billion years of earth history*. Springer Science & Business Media.
- Taubenböck, H., Esch, T., Felbier, A., Wiesner, M., Roth, A., & Dech, S. (2012). Monitoring urbanization in mega cities from space. *Remote sensing of environment*, 117, 162-176.
- Taubenböck, H., Wurm, M., Geiß, C., Dech, S., & Siedentop, S. (2019). Urbanization between compactness and dispersion: Designing a spatial model for measuring 2D binary settlement landscape configurations. *International Journal of Digital Earth*, 12(6), 679-698.
- Thapa, R. B., & Murayama, Y. (2009a). Examining spatio-temporal urbanization patterns in Kathmandu Valley, Nepal: Remote sensing and spatial metrics approaches. *Remote Sensing*, 1(3), 534-556.
- Thapa, R. B., & Murayama, Y. (2009b). Urban mapping, accuracy, & image classification: A comparison of multiple approaches in Tsukuba City, Japan. *Applied geography*, 29(1), 135-144.
- Thring, P. (2003). *HOUSING POLICY AND PRACTICE IN POST-APARTHEID SOUTH AFRICA*: Heinemann Educational Books.
- Tian, G., Qiao, Z., & Zhang, Y. (2012). The investigation of relationship between rural settlement density, size, spatial distribution and its geophysical parameters of China using Landsat TM images. *Ecological Modelling*, 231, 25-36.
- Tibane, E., & Honwane, M. (2015). South Africa yearbook 2014/15. *Twenty-second edition. Government Communications (GCIS), Pretoria, South Africa*.
- Tinker, D. B., Romme, W. H., & Despain, D. G. (2003). Historic range of variability in landscape structure in subalpine forests of the Greater Yellowstone Area, USA. *Landscape Ecology*, 18(4), 427.
- Tissington, K. (2010). A review of housing policy and development in South Africa since 1994. *Towards an SER Matrix: Monitoring the Progressive Realisation of Socio-Economic Rights in South Africa*.
- Todes, A., Karam, A., Klug, N., & Malaza, N. (2010). Beyond master planning? New approaches to spatial planning in Ekurhuleni, South Africa. *Habitat International*, 34(4), 414-420.
- Tomlinson, M. R. (2007). The development of a low-income housing finance sector in South Africa: have we finally found a way forward? *Habitat International*, 31(1), 77-86.
- Tomlinson, R. (2017). *Urbanization in post-apartheid South Africa* (Vol. 9): Routledge.
- Turner, R. (1978). *The Eye of the Needle: toward participatory democracy in South Africa*: Orbis Books.
- Turok, I. (2012). *URBANISATION AND DEVELOPMENT IN SOUTH AFRICA: ECONOMIC IMPERATIVES, SPATIAL DISTORTIONS AND STRATEGIC RESPONSES: United Nations Population Fund*.
- Turok, I. (2014a). South Africa's tortured urbanisation and the complications of reconstruction. In *Urban Growth in Emerging Economies* (pp. 157-204): Routledge.

- Turok, I. (2014b). *SOUTH AFRICA'S TORTURED URBANISATION AND THE COMPLICATIONS OF RECONSTRUCTION. Urban Growth in Emerging Economies: Lessons from the BRICS*. 143.
- UN-HABITAT. (2015). UN-Habitat Global Activities Report 2015. Increasing Synergy for Greater National Ownership. *United Nations Human Settlements Programme (UN-Habitat)*, 31.
- UNGA. (2017). United Nations Conference on Housing and Sustainable Urban Development (Habitat III) regional report for Africa: transformational housing and sustainable urban development in Africa.
- UNWUP. (2018). World Urbanization Prospects. The 2018 Revision, Highlights.
- Urban, M. C., Bokedi, G., Hendry, A. P., Mihoub, J.-B., Pe'er, G., Singer, A., Bridle, J., Crozier, L., De Meester, L., & Godsoe, W. (2016). Improving the forecast for biodiversity under climate change. *Science*, 353(6304), aad8466.
- Van Wyk, J. (2013). The legacy of the 1913 Black Land Act for spatial planning. *Southern African Public Law*, 28(1), 91-105.
- Van Wyk, J., & Oranje, M. (2014). The post-1994 South African spatial planning system and Bill of Rights: A meaningful and mutually beneficial fit? *Planning Theory*, 13(4), 349-369.
- Vatsavai, R. R., & Graesser, J. (2012). Probabilistic change detection framework for analyzing settlement dynamics using very high-resolution satellite imagery. *Procedia Computer Science*, 9, 907-916.
- Veldkamp, A., & Verburg, P. H. (2004). Modelling land use change and environmental impact. In: Elsevier.
- Verburg, P. H., Kok, K., Pontius, R. G., & Veldkamp, A. (2006). Modeling land-use and land-cover change. In *Land-use and land-cover change* (pp. 117-135): Springer.
- Vizzari, M. (2011). Spatial modelling of potential landscape quality. *Applied Geography*, 31(1), 108-118.
- Vizzari, M., & Sigura, M. (2015). Landscape sequences along the urban–rural–natural gradient: A novel geospatial approach for identification and analysis. *Landscape and Urban Planning*, 140, 42-55.
- Wainwright, J., Jiang, S., Mercer, K., & Liu, D. (2015). The political ecology of a highway through Belize's forested borderlands. *Environment and Planning A: Economy and Space*, 47(4), 833-849.
- Wallis, A. M., Graymore, M. L., & Richards, A. J. (2011). Significance of environment in the assessment of sustainable development: The case for south west Victoria. *Ecological Economics*, 70(4), 595-605.
- Watts, M. J. (2015). The origins of political ecology and the rebirth of adaptation as a form of thought. *The Routledge handbook of political ecology*, 19.
- Weber, C., & Puissant, A. (2003). Urbanization pressure and modeling of urban growth: example of the Tunis Metropolitan Area. *Remote sensing of environment*, 86(3), 341-352.
- Wei, W., Shi, P., Zhou, J., Feng, H., Wang, X., & Wang, X. (2013). Environmental suitability evaluation for human settlements in an arid inland river basin: A case study of the Shiyang River Basin. *Journal of Geographical Sciences*, 23(2), 331-343.

- Weng, Y.-C. (2007). Spatio-temporal changes of landscape pattern in response to urbanization. *Landscape and Urban planning*, 81(4), 341-353.
- Wilson, P. (2001). Listing the Irish hills and mountains. *Irish Geography*, 34(1), 89-95.
- Winters, P., Essam, T., Zezza, A., Davis, B., & Carletto, C. (2010). Patterns of rural development: A cross-country comparison using microeconomic data. *Journal of Agricultural Economics*, 61(3), 628-651.
- Woodhouse, H. (1996). *The rock art of the golden gate and Clarens districts: An enthusiast's guide*: W. Waterman Publications.
- Ye, H., He, X., Song, Y., Li, X., Zhang, G., Lin, T., & Xiao, L. (2015). A sustainable urban form: The challenges of compactness from the viewpoint of energy consumption and carbon emission. *Energy and Buildings*, 93, 90-98.
- Yu, X., & Ng, C. (2006). An integrated evaluation of landscape change using remote sensing and landscape metrics: a case study of Panyu, Guangzhou. *International Journal of Remote Sensing*, 27(6), 1075-1092.
- Yuan, D., & Elvidge, C. (1998). NALC land cover change detection pilot study: Washington DC area experiments. *Remote sensing of environment*, 66(2), 166-178.
- Zaidi, B., & Morgan, S. P. (2017). The second demographic transition theory: A review and appraisal. *Annual review of sociology*, 43, 473-492.
- Zandbergen, P. (2008). Applications of shuttle radar topography mission elevation data. *Geography Compass*, 2(5), 1404-1431.
- Zhang, X. (2016). Sustainable urbanization: a bi-dimensional matrix model. *Journal of Cleaner Production*, 134, 425-433.
- Zhang, Z., Wang, X., Zhao, X., Liu, B., Yi, L., Zuo, L., Wen, Q., Liu, F., Xu, J., & Hu, S. (2014a). A 2010 update of National Land Use/Cover Database of China at 1: 100000 scale using medium spatial resolution satellite images. *Remote sensing of environment*, 149, 142-154.
- Zhang, Z., Xiao, R., Shortridge, A., & Wu, J. (2014b). Spatial point pattern analysis of human settlements and geographical associations in eastern coastal China—A case study. *International journal of environmental research and public health*, 11(3), 2818-2833.
- Zhao, H., Li, X., & Wang, X. (2011). Heavy metal contents of road-deposited sediment along the urban–rural gradient around Beijing and its potential contribution to runoff pollution. *Environmental science & technology*, 45(17), 7120-7127.
- Zhiming, F., Yanzhao, Y., Zhen, Y., & Yande, Z. (2010). A GIS-based study on sustainable human settlements functional division in China. *Journal of Resources and Ecology*, 1(4), 331-338.
- Zlotnik, H. (2017). World urbanization: trends and prospects. In *New Forms of Urbanization* (pp. 43-64): Routledge.
- zu Selhausen, F. M. (2017). Growing cities: urbanization in Africa. In.

# APPENDICES



## APPENDIX I: INTERVIEW GUIDE 1

FACULTY OF AGRICULTURE AND NATURAL SCIENCE

DEPARTMENT OF GEOGRAPHY

PHUTHADITJHABA, SOUTH AFRICA.

### SPATIO-TEMPORAL CHANGE OF HUMAN SETTLEMENT PATTERN IN THABO MOFUNTSANYANE MUNICIPAL DISTRICT.

INTERVIEW GUIDE FOR GOVERNMENT OFFICIAL (HUMAN SETTLEMENT DEPARTMENT/ HOUSING AND TOWN PLANNING UNIT)

Date.....

Locality.....

#### SECTION A: DEMOGRAPHIC CHARACTERISTICS

<b>Gender</b>	Male	Female						
<b>Age Grp</b>	18-23	24 - 29	30 - 35	36 - 41	42 - 47	48 - 53	54 - 59	60 & Above
<b>Marital status</b>	Married	Single	Widowed	Divorcee				
<b>Educational qualification</b>	No former educ.	Primary Sch. Cert.	Matric	University education				
<b>Designation</b>	Senior officer	Junior officer						
<b>Years in office</b>	5 or less	6 - 10	11 – 15	16 - 20	21 - 30	Above 30		

#### SECTION B. Factors Responsible For Change in Settlement Development Pattern

1. Has there been changes in settlement development the locality since 1989 up till date  
(a) Yes (b) No
  
2. If yes, what are those changes that have occurred in relation to settlement development in the locality?
  
3. Do you think the change in government from apartheid in 1994 to majority rule affected settlement development patterns?  
(a) Yes (b) No
4. How will you describe settlement development before the change of government in 1994 from apartheid to majority rule?  
.....  
.....  
.....
5. What are the main changes in land use/ land cover in this locality since 1989  
(a) Built-up to other land uses  
(b) Other land uses to built-up  
(c) specify others
6. What are the factors of settlement development change between 1989 and 2018 in the study area?  
(a) Political factor  
(b) Economic Factor  
(c) Urban development factor  
(d) Demography factor  
(e) Policy and Planning factor.
7. What have been the trends in settlement development change in the locality between  
1989 to 1994 .....  
1995 to 2000 .....  
2001 to 2005.....  
2006 to 2010 .....  
2011 to 2015.....  
2016 up till date.....  
(a). Linear (b). Clustered (c). Irregular (d). scattered.
  
8. What are the municipality (locality)'s policies to manage/control settlement development within the locality?  
.....  
.....  
.....  
.....
9. What is the nature of the relationship between the local municipality, community leaders, and the other stakeholders in the planning and development of settlements?

- (a) cordial
- (b) relatively good
- (c) non-existence

10. Who are other main partners in settlement development, especially in the areas of projects developments?.....  
 .....  
 .....

**Section C: Effect of settlement development change on the environmental component**

11. Is there any effect of the settlement development change on the environmental components?

- (a) Yes (b) No

12. If yes, what are the biophysical and natural resources affected by these changes in the study area?

- a). Water
- b). Grassland
- c). Farmland
- d). Specify others

13. In what way is any or all of the above affected?

- a). Water Pollution
- b). Loss of farmland
- c). Land degradation
- d). Environmental Pollution
- e). Specify others

**Sections D and E are frequency weighted questions about the land-use change factors**

**Section D:** As the head of the unit, how do you rank the following factors responsible for the change in settlement development pattern in this locality? Where 5 is the most important, and 1 is the least important.

<b>Factor/ rank</b>	(5)	(4)	(3)	(2)	(1)
Political factors					
Economic factors					
Urban development					

Demographic factors

Policy and Planning factors

Others i.e. Social, Communal, etc.

**Section E:** How do you rank the factors that stand behind changing of built-up into other land use or vice versa in your locality? Where 5 is the most important, and 1 is the least important.

<b>Factor/ rank</b>	(5)	(4)	(3)	(2)	(1)
Income level/standard of living of residents					
The market value of land					
Level of education					
Availability of loan facility					
Increase in population					
Population migration to the city					
Cost of living					
Proximity to water					
The change in the political system from apartheid to majority rule					
Proximity to basic infrastructures					
Safety and security					
Planning policy					
Lack of development plan/control					
Lack of development law to guide the development					
Size of land/land fragmentation					
Lack of guidance					
Lack of planning law to protect the agricultural land					

## APPENDIX II: INTERVIEW GUIDE 2

FACULTY OF AGRICULTURE AND NATURAL SCIENCE

DEPARTMENT OF GEOGRAPHY

PHUTHADITJHABA, SOUTH AFRICA.

### SPATIO-TEMPORAL CHANGE OF HUMAN SETTLEMENT PATTERN IN THABO MOFUNTSANYANE MUNICIPAL DISTRICT.

INTERVIEW GUIDE FOR COMMUNITY HEADS, HEADS OF FARMERS AND DEVELOPERS.

#### SECTION A: DEMOGRAPHIC CHARACTERISTICS

<b>Gender</b>	Male	Female						
<b>Age Grp</b>	18-23	24 - 29	30 - 35	36 - 41	42 - 47	48 - 53	54 - 59	60 & Above
<b>Marital status</b>	Married	Single	Widowed	Divorcee				
<b>Educational qualification</b>	No former educ.	Primary Sch. Cert.	Matric	University education				
<b>Designation</b>	Senior officer	Junior officer						
<b>Years in office</b>	5 or less	6 - 10	11 – 15	16 - 20	21 - 30	Above 30		

#### SECTION B. Factors Responsible For Change in Settlement Development Pattern

1. Have there been changes in the locality since 1989 till date? (a). Yes, (b). No
2. What are the changes concerning settlement development that have occurred in the locality?

3. Do you think the change in government from apartheid in 1994 to majority rule affected settlement development patterns?  
(a). Yes, (b). No
  
4. What are the factors responsible for settlement development/growth in the community?
  - a). Political factor
  - b). Economic Factor
  - c). Urban development factor
  - d). Demography factor
  - e). Policy and Planning factor.
  
5. What are the measures (if any) taken to prevent uncontrolled development in the community?
  - a). Payment of penalty fee
  - b). Demolition of illegal structure
  - c). Strict warning
  - d). Specify others
  
6. How can you describe the situation with settlement development before the change of government in 1994 and after 1994 in the locality?

Before 1994	After 1994
a). Rapid	a). Rapid
b). Static	b). Static
c). Gradual	c). Gradual

7. What have been the trends in settlement development change in the locality between
  - 1989 to 1994 .....
  - 1995 to 2000 .....
  - 2001 to 2005.....
  - 2006 to 2010 .....
  - 2011 to 2015 .....
  - 2016 up till date .....
 (a). Linear (b). Clustered (c). Irregular (d). scattered.

8. What are the main problems with settlement development in the locality?

- a. Land degradation
- b. Environmental pollution.
- c. Loss of farmland/pasture
- d. Specify

9. Is there any effect of uncontrolled settlement development on the environmental components in the area?

(a) Yes (b) No

10. What is the effect of settlement expansion on environmental components such as water, grassland, and forest (if any)?

- a). Water Pollution
- b). Loss of farmland
- c). Land degradation
- d). Environmental Pollution
- e). Specify others

11. What are the factors determining siting buildings?

- a). proximity to infrastructure,
- b). roads,
- c). land ownership

### **Section C: Effect of settlement development change on the environmental component**

12. Is there any effect of the settlement development change on the environmental components?

(a) Yes (b) No

13. If yes, what are the biophysical and natural resources affected by these changes in the study area?

- a). Water
- b). Grassland
- c). Farmland
- d). Specify others

14. In what way is any or all of the above affected?

- a). Water Pollution

- b). Loss of farmland
- c). Land degradation
- d). Environmental Pollution
- e). Specify others

**Section D: Other Open-ended questions**

15. What are the main stages in the history of the community?  
 .....  
 .....  
 .....  
 .....
16. Are there tools used in monitoring settlement development? (a). Yes (b). No
17. Which tools are usually used to monitor development locally?  
 .....  
 .....  
 .....
18. Which tools/measures are usually used to manage development locally?  
 .....  
 .....  
 .....
19. Are these tools/measures effective enough to control development and manage development?  
 .....  
 .....  
 .....
20. In your own opinion, what more measures should be taken to manage development? .....  
 .....  
 .....
21. Do you think the application of development control to guide and predict settlement development can be beneficial for the management of the environment and prevention of future degradation?  
 .....  
 .....  
 .....
22. Who are the other main stakeholders in the planning and development in the locality? .....  
 .....  
 .....

**Sections E and F are frequency weighted questions about the land-use change factors**

**Section E:** How do you rank the following factors that are responsible for the change in settlement development pattern in the locality? Where 5 is the most important, and 1 is the least important.

<b>Factor/ rank</b>	(5)	(4)	(3)	(2)	(1)
Political factors					
Economic factors					
Urban development					
Demographic factors					
Policy and Planning factors					
Others i.e. Social, Communal, etc.					

**Section F:** How do you rank the factors that stand behind changing of built-up into other land use or vice versa in your locality? Where 5 is the most important, and 1 is the least important.

<b>Factor/ rank</b>	(5)	(4)	(3)	(2)	(1)
Income level/standard of living of residents					
The market value of land					
Level of education					
Availability of loan facility					
Increase in population					
Population migration to the city					
Cost of living					
Proximity to water					
The change in the political system from apartheid to majority rule					
Proximity to basic infrastructures					
Safety and security					
Planning policy					
Lack of development plan/control					
Size of land/ land fragmentation					

## APPENDIX III: ETHICS CLEARANCE



### GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

28-Aug-2019

Dear Mrs Onaolapo, Titilope TF

#### Application Approved

Research Project Title:

**SPATIOTEMPORAL CHANGE OF HUMAN SETTLEMENTS' DEVELOPMENT PATTERN IN AFROMONTANE REGION:**

**CASE STUDY OF THABO MOFUTSANYANA MUNICIPAL DISTRICT.**

Ethical Clearance number:

**UFS-HSD2018/1384**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. Furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

**Prof Derek Litthauer**

**Chairperson: General/Human Research Ethics Committee**

Digitally signed  
by Derek  
Litthauer  
Date: 2019.08.28  
14:19:21 +02'00'

206 Nelson Mandela Drive/Rylaan  
Park West/Parloves  
Bloemfontein 9301  
South Africa/Suid-Afrika

P.O. Box / Posbus 339  
Bloemfontein 9300  
South Africa / Suid-Afrika  
T: +27(0)51 401 2116  
F: +27(0)51 401 3702  
[WithhnrCG@ufs.ac.za](mailto:WithhnrCG@ufs.ac.za)  
[www.ufs.ac.za](http://www.ufs.ac.za)



UNIVERSITY OF THE  
FREE STATE  
UNIVERSITEIT VAN DIE  
VRYSTAAT  
YUNIVESITHI YA  
FREISTATA



## APPENDIX IV: CONSENT TO PARTICIPATE IN THIS STUDY

I, \_\_\_\_\_ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study, as explained in the information sheet. I have had sufficient opportunity to ask questions and am prepared to participate in the study. I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable). I am aware that the findings of this study will be anonymously processed into a research report, journal publications, and/or conference proceedings.

I agree with the recording of the *insert specific data collection method*.

I have received a signed copy of the informed consent agreement.

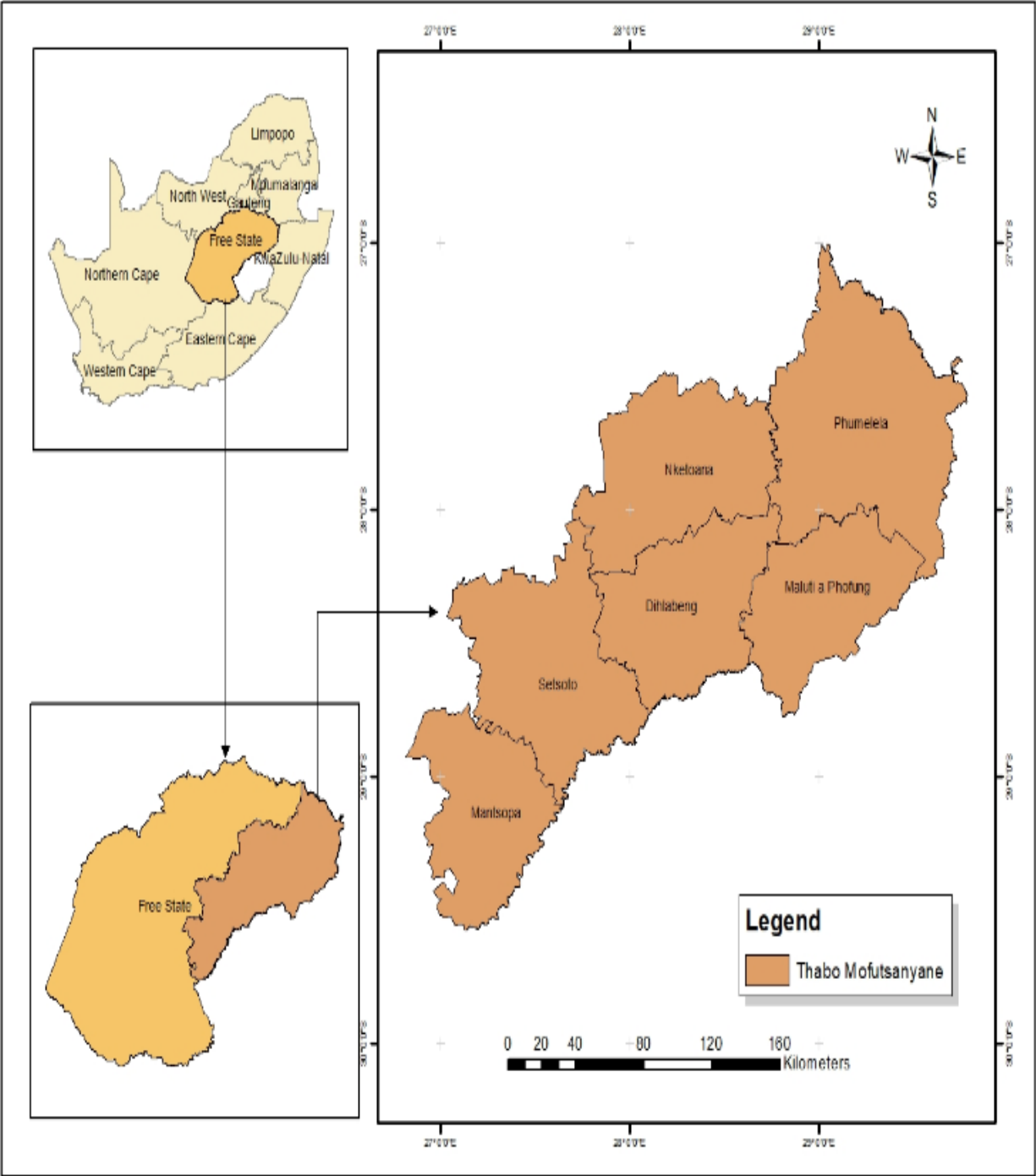
Full Name of Participant: \_\_\_\_\_

Signature of Participant: \_\_\_\_\_ Date: \_\_\_\_\_

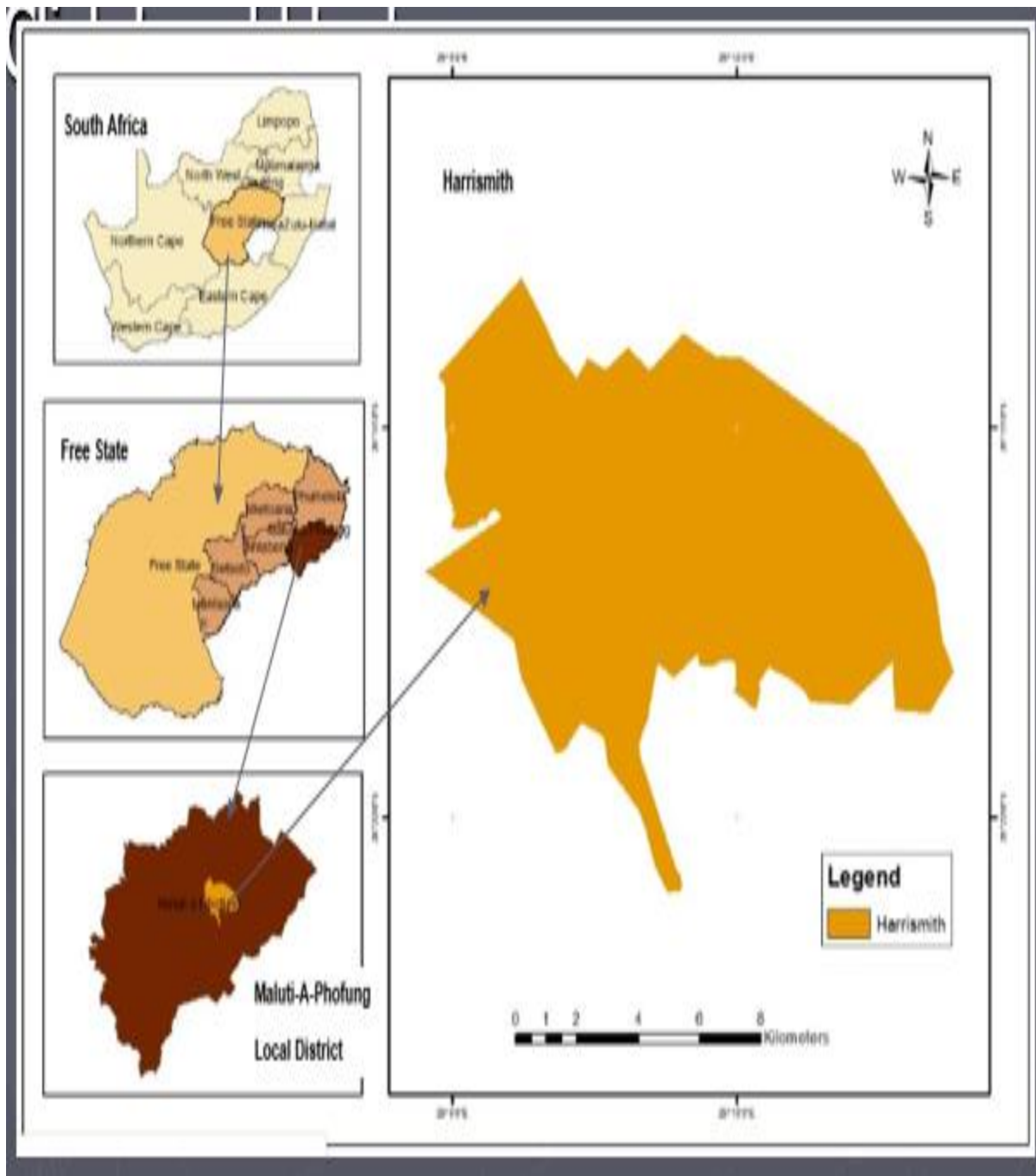
Full Name(s) of Researcher(s): \_\_\_\_\_

Signature of Researcher: \_\_\_\_\_ Date: \_\_\_\_\_

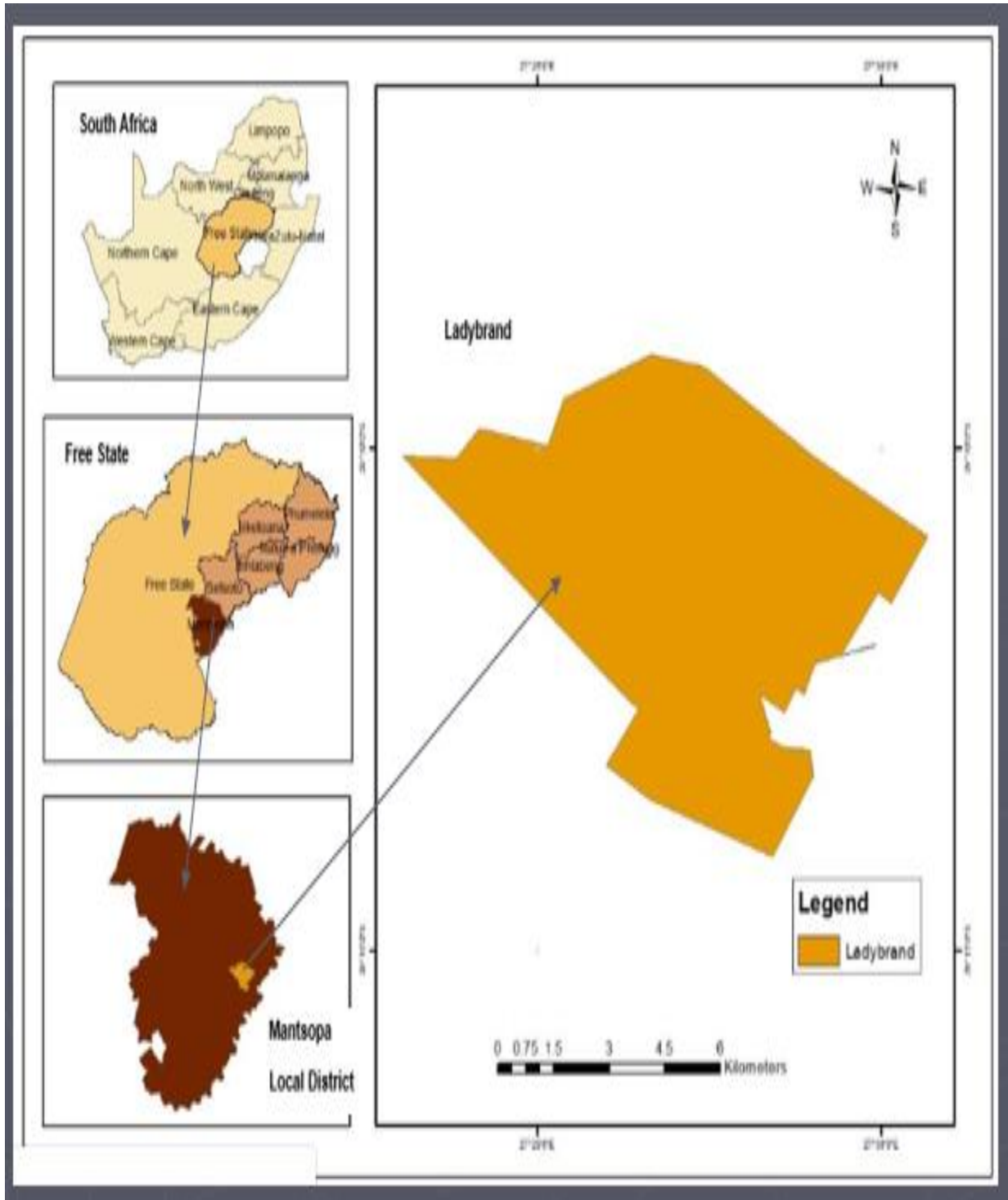
**APPENDIX V: MAP OF THABO MOFUTSANYANE MUNICIPALITY IN THE CONTEXT OF THE FREE STATE PROVINCE, SOUTH AFRICA**



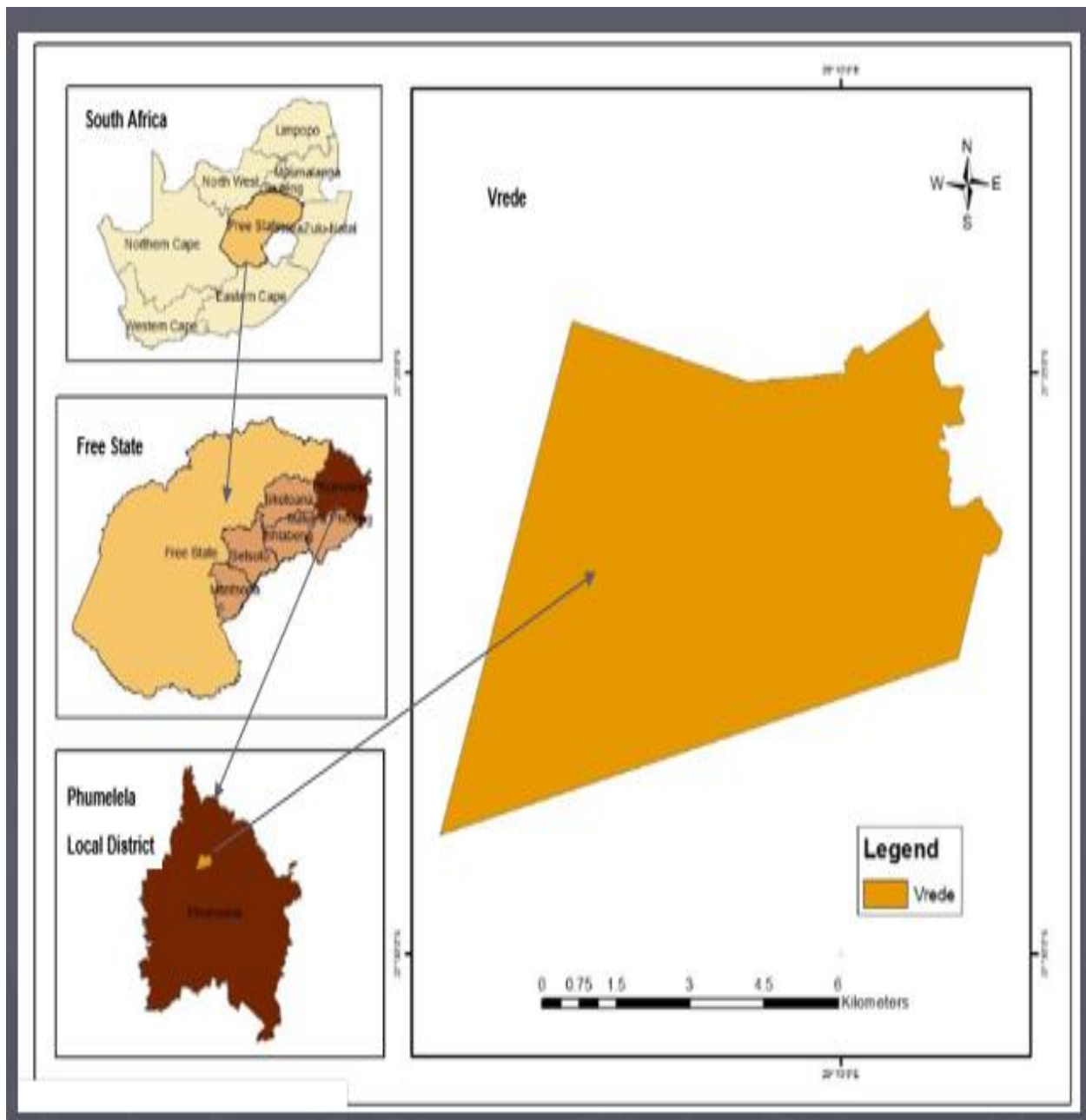
## APPENDIX VI: SHAPE MAP OF HARRISMITH



# APPENDIX VII: SHAPE MAP OF LADYBRAND



## APPENDIX VIII: SHAPE MAP OF VREDE



## APPENDIX IX: LANDSCAPE METRIC TABLES

### a. Harrismith

Class	Year	NP	PD	ED	LPI	FDI	COHESION
Built up	1989	983	0.9235	0.0044	4.8250	1.0366	9.7869
Green area		1242	1.1903	0.0102	7.5109	1.0419	9.98166
Bare surface		851	8.1556	0.0110	34.1680	1.0493	9.9109
Water		84	8.0502	0.0005	0.2829	1.0445	9.2117
Built up	1999	1780	1.0897	0.0072	8.1491	1.0312	9.8358
Green area		1328	1.2727	0.0108	14.7897	1.0413	9.8584
Bare surface		1372	1.3149	0.0132	26.6235	1.0456	9.9005
Water		44	4.2168	0.0002	0.0140	1.0564	8.8737
Built up	2009	1425	0.7137	0.0072	8.3389	1.0376	9.8335
Green area		476	4.5618	0.0034	10.8721	1.0433	9.8733
Bare surface		578	5.5393	0.0082	62.4130	1.0377	9.9414
Water		50	4.7918	0.0001	0.1466	1.0214	9.0979
Built up	2018	1061	0.5534	0.0109	33.6194	1.0475	9.9238
Green area		592	5.6735	0.0045	11.3784	1.0497	9.8667
Bare surface		731	7.0056	0.0082	6.2015	1.0488	9.7973
Water		81	7.7627	0.0005	0.4520	1.0396	9.3468

b. Vrede

Class	Year	NP	PD	ED	LPI	FDI	COHESION
Built up	1989	512	0.6830	0.0057	8.0555	1.0432	9.7639
Green area		434	8.6573	0.0087	10.5312	1.0521	9.7688
Bare surface		243	4.8473	0.0078	28.0821	1.0302	9.8625
water		7	1.3963	0.0002	0.9820	1.0302	9.5027
Built up	1999	695	0.7498	0.0078	11.2242	1.0342	9.7977
Green area		478	9.5350	0.0067	5.9514	1.0477	9.7008
Bare surface		314	6.2636	0.0092	48.5449	1.0416	9.8999
Water		2	3.9896	0.0001	0.8815	1.0730	9.4758
Built up	2009	564	0.6990	0.0076	16.1667	1.0330	9.8396
Green area		479	9.550	0.0101	6.3643	1.0475	9.6868
Bare surface		386	7.6998	0.0085	28.5560	1.0487	9.8658
Water		4	7.9791	0.0002	0.8815	1.0912	9.4680
Built up	2018	612	0.7098	0.0088	20.7303	1.0398	9.8513
Green area		527	1.0513	0.0104	6,2046	1,0490	9.6842
Bare surface		301	6.0043	0.0075	8.5726	1.0596	9.7336
Water		3	5.9843	0.0002	0.7792	1.1062	9.4342

b. Ladybrand

Class	Year	NP	PD	ED	LPI	FDI	COHESION
Built up	1989	715	0.6304	0.0044	3.5466	1.0294	9.6560
Green area		605	1.1136	0.0077	3.8349	1.0500	9.5839
Bare surface		245	4.5095	0.0089	68.5905	1.0260	9.9225
Water		117	2.1535	0.0008	0.4224	1.0370	8.9686
Built up	1999	780	0.6901	0.0056	4.8967	1.0316	9.7331
Green area		577	1.0620	0.0092	5.2578	1.0453	9.7066
Bare surface		306	5.6322	0.0103	54.6308	1.0341	9.9161
Water		230	4.2334	0.0016	0.5086	1.0388	8.8571
Built up	2009	826	0.8675	0.0083	14.9401	1.0378	9.8423
Green area		330	6.0726	0.0106	25.8128	1.0391	9.8859
Bare surface		443	8.1519	0.0058	6.2586	1.0384	9.7582
Water		64	1.1778	0.0005	0.2816	1.0469	8.7173
Built up	2018	834	0.8998	0.0090	13.0836	1.0368	9.8170
Green area		607	1.1170	0.0089	8.1549	1.0453	9.7373
Bare surface		443	8.1519	0.0100	15.8510	1.0431	9.8268
Water		127	2.3370	0.0009	0.1391	1.0413	8.2390

## APPENDIX X: CLASS METRIC TABLES

### a. Harrismith

	NP	PD	ED	LPI	COHESION	FDI	SHDI	SIDI	SHEI	PLAND	CLASS AREA	MPS
<b>1989</b>	3160	0.9258	0.0261	46.7868	38.7261	4.1723	0.9906	0.5796	0.7146	10.18	1061.7	1.0801
<b>1999</b>	4524	1.0897	0.0314	49.7063	38.4684	4.1745	1.0449	0.6235	0.07537	15.65	1633.4	0.9177
<b>2009</b>	2529	0.7137	0.0189	81.7706	38.7461	4.1400	0.8838	0.5047	0.6375	19.14	1996.7	1.4012
<b>2018</b>	2465	0.5534	0.0241	51.6513	38.9346	4.1856	1.1023	0.6407	0.7951	40.12	4186.5	3.9458

### b. Vrede

	NP	PD	ED	LPI	COHESION	FDI	SHDI	SIDI	SHEI	PLAND	CLASS AREA	MPS
<b>1989</b>	1196	0.6830	0.0224	47.6508	38.8979	4.1682	1.0428	0.6118	0.7522	13.62	682.83	1.3337
<b>1999</b>	1489	0.7498	0.0238	66.6020	38.8742	4.1965	1.0227	0.5866	0.7377	20.3	1017.5	1.4641
<b>2009</b>	1433	0.699	0.0264	51.9685	38.8602	4.2204	1.1217	0.6578	0.8091	21.93	1099.2	1.9489
<b>2018</b>	1443	0.7098	0.0269	36.2867	38.7033	4.2546	1.1394	0.6708	0.8219	29.28	1469.9	2.4018

### c. Ladybrand

	NP	PD	ED	LPI	COHESION	FDI	SHDI	SIDI	SHEI	PLAND	CLASS AREA	MPS
<b>1989</b>	1682	0.6304	0.0218	76.3944	38.1310	4.1424	0.8476	0.4624	0.6114	9.08	493.47	0.6902
<b>1999</b>	1893	0.6901	0.0267	65.2939	38.2129	4.1498	1.0525	0.5904	0.7592	16.51	897.12	1.1502
<b>2009</b>	1663	0.8675	0.0252	47.2931	38.2037	4.1622	1.0476	0.6057	0.7557	22.03	1197	1.4492
<b>2018</b>	2011	0.8998	0.0288	37.2286	37.6201	4.1665	1.1195	0.6485	0.8075	24.35	1323	1.5863